RAPPORT

Aanvraag Mbb-vergunning pijpleiding inclusief mededeling voornemen ten behoeve van mer-beoordeling

Verbindingsleiding CO2-distributieplatform naar CO2-injectieplatform L4A

Klant: TotalEnergies EP Nederland B.V.

Referentie: ARM-PFE-B10-ENV-EIA-2040

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CCS-ARAMIS Project

Environment Impact Assessment – Baseline report

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1 Inleiding

Een consortium onder de naam Aramis wil een CO_2-transportinfrastructuur ontwikkelen om koolstofdioxide (CO_2) geproduceerd op land op te slaan in lege offshore gasvelden. Een belangrijk onderdeel van deze infrastructuur is de hoofdtransportleiding (zeeleiding) waarmee de CO_2 vanaf de Maasvlakte richting de gasvelden wordt getransporteerd. Vanaf aftakkingen en het eindpunt van deze zeeleiding, het zogenaamde distributieplatform, transporteren meerdere verbindingsleidingen CO_2 naar platforms, vanwaar de CO_2 in leeggeproduceerde gasvelden onder de zeebodem wordt geïnjecteerd en daar permanent wordt opgeslagen. Naar dit geheel van activiteiten zal worden verwezen als het Aramis initiatief, waarin verschillende partijen samenwerken.

De infrastructuur vanaf de aftakkingen en het distributieplatform wordt door individuele partijen opgepakt. In dit kader vraagt TotalEnergies EP Nederland B.V. aan het ministerie van Klimaat en Groene Groei (hierna: KGG) toestemming voor de aanleg van een verbindingsleiding vanaf het distributieplatform naar het L4A-platform in de Noordzee. Voorliggend document betreft de aanvraag van een vergunning in het kader van artikel 94 van het mijnbouwvergunning voor het aanleggen van een pijpleiding in de territoriale zee of op het continentaal plat. In deze aanvraag wordt dit de aanleg van de verbindingsleiding genoemd.

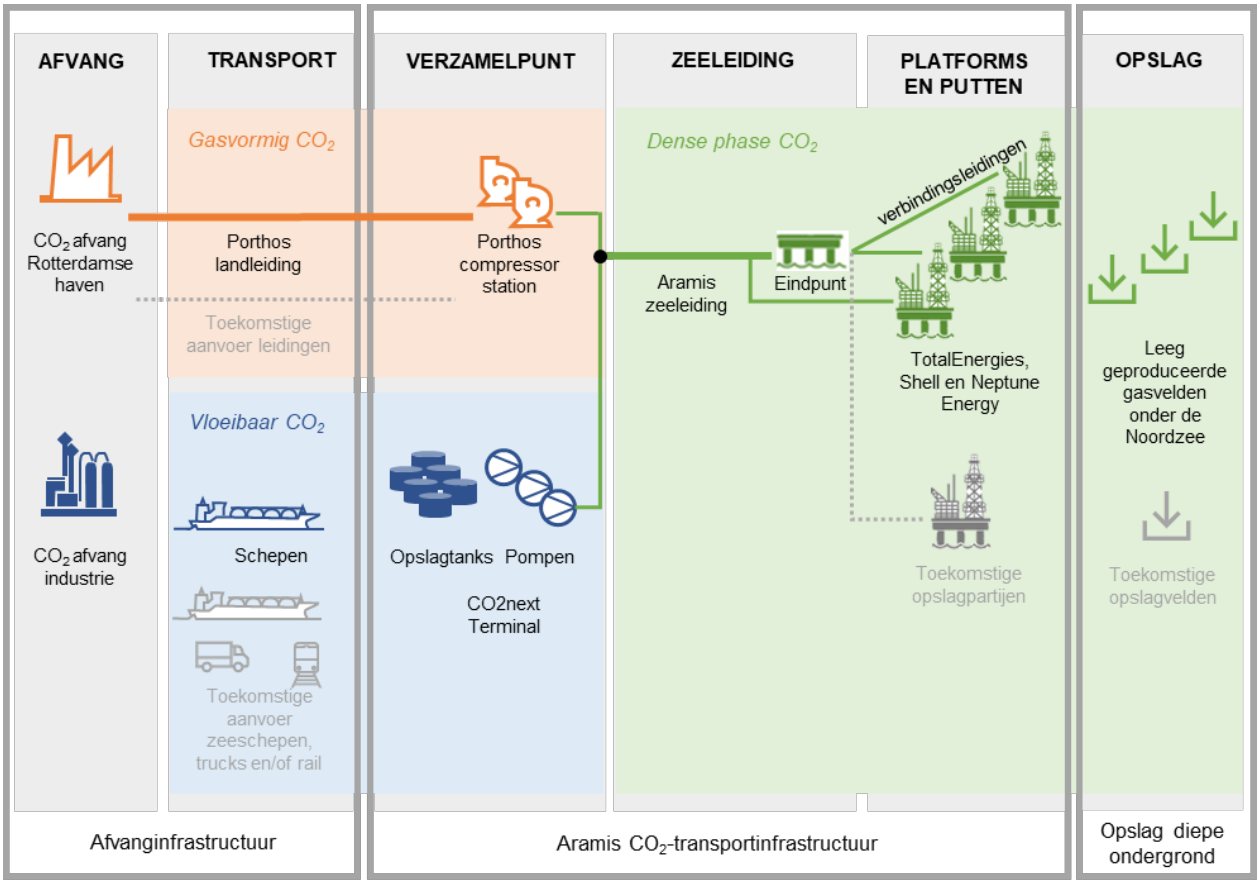
De aanleg en het in gebruik nemen van een dergelijk pijpleiding is mer-beoordelingsplichtig op grond van het Omgevingsbesluit (bijlage V, categorie J9). Het voorliggende document is naast de vergunningaanvraag in het kader van het Mijnbouwbesluit (hierna: Mbb) ook de mededeling voornemen aan de hand waarvan bepaald kan worden of aanzienlijke milieueffecten kunnen optreden en of een milieueffectrapport (MER) opgesteld moet worden[1].

Doel

Het doel van het Aramis iniatiatief is ondergrondse opslag van door bedrijven afgevangen CO_2 in lege aardgasvelden op zee mogelijk maken. Het project draagt hiermee bij aan het reduceren van de emissies van broeikasgassen naar de atmosfeer en het project draagt daarmee bij aan het beperken van de opwarming van de aarde. Het afvangen en opslaan van CO_2 in de diepe ondergrond staat bekend als Carbon Capture and Storage (CCS). Met het Aramis initiatief wordt vanuit het Rotterdamse havengebied CCS-infrastructuur ontwikkeld. Deze bestaat onder andere uit een zeeleiding van ongeveer 230 km lengte, die een eerste (klein) deel over land loopt, dan onder de zeewering en Maasgeul doorgaat, en vervolgens over de zeebodem loopt. De zeeleiding transporteert CO_2 in vloeibare of superkritische staat (dense phase) naar een centraal distributieplatform op de Noordzee waarop operators kunnen aansluiten met een eigen verbindingsleiding. Voor TotalEnergies EP Nederland B.V. geldt dat de verbindingsleiding CO_2 naar het L4A-platform van TotalEnergies transporteert. Vandaaruit wordt de CO_2 in het leeg geproduceerde gasveld L4A geïnjecteerd voor geologische opslag.

Figuur 1-1 geeft een overzicht van de nu geplande infrastructuur en de toekomstig mogelijke uitbreidingen.

[1] *De term mer staat voor milieueffectrapportage (procedure). Het MER is het milieueffectrapport.*



Figuur 1-1. Overzicht van de integrale CCS-keten met daarin de componenten die onderdeel zijn van de voorgenomen activiteit, namelijk: de Aramis CO_2 transport- en opslaginfrastructuur.

Vergunningen

Op grond van artikel 94 van het Mbb is het verboden zonder vergunning van de minister van KGG een pijpleiding aan te leggen in de territoriale zee, op het continentaal plat, of in een ander gebied waarvoor op grond van het Besluit milieueffectrapportage het maken van een milieueffectrapport (MER[2]) nodig is. Dit document behelst de vergunningaanvraag op grond van artikel 94 van het Mbb.

Milieueffectrapportage

Op grond van artikel 16.43 en bijlage V van het Omgevingsbesluit is de aanleg van een buisleiding mer-plichtig of mer-beoordelingsplichtig, dat hangt af van de afmetingen van de buisleiding In het onderhavige geval geldt dat de afmetingen van de verbindingsleiding (zie paragraaf 3.3) niet zodanig zijn dat sprake is van een mer-plicht, maar van een mer-beoordelingsplicht.

De initiatiefnemer van een mer-beoordelingsplichtig project deelt zo spoedig mogelijk mee aan het bevoegd gezag dat hij een dergelijk project wil ondernemen. Artikel 11.10 van het Omgevingsbesluit gaat nader in op de inhoud van de mededeling voornemen. De initiatiefnemer moet rekening houden met de relevante criteria van bijlage III bij de Europese mer-richtlijn en, voor zover relevant, met de beschikbare resultaten van andere relevante beoordelingen van de milieueffecten. Bij de mededeling voornemen kan een beschrijving worden verstrekt van de kenmerken van het voorgenomen project en van de voorgenomen maatregelen om mogelijk aanzienlijke milieueffecten te vermijden of te voorkomen.

[2] *In deze aanvraag leest u soms MER (met hoofdletters) en soms mer (met kleine letters). MER is de afkorting van milieueffectrapport (het onderzoeksrapport als eindproduct van de procedure) en mer is de afkorting van milieueffectrapportage (de procedure die tot een MER leidt).*

Het voorliggende document betreft naast de vergunningaanvraag ook de mededeling voornemen in het kader van de mer-beoordelingsplicht voor de verbindingsleiding. Het bevat de benodigde informatie voor het bevoegde gezag om te bepalen of het opstellen van een MER al dan niet nodig is. Voor de verbindingsleiding betreft het alleen de beoordeling van een project en niet van een plan.

Overigens is relevant te vermelden dat het Aramis initiatief als geheel inclusief transportleidingen op land en op zee mer-plichtig is. Hiervoor is een gecombineerd plan- en project-MER opgesteld, voor respectievelijk het projectbesluit en de vereiste vergunningen (anders dan die voor de verbindingsleidingen). In dit gecombineerde plan- en project-MER zijn de effecten van de verbindingsleidingen als onderdeel van het gehele project ook al beschouwd.

De voorliggende mededeling voornemen richt zich op het effect van de verbindingsleiding in het bijzonder. Het gecombineerde plan- en project-MER voor het gehele Aramis initiatief zal tevens bij deze vergunningaanvraag worden gevoegd. Hiermee kan de bredere context van de verbindingsleiding en milieueffecten worden meegewogen in het besluit of het noodzakelijk is om de effecten van de verbindingsleiding in een project-MER in meer detail te onderzoeken.

Initiatiefnemer
De vergunning in het kader van het Mbb wordt aangevraagd door TotalEnergies EP Nederland B.V. Met de voorliggende aanvraag vraagt TotalEnergies vergunning aan voor de aanleg van de genoemde verbindingsleiding.

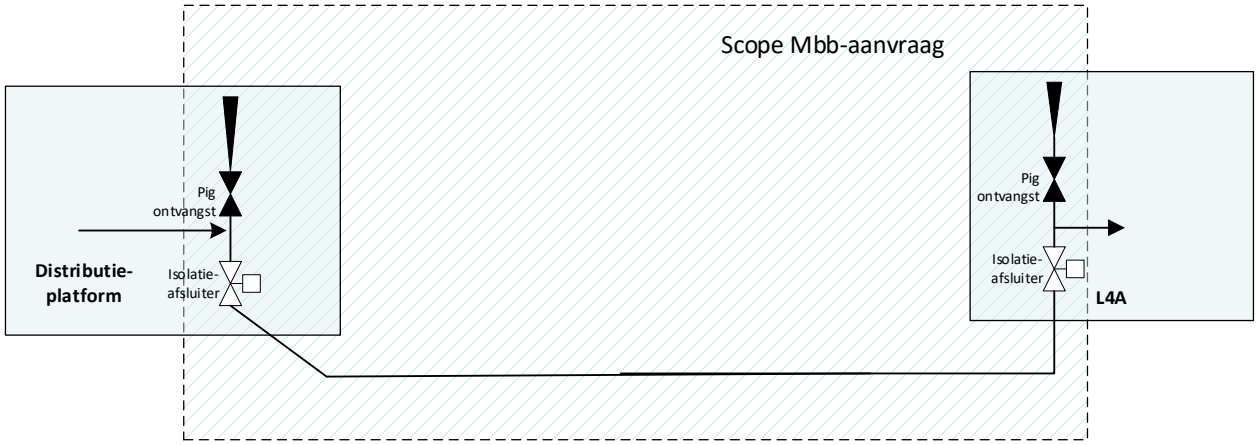
Planning
De verwachting is dat vanaf 2027 met de leidingaanleg op zee kan worden aangevangen. De totale doorloop van aanleg neemt ongeveer een jaar in beslag. Vanaf 2028 kan begonnen worden met testen en het opstarten van de CO_2-transport en -opslag. Mocht er beroep worden aangetekend tegen het ontwerpbesluit, het ontwerpprojectbesluit, of het MER, dan dient rekening gehouden te worden met een vertraging van een jaar tot anderhalf jaar. In dat geval wordt de start van CO_2-transport en -opslag verwacht vanaf 2029. De ontwerplevensduur van de pijpleiding is 30 jaar.

1.1 Omvang van de aanvraag

Deze aanvraag is opgesteld in het kader van de besluitvorming over de Mijnbouwvergunning voor de aanleg en ingebruikname van de verbindingsleiding voor het transport van CO_2. De Mijnbouwvergunning wordt aangevraagd bij de Minister van KGG in het kader van artikel 94 van het Mijnbouwbesluit.

De omvang van de aanvraag (zie Figuur 1-2) voor de verbindingsleiding is als volgt:

- Het beginpunt van de verbindingsleiding is het door Aramis te realiseren distributieplatform, van waar dense-phase CO_2 wordt gedistribueerd naar andere platforms;
- Het eindpunt van de verbindingsleiding is het platform L4A van TotalEnergies EP Nederland B.V. op de Noordzee (locatie is op een kaart weergegeven in Figuur 3-1.
- De leiding wordt met flensen verbonden aan de riser op het platform (zie Figuur 3-2);
- De lanceer- en ontvangstations voor het verzenden en ontvangen van ragers (pigs) maken tevens deel uit van de omvang van de aanvraag.



Figuur 1-2. Scope van de aanvraag in het kader van artikel 94 Mbb. Het gearceerde gebied geeft de omvang van de aanvraag weer.

Het leidingtracé omvat de gehele gesurveyde strook zoals weergegeven in bijlage 2.

Bij het ontwerp van verbindingsleiding wordt onderzocht of dit zodanig kan worden uitgevoerd dat de natuur hier voordeel van heeft. Hiermee wordt invulling gegeven aan de afspraken uit het Noordzeeakkoord (NZA) over natuurversterkend bouwen. Als duidelijk is waar natuurversterkend wordt gebouwd, wordt onderzocht of en in welk kader hiervoor toestemming van het bevoegd gezag vereist is. Het natuurversterkend bouwen valt buiten de omvang van deze artikel 94 Mbb-vergunningsaanvraag.

1.2 Leeswijzer

Hoofdstuk 2 geeft de algemene gegevens van de aanvrager, de pijpleiding, tijdvak, en locatie van de aanvraag. Hoofdstuk 3 gaat in op de details van de vergunningaanvraag, waaronder de aard en sterkte van de pijpleiding, het tracé, de wijze van aanleg, de getransporteerde stoffen, de wijze van kruisen met andere leidingen en kabels, testen, en bedrijfsvoering. Hoofdstuk 4 omvat de relevante effecten op het milieu en de omgeving in het kader van de vergunningaanvraag en mer-beoordeling. Hoofdstuk 5 gaat in datzelfde kader in op cumulatie met andere activiteiten. In hoofdstuk 6 is de conclusie van de mer-beoordeling aangegeven. Hoofdstuk 7 bevat ten slotte een kruisverwijzing tussen de indieningsvereisten van de mijnbouwwetgeving met deze aanvraag.

2 Algemene gegevens

2.1 Gegevens aanvrager

Tabel 1 bevat een overzicht van de relevante gegevens van de aanvrager.

Tabel 1: Gegevens aanvrager

Aanvrager	
Statutaire naam aanvrager	TotalEnergies EP Nederland B.V.
Ligging project	Exclusieve Economische Zone
Handelsnaam	TotalEnergies EP Nederland B.V.
Vestigingsadres bedrijf	Prinses Catharina-Amaliastraat 5 2496 XD, Den Haag
Correspondentieadres	Postbus 93280 2509 AG Den Haag
Contactpersoon	[redacted]
Telefoonnummer contactpersoon	
E-mailadres	

2.2 Activiteit

Verbindingsleiding

TotalEnergies EP Nederland B.V. heeft het voornemen een verbindingsleiding aan te leggen van het te realiseren distributieplatform naar het L4A platform van TotalEnergies EP Nederland B.V. op de Noordzee (zie ook Figuur 2-1). De verbindingsleiding begint bij het op te richten distributieplatform en eindigt bij het CO_2-injectieplatform L4A. Van daaruit wordt de CO_2 in het uitgeproduceerde offshore gasveld L04A geïnjecteerd voor geologische opslag.

De beoogde verbindingsleiding is ongeveer 28 kilometer lang en heeft een buitendiameter van 16” (circa 40 cm). De verbindingsleiding ligt uitsluitend in de exclusieve economische zone (EEZ). De verbindingsleiding wordt met een riser verbonden met zowel het distributieplatform als het L4A-platform. De verbindingsleiding wordt waar nodig ingegraven en, bij kruisingen met andere leidingen, afgedekt met stenen en/of matrassen. Bij het L4A platform wordt het uiteinde bedekt met stenen en/of betonmatrassen.

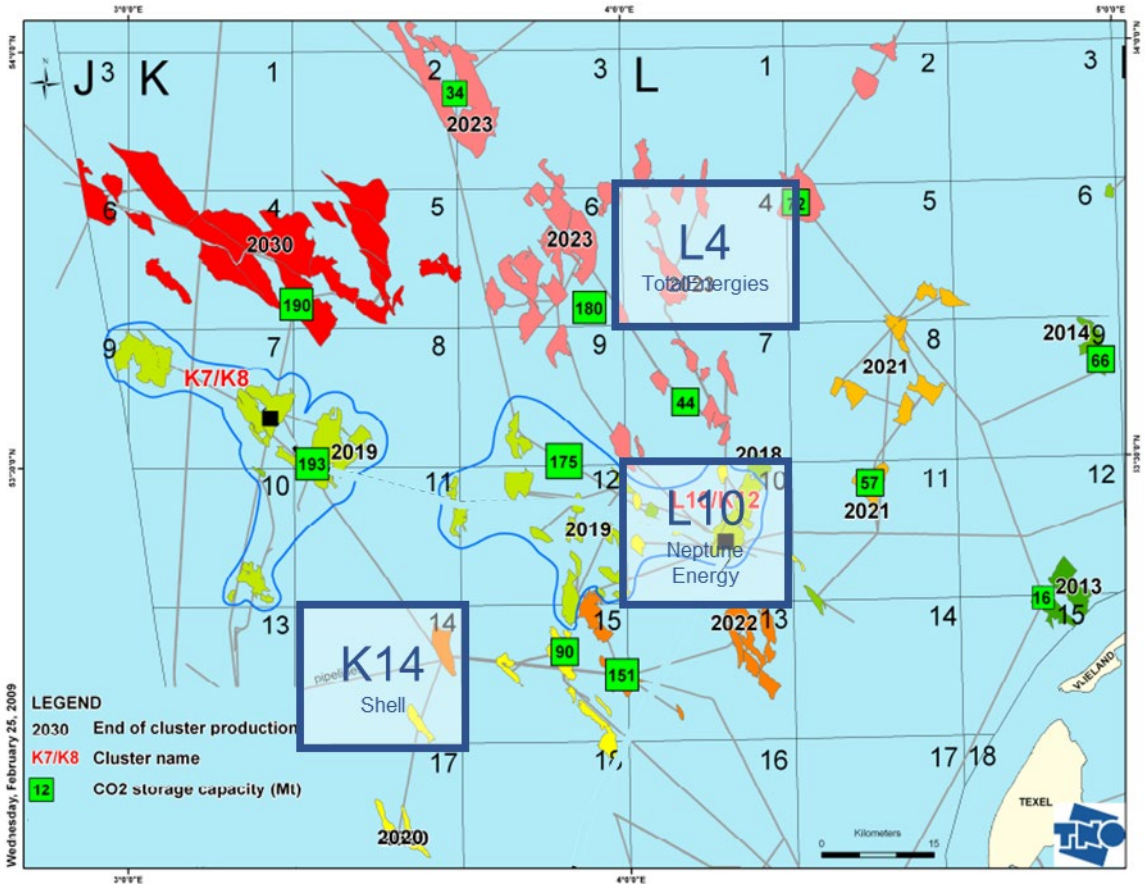
2.3 Tijdvak van de vergunning

Het tijdvak waarvoor een vergunning op grond van artikel 94 van het Mbb wordt aangevraagd loopt vanaf de start van de werkzaamheden, vooralsnog gepland in 2027. De vergunning voor de leiding wordt voor onbepaalde tijd aangevraagd. De pijpleiding wordt mechanisch ontworpen voor een periode van 30 jaar.

2.4 Gebied van de aanvraag

Deze aanvraag betreft de aanleg van een pijpleiding in de EEZ. De EEZ strekt zich uit voorbij de Nederlandse territoriale zee (vanaf 12 zeemijl[3] uit de kust) tot aan de EEZ van onze buurlanden en Nederland heeft hier soevereine economische rechten. De locatie van blok L4 is weergegeven op de kaart in Figuur 2-1.

3 1 zeemijl is 1852 meter



Figuur 2-1. Locatie van het L4 blok op de Noordzee.

2.5 Wettelijk kader en bevoegd gezag

Op grond van de definities in artikel 1 Mbw onder ag valt de aangevraagde pijpleiding onder de Mbw omdat dit een leiding betreft die twee of meer mijnbouwwerken met elkaar verbindt ten behoeve van het vervoer van stoffen. De relevante wet- en regelgeving met betrekking tot mijnbouwpijpleidingen is geregeld in het Mbb en de Mbr. § 6.2 van het Mbb regelt de vergunningplicht van pijpleidingen in de territoriale zee of op het continentaal plat, of in een ander gebied waarvoor op grond van het Omgevingsbesluit het maken van een milieueffectrapport verplicht is. §1.7.2 Mbr regelt de inhoud van de vergunningsaanvraag. Hoofdstuk 3 gaat in op de in artikel 1.7.1 Mbr gevraagde gegevens met betrekking tot de vergunningsaanvraag. De Minister van KGG is op grond van artikel 94 van het Mbb het bevoegd gezag. De aanvraag volgt de reguliere voorbereidingsprocedure.

Milieueffectrapportage

De voorgenomen activiteit van TotalEnergies EP Nederland B.V. is mer-beoordelingsplichtig op grond van categorie J9 in bijlage V van het Omgevingsbesluit:

> *De aanleg, wijziging, of uitbreiding van een buisleiding voor het transport van gas, olie, chemicaliën of voor het transport van kooldioxide (CO_2) stromen ten behoeve van geologische opslag.*

Er is geen sprake van een buisleiding met een diameter van meer dan 0,8 meter en een lengte van meer dan 40 km, zodat de beoogde activiteit niet mer-plichtig is. Wel is sprake van aanleg van een buisleiding voor het transport van kooldioxidestromen voor geologische opslag, zodat alleen sprake is van een mer-beoordelingsplicht. Uit hoofde van deze verplichting zijn de activiteiten van TotalEnergies EP Nederland B.V. beschreven, onderzocht en beoordeeld in dit document. Veel van de gegevens en studies zijn gebaseerd op c.q. uitgevoerd in het kader van het MER dat is opgesteld ten behoeve van het Aramis initiatief.

Het Aramis initiatief bestaat uit meerdere onderling samenhangende onderdelen. Voor de realisatie en gebruik hiervan zijn vergunningen nodig, waaronder vergunningen waarvoor een milieueffectrapportageprocedure (mer) nodig is. Zo zijn aanleg en gebruik van de Aramiszeeleiding mer-plichtig evenals de aanpassing en het gebruik van de platforms als onderdeel van de CO_2-opslaglocaties. Verder zijn net als deze verbindingsleiding de benodigde diepboringen (het boren van de CO_2-injectieputten) mer-beoordelingsplichtig. Om aan alle mer-verplichtingen te voldoen, is voor veel onderdelen van het Aramis initiatief één uitgebreide mer-procedure doorlopen.

2.6 Vooroverleg

Het tracé op zee is zo gekozen dat het zoveel mogelijk bestaande leidingen volgt en gevoelige gebieden en andere bestaande en toekomstige gebruiksfuncties zo min mogelijk te belemmert. Dit betreft zandwingebieden, huidige en toekomstige windparken, militaire gebieden, scheepswrakken, vaarroutes, visserijgebieden, en natuurgebieden. TotalEnergies heeft specifiek voor het aanleggen van de verbindingsleiding geen vooroverleg gevoerd. In het kader van de zeeleiding die door Aramis wordt gerealiseerd, is echter met verschillende instanties vooroverleg(gen) gevoerd, waarbij de aan te leggen verbindingsleidingen (van zowel TotalEnergies EP Nederland B.V. als andere operators) ook zijn besproken.

- Ministerie van Economische Zaken en Klimaat: afstemming met betrekking tot het project als geheel inclusief tracé offshore pijpleiding en vergunningen;
- Rijkswaterstaat: afstemming met betrekking tot boren onder de zeewering en pijpleidingtracé op zee;
- Staatstoezicht op de Mijnen: afstemming met betrekking tot technische aspecten en vergunningen;
- Gemeente Rotterdam: afstemming met Leidingenbureau voor het landdeel van de zeeleiding;
- Ministerie van Defensie: ligging leiding ten opzichte van defensiegebieden;
- Rijksdienst Cultureel Erfgoed: afstemming in het kader van mogelijke verstoring van archeologische waarden;
- Leidingeigenaren op zee: afstemming leidingtracé inclusief kruisingen van leidingen en kabels;
- Offshore olie- en gasoperators: afstemming leidingtracé inclusief kruisingen van leidingen;
- Operators offshore windparken: afstemming leidingtracé met bestaande en geplande windparken;
- Rijkswaterstaat Zee en Delta, Kustwacht en Loodswezen: Afstemming over nautische veiligheid, ligging ten opzichte van tracé bij kruisingen en parallelloop met scheepvaartroutes;
- Natuur- en milieuorganisaties: Afstemming over effect infrastructuur op natuur en biodiversiteit & natuurversterkend bouwen;
- Vissersbonden: Gevolgen Aramis infrastructuur op visserij.

Voor het gehele Aramis initiatief wordt een uitgebreid participatieproces doorlopen. De in dit kader uitgevoerde participatie is beschreven in het participatieplan voor het Aramis initiatief. Een samenvatting hiervan is opgenomen in bijlage 8.

3 Details vergunningsaanvraag

Dit hoofdstuk bevat informatie van de voorgenomen activiteit ten behoeve van de aanvraag voor de leidingvergunning op grond van artikel 94 Mbb.

3.1 Naleven van wettelijke eisen en normen

De pijpleiding voldoet aan de relevante eisen gesteld in de NEN 3650-serie of gelijkwaardig[4]:

- NEN 3650-1:2020 Eisen voor buisleidingsystemen (generiek)
- NEN 3650-2:2020 Eisen voor stalen buisleidingsystemen
- NEN 3654:2023 Wederzijdse beïnvloeding van buisleidingen en hoogspanningssystemen
- NEN 3655:2020 Veiligheidsbeheersysteem (VBS) voor buisleidingsystemen voor het transport van gevaarlijke stoffen - Functionele eisen
- NEN 3656:2022 Eisen voor stalen zeeleidingsystemen.

Er wordt voldaan aan de eisen van artikel 93 Mbb:

1 De pijpleiding bestaat uit pijpen die voldoende sterk zijn en op doelmatige wijze met elkaar zijn verbonden. De pijpleiding is tegen uitwendige corrosie en krachten beschermd.
   - De ontwerpdruk van de pijpleiding is gebaseerd op de maximale bedrijfsdruk. Overschrijding van de maximale bedrijfsdruk wordt voorkomen door instrumentele beveiliging indien nodig in combinatie met veiligheidskleppen. Alle leidinglassen worden volledig gecontroleerd, mogelijk met uitzondering van enkele ‘gouden lassen’ voor het koppelen van lange leidinglengtes. De gehele leiding wordt voor ingebruikname afgeperst of op een vergelijkbare wijze op drukvastheid beproefd. Zie voor een verdere toelichting paragraaf 3.4.2;
   - De pijpleiding wordt uitwendig gecoat tegen corrosie en waar nodig voorzien van een betonnen ballastcoating;
   - De pijpleiding wordt tegen uitwendig krachten beschermd door deze aan te leggen volgens NEN 3656.

2 De ligging van de pijpleiding is zodanig dat geen schade wordt veroorzaakt of zoveel mogelijk voorkomen.
   - Het tracé is afgestemd met de Kustwacht, Rijkswaterstaat en SodM;
   - Kruisingen met bestaande in bedrijf zijnde pijpleidingen en kabels worden zodanig uitgevoerd met stortsteen en betonmatrassen dat de bestaande leiding niet wordt beschadigd. De kruising wordt vervolgens afgedekt met stenen zodat ze overvisbaar zijn. Bij de platforms worden stenen en/of betonmatrassen op leidingen gelegd om te beschermen tegen ‘dropped objects’ en ter voorkoming van erosie (uitspoelingskuilen);
   - De beheerders van bestaande leidingen en kabels zijn waar mogelijk geïnformeerd en details met betrekking tot de ligging nabij bestaande Kabels en Leidingen (K&L) worden met hen afgestemd en eventueel in crossing agreements vastgelegd.

3 De eigenschappen, de aanleg, de ligging en het onderhoud van de pijpleiding voldoen aan bij ministeriële regeling te stellen eisen.
   - De pijpleiding voldoet aan artikel 10.1 Mbr: de leidingen zijn ontworpen conform de relevante bepalingen van de NEN 3650-serie of gelijkwaardig.

[4] De NEN 3650-serie of gelijkwaardig kan als BBT (Beste Beschikbare Technieken) worden beschouwd. De NEN 3650-serie is niet dwingend in de wetgeving voorgeschreven, dus er mag vanaf geweken worden. Er wordt aan de NEN 3650-serie voldaan of aan een vergelijkbaar kwaliteitsniveau zoals door gebruik van DNV-standards, waarmee wordt voldaan een artikel 93 van het Mijnbouwbesluit. Overal waar in deze aanvraag is vermeld dat aan de NEN 3650-serie wordt voldaan, kan dus ook een vergelijkbare wijze aan de voorschriften worden voldaan. Bij afwijken wordt in de ontwerpdocumentatie vastgelegd wat de afwijking betreft en hoe is zekergesteld dat alternatieve oplossing ten minste gelijkwaardig is. Waar nodig worden afwijkingen en de onderbouwing van de gelijkwaardigheid gemeld aan SodM.

3.2 Voorontwerp van de pijpleiding

Door TotalEnergies is een voorlopig ontwerp van de verbindingsleiding opgesteld. Het conceptrapport van het voorontwerp van de pijpleiding is bijgevoegd in bijlage 1 bij deze aanvraag. Specifiek voor de in artikel 1.7.1 Mbr onder e van de Mbr gevraagde punten staat hieronder aangegeven waar deze punten in deze aanvraag zijn beschreven:

1 De eigenschappen en diameter van de pijpleiding zijn beschreven in paragraaf 3.3 ;

2 De stoffen die erin worden vervoerd, zijn beschreven in paragraaf 3.5;

3 Een analyse van de veiligheids- en milieurisico's is gegeven in hoofdstuk 4 en de risico's zijn daarnaast ook beschreven in het MER dat gelijktijdig met deze aanvraag is ingediend;

4 De tijd gedurende welke de pijpleiding wordt gebruikt voor het vervoer van die stoffen zijn beschreven in paragraaf 2.3.

3.3 Karakteristieken van de pijpleiding

De karakteristieken van de pijpleiding zijn afkomstig uit de voorlopige ontwerpstudie. Het rapport van het voorontwerp van de pijpleiding zoals bedoeld in Artikel 1.7.1 lid 1 onder e van de Mbr is in de vorm van deze voorlopige ontwerpstudie van de verbindingsleiding opgenomen in bijlage 1. Detailinformatie ten aanzien van de verbindingsleiding komt in de loop van 2024 beschikbaar.

Materiaal, diameter en wanddikte

- De beoogde verbindingsleiding is ongeveer 28 kilometer lang;
- Buitendiameter 16" (40 cm), wanddikte van ongeveer 16 mm. Verschillende diktes gelden voor verschillende veiligheidszones (volgens NEN 3656), maar het grootste deel van de verbindingsleiding wordt uitgevoerd met een wanddikte van ongeveer 16 mm (medium veiligheidszone);
- Materiaal: laag- of ongelegeerd koolstofstaal voor lage temperaturen (fijnkorrel koolstofstaal/fine grain carbon steel);
- Ontwerpdruk: 200 bar CO_2 in 'dense phase';
- Ontwerptemperatuur: 50 °C[5];
- Corrosietoeslag: 3 mm;

Corrosiebescherming: externe anti-corrosie coating in combinatie met kathodische corrosiebescherming (met opofferingsanoden). De toepassing van een kathodisch beschermingssysteem is stand der techniek in aanvulling op de uitwendige bekleding, die de eerste beschermingslaag vormt. De toepassing van een kathodisch beschermingssysteem is vereist op grond van NEN 3635 voor offshore stalen buisleidingen.

- Interne corrosiebescherming is niet voorzien, maar corrosie wordt voorkomen door strikte eisen te handhaven aan de samenstelling van de CO_2. Tijdens de FEED-fase wordt nog nader ingegaan op de bewaking van het optreden van interne corrosie en worden documenten ontwikkeld om dit vast te leggen;
- Ballastcoating: betonmantel waar nodig.

Ligging op of in de bodem

De verbindingsleiding wordt in principe niet ingegraven maar op de zeebodem gelegd, behalve als dat op grond van NEN 3656 uit installatietechnische, operationele-, veiligheids- of stabiliteitsredenen ingraven van de leiding vereist is. Zie verder paragraaf 3.4.

Thermische expansie

Er is een voorlopige thermische uitzettingsevaluatie uitgevoerd, rekening houdend met de (voorlopige) ontwerptemperatuur van 50°C. Aan beide zijden van de pijpleidingen is een relatief lage uitzetting voorzien van ongeveer 40 cm, wat kan worden opgevangen door een standaard expansiepasstuk.

[5] *De optimale ontwerptemperatuur wordt nog verder onderzocht tijdens de FEED-fase en deze waarde kan hierdoor nog wijzigen.*

Monitoring
Om CO_2-lekkage vanuit de verbindingsleiding te voorkomen wordt corrosiebescherming en monitoring via pigging toegepast, zoals bedoeld in artikel 10.1 Mbr. Er wordt een programma opgesteld voor monitoring van de integriteit van de leiding in de gebruiksfase. De verbindingsleiding wordt inwendig geïnspecteerd met behulp van pigging en uitwendige inspectie vindt plaats ten behoeve van een goede stabiele ligging zonder ontoelaatbare free-spans. De toelaatbare omvang van free-spans wordt tijdens het detailontwerp van de leiding bepaald en wordt conform NEN 3656 in de ontwerpdocumenten vastgelegd.

Flow assurance (hydraulisch ontwerp)
Conform NEN 3656 moet de keuze van de leidingdiameter en het -materiaal berusten op een zorgvuldige analyse en optimalisatie van alle relevante aspecten. Deze analyse moet onder meer ingaan op alle mogelijke optredende bedrijfssituaties van debieten en drukken gedurende ontwerplevensduur, rekening houdend met de gewenste einddrukken. In lijn hiermee is voor het ontwerp van de Aramiszeeleiding een flow assurance-onderzoek (hydraulisch onderzoek) uitgevoerd, waaruit volgde binnen welke randvoorwaarden en onder welke omstandigheden CO_2 veilig en technisch effectief kan worden getransporteerd en geïnjecteerd. Het rapport van het onderzoek is als bijlage 5 toegevoegd.

Het flow assurancerapport presenteert de thermo-hydraulische analyse tijdens normaal stationaire operatie en tijdens bijzondere omstandigheden. De analyse is uitgevoerd voor het transport en de injectie van de CO_2 in leeggeproduceerde aardgasvelden en gaat met name in op het transport via de Aramiszeeleiding. Een aandachtspunt bij de analyse was dat de te injecteren CO_2 een aantal onzuiverheden kan bevatten die een belangrijk effect kunnen hebben op de operabiliteit van het injectiesysteem, en meer specifiek via de hoofdleiding. Bij de thermo-hydraulische analyse is de invloed van deze onzuiverheden daarom met name onderzocht. Naast stationair bedrijf zijn ook bijzondere bedrijfsomstandigheden onderzocht zoals de initiële vulling van het systeem en het van druk aflaten van de leiding.

De doelstellingen van het flow assurance-onderzoek waren als volgt:

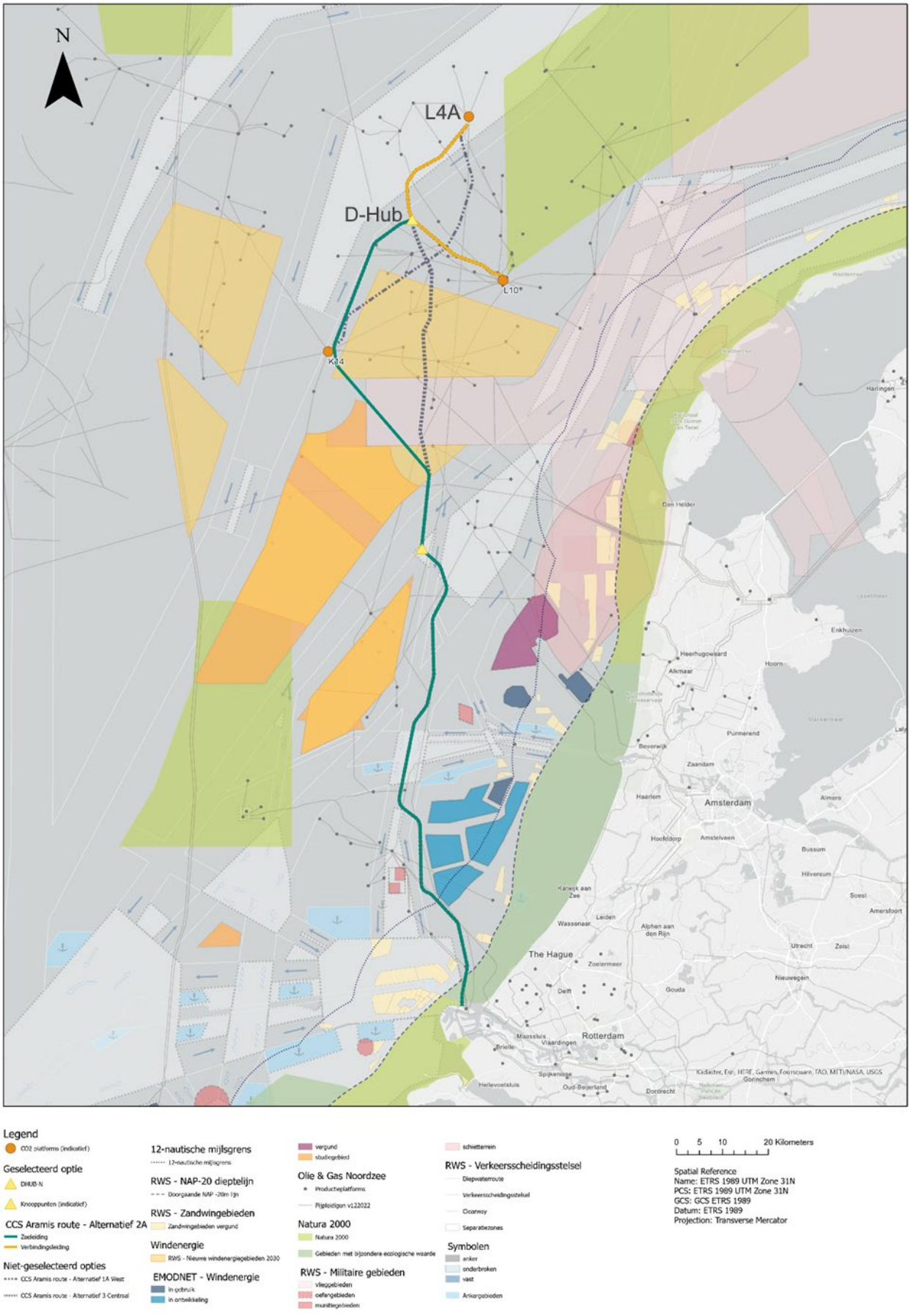
- Bepalen van stationaire condities om de operabiliteit van het netwerk te bevestigen, waarbij ervoor gezorgd moet worden dat de CO_2 in de dense phase blijft.
- Input leveren voor de voorbereiding van de operationele filosofie en van relevante procedures en apparatuur voor tijdelijke bedrijfsomstandigheden zoals de eerste vulling, drukverlaging, enzovoort.

De conclusie van de uitgevoerde flow assurance analyse is dat geen grote struikelblokken zijn geïdentificeerd voor het halen van de voorgenomen CO2-transportcapaciteit door de verbindingsleiding met de voorgestelde pijpdiameter. Hierbij wordt wel opgemerkt dat verder onderzoek naar bedrijfsomstandigheden als pigging operaties, first fill, druk aflaten etc. voor de verbindingsleiding in samenhang met de trunkline en bijgewerkte injectieprofielen nodig is.

3.4 Beschrijving tracé en aanleg zeedeel

3.4.1 Tracé

Het gehele tracé van de zeeleiding en de verbindingsleidingen, waaronder de leiding van TotalEnergies, is getoond in Figuur 3-1.



Figuur 3-1: Gepland tracé van de zeeleiding en de hierop aansluitende verbindingsleidingen waaronder die van TotalEnergies EP Nederland B.V. (van het distributieplatform naar L4A).

3.4.2 Aanleg verbindingsleiding

Op grond van paragraaf 6.4.2 van NEN 3656 hoeven leidingen van DN 400 of groter (≥ 400 mm of ca. 16”) niet te worden ingegraven omdat dit soort grote leidingen ‘overvisbaar’ zijn wat wil zeggen dat trawlnetten er niet achter blijven haken. Het uitgangspunt is daarom dat de verbindingsleiding boven op de zeebodem wordt aangelegd, behalve waar dat uit operationele- regelingen of veiligheidsredenen niet is toegestaan. In gebieden met een verhoogd risico wordt de diepteligging van de zeeleiding bepaald op basis van een risicogestuurde methode volgens paragraaf 6.3.1 van NEN 3656, waarbij rekening wordt gehouden met onder meer omstandigheden van de scheepvaartroutes (ligging, scheepsintensiteit en dergelijke, toekomstige diepte) en het specifieke gedrag van schepen in dergelijke routes. De aan te houden minimale gronddekking bij het ingegraven wordt vastgesteld aan de hand van NEN 3656. De nadere uitwerking van de ligging van de leiding vindt plaats in de FEED-fase. Daarbij wordt bepaald of en waar verdiepte ligging of steenstort nodig is.

Route survey en schoonmaken

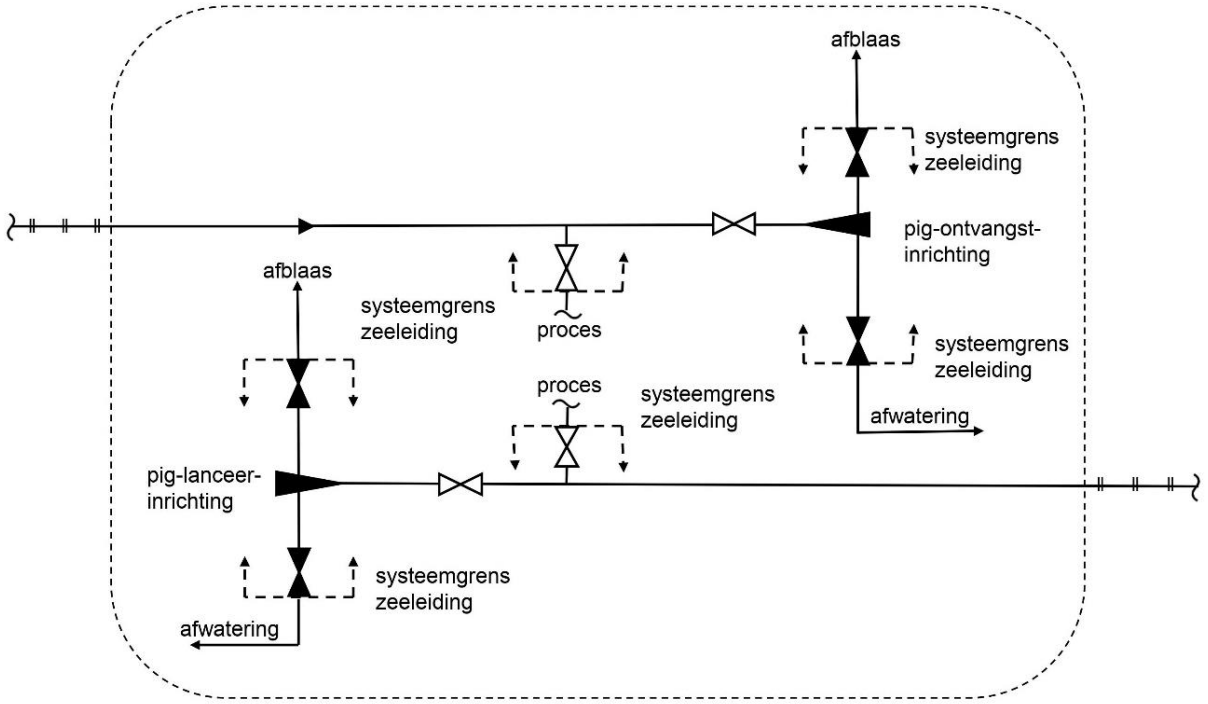
Voordat de verbindingsleiding wordt aangelegd, moet de leidingroute vrij zijn van obstakels, zoals buiten gebruik gestelde kabels, leidingen, schroot en van nature voorkomende stenen. Mogelijke obstakels zijn geïdentificeerd tijdens de route survey (zie paragraaf 3.4.3 en bijlage 4). Aan de hand van een analyse van de data van de route survey wordt beoordeeld of obstakels kunnen worden vermeden of vooraf verwijderd moeten worden. Bij de survey wordt ook de exacte ligging van te kruisen kabels en leidingen bepaald en wordt data verzameld hoe de kruisingen worden uitgevoerd.

Leggen van de leiding op de zeebodem

De verbindingsleiding wordt met een pijpenlegschip gelegd. De verbindingsleiding wordt opgebouwd uit leidingsegmenten met een lengte van ongeveer 12 meter. De leidingsegmenten zijn in de fabriek uitwendig al voorzien van een anticorrosiecoating van kunststof en betonnen mantel. Aan wal wordt in een geschikte haven een depot aangelegd voor de leidingsegmenten. De leidingsegmenten worden met bevoorradingsschepen vanuit dit depot naar het pijpenlegschip aangevoerd en op zee op het pijpenlegschip overgeladen. Op het pijpenlegschip wordt steeds een nieuw segment aan de opgebouwde leiding gelast. Alle lassen worden in- en uitwendig gecontroleerd. De leiding wordt voorzien van opofferingsanoden voor de kathodische bescherming. Vervolgens wordt de leiding gecontroleerd en worden de lassen behandeld tegen uitwendige corrosie. De leiding wordt hierna via de stinger op de achterzijde van de pijpenlegger het water ingeleid en op de zeebodem gelegd[6]. De leiding wordt leeg (niet gevuld met water) aangelegd om het gewicht van de leiding te beperken.

Het pijpenlegschip wordt bij het leggen met dynamic of static (ankeren) positioning in positie gehouden, zodat de leiding nauwkeurig op het vooraf vastgestelde tracé op de zeebodem kan worden gelegd. Op de plaatsen waar de leiding wordt ingegraven, wordt dit gedaan met een tweede schip met een ingraafmachine die over de zeebodem rijdt of wordt getrokken. Voor kruisingen van shipping lanes wordt mogelijk eerst een sleuf gebaggerd, als de benodigde ingraafdiepte te groot is voor een ingraafmachine. Waar nodig wordt de zeebodem na aanleg geëgaliseerd.
Bij het bereiken van het injectieplatform wordt op het uiteinde van de leiding een blindflens geplaatst, waarop later een metro spool wordt aangesloten. De leiding wordt daarna op de zeebodem achtergelaten totdat het L4A platform gereed is om de leiding te kunnen aansluiten. Op dat moment wordt het leidinguiteinde met een hiervoor geschikt werkschip aan de riser van L4A gekoppeld.

[6] *Er wordt nog onderzocht of het mogelijk is de leiding met behulp van reel lay te leggen.*



Figuur 3-2. Principeschets van de aansluiting van de verbindingsleiding op de DUBb (onderste schema) en het L4A-platform van TotalEnergies EP Nederland B.V. (bron NEN 3656).

Indien en waar de Kustwacht dat vereist, is tijdens het leggen van de leiding een wachtschip (guard vessel) bij het pijpenlegschip stand-by om andere scheepvaart op voldoende afstand te houden en voor het bieden van eerste hulp bijvoorbeeld bij man overboord.

Kruisingen met andere kabels en leidingen en expansiebochten

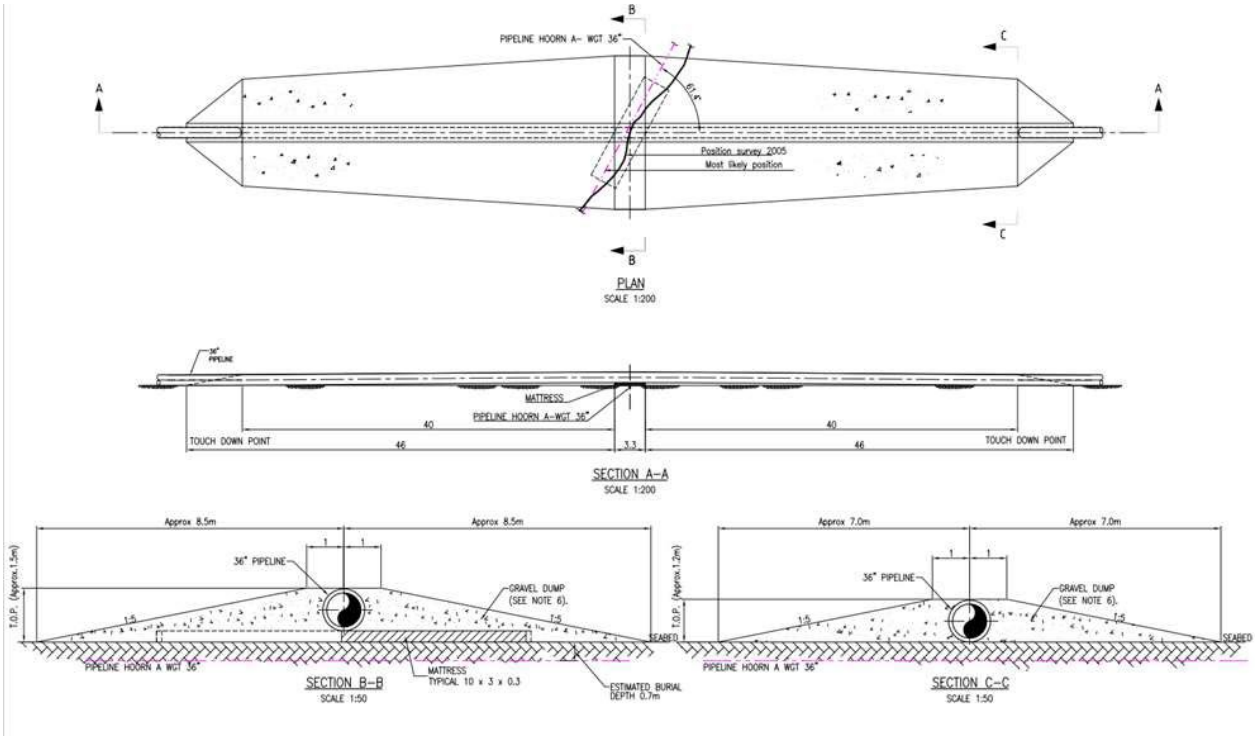
Het offshore tracé kruist vijf bestaande leidingen en kabels en één nieuw aan te leggen kabel, waarvan een aantal niet meer in gebruik is. Met betrekking tot deze niet meer in gebruik zijnde kabels wordt waar mogelijk contact gezocht met de eigenaar. Als dat niet mogelijk is, dan wordt de leiding in principe doorgesneden.

De overige bestaande leidingen en kabels worden in principe bovenlangs gekruist. De kruisingen worden uitgevoerd conform de regels in NEN 3656 artikel 9.4.5 met het oog op het voorkomen van schade aan de kabels en leidingen en het beperken van hinder bij derden zoals de scheepvaart of visserij. Met de kabel- en leidingoperators wordt contact opgenomen en de plannen besproken. Het typische ontwerp voor kruisingen bij leidingen op het zeebed is als volgt:

- Kruising in principe een hoek tussen de 90 (loodrecht) tot 45 graden;
- Storten van stenen op de bestaande pijpleiding of kabel waardoor een flauwe helling ontstaat. Op deze helling worden betonmatrassen geïnstalleerd. Een ‘matras’ met typische afmetingen van 10 bij 10 meter bestaat uit betonblokken die met elkaar verbonden zijn door staal- of kunststofkabels. De verbindingsleiding wordt boven op de matrassen gelegd. Omdat het pad over de matrassen slechts enkele meters breed is, moet het leggen van de pijpen zeer nauwkeurig zijn (enkele meters) en wordt gecontroleerd door ROV-observatie (met de steun van een onderzoeksschip). Bij het ontwerp van kruisingen wordt onderzocht of dit zodanig kan worden uitgevoerd dat de natuur hier voordeel van heeft. Dit houdt in dat wordt onderzocht waar en in welke vorm natuurversterkend bouwen mogelijk is. Natuurversterkend bouwen valt buiten de omvang van de voorliggende aanvraag.
- Na het leggen van de verbindingsleiding over de kruising, wordt het geheel afgestort met stenen (rock dumping) om het gevaar op beschadiging te beperken. De afdekking wordt ontworpen om dynamisch stabiel te zijn onder de ontwerpdata voor storm en stroming gebaseerd op een eens in de 100 jaarstorm. Hiertoe wordt de afstortlaag opgebouwd uit lagen met verschillende gradering.

- Aanbrengen van een grindlaag een voldoend kleine gradering (D90 <80 mm) boven op de steenbestorting met een dikte van minimaal 0.2 meter ter beperking van risico's door bevissingsactiviteiten.

Figuur 3-3 bevat een voorbeeld van een kruising (bovenlangs) van de zeeleiding met een ingegraven leiding of kabel.



Figuur 3-3. Voorbeeld van een kruising met een ingegraven leiding.

In bijlage 7 is een overzicht opgenomen van de kruisingen en typische uitvoeringen voor de verschillende type kruisingen. Wanneer de exacte details van de kruising verder uitgewerkt zijn, wordt dit verder met hen besproken. De afspraken met betrekking tot de kruisingen worden vastgelegd in crossing agreements.

Testen en inspectie van de leiding

Afsluitend aan de constructie van de verbindingsleiding wordt deze geïnspecteerd en getest. De exacte wijze van de eindinspectie en het testen ligt nog niet vast maar voorlopig wordt ervan uitgegaan dat drukvastheid met een hydrotest wordt beproefd. Hierbij wordt de leiding gevuld met gefilterd zeewater waaraan bepaalde chemicaliën zijn toegevoegd om onder andere corrosie tijdens het testen te voorkomen. Vervolgens worden achter elkaar verschillende pigs door de leiding gepompt met gefilterd en geconditioneerd zeewater om de leiding te reinigen, te inspecteren op onvolkomenheden (deuken of knikken) en hydrostatisch te beproeven. Na het testen wordt de leiding weer geleegd door speciale afsluitende pigs dit keer met perslucht door de leiding heen te sturen. De verwachting is dat de tijdsduur dat de leiding gevuld is met testwater minder dan 90 dagen duurt. Na het testen wordt de leiding weer geleegd en daarna drooggeblazen met lucht en vervolgens gevuld met stikstof om hem intern tegen corrosie te beschermen. Tot slot wordt de leiding tot ingebruikname aan weerszijden afgesloten zodat er niet opnieuw vocht in de leiding kan komen. Als het testen goed is verlopen, is de leiding geschikt voor ingebruikname.

Bovenstaand testproces wordt uitgevoerd met tijdelijke lanceer- en ontvangstinstallaties voor het versturen van de pigs die aan de uiteinden van de leiding zijn bevestigd en op hun beurt weer zijn aangesloten op tijdelijke pompen en ontwaterings(lucht)compressoren die zowel op de platformen, op de zeebodem als op een speciaal schip geplaatst zullen worden.

Het hydrostatisch testen wordt uitgevoerd met gefilterd zeewater. Er wordt verwacht drie spoelgangen nodig zijn met elk een volume van ongeveer 2800 m^3 zeewater om de pijpleiding voldoende te testen en te spoelen. Onderzocht wordt of het mogelijk is om het testwater niet te conditioneren, maar als nadere studies aantonen dat conditionering vereist is, wordt uitgegaan dat voor het conditioneren de volgende typen stoffen in het water worden gedoseerd[7]:

- Oxygen scavenger (zuurstofvanger): oxygen scavenger wordt gebruikt om de in het testwater opgeloste zuurstof te binden zodat deze niet het staal van de leiding kan aantasten. De zuurstofvanger moet worden geselecteerd als wateroplosbaar, zwak bio-accumulerend, minder giftig, en snel reagerend met opgeloste zuurstof. Een zuurstofvanger zoals ammoniumbissulfiet heeft deze kenmerken, of een gelijkwaardig equivalent. De te doseren concentratie is afhankelijk van het zuurstofgehalte van het testwater.
- Biociden in lage concentraties, doorgaans 100 - 200 ppm bij een testduur van 90 tot 180 dagen, om biologische groei in het water te remmen. Biologische groei kan de leidingwand vervuilen of aantasten.
- Corrosie-inhibitor(en) om corrosie van de leidingwand te remmen, indicatieve concentratie 100 ppm. De toe te passen inhibitor zijn olie-oplosbaar en waterdispergeerbaar en moeten biologisch afbreekbaar zijn.

Momenteel zijn nog geen specifieke chemicaliën voor de testwaterconditionering geïdentificeerd, maar Total Energies EP Nederland B.V. verplicht zich ertoe alleen chemicaliën te gebruiken die zijn geregistreerd onder REACH en HOCNF. Biocides zullen daarnaast zijn geregistreerd in de databank van het College voor de toelating van gewasbeschermingsmiddelen en biociden (Ctgb) of de Europese ECHA-database. TotalEnergies EP Nederland B.V. selecteert bij voorkeur chemicaliën met de laagste impact die aan de operationele vereisten voldoen. Deze beoordeling zal gebaseerd zijn op vastgestelde Hazard Quotients (HQ-)waarden (volgens het huidige CEFAS-register op het moment van gebruik) en leveranciersspecificaties. Voordat een in aanmerking komende stof offshore wordt gebruikt of geloosd, voert TotalEnergies een gedetailleerde chemische risicobeoordeling uit en zal een vergunning worden aangevraagd bij SodM. Op dat moment zal een gedetailleerde beoordeling van de mogelijke gevolgen voor milieureceptoren worden uitgevoerd.

Onderzocht wordt nog wat na gebruik met het hydrotestwater moet worden gedaan. Het testwater kan mogelijk aan land worden opgevangen, of het testwater kan mogelijk offshore worden geloosd op de D-Hub-locatie of elders. Verder wordt de mogelijkheid onderzocht een ontheffing voor de hydrostatische druktest van de leiding te verkrijgen. De leiding voldoet in principe al aan de testeisen vanwege de zeer strenge eisen die aan het fabricageproces worden gesteld (een hydrostatische test wordt in de fabriek al per pijpstuk uitgevoerd) en tijdens de constructiefase worden toegepast (alle lassen worden ultrasoon getest op eventuele lasfouten). Uitgangspunt voor het beproeven van de sterkte is dat aan de eisen van de NEN 3650-serie hierover wordt voldaan.

De te kiezen optie wordt op grond van nadere studie vastgesteld en gecommuniceerd met het bevoegd gezag. Hoe dan ook zal bij eventuele lozing het te lozen hydrotestwater voldoen aan de eisen van hoofdstuk 9 van de Mbr.

De mogelijkheid wordt onderzocht om een ontheffing voor de hydrostatische druktest van de leiding te verkrijgen. De leiding voldoet in principe al aan deze testeisen vanwege de zeer strenge eisen die zowel aan het fabricageproces worden gesteld (er wordt al een hydrostatische test per pijpstuk in de fabriek gedaan) als tijdens de constructiefase worden toegepast (alle lassen worden ultrasoon getest op eventuele lasfouten). Uitgangspunt voor het beproeven van de sterkte is dat aan de eisen van de NEN 3650-serie hierover wordt voldaan.

[7] *Het druktesten van de leiding en de daarbij te gebruiken chemicaliën wordt uitgevoerd op basis van de specificatie die Aramis hiervoor ontwikkeld heeft (Specification for Testing and Pre-commissioning Offshore Pipeline, ILT's, Riser and Pig Receiver distributionplatform (NL-ARM-010-PTC1-100505). Deze specificatie geeft de randvoorwaarden voor de contractor die de contractor in acht moet nemen bij het beproeven van de leiding. De toe te passen conditioneringsmiddelen voor het testwater zijn afhankelijk van de kwaliteit van het te gebruiken water en de tijd dat het water in de leiding aanwezig is. De in deze paragraaf genoemde specificaties geven een voorzichtig-realistische schatting. Maximale concentraties zijn gegeven in de genoemde specificatie.*

3.4.3 Tracéonderzoek

Geotechnisch onderzoek

§1.7 Mbr vraagt dat de aanvrager bij de aanvraag om een vergunning tot aanleg van een pijpleiding gegevens verstrekt ten aanzien van het geotechnisch onderzoek van het tracé en een strook ter weerszijden. Hiertoe heeft Fugro in opdracht van Aramis een geotechnisch onderzoek uitgevoerd naar het leidingtracé. Dit onderzoek dient om informatie te verzamelen over onder meer het zeebed, daar aanwezige objecten en de bodemopbouw van het zeebed.

Het geotechnisch onderzoek door Fugro is uitgevoerd voor het voorgenomen traject, waarvan de as van de strook samenvalt met het gekozen traject. In het rapport is beschreven:

1. Het profiel van de zeebodem;
2. De aanwezige obstakels;
3. De ligging van bestaande pijpleidingen en kabels;
4. De grondmechanische eigenschappen;
5. De stratigrafie van de zeebodem, en
6. De analyse en kwaliteit van de bodemmonsters en sonderingen.

Het rapport van het geotechnisch onderzoek is als bijlage 2 bij deze uitvraag opgenomen.

In het kader van het project is de zeebodem ter plaatse van het leidingtracé onderzocht om de leiding veilig en duurzaam aan te kunnen leggen. Dit onderzoek is in één keer uitgevoerd voor de gehele zeeleiding van het Aramis initiatief en tegelijk ook voor de verbindingsleidingen naar de diverse injectieplatforms waaronder het L4A-platform van TotalEnergies EP Nederland B.V. Op de belangrijkste secties van de geplande route is het onderzoek uitgevoerd met een breedte van meer dan vereiste 600 meter. Een breedte van 600 meter is ten minste onderzocht op secties die op basis van de eerste bevindingen tijdens de survey geïdentificeerd zijn als secties die mogelijk een aanpassing van de vooraf geplande route kunnen vereisen (rerouting). De middellijn van de surveycorridor (onderzoeksstrook) valt samen met de geselecteerde route.

Het onderzoek is uitgevoerd met een speciaal onderzoeksschip van Fugro. Ten behoeve van het onderzoek sleept een dergelijk schip een aantal surveylijnen (streamers) achter zich aan waarin sensoren zitten zoals hydrofoons. Het gecontracteerde onderzoeksschip was uitgerust met negen surveylijnen (de middenlijn plus acht ‘vleugellijnen’ (wing lines) op 60 meter afstand van elkaar. Met één vaarbeweging van het schip kan hiermee een strook van met een breedte van 480 meter worden onderzocht. Deze breedte is voor het grootste deel van het tracé meer dan afdoende om de vereiste overlap en hoge resolutie te bereiken en om voldoende informatie te krijgen om eventuele aanpassingen aan de route toe te passen om obstakels, onaanvaardbare vrije overspanningen, zandgolven, geogevaren, archeologische vondsten en door de mens gemaakte beperkingen te vermijden en zodanig de leiding veilig te kunnen leggen zonder schade aan de natuur, archeologie of derden te veroorzaken.

Aanvankelijk werd een lijnafstand van 100 meter over de gehele route overwogen, wat zou hebben geleid tot een surveystrookbreedte van 800 meter. Echter vanwege de beperkte waterdiepte (20 - 30 meter) in het delen van het projectgebied, zou daarmee niet de vereiste survey-overlappingen en de vereiste hoge resolutie kunnen worden bereikt. Het toevoegen van extra ‘vleugellijnen’ is onderzocht, om zo de strookbreedte te vergroten. Dit werd echter als onhaalbaar beschouwd omdat deze extra lijnen zouden leiden tot een significante impact op de kosten en planning wegens beschikbaarheid van schepen van de uitvoerende partij. Ook beperken extra vleugellijnen de manoeuvreerbaarheid van het schip, wat leidt tot meer overlast voor ander scheepvaartverkeer. Om deze redenen is ervoor gekozen een strook met een breedte van 600 meter of meer te onderzoeken waar dit op grond van de plaatselijke omstandigheden vereist en gewenst was. Om deze breedte te bereiken heeft het onderzoeksschip hier meermalen over het tracé gevaren. Voor het overige tracé is een breedte van 480 meter aangehouden met één vaarbeweging.

Cultuurhistorisch / archeologisch onderzoek

Er bestaat een kans dat in het tracé objecten met cultuurhistorische en/of archeologische waarde aanwezig zijn. Voor het bepalen of de aanleg van de verbindingsleiding kan leiden tot aantasting of vernietiging van mogelijk aanwezige archeologische resten is een archeologisch vooronderzoek (bureauonderzoek) uitgevoerd. Na bureauonderzoek is een nader onderzoek uitgevoerd om de archeologische verwachting te toetsen. Zie voor meer informatie hoofdstuk 4.7 en bijlage 6.

Mogelijke wijziging definitief tracé

Het definitieve tracé kan echter nog wijzigen. Als tracéwijzigingen niet binnen de onderzochte strook vallen, wordt hiervoor ter plaatse aanvullend onderzoek uitgevoerd. Conform artikel 98 Mbb zal TotalEnergies binnen vier weken na de aanleg van de pijpleiding de feitelijke ligging van de pijpleiding verstrekken.

3.5 Getransporteerde stoffen

In Tabel 3-1 staan de momenteel geldende grenswaarden voor de CO_2 die per schip of leiding wordt aangeleverd aan Aramis en uiteindelijk geïnjecteerd wordt in de gasvelden van TotalEnergies EP Nederland B.V. (en andere operators). De aangeleverde CO_2 van leveranciers moet aantoonbaar binnen deze randvoorwaarden blijven. Daarvoor komt er een meetprogramma bij elke leverancier.

Tabel 3-1. Specificaties aangeleverde CO_2 als geldend op dit moment.

Klasse	Component	Eenheid	Grenswaarde	Leiding
Koolstofdioxide	CO_2	mol%	Groter dan	95
Water	H_2O	ppm-mol	Minder dan	70(1)
Inerte stoffen	N_2	mol%	Minder dan	2,4
	O_2	ppm-mol	Minder dan	40
	H_2	ppm-mol	Minder dan	7500
	Ar	mol%	Minder dan	0,4
	CH_4	Mol%	Minder dan	1
	CO	ppm-mol	Minder dan	750
	$O_2+N_2+H_2+Ar+CH_4+CO$	ppm-mol	Som minder dan	40.000
Stikstof	NO_x	ppm-mol	Som minder dan	2,5(4)
Zwavelhoudende componenten	SO_x	ppm-mol	Som minder dan	-
	H_2S	ppm-mol	Minder dan	5
	CarbonylSulfide	ppm-mol	Minder dan	0,1(2)
	DimethylSulfide	ppm-mol	Minder dan	1,1(2)
	H_2S + COS + SO_x +DMS	ppm-mol	Som minder dan	20
Vluchtige organische componenten	Amine	ppm-mol	Minder dan	1
	Formaldehyde	ppm-mol	Minder dan	-
	Acetaldehyde	ppm-mol	Minder dan	0,2(2)
	Aldehyden	ppm-mol	Som minder dan	10
	Carbolylzuren en amines	ppm-mol	Som minder dan	1
	Fosforhoudende verbindingen	ppm-mol	Som minder dan	1
	NH_3	ppm-mol	Minder dan	3
	Ethyleen (C_2H_4)	ppm-mol	Som minder dan	1(2)
	H-cyanide (HCN)	ppm-mol	Minder dan	2

Klasse	Component	Eenheid	Grenswaarde	Leiding
	Totaal aan vluchtige organische stoffen (excl. MeOH, EtOH, aldehyden)	ppm-mol	Som minder dan	10
	Methanol	ppm-mol	Minder dan	620
	Ethanol	ppm-mol	Minder dan	20
Zwaardere koolwaterstof verbindingen	Glycolen (TEG)		Som minder dan	Volgens dauwpuntspec
	C_{2+} (alifatische koolwaterstoffen)	ppm-mol	Som minder dan	1200
	Aromatische koolwaterstoffen	ppm-mol	Som minder dan	0,1
Metalen	Hg	ppm-mol	Minder dan	-
	Cadmium + Thalium	ppm-mol	Som minder dan	-
Dauwpunt	Dauwpunt (elke vloeibare fase)	°C (@ 20 bar)	Som minder dan	-10(3)
Vaste stoffen	Volledige verwijderingsdiameter	micron	Minder dan	1(4)

Opmerkingen bij de tabel:

Voor een aantal componenten is geen specifieke concentratielimiet opgenomen. Als deze componenten in de aangeleverde CO_2-stroom worden verwacht in gehalten boven 1 ppm-mol, voert Aramis een risicobeoordeling uit om inzicht te krijgen in de maximale hoeveelheid die kan worden getolereerd. Als er componenten in de aangeleverde CO_2-stromen worden verwacht die niet in de specificatie van Tabel 3-1 zijn opgenomen en wel nadelige gevolgen kunnen hebben, stelt Aramis een bovenste concentratiegrens vast.

1 *Specificatie afgestemd met Porthos CO_2-specificatie v 3.1 voor Porthos-infrastructuur; watergehalte maximaal 40 ppm-mol).*

2 *Specificatie volgens OCAP-specificatie en alleen van toepassing op toeleveranciers die ook via de OCAP-infrastructuur leveren.*

3 *Dit is de ingangsspecificatie voor vaste stoffen/stof voor de beoogde Aramis-opslagen. Om dit te bereiken verzoekt Aramis de leveranciers stofverwijderingsinstallaties te installeren met een ondergrens van minimaal 10 micron. Voorts is Aramis van plan om op de beoogde compressor- en eindstations op optimale locaties filters met te plaatsen.*

4 *Strengere specificatie dan de Porthos CO_2-specificatie v 3.11.*

Druk en temperatuur

CO_2 wordt tijdens normaal bedrijf in de dense phase getransporteerd door de verbindingsleiding. De verbindingsleiding is ontworpen op de meest maatgevende belasting ten gevolge van druk en temperatuur. De ontwerpdruk van de verbindingsleiding is 200 bar. Bij de maximale transportcapaciteit van 22 Mton per jaar neemt de druk over de lengte van de verbindingsleiding af tot circa 140 bar bij het platform L4A.

De ontwerptemperatuur van de verbindingsleiding is 50 ˚C[8], maar de getransporteerde CO_2 is bij aankomst op het distributieplatform afgekoeld tot ongeveer zeewatertemperatuur. Dit is ook de aankomsttemperatuur op L4A.

De druk en temperatuur van het geïnjecteerde CO_2-mengsel worden geregeld vanaf het compressorstation. De condities in de verbindingsleiding worden zodoende gereguleerd vanuit het compressorstation met als doel onder in de put de juiste omstandigheden te creëren. Tevens zijn gewenste condities voor de verbindingsleiding zelf vastgesteld. Bij het transport van CO_2 is het van belang dat druk en debiet binnen de vastgestelde bandbreedte blijven, zodat de injectie van CO_2 in de putten kan worden uitgevoerd. Onder in de put zijn de druk en temperatuur afhankelijk van het aangevoerde gasmengsel en van de druk en temperatuur in het reservoir. Deze eigenschappen hebben invloed op de injectiviteit van de CO_2 in het opslagreservoir.

[8] *De ontwerptemperatuur wordt nog verder onderzocht.*

3.6 Bedrijfsvoering

L4A is een bestaand platform dat beschikt over alle relevante veiligheidssystemen en de noodzakelijke veiligheidsplannen. De inrichting is ontworpen in overeenstemming met de eisen van de Mijnbouwregelgeving en industriestandaards, en voldoet daarmee aan de eisen op het gebied van veiligheid en procesbeveiliging. Er zijn onderhouds- en inspectieplannen en calamiteiten- en reddingsplannen, waarin ook communicatie met de bemande platforms, het hoofdkwartier, de Kustwacht en andere relevante partijen wordt geadresseerd, ook wat betreft de aangesloten leidingen.

De bedrijfsvoering van de leidingen wordt gebaseerd op een risicomanagementsysteem (RMS) om een veilige en duurzame bedrijfsvoering voor mens en milieu gedurende de totale levensduur te waarborgen. De bedrijfsvoering kan worden uitgevoerd door TotalEnergies of door een aan te wijzen exploitant. Het nog op te stellen RMS wordt conform NEN 3656 gebaseerd op gedocumenteerde doelen op het gebied van risicomanagement en niet zozeer op middelen.

Een inspectieplan maakt deel uit van het RMS. De inspectie- en onderhoudsfrequentie wordt bepaald op basis van het RMS en de resultaten van eerdere inspecties en van een risico-inventarisatie en -evaluatie. Het RMS is gereed voordat de leiding in gebruik wordt genomen.

Procesregeling

Het CO_2 injectieplatform L4A is normaal onbemand. Dit betekent dat het proces voor normale operatie gecontroleerd wordt door industriële automatisering. Primair wordt er gestuurd op druk en temperatuur van de CO_2. Apparatuur op het platform kan vanaf de centrale controlekamer door de operators bestuurd worden. De druk en temperatuur van de CO_2 wordt op het platform gemeten. De regelkleppen van de putten worden bediend door de automatisering of vanuit de centrale controlekamer, en daarmee het debiet van de CO_2 gereguleerd. In het compressorstation en de CO_2-next-terminal is al veiliggesteld dat het watergehalte van de aangeleverde CO_2 dusdanig laag is dat geen condensvorming kan optreden, waardoor vochtophoping en corrosie voorkomen worden. De specificaties van de aangeleverde CO_2 zijn met voldoende marge vastgesteld en het watergehalte wordt bewaakt met analysers bij de CO_2-leveranciers en de CO_2Next-terminal.

Procesbeveiliging

Onafhankelijk van het regelsysteem is een beveiligingssysteem geïnstalleerd, dat de installatie naar een veilige situatie brengt in geval het regelsysteem uitvalt. Tijdens een Emergency Shut Down (ESD) worden de installaties ingesloten en onder druk gehouden.

De leiding tussen de platforms zijn aan weerszijde voorzien van automatische veiligheidskleppen waardoor de leidingen kunnen worden ingesloten. In de gebruiksfase wordt de staat van de riser en de aansluiting op de platforms regelmatig geïnspecteerd.

Verzoek tot instemming ingebruikname

Conform het Mbb dient de operator van de verbindingsleiding uiterlijk twee weken voor de geplande ingebruikname van de pijpleiding een verzoek in bij het ministerie van KGG (gemandateerd aan de Inspecteur-Generaal der Mijnen (IGM)) voor instemming met de ingebruikname daarvan. Onderdeel van dit verzoek zijn:

1. Een verklaring van een onafhankelijke deskundige, waarin wordt beoordeeld of de eigenschappen en de aanleg van de pijpleiding voldoen aan de bij of krachtens artikel 93 gestelde eisen, en
2. Gegevens waaruit blijkt dat de ligging van de pijpleiding die is aangelegd in de territoriale zee of het continentaal plat voldoet aan de bij of krachtens artikel 93 gestelde eisen en, voor zover van toepassing, aan de desbetreffende vergunningvoorschriften.

3.7 Buitengebruikstelling en verwijderen van de transportleiding

Na de buitengebruikstelling aan het einde van de levensduur wordt de verbindingsleiding conform de dan geldende regelgeving uit bedrijf genomen en veiliggesteld. Vervolgstappen met betrekking tot eventuele verwijdering van de pijpleiding zullen worden genomen conform de dan geldende wet- en regelgeving.

4 De effecten op het milieu en de omgeving

4.1 Inleiding

In het kader van deze vergunningaanvraag dient ook te worden beoordeeld of de milieugevolgen van het project aanleiding geven om een mer te doorlopen. Met het oog daarop worden in onderstaande paragrafen de milieugevolgen van het project weergegeven. Daarbij wordt gebruik gemaakt van de onderzoeken van het MER dat voor het Aramis initiatief als geheel is opgesteld (Deelrapport Milieueffecten, MER CO_2-transportinfrastructuur Aramis, Royal HaskoningDHV, 9 februari, ARM-PFE-B10-ENV-EIA-2030).

4.2 Bodem en water

Bestaande situatie

Morfologie en dynamiek

De waterdiepte op zee in het studiegebied van het Aramis initiatief varieert van 0 tot circa 46 meter. De helling van de bodem is over het grootste gedeelte minder dan 1°, maar kan lokaal oplopen tot 30°. Deze steilere hellingen zijn gerelateerd aan antropogene kenmerken (zoals navigatiekanalen, baggergebieden, losgebieden en scheepswrakken) en toppen van zandbanken. In het algemeen wordt de zeebodem dieper richting het westen tot westnoordwesten, loodrecht op de kust.

De verbindingsleiding vanaf het distributieplatform naar L4A ligt in een gebied met een waterdiepte aflopend van 30 naar 40 meter. De zeebodem in dit gebied is overwegend vlak zonder duidelijke structuren. De bodem bestaat hier uit (licht grindig) zand.

Aanleg

Morfologie en dynamiek

In de aanlegfase vinden diverse werkzaamheden plaats die van invloed zijn op de zeebodem en de lokale waterkwaliteit. De werkzaamheden zijn in paragraaf 3.4.2 beschreven en worden hier kort aangehaald:

- Survey en schoonmaken van zeebodem ten behoeve van de verbindingsleiding;
- Egaliseren van de zeebodem daar waar nodig en mits noodzakelijk;
- Leiding leggen op of in zeebodem (de leiding wordt ingegraven waar dit op grond van een risicoanalyse nodig is).
- Storten van stenen en leggen van matrassen daar waar bestaande leidingen en/of kabels worden gekruist en nabij platformen.

Wanneer op grote schaal bodemberoering plaatsvindt tijdens de aanlegfase kan de integriteit van de zeebodem in het gedrang komen. De integriteit van de zeebodem dient zodanig te blijven dat de structuur en de functies van de ecosystemen gewaarborgd blijven en dat met name bentische ecosystemen niet onevenredig worden aangetast.

Zeewaterkwaliteit
De zeewaterkwaliteit kan beïnvloed worden door de lozing van testwater dat geringe hoeveelheden conditioneringschemicaliën kan bevatten. Momenteel zijn nog geen specifieke chemicaliën voor de testwaterconditionering geïdentificeerd, maar de chemicaliën die gebruikt worden, zijn toegelaten meldingsplichtige chemicaliën die mogen worden geloosd. Bij de lozing voldoet het te lozen hydrotestwater aan de eisen van hoofdstuk 9 van de Mbr. Mede door de continue verversing en stroming van het zeewater wordt het effect van de lozing op de kwaliteit van het zeewater als nihil geschat.

Daarnaast komen bij de inzet van schepen kleine hoeveelheden antifouling vrij in zee en kan depositie van rookgassen van werkschepen invloed hebben op de waterkwaliteit. In het MER voor het Aramis initiatief is uiteengezet dat de concentraties koper die vanwege het gebruik van koperhoudende antifoulings in het zeewater terecht kunnen komen, dermate laag zijn dat enig effect op de kwaliteit van habitats uit te sluiten is. Ook de depositie van door werkmaterieel uitgestoten verbrandingsstoffen (stikstof- en zwaveloxiden) leidt niet tot enige effect op het marine milieu. De maximale verhoging van de stikstof- en zwavelconcentraties in het water als gevolg van de verbranding en uitstoot van de verbrandingsstoffen is verwaarloosbaar, ten opzichte van de in de kustzee voorkomende achtergrondconcentraties van 51 mg N/l en 910 g S/l. Als gevolg van de netto noordwaarts gerichte getijdestroming vindt namelijk voortdurend verversing van het water rond de aanleglocatie plaats, waardoor de nutriënten zich over een veel grotere oppervlakte verspreiden.

Als bovenstaande analyse van toepassing is op het Aramis initiatief als geheel, dan geldt het zeker ook voor de verbindingsleiding naar L4A.

Gebruiksfase
Zodra de leiding is aangelegd is geen sprake meer van bodemroering waardoor geen sprake meer is van een impact op de zeebodem. Tijdens de gebruiksfase van het Aramis initiatief vinden geen lozingen van antifoulings op het zeewater of uitstoot van emissies van verbrandingsstoffen plaats door werkmaterieel met uitzondering van een jaarlijkse monitoring naar de ligging van de leiding.

In paragraaf 3.3 is de voorziene bescherming tegen externe corrosie van de verbindingsleiding beschreven. De opofferingsanoden bestaan uit blokken van een aluminiumlegering (AL – Zn). Omdat de anoden uit een onedelere metaallegering bestaan dan het staal van de verbindingsleiding, corroderen de anodes bij eventuele beschadigingen van de coating eerder dan het staal van de leiding en voorkomen op deze wijze dat de stalen leiding corrodeert. De opofferingsanoden worden verspreid over de gehele leidinglengte aangebracht.

Tijdens de levensduur van de leiding lossen de opofferingsanoden langzaam op in het zeewater en resulteren daarbij in een emissie naar water. Deze emissie treedt op tijdens de hele levensduur van de leiding. De specificatie van het corrosiebeschermingssysteem is:

- Ontwerplevensduur: 30 jaar;
- Anodesamenstelling:
    - aluminium 94 %
    - zink 5 %
    - overig 1 %
- Aantal anodes: 198 stuks
- Gewicht per anode: 60 kg

Als conservatief wordt uitgegaan dat alle anodes in 30 jaar volledig oplossen, resulteert dit in een jaarlijkse emissie naar water van 372 kg Al en 20 kg Zn. Deze emissie treedt op over de gehele lengte van de verbindingsleiding van circa 28 km. Gezien de langzame, geleidelijke oplossing en het grote volume zeewater waarin de anoden oplossen, leidt deze emissie tot een niet of nauwelijks meetbare concentratieverhoging van de anodecomponenten in zeewater.

Overige situaties

Onder de overige situaties vallen de opstartfase, regulier onderhoud, en eventuele onvoorziene situaties. Uit het monitoringsprogramma kan blijken dat onderhoudswerkzaamheden nodig zijn; zo kunnen er delen van de verbindingsleiding zijn komen bloot te liggen of vrije overspanningen zijn ontstaan (ten gevolge van de verplaatsing van zandbanken en zandgolven) die moeten worden gestabiliseerd of herbegraven.

In geval van falen of beschadigen van de verbindingsleiding, als gevolg van aanvaring door of ongeval met de scheepvaart, zijn ingrijpendere werkzaamheden nodig om de verbindingsleiding te vervangen of repareren.

De onderhouds- en eventuele reparatiewerkzaamheden zijn in het uiterste geval vergelijkbaar met de aanlegactiviteiten, maar zullen zeer waarschijnlijk slechts zeer beperkt zijn.

Conclusie

Er zijn geen aanzienlijke gevolgen voor de zeebodem en het zeewater te verwachten als gevolg van de aanleg en het gebruik van de verbindingsleiding. Ook reguliere onderhouds- en eventuele reparatiewerkzaamheden zullen niet tot aanzienlijke gevolgen leiden voor de zeebodem en waterkwaliteit.

4.3 Verstoring door onderwatergeluid

Bestaande situatie

Op verschillende plaatsen op de Noordzee is sprake is van onderwatergeluid. Logischerwijs treedt dat voornamelijk op bij de bouw van windparken op zee en door de scheepvaart nabij scheepvaartroutes, havenactiviteiten en andere activiteiten die op de Noordzee plaatsvinden.

Aanleg

Tijdens de aanlegfase vinden diverse werkzaamheden plaats waardoor onderwatergeluid optreedt. Voor de verbindingsleiding betreft dit hoofdzakelijk werkzaamheden met het pijplegschip en eventuele andere werkschepen. In het MER voor Aramis is aangegeven wat hiervan de te verwachten geluidbelasting is.

Voor een representatief groot pijplegschip zijn het geluiddrukniveau (SPL) en het bijbehorende sound exposure level over 24 uren op 100 meter afstand bepaald.[9] Deze zijn afgezet tegen de PTS (permanent threshold schift) van verschillende vis- en zoogdiersoorten; oftewel het sound exposure level waarbij een permanente verhoging van de gehoordrempel optreedt (gehoorschade). Vervolgens zijn de veilige afstand en veilige verblijfstijd berekend voor vissen en zeezoogdieren samenhangend met het in werking zijnde pijplegschip. Tot slot is bepaald vanaf welke afstand diersoorten het onderwatergeluid zullen mijden (gedragsbeïnvloeding). De verkregen informatie is in onderstaande tabellen weergegeven. Ook duikende vogels kunnen last hebben van onderwatergeluid maar de impact daarvan is vergelijkbaar of kleiner dan die op zeezoogdieren.

Tabel 4-1 Afstand en verblijftijd samenhangend met PTS vanwege een groot pijplegschip, representatieve situatie

Bron van onderwater geluid	PTS gerelateerd					
	Diersoort	Drempel PTS SEL in dB re 1 µPa2s	SEL op 100m 1 µPa2s (24u)	Veilige afstand in m bij verblijf van 24 uur	Veilige afstand in m bij verblijf van 3 uur	Veilige verblijftijd op 100m afstand in uren
Pijpenleggen	Bruinvis	173	199	7	1	(>) 24
	Grote vis	207	199	16	2	(>) 24
	Kleine vis	207	199	16	2	(>) 24
	Zeehond	201	199	16	2	(>) 24

[9] *Mogelijk wordt een kleiner pijplegschip gebruikt. De hiervan te verwachten hinder zal kleiner zijn. Voor de effect inschatting wordt vooralsnog van een groot schip uitgegaan zodat de worst case in beeld is gebracht.*

Tabel 4-2 Afstand samenhangend met mijding vanwege een groot pijplegschip, representatieve situatie

Bron van onderwater geluid	Mijding gerelateerd				
	Diersoort	Drempel mijding SPL in dB re 1 µPa	Drempel mijding* SPL in dB re 1 µPa verhoogde achtergrond	Mijding op afstand in m	Mijding op afstand in m mits verhoogde achtergrond
Pijpenleggen	Bruinvis	120	130	16	2
	Grote vis	150	n.v.t.	89	n.v.t.
	Kleine vis	150	n.v.t.	89	n.v.t.
	Zeehond	120	130	22909	2291

*NOAA stelt dat de drempel van 120 dB mag worden verhoogd bij achtergrondgeluidniveaus ≥ 120 dB re 1 µPa

In de zuidelijke delen van de Noordzee (Nederlands deel) zijn geluidniveaus door scheepvaart van globaal 130 dB re 1 µPa niet ongewoon. In tabel 4-2 is dit aangeduid als een zogenoemde verhoogde achtergrond.

De berekende veilige afstanden en verblijfstijden zijn in de tabellen 4-1 en 4-2 vermeld. De drempels PTS SEL in tabel 4-1 betreffen ongewogen waarden. Het verschil in de eigenschappen tussen de bruinvis en zeehond (uitgedrukt in de weegfactoren) is significant, als gevolg daarvan treedt bijvoorbeeld in tabel 4-2 bij een identieke drempel een groot verschil in mijdingsafstand op.

Werkzaamheden op de zeebodem die worden verricht voorafgaand en na het realiseren van leidingen en kabels, betreffen het plaatsen van zogenoemde matrassen en andere zeebodemstabilisatie, het graven van sleuven, het storten van rotsblokken en het verwijderen van oneffenheden met een sleephopperzuiger (baggeren). Daarvan is uitsluitend het baggeren geluidrelevant en kan een impact hebben in de omgeving. De geluiduitstraling van een groot baggervaartuig is beperkt lager of gelijkwaardig aan het genoemde pijplegschip.

De geluidbelasting onderwater kan impact hebben op het marine milieu.

Gebruiksfase
In de gebruiksfase treedt geen onderwatergeluid op vanaf de verbindingsleiding.

Overige situaties
Tijdens onderhouds- en eventuele reparatiewerkzaamheden wordt materieel ingezet. Bij de periodieke monitoring van de goede ligging van de leiding wordt gebruik gemaakt van sonar, wat een bron van onderwatergeluid is. Dit zal doorgaans (aanzienlijk) minder onderwatergeluid veroorzaken dan de aanlegactiviteiten.

Conclusie
Als gevolg van de aanlegwerkzaamheden, en in mindere mate ook de onderhouds- en eventuele reparatiewerkzaamheden zijn tijdelijk negatieve effecten te verwachten van onderwatergeluid maar gezien de bepekte omvang van het geluid, zal dit niet aanzienlijk zijn.

4.4 Emissies naar de lucht

Bestaande situatie
Luchtkwaliteit wordt bepaald nabij woongebieden zodat de gevolgen voor de volksgezondheid in acht kunnen worden genomen. Op zee is dit niet aan de orde. Daarnaast worden op zee behalve door schepen en platforms geen emissies naar de lucht uitgestoten, waardoor de luchtkwaliteit doorgaans goed is.

Aanleg
Tijdens de aanleg van de verbindingsleiding worden diverse schepen en werktuigen met verbrandingsmotoren ingezet die emissies naar de lucht veroorzaken (stikstof- en zwaveloxiden en fijnstof). De uitgestoten stoffen kunnen een effect hebben op het marine milieu en in theorie op de natuur op land.

In paragraaf 4.2 is al aangegeven dat geen effect van deze emissies en dientengevolge depositie op het marine milieu verwacht hoeft te worden.

Voor de aanleg van de verbindingsleiding geldt dat deze aanleg veel verder dan 25 km van stikstofgevoelige Natura 2000-gebieden plaatsvindt omdat de Natura 2000-gebieden niet stikstofgevoelig zijn. Door de vaste afstandsgrens in AERIUS-calculator van 25 km, zullen stikstofemissies als gevolg van de leidingaanleg niet tot relevante stikstofdepositities leiden. Bovendien hoeven emissies van scheepvaart buitengaats volgens de instructiegegevens invoer voor AERIUS 2023 van BIJ12 niet te worden gemodelleerd omdat zeescheepvaart wordt beschouwd als onderdeel van het heersende verkeersbeeld.

Het effect van de stikstofemissies die samenhangen met de aanleg van de verbindingsleiding is daarmee te verwaarlozen en is zeker geen aanzienlijk effect.

Gebruiksfase
Tijdens de gebruiksfase treden geen emissies op naar de lucht en zijn daarvan geen effecten te verwachten.

Overige situaties
Tijdens onderhouds- en eventuele reparatiewerkzaamheden wordt materieel ingezet dat emissies naar de lucht uitstoot. Dit zal in geen geval meer bedragen dan de emissies tijdens de aanlegfase.

Conclusie
Emissies naar de lucht treden alleen op door de inzet van materieel tijdens de aanlegfase, en in (veel) mindere mate tijdens onderhouds-, monitoring en eventuele reparatiewerkzaamheden. De emissies zijn te laag om via depositie tot relevante effecten in het marine milieu of de natuur op land te leiden. Er wordt niet getoetst aan de luchtkwaliteit ter plaatse van de werkzaamheden voor de verbindingsleiding omdat het Bkl niet van toepassing is. Ten aanzien van de mer-beoordeling geldt dat emissies naar de lucht zeker geen aanzienlijk effect zullen veroorzaken.

4.5 Visuele aspecten

Bestaande situatie
De verbindingsleiding van het distributieplatform naar platform L4A ligt op zee waar scheepvaart en visserij plaatsvindt.

Aanleg
Tijdens de aanleg van de verbindingsleiding is werkmaterieel ter plaatse aanwezig. De locatie ligt te ver van de kust om zichtbaar te zijn voor bewoners. Wel geven de werkzaamheden na zonsondergang enige lichtuitstraling die echter ook niet zichtbaar is van land.

Gebruiksfase
Tijdens de gebruiksfase ligt de verbindingsleiding onder het zeeoppervlak waardoor geen visuele hinder optreedt.

Overige situaties
In geval van onderhouds-, monitoring- of reparatiewerkzaamheden treden mogelijk gelijksoortige (tijdelijke) effecten op als in de aanlegfase.

Conclusie
Tijdens aanleg-, onderhouds- en eventuele reparatiewerkzaamheden treedt mogelijk tijdelijk enige hinder op door lichtverstoring maar deze is zeker niet aanzienlijk gezien de grote afstand tot land.

4.6 Effecten op beschermde gebieden en soorten

Bestaande situatie
In de wijdere omgeving van de verbindingsleiding zijn meerdere beschermde Natura 2000-gebieden aangewezen, waarvan het Friese Front en de Klaverbank de dichtstbijzijnde zijn. Daarin en in de omringende Noordzee komen tevens diverse beschermde vissoorten, zeezoogdieren, vogels en vleermuizen voor.

Aanleg
In het MER voor het Aramis initiatief (en bijhorende passende beoordeling) zijn de effecten op deze (en andere) beschermde gebieden en soorten onderzocht. Relevante effecten worden hieronder genoemd.

Gebieden
In de passende beoordeling bij het MER (bijlage 5) wordt geconcludeerd dat ter plaatse van het voornemen directe (lokale) effecten optreden en die indirect kunnen doorwerken in Natura 2000-gebieden op enige afstand van het voornemen.

Zo kunnen door oppervlakteverlies en verandering in dynamiek vanwege het voornemen directe effecten optreden op zandkokerwormen. Zandkokerworm riffen kunnen bijdragen aan een habitat dat bijdraagt aan de natuurdoelstellingen van beschermde gebieden (Friese Front). Specifiek rond de verbindingsleiding komt de zandkokerworm niet of amper voor.

Verder treden indirecte effecten op voor bruinvissen door onderwatergeluid. Hierbij geldt dat er in de Natura 2000-gebieden (waaronder Natura 2000-gebied de Klaverbank, de Noordzeekustzone en de Voordelta) geen significante directe effecten optreden, maar wel mogelijk op de gehele Noordzee bruinvispopulatie buiten de aangewezen gebieden. Bij de verbindingsleiding wordt niet geheid waardoor geluidsbeperkende maatregelen voor heigeluid hier niet van toepassing zijn. Om continu onderwatergeluid door de in te zetten schepen te minimaliseren, moet zoveel mogelijk gebruik gemaakt worden van stille schepen.

Soorten
In het MER voor Aramis wordt aangegeven dat voor verschillende voorkomende beschermde soorten mitigerende maatregelen nodig zijn om negatieve effecten zoveel mogelijk te voorkomen of verzachten. Hiervoor wordt vergunning aangevraagd.

Gebruiksfase
In de gebruiksfase zijn geen effecten op beschermde gebieden en soorten te verwachten.

Overige situaties
Tijdens onderhouds- en eventuele reparatiewerkzaamheden wordt materieel ingezet. Dit zal doorgaans (aanzienlijk) minder onderwatergeluid veroorzaken dan de aanlegactiviteiten.

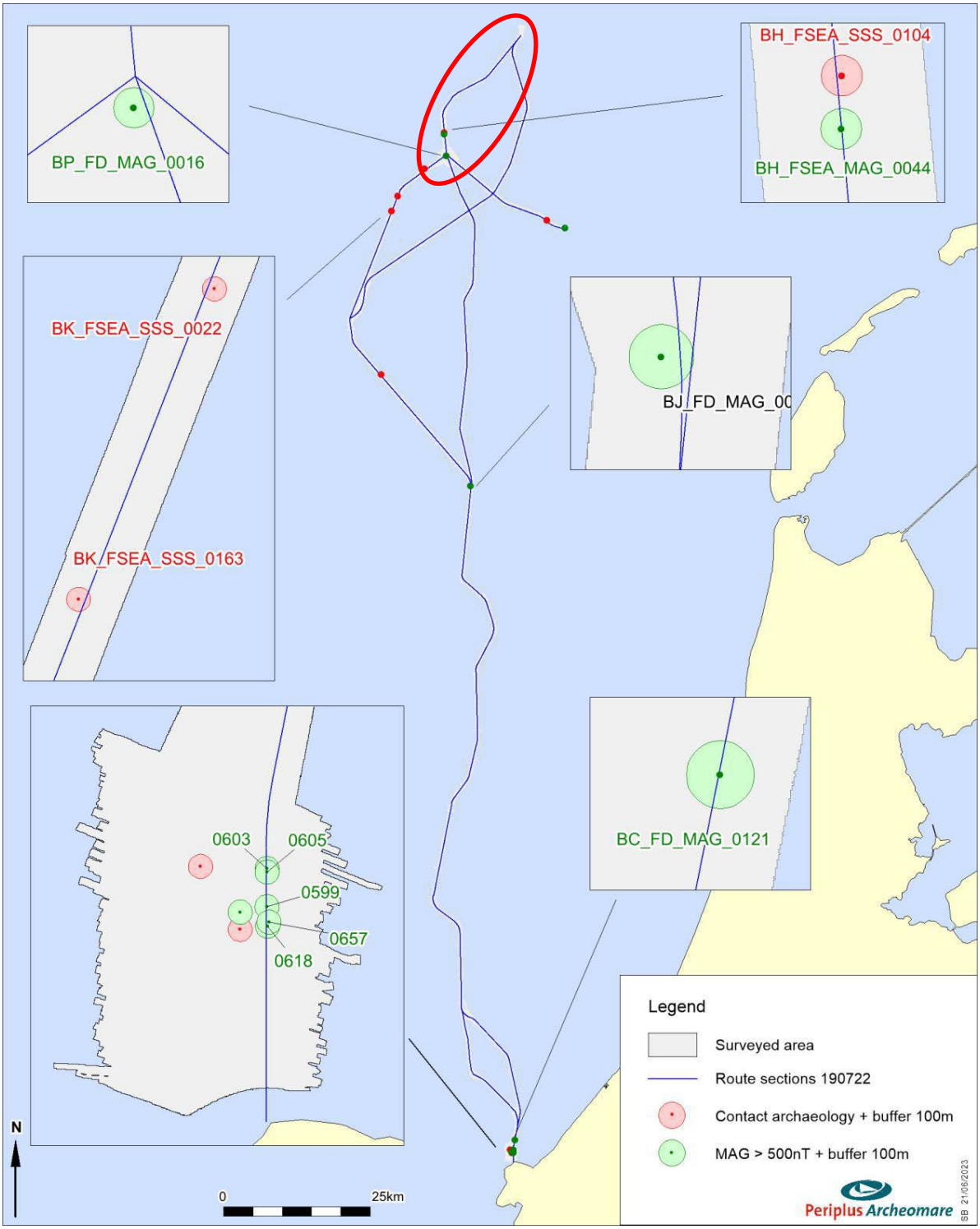
Conclusie
Negatieve effecten op beschermde gebieden en soorten als gevolg van de voorziene werkzaamheden zijn niet uit te sluiten maar deze effecten kunnen in voldoende mate worden beperkt worden door de aanwezige voorzieningen. In het MER voor het Aramis initiatief wordt aangegeven dat aanzienlijke effecten kunnen worden uitgesloten.

4.7 Archeologie

Bestaande situatie

Voor het MER voor het Aramis initiatief zijn diverse onderzoeken uitgevoerd naar archeologische resten op of in de zeebodem[10]. Hieruit blijkt dat zich verschillende objecten op de zeebodem bevinden waaraan een archeologische verwachting moet worden toegekend. In overeenstemming met de Nederlandse wet- en regelgeving mogen er geen bodemberoeringen worden uitgevoerd binnen 100 meter van elk van deze locaties. Indien er werkzaamheden plaatsvinden binnen 100 meter van een potentiële archeologische vindplaats, wordt in overleg met Rijkswaterstaat en de Rijksdienst voor het Cultureel Erfgoed (RCE) per geval bekeken of de 100 meter afstand behouden blijft. Daarnaast zijn er magnetische anomalieën aangetroffen die van archeologische waarde kunnen zijn. Figuur 4-1 geeft deze locaties weer.

[10] *Het onderzoek betrof een bureaustudie en geofysisch onderzoeken binnen het studiegebied, waaronder:*
- *Aramis Pipeline Routing Desktop Study – Expected Site Conditions, Consultancy Report (R201644 (03) | 10 February 2022)*
- *Geophysical Results Report, Geophysical and Geotechnical Site Investigation F197217-REP-001 | 01 | 18 April 2023*
- *Document 22A030-01 Aramis pipeline – an archaeological assessment of geophysical survey data, by Periplus Archeomare, 31-08-2023 Final*
- *Route selection document including aspects as morphology, safety.*



Figuur 4-1 Kaart met 8 objecten (Archeologische verwachting, die zichtbaar zijn aan het bodemoppervlak) en 10 anomalieën (Archeologie, objecten alsook potentieel NGE, die niet zichtbaar zijn aan het bodemoppervlak). Rood omlijnd de verbindingsleiding naar L4A.

Aanleg

Op basis van de uitgevoerde archeologische onderzoeken moeten archeologische resten in het studiegebied worden verwacht. Het uitgevoerde sonaronderzoek geeft aan dat er binnen een zone van 100 meter naast de verbindingsleiding mogelijk archeologische waardevolle resten aanwezig zijn. Als gevolg hiervan kan de verbindingsleiding niet zonder meer gelegd worden, maar is vervolgonderzoek nodig. Een andere oplossing is om het tracé van de verbindingsleiding te optimaliseren zodat voldoende afstand tot de verwachte archeologische resten kan worden aangenomen en aantasting van archeologische resten wordt voorkomen.

Gebruiksfase
De bodem ter plaatse van de verbindingsleiding wordt tijdens de aanleg geroerd. Daardoor kan nadien, tijdens de gebruiksfase, geen nieuwe impact meer optreden op archeologische resten. Deze zijn dan immers al verwijderd.

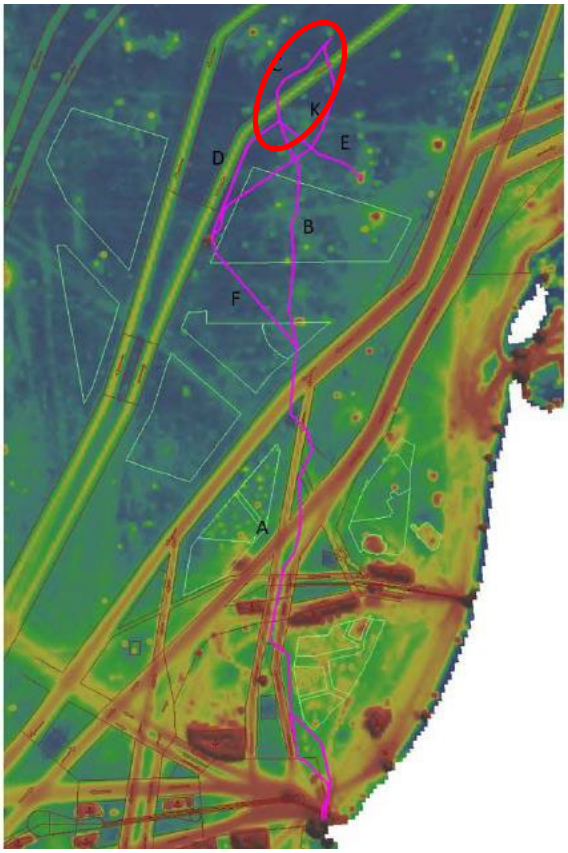
Overige situaties
De bodem ter plaatse van de verbindingsleiding wordt tijdens de aanleg geroerd. Daardoor kan nadien, tijdens onvoorziene situaties, geen nieuwe impact meer optreden op archeologische resten. Deze zijn dan immers al verwijderd.

Conclusie
Ter plaatse van het tracé voor de verbindingsleiding bevinden zich objecten op of in zeebodem waar een archeologische waarde aan moet worden toegekend of verwacht. Of de aanleg van de verbindingsleiding daadwerkelijk tot aantasting van archeologische resten leidt, moet nader worden onderzocht, of het tracé moet worden geoptimaliseerd zodat deze (verwachte) resten worden vermeden. Daarmee kan een negatief effect worden voorkomen.

4.8 Nautische veiligheid

Bestaande situatie
Voor de nautische veiligheid is relevant dat het gebied van de verbindingsleiding gekruist wordt door een scheepvaartroute en dat de visserij gebruik maakt van het gebied.

Aanleg
De verbindingsleiding wordt ingegraven op de locaties waar dat vereist is op basis van een risicoanalyse van het gebied volgens paragraaf 6.3.1 van NEN 3656. Het tracé kruist een scheepvaartroute (VSS: Verkeers-Scheiding-Stelsels). Zie hiervoor Figuur 4-2, waar de verbindingsleiding naar L4A rood omlijnd is.



Figuur 4-2 Overzicht scheepvaartbewegingen in de Noordzee

Een ingegraven buisleiding wordt gelegd door een combinatie van een legschip en een ingraafmachine. De snelheid waarmee gevaren wordt is geschat op 3 km per dag. Gezien de korte afstand van de te kruisen vaarroute en de werksnelheid, zal de hinder van werkmaterieel naar het overige scheepvaartverkeer naar verwachting gedurende een dag plaats vinden. Bovendien worden voorzorgsmaatregelen ingesteld in overleg met de Havenmeester en Kustwacht zodanig dat de kans op rammen van doorgaande scheepvaart met werkmaterieel en los drijvend bouwmateriaal nihil zal zijn. Aanwezigheid van een sleepboot voor werkmaterieel als begeleiding kan een goede maatregel zijn of de aanwezigheid van een Noordzeeloods op de pijpenlegger.

Er is een inventarisatie gemaakt van de kruisingen op het tracé van de buisleiding met andere leidingen. De locatie van de bestaande leidingen is bekend en daar wordt het ontwerp en de uitvoering rekening mee gehouden. De kans dat er onbekende leidingen beschadigd raken wordt als nihil ingeschat.

Gebruiksfase
De risico's tijdens de gebruiksfase zijn het mogelijk falen of beschadigen van de verbindingsleiding als gevolg van aanvaring door of ongeval met de scheepvaart. De kans hierop wordt bepaald door corrosie of materiaaldefecten, en door de impact van bijvoorbeeld ankers of een aanvaring door of ongeval met de scheepvaart. De vier hoogste ongevalsfrequenties betreffen:

- Vissende vissersschepen die over de buisleiding varen;
- Anker haakt achter de buisleiding;
- Containers vallen overboord op de buisleiding;
- Schip zinkt op buisleiding (al dan niet als gevolg van een aanvaring).

Naar aanleiding van het onderzoek dat in het kader van de MER is uitgevoerd is besloten tot aanvullend onderzoek om de risico's beter in kaart te brengen en zo nodig mitigerende en/of beheersmaatregelen vast te stellen waarmee de risico's kunnen worden gereduceerd.

Overige situaties
Tijdens regulier onderhoud en eventuele reparatiewerkzaamheden is ter plaatste werkmaterieel aanwezig. Als gevolg daarvan zijn tijdelijk vergelijkbare risico's te verwachten als in de aanlegfase.

Conclusie
Als gevolg van aanleg-, onderhouds- en eventuele reparatiewerkzaamheden zijn goed beheersbare nautische risico's te verwachten. Naar de nautische risico's tijdens de gebruiksfase wordt nog nader onderzoek gedaan om vast te stellen in hoeverre de risico's optreden en hoe die eventueel kunnen worden beheerst.

4.9 Afvalproductie

Bestaande situatie
Vanzelfsprekend is er voorafgaand aan het project geen sprake van afval vanwege het project.

Aanleg
Tijdens de aanleg van de verbindingsleiding worden geen gevaarlijke stoffen gebruikt.

Ook komt er vrijwel geen restafval vrij bij de aanleg. Het restafval dat vanwege de aanlegoperatie vrijkomt wordt op een reguliere wijze verwerkt.

Gebruiksfase
Tijdens de gebruiksfase worden geen gevaarlijke stoffen gebruikt en komt geen restafval vrij.

Overige situaties
Ook tijdens onderhouds- en eventuele reparatiewerkzaamheden worden geen gevaarlijke stoffen gebruikt en komen niet of nauwelijks reststoffen vrij.

Decommissioning
Na de buitengebruikstelling aan het einde van de levensduur wordt de verbindingsleiding conform de dan geldende regelgeving uit bedrijf genomen en veiliggesteld. Vervolgstappen met betrekking tot eventuele verwijdering van de pijpleiding zullen worden genomen conform de dan geldende wet- en regelgeving.

Conclusie
Er is geen sprake van het gebruik van gevaarlijke stoffen die tot gevaarlijk afval kunnen leiden, noch van grote hoeveelheden restafval. Na de aanleg en voor de ingebruikname wordt de verbindingsleiding getest met water met een beperkte hoeveelheid chemicaliën. Dit leidt niet tot nadelige gevolgen voor het ontvangende water en aquatisch milieu.

4.10 Energieverbruik en CO_2 balans

Voor de aanleg van de verbindingsleiding en de overige onderdelen van de Aramis CO_2-infrastructuurketen wordt materiaal vervaardigd (staal) en wordt werkmaterieel ingezet waarvoor aanzienlijke hoeveelheden energie nodig zijn. Het grootste energieverbruik vindt echter plaats in de gebruiksfase. De verbindingsleiding heeft in dit geheel een beperkt aandeel.

In het MER voor het Aramis initiatief is het totaal van de benodigde energie voor de aanleg en de gebruiksfase omgezet naar CO_2-emissies, en zijn deze afgezet tegen de hoeveelheid CO_2-uitstoot die met het initiatief wordt vermeden. Daaruit volgt dat over de gehele levensduur van de keten gezien, de initiële extra hoeveelheid benodigde energie per saldo resulteert in een grote reductie van CO_2-emissies naar de atmosfeer.

Geconcludeerd kan worden dat voor het Aramis initiatief als geheel grote hoeveelheden energie benodigd zijn, en dat er tegelijkertijd per saldo een grote reductie van CO_2-emissies bereikt wordt.

4.11 Overige aspecten

In voorgaande paragrafen zijn de relevante milieuonderwerpen en -risico's besproken. Het MER voor het Aramis initiatief gaat daarnaast ook in op de gevolgen voor overige gebruiksfuncties op zee. Deze wegen vanuit milieuoogpunt echter niet mee in een mer-beoordeling, oftewel in het bepalen of een volledige mer nodig is voor de verbindingsleiding. Deze aspecten laten we hier daarom buiten beschouwing.

5 Cumulatie van effecten

De effecten van afzonderlijke projecten kunnen op zichzelf relatief beperkt zijn, maar kunnen in combinatie met andere projecten of handelingen, significant negatieve gevolgen hebben voor een (Natura 2000-)gebied. Dit wordt cumulatie genoemd. Het al dan niet optreden van cumulatie is afhankelijk van de milieueffecten, effectafstanden, de planning en de locatie van uitvoering van de activiteit. Het optreden van cumulatie kan uitgesloten worden als aan de volgende twee criteria wordt voldaan:

- De afstand tussen de locaties van twee activiteiten is groter dan de som van de maximale effectafstanden van gelijktijdig optredende effecten;
- De tussenpozen tussen de uitvoering van twee activiteiten is voldoende om samenloop van effecten te voorkomen.

Voor wat betreft de verbindingsleiding is er naast de overige onderdelen van de Aramis-CO_2-infrastructuur nog een aantal andere ontwikkelingen op het Nederlandse deel van de Noordzee die tot cumulatie kunnen leiden. In de volgende paragrafen wordt mogelijke cumulatie van effecten met deze twee categorieën beschouwd.

5.1 Cumulatie met overige onderdelen van het Aramis initiatief

In het MER voor het Aramis initiatief zijn de effecten van het gehele initiatief in beeld gebracht. Deze merbeoordeling voor de verbindingsleiding naar L4A gaat in op de gecumuleerde effecten van stikstofdepositie van het gehele initiatief en op de gecumuleerde effecten van andere ketenonderdelen op zee op andere factoren dan stikstofdepositie (zoals verstoring door geluid, licht, oppervlakteverlies etc.). De effectafstanden van onderdelen op land op andere milieuthema's dan stikstof zijn te groot om tot cumulatie te leiden op het mariene milieu nabij de verbindingsleiding.

5.1.1 Stikstofdepositie

Voor stikstofemissies is een rekenmodel gebouwd waarmee cumulatieve verspreidingsberekeningen van alle Aramis-onderdelen in de aanlegfase en in de gebruiksfase zijn uitgevoerd. Daarmee zijn de effecten van stikstofdepositie van Aramis op Natura 2000-gebieden bepaald. Tijdens de aanlegfase zijn de emissies en depositie het hoogst waardoor deze situatie maatgevend is. Uit de berekeningen komt naar voren dat het noodzakelijk is de depositie zoveel mogelijk te beperken; daarvoor wordt zoveel mogelijk elektrisch materieel ingezet en wordt de uitstoot van fossiele emissies zoveel mogelijk beperkt.

Uit de beoordeling van de effecten van de berekende tijdelijke extra stikstofdepositiebijdrage op de kwaliteit van deze habitattypen blijkt dat de beperkte eenmalige extra stikstofdepositie in de aanlegfase niet zal leiden tot veranderingen in de vegetatiesamenstelling, groeisnelheid of onderlinge concurrentieverhoudingen tussen plantensoorten van de betreffende habitats. Evenmin leidt deze eenmalige en kleine stikstofdepositie tot een verzwaring van de beheeropgave of tot een belemmering bij het uitvoeren van herstelmaatregelen.

Geconcludeerd wordt dat tijdelijke gecumuleerde depositiebijdrage tijdens de aanlegfase leidt niet tot een aantasting van de kwaliteit van de beoordeelde Natura 2000-gebieden of tot belemmering van de mogelijkheden maatregelen te treffen die noodzakelijk zijn voor het behalen van de instandhoudingsdoelstellingen van de Natura 2000-gebieden.

5.1.2 Onderwatergeluid

Onderwatergeluid heeft een negatief effect op de mariene ecologie, en in het bijzonder voor zeezoogdieren bruinvis, grijze zeehond en zeehond. Voor onderwatergeluid is bepaald in hoeverre de geluidscontouren overlappend zijn in ruimte en tijd. Vooral het heien van verankeringspalen en conductors van het distributieplatform en platforms op zee leidt tot verstoring van zeezoogdieren en overlapt met de verstoring vanwege de aanleg van de verbindingsleiding.

Om het onderwatergeluid te minimaliseren worden onder andere de volgende maatregelen genomen in verschillende onderdelen van de CO_2 -infrastructuurketen:

- Een deel van het onderwatergeluid is gerelateerd aan scheepvaart. Zoveel als mogelijk worden de bestaande scheepvaartroutes gevolgd waar in de referentiesituatie al veel scheepsverkeer plaatsvindt.
- De meeste invloed van onderwatergeluid is afkomstig van het heien van de funderingspalen voor platforms en conductors bij het boren van putten. Om dit geluid te verminderen wordt allereerst een ADD (wat staat voor het Engelse Acoustic Deterrent Device) toegepast bij het heien van de conductor, het platform en de aanlegsteigers in combinatie met een soft start. Tevens wordt een HSD-systeem gebruikt (dat staat voor het Engelse Hydrosound Demper) en een bellenscherm toegepast om het onderwatergeluid te beperken. Ook wordt waar nodig gebruik gemaakt van een Marine Mammal Observer (MMO) en Passive Acoustic Monitoring (PAM).

5.1.3 Overige storingsfactoren

Van overige storingsfactoren worden geen relevante gecumuleerde effecten verwacht.

5.2 Cumulatie met andere ontwikkelingen

In het MER voor het Aramis initiatief is cumulatie met andere ontwikkelingen onderzocht. Op zee betreft dit de volgende ontwikkelingen:

Tabel 5-1. Overzicht van projecten die worden meegenomen in de cumulatietoets en relevante effecten voor cumulatie

Project	Planning	Relevante effecten
Aramis CCS	2025 – 2030	Vertroebeling, onderwatergeluid, verstoring door licht en beweging/optiek, stikstofdepositie
Net op Zee IJmuiden Ver Alpha	2024 – 2029	Vertroebeling, onderwatergeluid, verstoring door licht en beweging/optiek, stikstofdepositie
Net op Zee IJmuiden Ver Beta en Gamma	2024 – 2029	Vertroebeling, onderwatergeluid, verstoring door licht en beweging/optiek, stikstofdepositie
Net op Zee Nederwiek 1 en 2	2025 – 2030	Vertroebeling, onderwatergeluid, verstoring door licht en beweging/optiek, stikstofdepositie
Wind op Zee Nederland	2024 – 2031	Onderwatergeluid, verstoring door licht en beweging/optiek, stikstofdepositie
Seismisch onderzoek Shell	2024	Onderwatergeluid, verstoring door licht en beweging/optiek, stikstofdepositie
Exploratieboring P11-B	2023 - 2024	Vertroebeling, onderwatergeluid, verstoring door licht en beweging/optiek, stikstofdepositie

Bij deze ontwikkelingen is sprake van effecten van onderwatergeluid op zeezoogdieren, vogelslachtoffers door aanvaringen en habitatverlies, verstoring van vogels en zeezoogdieren door licht, beweging en optiek en stikstofdepositie. Deze effecten kunnen cumuleren met de effecten van het Aramis initiatief.

Uit de passende beoordeling bij het MER voor Aramis blijkt dat rondom de Natura 2000-gebieden Voordelta en de Noordzeekustzone mitigerende maatregelen nodig zijn om cumulatie van negatieve effecten te voorkomen:

- In de Voordelta zal gedurende de winter een afstand van 1.500 meter aangehouden moeten worden van het deel van de zandplaat(platen) waarop zich grijze of gewone zeehonden bevinden.
- In de Noordzeekustzone moeten schepen minimaal 500 meter afstand houden van vogelconcentraties van topper, eidereend en zwarte zee-eend alsmede 1.500 meter van het deel van de zandplaat(platen) waarop zich grijze of gewone zeehonden bevinden.

In de passende beoordeling is ingeschat dat de cumulatie van deze effecten na mitigatie beperkt zal zijn. Dit geldt temeer voor de verbindingsleiding naar L4A omdat deze ver van de genoemde gebieden ligt.

5.3 Conclusie

Er treedt cumulatie op van effecten van de verbindingsleiding met effecten van andere onderdelen van het Aramis initiatief en in beperkte mate met effecten van andere ontwikkelingen op de Noordzee dan het Aramis initiatief. Door mitigerende maatregelen te treffen kunnen aanzienlijke cumulerende effecten worden voorkomen.

6 Conclusie mer-beoordeling

6.1 Inleiding

In dit hoofdstuk worden de verschillende kenmerken van de voorgenomen leidingaanleg voor het transport van CO_2 van het distributieplatform naar het nog om te bouwen CO_2-injectieplatform L4A beoordeeld op basis van de formele mer-beoordelingscriteria uit bijlage III van de Europese richtlijn inzake milieueffectbeoordeling. Op grond van artikel 16.43 derde lid onder a van de Omgevingswet moet het bevoegd gezag bij het nemen van een mer-beoordelingsbesluit ook rekening houden met deze criteria.

6.2 Beoordeling voorgenomen activiteit

In bijlage III van de Europese richtlijn wordt onderscheidt gemaakt tussen drie aspecten van een voorgenomen activiteit of project:

1 De kenmerken van het project;

2 De locatie van het project;

3 De soort en kenmerken van het potentiële effect.

De voorgenomen pijpleidingaanleg wordt hieronder beoordeeld aan de hand van de verschillende criteria die aan deze drie aspecten zijn verbonden.

De kenmerken van het project

In Tabel 6-1 is de beoordeling van de meest relevante kenmerken van het project opgenomen.

Tabel 6-1: Beoordelingscriteria in relatie tot de kenmerken van het project.

Criterium	Beoordeling	Referentie
De omvang en het ontwerp van het project.	Het project (de verbindingsleiding) is onderdeel van een omvangrijk initiatief om CO_2 infrastructuur aan te leggen waarmee CO_2 in leeggeproduceerde gasvelden kan worden opgeslagen.	Hfst. 2
De cumulatie met andere bestaande en/of goedgekeurde projecten.	Het project (de verbindingsleiding) is onderdeel van een het Aramis initiatief, waartoe gelijktijdig met een Projectbesluit besloten wordt.	§ 5
Het gebruik van natuurlijke hulpbronnen, met name land, bodem, water en biodiversiteit.	De uitvoering van het project vereist het gebruik van een relatief beperkte hoeveelheid (natuurlijke) hulpbronnen: ▪ Brandstof voor de schepen; ▪ Staal voor de leidingen; Beperkt ruimtebeslag van de zeebodem voor het leggen van de leiding.	Hfst. 3 § 4.10 § 4.11
De productie van afvalstoffen.	Na de buitengebruikstelling aan het einde van de levensduur wordt de verbindingsleiding conform de dan geldende regelgeving uit bedrijf genomen en veiliggesteld. Bij het testen van de leidingen tijdens de aanleg zal circa 8400 m^3 water worden geloosd. De gevolgen van het vrijkomen van afval tijdens de aanleg, zijn verwaarloosbaar door de kleine hoeveelheid en de aard van de gebruikte stoffen. Daarnaast zal er bij de aanleg een beperkte hoeveelheid restafval vrijkomen dat op gecontroleerde wijze wordt verwerkt zodat de effecten daarvan ook minimaal zijn.	Hfst. 3 § 4.9
Verontreiniging en hinder.	De aanlegwerkzaamheden voor de pijpleidingen kunnen hinderlijk zijn voor de scheepvaart, vooral bij het kruisen van vaarroutes. Door een goede planning in overleg met de scheepvaartautoriteiten en het inzetten van loodsen kan de hinder beperkt blijven. Risico's op verontreiniging van het aquatisch milieu zijn verwaarloosbaar (zie hiervoor bovenstaande punt over afvalstoffen).	Hfst. 4

Criterium	Beoordeling	Referentie
Het risico van zware ongevallen en rampen die relevant zijn voor het project in kwestie, waaronder rampen die worden veroorzaakt door klimaatverandering, in overeenstemming met wetenschappelijke kennis.	Het risico van zware ongevallen is vanwege de zeer hoge offshore-veiligheidstandaard minimaal.	Hfst. 3 § 4.8
De risico's voor de menselijke gezondheid (bijvoorbeeld als gevolg van waterverontreiniging of luchtvervuiling).	Het project wordt uitgevoerd op de Noordzee vanaf circa 90 kilometer uit de kust van Den Helder. Risico's voor de menselijk gezondheid kunnen op basis van de verwachte effecten uitgesloten worden.	Hfst. 4

De locatie van het project

In Tabel 6-2 zijn de belangrijkste criteria opgenomen ten aanzien van de kwetsbaarheid van het milieu in de gebieden waarop het project van invloed kan zijn.

Tabel 6-2: Beoordelingscriteria in relatie tot de locatie van het project.

Criterium	Beoordeling	Referentie
Het bestaande en goedgekeurde grondgebruik.	Het deel van de Noordzee waar het project wordt uitgevoerd, wordt tevens gebruikt door de scheepvaart en visserij. Tijdens de uitvoering van het project gelden plaatselijk geringe beperkingen voor deze activiteiten.	§ 2.4 en 4.8
De relatieve rijkdom aan en beschikbaarheid, kwaliteit en regeneratievermogen van natuurlijke hulpbronnen (met inbegrip van bodem, land, water en biodiversiteit) in het gebied en de ondergrond ervan.	Het project heeft geen permanente gevolgen voor de relevante natuurlijke hulpbronnen van het gebied.	Hfst. 4
Het opnamevermogen van het natuurlijke milieu, met in het bijzonder aandacht voor de volgende typen gebieden: **I.** Wetlands, oeverformaties, riviermondingen; **II.** Kustgebieden en het mariene milieu; **III.** Berg- en bosgebieden; **IV.** Natuurreservaten en -parken; **V.** Gebieden die in de nationale wetgeving zijn aangeduid of door die wetgeving worden beschermd; Natura 2000-gebieden die door de lidstaten zijn aangewezen krachtens Richtlijn 92/43/EEG en Richtlijn 2009/147/EG; **VI.** Gebieden waar de milieukwaliteitsnormen, in de wetgeving van de Unie vastgesteld en relevant voor het project, al niet worden nagekomen of worden beschouwd als niet-nagekomen; **VII.** Gebieden met een hoge bevolkingsdichtheid; **VIII.** Landschappen en plaatsen van historisch, cultureel of archeologisch belang.	In de omgeving bevinden zich Natura 2000-gebieden. Het mariene milieu van de Noordzee ter plaatse van de verbindingsleiding hangt daarmee samen. Er zijn van de aanlegwerkzaamheden tijdelijke negatieve effecten te verwachten op beschermde natuurwaarden. In het MER voor het Aramis initiatief is beoordeeld dat significant negatieve effecten op de instandhoudingsdoelstellingen van deze Natura 2000-gebieden uitgesloten kan worden. Ter plaatse van het tracé voor de verbindingsleiding bevinden zich objecten op of in zeebodem waar een archeologische waarde aan moet worden toegekend of verwacht. Of de aanleg van de verbindingsleiding daadwerkelijk tot aantasting van archeologische resten leidt moet nader worden onderzocht, of het tracé moet worden geoptimaliseerd zodat deze (verwachte) resten worden vermeden. Daarmee kan een negatief effect worden voorkomen.	Hfst. 4 Bijl. 2 Bijl. 3

De soort en kenmerken van het potentiële effect

Tabel 6-3 geeft een beoordeling van de meest waarschijnlijke aanzienlijke milieueffecten van het project in relatie tot de kenmerken en locatie van het project.

Tabel 6-3: Beoordelingscriteria in relatie tot de soort en kenmerken van het potentiële effect

Criterium	Beoordeling	Referentie
De orde van grootte en het ruimtelijk bereik van de effecten (bijvoorbeeld geografisch gebied en omvang van de bevolking die getroffen kan worden).	Het bereik van de potentiële effecten van het project is beperkt tot het plangebied en de omgeving daarvan. Wel kunnen de tijdelijke aanlegwerkzaamheden op grotere afstand tot hinder van onderwatergeluid leiden voor met name zeezoogdieren.	Hfst. 4 Bijl. 2
De aard van het effect.	De potentiële effecten van het project zijn over het algemeen beperkt en lokaal van aard. De meest relevante effecten hebben betrekking op natuur en nautische veiligheid. Hiervoor worden maatregelen genomen om de effecten in voldoende mate te mitigeren.	Hfst. 4 Bijl. 2
Het grensoverschrijdende karakter van het effect.	Het projectgebied ligt niet nabij een grens van een buurland.	Hfst. 2 Bijl. 2
De intensiteit en de complexiteit van het effect.	De intensiteit en complexiteit van de potentiële effecten van het project zijn beperkt, met name door de relatief korte tijdsduur waarbinnen effecten optreden (aanlegfase) in combinatie met de snelle verspreiding en/of verwijdering van de optredende emissies in het zeewater en de atmosfeer.	Hfst. 4 Bijl. 2
De waarschijnlijkheid van het effect.	Het optreden van de potentiële effecten van het project is goed voorspelbaar omdat de werkzaamheden vaker voorkomen.	Hfst. Hfst. 4 Bijl. 3
De verwachte aanvang, duur, de frequentie en de omkeerbaarheid van het effect.	De potentiële effecten van het project zijn beperkt, en treden voor een groot deel slechts op over een periode van maximaal enkele maanden. Ook zijn de (belangrijkste) effecten omkeerbaar.	Hfst. Hfst. 4 Bijl. 2
De cumulatie van effecten met de effecten van andere bestaande en/of goedgekeurde projecten.	Cumulatie met bestaande en/of goedgekeurde projecten is niet uit te sluiten maar zal naar verwachting niet tot significant grotere of andere effecten leiden.	Hfst. 5
De mogelijkheid om de effecten doeltreffend te verminderen.	De potentiële effecten van het project kunnen, indien nodig, met behulp van diverse maatregelen verminderd of voorkomen worden.	Hfst. 4 Bijl. 3

6.3 Conclusie mer-beoordeling

Voor de besluitvorming over de vergunning voor de verbindingsleiding moet het bevoegde gezag afwegen of een mer nodig is. In de voorliggende aanvraag is de informatie beschreven op basis waarvan deze afweging kan worden uitgevoerd.

Uit de voorgaande hoofdstukken komt naar voren wat de kenmerken van het project zijn (verbindingsleiding), en wat de kenmerken van de omgeving en milieueffecten zijn. Over het geheel gezien kan worden geconcludeerd dat van de aanleg en het gebruik van de verbindingsleiding in relatie tot in de omgeving aanwezige gevoeligheden geen aanzienlijke effecten verwacht worden. Op grond daarvan kan geoordeeld worden dat geen mer nodig is.

De verbindingsleiding is onderdeel van het Aramis initiatief dat meer omvattend is dan de verbindingsleiding. Voor het Aramis initiatief als geheel wordt een mer-procedure doorlopen en een MER opgesteld.

7 Indieningsvereisten

Tabel 4 bevat een kruisverwijzing tussen de indieningsvereisten conform artikel 1.7.1 Mbr en de vindplaats(en) hiervan in deze aanvraag.

Tabel 4: Kruisverwijzing indieningsvereisten Mbr

Kader	Indieningsvereiste	Paragraaf	Rapport / bijlage
Algemeen	Gegevens aanvrager	2.1	
	Ligging project	2.4	
	Statutaire naam aanvrager	2.1	
	Handelsnaam	2.1	
	Vestigingsadres bedrijf	2.1	
	Correspondentieadres	2.1	
	Telefoonnummer contactpersoon	2.1	
	E-mailadres	2.1	
Vereisten Mbr 1.7.1	1 Bij de aanvraag om een vergunning tot aanleg van een pijpleiding als bedoeld in artikel 94 van het besluit verstrekt de aanvrager gegevens omtrent:		
	a. het tijdvak waarvoor de vergunning wordt gevraagd;	2.3	
	b. het traject van de pijpleiding;	3.4	
	c. de wijze waarop de pijpleiding wordt aangelegd en de diepte waarop de pijpleiding in de bodem wordt gelegd;	3.4	
	d. de resultaten van het onderzoek van het voorgenomen traject in een strook van 600 meter, waarvan de as van de strook samenvalt met het gekozen traject, en waarin is beschreven:	3.4	Bijlage 2, 3, en 7
	1°. het profiel van de zeebodem;		
	2°. de aanwezige obstakels;		
	3°. de ligging van bestaande pijpleidingen en kabels;		
	4°. de grondmechanische eigenschappen;		
	5°. de stratigrafie van de zeebodem;		
	6°. de analyse en kwaliteit van de bodemmonsters en sonderingen.		
	e. een rapport van het voorontwerp van de pijpleiding waarin is beschreven:	3.2, 3.3, en 3.5	Bijlage 1
	1°. de eigenschappen en diameter van de pijpleiding;		
	2°. de stoffen die erin worden vervoerd;		
	3°. een analyse van de veiligheids- en milieurisico's, en		
	4°. de tijd gedurende welke de pijpleiding wordt gebruikt voor het vervoer van die stoffen.		

Bijlage 1: Voorontwerp van de verbindingsleiding

Bijlage 2: Geotechnisch tracéonderzoek

Bijlage 3: Onderbouwing tracékeuze en bodemgesteldheid

Bijlage 4: Kaarten met ligging tracé

Bijlage 5: Aramis flow assurance study

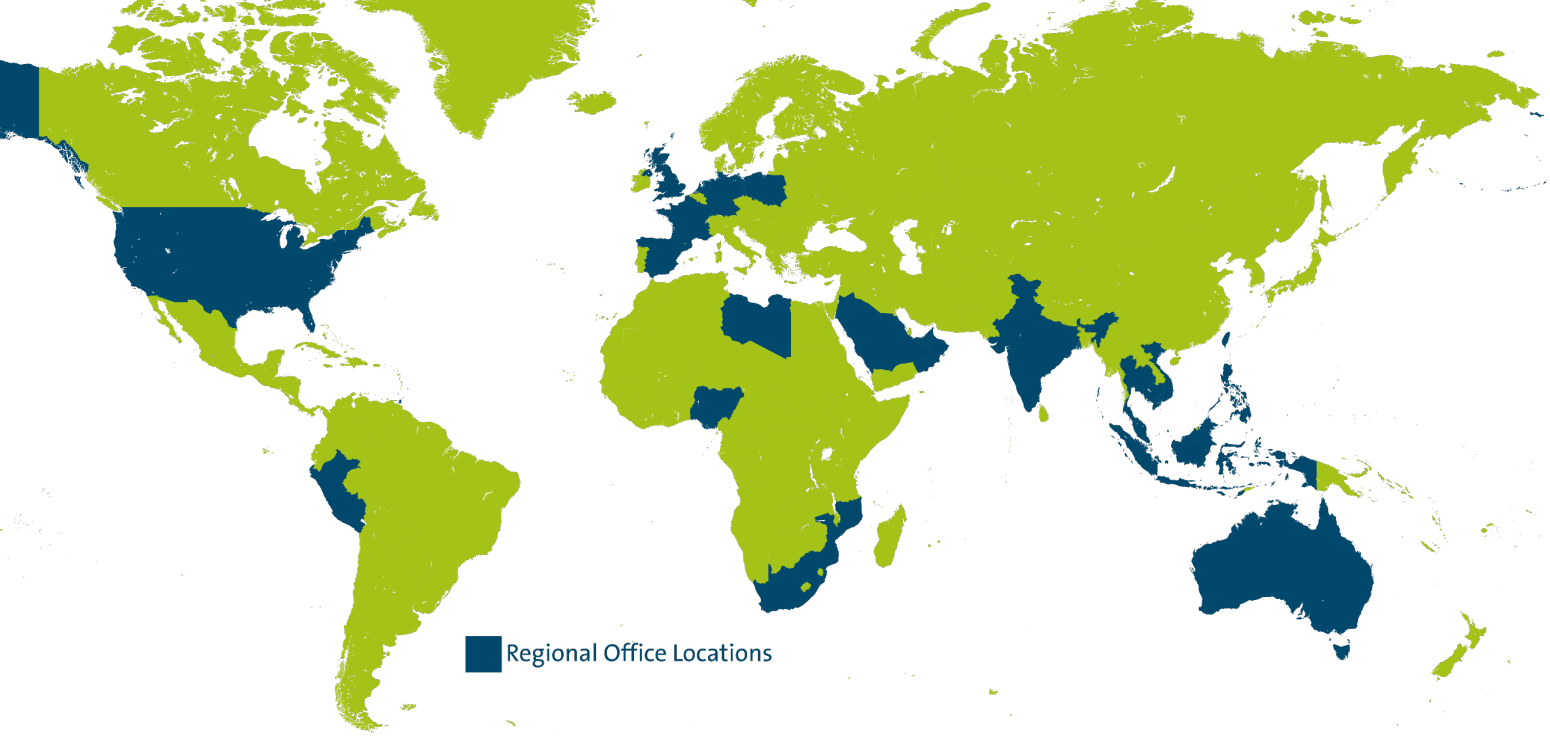
Bijlage 6: Archeologisch onderzoek

Bijlage 7: Ligging van bestaande pijpleidingen en kabels

Bijlage 8: Participatie

Bijlage 9: Natuurtoets

Bijlage 10: Nautische veiligheidsstudie



Royal HaskoningDHV is een onafhankelijk internationaal advies- en ingenieursbureau. We combineren 140 jaar engineering- en ontwerpexpertise met consultancy, software en technology diensten. We leveren hiermee toegevoegde waarde voor klanten en hebben een positieve impact op mensen en onze leefomgeving. Dat is onze drijfveer: Enhancing Society Together. Daar hoort bij dat we onszelf en anderen voortdurend uitdagen om bij te dragen aan duurzame oplossingen voor lokale en wereldwijde vraagstukken in de gebouwde omgeving en de industrie.

In onze snel veranderende wereld wordt de agenda bepaald door onder meer klimaatverandering, de digitale transformatie, een veranderende consumentenvraag en hybride werken. Met onze geïntegreerde duurzame oplossingen willen we bijdragen aan het bredere technologische en maatschappelijke plaatje.

Gesteund door de kennis en ervaring van meer dan 6.000 collega's werken we vanuit kantoren in meer dan 20 landen. We ondersteunen klanten om de transitie te maken naar een slimme en duurzame organisatie. We koppelen onze engineering- en ontwerpexpertise aan onze software- en technologische diensten om toegevoegde waarde te leveren voor onze klanten en de lifecycle van hun assets.

We zijn oprecht, handelen integer en transparant in al onze activiteiten, ook onze bedrijfsvoering Ons team is divers en inclusief. De veiligheid en het welzijn van mensen, in ons team en daarbuiten, staat onder alle omstandigheden voorop.

In projecten en initiatieven werken we actief samen met overheden en het bedrijfsleven, partners en stakeholders. We zien een belangrijke rol voor onszelf in innovatieve duurzame ontwikkeling en willen bijdragen aan een betere leefomgeving, nu en in de toekomst.

Ons hoofkantoor is gevestigd in Nederland en we hebben kantoren in Europa, Azie, Afrika, Australie en Amerika.

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ARAMIS

ARAMIS PROJECT

Petrofac

Rev	Step	Date	Revision memo	Issued by	Checked by	Approved by
00	IFR	28-03-2024	Issued for Review	[redacted]	[redacted]	[redacted]
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ABBREVIATIONS

Abbreviation	Description
ALARP	As Low as Reasonably Practicable
APR	Applicable Prime Reference
CCS	Carbon Capture & Storage
Cmax	Maximum Crest Height During 3 Hours
CWC	Concrete Weight Coating
D-HUBN	Distribution Hub North
DNV	Det Norske Veritas
EBN	Energie Beheer Nederland
ECA	Engineering Criticality Assessment
FEED	Front-End Engineering Design
GS	General Specification by Total
Hmax	Maximum Individual Wave Height During 3 Hours
Hs	Significant Wave Height
ID	Inner Diameter
JIP	Joint Industry Project
KOM	Kick-Off Meeting
LCC	Load Controlled Condition
NAP	Normaal Amsterdams Peil (a vertical datum near shore)
OD	Outer Diameter
PSI	Pipe Soil Interaction
SCF	Stress Concentration Factor
SMYS	Specified Minimum Yield Strength
TBC	To Be Confirmed
THmax	Period Associated With Maximum Individual Wave Height During 3 Hours
Tp	Spectral Peak Period
TTE	TotalEnergies
UXO	UneXploded Ordnance
WT	Wall Thickness
3LPE	3-Layer PolyEthylene

DEFINITIONS

Terminology	Definition
COMPANY	Aramis (cooperation between Shell, TotalEnergies, Gasunie and EBN)
CONTRACTOR	Petrofac

HOLDS

No.	Section	Hold	Responsibility
[HOLD 1]	2.5	Maximum CO_2 density	CONTRACTOR
[HOLD 2]	2.5	No flow assurance data supplied/confirmed for 16" spurline.	COMPANY
[HOLD 3]	2.6	Number of planned shutdowns during design life	COMPANY

1 INTRODUCTION

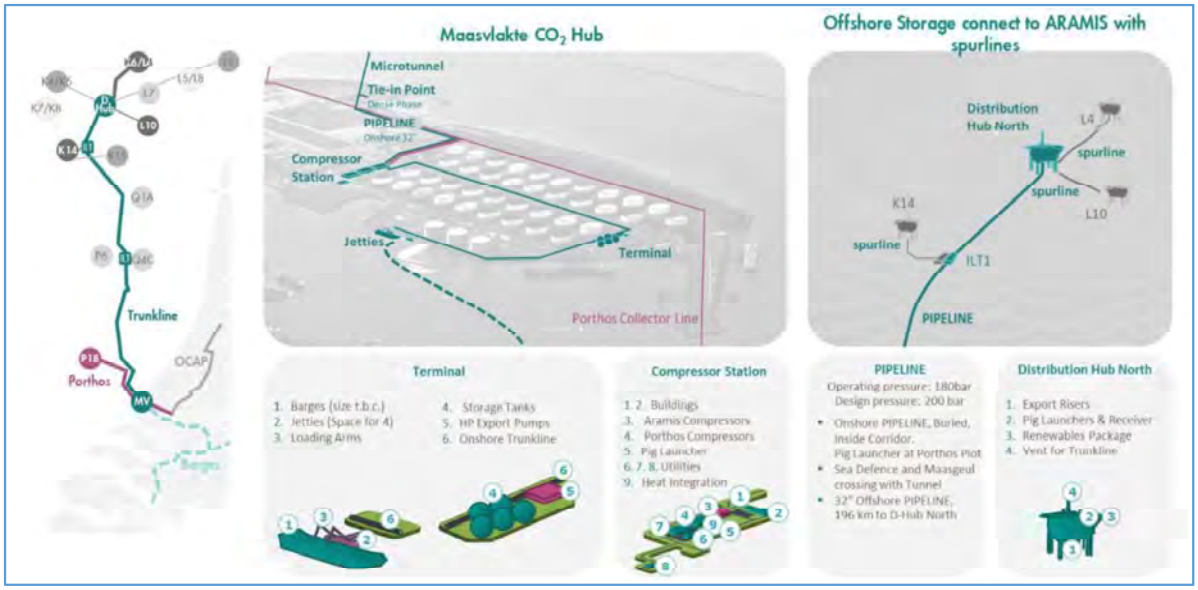
1.1 Background

The Aramis project is a cooperation between Shell, TotalEnergies, Gasunie and EBN to utilise depleted gas fields and potentially aquifers in the Dutch North Sea to establish an open-access CCS infrastructure for transport and storage, targeting hard-to abate industrial emissions in the Netherlands and Europe.

This part of the project provides the transport of CO_2 from the onshore terminal to an offshore platform, which is used as distribution hub (D-HUBN). Other parts of the project are provided by CO2next and Porthos, while the actual storage in the depleted offshore gas fields under the North Sea is performed by Shell and TotalEnergies as part of their offshore operations.

Figure 1-1 below provides an overview of the envisaged CCS infrastructure. The left panel illustrates the trunkline that transports the CO_2 from the Maasvlakte to the offshore storage. The middle panels illustrate the Maasvlakte Hub with the Porthos compressor station and the CO2next Terminal. The right panel shows the platforms of TTE and Shell.

Figure 1-1 - Overview of CCS Infrastructure



1.2 Purpose of Document

The purpose of this document is to provide the background, design requirements, design data, key assumptions and design criteria for the L4A spurline including riser and spools.

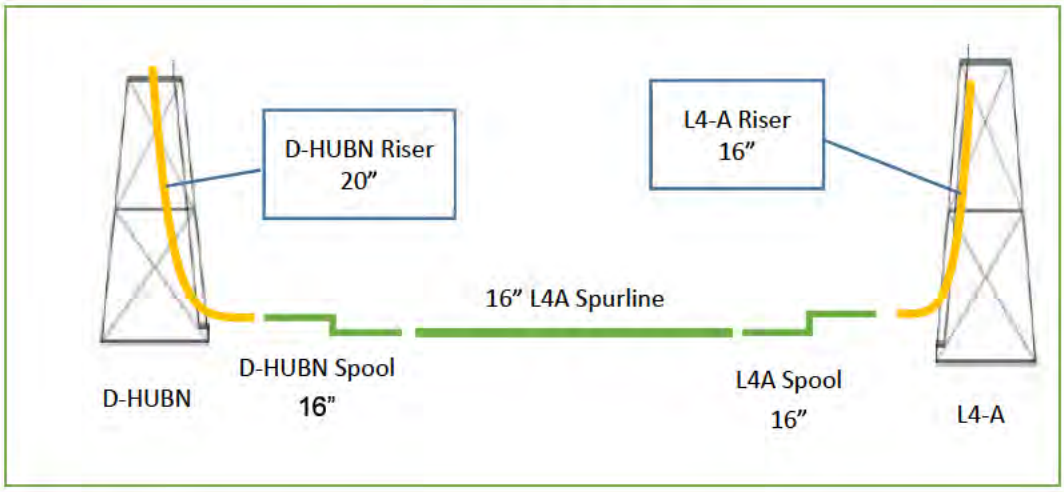
The pipeline systems shall be designed in accordance with best engineering practice to minimise the risks to personnel and environment, i.e., as low as reasonably practicable (ALARP).

1.3 Battery Limits

The 16" pipeline spurs from the D-HUBN platform and after traversing approximately 28kms terminates at TTE L4A platform. The design covered by this document is limited to the spools at both ends of the spurline. The riser-spool-pipeline connections are flange connections.

The battery limit of this document is shown as green in Figure 1-2 below.

Figure 1-2 – Scope of Document



1.4 Units

All dimensional data and results presented shall be expressed in SI (metric) units. In addition, other units may be used where they are universally accepted standards, such as for standard flow rates, temperature (°C), pressure (barg), or pipeline diameters (inch). For avoidance of doubt, all data and results shall be presented with units used.

Other than design pressures, where applicable, pressures will be stated together with elevation to reference depth.

1.5 Coordinate System

The selected coordinate system for the spurline is ETRS 89/UTM zone 31N as per NEN 3656 [A1].

The KP0 point for the L4A spurline will be at the riser bottom flange at D-HUBN.

1.6 Vertical Datum

The water depths, tidal level and offshore platform levels shall be defined by reference to lowest astronomical tide (LAT) as per NEN 3656 [A1].

1.7 Standards, Codes and Regulations

In addition to COMPANY General Specifications (GS), the L4A spurline and spools design is subject to EU and Dutch Directives and design codes (NEN codes). Where there is misalignment between standards, codes, or regulation the most stringent should be adhered to. The misalignment and ultimate design choice shall be reported to COMPANY.

1.7.1 List of relevant design standards for offshore CO2 pipelines

NEN 3656 Requirements for submarine steel pipeline systems

NEN 3654 Mutual influence of pipelines and high-voltage circuits

DNV-ST-F101 Submarine pipeline systems.

DNV-RP-F104 Design and operation of carbon dioxide pipelines.

1.7.2 Order of Precedence for Standards

The pipeline will be located in the Netherlands and the technical standards mandated by Dutch regulations will apply. In addition, since BB4 is developed by Total Energies (TTE), the TTE general specifications are to be used, which in many cases are additions/amendments to international codes and standards.

The proposed technical standards to be used during the FEED phase in order of precedence are:

1. Statutory Netherlands laws and regulations (e.g. NEN36XX)
2. Project documents (requisitions, specifications, datasheets, basis of design and philosophies) covering qualifications and derogations to General Specifications.
3. Company General Specifications (GS)
4. International codes and standards

Commentary:

Following the order of precedence stated above, the applicable prime reference (APR) for the L4A spurline and spools is NEN 3656 [A1].

The project documents supplied by Company (before the contract award on 13th Nov 2023 and the information received afterwards) listed in sections 4.3 and 4.5 are used.

Partial use of other Prime References (PRs) is allowed in the GS [B1] when the APR is silent on specific matters and upon approval from Company. GS [B1] recommends to use DNV-ST-F101 [A3] if the water depth is greater than 150m. It is therefore proposed to use DNV-ST-F101 [A3] with the modifications listed in Appendix 3 of GS [B1] where NEN 3656 [A1] is silent.

2 DESIGN BASIS

The basis of design document developed during pre-FEED [D3] did not include the L4A spurline, spools and riser but only the 32" trunkline. The survey and metocean data were issued by client after the contract award.

The current document is therefore the first basis of design to be developed for the L4A spurline and spools. Some values of the parameters are assumed to be the same as for the trunkline [D3].

2.1 Design Life

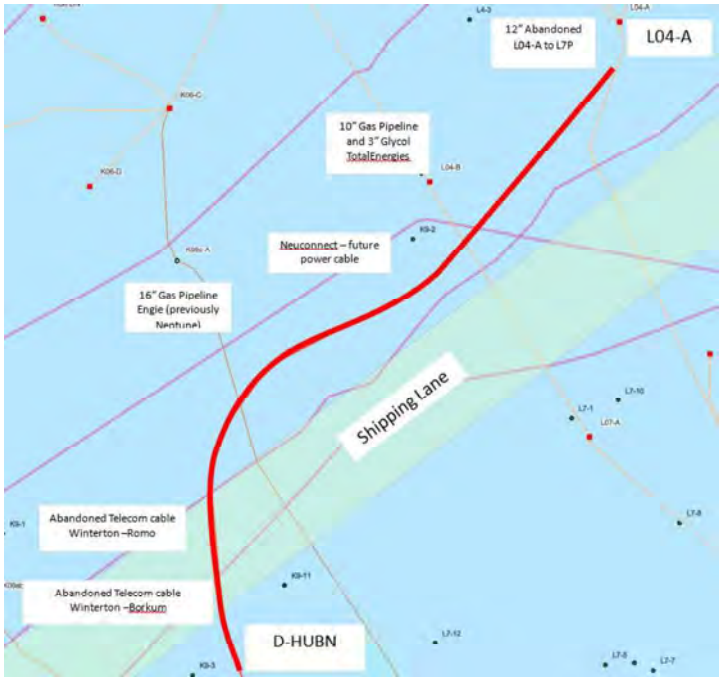
Offshore pipeline design life is 30yrs. Ref. [D1].

2.2 Routing Data

The data is this section is taken from ref. [C3] unless noted otherwise.

In the pre-FEED stage, various route sections were studied including the section between the proposed D-HUBN location and the existing L4A platform. This section was referred to as 'Section C' and terminates at a PLET about 1900m from the L4A platform (there is no more PLET in FEED, the spurline will continue to the riser-base spool at L4A platform). The route as per pre-FEED work is shown as red line in Figure 2-1 along with 3rd party pipeline and cable crossings. The route will be further developed in FEED to close this gap. A routing report along with a set of alignment sheets will be prepared.

Figure 2-1 – Pipeline Route with Crossings



2.2.1 Geodetic System

The project selected projection system is ETRS 89 as per Ref. [C2] and in line with NEN 3656 [A1] requirements.

Existing platform locations are based on ED 50 projection which is the geodetic system used in Dutch sector of the North Sea. Details of geodetic systems are shown in Table 2-1 as per Ref. [C1] for ED 50 and as per Ref. [D6] for ETRS 89.

Table 2-1 – Geodetic Parameters

Parameter		ED 50	ETRS 89
EPSG code		23031	25831
Datum	Horizontal	European Datum 1950 (ED50) North Sea - UKCS	ETRS 1989
	Vertical	MSL	LAT
Spheroid	Name	International 1924 (Hayford 1909)	GRS 1980
	Semi Major Axis	6 378 388.000	6 378 137.000
	Semi Minor Axis	6 356 911.946	6 356 752.314
	Inverse Flattening	297.000	298.257222101
Projection	Name	Universal Transverse Mercator (UTM)	
	Zone	31 North	
	Central Meridian	3° East	
	Latitude of Origin	Equator	
	False Easting	500000m	
	False Northing	0m	
	Scale Factor on CM	0.9996	

2.2.2 Platform Location

The coordinates of the platforms at the two ends of the spurline are given below.

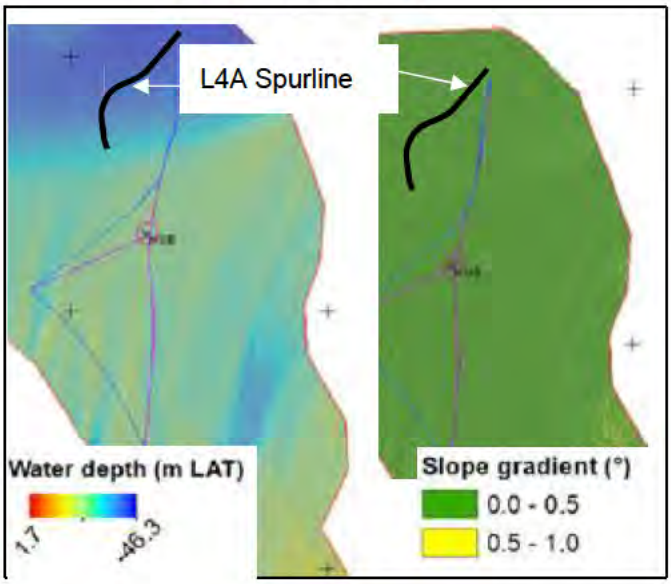
Table 2-2 – Platform Locations

Platform	Easting (m)	Northing (m)	Water Depth (m)
D-HUBN	560 130.00	5 931 040.00	30.8
L4-A (well)	572 513.73	5 953 657.55	39.5

2.2.3 Bathymetry

The L4A spurline is located in 30m to 40m water depth. The seabed is almost flat with slope of less than 0.5degrees as shown in Figure 2-2.

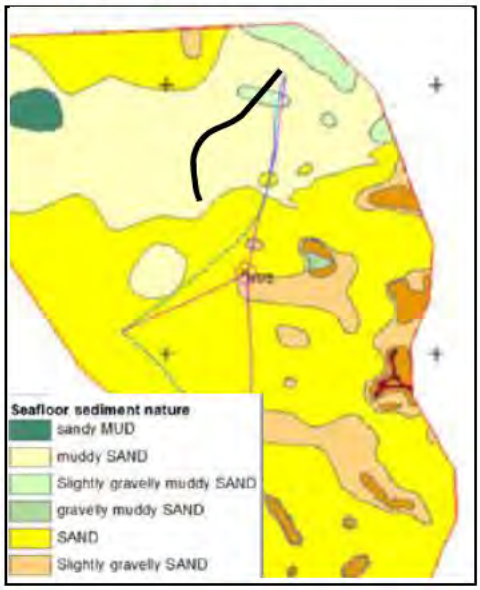
Figure 2-2 – Bathymetry



2.2.4 Seabed Sediments

The seabed surface is muddy SAND along the whole route of L4A spurline as shown in Figure 2-3. An area of gravely muddy SAND is also found near the L4A platform.

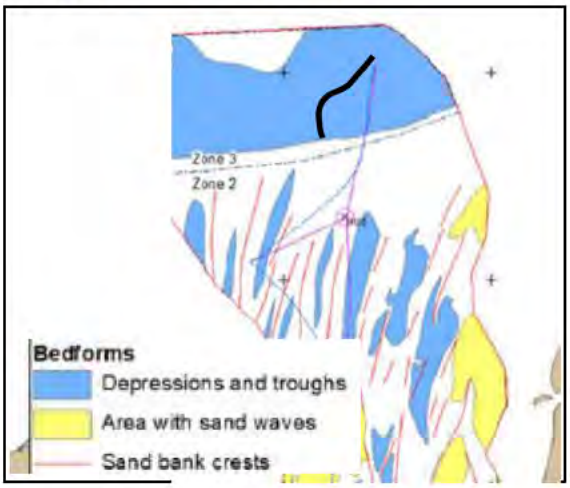
Figure 2-3 – Sediments



2.2.5 Seafloor Bedforms

The Aramis pipeline route runs through some sand waves as shown in Figure 2-4. The L4A spurline route does not have any sand wave area.

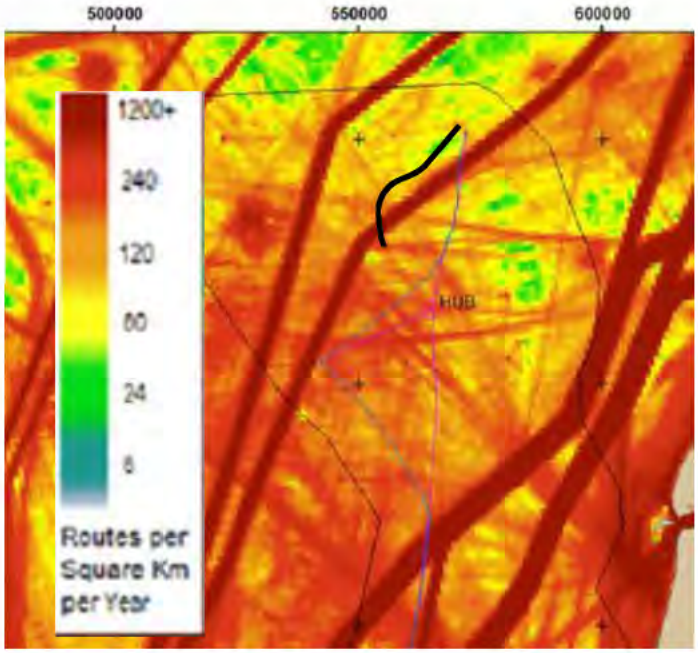
Figure 2-4 – Seafloor Bedforms



2.2.6 Shipping Channels

The Aramis pipeline route is situated in shipping area. The L4A spurline crosses a busy shipping channel as shown in Figure 2-5.

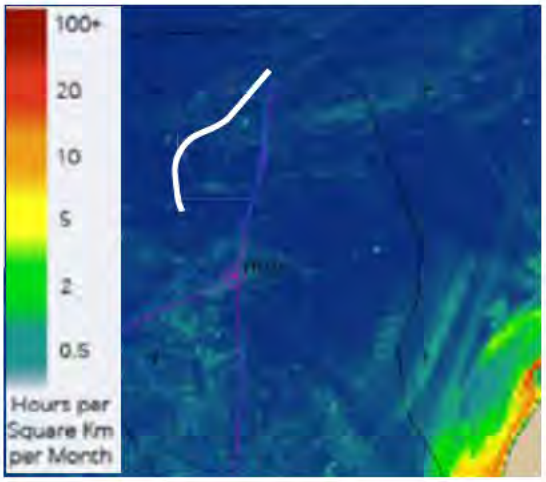
Figure 2-5 – Vessel Route Density per km^2 per year for 2020



2.2.7 Fishing Activities

The fishing activities in along the L4A spurline route is shown in Figure 2-6 below.

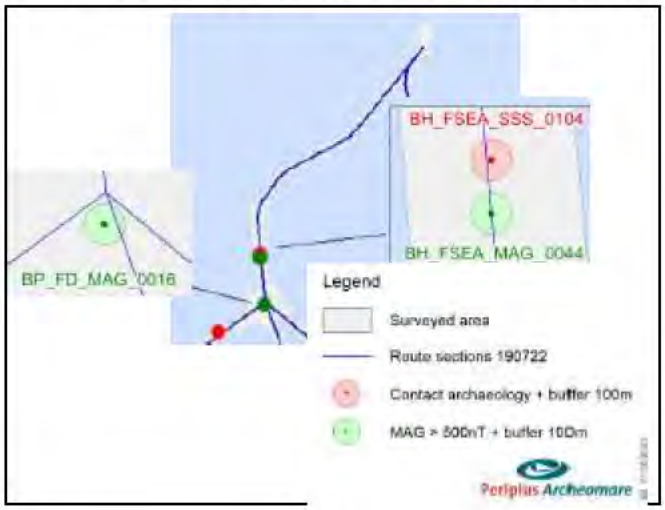
Figure 2-6 –Fishing Activity (EMODnet, 2020)



2.2.8 Archaeological / Magnetometer Data

Appendix B of Ref. [C3] provides archaeological desktop study. Ref. [C4] is the latest revision and the result is shown in Figure 2-7. A magnetic anomaly (MAG_0044) of intensity greater than 500 nanoTesla and a wreck of potential archaeological interest (SSS_0104) were found within 100m of the pre-FEED route of the L4A spurline. The FEED route will avoid this anomaly.

Figure 2-7 – Archaeological Wreck and Magnetic Anomalies



2.2.9 3rd Party Crossings

The L4A spurline crosses a number of 3rd party pipelines and cables as shown in Figure 2-1 and listed in Table 2-3.

Table 2-3 – List of Crossings

No.	KP	Type	Status	ID	Name	Owner	Burial
1	3.9	Telecom Cable	Abandoned	KB0010	Windterton-Borkum 1	Most likely Deutsche Telecom	Buried [D8]
2	6.8	Telecom Cable	Abandoned	KB0025	UK-DK 3	Most likely Danish PTT	Buried (Note 1)
3	9.7	Pipeline 16" Gas	Active	PL0064_PR	K9C to L10AR	Neptune / ENGIE	Buried [D8]
4	19.2	Pipeline 10" Gas	Active	PL0047_PR	L4B to L7A	Total	Buried [D8]
5	19.3	Pipeline 3" Glycol	Active	PL0048_PR	L4B to L7A	Total	Buried [D8]
6	19.7	Power Cable	Future	KB0112	UK - Germany	Neuconnect	1.5m to 2m burial (Note 2)

Notes:
1. Not detected by the survey [D8].
2. Aramis meeting with Neuconnect on 2nd February 2024.

2.3 Line Pipe

The design data for the line pipe to be used for the spurline, spools and riser is given in Table 2-4.

Table 2-4 – Line Pipe Data

Parameter	Value	Units	Reference
Outside Diameter	16	inch	[E1], [D3]
Corrosion Allowance	3.0	mm	
Material	Carbon Steel NEN-EN ISO 3183 / API 5L L450	-	
Pipe Manufacturing	SMLS or Welded		
H_2S concentration	less than 5	ppmmol	
Material Grade	L450 (X65) PSL2		[A4]
Safety Class	Medium/High (1)		
Negative WT Fabrication Tolerance	-0.1t for SMLS -1.0 for welded (t > 10mm)	mm	[A2] J.6.2 and Table J.11
Steel Density	7850	kg/m^3	[C5]
Poisson's Ratio	0.3	-	
Young's Modulus	207	GPa	

Coefficient of Thermal Expansion	11.7 x 10^{-6}	1/°C	
SMYS	450 at temperature ≤ 50°C	MPa	[A1]
SMTS	535		[A4]
Joint Length	12.1	m	[A4], [B3]
Manufacturing Tolerance [Note 2]	<5mm wall thickness: ± 0.5mm >5mm and <15mm: ± 10% >15mm: ±1.5mm		

Notes:

1. High safety class is applicable for 500m section at the platform approach at each end of the spurline. This includes risers and tie-in spools
2. The use of API Spec 5L [A4] for the line pipe is in compliance with NEN [A1] and GS GS PLR 100 [B1]. The modifications and supplementary requirements of GS PLR 205 [B3] and IOGP S-616 [A2] are also included. It is noted that Shell has agreed to consider IOGP S-616 for Aramis project [C5].

2.4 Coatings Data

The spurline shall be protected against external corrosion by a combination of an external anti-corrosion coating system and a sacrificial anode CP system.

Typical anti-corrosion coating properties are presented in Table 2-5. All data is obtained from inhouse sources.

Table 2-5 – Coatings Data

System	Density (kg/m^3)	Thermal Conductivity (W/m K)	Specific Heat Capacity (J/kg K)
Fusion-bonded Epoxy / Glass Flake Epoxy / Phenolic Epoxy	1450	0.30	1410
3LPE/3LPP	900	0.22	2200

All anti-corrosion coating and field joint coating systems, including thicknesses, will be confirmed during the FEED.

The pipelines may be concrete coated for stability purposes. A high-density concrete weight coating will be considered for design purposes with a density of 3450 kg/m^3. A typical minimum practical thickness of 40mm will be considered [A3] & [B1].

2.5 Design, Hydrotest and Operation Data

Design, hydrotest and operation data is presented in Table 2-6.

Table 2-6 – Design, Hydrotest and Operation Data

Parameter	Pressure (barg)	Temperature (°C)		Density (kg/m^3)
		max	min	
Design	200 at +5m relative to NAP (1), [HOLD 2] (Ref. [C6])	17(4)	-25	[HOLD 1]
Hydrotest (2)	250 (3)	17 (4)		1027 [C6]
Operation (1)	150 at 5m NAP (2) [HOLD 2]	17(4)	-5	900 at ambient temperature, 660 at 50°C, 400 at 85°C [C5]

Notes:
1. LAT= -1.03 m NAP (Ref. [C7]).
2. Hydrostatic testing to be performed as per Ref. [B7].
3. As per Ref. [A1], coefficient of 1.25 has been used.
4. Max ambient temperature.

The temperature and pressure profiles along the spurline will be developed during FEED by flow assurance assessment. These will be used where applicable.

2.6 Shutdown Data

Number of planned shutdowns is TBC [HOLD 3].

2.7 Pipeline Installation Window

Installation is recommended to be performed in the period between May to August. Ref. [C6].

2.8 Installation Tolerances

Installation tolerances are stated in Table 2-7 as per Ref. [B2].

Table 2-7 – Installation Tolerances

Parameter		Lateral Tolerance (m)
Pipeline	On the seabed	± 15.0 (1)
	In a trench/at crossings/platform approaches	± 2.5
Concrete Mattresses at Crossing Location		± 1.0 (assumed)

Note:
1. In case of use of LBL or equivalent system for positioning during pipeline installation tolerance is ±5m.

2.9 Environmental Data

All data presented below is taken from metocean design basis Ref. [D2] unless stated otherwise. Metocean Design Basis provides data at the locations shown in Table 2-8.

Table 2-8 – Metocean Data Locations

Location	Water Depth (m)	WGS 84 (Ref. [D2])	
		North (degrees)	East (degrees)
D-HUBN(1)	30.8	3.907	53.5245
PLEM	38.9	4.094	53.710

Note:

1. For environmental data at D-HUBN see [D9].
2. For spool and riser at D-HUBN, the metocean data at D-HUBN will be used. The spurline and the spool at L4A will use the data at PLEM location. The PLEM was a pre-FEED concept and is not being considered for FEED.

2.9.1 Currents

The data (at PLEM location) for extreme current Uc in m/s for 1year, 10year and 100year return period is presented in [D2]. Monthly distribution is also available in [D2]. The Uc value in Table 2-9 (at PLEM location) is multiplied by a factor given in Table 2-10 [D2] to calculate current at a certain elevation. Linear interpolation will be used for intermediate water depths.

Table 2-9 – Currents Data, Uc (m/s)

Direction	Return Period		
	1yr	10yr	100yr
From N \ Omni	**0.74**	**0.87**	**1.02**
0	0.46	0.54	0.63
22.5	0.57	0.67	0.79
45	0.69	0.82	0.96
67.5	0.74	0.87	1.02
90	0.61	0.72	0.84
112.5	0.41	0.49	0.57
135	0.42	0.49	0.58
157.5	0.42	0.49	0.58
180	0.43	0.5	0.59
202.5	0.35	0.41	0.48
225	0.44	0.52	0.6
247.5	0.53	0.63	0.74
270	0.47	0.56	0.65
292.5	0.37	0.43	0.51
315	0.31	0.37	0.43
337.5	0.37	0.43	0.51

Table 2-10 – Current in Water Column (Uc factor)

Depth (m)	Return Period		
	1yr	10yr	100yr
0	0.84	1	1.17
5	0.83	0.98	1.15
19.5	0.76	0.9	1.06
1m above seabed	0.5	0.59	0.69

2.9.2 Waves

Omnidirectional waves are presented in Table 2-11. Directional and monthly distribution wave data is also available in the Metocean Design Basis.

Table 2-11 – Omnidirectional Waves Data

Parameter	Return Period		
	1yr	10yr	100yr
Hs (m)	6.67	8.04	9.78
Tp (s)	11.9	13	14.4
Hmax (m)	12.52	15.36	18.02
THmax (s)	10.86	11.96	13.166
Cmax (m)	7.76	9.62	11.42

2.9.3 Sea Levels

Tidal datum (HAT and MSL) relative to LAT are presented in (as per Table 15-1 of [D2]). Positive and negative level and surge for different return periods are presented in Table 2-12.

Table 2-12 – Sea Levels (m)

Highest Astronomical Tide (HAT)	Mean Sea Level (MSL)	Lowest Astronomical Tide (LAT)
2.14	1.07	0.00

2.9.4 Seawater Data

Seawater minimum and maximum temperature at PLEM location are presented in Table 2-13. Monthly variations are also presented in Metocean Design Basis.

Seawater density was measured between 1021 kg/m^3 and 1030 kg/m^3 as per Ref. [D4], for FEED a value of 1027 kg/m^3 will be used.

Table 2-13 – Seawater Temperature

Depth (m)	Temperature (°C)		
	Minimum	Mean	Maximum
0	-0.51	10.32	21.11
30	0.52	9.79	20.3

2.9.5 Marine Growth

From reference [B13], the density of marine growth to be used will be 1400 kg/m^3 with the following thicknesses.

Table 2-14 – Marine Growth

Elevation	Thickness (mm)
+2.0m to -15.0m	100
-15.0m to -30.0m	50
-30.0m to seabed	25

2.10 Geotechnical Data

The results of in-situ geotechnical investigation and laboratory tests are presented in ref. [C8]. The relevant parameters for the spurline design will be defined in pipe-soil interaction document [D5]. The summary of these parameters can be captured in this document at a later stage.

2.11 Seismicity

No seismic events are anticipated to impact the pipeline, therefore seismic analysis is not included in the design.

2.12 Bends

The pipeline systems including spools and riser bends shall be designed to accommodate pigging for pre-commissioning and through-life intelligent pigging.

A minimum bend radius of 5D shall be used for the pipeline system design as per Ref. [B1].

All bends shall be supplied with minimum of 500mm long tangent lengths [B15] unless otherwise specified.

2.13 Flanges and Gaskets

The flange material shall meet the requirements of the design data and be compatible for welding to the linepipe.

Gasket type will depend on the type of flanges used. Standard RTJ flanges are recommended for ease of make-up subsea.

Weld neck, blind and swivel ring flanges will be specified by their appropriate size and rating designation.

All flange connections to be made-up subsea shall comprise a weld neck and swivel ring pair.

All materials shall be appropriate for CO_2 service.

The requirements of GS EP PLR 227 [B4] shall be fully met.

2.14 Pipeline Cleanliness, Dryness and Preservation

In order not to compromise the well integrity, a high level of pipeline cleanliness, dryness and special preservation will be required. The project specifications shall be complied with during specification, manufacture, fabrication, assembly, installation, pre-commissioning and commissioning of the pipeline and associated facilities. A pipeline commissioning philosophy will be developed during FEED.

3 DESIGN PREMISE

A high-level methodology for the following design activities is given in this section. The details will be fully developed in the individual analysis reports.

- wall thickness calculation
- internal corrosion assessment
- soil interaction calculation
- allowable span calculation
- expansion calculation
- on-bottom stability calculation
- lateral buckling analysis
- pipe walking analysis
- upheaval buckling analysis
- bottom roughness calculation
- fatigue analysis
- spools and risers design report (strength and fatigue)
- routing report
- crossing design & analysis report

3.1 Wall Thickness Calculation

Wall thickness will be calculated using the input data in Table 2-4 in accordance with NEN 3656 [A1]. The following design cases shall be considered:

- Pressure containment (burst)
- Collapse due to external overpressure
- Local buckling
- Propagation buckling
- Running ductile fracture

In addition, a verification with the DNV code, Ref. [A3], will be done to ensure that DNV recommended practice can be used for specific analyses.

3.1.1 Pressure containment

NEN [A1]:

Stress limit state is used for internal pressure only (load combination 2, LC2 in Table 3). Hoop stress is checked using the 'boiler formula' given in equation (K.1). The load factor of 1.25 is used from Table 3. Since the maximum temperature is less than 50C, the temperature derating to SMYS given in Table F.1 is not applicable. A material factor of 1.1 is used from Table K.2.

Combining the above gives the following condition for the burst check;

$$\frac{\gamma_s p_d D_g}{2d} \leq \frac{R_e(\theta)}{\gamma_m}$$

Where:

γ_s = load factor = 1.25

p_d = design pressure

D_g = average diameter

d = minimum wall thickness = nominal WT - fab.tol - corr.all

see Table 2-4 for fabrication tolerance and corrosion allowance values.

$R_e(\theta)$ = SMYS at temperature θ

γ_m = material factor = 1.1

An in -house MathCAD [E2] sheet will be used to perform this calculation.

GS [B1]:

As noted in section 1.7.2, [B1] recommends to use DNV [A3] for water depth greater than 150m. Since the maximum water depth along the L4A route is only 40m, therefore DNV check is not necessary. However, as a comparison, the DNV burst check will be performed using DNV spreadsheet [E3].

Note: The temperature de-rating at temperatures > 50C is different in Table F.1 of NEN and Figure 5-2 of DNV. The values in NEN are more onerous. GS [B1] specifies to use DNV values irrespective of APR.

Since the maximum temperature in the L4A spurline does not exceed 50C, therefore no temperature de-rating to the steel yield strength will be used.

3.1.2 Collapse due to external pressure

NEN [A1]:

For external pressure only, formula (K.13) can be used. It is comparable to equation (5.13) of DNV [A3]. The only difference is the definition of ovality.

GS [B1]:

DNV spreadsheet [E3] will be used to perform the collapse check.

Note: Collapse under external water pressure is generally critical in deep water pipelines. For L4A pipeline this is not likely to be the governing case. Due to a high design pressure, the most likely governing case is the pressure containment.

3.1.3 Local buckling

Local buckling is a phenomenon in which the cross-section of a pipeline can fail (buckle) locally under the actions of pressure (internal and external), bending and axial force. The pipe wall must be thick enough that it does not locally buckle under the various combinations of these loads during its lifetime.

NEN [A1]:

The limit state for compressive strain under bending and normal force (section K.3.3) is given for local buckling check. This is generally applicable when external load is deforming the pipe. This is roughly equivalent to displacement-controlled local buckling check in DNV code.

A strain limit in compression is calculated using equations (K.7) or (K.8). The limit criterion in equation (K.10) will then be applied.

From Note 2 of K.3.3.3;

If $\frac{D_g}{d_n} \leq 55$ usually no check for local buckling needs to be carried out.

GS [B1]:

DNV spreadsheet [E3] can be used to perform the local buckling checks. Load controlled check (LCC) will be performed by using moment and axial force outputs from various assessments listed in section 3. LCC is generally more stringent than the displacement controlled check.

3.1.4 Running Ductile Fracture

NEN [A1], Annex Q

To prevent/limit crack (fracture) propagation in the pipeline material, the ductility of the material should be adapted in relation to the decompression behaviour of supercritical CO2.

DNV-RP-F104, Ref. [A7], provides guidance on preliminary assessment of crack propagation based on full-scale tests done in the industry. COMPANY has commissioned a study with SINTEF to perform numerical simulations of running ductile fracture and assess if this could be a risk (i.e if fracture propagation could occur in case of rupture) for the ARAMIS pipeline.

The results of the SINTEF ductile fracture program will be integrated into linepipe material specifications and the pipeline mechanical design scope of work if made available within the project duration.

The wall thickness, toughness and yield strength of the linepipe will be selected to suit the saturation pressure expected under operating conditions for the various compositions to ensure that a running ductile fracture is arrested by the pipe within a short distance.

The fracture arrest capacity of the pipeline material should be within 5 pipe lengths, Ref. [A1]. If crack arrestors are used, optimization of the number of crack arrestors versus pipeline design should be investigated.

3.1.5 Bends

The riser and spool bends with R < 10D will be subject to following additional checks;

i. Increase in hoop stress due to torus effect J.1.2 of NEN [A1].

ii. Bend thinning, section 6.2.2.3 of [A15].

3.2 Internal Corrosion Assessment

The CO2 specification is set such that fluids are not corrosive over the normal operating envelope. Specification control is strict at emitters and pipeline inlet to ensure fluids enter the pipeline at the right spec. Despite this, a corrosion allowance as given in section 2.3 is selected to cater for improper handling and/or issues during commissioning as well as small upsets during the operating life of the pipeline.

3.3 Soil Interaction Calculation

Pipe-soil interaction models will be developed in accordance with NEN 3656 for use in the global buckling analysis. The pipe-soil interaction assessment will also be compliant with GS EP GEO 701 [B14].

PSI models will be developed considering:

- Embedment vs soil type for as-laid (empty), flooded and post-hydrotest condition;
- All pipe combinations (with or without CWC) + relevant soil types for each pipe combination, plus trenched sections;
- Lower estimate, best estimate and higher estimate soil parameters;
- Empty, flooded, hydrotest and gas-filled conditions.

3.4 Expansion Calculation

Pipeline end expansion is determined using in-house spreadsheets for hydrotest and operational conditions. Further assessment of end expansion will be performed as necessary as part of the buckling and walking assessments.

The expansion analysis will conservatively assume that residual lay tension, H, in the pipeline is zero and that the pipeline is completely straight and on a flat seabed.

Depending on the location, the pipeline will be either fully buried and modelled as such or fully exposed and modelled as such.

The fully constrained effective axial force in the pipeline, S, is calculated from the equation below [A3]. Note that S will vary along the length of the pipeline due to changes in A_s, ΔT and ΔP_i.

$$S = H - \Delta P_i A_i (1 - 2\nu) - E A_s \alpha \Delta T$$

Where:

H = Pipeline Residual Lay Tension (N), taken as zero

E = Young's Modulus of Steel (Pa)

A_s = Area of Steel Pipe (m^2)

α = Steel Coefficient of Thermal Expansion (1/°C)

ΔT = Temperature Differential Relative to As Laid (°C)

ΔP_i = Pipe Internal Pressure Relative to As Laid (Pa)

A_i = Pipe Internal Area (m^2)

ν = Steel Poisson Ratio (-)

The virtual anchor length, L_h, as measured from the free ends of the pipeline is calculated using the equation below. Note that the calculation of L_h will also consider changes in S, μ_{ar} and W along the length of the pipeline. The resistance force at the ends of the pipeline, S_{end}, comes from the resistance of any connected structures at the pipeline ends.

$$L_h = \frac{S - S_{end}}{\mu_{ar} W'}$$

Where:

S_{end} = Resistance at End of Pipeline (N) (conservatively taken as 0)

μ_{ar} = Minimum Residual Axial Friction Coefficient (-)

W' = Submerged Weight of Pipe during Stage Analysed (N/m)

The expansion at the free ends of the pipeline, Δ_x (m), is calculated as follows:

$$\Delta_x = \int_0^{L_h} \frac{S - (\mu_{ar} W' x + S_{end})}{E A_s} dx$$

Section J.2 of NEN [A1] gives a similar methodology for pipeline expansion calculation under temperature, pressure and soil friction effects.

3.5 On-bottom Stability Calculation

An on-bottom stability assessment of the pipeline shall be performed in accordance with DNV-RP-F109 On-Bottom Stability Design of Submarine Pipelines, Ref. [A8], to determine:

- the required concrete coating thickness to maintain the pipeline stability on the seabed or within a trench throughout its design life
- the required additional stabilisation measures, e.g. pre-lay trenching, post-lay trenching, spot rock berms

The following design conditions will be assessed:

- empty
- flooded

- operation

Seasonal and/or directional environmental data will be considered.

The stability analysis will be performed for both environmental data zones at each end of the pipeline route using DNV's StableLines [E4].

The limited displacement criterion given in DNV-RP-F109 which allows for a lateral displacement up to 10 x OD will be considered for the pipeline.

At crossings and within 500m form the platform, the lateral pipeline displacement will be restricted to the virtual stability criterion of maximum 0.5D in line with GS [B1].

The stability assessment will also include the vertical stability of the pipeline in accordance with DNV-RP-F109. To avoid floatation in water, the minimum specific gravity of the pipeline shall be equal or greater than 1.1.

The pipeline will also be checked for vertical stability on soil. To avoid sinking into the soil, the specific weight of the pipeline at its heaviest with no corrosion should be less than that of the soil.

NEN [A1] gives the lateral stability calculation in formula (I.13). This is based on zero lateral movement of the pipe under wave and current loads. This absolute static stability is considered to be too conservative approach and not suitable for sandy soil where some movement will allow the pipe to embed in the seabed and become more stable. Therefore, the DNV approach using StableLines will be used as described above.

3.6 Global Buckling and Pipeline Walking

3.6.1 General

The pipeline will be designed against global buckling, according to procedures and criteria given in NEN 3656 [A1], with support as necessary from DNV-RP-F110, Ref. [A9], and SAFEBUCK, Ref. [A10].

The design process includes the following design steps:

- Determination of the effective axial force due to pressure loads and thermal gradient along the pipeline route for the operating and hydrotest conditions
- Assessment of the pipeline susceptibility to global buckling due to geometric imperfections randomly located along the route and/or external interference loads.
- Analysis of pipeline response after initiated upheaval / lateral buckling due to local out-of-straightness and implications on structural integrity.
- Design of suitable mitigation measures to control and limit the development of bending stresses/strains within allowable criteria as outlined in NEN 3656.

Methods of mitigation will be discussed with COMPANY and suitable methods agreed prior to commencement of mitigation design.

3.6.2 Susceptibility to Buckling

The initial assessment involves determining whether the pipeline is susceptible to buckling under the specified design pressure and temperature. The evaluation of the pipeline's vulnerability to buckling adopts the Hobbs infinite mode criteria for a straight pipe. The criterion states that the overall design effective axial force on the pipeline shall remain below 65% of the Hobbs infinite mode capacity, see DNV-RP-F110 Global Buckling of Submarine Pipeline, Ref. [A9].

The susceptibility to lateral buckling can be evaluated based on the following critical level of the effective axial force for the infinite buckling mode, based on low estimate pipe-soil resistance:

$$S_{\infty} = 2.26 \cdot (EA)^{0.25} \cdot (EI)^{0.25} \cdot f_L^{0.5}$$

$$f_L = \min\left[f_L^{LE}; \frac{f_L^{BE} \cdot \left(w - F_L\right)}{w} - F_D\right]$$

Where:

EA = the axial stiffness of the pipe

EI = Bending stiffness of the pipe

f_L = lateral break-out pipe-soil resistance force

f_L^{LE} = low estimate lateral break-out pipe-soil resistance force

f_L^{BE} = best estimate lateral break-out pipe-soil resistance force

F_D = hydrodynamic drag force per unit length

F_L = hydrodynamic lift force per unit length

w = pipeline submerged weight

Hence f_L is taken as the minimum of the low estimate lateral soil resistance and the effective resistance in the presence of hydrodynamic loads from wave and current with a specified period.

Then the pipeline is not susceptible to lateral buckling if:

$$|S(op)| < 0.65 \cdot |S_{\infty}(100year)|$$
$$|S(des)| < 0.65 \cdot |S_{\infty}(1\,year)| \quad and$$

Where:

S(op) = effective axial force based on operating pressure and temperature

S(des) = effective axial force based on incidental pressure and design temperature

S∞(1yr) = effective axial force for the infinite buckling mode corresponding to the 1-year return period environmental condition

S∞(100yr) = effective axial force for the infinite buckling mode corresponding to the 100-year return period environmental condition

Additionally, route curves will be evaluated as per the route curve criterion shown below.

$$|S(op)| < |S_{LECurve}(100year)|$$
$$|S(des)| < |S_{LECurve}(1\,year)| \quad and$$

$$|S_{LECurve}| = \min\left(|f_L^{BE} \cdot R_{LE}|; |f_L^{LE} \cdot R_{BE}|\right)$$

Where:

$S_{LECurve}$ = low estimate critical level of the effective axial force for the route curve

R_{LE} = expected low estimate radius of the route curve

R_{LE} = expected best estimate radius of the route curve

$S_{LECurve}(1yr)$ = effective axial force for the route curve corresponding to the 1-year return period environmental condition

$S_{LECurve}(1yr)$ = effective axial force for the route curve corresponding to the 100-year return period environmental condition

3.6.3 Lateral Buckling Assessment

If the pipeline is shown to be prone to lateral buckling and the section in question is not planned to be trenched, then a finite element lateral buckling analysis will be performed.

The pipeline will be modelled on a flat seabed using ABAQUS FEA software and a series of out of straightness (OOS) introduced. The pipeline will then be cycled from ambient to the maximum pressure and temperature and back to ambient. The condition giving the maximum compression from the following two load combinations will be considered in the buckling analysis:

- Design temperature profile & associated pressure profile
- Incidental pressure profile & associated temperature profile

The analysis will be repeated for a range of friction combinations according to DNV-RP-F110, Ref. A.1.[A9] and as presented in Table 3-1.

Buckles will be checked to ensure the following limit states are satisfied:

- Local Buckling utilisations do not exceed unity.
- Fatigue - Both Weld Root and Weld Toe damage does not exceed the allowable limit for buckling.
- Fracture and ECA - Tensile strains do not exceed 0.4%.

Residual lay tension is conservatively set to 50% of the minimum static bottom tension derived from pipelay analyses.

The pipeline is assumed to be installed at the average ambient seabed temperature.

The load cases considered in the buckling assessment are given in Table 3-1.

Table 3-1: Deterministic Load Cases

Parameter	Load Cases	
Friction Coefficient	Global Buckling	Combination 1: BE Axial + LE Lateral Combination 2: BE Axial + BE Lateral Combination 3: BE Axial + HE Lateral Combination 4: LE Axial + LE Lateral Combination 5: HE Axial + HE Lateral
OOS	Initial Imperfection determined based on pipeline natural curvature and characteristic OOS	
Model Length	Full extent of susceptible region plus feed in region	
Loading	Hydrotest Start-up operational pressure & temperature profiles	
Residual Lay Tension	50%	
Seabed	Flat	

The lateral buckling analysis will be combined with the fishing trawl board pullover analysis which will also introduce out of straightness into the pipeline. Evaluation of lateral buckling triggered by trawl interference will be in accordance with DNV-RP-F110.

If the analysis highlights that lateral buckling results in the failure of any of the limit states, then a discussion will be held with COMPANY to determine the best methods of mitigation.

The design will ensure that buckles cannot develop in the vicinity of the inline structures, considering all possible out of straightness at these locations.

3.6.4 Pipeline Walking Assessment

A pipeline walking assessment will be performed in accordance with the methodology outlined in OTC17945 Ref. [A11].

As the overall seabed slopes are minimal for the pipeline, only the transient pressure and temperature data will be used in the walking analysis.

3.6.4.1 Susceptibility to Walking

A pipeline is considered susceptible to walking if the ratio of the axial frictional force f to the constraint friction force f^* is less than 2. The ratio can be further defined into cyclically constrained and fully constrained by the following definition:

- Fully mobilized (f/f*<1) and so susceptible to pipeline walking
- Fully constrained (f/f*>2) and so not susceptible to pipeline walking
- Cyclically constrained (1<f/f*<2) and possibly susceptible to walking

These checks will be performed prior to the walking analysis to determine which sections are considered susceptible to walking.

The friction force at which cyclic constraint occurs is calculated as:

$$f^* = \frac{|\Delta P|}{L}$$

$$\Delta P = -(p2 - p1).Ai.(1 - 2v) - E.As.\propto.(\theta 2 - \theta 1)$$

Where:

|ΔP| = change in the fully constrained force associated with an unloading event (e.g. between operation and shutdown) (N)

p1,p2 = pressure before and after the operating change (Pa)

θ1,θ2 = temperature before and after the operating change (ºC)

Ai = cross sectional area of pipe ID (bore) (m^2)

As = cross sectional area of pipe wall (m^2)

v = Poisson's ratio

E = Young's modulus (N/m)

α = coefficient of thermal expansion (1/ºC)

L = pipeline length (m)

The axial friction force is calculated as:

$$f = \mu \cdot W$$

where:

μ = axial friction coefficient (-)

W = pipe submerged unit weight (N/m)

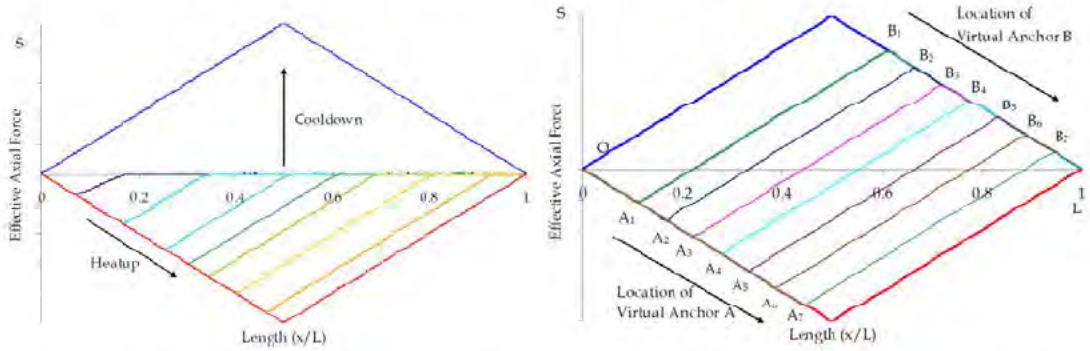
3.6.4.2 Walking due to Thermal Transients

If the pipeline is found to be susceptible to walking, then the displacement due to thermal transients will be calculated as outlined below.

The primary characteristic for the thermal transient walking phenomenon is the shape and steepness of the thermal profile that develops over time as the pipeline heats-up. Although walking occurs on first cycle, it is the second and subsequent cycles which dominate the process.

Sample effective axial force profiles for first and second heat-up are shown in Figure 3-1 taken from Ref. [A11].

Figure 3-1: Effective Axial Force Profile - for First and Second Heat-up



There are two solutions to analytically evaluate the pipeline displacements due to thermal transients:

- Approximate solution which assumes XA = L/4
- Incremental solution

For this assessment the simpler approximate solution is used as, based on previous experience, it shows good agreement with the incremental solution and more detailed FEA.

To calculate the approximate displacement due to thermal transients, the force generated by a thermal transient, f_θ (N), and the soil axial friction force, f (N), must first be calculated:

$$f_\theta = E \cdot A_s \cdot \alpha \cdot q_\theta$$

$$f = \mu \cdot W$$

Where:

E = Young's Modulus of Steel (Pa)

A_s = Area of Steel (m^2)

α = Coefficient of Thermal Expansion of Steel (1/°C)

q_θ = Thermal Gradient (°C/km)

μ = Axial Breakout Friction Coefficient (-)

W = Submerged Weight of the Pipeline (N/m)

The approximate displacement per cycle due to thermal transients, Δ_T (m), is then calculated using Equation 17 from OTC 17945, Ref. [A11] :

$$\Delta_T = \frac{f \cdot L^2}{16 \cdot E \cdot A_s} \cdot \left(\sqrt{24 \cdot \frac{f_\theta}{f}} - \frac{f_\theta}{f} - 4 \right) \; if \; f > \frac{f_\theta}{6}$$

$$\Delta_T = \frac{f \cdot L^2}{8 \cdot E \cdot A_s} \; if \; f < \frac{f_\theta}{6}$$

$$f = \mu \cdot W$$

Where:

L = Length of Pipe between Ends or Virtual Anchors (m)

E = Young's Modulus of Steel (Pa)

A_s = Area of Steel (m^2)

f_θ = Force Generated by Thermal Transient (N)

f = Soil Axial Friction Force (N)

3.6.5 Upheaval Buckling Assessment

Where trenching or dredging is required, the susceptibility to upheaval buckling will be checked and required overburden determined. Overburden will be determined either as soil cover or as additional concrete weight coat. This will be discussed, and the preferred mitigation approach agreed with COMPANY.

The minimum required backfill depth to prevent upheaval buckling is assessed using the Palmer Guidelines, Ref. [A12]. The method assumes a flat seabed profile with a symmetric vertical imperfection on which a perfectly elastic pipe rests. The following calculations are taken from OTC 6335, Ref. [A12].

The basic inequality to be checked is:

$$w \leq \frac{q}{\gamma_{qs}}$$

Here, the download required to stabilise the pipeline against upheaval buckling, w (N/m), is compared against the download that can be provided by the backfill resistance and the pipe's self-weight, q (N/m). A factor of safety, γ_{qs}, equal to 1.8 is included on the download to account for any inaccuracies in the data such as soil density.

The required download, w (N/m), is calculated using:

$$w = \frac{S^2 \cdot \Phi_w \cdot \delta}{E \cdot I}$$

The total download per unit length which can be provided, q (N/m), is calculated using:

$$q = W_{pipe} + \gamma_{backfill} \cdot H_{top} \cdot D_{total} \cdot \left(1 + f_{backfill} \cdot \frac{H_{top}}{D_{total}}\right)$$

Where:

$$\Phi_w = \begin{cases} 0.0646 \; for \; \Phi_L < 4.4934 \\ \frac{5.68}{\Phi_L^2} - \frac{88.35}{\Phi_L^4} \; for \; 4.4934 < \Phi_L < 8.06 \\ \frac{9.6}{\Phi_L^2} - \frac{343}{\Phi_L^4} \; for \; \Phi_L > 8.06 \end{cases}$$

$$\Phi_L = L \cdot \sqrt{\frac{S}{EI}}$$

Based on:

$$L = 2 \cdot \sqrt[4]{\frac{72 \cdot E \cdot I \cdot \delta}{W_{burial}}}$$

w	=	Required Download to Stabilise Pipe Against Upheaval Buckling (N/m)
q	=	Download Provided by Backfill and Pipe Self Weight (N/m)
γ_{qs}	=	Safety Factor on Download (-) = 1.8
S	=	Effective Axial Force during Phase Being Considered (N)
Φ_w	=	Maximum Download Parameter (-)
δ	=	Vertical Imperfection Height (m)
E	=	Pipe Young's Modulus (Pa)
I	=	Pipe Second Moment of Area (m^4)
W_{pipe}	=	Pipe Weight during Phase Being Considered (N/m)
$\gamma_{backfill}$	=	Effective Unit Weight of Backfill Material (N/m^3)
H_{top}	=	Burial Depth from Top of Pipe to Surface (m)
D_{total}	=	Pipe Total Outside Diameter Including all Coatings (m)
$f_{backfill}$	=	Uplift Coefficient (-) = 0.1 for Loose Materials
Φ_L	=	Shape Profile Parameter (-)
L	=	Half Wavelength of Pipe for Given Vertical Imperfection (m)
W_{burial}	=	Pipe Weight at Time of Burial (N/m)

The assessment will comprise the following steps:

- Investigate susceptibility to upheaval buckling for a range of single-prop imperfection heights. A prop height equal to the standard deviation of the post-lay survey accuracy is also considered to establish the blanket cover height requirement for imperfections too small to be detected by the survey. Prop heights up to 0.5m will be considered as per GS [B1].
- The condition giving the maximum compression from the following two load combinations will be considered in the analysis:
  - Design temperature profile & associated pressure profile
  - Incidental pressure profile & associated temperature profile
- The hydrotest case is also assessed with the contents assuming the maximum seasonal ambient temperature.

- Determine remedial measures (i.e. level of overburden) along the pipeline.

Calculate overall predictive overburden tonnage (soil or rock).

3.7 On-bottom Roughness and Freespan Assessment

The following analyses will be performed along the selected pipeline route:

- a static analysis of the on-bottom roughness of the pipeline, to determine locations for intervention works to satisfy code criteria for local buckling in the temporary and operational pipeline phases.
- a check of the anticipated freespans (calculated by static analysis) vs the allowable freespan length, to determine locations for intervention works to satisfy code criteria in the temporary and operational pipeline phases.

The following pipeline design conditions will be analysed with the static analyses:

- As-laid (empty)
- Flooding for hydrotest, (water filled)
- Hydrotest (water filled)
- Operating for unburied sections of the pipeline (gas filled)
- The allowable freespan length will be determined in accordance with NEN 3656, section I.5.2.5 and Annex K.3.6. The approach in NEN 3656 is aimed at preventing vortex induced vibrations.
- If fatigue due to environmental loads is to be allowed, then initial screening of freespans shall be performed in accordance with DNV-RP-F105 Free Spanning Pipelines, Ref. [A14], for the screening fatigue criterion which provides a fatigue life in excess of 50 years. The assessment will also include mechanical integrity of the spans, alternatively allowable span length may be determined using the DNV FATFREE software and the project specific parameters.

An on-bottom roughness analysis shall be performed using Abaqus software to establish the likely occurrence of unacceptable freespans based on the screening fatigue criterion. Freespans with average gap heights less than 30% OD measured over the central 1/3rd of the span are not considered to be at risk from VIV fatigue, this is industry standard and is in accordance with Ref. [A13].

The residual lay tension will be conservatively ignored in the allowable freespan assessment, and conservatively included in the on-bottom roughness analysis.

If unacceptable freespans are present and local rerouting is not possible, then additional mitigation measure will be investigated. Where possible, jetting or dredging will be proposed prior to rock dumping.

The stresses will be extracted from the analysis and compared to the allowable stress criteria within NEN 3656. For reference the DNV LCC criteria will also be presented. Areas of excessive stress will be rerouted or mitigation presented.

The allowable spans at crossings shall also be determined.

3.8 Fatigue Analysis

Fatigue design of the pipeline will be performed in accordance with NEN 3656, Annex K.2.3 and K.3.5.

3.8.1 Total Fatigue Damage

The assessment will determine overall fatigue damage accrued from the following sources:

- Pipeline installation
- Lateral buckling
- Operating cycles
- Fatigue in freespans due to VIV and direct wave loading

The total amount of fatigue damage and the proportion assigned to the various loading scenarios will be discussed with COMPANY and agreed prior to completion of the work.

The fatigue limit state shall be based on the S-N curve approach.

Miner's rule shall be used to combine all cyclic load cases and evaluate the accumulated fatigue damage as per the equation below, considering applicable S-N Curves and pipe girth weld stress concentration factors (SCF). SCFs due to the concrete weight coat stiffening the pipe and intensifying stresses at the field joints will be included in analyses where the concrete weight coating stiffness is not directly modelled.

$$D = \sum_{i=1}^{k} \frac{n_i}{N_i} \leq \frac{1}{\gamma_{fat}}$$

where:

n_i = number of cycles with stress range σ_i

N_i = number of fatigue cycles to failure based on applicable S-N curve for stress range σ_i

γ_{fat} = 10 (as per Table 4, NEN 3656,)

3.8.2 Operating Cycles

Fluctuations in pressure and temperature during operation will give rise to variations in stresses and strains. This may lead to fatigue damage.

Fatigue in pipeline girth welds due to pressure variations in the operational phase (in relation to limit state of fatigue) will be looked at. The following scenarios will be included:

- Steady state conditions – maximum & minimum operating pressure and temperature combinations
- Shutdown and cool-down

Wall loss due to corrosion will be considered as follows in the fatigue assessments:

- The nominal wall thickness is used in the analyses and calculations performed to determine the cyclic loading conditions
- The extracted sectional forces and moments are post-processed to determine stress ranges using the cross sectional properties of the pipe with 50% of the corrosion allowance removed as per GS [B1].

3.9 Tie-in Spool Design

Preliminary sizing of the rigid tie-in spool will be determined by performing stress analysis using AutoPIPE software. A 3D model of spool and riser will be developed for this purpose.

A spool configuration that can absorb the pipeline end expansion will be selected.

Consideration shall be given to any potential soil settlement of the spool causing additional load on the riser base flange.

Equivalent frictions shall be used to take account of the proposed mattress or rock-cover dropped-object protection over the tie-in spool.

Equivalent stresses shall be checked in accordance with NEN 3656.

3.10 Pipeline Routing

A preliminary pipeline route has been selected during the pre-FEED phase. This route takes the pipeline from D-HUBN to a PLEM about 1.5km from the L4A platform. It is understood that the PLEM concept has not be selected for FEED. The route is therefore to be extended to the L4A platform. The location of the distribution hub is chosen such that – within the constraints of shipping lanes, windfarms etc – it provides 'equal opportunity' to future stores. Similarly, the routing of the pipeline has considered existing and future constraints, such as windfarms, shipping lanes, anchoring areas, etc.)

In principle the route shall be as short as possible. The proposed route and alignment are to be optimised during the FEED considering but not limited to the following:

- Project execution strategy
- Future developments
- Seabed bathymetry
- Route specific metocean criteria
- Pipelay vessel capabilities
- Avoid the 500m safety zone around offshore wind farms and platforms
- Minimise routing in the vicinity of sand waves and through areas in which they are known to migrate
- Avoid/minimise routing in restricted areas and zones that can result in hazards to the pipeline, or cross block boundaries:
  - Military areas (ammunition dumping area, practice area, shooting area)
  - Minefields and other areas with high likelihood of UXOs
  - Anchoring areas
  - Approach areas for shipping and access channels to seaports

- Areas for sand extraction, mining areas, mineral extraction

- Environmentally sensitive areas of international importance, areas forming part of the national ecological network, valuable protection areas according to Netherlands Nature Conservation Act, Habitats Directive / Natura 2000, Malta Convention (cultural heritage).
- Routing of the pipeline in parallel with high voltage cables is to be avoided. If this is not possible, a minimum distance of 500m shall be applied. Account shall be taken of planned/future developments, e.g. cable installation for wind farms.
- Parallel position in relation to other pipelines/cables: a horizontal distance of at least 100m, or more if required by the construction method, and/or the licensing authority or the line owner.

Minimise the number of bends/curves and achieve a maximum stable route radius for each curve.

- The radius of route curves shall not be lower than the value generating a bending stress of 10% of SMYS as per GS [B1]:

$$R \geq \frac{E * OD}{2 * 0.1 * SMYS}$$

- Minimise the steepness along the route and avoid areas which can result in free spanning.
- Minimise the number of crossings with other pipelines and cables
- Minimise crossing lengths; the crossing angle should be as close as possible to 90º and no less than 30º
- Avoid geohazards and minimise interference with pockmarks / seabed undulations.
- Minimise the risk of pipeline exposure from localised sea-bottom evolution.
- Avoid interference with shipwrecks and existing subsea structures.
- Minimise pre-lay and post lay intervention requirements.
- Optimise the approach to D-HUBN, considering the positioning of the riser and leaving room for construction vessels, supply vessel manoeuvres, planned spurlines, future platform extensions, etc.
- Endeavour to minimise the requirement for further survey.

ArcGIS software will be used for visualisation of the route and to produce seabed profiles.

The route will be assessed to determine whether any local re-routing is required due to potential spans, obstructions etc. Any re-routing indicated as beneficial or necessary by the assessment will be incorporated and suitable configurations will be developed.

The final route will be confirmed following completion of the bottom roughness analysis.

3.11 Crossing Design

There are 6 crossings of existing cables and pipelines along the L4A spurline route, see Table 2-3.

The design of the pipeline and cable crossings will comply with technical requirements given in NEN 3656 [A1], and GS [B1].

The spurline pipeline will cross Neuconnect high voltage power cable along the route. NEN 3654 gives guidance on establishing if a pipeline and high-voltage cable adversely affect each other, and requirements for safety and corrosion protection.

Additional requirements for crossings by owners of crossed lines will be considered in the crossing design. The crossing design and construction method shall be agreed between both parties, laid down in a written agreement, and signed for each crossing.

The crossing configuration will be assessed to ensure that:

- the stresses and spans of the pipeline elevated sections remain within the allowable limits;
- the induced stresses (if any) on the crossed pipeline/cable remain within the allowable limits to avoid 3rd party items damage.

The burial status of the existing line and the burial requirements for the Aramis pipeline will be taken into consideration to determine the crossing method.

The crossing angle will be as close as possible to 90º and not less than 30º as per GS [B1].

The crossing design will allow for a minimum vertical separation of 0.3m between the crossing lines as per GS [B1]. This will be achieved by laying concrete mattresses over the existing line (whether exposed or buried) to provide the required separation and laying the Aramis pipeline on top. Such vertical separation is to be maintained throughout the design life.

To limit stresses and spans in the pipeline or limit/prevent induced stresses on the crossed lines, pre-lay supports on either side of the crossed line may be necessary with concrete mattresses or rock dump. The horizontal separation between the edge of the crossing supports and the existing line shall be at least 2m, considering the worst possible position of the existing line and support installation tolerances as per GS [B1]. The supports will be sized to provide adequate stability against overturning under installation loads, and adequate bearing and sliding capacity under installation, hydrotest and operating loads.

The crossing configuration will consider the pipelay tolerance at crossings, support installation tolerances, min/max support embedment and settlements (short and long term), and the maximum allowable pipeline freespan length and limiting curvature to prevent global buckling considering all installation tolerances.

All crossings will be rock dumped post pipelay to ensure stable location of the pipeline at the crossing. Sufficient cover will be provided to prevent global buckling or axial movement of the pipeline, and to prevent damage from shipping (dropped and dragged anchors) and fishing gear (outside the 500m safety zone). The rock dump cross section will be designed such that it is stabilized with a top layer (armour layer) sufficient to withstand a 100-year storm. The minimum armour layer height will be at least 0.2m as per section 9.4.5 of NEN 3656 [A1].

Crossings shall be modelled and analysed using Abaqus software. Initially, the crossings will be analysed with no supports provided and resulting span lengths and curvatures checked against allowable limits. If these limits are exceeded, supports will be applied to the model as required to obtain an acceptable design.

Design checks on the pipeline at crossings will include:

- a local buckling check for the combined loading criterion in accordance with NEN 3656
- assessment of upheaval buckling due to vertical out-of-straightness created by the supports and the rock cover requirement
- allowable freespan in the temporary phase
- assessment of on-bottom stability in the temporary phase before rock cover

Predictive rock cover heights and estimated rock volumes shall be provided.

Additional anodes will be installed at crossing locations to ensure adequate cathodic protection if required.

When crossing an abandoned cable in a section of the route where the pipeline is to be trenched and buried, it is planned to seek the owner's permission to cut the cable at two points and remove the cut section to create the required pipeline corridor. Then the ends of the cable on either side of the corridor will be weighed down with a clump weight to prevent the cable from becoming loose.

The crossing design will incorporate nature inclusive design measures as per ref. [C9]. The design will consider implementing eco-friendly rock berms with a sprinkle layer of calcareous rock or an armour layer intermixed with calcareous material, nature inclusive mattresses at crossings, and nature inclusive clump weights for cut cable ends. The nature inclusive design measures are to be implemented in areas where fishing is not allowed, i.e. within the 500-meter zone and the windfarms.

4 REFERENCES

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4.2 TTE Standards

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[B6] GS EP PLR 410, Concrete Coating for Pipelines, rev.12, 11/2020.

[B7] GS EP PLR 501, Hydrostatic Testing of Pipelines, rev.13, 12/2018.

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[B10] GS EP COR 102, Design of Cathodic Protection of Submarine Pipelines by Galvanic Anodes according to ISO 15589-2, rev.12, 04/2020.

[B11] GS EP COR 350 (GS HM COR 821), External Protection of Offshore and Coastal Structures and Equipment by Painting according to IOGP S-715, rev.16, 07/2022.

[B12] GS EP COR 100, Cathodic Protection of Offshore Structures according to DNV-RP-B401, rev.13, 11/2019.

[B13] GS EP STR 101, Design of offshore jacket and subsea structures

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Aramis Pipeline Route
Integrated Geophysical Survey Results Report

ARAMIS

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Managementsamenvatting geofysisch onderzoek

Op instructie van TotalEnergies MV hebben Fugro Discovery, Fugro Seeker en Fugro Searcher een geofysisch onderzoek uitgevoerd langs het tracé van de Aramis-zeeleiding (trunk line). Het algemene routeprogramma is onderverdeeld in de volgende gebieden: geofysisch onderzoek, UXO, 2D-UHRS, EBS en geotechnisch onderzoek.

De gegevens werden verzameld tussen juli 2022 en januari 2023.

Dit rapport geeft informatie over de resultaten van de geofysische onderzoeken die zijn uitgevoerd boven de Aramis-route.

Sectie 2 van het rapport geeft informatie over mobilisatie, werkzaamheden, methodologie en interpretatie van gegevens. Secties 3 en 4 geven een overzicht van de omstandigheden op de zeebodem en onder de zeebodem. Gedetailleerde resultaten en beschrijvingen voor elk deel van de route vindt u in de secties 5 tot en met 14.

Locatieonderzoek Aramis-trunklijn		
Onderzoeksdata	Geofysisch	Juli 2022 tot januari 2023
Uitrusting	Geofysisch	Multibeam echolood (MBES), side scan sonar (SSS), enkelvoudige magnetometer (MAG), sub-bottom profiler (SBP), 2D-UHRS.
	UXO	Dicht bij de kust: Miniwing (2 x G882 MAG) Offshore: dubbele Katria Scanfish magnetometer array, (8 x G882 MAG)
Coördinatensysteem		ETRS89 / UTM zone 31N
Bathymetrie		
De algemene waterdiepte varieert tussen 0 m en 39,5 m langs het traject van de Aramis-trunklijn.		
Morfologie van de zeebodem		
De volgende morfologische kenmerken werden geïdentificeerd: bedvormen (rimpelingen, megarippels en zandgolven), onregelmatige zeebodem, gebied met talrijke keien, gebied met af en toe keien.		
Sedimenten van de zeebodem		
De interpretatie en classificatie van zeebodemsedimenten was gebaseerd op een combinatie van gegevens van MBES en SSS, waarbij gebruik werd gemaakt van akoestische kenmerken zoals algemeen patroon, ruwheid en reflectiviteit. De interpretatie is herzien aan de hand van de resultaten van geotechnische gegevens. De geïdentificeerde zeebodemsedimenten zijn: (1) kiezelhoudend ZAND, (2) licht kiezelhoudend ZAND, (3) modderig (ziltig) ZAND en (4) ZAND		
Doelen op de zeebodem en potentiële locatiespecifieke gevaren		
Wrakken	4 Wrakken zijn geïdentificeerd en geïnterpreteerd	
Pijpleidingen/kabels	Verschillende pijpleidingen kruisen de route. Sommige pijpleidingen liggen gedeeltelijk bloot en gedeeltelijk begraven, maar de meeste pijpleidingen liggen begraven.	
Puin / vermoedelijk puin	159 sonarcontacten zijn geclassificeerd als puin 517 sonarcontacten zijn geclassificeerd als vermoedelijk puin	
Matrassen	2 Matrassen zijn geclassificeerd in de nabijheid van het Platform L4A	
Keien	3110 keien zijn geïnterpreteerd	
Andere doelen	Er zijn schuurplekken van vistuig en sporen van sleepnetten gevonden	
Magnetische anomalieën.	2745 magnetische anomalieën zijn gevonden	
Gekruiste gecorreleerde contacten	11 SSS-contacten zijn gekruist gecorreleerd met MAG doelen	

Ondergrondse geologische kenmerken	
Begraven kanalen	Interne ondergrondse geulen en geulen aan de basis werden waargenomen in alle units, behalve Unit A. Ingegraven geulen in Unit B werden in kaart gebracht op basis van SBP-gegevens. Deze kanalen bevinden zich vaak aan de bovenkant van de eenheid, zijn NW-ZO georiënteerd en hebben een beperkte omvang. Ze hebben vaak een gelaagde vulling. De basis van Unit B, Unit C en Unit D is plaatselijk gekanaliseerd. De basis van Unit F vormt de diep ingesneden glaciale tunneldalen. Nabij de top van Unit F werden plaatselijk beddingvormige, kanaalachtige reflectoren waargenomen. Deze kenmerken lijken een late fase van de opvulling van deze tunnelvalleien te vertegenwoordigen, die mogelijk in een lacustriene omgeving plaatsvond.
Veen	Hoge negatieve amplitudeanomalieën werden waargenomen in de 2D-UHRS seismische gegevens. Deze gebeurtenissen met een negatieve amplitude vertegenwoordigen waarschijnlijk veen en/of organisch-rijke klei. Er werden veenlagen geïdentificeerd op drie stratigrafische niveaus: *veenniveau 1* - behorend bij Unit B, *veenniveau 2* - behorend bij Unit C, Unit D en Unit E en *veenniveau 3* - behorend bij Unit F en Unit G. Op de SBP-gegevens werden de reflectoren met hoge amplitude, die op veen en/of organische klei kunnen duiden, geassocieerd met eenheid B. Veen komt het meest voor in het noordelijke deel van de route, met uitzondering van 2D-UHR_peat level 3, dat langs de hele route aanwezig is, maar de verspreiding ervan is zeer beperkt.
Ondiep gas	Akoestische blanking kan de aanwezigheid van gas in de bodem aangeven. Het werd plaatselijk in het kustgebied waargenomen. De kleine akoestische blanking of signaalvervorming die onder enkele van de negatieve amplitudeanomalieën werd waargenomen, houdt vermoedelijk verband met de aanwezigheid van veen. De aanwezigheid van met gas/vloeistof gevulde sedimenten kan echter niet volledig worden uitgesloten.
Rotsblokken, keien en grind	In de SBP-gegevens werden een paar diffractiehyperbolen waargenomen. Deze worden geïnterpreteerd als mogelijke rotsblokken, keien en/of grof grind. Er moet opgemerkt worden dat de interpretatie van deze kenmerken speculatief is en dat hyperbolen van diffractie het resultaat kunnen zijn van andere factoren dan de aanwezigheid van rotsblokken, keien of grof grind. Gezien de geologische omgeving (d.w.z. de verwachte aanwezigheid van periglaciale en glaciale sedimenten) kunnen keien en keien worden verwacht langs de Aramis-route. Hun aanwezigheid kan dus niet worden uitgesloten.
Glaciale vervorming	Glaciale vervorming komt typisch tot uiting in seismische gegevens als chaotische interne reflecties, hellende afschuifvlakken, vervormde en geplooide lagen en verstoring van de oorspronkelijke interne structuur. Bewijzen van mogelijke vervorming werden waargenomen in Unit G, vooral in de buurt van glaciale tunneldalen (Unit F). Men denkt dat deze kenmerken verband houden met de Elsteriaanse ijstijd.
Fouten	Breuken werden niet eenduidig geïdentificeerd in de seismische reflectiegegevens. De aanwezigheid van breuken en/of scheuringen kan echter niet worden uitgesloten.
Geologie van de ondergrond	
Unit A	Unit A is over de hele route aanwezig. Het lijkt akoestisch transparant te zijn. Plaatselijk werden hoge amplitude interne puntreflecties of korte reflectoren waargenomen. In de grotere zandgolven werden lokaal zwakke progradatiestructuren waargenomen. De eenheid wordt geïnterpreteerd als afgezet in een open mariene omgeving, als reactie op de mariene transgressie tijdens het Laat-Holoceen, en behoort tot de zuidelijke Bocht Formatie. Bodemtype: Zeer los tot zeer dicht zwak ziltig tot zwak fijn en matig ZAND, plaatselijk zwak zandige KLEI.
Unit B	Unit B is aanwezig in de hele route, behalve in het Maasmondkanaal. De unit heeft een variabel intern seismisch karakter, variërend van semi-transparant tot chaotisch met talrijke discontinue en vaak onder een grote hoek liggende reflecties met middelhoge tot hoge amplitude. Interne kanalen en kanalen aan de basis met verschillende afmetingen werden waargenomen in de unit.

Geologie van de ondergrond	
	De vulling van de geulen is variabel, maar meestal goed gelaagd en met reflectoren met een hoge amplitude. Hoge negatieve amplitudeanomalieën komen vaak voor in deze eenheid, vooral in het noordelijke deel van de route, die mogelijk lagen veen en/of organisch-rijke klei voorstellen. De unit wordt geïnterpreteerd als kust- en getijdenafzettingen uit het vroege Holoceen en behoort mogelijk tot de Naaldwijk Formatie. Plaatselijk kan de eenheid sedimenten van de Formatie van Boxtel bevatten en vooral in het zuidelijke en zuid-centrale deel van de route kan een groot deel van deze eenheid tot de Kreftenheye Formatie behoren. Het onderscheid tussen deze formaties is moeilijk te maken vanwege de vergelijkbare bodemgesteldheid (voornamelijk zand). In het kustgebied liggen afzettingen van de Kreftenheye Formatie onder de basis van de geïnterpreteerde Naaldwijk Formatie. Bodemtype: Matig tot zeer dicht zwak ziltig fijn en matig ZAND, plaatselijk met bedden van zandige KLEI en VEEN.
Unit C	Unit C is aanwezig in het centrale en gedeeltelijk in het noordelijke deel van de route. De unit wordt voor het grootste deel van de route gekarakteriseerd door bedding van seismische facies, bestaande uit parallelle reflectoren. Plaatselijk, in het bovenste deel van de unit, werden structuurloze, semi-transparante intervallen waargenomen. In het noordoostelijke deel van de route wordt de unit gekenmerkt door algemene semi-transparante seismische facies met lokale negatieve reflectoren met hoge amplitude (2D-UHRS) van verschillende omvang. De reflectoren met hoge amplitude kunnen duiden op lagen met lagen veen en/of organische klei. De gelaagde aard van de unit zal naar verwachting correleren met afwisseling van zand en klei en plaatselijke veenbedden. De unit wordt geïnterpreteerd als afgezet in een reeks van kust- (estuariene), getijdenvlakte- of laguneomgevingen en komt overeen met het Brown Bank Lid. Bodemtype: Zeer los tot dicht zeer ziltig fijn en middelfijn ZAND, plaatselijk zandig KLAAR en zandig kleiig SILT.
Unit D	Unit D is over de hele route aanwezig, met uitzondering van een klein deel van de route (ongeveer 15 km) in het centrale deel, en in het meest zuidelijke deel. De unit heeft over het algemeen een structuurloos en semi-transparant akoestisch karakter. Plaatselijk gelaagde intervallen, interne erosieoppervlakken gemarkeerd door sterk hellende reflectoren of die brede kanaalachtige kenmerken vormen. Inwendige begraven kanalen zijn plaatselijk aanwezig. Unit D bestaat naar verwachting voornamelijk uit zand, met zeer plaatselijk klei- of veenafwisselingen, afgezet in omgevingen van open zee en getijden. Men denkt dat de eenheid tot de Eem Formatie behoort. Bodemtype: Los tot zeer dicht zwak ziltig fijn en matig ZAND, af en toe licht grindig.
Unit E	Unit E is alleen aanwezig in het noordelijke deel van de route. Wordt gekenmerkt door akoestisch transparante tot semi-transparante en structuurloze seismische fracties. Unit D zal naar verwachting voornamelijk uit zand bestaan, afgezet in omgevingen van open zee en getijden. Men denkt dat de eenheid behoort tot de Egmond Formatie. Bodemtype: Gemiddeld dicht tot zeer dicht ZAND plaatselijk met bedden van KLEI en ZOUT.

Unit F	Unit F is plaatselijk aanwezig in de noordelijke helft van de route. De unit vormt de opvulling van diep insnijdende U-vormige kanaalachtige kenmerken met steile flanken. Ze snijden in de onderliggende Unit G en bereiken plaatselijk diepten onder de penetratie van de 2D-UHRS gegevens. Dergelijke kenmerken in dit deel van de Noordzee worden beschouwd als glaciale tunneldalen. De unit zal naar verwachting voornamelijk bestaan uit klei met frequente (ziltige) zandbeddingen afgezet in glaciale, glaciofluviale en glaciolacustriene omgevingen. Deze afzettingen worden geïnterpreteerd als behorend tot de Peelo Formatie. Het interne karakter wordt over het algemeen gekenmerkt door semi-transparante tot chaotische seismische facies. Vaak, vooral in het bovenste deel, werden discontinue, onregelmatige en golvende (geplooide?) reflectoren van gemiddelde tot hoge amplitude waargenomen. Bodemtype: Verweven matig dicht tot zeer dicht (ziltig) ZAND en hoogvast tot zeer hoogvast (zandige) KLEI
Geologie van de ondergrond	
Unit G	Unit G is de diepste unit die is waargenomen in de seismische gegevens binnen de diepte van interesse en is aanwezig over het hele traject. De basis van deze unit ligt buiten de penetratiediepte van de 2D-UHRS. Het interne akoestische karakter van de unit is complex, van semi-transparant tot chaotisch, met plaatselijk discontinue reflectoren, interne erosieoppervlakken en verschillende interne kanalen. Deze complexiteit is het gevolg van de aard van de afzettingsomgeving van deze unit (fluviatiel tot deltaïsch) en post-depositionele processen zoals glaciale activiteit, inclusief erosie en mogelijk vervorming. De eenheid bestaat naar verwachting voornamelijk uit zand met af en toe klei- en sliblagen en plaatselijk dunne veenbedden. De eenheid wordt geïnterpreteerd als overeenkomend met de Yarmouth Roads Formatie. Bodemtype: Matig dicht tot zeer dicht ZAND, plaatselijk met lagen hoogvaste tot zeer hoogvaste KLEI of ZILT, plaatselijk gelamineerd

Geophysical Survey Results Report

Aramis Project – Geophysical and Geotechnical Site Investigation

Survey Period: July 2022 – January 2023

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Executive Summary

On the instruction of TotalEnergies MV Fugro Discovery, Fugro Seeker and Fugro Searcher performed a geophysical survey along the Aramis trunkline route. The overall route program has been divided into following scopes: geophysical survey, UXO, 2D-UHRS, EBS and geotechnical surveys.

Data acquisition was carried out between July 2022 and January 2023.

This report provides information on the results of the geophysical surveys conducted over the Aramis route.

Section 2 of the report provides information about mobilisation, operations, methodology and data interpretation. Sections 3 and 4 provide overview of the seafloor and sub-seafloor conditions. Detailed results and descriptions for each section of the route are provided in Sections 5 through 14.

Site Investigation Aramis trunkline		
Survey Dates	Geophysical	July 2022 to January 2023
Equipment	Geophysical	Multibeam echo sounder (MBES), side scan sonar (SSS), single magnetometer (MAG), sub-bottom profiler (SBP), 2D-UHRS.
	UXO	Nearshore: Miniwing (2 x G882 MAG) Offshore: dual Katria Scanfish magnetometer array, (8 x G882 MAG)
Coordinate System		ETRS89 / UTM zone 31N
Bathymetry		
The overall water depth varies between 0 m and 39.5 m along the Aramis trunkline route.		
Seafloor Morphology		
The following morphological characteristics were identified: bedforms (ripples, megaripples and sand waves), irregular seafloor, area with numerous boulders, area with occasional boulders.		
Seafloor Sediments		
Seafloor sediment interpretation and classification was based on a combination of data from MBES and SSS, using acoustic characteristics such as overall pattern, roughness and reflectivity. The interpretation has been revised using geotechnical data results. The seafloor sediments identified are: (1) gravelly SAND, (2) slightly gravelly SAND, (3) muddy (silty) SAND and (4) SAND		
Seafloor Targets and Potential Site-Specific Hazards		
Wrecks	4 Wreck have been identified and interpreted	
Pipeline/Cables	Several pipelines are crossing the route. Some pipelines are partially exposed and partially buried, however most of the pipelines are buried.	
Debris / Suspected debris	159 sonar contacts have been classified as debris 517 sonarcontacts have been classified as suspected debris	
Mattresses	2 Mattresses have been classified in proximity of the Platform L4A	
Boulders	3110 boulders have been interpreted	
Other targets	Fishing gears scours, trawl marks have been found	
Magnetic anomalies.	2745 magnetic anomalies have been picked	
Cross correlated contacts	11 SSS contacts have been cross correlated with MAG targets	

Sub-Seafloor Geological Features	
Buried channels	Internal buried channels and channels at the base were observed in all units except Unit A. Buried channels in Unit B were mapped based on SBP data. These channels are often located towards the top of the unit, have NW-SE orientation and limited extent. They often have a layered infill. The base of Unit B, Unit C and Unit D is locally channelised. The base of Unit F forms the deeply incised glacial tunnel valleys. Near the top of Unit F, locally bedded, forming channel-like shape reflectors were observed. These features appear to represent a late stage of the infill of these tunnel valleys that may took place in lacustrine environment.
Peat	High negative amplitude anomalies were observed in the 2D-UHRS seismic data. These negative amplitude events most likely represent peat and/or organic-rich clay. Peat layers were identified at three stratigraphic levels: *peat level 1* – associated with Unit B, *peat level 2* – associated with Unit C, Unit D and Unit E and *peat level 3* – associated with Unit F and Unit G On the SBP data, the high amplitude reflectors that may indicate peat and/or organic clay were associated with Unit B. Peat is most common in the northern part of the route, except 2D-UHR_peat level 3, which is present along the entire route, but its distribution is very limited.
Shallow gas	Acoustic blanking can indicate presence of gas in soil. It was observed locally in the nearshore area. The minor acoustic blanking or signal distortion that was observed below some of the negative amplitude anomalies is thought to be related to the presence of peat. However, the presence of gas/fluid-charged sediments cannot be excluded entirely.
Boulders, cobbles and gravel	A few diffraction hyperbolas were observed in the SBP data and are interpreted to represent possible boulders, cobbles and/or coarse gravel. It should be noted that interpretation of these features is speculative and diffraction hyperbolas may be the result of factors other than the presence of boulders, cobbles or coarse gravel. Given the geological setting (i.e. the expected presence of periglacial and glacial sediments), boulders and cobbles can be expected along the Aramis route. Hence, their presence cannot be ruled out.
Glacial deformation	Glacial deformation is typically expressed in seismic data as chaotic internal reflections, inclined shear planes, deformed and folded strata and disturbance of the original internal structure. Evidence of possible deformation was observed in Unit G, especially in proximity of glacial tunnel valleys (Unit F). These features are thought to be related to the Elsterian glaciation.
Faults	Faults were not unequivocally identified in the seismic reflection data. However, the presence of faults and/or fractures cannot be ruled out.
Sub-Seafloor Geology	
Unit A	Unit A is present across the entire route. It appears to be acoustically transparent. Locally, high amplitude internal point reflections or short reflectors were observed. In the larger sand waves, locally weak progradational structures were observed. The unit is interpreted to be deposited in an open marine environment in response to the marine transgression during the Late Holocene and belongs to the southern Bight Formation. Soil type: Very loose to very dense slightly silty to silty fine and medium SAND, locally slightly sandy CLAY.
Unit B	Unit B is present in the entire route, except in the Maasmond Kanaal. The unit has a variable internal seismic character, ranging from semi-transparent to chaotic with numerous discontinuous and often high-angle medium to high-amplitude reflections. Internal channels and channels at the base with different dimensions were observed in

Sub-Seafloor Geology	
	the unit. The infill of the channels is variable, but typically well-layered and with high-amplitude reflectors. High negative amplitude anomalies are common in this unit, especially in the northern part of the route, which potentially represent layers of peat and/or organic-rich clay. The unit is interpreted to represent early Holocene coastal and tidal deposits, and possibly belonging to the Naaldwijk Formation. Locally the unit may include sediments of Boxtel Formation and especially in the southern and south-central part of the route, a large part of this unit may belong to the Kreftenheye Formation. The differentiation between these formations is difficult due to similar soil conditions (predominantly sand). In the nearshore area, deposits of the Kreftenheye Formation are below the base of the interpreted Naaldwijk Formation. Soil type: Medium to very dense slightly silty fine and medium SAND, locally with beds of sandy CLAY and PEAT.
Unit C	Unit C is present in the central and partially in the northern part of the route. The unit for most of the route is characterised by bedded seismic facies, consisting of parallel reflectors. Locally, in the upper part of the unit, structureless, semi-transparent intervals were observed. In the north-eastern part of the route, the unit is characterised by overall semi-transparent seismic facies with local high amplitude negative (2D-UHRS) reflectors of various extent. The high amplitude reflectors may indicate layers of pockets of peat and/or organic clay. The layered nature of the unit is expected to correlate with sand and clay alternations, and local beds of peat. The unit is interpreted to be deposited in a range of coastal (estuarine), tidal flat or lagoonal environments and corresponds to the Brown Bank Member. Soil type: Very loose to dense very silty fine and medium SAND, locally sandy CLAY and sandy clayey SILT.
Unit D	Unit D is present across the entire route, except small part of the route (approximately 15 km) in the central part, and in the most southern part. The unit has in general a structureless and semi-transparent acoustic character. Locally, layered intervals, internal erosion surfaces marked by strong inclined reflectors or forming broad channel-like features. Internal buried channels are locally present. Unit D is expected to comprise predominantly sand, with very locally clay or peat alternations, deposited in open marine and tidal environments. The unit is thought to belong to the Eem Formation. Soil type: Loose to very dense slightly silty fine and medium SAND, occasionally slightly gravelly.
Unit E	Unit E is present only in the northern part of the route. Is characterised by acoustically transparent to semi-transparent and structureless seismic facies. Unit D is expected to comprise predominantly sand, deposited in open marine and tidal environments. The unit is thought to belong to the Egmond Ground Formation. Soil type: Medium dense to very dense SAND locally with beds of CLAY and SILT.
Unit F	Unit F is present locally in the northern half of the route. The unit forms the infill of deeply incisive U-shaped channel-like features with steep flanks. They cut into the underlying Unit G, reaching locally depths below the penetration of the 2D-UHRS data. Such features in this part of the North Sea are considered as glacial tunnel valleys. The unit is expected to consist of mainly clay with frequent (silty) sand interbeds deposited in glacial, glaciofluvial and glaciolacustrine environments. These deposits are interpreted to belong to the Peelo Formation. The internal character is characterised in general by semi-transparent to chaotic seismic facies. Often, especially in the upper part, discontinuous, irregular, and wavy (folded?) medium to high-amplitude reflectors were observed. Soil type: Interbedded medium dense to very dense (silty) SAND and high strength to very high strength (sandy) CLAY

Sub-Seafloor Geology	
Unit G	Unit G is the deepest unit observed in the seismic data within depth of interest and is present across the entire route. The base of this unit is beyond the penetration depth of the 2D-UHRS. The internal acoustic character of the unit is complex, from semi-transparent to chaotic, with locally discontinuous reflectors, internal erosion surfaces and various internal channels. This complexity results from the nature of the depositional setting of this unit (fluvial to deltaic) and post-depositional processes such as glacial activity, including erosion and possibly deformation. The unit is expected to consist of predominantly sand with occasional clay and silt interbeds, and local thin beds of peat. The unit is interpreted to correspond to the Yarmouth Roads Formation. Soil type: Medium dense to very dense SAND, locally with layers of high strength to very high strength CLAY or SILT, locally laminated

Document Arrangement

Document Title	Description	Client Document No.
F197217-REP-ENV-001	Environmental Desk Top Study	
F197217-REP-MOB-SK	Mobilisation Fugro Seeker	
F197217-REP-MOB-SR	Mobilisation Fugro Searcher	
F197217-REP-MOB-DIS	Mobilisation Fugro Discovery	
F197217-REP-OPS-SEA	Operations Report Fugro Searcher	
F197217-REP-OPS-FD 01	Operations Report Fugro Discovery	
F197217-R-1 01	Field Operations and Preliminary Results Report NMM & K.Orca	
F197217-REP-RES-001	Nearshore Geophysical Survey Report (preliminary results)	
F197217-REP-001	Geophysical Survey Results Report	
F197217-REP-002	Environmental Field Report	
F197217-REP-003	Diversity Observation Report	
F197217-REP-004	EBS (includes Habitat Report)	
F197217-REP-005	eDNA Report	
F197217-REP-006	Measured and Derived Geotechnical Parameters and Final Results Report	

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Abbreviations

bsb	Below seabed
BS	British Standard
BSF	Below seafloor
CPT	Cone penetration test
CRP	Common reference point
CUBE	Combined Uncertainty and Bathymetric Estimator
DGPS	Differential global positioning system
DTM	Digital Terrain Model
EBS	Environmental baseline survey
EPSG	European Petroleum Survey Group
ETRF	European Terrestrial Reference Frame
ETRS	European Terrestrial Reference System
EVT	Equipment verification test
FF	Fugro Frontier
Fm	Geological formation
FNLM	Fugro Netherlands Marine
FV	Fugro Venturer
GIS	Geographic Information System
GNSS	Global Navigation Satellite System
GRS	Geodetic Reference System
GS	Grab sample
HVF	Hips vessel file
IHO	International Hydrographic Organization
ISO	International Hydrographic Organization
ITRF	International Terrestrial Reference Frame
IAC	Inter-array cable
KP	Kilometre post
LAT	Lowest Astronomical Tide
LGM	Last Glacial Maximum
MAG	Magnetometer
MASW	Multichannel analysis of surface waves
Mb	Geological member
MBES	Multibeam echosounder
MSL	Mean Sea Level
MV	Motor vessel
OCR	Offshore client representative
OPS	Operations

OWF	Offshore windfarm
PSD	Particle size distribution
QA	Quality Assurance
QC	Quality control
REP	Report
RPL	Route Position List
SBP	Sub-bottom profiler
SHP	Shapefile
SSS	Side scan sonar
SVP	Sound velocity profile
THU	Total horizontal uncertainty
TPU	Total propagated uncertainty
TVU	Total vertical uncertainty
TWTT	Two-way travel time
UHRS	Ultra high resolution seismic
UKHO	United Kingdom Hydrographic Office
USBL	Ultra-short Baseline
UTC	Coordinated Universal Time
UTM	Universal Transverse Mercator
UXO	Unexploded ordinance
VC	Vibrocore
VORF	Vertical Offshore Reference Frame
WP	Work package
WTG	Wind turbine generator

1. Introduction

1.1 Project Description

The Carbon Capture and Storage (CCS) Aramis Project is developing CO_2 transport facilities to enable offshore gas storage. Once captured, the CO_2 is collected at the compressor station and shipping terminal at Maasvlakte, a hub in the port of Rotterdam. From this hub, CO_2 is transported to offshore gas fields to be injected into depleted offshore gas field at a depth of approximately 3 km to 4 km below the seafloor.

TotalEnergies contracted Fugro to perform an offshore geophysical, geotechnical and environmental site investigations of the proposed offshore pipeline corridor, running from landfall at the Maasvlakte to offshore Blocks L4/K6. A map of the site investigation location, including the proposed pipeline routes is shown in Figure 1.1.

1.2 Scope of Report

This report provides results of the geophysical survey and interpretation of the proposed 500 m wide pipeline corridors and a 2 km radius offshore distribution hub (Hub Area).

The report includes:

- Multibeam echosounder (MBES) data to provide accurate bathymetry in order to determine water depths, seafloor morphology and seafloor gradient;
- High-resolution side scan sonar (SSS) data to determine seafloor features, possible presence of boulders, seafloor sediments, objects / debris and items that may impact foundation and pipeline installation;
- Magnetometer (MAG) data across the site to determine any metallic objects / debris items;
- High-resolution sub-bottom profiler (SBP) and 2D-UHRS data to determine the sub-seafloor conditions that may influence foundation and pipeline installation such as shallow geology, geological features and geohazards;
- Cone Penetration Tests (CPT) and vibrocore samples (VC) along the pipeline route to ground truth the seismic reflection data and to allow for geotechnical soil characterisation of the interpreted units.

The CCS Aramis trunkline route has been divided into sections (Figure 1.1). Report Sections 3 and 4 provide a general overview of the results and interpretation, while Sections 5 to 14 provide a detailed description of each section of the CCS Aramis trunkline route.

This report is one in a series of reports that are prepared as part of this project and relate to offshore operations, processing, environmental and geotechnical surveys (refer to page 'Document Arrangement').

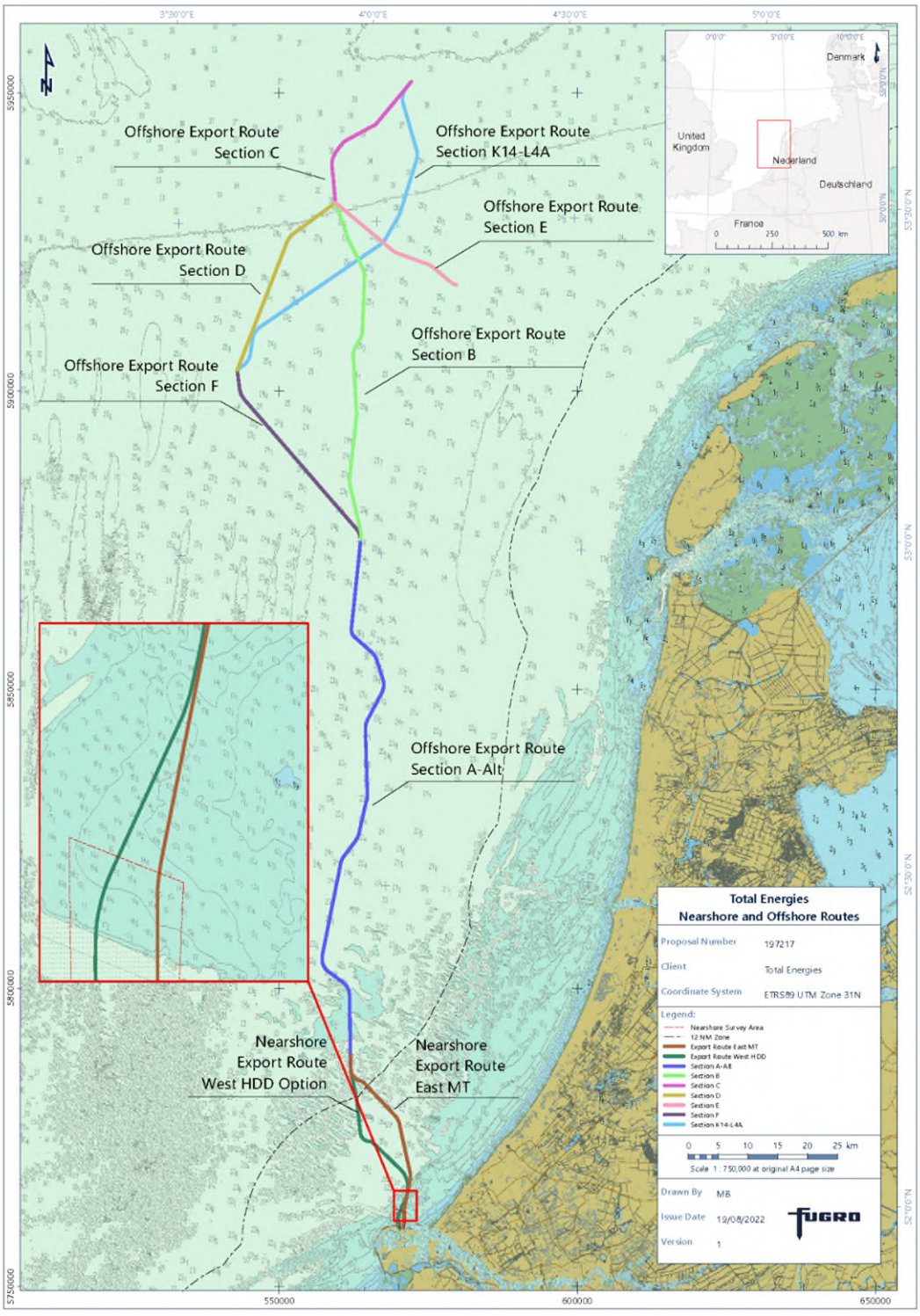


Figure 1.1: Overview of the Aramis trunkline route section divisions.

1.3 Geodesy

The project geodetic and projection parameters are summarised in Table 1.1.

Table 1: Project geodetic parameters

Name: ETRS89 / UTM zone 31N (ETRF2000-ITRF2014), LAT (NL) [NLLAT2018]		
EPSG Code	EPSG:25831	
Global Navigation Satellite System (GNSS) Geodetic Parameters*		
Datum:	International Terrestrial Reference Frame 2014	EPSG: 1165
Ellipsoid:	GRS 1980	
Semi major axis:	a = 6 378 137.000 m	
Inverse Flattening:	1/f = 298.257 222 101	
Local Geodetic Datum Parameters		
Datum:	ETRS89	EPSG: 6258
Ellipsoid:	GRS 1980	
Semi major axis:	a = 6 378 137.00 m	
Inverse Flattening:	1/f = 298.257 222 101	
Datum Transformation Parameters from ITRF2014 to ETRS89 (Note 2, Note 3)		
X-axis translation 0.05595 m	X-axis rotation –0.0027132"	Scale difference 0.00349455 ppm
Y-axis translation 0.05345 m	Y-axis rotation –0.016413"	Coordinate Frame Rotation
Z-axis translation –0.09784 m	Z-axis rotation 0.0265287"	FUGRO: 41366
Project Projection Parameters		
Map projection	Transverse Mercator	
Grid system	UTM zone 31N	EPSG: 16031
Latitude origin:	00° 00' 00.000" N	
Central meridian:	003° 00' 00.000" E	
Scale factor on central meridian:	0.9996	
False easting:	500 000 m	
False northing:	0 m	
Project Vertical Parameters		
Vertical coordinate reference system	LAT (NL)	FUGRO: 41043
Datum	LAT Datum (NL)	FUGRO: 40917
Transformation	ETRS89 to LAT (2018)	FUGRO: 41475
Notes: *The geodetic datum of Fugro's global GNSS correction data is ITRF2014, epoch 2022.496 (01/07/2022)		

Table 2: Validation calculation

ITRF2014	Test Point [Position]	Computed Point
Latitude	53° 32' 37.50000" N	53° 32' 37.50000" N
Longitude	004° 16' 30.00000" E	004° 16' 30.00000" E

ITRF2014	Test Point [Position]	Computed Point
Ellipsoidal height	0.000 m EII	0.000 m EII
ETRS89		
Latitude	53° 32′ 37.48043″ N	53° 32′ 37. 48043″ N
Longitude	004° 16′ 29.97086″ E	004° 16′ 29.97086″ E
Ellipsoidal height	-0.023 m EII	-0.023 m EII
UTM zone 31N		
Easting	584 484.290 m	584 484.290 m
Northing	5 933 516.515 m	5 933 516.515 m
Chart datum height	-40.248 m	-40.248 m

1.4 Vertical Datum

All vertical data for the survey were reduced to Lowest Astronomical Tide (LAT).

Vertical Datum	
Vertical coordinate reference system	ETRS89 to LAT height using NLLAT2018

2. Mobilisation, Operation and Processing

2.1 Mobilisations

The geophysical survey was carried from 3 July 2022 with the Fugro Seeker to 24 January 2023 when the Fugro Searcher left the project.

Table 3: Summary of events

Event	Dates
Mobilisation of Fugro Seeker	3-12 July 2022
Demobilisation of Fugro Seeker	14-15 October 2022
Mobilisation of Fugro Discovery	8-11 November 2022
Demobilisation of Fugro Discovery	17 December 2022
Mobilisation of Fugro Searcher	7 October 2022
Demobilisation of Fugro Searcher	24 January 2023

Please refer to the single vessel mobilisation reports for details regarding the equipment calibrations performed prior the project (*197217-REP-MOB-SK(04)_Mobilisation Fugro Seeker, F197217-REP-MOB-DIS_R01_Mobilisation Fugro Discovery , 24-197217_FugroSearcher_Mobilisation_Report_Issue_01*)

2.2 Operations, Acquisition and Processing

Refer to table Table 2.2 for an overview of the different scope of work for each vessel.

Table 4: Survey structure

Vessel	Scope of Work
Fugro Seeker	Geophysical Survey, Nearshore Including: MBES, SSS, SBP, MAG, 2D UHRS, seismic refraction and MASW, UXO Survey
Fugro Discovery	Geophysical Survey, Offshore Including: MBES, SSS, SBP, MAG
Fugro Searcher	Geophysical Survey, Offshore Including: MBES, SSS, SBP, MAG, 2D-UHRS, UXO survey and EBS
Kommandor Orca / Normand Mermaid	Geotechnical Survey Including: CPT testing and Vibrocore sampling

2.2.1 Operations – Fugro Seeker

The Seeker conducted a geophysical survey for the Nearshore area with multiple scopes as detailed in Table 2.3.

The objective of the survey was to identify and delineate any possible constraints and hazards from man-made, natural and geological features, which may affect the integrity of the investigation site/development area.

Table 5: Scope of work of Seeker

Area of Operation	No. Lines	Line km	Scope Requirements
Analogue Geophysical Scope	91	141.4	MBES, SSS, SBP and MAG collected on all survey lines.
UXO Scope	225	58.1	UXO - Miniwing
UHRS Scope	41	71.9	2D-UHRS seismic equipment
Refraction Seismic and MASW Scope	32	31.7	150 m refraction and MASW streamer & 90m MASW streamer

Initial Quality Assurance (QA) and processing of data acquired by all sensors was carried out onboard the vessel. Multibeam backscatter (MBBS), multibeam echosounder (MBES), side scan sonar (SSS) and sub-bottom profiler (SBP) data were sent to the Fugro office in Portchester, UK for full quality control (QC), final processing, and interpretation. UHRS data were sent to the Geo Surveys office for full QC, final processing, and interpretation. Refraction Seismic and MASW data were sent to the Fugro France officer for full QC, final processing, and interpretations.

2.2.2 Survey Requirements – Fugro Seeker

Table 6: Survey requirements overview

Equipment Method	Survey Requirements
Vessels	Seeker
Proposed Pipeline Survey Line Spacing	■ Line spacing varied between blocks A & B: ■ Block A line spacing was 20 m ■ Block B line spacing was 40 m. ■ Crosslines were set along the two potential cable routes with parallel wing lines offset 50 m either side of the main crosslines.
Survey Priority	Where sufficient overlap was not created infill lines were collected;
Target Vessel Speed	4.0 Kts
Surface Positioning	■ Two independent positioning systems with full quality control amenities ■ Positioning accuracy ± 2 m
USBL	■ <10s gaps; ■ Positioning accuracy ± 2 m;
Multibeam Echosounder	■ As per Section 4.4 of the Scope of Work and tender deviations ■ THU < 1.0 m (1.141σ), TVU < 30 cm (1σ) ■ Acquisition of high-resolution swath bathymetry data within the planned survey area. ■ Minimum hit count of 16 soundings per 1 m DTM cell size. 200 m^2 of continuous area with <16 soundings per 1 m bin require infill. ■ 20 % overlap of MBES
Multibeam Backscatter	To be recorded and processed at 0.5 m resolution.

Equipment Method	Survey Requirements
Side Scan Sonar	■ As per Section 4.5 of the Scope of Work. ■ Dual operating frequency fish: minimum 300 kHz (low frequency) & minimum 600 kHz (high frequency). ■ 200 % coverage across the site, 100 % in the SSS nadir ■ Target resolution ≥ 0.5 m with high frequency (HF). ■ Mosaic resolution at 0.1 m
Innomar SBP	■ As per section 4.6 of the Scope of Work. ■ System resolution of up to 0.2 m penetration through unconsolidated sediments to a target depth of up to 10 m depending on water depth, geological and environmental conditions. ■ Output > 8 Kw ■ Beamwidth at 3 dBD ± 1° ■ Primary frequency 85 kHz to 115 kHz ■ Low frequency 2 kHz to 222 kHz ■ Soft start required
Magnetometer	■ As per section 4.7 in the Scope of Work ■ Single magnetometer with high sensitivity (0.01 nT) ■ Positioning known to within ± 2 m
SVP	■ Speed of sound in water measured in the survey area at the start of each day (as a minimum) and whenever deemed necessary (i.e. beginning to have MBES refraction artefact); ■ SVP sensor should have an accuracy of ± 0.05 m/s
2D-UHRS	As per section 4.9 in the Scope of Work.
Refraction Seismic and MASW	■ As per section 4.10 in the Scope of Work ■ 48 hydrophone streamer plus one spare; ■ Source (air gun) and trigger together with spare parts; ■ PC's in sufficient quantity to cover data acquisition and QC needs; ■ Software sufficient to cover data acquisition and QC/computing needs (refraction software); ■ Relevant Geodetic instrumentation for positioning/grid setting.

2.2.3 Processing – Fugro Seeker

2.2.3.1 Multibeam Echosounder

Table 7: Multibeam echosounder

Multibeam Echosounder	
Requirement	■ 0.25 m grid resolution ■ Minimum density 16 valid pings per 1 m^2 ■ Simultaneous recording of backscatter
Equipment	Two hull mounted Teledyne RESON 7125 multibeam echosounders with full rate dual head functionality.

Multibeam Echosounder	
Data Collection	■ Multibeam data were collected in accordance with Fugro's standard work instructions, a component of Fugro's quality management system, which complies with the requirements of ISO 9001:2015, ensuring that data is collected in accordance with the scope of work and Fugro's work instructions WI351,352,356,362,110-402. ■ On Seeker a dual-head Teledyne RESON 7125 multibeam echosounder system was pre-mobilised and consists of two transmit and receive arrays, one mounted on each hull. ■ A Valeport Mini SVP was deployed by hand to measure the sound velocity of the water column, prior to the start of survey operations and at least once during each 6 to12 hour period. ■ A RESON SVP-70 was mounted near the transmit array to determine the speed of sound at the transducer face and account for ray bending at the acoustic source. Continuous speed of sound measurements was provided by the SVS to the multibeam system. ■ A real-time comparison was set up between the SVS and SVP readings as an indication of MBES refraction errors. If the comparison was greater than 2 m/s, the online surveyor assessed the raw data for refraction artefact. If an unresolvable refraction error existed, another SVP cast was taken and input to Starfix NG. ■ Fugro used best industry practice to achieve the required 16 hits per 1 m bin requirement in the first instance by operating the multibeam echosounder at full rate dual head mode. During survey operations multibeam settings were constantly monitored to ensure optimal performance. Swath angle and vessel speed was monitored and reduced in deeper waters to focus the same number of receive beams over a smaller seabed area to ensure hit count was maintained. The effect of reducing swath width was reduced seabed coverage and therefore reduced line spacing. ■ Prior to commencement of the survey a verification was undertaken for the following variables: i) latency, ii) pitch, iii) roll, iv) yaw. The verification data were processed before the start of the survey as described in Fugro's work instruction WI-207 and WI-229. At intervals throughout the survey this was repeated to ensure there has been no change to the calibration parameters. Calibrations were described in a mobilisation report. ■ During vessel calibrations, a comparison of all SVP's was carried out with a simultaneous cast in a water depth similar to that expected during the survey. ■ Survey data were collected to the required survey specification and monitored using Starfix.NG online sounding grid and Caris HIPS&SIPS offline sounding grid QC statistics.
Processing	■ The data were processed according to Fugro's standard procedures. • CARIS HIPS files were corrected for any sound velocity refraction errors. • When required, data point cleaning was conducted in CARIS using the CUBE algorithm, which used site specific parameters to ensure no valid data were removed (noise was flagged only and remained within the raw data set). ■ The CUBE algorithm search radius did not exceed the specified bin size. Data were finally quality controlled again to ensure compliance to the specification.
Data Outputs	■ Gridded soundings at 0.25 m (.XYZ ASCII / .tif); ■ Gridded hill shaded map (.tif) ■ Gridded THU at 1 m (XYTHU ASCII) ■ Gridded TVU at 1 m (XYTVU ASCII) ■ Gridded Slope at 1 m (XYS ASCII) ■ Vessel tracks (.shp)

Multibeam Echosounder	
Methods and Resolution Limitations	■ The multibeam bathymetry data collected were of good quality. Any noise present in the data were removed and the remaining data were corrected for residual tide and sound velocity errors. Density, THU and TVU of MBES footprints were monitored during acquisition. This ensured all data met the requirements as set out in the technical specifications. ■ The multibeam backscatter data collected were of good quality. Optimum power and gain settings were utilised during data acquisition to ensure high quality acquisition. During the survey multibeam range changes were minimised to maintain the quality of the MBES data. ■ There was some nadir noise present, primarily on the lines in the shallowest areas. To counter this, noise filters have been applied over these areas and manual cleaning has been performed to remove the remaining worst affected areas.

2.2.3.2 Backscatter

Table 8: Backscatter methodology

Item	Description
Equipment	As per the Multibeam
Data Collection	A dual-head Teledyne RESON SeaBat 7125 SV2 FP3 multibeam echo sounder system was pre-mobilised and mounted onto the hull of the vessel. To minimise intensity variations of the backscatter mosaic, power and gain changes were kept to a minimum during the survey. Any setting changes were done during line turns if possible. Survey data were collected to the required survey specification.
Processing and Interpretation	Following acquisition, data were returned to Fugro's Portchester office and copied to a dedicated project network with replication between the Portchester office and an on-site location. Backscatter data contained in the files were imported to the Fledermaus Geocoder toolbox (FMGT) in order to generate a georeferenced mosaic at suitable resolution. The software package was processed by taking the backscatter intensity of each survey line and applying corrections in an attempt to normalise the backscatter intensities. Corrections applied allowed for the differing intensity due to beam angle gain power, beam pattern and radiometric correction due to signal attenuation. Once the corrections were applied the final mosaicked intensity values represented the actual reflectivity of the seafloor. Manual normalisation was carried out where necessary, within FMGT to apply a brightness bias to individual survey lines to further improve the mosaic.
Data Outputs	Multibeam backscatter data grid at 0.5 m resolution (.XYA ASCII / .tif)

2.2.3.3 Subsea Positioning

Table 9: Subsea positioning.

Subsea Positioning	
Requirement	■ Provide positioning information to towed seabed sensors; ■ Update rate of 0.5 Hz or better (preferred is 1 Hz); ■ Consistent dropouts of duration > 5 seconds not accepted; ■ Following calibration of the USBL system, 95% (2 sigma) of beacon positions within ± 1 m.

Subsea Positioning	
Equipment	■ Sonardyne Mini Ranger 2 USBL system ■ Sonardyne WSM6+ transponders.
Data Collection	■ Underwater positioning data were collected in accordance with Fugro's quality management system, which complies with the requirements of ISO 9001:2015 with specific reference to work instruction WI-212; ■ The USBL transceiver was pole mounted. The USBL system received the following data corrected for the USBL transceiver location from the Fugro Starfix.NG navigation system: • Position (from Fugro StarPack GNSS); • Heading (from Applanix POSMV); • Motion (from Applanix POSMV). ■ Additionally, SVP cast information was uploaded to the USBL system after each SVP was undertaken; ■ The Fugro Starfix.NG navigation software was setup with a visual alert to highlight consistent and/or long-duration beacon dropouts to the online surveyor; ■ Prior to the start of the survey the system was calibrated, and the calibration verified by "boxing in" a seabed transponder. During calibration a transponder beacon was deployed in an area where seabed depth was appropriate for the survey site and expected towing distance. An SVP cast was conducted and entered into the system, to ensure scale errors and errors due to refraction are minimised. A series of calibration lines were recorded while the USBL interrogated the transponder. After the calibration lines were recorded, the data were processed, and a calibration report generated. Data had to be filtered to ensure accurate calibration values. The calibration values were entered into Starfix and verified by confirmation lines recorded over the seabed transponder. Once the calibration was completed, the seabed transponder was recovered by use of an acoustic release system.
Methods and Resolution Limitations	The subsea positioning was generally good throughout the survey. At mobilisation, unprocessed SSS data were found to have an average target position deviating less than < 2.0 m from the position of the same target derived from MBES. Data required a very minimal amount of de-spiking, positioning was generally good throughout the survey.

2.2.3.4 Side Scan Sonar

Table 10: Side scan sonar

Side Scan Sonar	
Requirement	■ Minimum 200% coverage (100% nadir coverage is required); ■ Data resolution sufficient for detection of seabed objects/features ≥ 0.5 m (height, width or length); ■ XY precision and accuracy of ≤ ±2.0 m; ■ Survey speed of 4.0 knots ±10%, dependent on currents and acceptability of the data; ■ Infill required where USBL gaps of more than 10 seconds along the survey line; ■ Altitude of approximately 10% of operational range, dependant on water depth and operational safety considerations such as the height of the piggybacked MAG.
Equipment	■ EdgeTech 4200 side scan sonar (300/600 kHz); ■ USBL sub-sea positioning;

Side Scan Sonar	
	■ EdgeTech Discover data acquisition software; ■ Chesapeake SonarWiz data processing software.
Data Collection	■ Side scan sonar data were collected in accordance with Fugro's Standard Procedures WI02_351, WI02_353 and WI02_354; ■ The dual channel, dual frequency side scan sonar operated at a 50-75 m range to achieve the project requirements for coverage and resolution; ■ Throughout the survey, both the high and low frequencies were recorded. Data were recorded as both XTF and JSF formats. Survey logs listing the data collection parameters were maintained throughout the survey; ■ The SSS was positioned using USBL, with a beacon mounted on the aft handle of the instrument itself with no additional offset to the transceiver required. The system was set up, and data recorded in adherence to WI02_120 and WI02_220; ■ Comprehensive survey logs listing the data collection parameters were maintained throughout the survey. Quality was continuously monitored by the online geophysicist using the online displays; further details regarding quality, possible re-runs and equipment performance were noted in the online log.
Processing	■ Data QC, data processing and contact picking were completed by geophysicists at Fugro's Portchester office; ■ The high frequency data were processed in SonarWiz from the JSF files (processing of low frequency data were not required, as stipulated in the scope of work); ■ Data files were imported into SonarWiz processing software. The navigation was checked on import with corrections applied where required. The files were then bottom-tracked before the data files were gain adjusted. As a standard the Empirical Gain Normalisation (EGN) function was used to preserve changes in reflectivity from seabed sediment variations. Where required, additional Automatic Gain Control (AGC) was used to minimise the effects of motion on the data. ■ The processor undertook QC of the positioning quality by using contacts or seabed features on lines run in opposite directions. The bathymetry data were also checked to ensure the data positioning was within expected tolerances; ■ Contacts over 0.5 m in any dimension were picked and classified. Where required, contacts were rationalised to the MBES position or to their position within sonar files.
Methods and Resolution Limitations	SSS data quality was generally good across the site. Areas of data observed to experience excessive snatch were removed and subsequently infilled with acceptable data, whilst artefacts were always minor they were easily trimmed due to the high data density. Positioning of the SSS data was generally very good across the site and was continually checked throughout the survey to ensure that it remained within the project specification of ± 2.0 m. Features present at the survey site were used to check the SSS positioning against the MBES data. During acquisition four factors resulted in limitations within the SSS data. Limitations were mitigated through processing or data were recollected where required. The limitations were: ■ Snatch in SSS data during marginal weather ■ Interference from the MBES ■ Sea defences in south of the survey area that bounces some of the acoustic signal back towards the vessel ■ Steep escarpment resulting in shadowing On numerous SSS lines, snatch was observed in varying degrees of severity, from only minor intensity differences requiring additional automatic gain control (AGC) to

Side Scan Sonar	
	strong distortion of contacts and features resulting in infill or re-runs. This was attributed to a combination of marginal weather, marine and river currents, and passing ship waves and was therefore unpredictable and difficult to mitigate. The data were reviewed on a line-by-line basis with EGN applied to ensure quality was always sufficient to meet the interpretation requirements. After the data were deemed acceptable, high-resolution low-intensity AGC filters were applied to the final mosaic which greatly enhanced the interpretability of the data. On the majority of the SSS data acquired with 75 m range, noise in the outer ranges was observed in both channels. Due to sufficient data coverage and overlap it was determined that there was no significant impact on the interpretability of the data. All lines had their displayed ranges limited to 60 m in the final mosaic which removed this noise. The western half of the southern boundary of the survey area was characterised by an extensive sea defence related to the port of Rotterdam. This extends approximately 50 m from the boundary and consists of regularly shaped rock armour for 10-15 m from the boundary, becoming irregular rock dump for the final 35-40 m of the slope. Shadowing was observed in the centre of the site following a general trend of WNW-ESE. This represented an escarpment along the northern edge of the actively dredged channel. As lines were run near-parallel with this feature, many of the shadow zones were subsequently ensonified by adjacent lines, enabling identification of contacts. However, in regions where the gradient became very steep, the SSS was unable to ensonify these regions regardless of heading direction.

2.2.3.5 Sub-bottom Profiler

Table 11: Parametric sub-bottom profiler

Parametric Sub-bottom Profiler	
Requirement	■ 10 m penetration; ■ Vertical resolution: 0.2 metres; ■ Total horizontal uncertainty 2 m or better.
Equipment	■ System: Innomar SES-2000 Medium Parametric sub-bottom profiler; ■ Acquisition system: SESWIN; ■ Conversion Software: SES Convert; ■ Processing Software: RadExPro.
Data Collection	■ Sub-bottom profiler data were collected in accordance with Fugro's standard procedures, a component of Fugro's Quality Management System, which complies with the requirements of ISO 9001:2015, ensuring that data is collected in accordance with the scope of work and Fugro's procedures; ■ A test was undertaken at the start of the survey to determine the optimum settings to achieve the best records with the system. As the survey progressed the system was adjusted to obtain the best records. Each change was entered into the survey logs; ■ The data were acquired in a raw format and converted into SEGY. The data were frequency filtered online for the purposes of QA, although this filter was not applied to the recorded SES3 files. The optimum settings were determined as appropriate to the site; ■ All data were recorded digitally in the SESWIN acquisition system along with positional data from the positioning system provided by Fugro Starfix. Any duplicates in source coordinates caused by shot interval and navigation point separation were corrected using an interpolation method;

Parametric Sub-bottom Profiler	
	■ Comprehensive survey logs listing the data collection parameters were maintained throughout the survey. Quality was continuously monitored by the online geophysicist using the online displays; further details regarding quality, possible re-runs and equipment performance were noted in the online log.
Processing	■ All data were quality checked and processed according to Fugro's standard procedures; ■ Initial data QC, data processing and deliverables were completed at Fugro's offices in Portchester: • Heave compensation. • Amplitude Correction: Time raised to the power: 2.0; • Bandpass filtering Low cut frequency 2,200 Hz and High cut frequency 14,000 Hz; • Burst Noise Removal: Window size: 7 traces, Rejection percentage of alpha trimmed average: 50%, Exclude amplitudes lower than 5% of average. ■ Data and navigation QC.
Methods and Resolution Limitations	SBP data quality was monitored throughout the survey and generally deemed to be high. The acquisition frequency was kept constant (6 kHz) throughout the project to maximise penetration. Across the site average depth penetration of the SBP data ranged between 5 – 10 m. Positioning of the SBP data was verified to ensure that it remained within the project specification of ± 2 m. Features present within the survey site were used to check the SBP positioning against the MBES data. During acquisition several factors resulted in limitations within the SBP data. Limitations were mitigated or data were recollected where possible. Limitations included: ■ Anthropogenic features impacting data penetration and quality. ■ Regions of seismic data transparency ■ Masking of data due to acoustic blanking ■ Unfit data quality due to aeration of water column ■ Weather effects

2.2.3.6 Single Magnetometer

Table 12: Magnetometer

Single Magnetometer	
Requirement	■ 10 m maximum flying altitude; ■ Magnetometer sampling frequency: 10 Hz; ■ Maximum noise level: ±1.5 nT; ■ Lateral blanking distance shall be 2.5 m and cell size of 0.5 m for grids; ■ Data rejected for any USBL gap or altitude out of spec for more than 10 seconds.
Equipment	■ 1x Geometrics G882 magnetometer fitted with a depth sensor and altimeter; ■ USBL subsea positioning; ■ Starfix data acquisition software; ■ Oasis Montaj data processing software.
Data Collection	■ Magnetometer data were collected and processed in accordance with Fugro's standard procedures, a component of Fugro's Quality Management System, which complies with the requirements of BS EN ISO 9001:2008.

Single Magnetometer	
	■ The magnetometer was positioned using the USBL. Real-time positions for the sensor was then output to the acquisition software and recorded along with the magnetometer readings and altitude data. Magnetometers were towed at less than 10 m altitude, as close to the seafloor as possible. ■ Magnetometer values in nT, depth and altimeter readings were collected at an update rate of 10 Hz. The data were logged in Starfix acquisition software together with navigation information and a time stamp. ■ Additional required fields such as USBL sensor to vessel range were output from the navigation software and were logged as a separate text file. The data were sampled into the raw Oasis Montaj database on import. ■ Magnetometer data were continuously QC'ed by personnel in Fugro's office in Portchester, UK. Re-runs and infills were acquired based on out of specification cases for magnetometer data.
Processing	■ All data were processed and reported according to Fugro's standard procedures; ■ All magnetometer data were QC'ed for data quality and processed at Fugro's offices in Portchester, UK. Processing was followed by gridding, picking and preparation of final deliverables; ■ Magnetometer gaps / reruns and infill sections were finalized from onboard Seeker when required; ■ Fugro's magnetometer processing and interpretation procedure can be broadly separated into the following stages: • Data import; • Navigation processing and QC of all data; • Export of all data for processing in Oasis Montaj; • Import into Oasis Montaj; • QC all data channels and double check for navigational errors; • De-spiking and QC of total field and altitude data; • Removal of data where the signal strength <100; • Removal of data set sections exhibiting greater than ±1.5 nT noise tolerance; • QC of total field data, signal strength and altitude; • Filtering and calculating residual. • Gridding of the total field data, magnetic residual, signal strength and altitude; ■ Data were reviewed on a line-by-line basis and any sections exceeding system noise parameters (typically ±1.5 nT), altitude > 10 m and signal strength <100 were removed before gridding. Any data gaps resulting from such a process were infilled as required; ■ Filtering and calculating the residual values involved the selection of suitable parameters to ensure that background variations in the magnetic field were removed, without affecting any potential anomalies. Data were subject to a beta-spline filter, followed by a series of non-linear filters with decreasing width and tolerance; ■ The calculated background field was subtracted from the measured field to produce the magnetic residual; ■ Data were interpreted as gridded datasets and profiles.
Methods and Resolution Limitations	The magnetometer data quality was monitored throughout the survey. Spatial accuracy within 2 m was achieved with a USBL positioning beacon placed on the towed side scan sonar fish. The overall data quality was good. The processors QCed the positioning and quality of the magnetometer data, all data met the specification requirements of the project.

Single Magnetometer	
	During acquisition, limitations to the data quality arose from challenges that were encountered as part of data collection. Limitations included: ■ Magnetic signal spikes (due to defect equipment) ■ Signal strength below 400 ■ Navigation gaps longer than 10 seconds due to USBL failures When limitations in the data quality arose, the data were checked. Where possible small spikes were interpolated and short drops in signal strength were assessed to identify the impact on data quality. For the navigation gaps, and in regions where the reduction of signal strength impacted the data quality, data were infilled.

2.2.3.7 2D-UHRS

The seismic data acquisition was performed using an ultra-high-resolution seismic system including a single Geo-Source 400 tips LW sparker, two 2000XFO HV Geo-Spark power supplies, 24- channel streamer with a 1+2 m group interval, a 24-channel recording system, a single element reference hydrophone and GNSS positioning systems for the streamer's front buoy and tail buoy and source.

Figure 2.1 describes the 2D-UHRS equipment and the general acquisition parameters used in this project.

Sources	1x Geo-Source 400 tips LW
Source Towing Depth	0.3 m
SP Interval	1 m
Operating Power	Source @ 400J
Tuned delay	-
Power Supply	2 X Geo-Spark 2000XFO
CDP Bin Coverage	≈24 fold for 1 m CDP bin
Recorder	4x Multitrace24 – Geomarine Survey systems
Sample Rate	0.1 msec
Record Length	200 ms
Format	SEG-Y
Multichannel Streamer	Geo-Sense LW 24 channels
Streamer Depth	≈ 0.4 – 1.3 m
Group Interval	1+2m
Group Active Length	35 m
Reference hydrophone	Geo-Sense reference hydrophone – single element
Hydrophone Depth	5 m from the source
Group Interval	Single element
Group Active Length	Point receiver

Figure 2.1: Fugro Seeker 2D-UHRS system and parameters.

The seismic spread geometry used during the survey is presented in the Figure 2.2 with the respective measurements - offsets.

Refer to the *2D UHRS Survey Field Report*, part of the *F197217-REP-RES-002_Nearshore Geophysical Survey Report*, for a detailed description of the 2D-UHRS processing method.

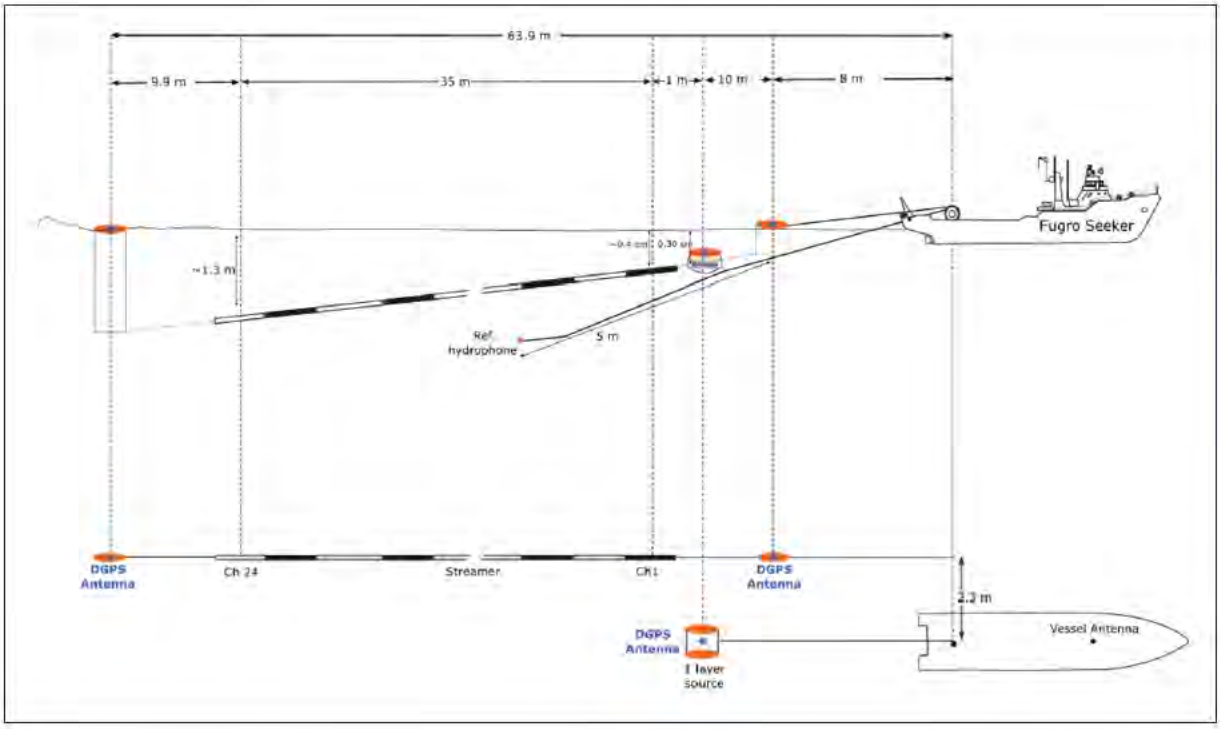


Figure 2.2: Vessel layout.

2.2.3.8 Refraction Seismic and MASW Scope

For the Refraction Seismic and GAMBAS scope, the line plan consisted of 39 lines in two parts. Within the shallow parts of the site, to the north and south of the channel, a 150m refraction and MASW stream was used. Within the deeper area of the channel, a 90m MASW streamer was used. The lines in the main channel, and some lines to the South, were parallel to the channel. The lines to the North of the channel were oriented North – South.

During acquisition, the Client requested Seeker concentrated on a set of priority lines due to the prospect of unworkable weather impacting progress. This reduced the number of remaining lines by half and involved acquiring every second line. Following the completion of priority lines, a further two non-priority lines were acquired whilst awaiting Client confirmation to cease acquisition. A total of 32 lines covering 31.7km were acquired.

Table 13: Refraction Seismic and MASW Scope

Single Magnetometer	
Requirement	■ Vessel speed <2.2knots ■ Sledge and streamer on the seabed
Equipment	■ Access channel: 48 hydrophones variable spacing, total length 90m, for MASW and Refraction acquisition ■ Shallowest water: Combination of 1 x 24 low frequency hydrophones (MASW+refrac) ■ 45m and 1x24 standard hydrophones (refrac only) 115m long. Total streamer length of approximately 150m allowing deeper penetration. ■ USBL subsea positioning for the sledge

Single Magnetometer	
Data Collection	■ Streamer and sledge were lowered down on the seabed 300m before the start of a line and brought back at the surface when a line was completed. ■ Acquisition started when the USBL showed that the sledge was at the beginning of the line and stopped when the sledge was after the end of the line to maximise coverage. ■ Buffer zones were decided onboard, for example when we had to deviate from the line because a buoy was there and equipment could get tangled in it. ■ The control panel on deck that fires the airgun gave the instruction to both the seismic recording system and the navigation system to log the data. ■ Recording parameters: length of 2sec and sampling rate of 0.250ms. ■ Air gun pressure between 95 and 110bars. ■ On-line QC was done for refraction and MASW data. It consisted of a check of individual hydrophone validity, validation of signal to noise ratio, checking that we could pick the first arrivals on the whole streamer for refraction and checking that we could see a dispersion curve for MASW. The position of the sledge was also checked in real time.
Processing	■ The processing involves 3 main steps: • Merge of positioning, bathymetric and seismic data; • Picking of regression curves for refraction; Picking of dispersion curves for MASW; • QC and exports of bar charts and maps. ■ The seismic refraction processing itself includes starts with the picking of the first arrival of the compressional wave recorded at each hydrophone. Picked times measured for each trace feed a Time-Distance curve for each shot point. Regression of Time-Distance curve allows to extract a series of compressional wave velocities (Vp) and corresponding thicknesses are identified. Each pair of values Vp - thickness is representative of a layer of constant average velocity. ■ The MASW processing starts with the picking and extraction of the dispersion curve of the fundamental mode for every shot. After inversion of every dispersion curve, data are merged and kriged to produce a 2D section of shear waves velocities (Vs).
Data Outputs	■ Refraction: Gridded bar charts which is the raw VP profile, meaning no smoothing, filtering or kriging has been applied. ■ MASW: Gridded 2D sections with kriging applied.

2.2.4 Operations – Fugro Discovery

The objective of the survey was to identify and delineate any possible constraints and hazards from man-made, natural and geological features which may affect the integrity of the exploration site/development area.

The geophysical survey line plan covers the pipeline RPL options with a centreline and contains a further eight wing lines, four per side. Line spacing is 60 m inside a 480-metre-wide corridor.

2.2.5 Survey Requirements – Fugro Discovery

Table 14: Work Element 3 survey requirements overview

Equipment Method	Survey Requirements
Vessel	Fugro Discovery
Line Spacing	Geophysical 60 m
Max. Vessel Speed	4 knots (±10%)
Surface Positioning	▪ THU < 1.0 m (1.414 – σ) ▪ TVU < 30 cm (1 - σ)
Subsea Positioning	Fugro will only be able to repeatedly achieve +/- 1 m accuracy for USBL calibration and +/-2 m accuracy for data acquired from towed sensors. i.e., a processed target accuracy of +/-2 m for SSS and magnetometer.
Multibeam Echosounder	▪ 100% coverage with 20% overlap between lines ▪ 0.25 m x 0.25 m bin size / 16 x pings per 1.0 m x 1.0 m
SVP	▪ The speed of sound in water shall be measured in the survey area. ▪ The Vertical Sound Velocity Profiles should be undertaken with an accuracy of ±0.05 m/s
Side Scan Sonar	▪ ≥0.5 m target size ▪ 200% coverage, 100% coverage in the SSS nadir ▪ Infill required where USBL gaps > 10 s
Magnetometer	▪ Single magnetometer ▪ 5 – 10 m altitude ▪ Magnetometer sampling frequency: 10 Hz ▪ Target size 5 nT ▪ Noise Level ± 1.5 nT (3 nT in total) ▪ Lateral blanking distance shall be 2.5 m ▪ Infill required where USBL gaps > 10 s, altitude out of spec for more than 5 m, or signal strength < 100
Sub-bottom profiler	10 m penetration with 0.2 m resolution

2.2.6 Processing – Fugro Discovery

2.2.6.1 Multibeam Echosounder

Bathymetry data collected from the hull mounted dual head Kongsberg EM2040 multibeam echosounder onboard the survey vessel, were processed with CARIS Hydrographic Information Processing System and Sonar Information Processing System (HIPS and SIPS) software (Version 11.4). The CARIS HIPS and SIPS general workflow is presented in Table 2.12. Neighbouring blocks were systematically merged towards completion of data processing.

Table 15: CARIS HIPS and SIPS bathymetry processing workflow

CARIS HIPS Work Step	Description
1. Raw MBES Data	MBES raw data as logged by Kongsberg SIS
2. HIPS Vessel File	Before data were converted into Caris HIPS, a so-called HIPS Vessel File (HVF) was defined. This HVF contains all relevant sensor definitions with information regarding offsets, correction values, and system configurations. The HVF defines amongst others: ▪ Offsets relative to the centre reference point (CRP);

CARIS HIPS Work Step	Description
	■ Sound velocity information; ■ Dynamic MBES motion (heading, roll, heave, pitch); ■ Static corrections for gyro heading and error for roll, heave and yaw heading alignment of the multibeam system; ■ Static TPU (total propagated uncertainty) settings including offsets and survey equipment standard deviations (based on technical specifications).
3. Data Conversion to HIPS	The multibeam raw data exported from the acquisition software was converted into HIPS format. Positioning information included in the raw data is based on geographical coordinates.
4. Quality Control (navigation, attitude data)	Navigation and attitude data were checked for spikes. This was done manually or by using self-defined filters. Spikes were marked and flagged as 'not to be used for further calculation.' Coverage was carefully checked for gaps and data density and infill lines were surveyed if necessary. Secondary (backup) systems for navigation and attitude data could be added to the HIPS and SIPS project if required.
5. Swath Filter	Depth information of one survey line was filtered for spurious values and data not to be used. Filter settings for flagging data as rejected can include the following settings: ■ Min-max. accepted depth range; ■ Distance off nadir; The filters are applied according to the encountered morphology, weather conditions etc. The applied values may vary from area to area. Nevertheless, each line was checked separately, and the filter parameters were adapted if necessary.
6. Tide Reduction	All depths were reduced to LAT using the NL2018LAT MSS model within Caris HIPS & SIPS. Navigation, motion and StarFix.G4+ GNSS elevation data were processed using Novatel´s Intertial Explorer software package. Ellipsoidal heights of the GNSS antennas were corrected for motions. The heights were reduced to the water line using draught and dimensional offset measurements. Waterline elevations are further reduced to the vertical datum (LAT) by means of NL2018LAT MSS model. A smooth tide curve was created to reduce MBES data to datum.
7. Sound Velocity Correction	Each track line was corrected for sound velocity.
8. Calculation of Final Position and Depth for each Beam (georeferenced bathymetry)	For each individual beam a position and a depth value were calculated with respect to vessel (gyro) heading, tide data (including dynamic draft) and sound velocity correction using time as correlation. In addition, the TVU and THU[1] for each sounding was calculated.
9. Create Work Surface	The pre-checked data were used to calculate a CUBE (Combined Uncertainty and Bathymetric Estimator) surface.
10. Surface Filter using "Swath Angle" grids	A HIPS "Swath Angle" surface allowing maximum sounding footprints was then used as a base for a surface filter, for which a data window of acceptance around this surface must be specified using certain parameters. The survey data is then checked against these conditions. Data outside the specified window of acceptance were rejected.
11. Create Quality Control Surfaces (CUBE)	The CUBE algorithm creates a hypothesis for the depth value of a grid cell from the first depth value that falls into a cell. Every following depth value is checked against this hypothesis and according to a variety of settings selected to contribute to the existing hypothesis, to create a new, second hypothesis or to be rejected. A most probable surface is resulting from these calculations. New base surfaces were calculated to check the result. Having undergone these procedures, the data is in a final state for delivery. Contour calculation was achieved by using Fugro Starfix Workbench and ESRI ArcGIS.

CARIS HIPS Work Step	Description
12. Quality Control	The data quality is mainly checked using the standard deviation, density (hit count), TVU/THU and visual bathymetry inspection. Local anomalies are removed manually or by a locally applied filter.
13. Data Export	As a deliverable from HIPS, a gridded and ungridded datasets were produced and exported as ASCII files. Fugro Starfix.Workbench and ArcGIS were used to create final deliverables.

Note 1:
TVU and THU values were calculated using Caris HIPS&SIPS considering all contributing factors applicable for the vessels.
TVU and THU are defined as follows by the IHO Standards for Hydrographic Surveys (S-44), 6th Edition:

- Total horizontal uncertainty (THU): Component of total propagated uncertainty (TPU) calculated in the horizontal dimension. THU is a two-dimensional quantity with all contributing horizontal measurement uncertainties included. Total propagated uncertainty (TPU): Three-dimensional uncertainty with all contributing measurement uncertainties included.
- Total vertical uncertainty (TVU): Component of total propagated uncertainty (TPU) calculated in the vertical dimension. TVU is a one-dimensional quantity with all contributing vertical measurement uncertainties included.
- Uncertainty: Estimate characterising the range of values within which the true value of a measurement is expected to lie as defined within a particular confidence level. It is expressed as a positive value.

2.2.6.2 Side Scan Sonar

Table 16: Side Scan Sonar

Side Scan Sonar	
Requirement	■ Minimum 200% coverage (100% nadir coverage is required); ■ Data resolution sufficient for detection of seabed objects/features ≥ 0.5 m (height, width or length); ■ XY precision and accuracy of ≤ ±2.0 m; ■ Survey speed of 4.0 knots ±10%, dependent on currents and acceptability of the data; ■ Infill required where USBL gaps of more than 10 seconds along the survey line; ■ Altitude of approximately 10% of operational range, dependant on water depth and operational safety considerations such as the height of the piggybacked MAG.
Equipment	■ EdgeTech 4200 side scan sonar (300/600 kHz); ■ USBL sub-sea positioning; ■ EdgeTech Discover data acquisition software; ■ Chesapeake SonarWiz data processing software.
Data Collection	■ Raw SSS data were logged in XTF and JSF formats in the EdgeTech Discover acquisition software, with smoothed navigation integrated within them from the Qinsy online navigation software. ■ The dual channel, dual frequency side scan sonar operated at a 50-75 m range to achieve the project requirements for coverage and resolution; ■ Throughout the survey, both the high and low frequencies were recorded. Data were recorded as both XTF and JSF formats. Survey logs listing the data collection parameters were maintained throughout the survey
Processing	■ The JSF formats files were then imported into SonarWiz on two separate projects, one for LF and HF. Navigation was smoothed with a 50-ping rolling mean on import. ■ All data were bottom tracked to allow slant range corrections to be applied. Position and heading smoothing were applied to remove slight navigation jumps. Further navigation filters were applied in SonarWiz where required. Empirical gain normalization (EGN) was applied for every single line to level and average the sonar amplitudes by altitude and range to construct a homogenous

Side Scan Sonar	
	mosaic. Some manual adjustments to the gains were required to ensure a good match throughout. ■ To check the accuracy of the navigation data, SSS data from adjacent lines, run in opposite directions on a known MBES position, are compared and verified against each other and against the bathymetry. ■ Nadir transparency was set to 1.5 m and where necessary, the displayed sonar range was reduced to trim out any environmental artifact or fish ghosts. ■ Line order was adjusted to improve the overall appearance of the mosaic, sending marginal quality data to the back, and aiming to minimise the number of visible artifacts. ■ All contacts greater than 0.5 m in any dimension were identified and listed. Contacts were manually picked on a line-by-line basis from the waterfall display using the HF data. These were then measured (width, length, and height), classified, and moved to the MBES position, where possible. ■ The contact list was exported as csv and after curating, was converted to shapefile format in ArcGIS.
Methods and Resolution Limitations	■ SSS data quality was generally good across the site.

2.2.6.3 Parametric Sub-bottom Profiler

Table 17: Parametric sub-bottom profiler

Parametric Sub-bottom Profiler	
Requirement	■ 10 m penetration; ■ Vertical resolution: 0.2 metres; ■ Total horizontal uncertainty 2 m or better.
Equipment	■ System: Innomar SES-2000 Medium Parametric sub-bottom profiler; ■ Acquisition system: SESWIN;
Data Collection	■ Innomar SBP data were logged in SES3 format by the SESWIN acquisition software, with navigation integrated within them from the Qinsy online navigation software. The geometry correction of the transducers to the Centre of Gravity (COG) is applied during acquisition in Qinsy and SESWin. The SES3 files were converted to SEGY format with the Innomar SESConvert software and merged if the file had been split on different segments on acquisition. During conversion, deduplication and interpolation of the raw navigation was conducted to ensure each slot contained a unique coordinate. ■ The output SEGY files were processed in the GeoSuite Allworks processing software.
Processing	■ The signal processing flow comprised the following steps: ■ Shifting the data as per the record delay; ■ Amplitude correction Automatic Gain Control Window Length: 10 ms Percent: 25 %; ■ Butterworth bandpass filter with a low-cut of 2 kHz, and a high-cut of 15 kHz; ■ Burst noise removal (Window: 7, Rejection: 50 %); ■ Where occasional residual heave was observed, a swell filter was designed on a line-by-line basis over a 50 trace length smoothing filter

Parametric Sub-bottom Profiler	
	■ After signal processing the tide correction was applied as a trace-by-trace tidal reduction applied to the COG using the tidal curve and further corrections of the SBP data for the vessel's heave and reduction of the data to LAT. ■ Ultimately, the LAT corrected SEGY files were exported together with their headers and imported into the Kingdom software for QC against the MBES data to ensure that the tidal correction was successful and that there was a good correlation between the two datasets.

2.2.6.4 Single Magnetometer

Table 18: Magnetometer

Single Magnetometer	
Requirement	■ 10 m maximum flying altitude; ■ Magnetometer sampling frequency: 10 Hz; ■ Maximum noise level: ±1.5 nT; ■ Lateral blanking distance shall be 2.5 m and cell size of 0.5 m for grids; ■ Data rejected for any USBL gap or altitude out of spec for more than 10 seconds.
Equipment	■ 1x Geometrics G882 magnetometer fitted with a depth sensor and altimeter; ■ USBL subsea positioning;
Data Collection	■ The data was recorded in QPS qpd-format and exported in an ascii text file format, with raw navigation integrated. Exported ascii files were then imported into Oasis Montaj for processing.
Processing	■ Once into Oasis Montaj the navigation data were cleaned; large spikes caused by any jumps in the USBL navigation were identified, removed manually and data interpolated. A 150-ping rolling mean filter was applied to remove any smaller erroneous values. ■ The raw altitude, signal, and magnetic total field were checked and manually de-spiked, with altitudes above the 5 m specification being masked in most areas. ■ Areas with signal strength below 400nT were carefully reviewed to ensure the data quality was still sufficient and consistent, being removed if not. Areas with signal strength below 100nT were deemed unreliable and were masked. ■ The optimum ß-Spline filter settings for this project have been evaluated to be Smoothness 0.6 and Tension 0. These values were used to filter the raw magnetometer readings. ■ A series of non-linear filters were applied to fit a smoothed curve to the data. The results of the non-linear filters were then subtracted from the results of the β-spline filter to calculate a residual magnetometer data channel. ■ The filtered data were gridded using the minimum curvature gridding method. For gridding, a grid cell size of 0.5 m and a blanking distance of 2.5 m were used. ■ Magnetic anomalies were picked manually on the total field profiles and reviewed against the residual field grid to remove duplicates and erroneous picks, and to manually pick any missed anomalies. The reviewed list of anomalies was then manually measured for peak-to-peak amplitude.

2.2.7 Operations – Fugro Searcher

The objective of the survey was to identify and delineate any possible constraints and hazards from man-made, natural and geological features which may affect the integrity of the exploration site/development area.

The Fugro Searcher was assigned four sections (Section C, Section F, Section D and Section K14-L4A) of the offshore main pipeline corridor and the offshore hub area. The scope was divided in four scopes as presented in Table 2.13.

Table 19: Scope of work of Fugro Searcher

Area of Operation	Scope Requirements
UHRS Scope	2D UHRS, MBES Acquired on pipeline route centreline & offshore hub area
UXO Scope	MBES, SSS, SBP and MAG Acquired at two lines in the areas assessed as moderate UXO risk
Analogue Geophysical Scope	MBES, SSS, SBP, MAG Acquired at pipeline route centreline with 8 wing lines, as well as offshore hub area.
Environmental Scope	Environmental Baseline Study

The UXO Scope dataset is not presented in this report and dataset.

The results of the Environmental Baseline Study will be incorporate in the upcoming integrated report.

2.2.8 Processing – Fugro Searcher

2.2.7.1 Multibeam Echosounder

Table 20: Multibeam Echosounder

Multibeam Echosounder	
Requirement	■ 0.25 m grid resolution ■ Minimum density 16 valid pings per 1 m^2 ■ Simultaneous recording of backscatter
Equipment	■ Hull mounted dual head Kongsberg EM2040
Data Collection	■ Bathymetric data were logged within the Kongsberg SIS software for the EM2040 MBES, and within the Starfix. Logging application EA600 SBES system.
Processing	■ Data were post-processed using the Caris HIPS&SIPS suite of applications. Both single beam and multibeam echosounder data were corrected for transducer draught, acoustic velocity through sea water and vessel heave, pitch and roll, and then positioned with reference to the echosounder transducer. ■ Observed Mean Sea Surface (MSS) tides were recorded online. These tides were then reduced to Lowest Astronomical Tide (LAT) using the NL 2018 LAT model in the Dutch sector. ■ The multibeam echosounder (MBES) data were processed using both Kongsberg's online software, SIS, and Caris HIPS&SIPS SIS computed the x,y,z coordinates of the multibeam data by transforming the travel time and angle of the beams, using the water's sound velocity and the vessel's motion data. The MBES data were then processed using Caris HIPS&SIPS to monitor quality and overlap using automated methods and then edited using manual methods for final cleaning of any erroneous data from the swathes. The files were then merged to form one large regular 0.25 m× 0.25 m grid and filtered. Points

Multibeam Echosounder	
	outside the accepted tolerances were removed automatically. The resultant output file was generated to form a regular XYZ file. ■ All depths were reduced to Lowest Astronomical Tide (LAT).

2.2.7.2 Side Scan Sonar

Table 21: Side Scan Sonar

Side Scan Sonar	
Requirement	■ Minimum 200% coverage (100% nadir coverage is required); ■ Data resolution sufficient for detection of seabed objects/features ≥ 0.5 m (height, width or length); ■ XY precision and accuracy of ≤ ±2.0 m; ■ Survey speed of 4.0 knots ±10%, dependent on currents and acceptability of the data; ■ Infill required where USBL gaps of more than 10 seconds along the survey line; ■ Altitude of approximately 10% of operational range, dependant on water depth and operational safety considerations such as the height of the piggybacked MAG.
Equipment	■ EdgeTech 4200 side scan sonar (300/600 kHz); ■ USBL sub-sea positioning; ■ EdgeTech Discover data acquisition software; ■ Chesapeake SonarWiz data processing software.
Data Collection	■ Raw SSS data were logged in XTF and JSF formats in the EdgeTech Discover acquisition software, with smoothed navigation integrated within them from the Starfix online navigation software. ■ The dual channel, dual frequency side scan sonar operated at a 50-75 m range to achieve the project requirements for coverage and resolution; ■ Throughout the survey, both the high and low frequencies were recorded. Data were recorded as both XTF and JSF formats. Survey logs listing the data collection parameters were maintained throughout the survey
Processing	■ The JSF formats files were then imported into SonarWiz on two separate projects, one for LF and HF. Navigation was smoothed with a 50-ping rolling mean on import. ■ All data were bottom tracked to allow slant range corrections to be applied. Position and heading smoothing were applied to remove slight navigation jumps. Further navigation filters were applied in SonarWiz where required. Empirical gain normalization (EGN) was applied for every single line to level and average the sonar amplitudes by altitude and range to construct a homogenous mosaic. Some manual adjustments to the gains were required to ensure a good match throughout. ■ To check the accuracy of the navigation data, SSS data from adjacent lines, run in opposite directions on a known MBES position, are compared and verified against each other and against the bathymetry. ■ Nadir transparency was set to 1.5 m and where necessary, the displayed sonar range was reduced to trim out any environmental artifact or fish ghosts. ■ Line order was adjusted to improve the overall appearance of the mosaic, sending marginal quality data to the back, and aiming to minimise the number of visible artifacts. ■ All contacts greater than 0.5 m in any dimension were identified and listed. Contacts were manually picked on a line-by-line basis from the waterfall display

Side Scan Sonar	
	using the HF data. These were then measured (width, length, and height), classified, and moved to the MBES position, where possible. ■ The contact list was exported as csv and after curating, was converted to shapefile format in ArcGIS.

2.2.7.3 Single Magnetometer

Table 22: Magnetometer

Single Magnetometer	
Requirement	■ 10 m maximum flying altitude; ■ Magnetometer sampling frequency: 10 Hz; ■ Maximum noise level: ±1.5 nT; ■ Lateral blanking distance shall be 2.5 m and cell size of 0.5 m for grids; ■ Data rejected for any USBL gap or altitude out of spec for more than 10 seconds.
Equipment	■ 1x Geometrics G882 magnetometer fitted with a depth sensor and altimeter; ■ USBL subsea positioning;
Data Collection	■ The MAG data were recorded in StarfixNG and produced in FBF file.
Processing	■ Once into Oasis Montaj the navigation data were cleaned; large spikes caused by any jumps in the USBL navigation were identified, removed manually and data interpolated. A 150-ping rolling mean filter was applied to remove any smaller erroneous values. ■ The raw altitude, signal, and magnetic total field were checked and manually de-spiked, with altitudes above the 5 m specification being masked in most areas. ■ Areas with signal strength below 400nT were carefully reviewed to ensure the data quality was still sufficient and consistent, being removed if not. Areas with signal strength below 100nT were deemed unreliable and were masked. ■ The optimum ß-Spline filter settings for this project have been evaluated to be Smoothness 0.6 and Tension 0. These values were used to filter the raw magnetometer readings. ■ A series of non-linear filters were applied to fit a smoothed curve to the data. The results of the non-linear filters were then subtracted from the results of the β-spline filter to calculate a residual magnetometer data channel. ■ The filtered data were gridded using the minimum curvature gridding method. For gridding, a grid cell size of 0.5 m and a blanking distance of 2.5 m were used. ■ Magnetic anomalies were picked manually on the total field profiles and reviewed against the residual field grid to remove duplicates and erroneous picks, and to manually pick any missed anomalies. The reviewed list of anomalies was then manually measured for peak-to-peak amplitude.

2.2.7.4 Parametric Sub-bottom Profiler

Table 23: Sub-bottom profiler

Parametric Sub-bottom Profiler	
Requirement	■ 10 m penetration; ■ Vertical resolution: 0.2 metres; ■ Total horizontal uncertainty 2 m or better.
Equipment	■ System: Innomar SES-2000 Medium Parametric sub-bottom profiler; ■ Acquisition system: SESWIN;

Parametric Sub-bottom Profiler	
Data Collection	■ Innomar SBP data were logged in SES3 format by the SESWIN acquisition software, with navigation integrated within them from the Starfixonline navigation software. The geometry correction of the transducers to the Centre of Gravity (COG) is applied during acquisition in Starfix and SESWin. The SES3 files were converted to SEGY format with the Innomar SESConvert software and merged if the file had been split on different segments on acquisition. During conversion, deduplication and interpolation of the raw navigation was conducted to ensure each slot contained a unique coordinate. ■ The output SEGY files were processed in the RadExPro.
Processing	■ The signal processing flow comprised the following steps: ■ Shifting the data as per the record delay; ■ Amplitude correction Automatic Gain Control Window Length: 10 ms Percent: 25 %; ■ Butterworth bandpass filter with a low-cut of 2 kHz, and a high-cut of 15 kHz; ■ Burst noise removal (Window: 7, Rejection: 50 %); ■ Where occasional residual heave was observed, a swell filter was designed on a line-by-line basis over a 50 trace length smoothing filter ■ After signal processing the tide correction was applied as a trace-by-trace tidal reduction applied to the COG using the tidal curve and further corrections of the SBP data for the vessel's heave and reduction of the data to LAT. ■ Ultimately, the LAT corrected SEGY files were exported together with their headers and imported into the Kingdom software for QC against the MBES data to ensure that the tidal correction was successful and that there was a good correlation between the two datasets.

2.2.7.5 2D-UHRS

The 2DUHR Sparker data was recorded in Geometric GeoEel Controller with output file format as SEGD. The SEGD files were loaded into SeisQC software for quality check on acquisition geometry, basic geometry (streamer and gun depth), active channel, noise level, and velocity picking. Brutestack of SEGY data were prepared for onboard deliverable. Further processing such as noise filtering, processing derived stacking velocities and output to fully migrated SEGY were carried out onshore.

Detailed description of the processing flow can be found in Appendix C (F197217-REP-2UHR-SR Seismic Processing Report).

3. Seafloor Overview

3.1 Bathymetry

The bathymetry along the Aramis trunkline route ranges between 0 m and 39.5 m. The nearshore area is relatively flat intersected by the dredged Maasmond Kanaal (navigation channel). The middle of the route is characterised by bedforms such as ripple, megaripple and sand waves.

The seafloor in the northern part of the route, till the Platform L4A, is mainly featureless without bedforms and water depth decreases gradually towards the north.

Bathymetry and its relative slope are given per route section (Section 5 to Section 14).

3.2 Seafloor Morphology

Seafloor morphology interpretation was based on the combination of data from MBES and SSS. The data analysis was carried out using acoustic characteristics such as overall pattern, roughness and reflectivity.

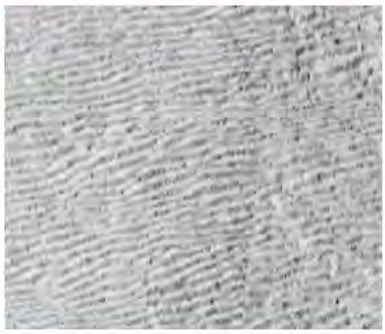
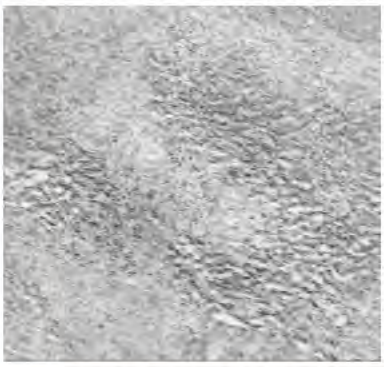
The following morphological characteristics / types were identified:

- Bedforms (ripples, megaripples and sand waves)
- Irregular seafloor
- Area with numerous boulders/debris
- Area with occasional boulders/debris

The acoustic characteristics of the identified morphological types are summarized in Table 3.1.

Table 24: Interpretation of seafloor morphology

SSS Image	Acoustic Description	Morphological Interpretation
	Low to medium reflectivity	Megaripples and sand waves

SSS Image	Acoustic Description	Morphological Interpretation
	Low to medium reflectivity	Ripples
 	Medium to high reflectivity	Irregular seafloor
	Medium to high reflectivity	Area with numerous boulders
	Medium reflectivity	Area with occasional boulders

The majority of the seafloor in the offshore area is featureless or characterised by presence of seafloor bedforms (i.e. ripples). Areas of boulders are observed through the entire route.

In the nearshore area, the seafloor is characterised by the presence of megaripples and sand waves, in addition, the seafloor is intersected by anthropogenic features.

3.2.1 Bedforms

Bedforms are produced by the action of bottom and tidal currents, which redistribute seabed sediments. Three types of bedforms were identified along the Aramis trunkline route:

- Sand waves
- Megaripples
- Ripples

Classification scheme by Ashley et al. 1990, was adopted in this report to distinguish and characterise bedforms and is detailed in Table 3.2.

Table 25: Classification scheme for bedforms (modified from Ashley et al. (1990)

First Order Description				
Size				
Spacing	0.6 to 5 m	5 to 10 m	10 to 100 m	>100 m
Height	0.075 to 0.4 m	0.4 to 0.75 m	0.75 to 5 m	>5 m
Term	*Small (ripples)*	*Medium (megaripples)*	*Large (sand waves)*	*Very large (sand dunes)*
Shape				
2D	Symmetric or asymmetric			
3D	Sinuous or hummocky			
Second Order Description				
Superposition				
Simple	No bedforms superimposed			
Compound	Smaller bedforms superimposed			

Along the Aramis trunkline route most of the bedforms fit in the range classified as ripples, although sometimes slight mismatch with the Ashley classification occurs.

Megaripples and sand waves can be found in topographical lows, where the sediment accumulates, and the currents rework the sediment creating these bedforms (Table 3.2 and Figure 3.1). In the nearshore area, the observed shape is symmetric, and the orientation is north-west to south-east. Their wavelength ranges from approximately 5.0 m to 8.0 m and the wave height varies between 0.3 m and 0.9 m. These bedforms are mostly associated with slightly gravelly SAND as interpreted from SSS and MBES data.

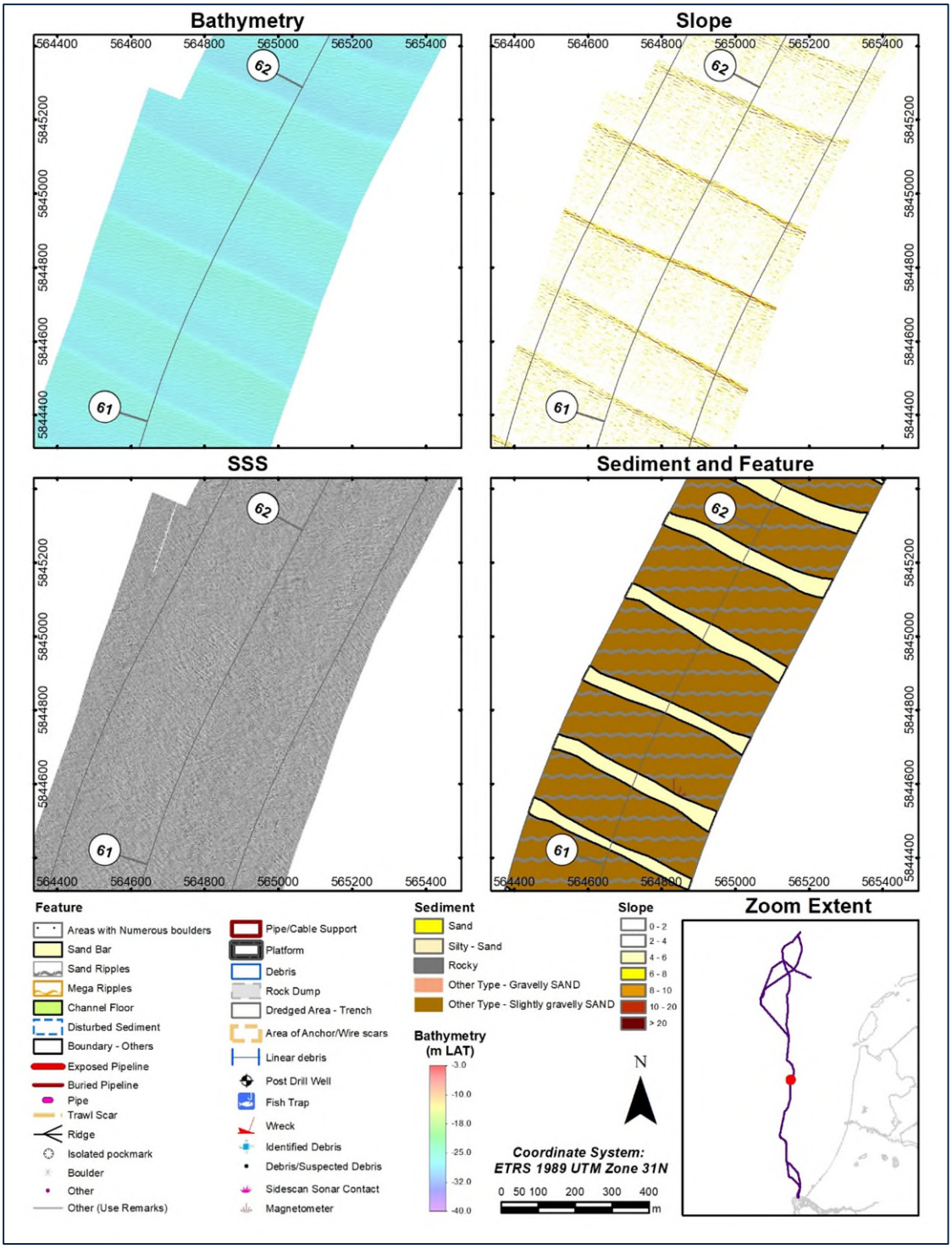


Figure 3.1: Example of megaripples ad sandwaves along the Aramis trunkline route.

In the offshore area, symmetrical (linear) ripples are the most common bedform type along the Aramis trunkline route. This type of ripples is typically found in shallow coastal waters and sandy substrate. They have generally north-west to south-east orientation. The wavelength ranges from approximately 3.0 m to 9.0 m and wave height varies between 0.1 m and 0.3 m (Figure 3.2). They are mostly associated with areas of slightly gravelly SAND as interpreted from the SSS and MBES data.

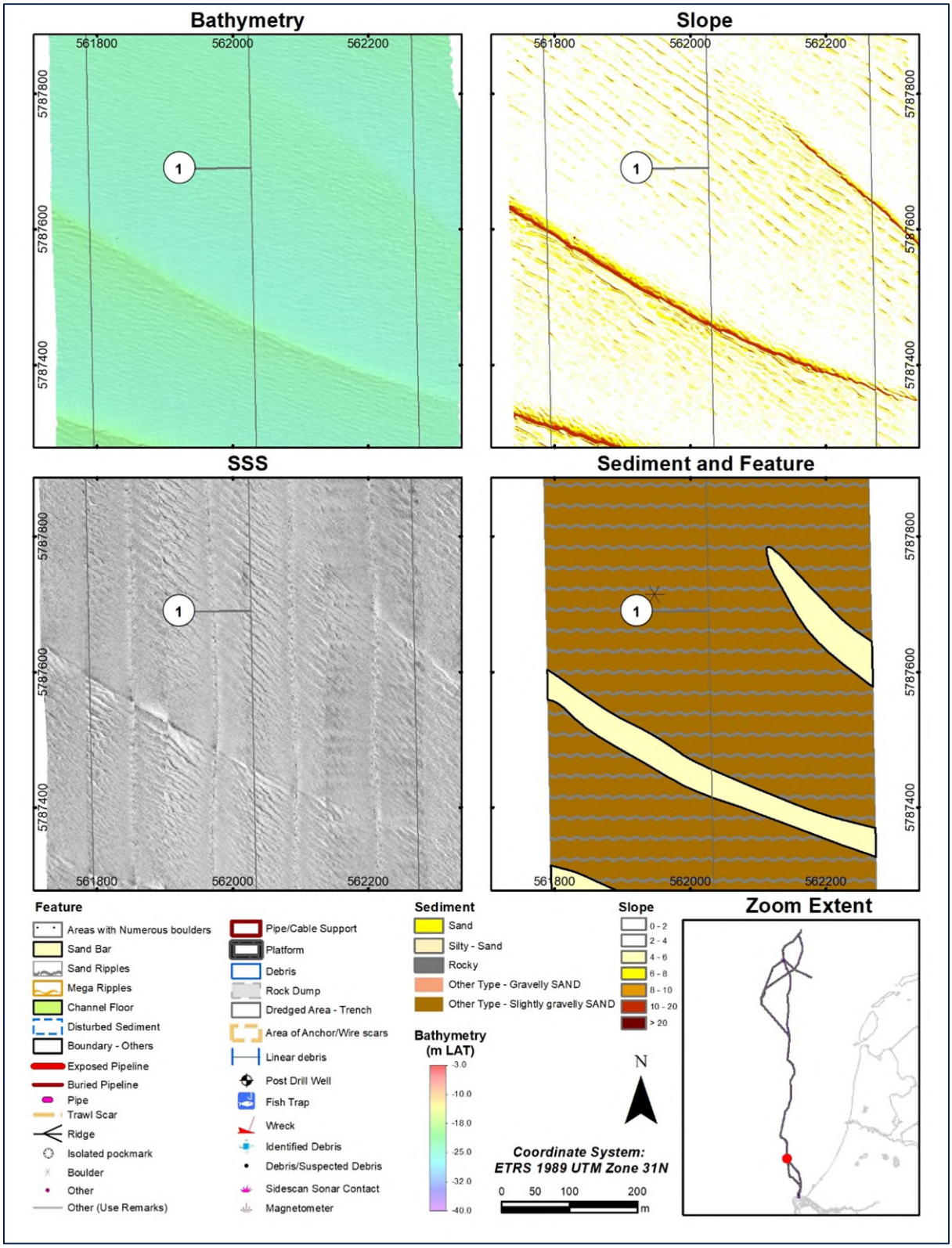


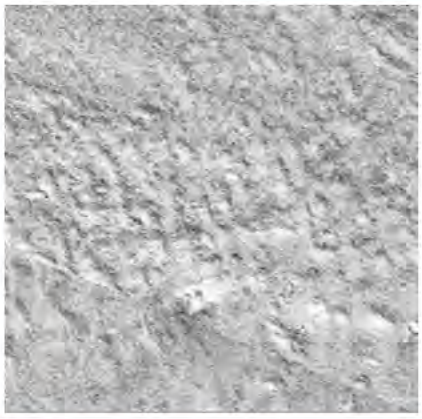
Figure 3.2: Typical area of symmetrical ripples along the Aramis trunkline route.

3.3 Seafloor Sediment Classification

Seafloor sediment interpretation and classification was based on a combination of data from MBES and SSS. The sediment classification was based on the British Standard code of practice (BSI, 2015). The data analysis was carried out using acoustic characteristics such as overall pattern, roughness and reflectivity.

The acoustic characteristics and the lithology (seafloor sediment types) identified are summarized in Table 3.3.

Table 26: Lithological classification

SSS Image	Acoustic Description	Lithological Classification
	High reflectivity	Gravelly SAND
	Medium to high reflectivity	Slightly gravelly SAND
	Patchy medium to high reflectivity areas	Muddy (silty) SAND

SSS Image	Acoustic Description	Lithological Classification
	Low reflectivity	SAND

The seafloor sediments identified by these sensors were as follows:

- Gravelly SAND
- Slightly gravelly SAND
- Muddy (silty) SAND
- SAND

3.4 Seafloor Features and Objects

Seafloor features and contacts were identified from one or more of the SSS, MBES and MAG sensors and cross-correlated, where possible. Only contacts greater than or equal to 0.5 m in any dimension were interpreted along the Aramis trunkline route.

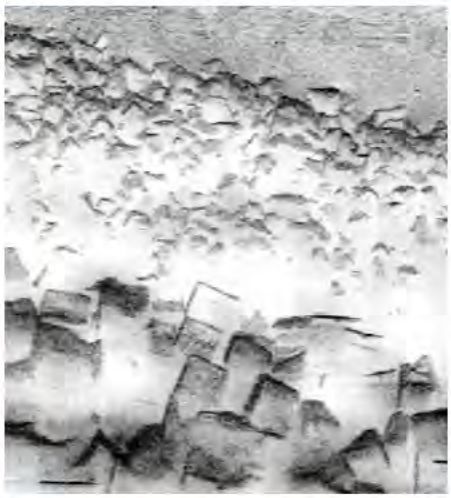
Table 3.4 summarises the identified seafloor features and Table 3.5 the quantities of contacts picked. Detailed description of distribution of the seafloor features is given in in Section 5 to Section 14).

The following seafloor features were identified:

- Scours/trawl marks
- Sediment dumping features
- Anthropogenic channel
- Wreck debris and possible wreck
- Possible fishing gear
- Cable trench (HKZ)
- Pipelines (buried or exposed)
- Cables
- Rock armour
- Unknown circular feature
- Unknown linear features

Table 27: Interpretation of seafloor features

SSS Image	Acoustic Description	Features Interpretation
	Low to medium reflectivity	Scours/Trawl marks
	Low to medium reflectivity	Sediment dumping features
	Low to high reflectivity	Anthropogenic channel
	Low to high reflectivity	Wreck debris and possible wreck

SSS Image	Acoustic Description	Features Interpretation
		
	Low to medium reflectivity	Possible fishing gear/fishing net
	Low to high reflectivity	Cable trench (HKZ)
	Low to high reflectivity	Rock armour

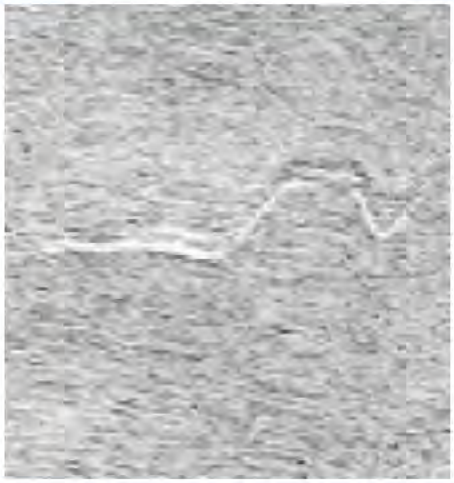
SSS Image	Acoustic Description	Features Interpretation
	Low to high reflectivity	Unknown circular features
	Low to high reflectivity	Unknown linear features
	Low to high reflectivity	Exposed pipeline

Table 28: Summary of seafloor contacts

Sensor	Contact Classification	Quantity
SSS/MBES/MAG Point Features	Boulder	3110
	Debris	159
	Depression pockmark	5
	Fishing gear	7
	Mattress	2
	Exposed pipe	4
	Seafloor mound	98
	Suspected debris	517
	Wreck	4
	Magnetic anomalies	2745
SSS/MBES/MAG	Debris	1

Sensor	Contact Classification	Quantity
Linear Features	Possible debris	1
	Fishing gear	4
	Possible fishing gear	42
	Large trawl scour	40
	Mound ridge	21
	Scour	7987
	Unknown linear feature	9
	Telecommunication cable	5
	Exposed pipeline	5
	Buried pipeline	41
	Magnetic linear feature	28

3.4.1 Cross Correlation of Contacts

A 2 m radius cross correlation between all SSS contacts and all MAG anomalies was performed. Only 11 point feature contacts cross correlate between the SSS and MAG sensors as reported in Table 3.6.

Table 29: Summary of cross corelating seafloor contacts

Section	SSS Target Name	MAG Target Name	Description
Section D	BK_FSEA_SSS_0084	BK_FSEA_MAG_0090	Debris
Section D	BK_FSEA_SSS_0086	BK_FSEA_MAG_0133	Debris
Section D	BK_FSEA_SSS_0163	BK_FSEA_MAG_0093	Debris
Nearshore area (Export Route East MT)	BB_FS_SSS_0593	BB_FS_MAG_0222	Boulder
Nearshore area (Export Route East MT)	BB_FS_SSS_0607	BB_FS_MAG_0247	Boulder
Nearshore area (Export Route East MT)	BB_FS_SSS_0642	BB_FS_MAG_0274	Suspected Debris
Nearshore area (Export Route East MT)	BB_FS_SSS_0884	BB_FS_MAG_0567	Boulder
Nearshore area (Export Route East MT)	BB_FS_SSS_0916	BB_FS_MAG_0605	Boulder
Nearshore area (Export Route East MT)	BB_FS_SSS_0929	BB_FS_MAG_0691	Boulder
Nearshore area (Export Route East MT)	BB_FS_SSS_0946	BB_FS_MAG_0710	Boulder
Nearshore area (Export Route East MT)	BB_FS_SSS_0678	BB_FS_MAG_0298	Wreck

4. Sub-seafloor Overview

4.1 Geological Setting

The investigation site is located in the southern North Sea.

The geological history of the southern North Sea started with the development of a complex system of basins and rifts in Northwest Europe during the Triassic (Geluk, 2005). Alpine inversion of these basins took place during the Late Cretaceous and early Paleogene as a result of the collision of Iberia and Europe. This was followed by multiple phases of subsidence from the Eocene up to recent times (Wong et al., 2007).

From the late Miocene onwards, a complex fan delta system developed, which gradually evolved into an alluvial plain prograding from the east. Until the end of the Neogene, deposition in the North Sea was dominated by sediment input from the Eridanos (Baltic) river system (Overeem, 2002; Knox et al., 2010; Rasmussen & Dybkjaer, 2014).

By the mid-Pleistocene (~1 Ma), the Rhine, Meuse and Scheldt Rivers had become important contributors of sediment influx to the North Sea basin, as a result of uplift of highland areas in Germany (Laban and Rijsdijk, 2002). Subsidence decreased during this time and the basin had become largely filled with deltaic deposits.

During the Middle and Late Pleistocene, the depositional evolution of the North Sea basin was strongly influenced by climatic variations, glaciations and associated sea level fluctuations. Series of an alternating glacial and interglacial periods occurred (Figure 4.1) This resulted in a complex interplay of glacial, glaciolacustrine, glaciofluvial, fluvial, aeolian, deltaic and (shallow) marine environments and deposits (Laban, 1995; Peeters et al., 2015).

Detailed description of the different glacial and interglacial stages during the Pleistocene in the southern North Sea is provided below Figure 4.1.

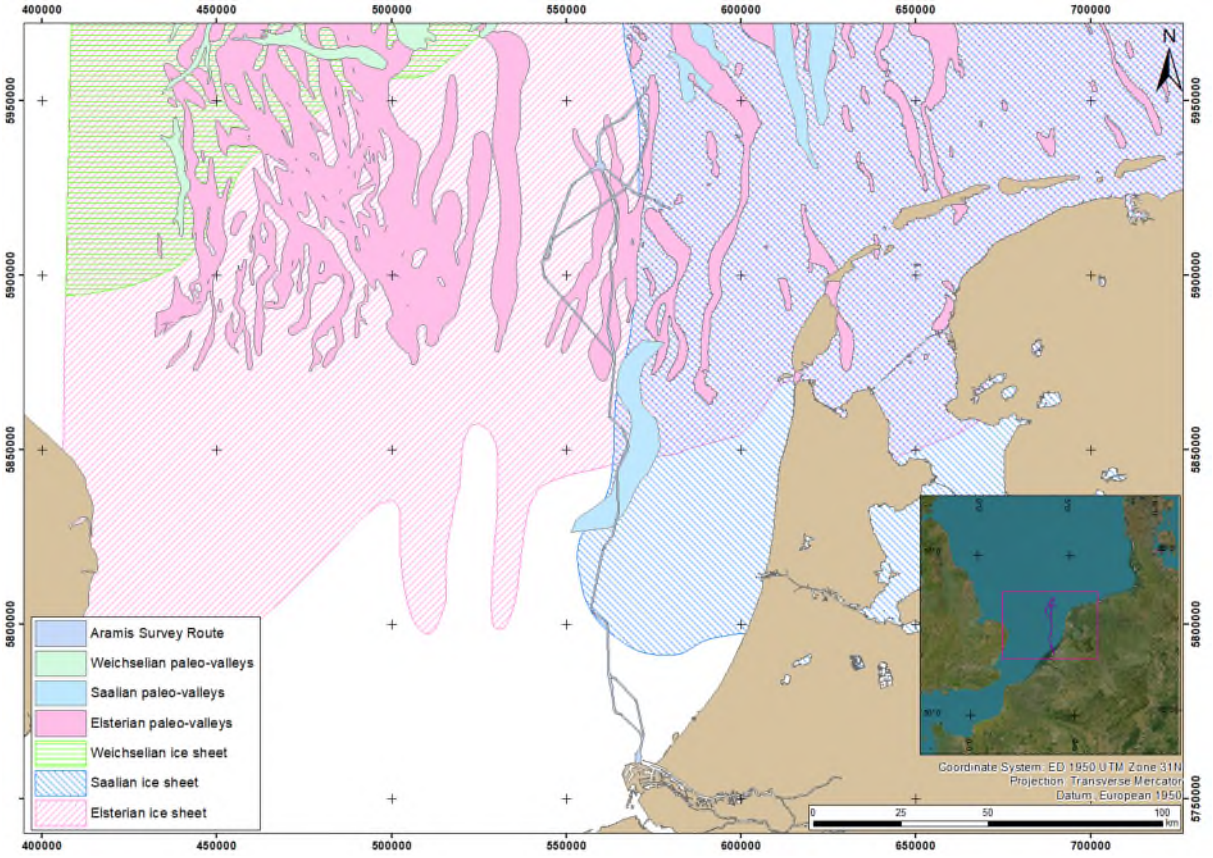


Figure 4.1: Maximum extent of the Quaternary glaciations in the southern North Sea.

Elsterian Glaciation (Middle Pleistocene)

During the Elsterian glaciation (475 ka to 410 ka BP), the Scandinavian and British ice masses coalesced and spread in southern direction to cover the northern part of the Netherlands and the southern North Sea (Ehlers, 1990; De Gans, 2007). The northern half of the Aramis route has been affected by the Elsterian ice sheet, while the southern half was influenced by the Rhine and Meuse River systems (Figure 4.2a). Deposition of predominantly low energy open marine deltaic sediments consisting of siliceous sands and clays resulted, which are thought to belong to the Yarmouth Roads Formation (Rijsdijk et al., 2005). Elsterian subglacial tunnel valleys were cut into the Yarmouth Roads Formation. They are present in the northern half of the route. The infill of these tunnel valleys comprises glaciofluvial (sand), glaciolacustrine (clay) and proglacial clays and sands of the former Swarte Bank Formation (now part of the Peelo Formation; Praeg, 1996; Graham et al., 2011; Moreau et al., 2012). The Elsterian valleys form a complex system of anastomosing, but mainly NNE–SSW trending, broad (approximately 1 km to 10 km wide) and deep (locally up to 400 m BSF) erosional features.

Holsteinian Interglacial (Middle Pleistocene)

During the subsequent Holsteinian interglacial (410 ka to 370 ka BP), sea level rose because of climate amelioration and melting ice masses. Fluvial and marine deposits were prevalent in this period. The fluvial deposits have been defined as the the Egmond Ground Formation (Bosch et al., 2003; Rijsdijk et al., 2005). Laterally, the Urk Formation grades into the Egmond

Ground Formation (Bosch et al., 2003). The Urk Formation can contain clay interbeds, while The Egmond Ground Formation comprise predominanlty marine sands, but locally can contain clay interbeds. The Egmond Ground Formation may locally incise into the underlying Yarmouth Roads Formation.

Saalian Glaciation (Middle to Late Pleistocene)

During the Saalian glaciation (370 ka to 130 ka BP), the Aramis route was near the Saalian Ice Margin (Figure 4.2.b). However, the exact limit of the ice sheet advance offshore remains uncertain.

Ice masses formed glacially scoured basins and several ice-pushed ridges (moraines). Numerous tunnel valleys were created during the Saalian in subglacial and proglacial settings. A major subglacial valley runs in a N–S direction, along the margin of the maximum extent of the Saalian ice sheet, located in the centre of the Aramis route. It is approximately 10 km wide and up to 80 m deep. The infill consists locally of glaciolacustrine clay (Uitdam Member) near the base, covered with marine sand of the Eem Formation (Laban, 1995). More tunnel valleys may be present near the north-eastern boundary of the Aramis route (Cameron et al., 1986; Joon et al., 1990).

During the Saalian glaciation, the Rhine–Meuse River system merged with a proglacial river system south of the ice margin (Peeters et al, 2015). This setting implies variable soil conditions dominated by extensive areas of glaciofluvial sands and gravels (outwash plains/sandurs) deposited in front of the ice sheet, with clays deposited in glaciolacustrine environments. Local aeolian deposition took place near the Saalian Ice Margin. The glaciofluvial and aeolian sediments belong to the Drachten Formation (formerly Tea Kettle Hole Formation), while the glaciolacustrine sediments belong to the Uitdam Member of the Drenthe Formation (formerly Cleaver Bank Formation). The latter is mainly confined to the Saalian tunnel valleys (Laban, 1995).

Saalian sediments in the southern North Sea have been largely eroded by the subsequent Eemian transgression but are still present in Saalian channels and valleys.

Eemian Interglacial (Late Pleistocene)

A major marine transgression affected the southern North Sea during the Eemian interglacial (130 ka to 115 ka BP). The area became part of the delta plain of the river Rhine (Figure 4.2.c). Shallow marine sands (Eem Formation), lagoonal and estuarine clays and sands, and fluvial sands (Kreftenheye Formation) were laid down in a complex depositional setting (Peeters et al., 2015). Existing glacial valleys and channels were inundated by the marine transgression.

With the onset of the marine regression at the end of the Eemian and beginning of the Weichselian glaciation, brackish marine clays and lagoonal or lacustrine silty laminated clays, identified as the Brown Bank Member (part of Eem Formation), were deposited in a low-energy environment in the northern part of the Aramis route (Figure 4.2.d; Cameron et al., 1986; GDN, 2018).

Weichselian Glaciation (Late Pleistocene)

During the youngest glacial period, the Weichselian (115 ka to 18 ka BP), the limit of the ice sheet extent was north-west of the Aramis site. At the time, deposition in the southern North Sea was dominated by periglacial conditions with temporary fluvial influences of the Rhine–Meuse River system (Figure 4.2.e).

The periglacial deposits comprise sand, sandy loam, peat, thaw-lake deposits and aeolian sediments. The aeolian deposits are considered to have little preservation potential in a dominantly (glacio)fluvial environment. The glaciofluvial deposits comprise sand, gravelly sand and locally clay of the Kreftenheye Formation. Erosion of underlying formations probably occurred.

Holocene (Recent)

With the transition from late glacial to early Holocene (11.6 ka BP to present), climatic amelioration resulted in sea level rise, and the North Sea basin became flooded. Deposition took place in a terrestrial periglacial environment, transitioning into tidal and lagoonal as the sea level rose. Sediments from this period belong to the Naaldwijk Formation and are preserved as (scattered) sands and clays that often infill of paleochannels. Locally, peat beds were deposited in shallow marsh settings (Nieuwkoop Formation). As transgression progressed, the site was overlain by sands of the Southern Bight Formation and muddy sands of the Urania Formation (only in the furthest north of the site).

The North Sea Basin has remained essentially sediment starved since the start of the Holocene, and deposits occur mainly in the form of sand banks and sand waves (Liu et al., 1993). Surficial sediments mainly consist of sand with shells and shell fragments typical of a high energy, open marine environment. These sands are partly derived from reworking of the sediments from the underlying fluvial deposits. Sands with a higher mud fraction are present in deeper parts and are indicative of a low energy open marine environment.

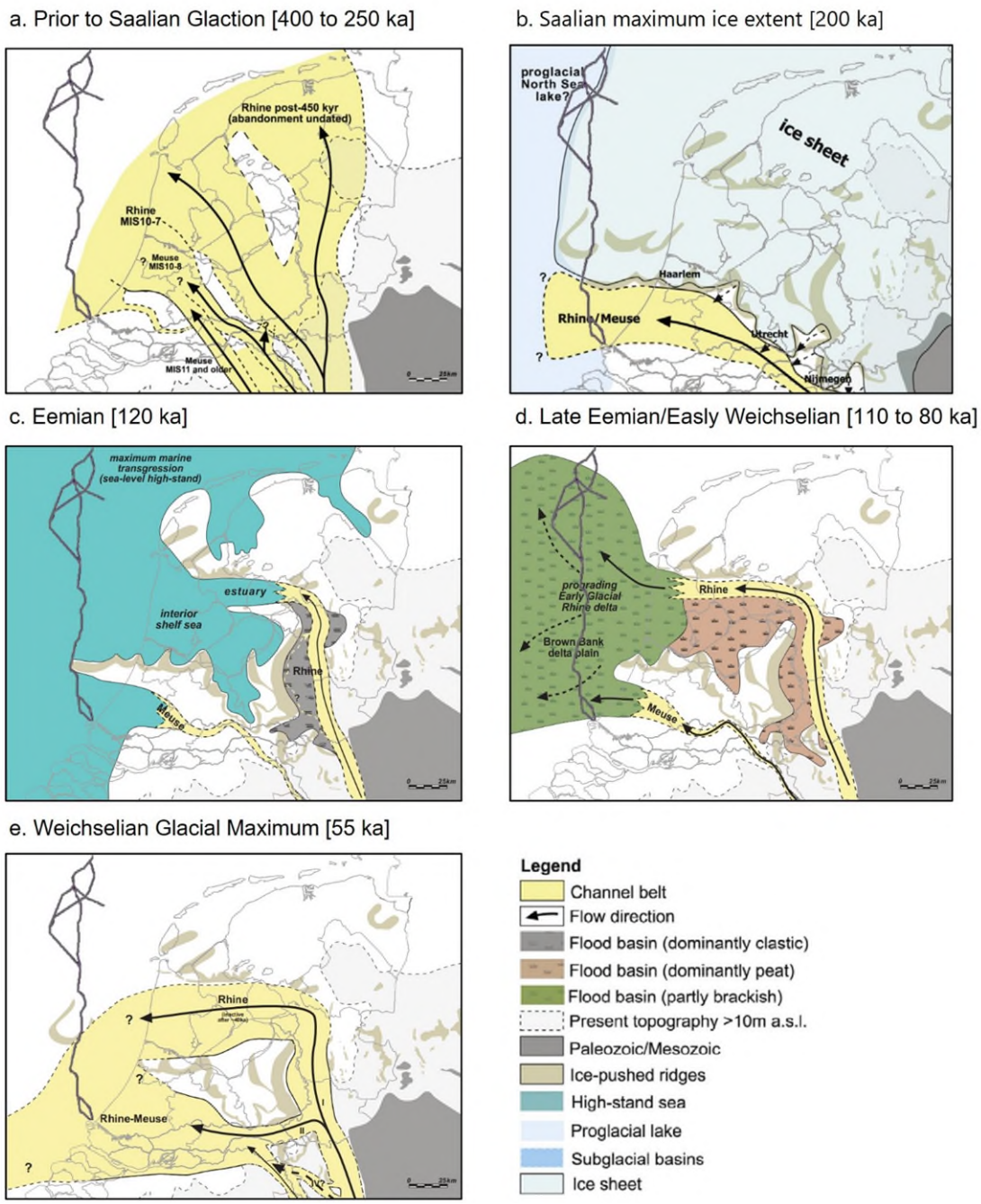


Figure 4.2: Palaeo-geographical reconstructions of the Netherlands during the Middle to Late Pleistocene. illustrated by five successive time frames. a) Rhine–Meuse drainage configuration prior to Saalian Glaciation. b) Maximum Saalian ice extent. c) Eemian interglacial maximum transgression during sea level highstand. d) Rhine delta prograding into lower-deltaic flood basin environment. e) Configuration of the Rhine and Meuse during the Weichselian glacial maximum (modified after Peeters et al., 2015).

4.2 Seismostratigraphy

4.2.1 Overview

Table 4.1 provides an overview of the seismic horizons and corresponding seismostratigraphic units as interpreted in the SBP and 2D-UHRS data. The table and this section should be read in conjunction with the charts provided in Appendix A.

Nine horizons were interpreted, each representing a significant acoustic interface consistent across the site, which forms the base of a seismostratigraphic unit. In addition, the extent of geological features, such as intraformational buried channels, layers of potential peat and acoustic blanking, indicating possible gas in soil were interpreted.

The sub-seafloor information presented in this section considers two seismic reflection datasets. These include:

- Sub-bottom profiler (SBP) data with a typical penetration of the seismic signal below seafloor between approximately 8 m and 15 m BSF;
- 2D ultra-high-resolution multichannel seismic (2D-UHRS) data with a typical penetration of the seismic signal below seafloor of approximately 200 m BSF.

The SBP data were acquired within an approximately 500 m-wide corridor and the 2D-UHRS data, except of the nearshore area and the HUB area, were acquired along the centre line only. The 2D-UHRS data were interpreted down to a minimum depth of 100 m BSF.

Shallow seafloor CPT data were used to aid the interpretation of the SBP data. Details on geotechnical data (CPT and VC boreholes) with be integrated and provided in the next issue of this report.

The vertical scale in the seismic data examples presented in the following sections and on the geological profiles is in two-way travel time (TWTT) in seconds below LAT. Included is a vertical scale bar in metres that was estimated using a constant sub-seafloor velocity of 1600 m/s.

Refer to Section 3 for details on data processing, interpretation methodology and data resolution limitations.

Section 4 provides a general overview of the sub-seafloor geology, while a more detailed description is provided in Sections 5 through 14, where each section of the route is treated separately.

Table 30: Overview of interpreted seismostratigraphic units

Dataset	Unit	Horizon Top	Horizon Base	Seismic Signature and Character of the Base	Distribution	Lithology	Geological Formation / *Member*	Depositional Environment
SBP	DS	H00	H_DS	Semi-transparent and chaotic. The basal reflector marks the change from chaotic to acoustically transparent or structured seismic facies.	Present in nearshore part only (Maaskanaal)	Very loose to very dense slightly silty fine and medium SAND	-	-
	A	H00	H10	Acoustically transparent to chaotic, with locally high amplitude reflections. Base is marked by a medium to high amplitude, flat reflector.	Present across the entire route	Very loose to very dense slightly silty to silty fine and medium SAND with occasional shells and shell fragments Locally low to medium strength slightly sandy CLAY, with closely spaced thin laminae of silt Locally clayey fine SAND	Southern Bight	Marine
SBP, 2D-UHRS	B	H00, DS, H10	H15	Various; semi-transparent and structureless to locally bedded with low to medium amplitude parallel reflectors; locally, internal channels with high amplitude parallel reflectors observed; locally internal erosion surfaces observed. The base is locally channelised and the infill of these channels has typically chaotic or structured (layered) character with high amplitude reflections. The basal reflector has a medium to high amplitude; irregular to undulating. High amplitude (negative on the 2D-UHRS) reflectors may indicate layers/pockets of peat / organic clay frequently present in this unit.	Present basically across the entire route; locally absent in the southern part of the route	Medium to very dense slightly silty fine and medium SAND with occasional shells and shell fragments Locally with medium to thick beds of extremely low to high strength sandy CLAY Locally with very closely spaced thin laminae to medium beds of peat	Naaldwijk Boxtel Kreftenheye	Coastal to tidal-flat, locally lagoonal; locally periglacial to fluvial
2D-UHRS	C	H15	H20	Mostly structured (layered) with low to medium-amplitude parallel reflectors. Locally, in the upper part of the unit, structureless, semi-transparent interval locally semi-transparent, structureless. In the north-eastern part of the route, the unit is characterised by overall semi-transparent seismic facies with local high amplitude negative reflectors of various extent. The high amplitude reflectors may indicate layers of pockets of peat and/or organic clay. Base forms a sub-horizontal erosional surface, locally forming broad channels/depressions.	Present in the central and large portion of the northern part of the route	Very loose to dense very silty fine and medium SAND with occasional pockets of organic matter Locally low strength to high strength sandy CLAY with medium spaced very thin beds of sand Locally low to medium strength sandy clayey SILT	*Brown Bank*	Lagoonal, estuarine, tidal flat
	D	H15, H20	H25	Acoustically transparent to semi-transparent, structureless. Locally, layered intervals, internal erosion surfaces marked by strong undulating or inclined reflectors. Internal channelling features are locally present. The infill of these channels is various from chaotic to structured (layered). Base forms a sub-horizontal erosional surface, locally forming channels.	Present almost across the entire route, except small area in the centre and in the most southern part of the route	Loose to very dense slightly silty fine and medium SAND, occasionally slightly gravelly	Eem Kreftenheye (nearshore)	Marine
	E	H25	H30	Acoustically transparent to semi-transparent, structureless; locally chaotic. Base forms a sub-horizontal erosional surface, locally forming channels.	Present in the northern part of the route	Medium dense to very dense SAND locally with beds of CLAY and SILT	Egmond Ground	Marine
	F	H25, H30	H35	Semi-transparent infill with occasional amplitude anomalies. locally discontinuous, wavy and steeply inclined medium-amplitude reflectors. Internal channels near the top. The basal reflector forms U-shaped channel / valley.	Present locally in the northern and central part of the route	Interbedded medium dense to very dense (silty) SAND and high strength to very high strength (sandy) CLAY	Peelo	Fluvio-glacial, glacio-lacustrine (subglacial valley infill)
	G	H20, H25, H30, H35	H40 (internal) BPD	Chaotic to acoustically semi-transparent, locally discontinuous, inclined medium-amplitude reflectors. Locally, internal erosion surfaces and internal channels / channelling features. Horizon H40 marks internal erosion surface, at which locally high amplitude negative reflectors are present, indicating a thin bed or laminae of peat /organic clay.	Present across the entire route	Medium dense to very dense SAND Locally with layers of high strength to very high strength CLAY or SILT, locally laminated	Yarmouth Roads	Fluvio-deltaic to marine

Notes:
DS = disturbed sediments
Hyphen = not applicable
BPD = below penetration depth of seismic reflection data

4.2.2 Unit DS

Disturbed sediments are present exclusively in the dredged Maasmond Kanaal. The base of these sediments is uncertain and taken at the base of high amplitude reflections or at the top of structured seismic facies, which were very locally observed. The unit has semi-transparent and chaotic seismic character.

4.2.3 Unit A

Unit A is the shallowest unit and is interpreted to be present across the entire route. The unit is interpreted to be absent in the Maasmond Kanaal in the nearshore part. Locally it is very thin and may be absent (seismic data cannot resolve the top approximately 30 cm). The thickness variation of the unit largely follows the seafloor morphology. The unit is thickest (approximately 3 m) near the crests of sand banks and sand waves and thins towards the troughs, where it may be locally absent (Figure 4.3).

The base is marked as Horizon H10, which is characterised by a near-flat surface It is typically a medium to high-amplitude reflector and/or the interface between seismically different characters.

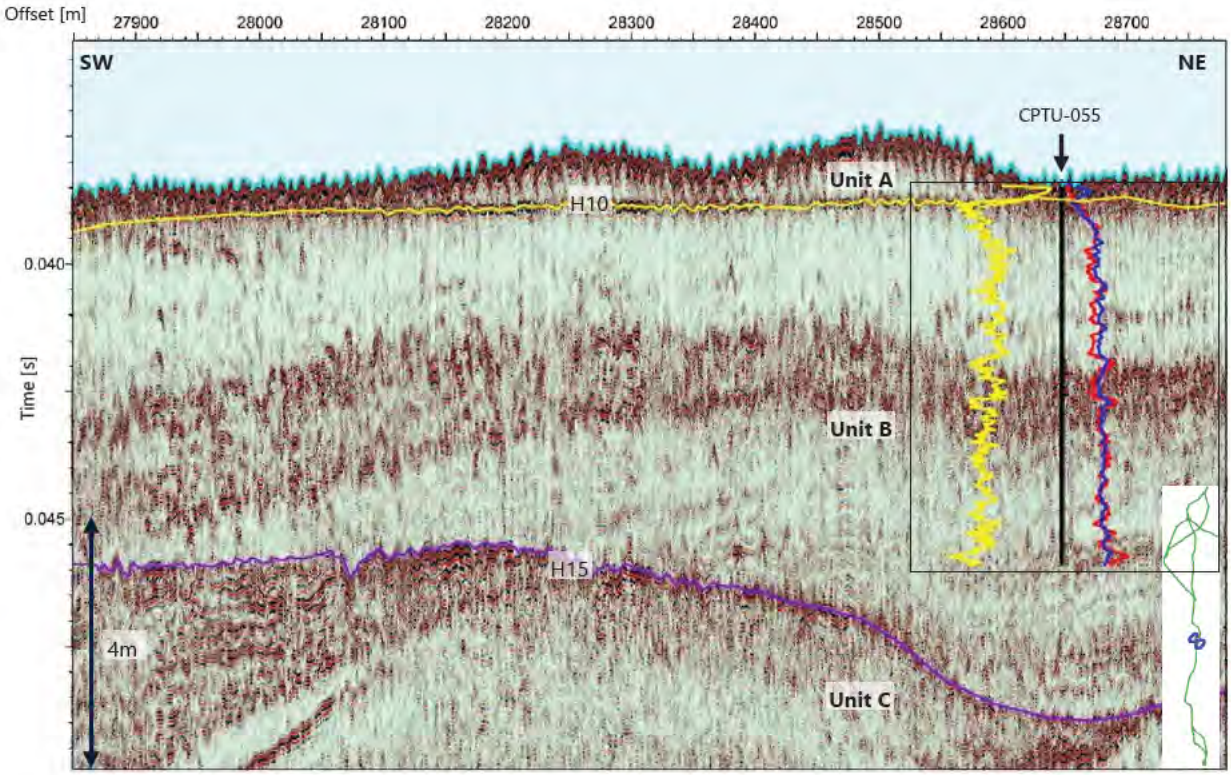


Figure 4.3: SBP data example of the internal seismic character of Unit A at sand waves. (Line SBP_TA3E2132P1) Width of the CPT boxes show cone resistance values (blue curve) within range of 0 to 5 MPa, sleeve friction values (red curve) from 0 to 0.125 MPa and friction ratio (yellow curve) from 0 to 4 %.

Unit A generally appears to be acoustically transparent. Locally, high amplitude internal point reflections or short reflectors were observed. In the larger sand waves, locally weak progradational structures were observed.

The unit consists of loose to very dense sand. The unit is interpreted to be deposited in an open marine environment in response to the marine transgression during the Late Holocene and belongs to the southern Bight Formation. The unit represents mobile sediments, reworking material of underlying deposits.

4.2.4 Unit B

Unit B is interpreted to be present in the entire Aramis route, except in the Maasmond Kanaal. The thickness of this unit varies and is driven by the depth of the basal erosional surface, reaching locally a maximum depth of approximately 15 m BSF. Unit B is overlain by Unit A but may be locally exposed at seafloor, mostly in the troughs between the sand waves.

The base of Unit B is marked by Horizon H15, which forms a distinctive irregular erosional surface, locally cutting deeply into the underlying units (Figure 4.4).

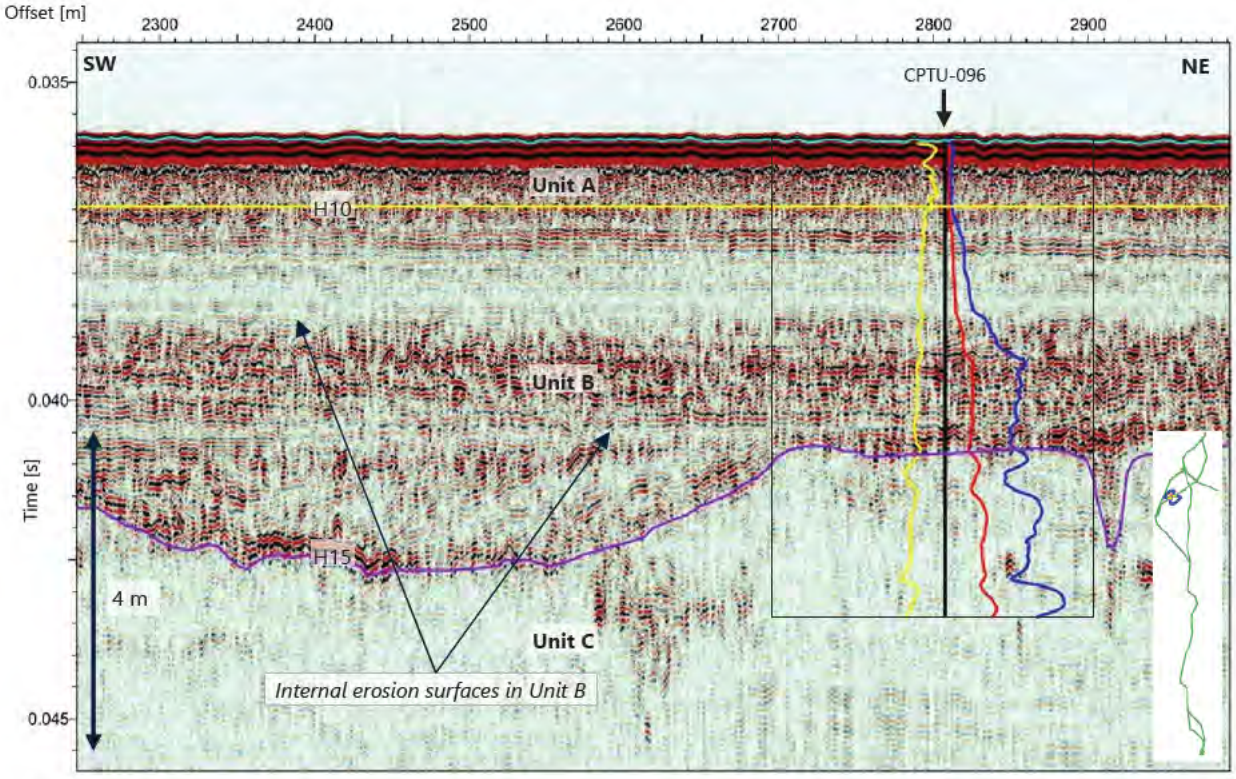


Figure 4.4: SBP data example of the internal seismic character of Unit B. (Line SBP_TA3M2320R1_2) Width of the CPT boxes show cone resistance values (blue curve) within range of 0 to 25 MPa, sleeve friction values (red curve) from 0 to 0.625 MPa and friction ratio (yellow curve) from 0 to 4 %.

In the SBP data, the basal reflector is typically a weak, low amplitude reflector in the southern part of the route and a medium to high amplitude reflector in the northern part of the route. In the south-central part of the route (Section A-Alt) the base of the unit is not visible or lies below penetration of the SBP data. This can be due the similar soil conditions (and thus low impedance contrast) between Unit B and the underlying Unit D in this part of the route.

In the 2D-UHRS data, the base of the unit is marked by a weak reflector of variable polarity, towards the north the base is marked increasingly by a medium to high amplitude negative reflector.

The unit has a variable internal seismic character, ranging from semi-transparent to chaotic with numerous discontinuous and often high-angle medium to high-amplitude reflections.

Internal channels and channels at the base with different dimensions were observed in the unit. The infill of the channels is variable, but typically well-layered and with high-amplitude reflectors.

High negative amplitude anomalies are common in this unit, especially in the northern part of the route, which potentially represent layers of peat and/or organic-rich clay.

The unit is variable in terms of soil conditions, comprising medium dense to very dense (silty) sand, with laminations and beds of clay, silt, and peat.

Based on its variable seismic character, stratigraphic position, and the presence of internal channels, this unit is interpreted to represent early Holocene coastal and tidal deposits, and possibly belonging to the Naaldwijk Formation. Locally the unit may include sediments of Boxtel Formation and especially in the southern and south-central part of the route, a large part of this unit may belong to the Kreftenheye Formation. The differentiation between these formations is difficult due to similar soil conditions (predominantly sand).

In the nearshore area, deposits of the Kreftenheye Formation are below the base of the interpreted Naaldwijk Formation.

4.2.5 Unit C

Unit C is present in the northern and central part of the route. The base of the unit is marked by Horizon H20, which typically forms a distinctive nearly flat erosional surface, locally, in the central part of the route it cuts into the underlying unit forming a wide depression(s). In this part of the route, the unit is thickest and several internal erosion surfaces were observed (Figure 4.5).

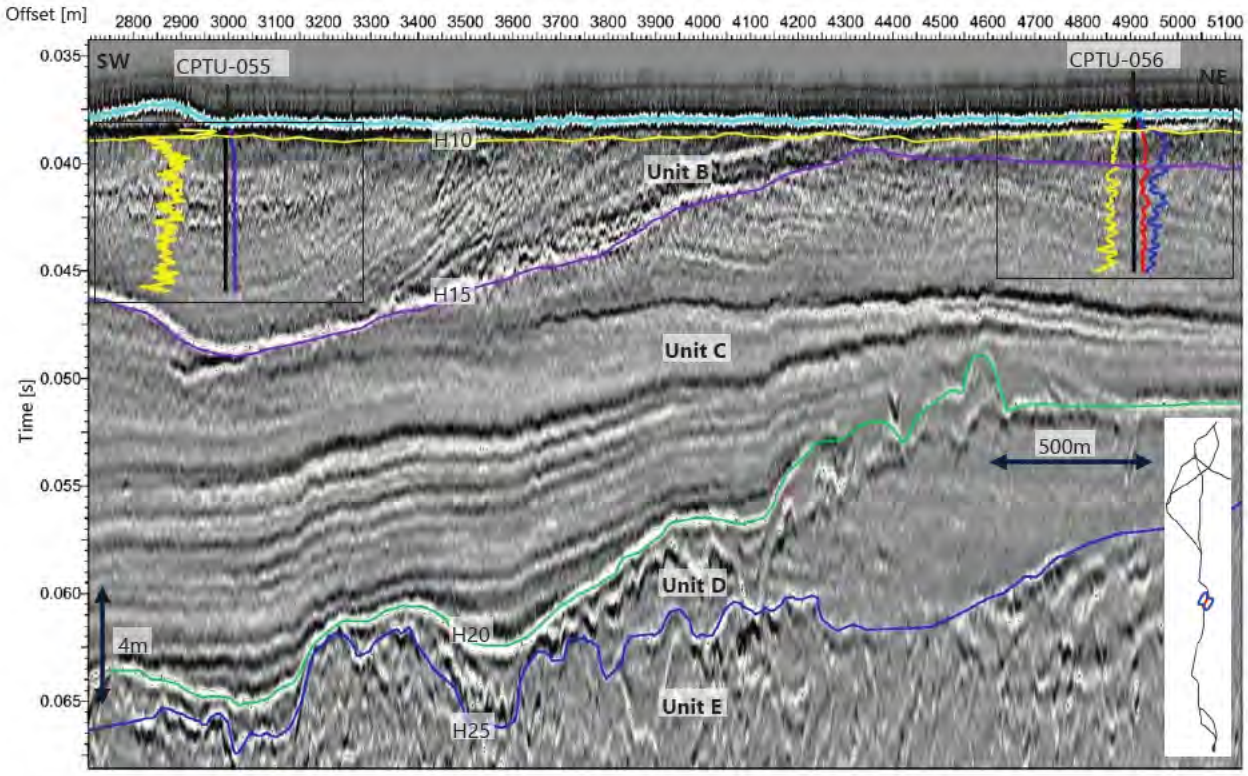


Figure 4.5: 2D-UHRS data example of the internal seismic character of Unit C. (Line 059-TA3A1542P1) Width of the CPT boxes show cone resistance values (blue curve) within range of 0 to 25 MPa, sleeve friction values (red curve) from 0 to 0.625 MPa and friction ratio (yellow curve) from 0 to 4 %.

The unit for most of the route is characterised by bedded seismic facies, consisting of parallel reflectors. Locally, in the upper part of the unit, structureless, semi-transparent intervals within the unit were observed. In the north-eastern part of the route, the unit is characterised by overall semi-transparent seismic facies with local high amplitude reflectors of various extent. The high amplitude negative (2D-UHRS data) reflectors may indicate layers of pockets of peat and/or organic clay.

The layered nature of the unit is expected to correlate with sand and clay alternations, and local beds of peat. The unit is interpreted to be deposited in a range of coastal (estuarine), tidal flat or lagoonal environments and corresponds to the Brown Bank Member.

4.2.6 Unit D

Unit D is present across the entire route, except small part of the route (approximately 15 km) in the central part, and in the most southern part, where it is interpreted to be absent. In the central part, the area where unit is absent, the base of the overlying Unit C is thickest and forms a wide depression.

The base of the unit is marked by Horizon H25 and generally forms a flat erosional surface, which is occasionally undulating and channelised (Figure 4.6). The base typically forms a medium to high-amplitude negative reflector, although this may vary due to the heterogeneity of the underlying sediments.

The unit has in general a structureless and semi-transparent acoustic character. Locally, layered intervals, internal erosion surfaces marked by strong inclined reflectors or forming broad channel-like features. Internal buried channels are locally present. The infill of these channels is various from chaotic to bedded with inclined parallel reflectors.

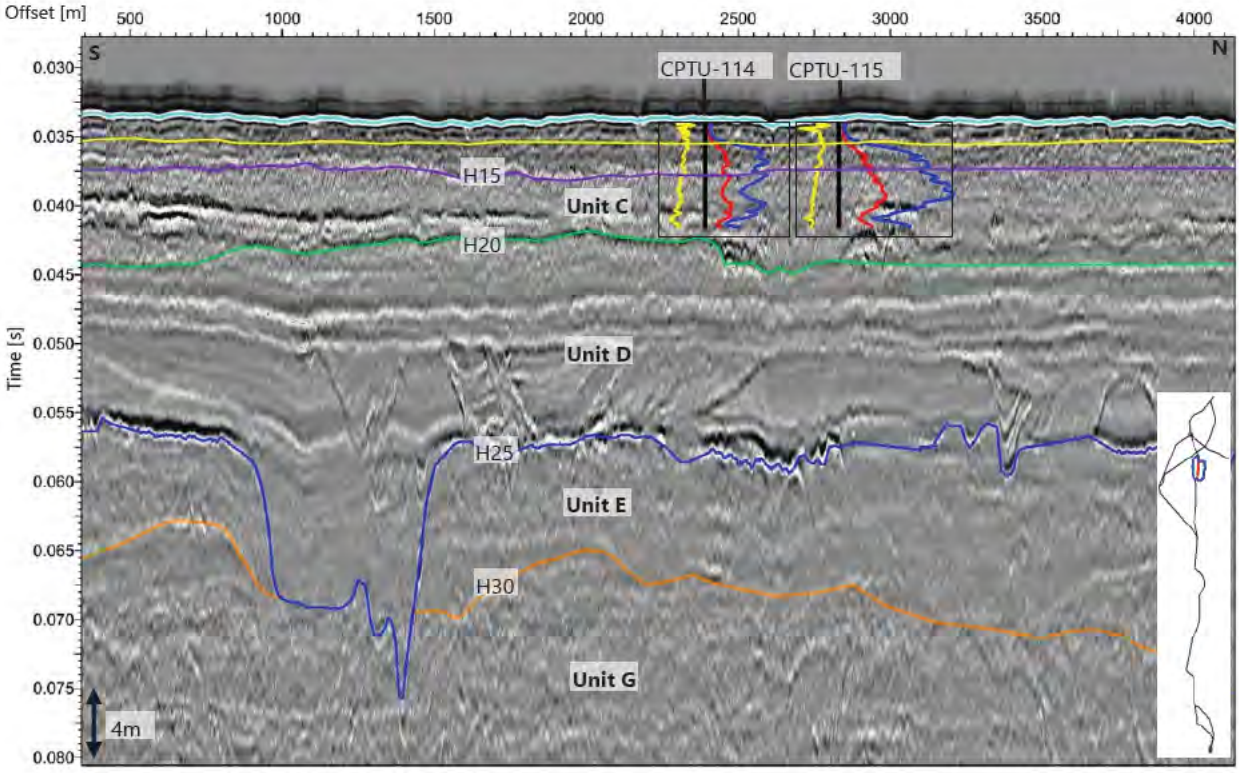


Figure 4.6: 2D-UHRS data example of the internal seismic character of Unit D. (Line 085-TA3A1562P1) Width of the CPT boxes show cone resistance values (blue curve) within range of 0 to 25 MPa, sleeve friction values (red curve) from 0 to 0.625 MPa and friction ratio (yellow curve) from 0 to 4 %.

Unit D is expected to comprise predominantly sand, with very locally clay or peat alternations, deposited in open marine and tidal environments. The unit is thought to belong to the Eem Formation.

4.2.7 Unit E

Unit E is present in the northern part of the route.

The base of the unit is marked by Horizon H30 and generally forms an undulating erosional surface. The base typically forms a weak low amplitude reflector.

The unit has in general a structureless and semi-transparent acoustic character, to locally chaotic with high amplitude negative point reflections (Figure 4.7). The acoustic facies of this unit are similar to the underlaying unit. As a result, it is very difficult to trace this interface in some parts of the route.

Unit D is expected to comprise predominantly sand, occasionally with thin layers or pockets of clay or peat, deposited in open marine and tidal environments. The unit is thought to belong to the Egmond Ground Formation.

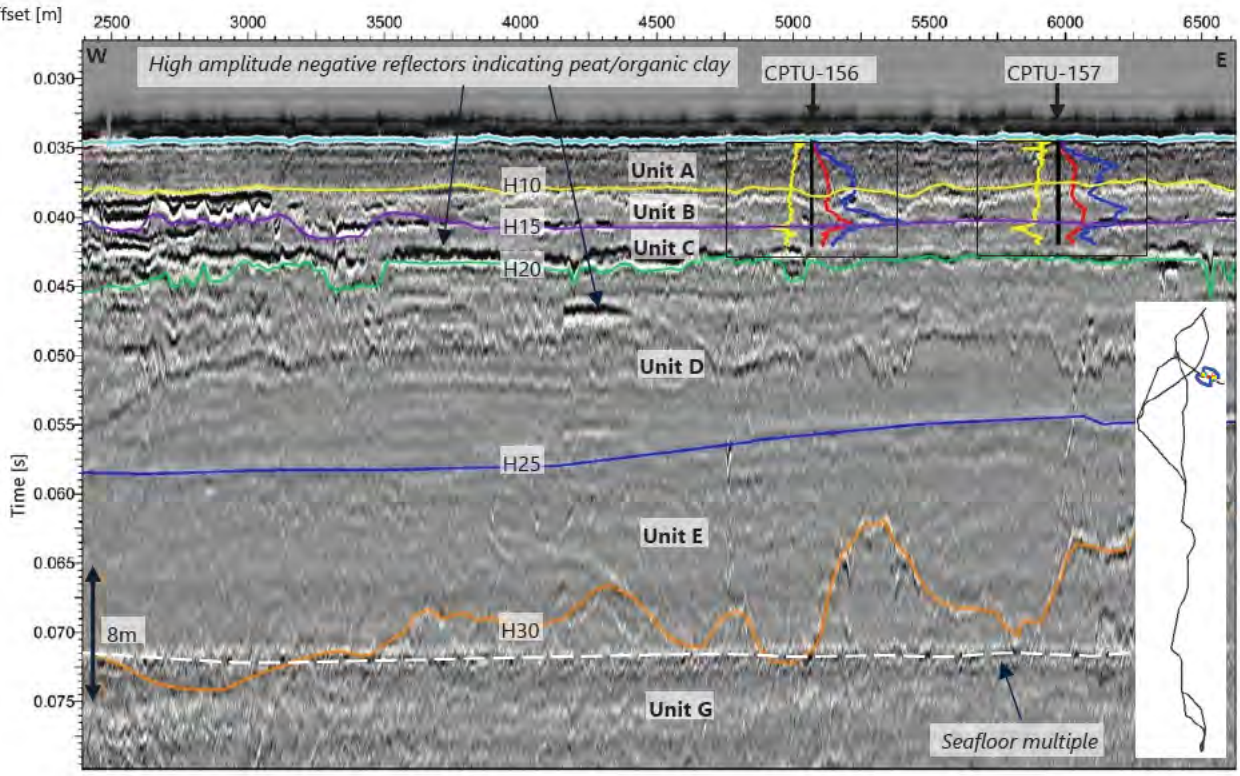


Figure 4.7: 2D-UHRS data example of the internal seismic character of Unit E. (Line 196-TA3A1608P1) Width of the CPT boxes show cone resistance values (blue curve) within range of 0 to 25 MPa, sleeve friction values (red curve) from 0 to 0.625 MPa and friction ratio (yellow curve) from 0 to 4 %.

4.2.8 Unit F

Unit F is present locally in the northern half of the route. The unit forms the infill of deeply incisive U-shaped channel-like features with steep flanks. They cut into the underlying Unit G, reaching locally depths below the penetration of the 2D-UHRS data. Such features in this part of the North Sea are considered as glacial tunnel valleys.

The base of the unit is marked by Horizon H35, which form a boundary between relatively more acoustically transparent infill (Unit F) and chaotic facies outside (Unit H). Flanks of these glacial valleys are not always clear on seismic data and given the data were acquired on a single line, they are difficult to trace locally. As a result, the extent of this unit is locally uncertain and may be larger than interpreted.

The internal character of Unit F is characterised in general by semi-transparent to chaotic seismic facies. Often, especially in the upper part, discontinuous, irregular, and wavy (folded?) medium to high-amplitude reflectors were observed (Figure 4.8). Occasional amplitude anomalies may be present within the unit.

Intra-formational channels with high-amplitude reflections are observed sometimes near the top of the unit.

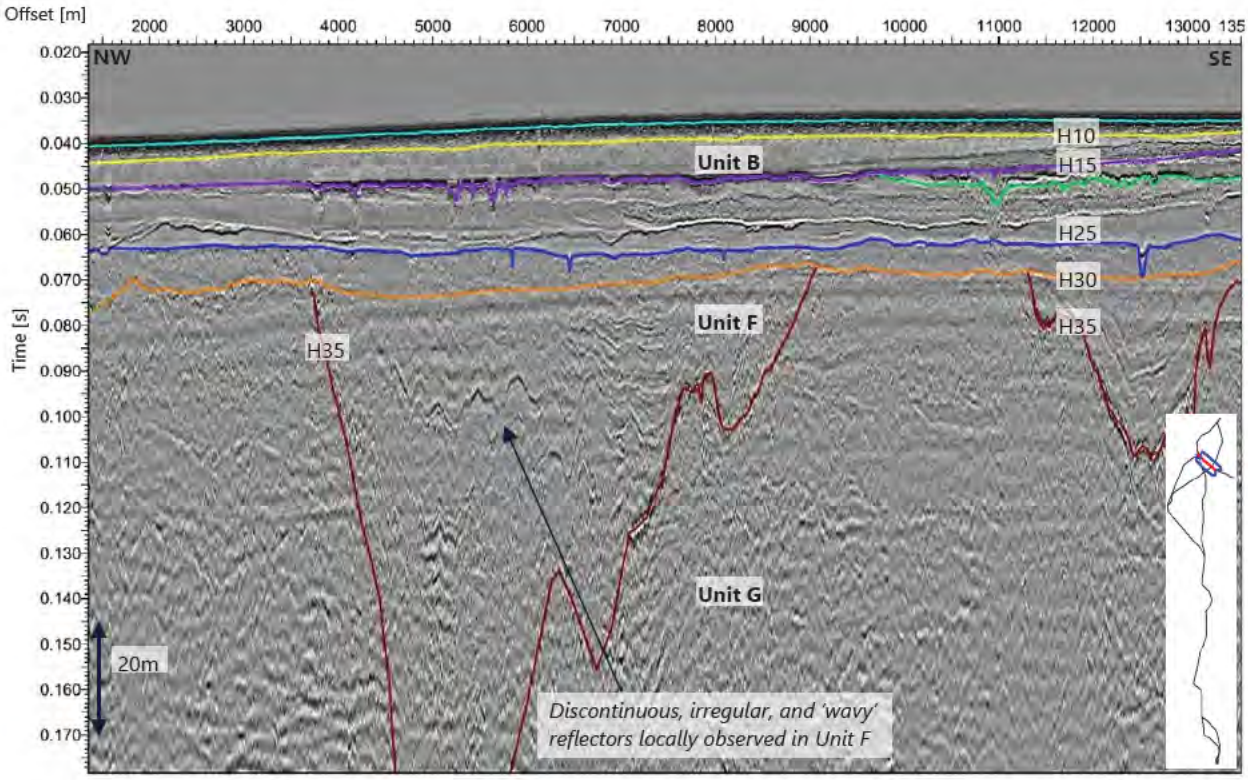


Figure 4.8: 2D-UHRS data example of the internal seismic character of Unit F. (Line 180-TA3A1606P1)

The dimensions and stratigraphic position of the glacial tunnel valleys correspond to the Elsterian age. Based on the public domain data and Fugro database, the unit is expected to consist of mainly clay with frequent (silty) sand interbeds deposited in glacial, glaciofluvial and glaciolacustrine environments. These deposits are interpreted to belong to the Peelo Formation.

4.2.9 Unit G

Unit G is the deepest unit observed in the seismic data within depth of interest and is present across the entire route. The base of this unit is beyond the penetration depth of the 2D-UHRS.

An internal reflector Horizon H40 was interpreted in the southern part of the route. Locally, this reflector shows high amplitude and negative polarity, indicating possible bed or laminae of peat and/or organic clay (Figure 4.9).

The internal acoustic character of the unit is complex, from semi-transparent to chaotic, with locally discontinuous reflectors, internal erosion surfaces and various internal channels. This complexity results from the nature of the depositional setting of this unit (fluvial to deltaic) and post-depositional processes such as glacial activity, including erosion and possibly deformation. Particularly, extensive glacial erosion affected the unit during Elsterian and Saalian glaciations.

The unit is expected to consist of predominantly sand with occasional clay and silt interbeds, and local beds of peat. Unit G is interpreted to be deposited in a fluvio-deltaic to marine environment and corresponds to the Yarmouth Roads Formation.

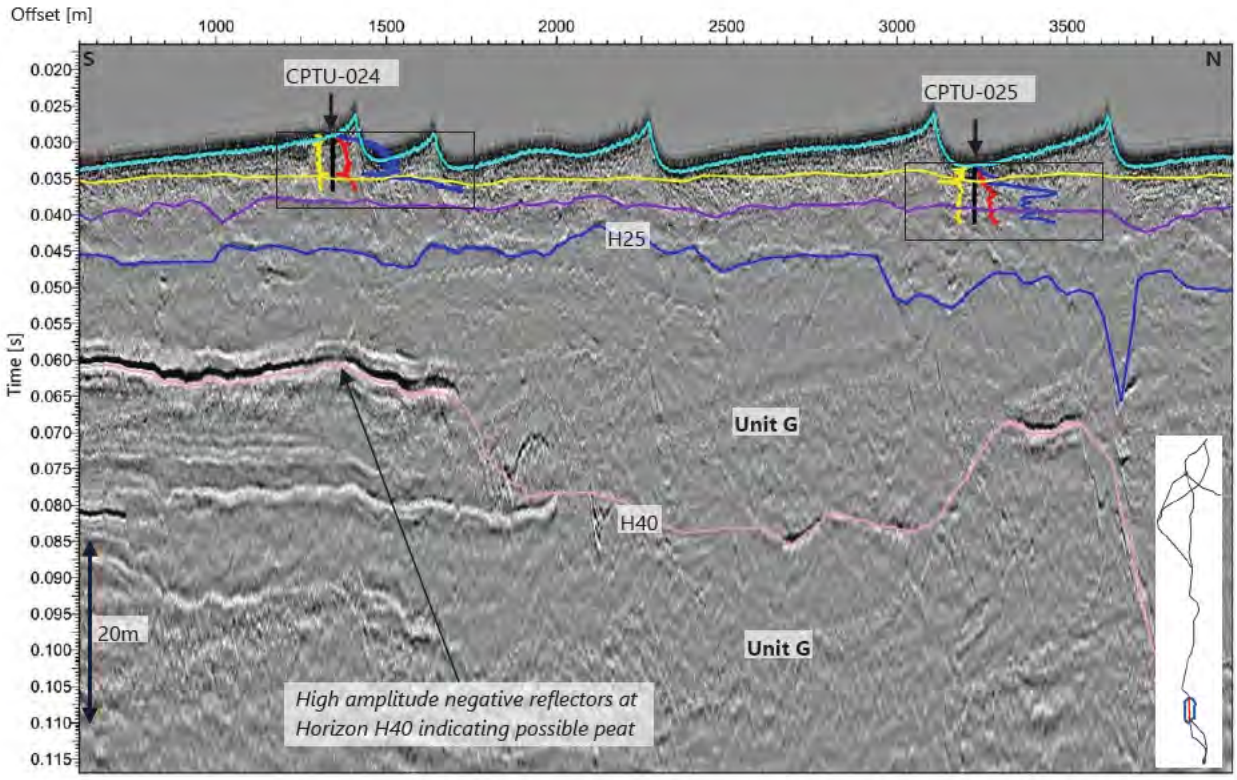


Figure 4.9: 2D-UHRS data example of the internal seismic character of Unit G. (Line 012-TA3A1525R1) Width of the CPT boxes show cone resistance values (blue curve) within range of 0 to 50 MPa, sleeve friction values (red curve) from 0 to 1.25 MPa and friction ratio (yellow curve) from 0 to 4 %.

4.3 Geological Features and Geohazards

4.3.1 Buried Channels

Repeated changes in depositional environment, multiple episodes of subaerial exposure, combined with marine transgression events and glacial and marine erosion during the Pleistocene have caused buried channel to be formed and filled over time.

Internal buried channels and channels at the base were observed in all units except Unit A.

Buried channels in Unit B were mapped based on SBP data. These channels are often located towards the top of the unit, have NW-SE orientation and limited extent (Figure 4.10). They often have a layered infill. The formation of these channels may be related to low-energy, coastal (tidal flat) depositional environments of the Early Holocene.

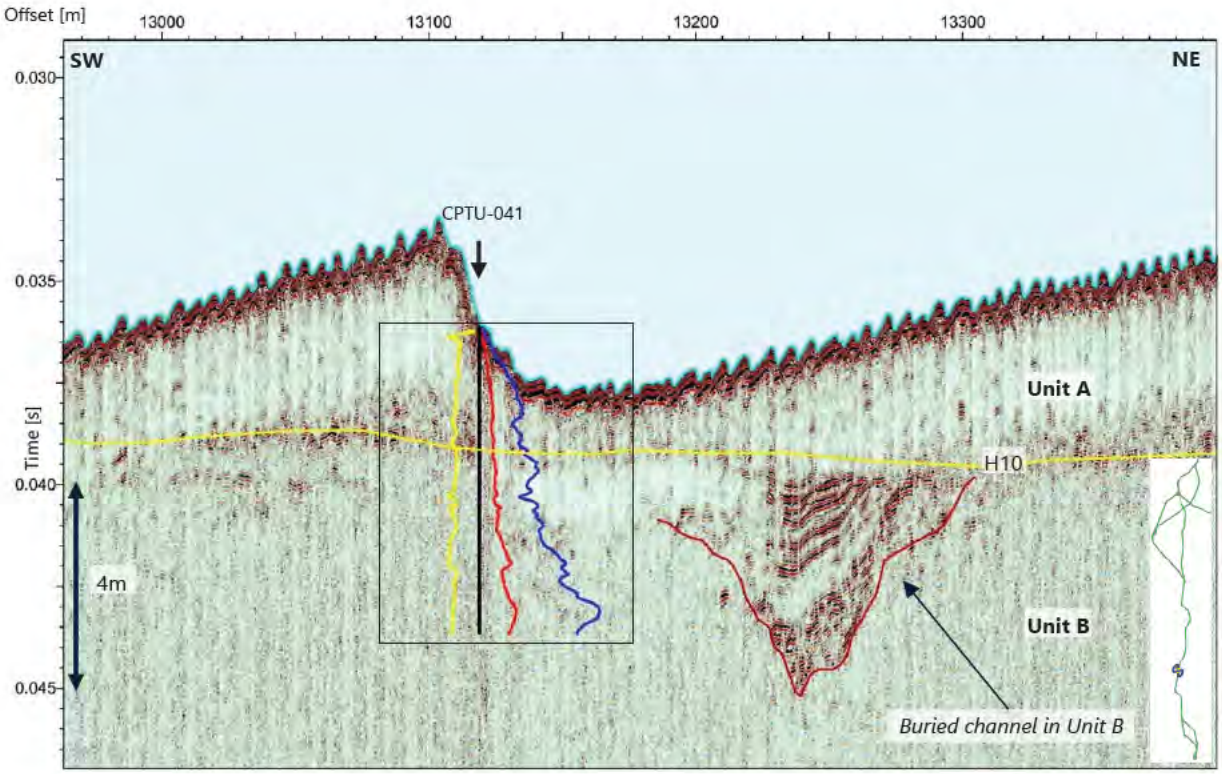


Figure 4.10: SBP data example of buried channels in Unit B. (Line SBP_TA3D2118P1) Width of the CPT boxes show cone resistance values (blue curve) within range of 0 to 25 MPa, sleeve friction values (red curve) from 0 to 0.625 MPa and friction ratio (yellow curve) from 0 to 4 %.

The base of Unit B, Unit C and Unit D is locally channelised (Figure 4.11). The base of Unit B is mainly channelised in the western part of the northern and central part of the route.

The base of Unit F forms the deeply incised glacial tunnel valleys.

Near the top of Unit F, locally bedded, high-amplitude reflectors forming channel-like shape were observed. These features are associated with the glacial tunnel valleys of Elsterian age and appear to represent a late stage of the infill of these tunnel valleys that may took place in lacustrine environment.

4.3.2 Peat

On the SBP data, the high amplitude reflectors that may indicate peat and/or organic clay were associated with Unit B (Figure 4.11).

High negative amplitude anomalies were observed in the 2D-UHRS seismic data. These negative amplitude events most likely represent peat and/or organic-rich clay. Peat layers were identified at a few stratigraphic levels: *2D-UHR_peat_level 1* – associated with Unit B; *2D-UHR_peat_level 2* – associated with Unit C, Unit D and Unit E; *2D-UHR_peat_level 3* – associated with Unit F and Unit G.

Peat is most common in the northern part of the route, except 2D-UHR_peat level 3, which is present along the entire route, but its distribution is very limited.

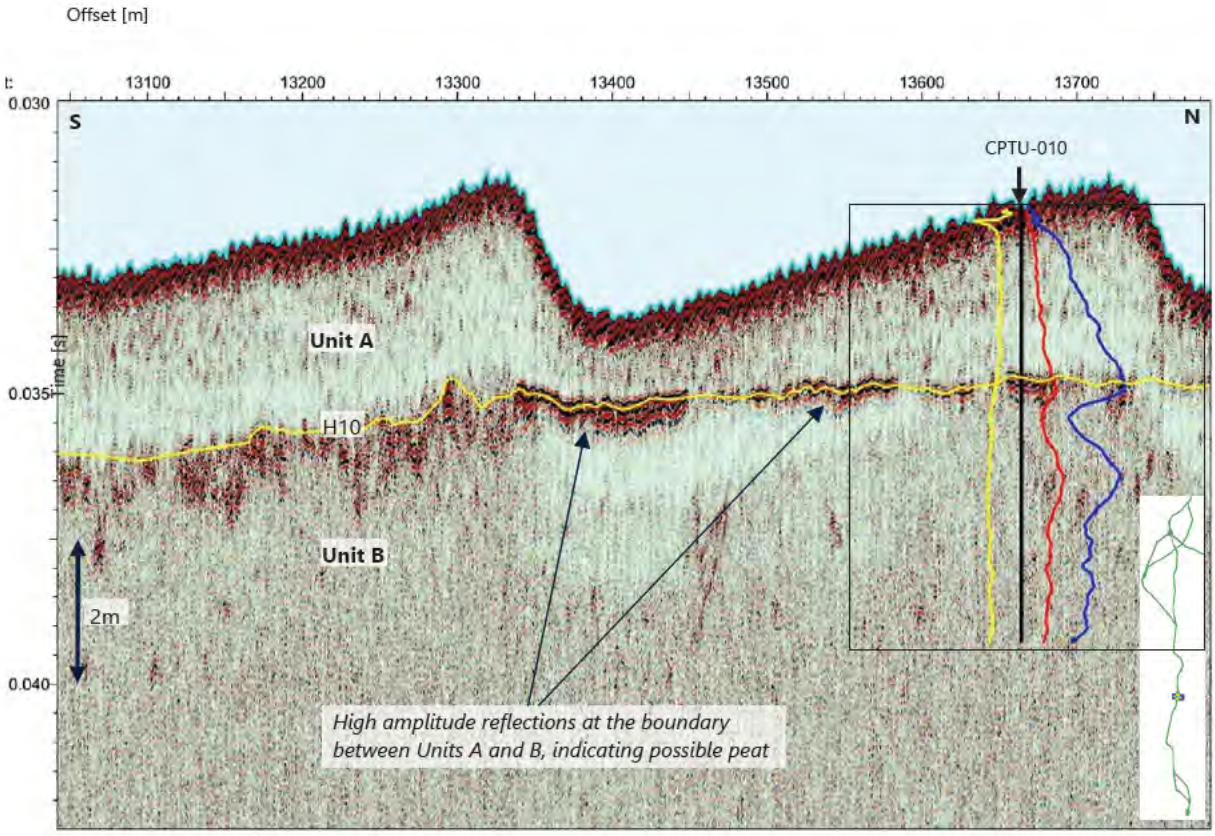


Figure 4.11: SBP data example of anomalies indicating possible peat in Unit B. (Line SBP_TA3E2134P1) Width of the CPT boxes show cone resistance values (blue curve) within range of 0 to 25 MPa, sleeve friction values (red curve) from 0 to 0.625 MPa and friction ratio (yellow curve) from 0 to 4 %.

4.3.3 Shallow Gas

Acoustic blanking can indicate presence of gas in soil. It was observed locally in the nearshore area. The minor acoustic blanking or signal distortion that was observed below some of the negative amplitude anomalies is thought to be related to the presence of peat (Figure 4.12). However, the presence of gas/fluid-charged sediments cannot be excluded entirely.

Acoustic blanking or signal distortion beneath some channels (mostly in Unit B) may be related to the high acoustic impedance contrast between the channel infill and surrounding sediments, in combination with the flanks of the channels being too steep to be imaged properly.

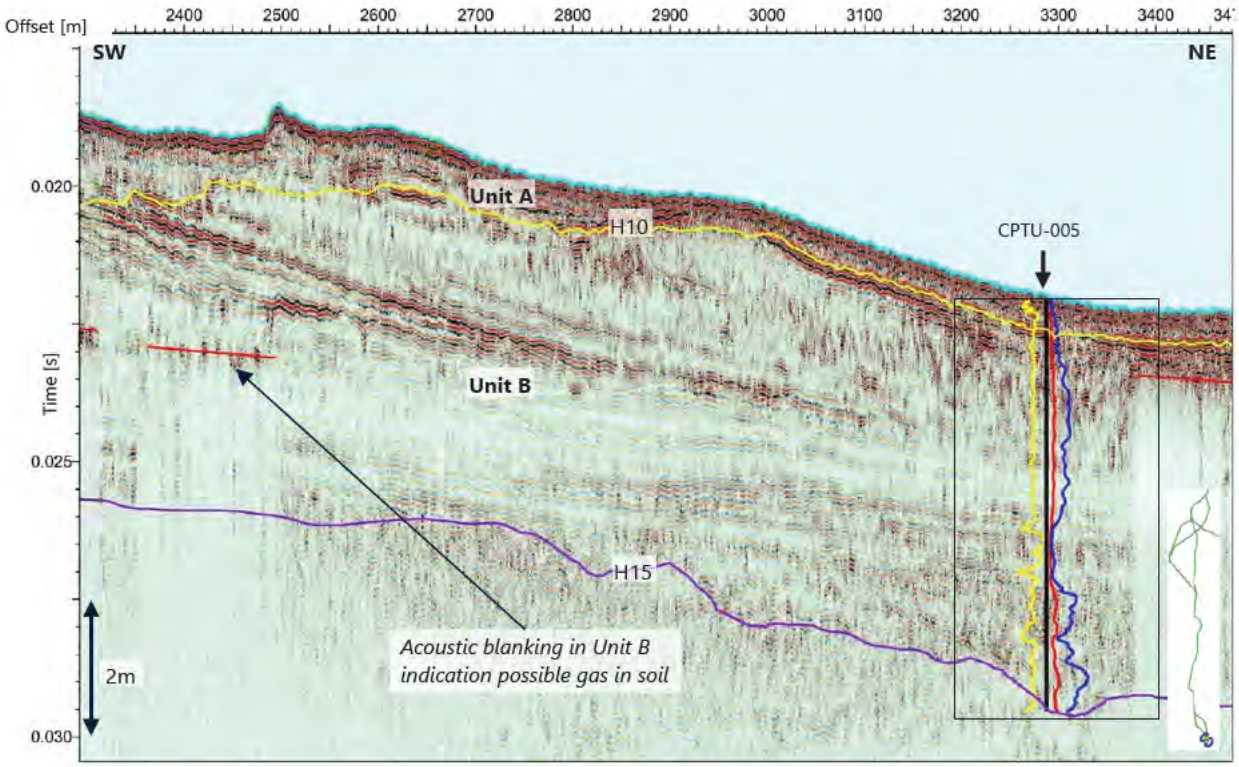


Figure 4.12: SBP data example of acoustic blanking in Unit B. (Line SBP_TA3C2020P1) Width of the CPT boxes show cone resistance values (blue curve) within range of 0 to 25 MPa, sleeve friction values (red curve) from 0 to 0.625 MPa and friction ratio (yellow curve) from 0 to 4 %.

4.3.4 Boulders, Cobbles and Gravel

A few diffraction hyperbolas were observed in the SBP data and are interpreted to represent possible boulders, cobbles and/or coarse gravel.

It should be noted that interpretation of these features is speculative and diffraction hyperbolas may be the result of factors other than the presence of boulders, cobbles or coarse gravel. Diffraction hyperbolas might be out of plane reflections which represent objects away from the SBP track line. Objects in between track lines may not be imaged in the SBP data and therefore not identified. Data quality influences the ability to image diffraction hyperbolas. Interpreting diffraction hyperbolas is subjective to some extent.

Given the geological setting (i.e. the expected presence of periglacial and glacial sediments), boulders and cobbles can be expected along the Aramis route. Hence, their presence cannot be ruled out.

4.3.5 Glacial Deformation

Glacial deformation is typically expressed in seismic data as chaotic internal reflections, inclined shear planes, deformed and folded strata and disturbance of the original internal structure.

The Aramis trunkline area has been affected by two glaciations, the Saalian and the Elsterian, which may have resulted in thrusting and folding of sediments due to glacial loading and ice

sheet advances and retreats. The units that may have been affected are the pre-Saalian units (Unit F and Unit G).

Evidence of possible deformation was observed in Unit G, especially in proximity of glacial tunnel valleys (Unit F). These features are thought to be related to the Elsterian glaciation (Figure 4.13).

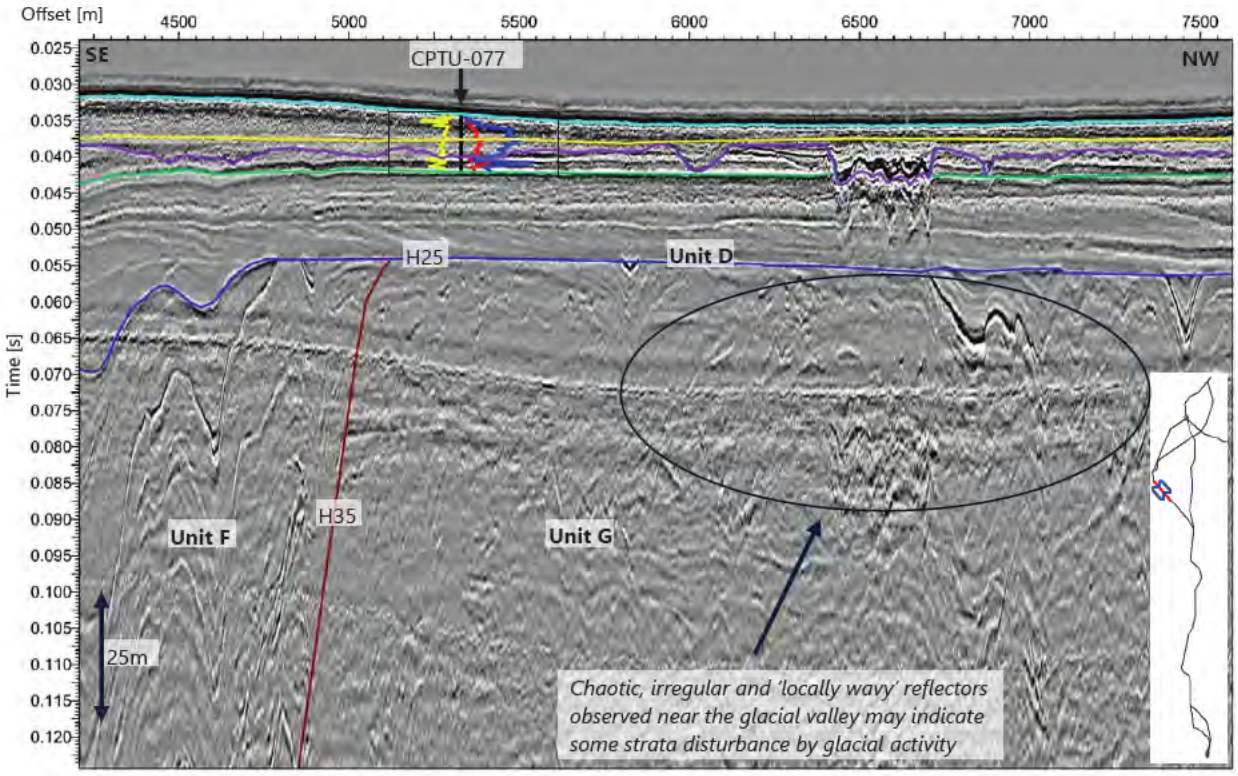


Figure 4.13: 2D-UHRS data example of possible glacial deformation in Unit G. (Line 212-TA3A1547P1) *Width of the CPT boxes show cone resistance values (blue curve) within range of 0 to 25 MPa, sleeve friction values (red curve) from 0 to 0.625 MPa and friction ratio (yellow curve) from 0 to 4 %.*

4.3.6 Faults

Due to the structureless seismic aspect that characterises a large part of the sub-seafloor vertically extensive / tectonic faults were not observed in the seismic reflection data. Small-scale faults associated with possible glaciotectonism or dewatering features may be present, as well as faults associated with the steep flanks of the tunnel valleys. The presence of more faults and/or fractures cannot be ruled out.

5. Export Route East MT

5.1 Export Route East MT Location

The location of the route section Export Route East MT is shown in Figure 5.1. This section of the route has a length of 30.5 km.

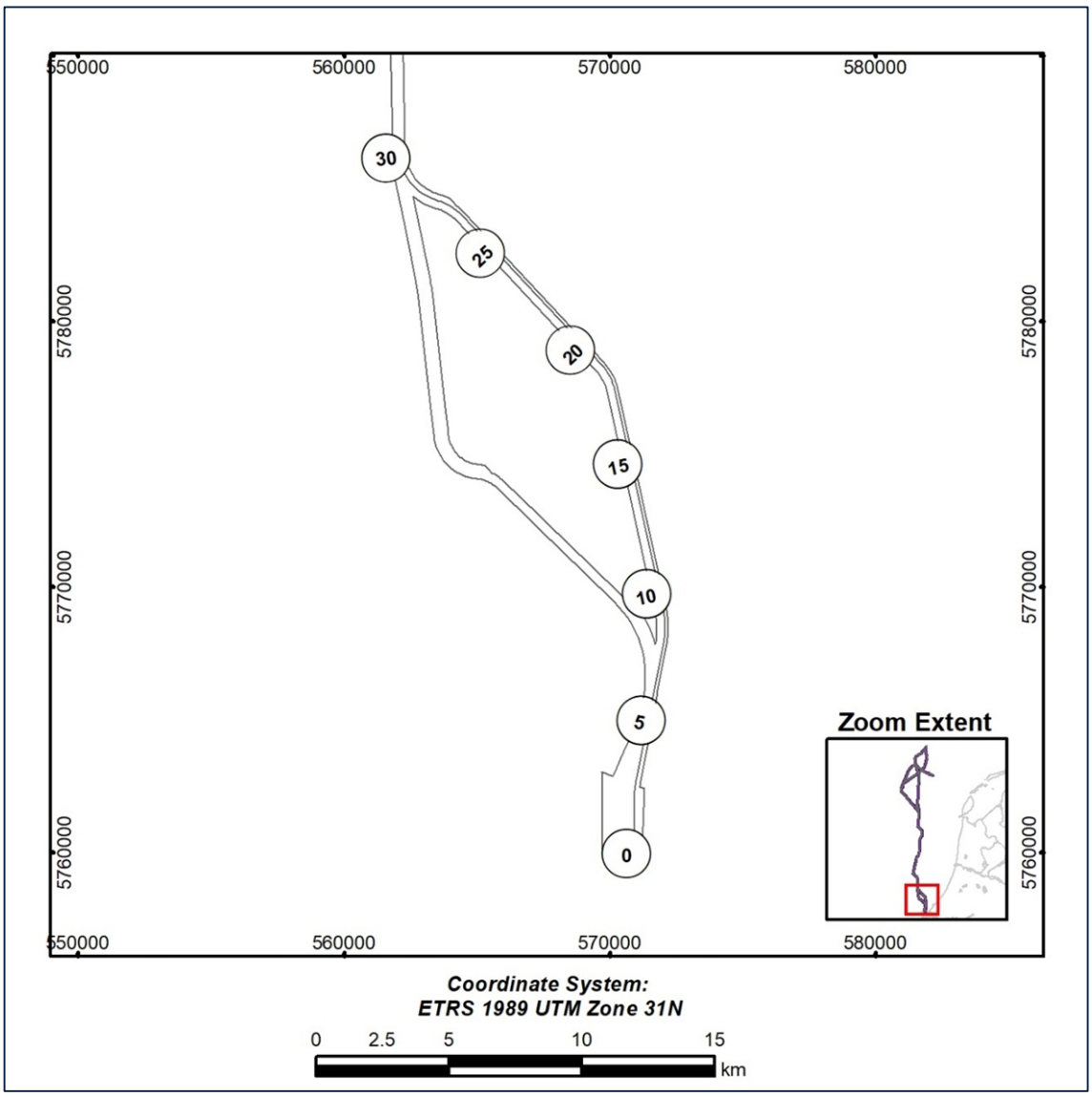


Figure 5.1: Location of the route section Export Route East MT.

5.2 Results

5.2.1 Bathymetry

The water depth within the Export Route East MT section ranges between 3.0 m and 24.0 m. An overview of the bathymetry is given in Figure 5.2.

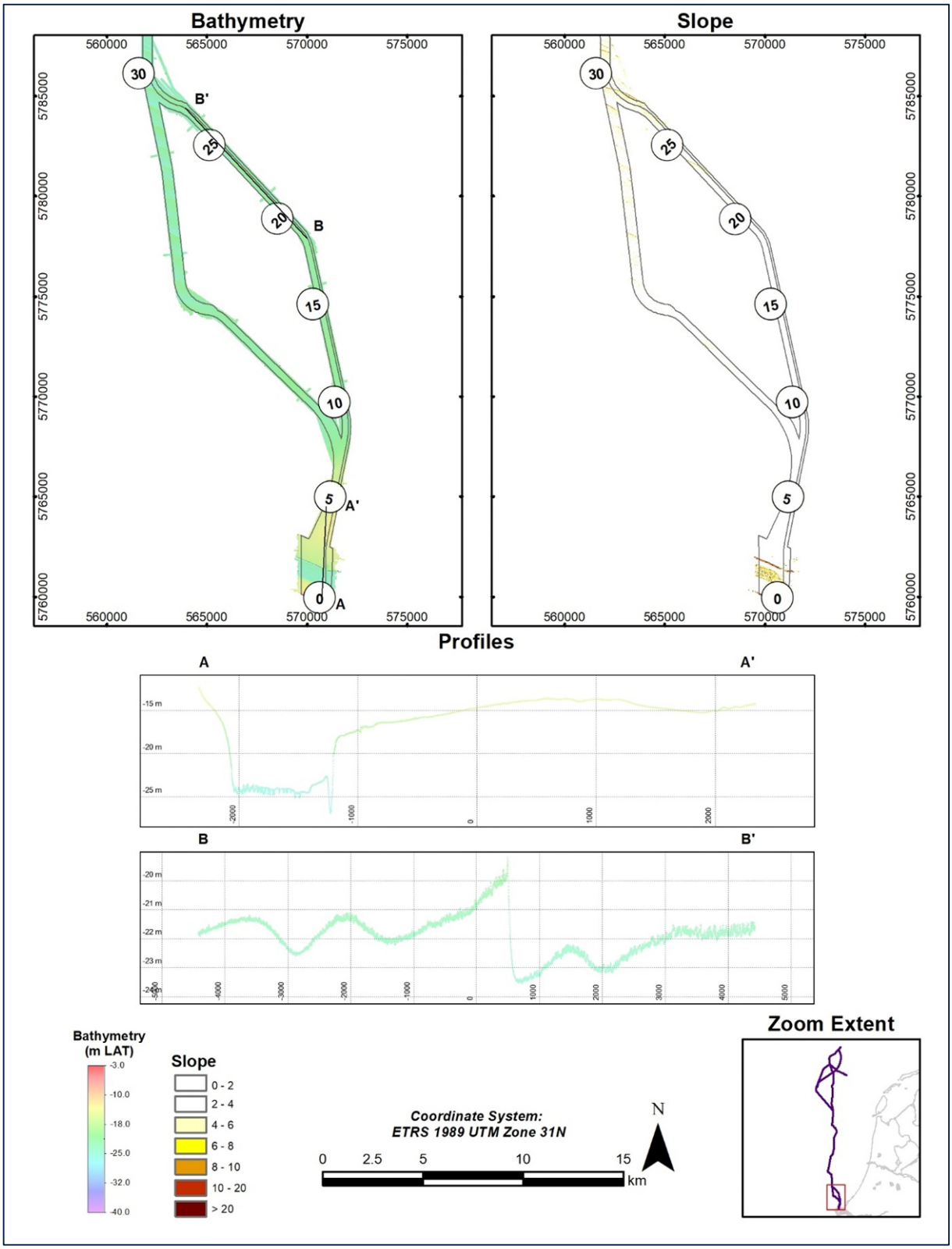


Figure 5.2: Bathymetry along Export Route East MT.

5.2.2 Seafloor Morphology

Overall, a strong correlation between seafloor sediment types and morphological types was observed along the Export Route East MT. An overview of the sediment and features encountered is given in Table 5.1.

Table 31: Sediment type with associated morphology in Export Route East MT

Sediment Type	Morphological Type
Gravelly SAND	Area with numerous boulders/debris Area with occasional boulders/debris Irregular seafloor or featureless
Slightly gravelly SAND	Ripples, megaripples and sand waves Irregular seafloor Cable trench (HKZ)
SAND	Featureless Irregular seafloor Navigation Channel / Maasmond Kanaal
Rock armour	Rock armour

Figure 5.3 to Figure 5.6 show the first 4 KPs of the Export Route East MT section. In the nearshore area, the main bathymetrical feature is the dredged Maasmond Kanaal (navigation channel) with its dredging scour marks.

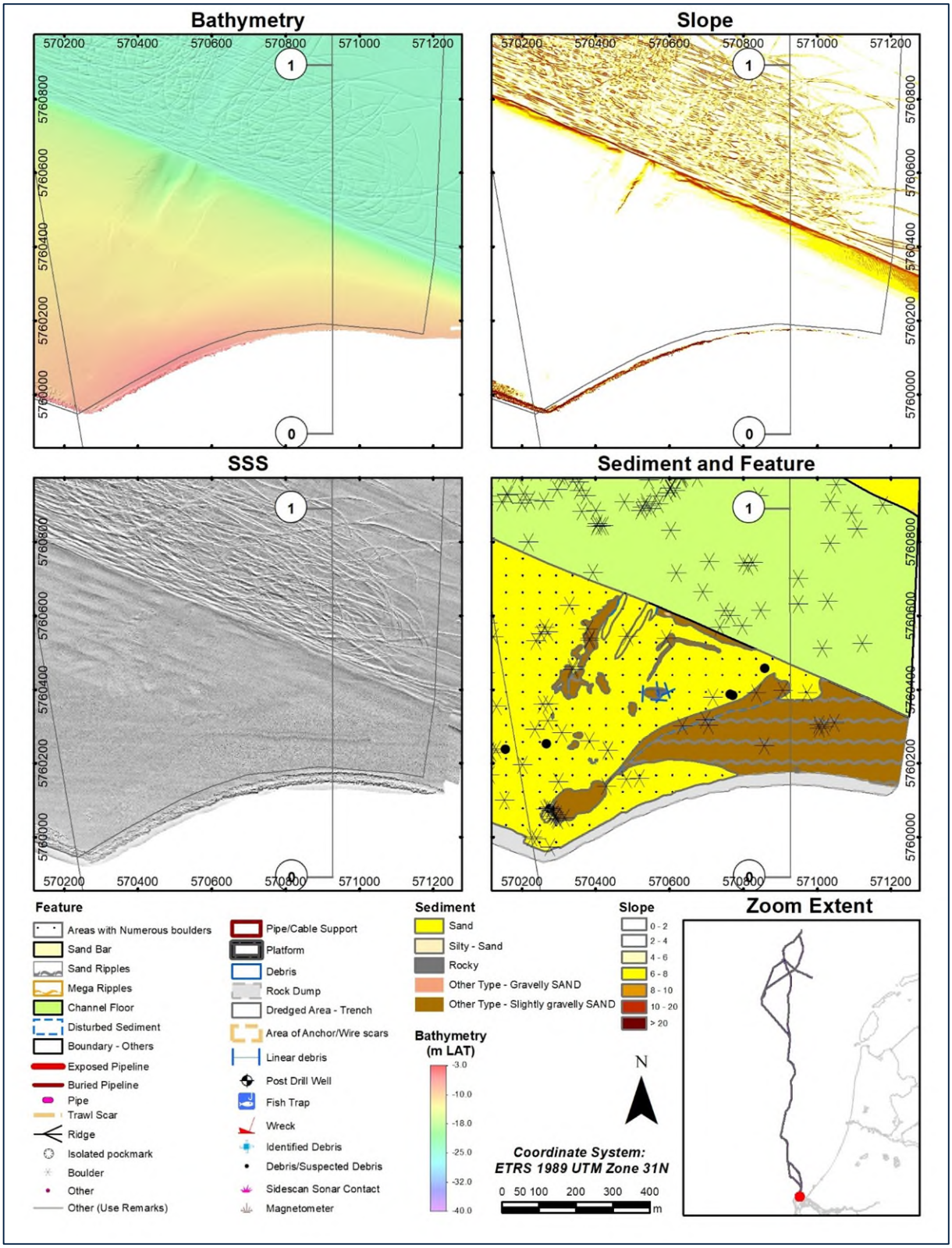


Figure 5.3: Overview of the sediments and morphology in Export Route East MT. : KP 0.0 to KP 1.0. Maasmond Kanaal with dredging scours visible.

Between KP 1.0 and KP 2.0 of the route section (Figure 5.4), trenches of the recently installed cables (Kabel van windgebied HK(Zuid) naar Maasvlakte) are visible.

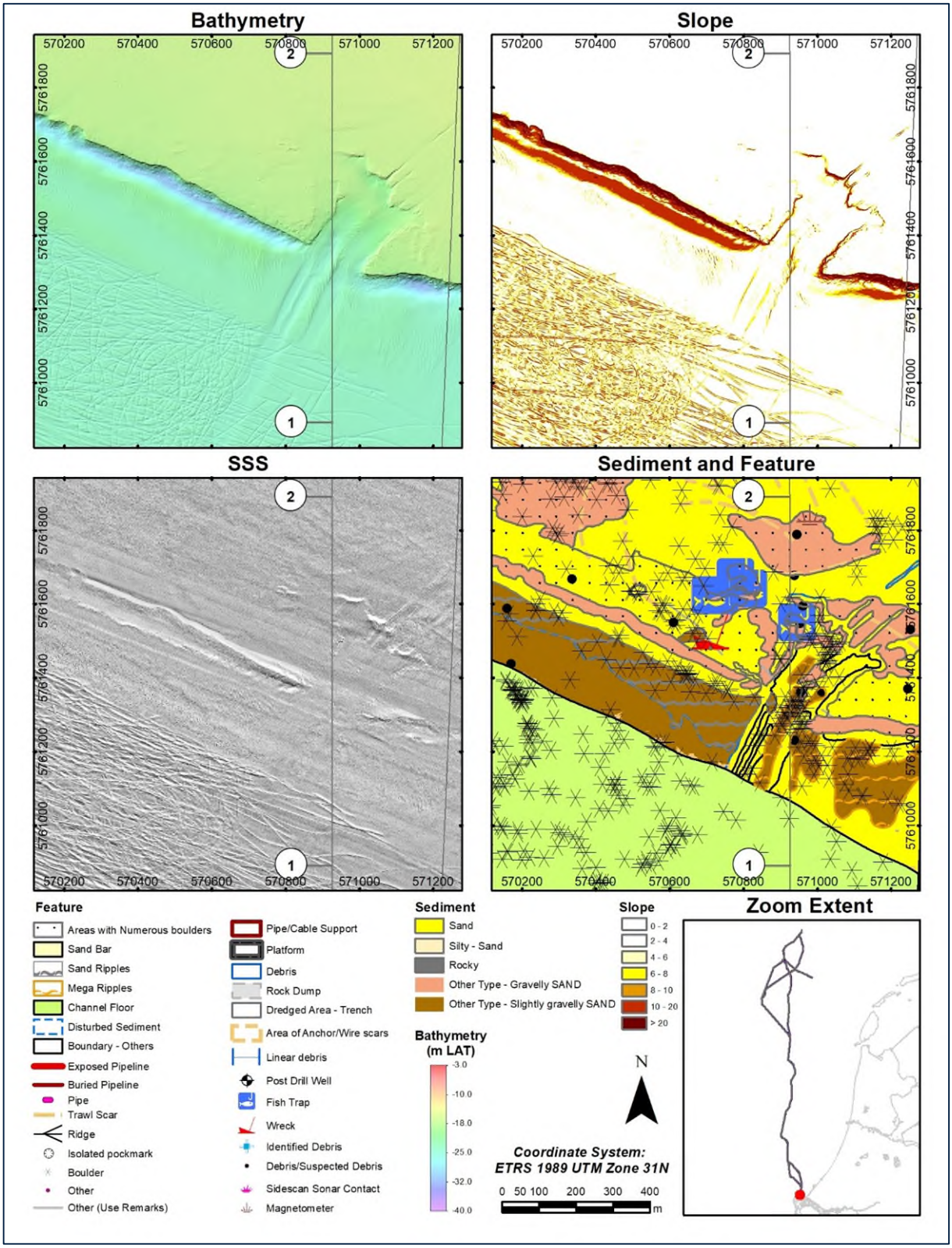


Figure 5.4: Overview of the sediments and morphology in Export Route East MT.: KP 1.0 to KP 2.0. Maasmond Kanaal with dredging scours and HKZ cable trenches visible.

Between KP 2.0 and KP 3.0 (Figure 5.5), an area with numerous boulders/debris and sediment dumping features is visible. At KP 2.5 there is a change in sediment type from SAND with sediment dumping features to slightly gravelly SAND with irregular seafloor.

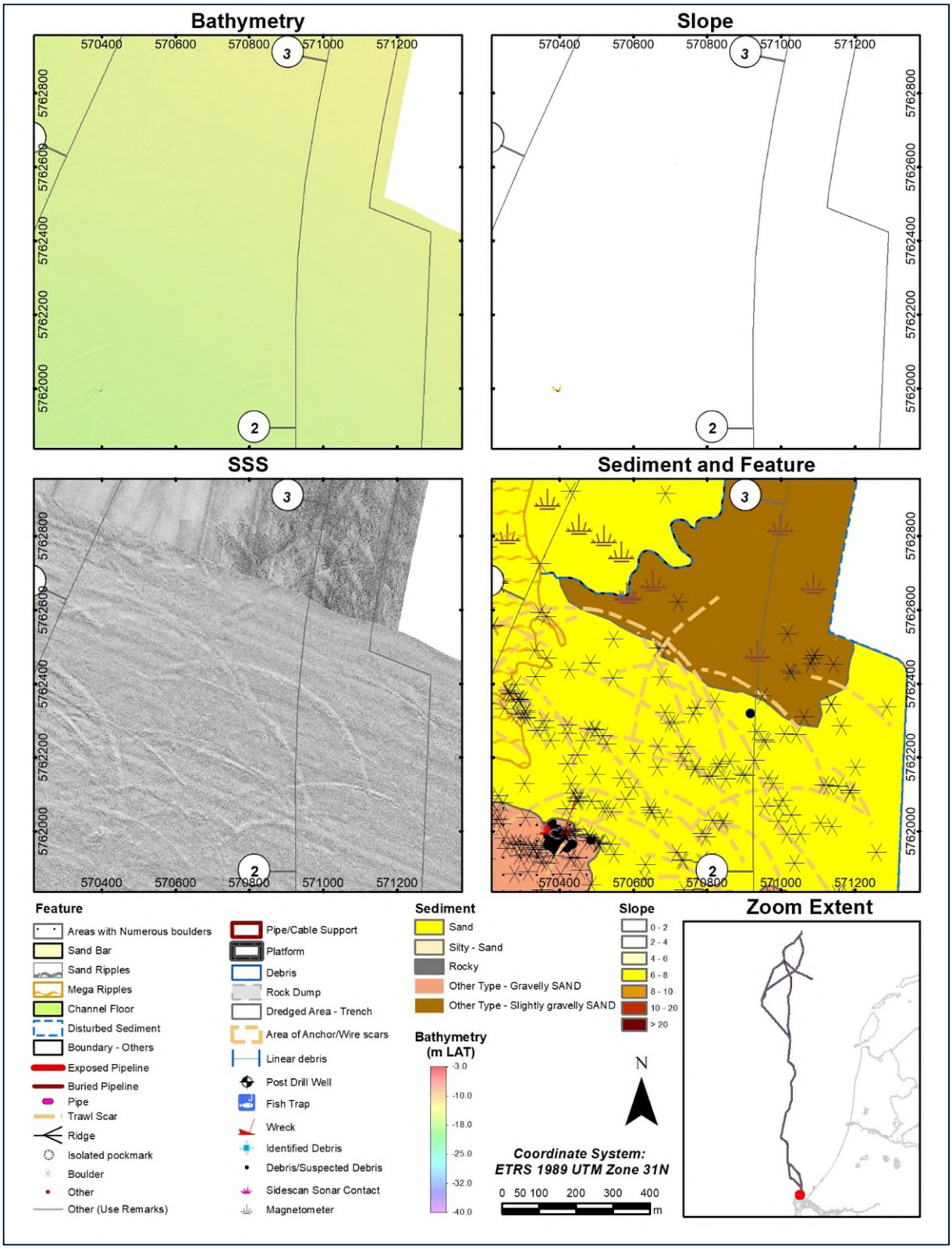


Figure 5.5: Overview of the sediments and morphology in Export Route East MT: KP 2.0 to KP 3.0.

Between KP 3.0 and KP 4.0 (Figure 5.6), an area with various MAG contacts is visible. This part of the section is relatively flat and characterised by various sediment types from featureless SAND to slightly gravelly SAND with irregular seafloor and patchy SSS reflectivity.

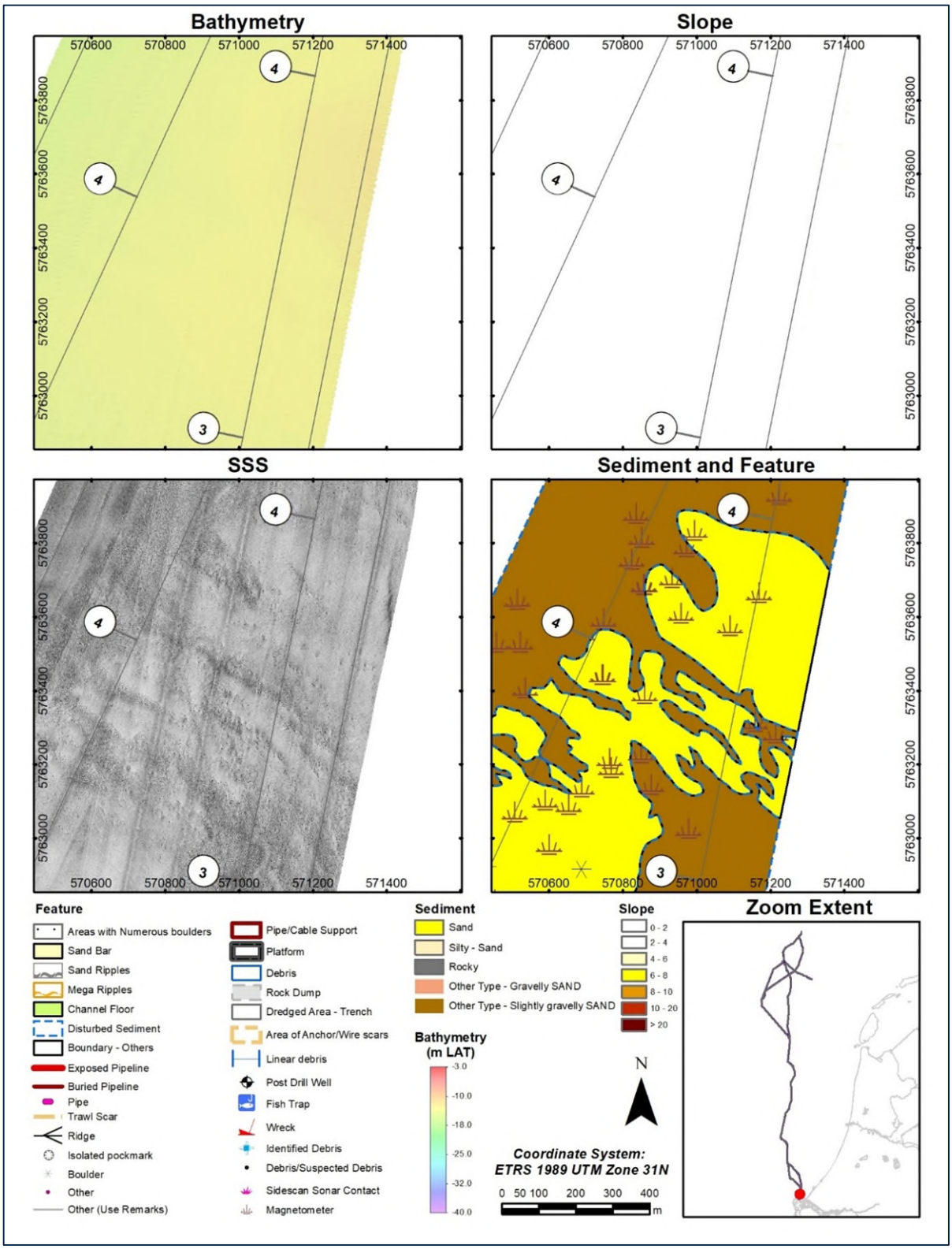


Figure 5.6: Overview of the sediments and morphology in Export Route East MT: KP 3.0 to KP 4.0.

Between KP 14.0 and the end of the section, the sediment type identified as slightly gravelly SAND is present, with the presence of ripples, megaripples and sand waves.

The sand waves are mostly symmetrical, with a northwest – southeast orientation, with an average length of 3.0 km, with the height between 1 m and 4 m.

5.2.3 Seafloor Features and Contacts

Seafloor features and contacts were identified from one or more of the SSS, MBES, MAG and SBP sensors and cross correlated where possible.

Table 5.2 summarises the quantities of contacts picked. The survey extent for each sensor varied and contacts were picked within the section boundary of each sensor and cross-correlated where multiple datasets were available. No targets cross correlate between sensors.

Table 32: Summary of seafloor contacts in Export Route East MT

Sensor	Contact Classification	Quantity
SSS/MBES/MAG Point Features	Boulder	576
	Debris	11
	Fishing gear	5
	Suspected debris	20
	Wreck	1
	Magnetic anomalies	1174
SSS/MBES/MAG Linear Features	Scour	1527
	Unknown linear feature	8
	Buried pipeline	6 segments (2 pipeline in total)
	Magnetic linear feature	7

An area of numerous boulders / debris has been identified between KP 23.5 and KP 26.0 (Figure 5.7).

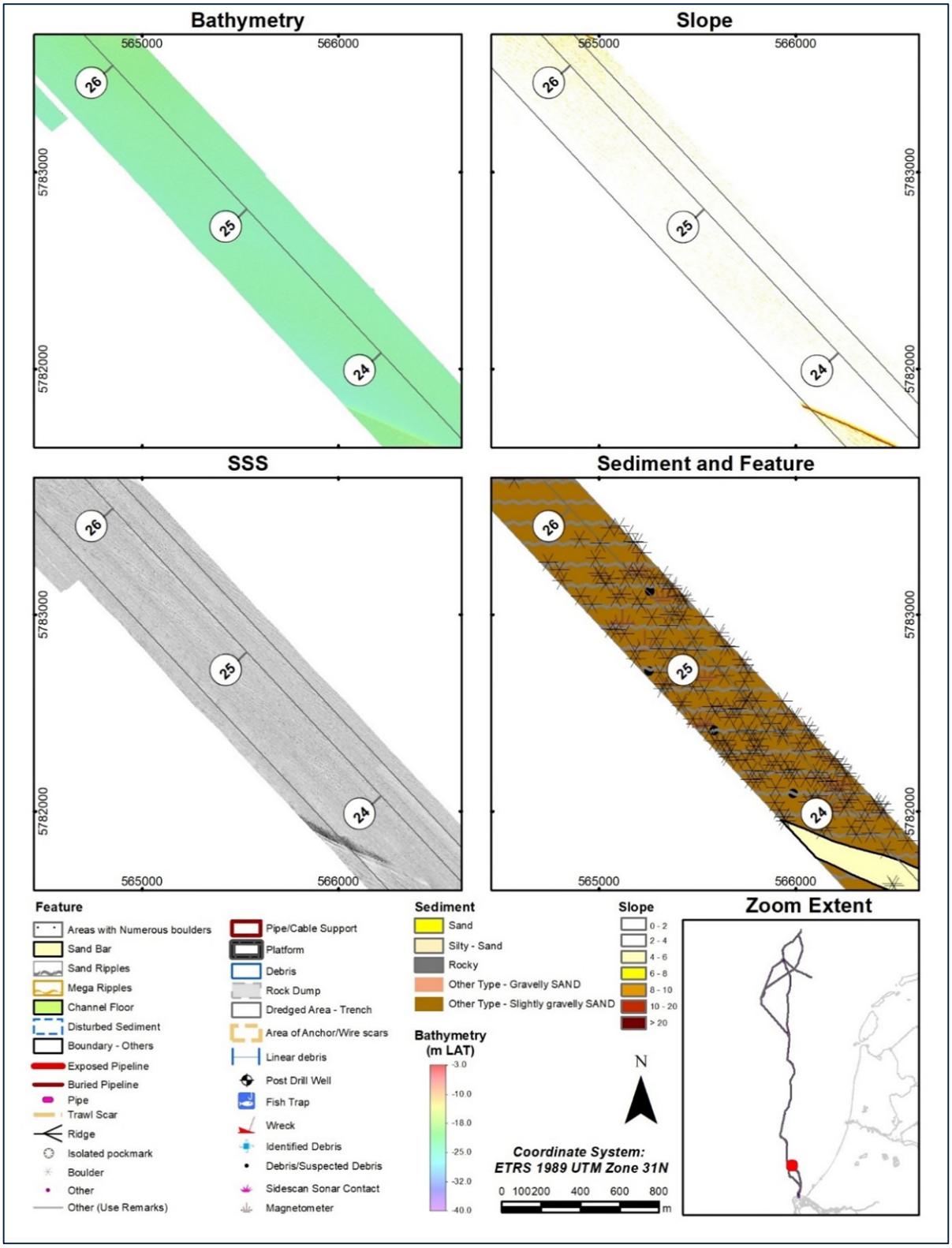


Figure 5.7: Overview of the sediments and morphology in Export Route East MT: KP 24.0 to KP 26.0.

Six (6) segments of two (2) buried pipelines are observed in route section Export Route East MT (Table 5.3 and Figure 5.8). The pipelines also cross the Export Route West HDD and the beginning of section A – Alt.

Table 33: Summary of pipelines in Export Route East MT

Contact ID	Pipeline Name	Comment
Pipeline (PL0039_PR)	P15-C to Hoek van Holland 10-inch oil trunkline	Buried (3 segments)
Pipeline (PL0099_PR)	P15-D to Maasmonding 26-inch gas pipeline	Buried (3 segments)

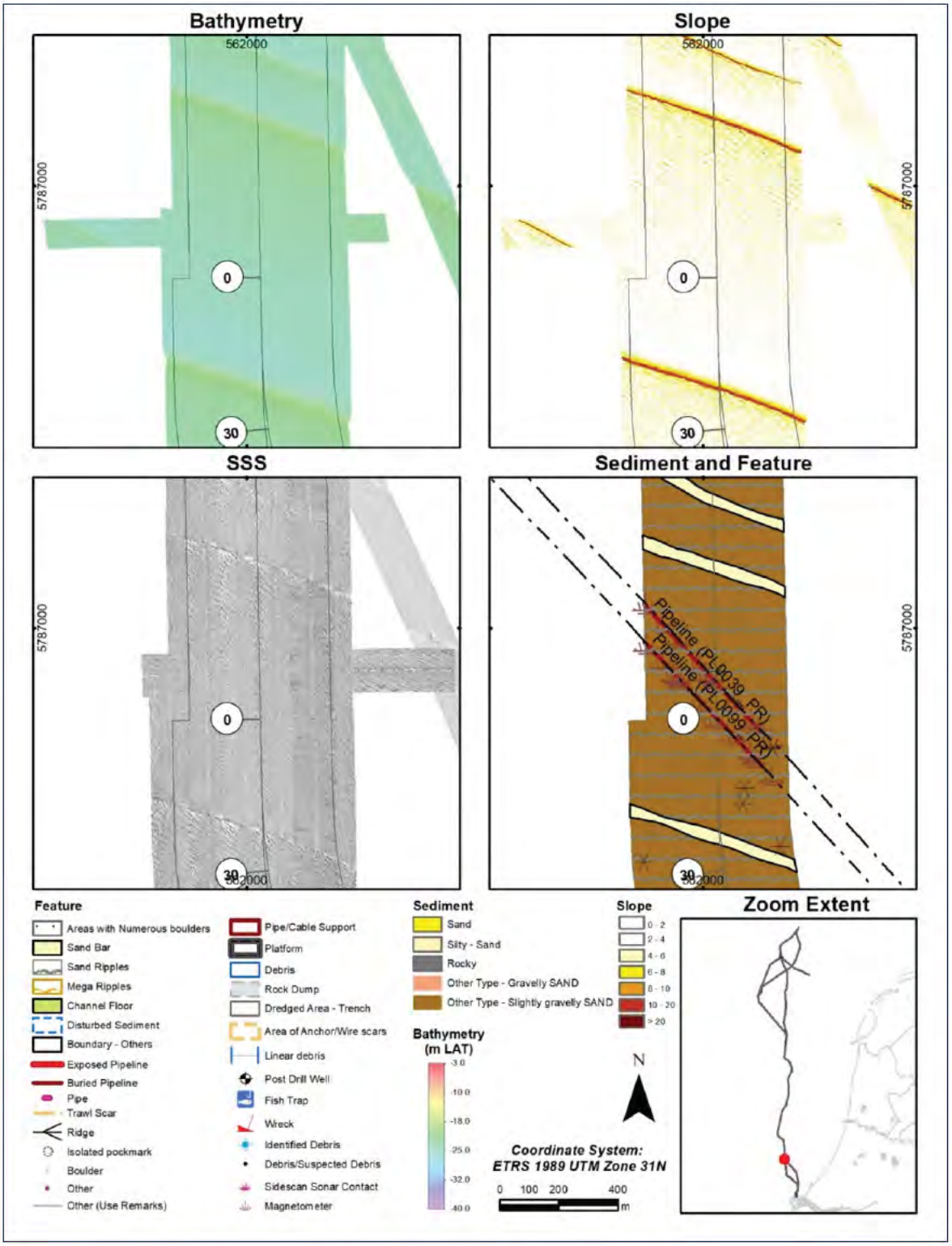


Figure 5.8: Pipelines encountered in Export Route East MT: KP 30.5.

5.2.4 Magnetometer Contacts

1174 magnetic contacts were found at the time the geophysical scope (single MAG survey) in Export Route East MT. The magnetometer anomalies range between 0.9 nT and 3867.1 nT. The highest magnetic amplitude is associated with the encountered pipelines. Most of the magnetic anomalies are located in the nearshore area, between KP 0.5 and KP 2.5, and are probably related to the very anthropogenically altered area close to the Port of Rotterdam.

5.2.5 Sub-seafloor Geology

Units DS, A, B, D and G are present in Export Route East MT (Figure 5.9).

Unit DS is present exclusively in the dredged Maasmond Kanaal. The base of these sediments is uncertain and taken at the base of high amplitude reflections or at the top of structured seismic facies, which were very locally observed. The unit has semi-transparent and chaotic seismic character.

Unit A is present basically in the entire section, except in the Maasmond Kanaal. The top unit in the Maasmond Kanaal consists of disturbed sediments (Unit DS) and deposits of Unit A were removed during dredging activities. Between KP 0.3 and KP 1.8 Unit A was not observed, however in this part of the section acoustic blanking is widespread, what greatly obscure the acoustic signal. Unit A is characterized by chaotic in the nearshore area to semi-transparent seismic facies, with locally point reflections further offshore. High amplitude reflectors of limited extent were observed locally between KP 2.0 and KP 10.0 in this unit. The maximum thickness of Unit A in this section is approximately 4.5 m.

Unit B is present across the entire section. Between KP 0.0 to KP 2.7 it is observed locally (as patches), what can be due to the acoustic blanking that hinder the interpretation. The unit exhibits transparent to semi-transparent seismic character. Between approximately KP 2.5 and KP 7.5 the unit exhibits often layered facies with flat to inclined parallel reflectors. Internal buried channels with layered infill were observed in this unit. The maximum thickness of Unit B in this section is approximately 5 m.

Unit B is underlain by Unit D (interpreted to be present from approximately KP 17.3) and Unit G. Unit D and G exhibit structureless acoustically transparent to semi-transparent seismic character in this section.

High amplitude anomalies in Unit G were interpreted between KP 18.3 to KP 30.0. These negative amplitude events most likely represent laminae or thin bed of peat and/or organic-rich clay (peat level 3).

Table 5.4 provides lithology in the shallow sub-seafloor (within penetration depth of the SBP data), which is based on the seafloor CPT and VC geotechnical data acquired as part of this geophysical survey. Details of the geotechnical data can be found in report F197217-REP-006.

Table 34: Soil conditions in shallow sub-seafloor

Unit	Depth to Base [m BSF]	Lithology
DS	0 to 4.5	Very loose to very dense slightly silty fine and medium SAND
A	0.2 to 4.0	Very loose to very dense slightly silty fine and medium SAND with frequent shells and shell fragments
B	2.0 to 10.5	Medium to very dense slightly silty fine and medium SAND with numerous shells and shell fragments
D	BPD	Dense to very dense slightly silty fine and medium SAND, occasionally slightly gravelly
Notes: BPD = below penetration depth of SBP data		

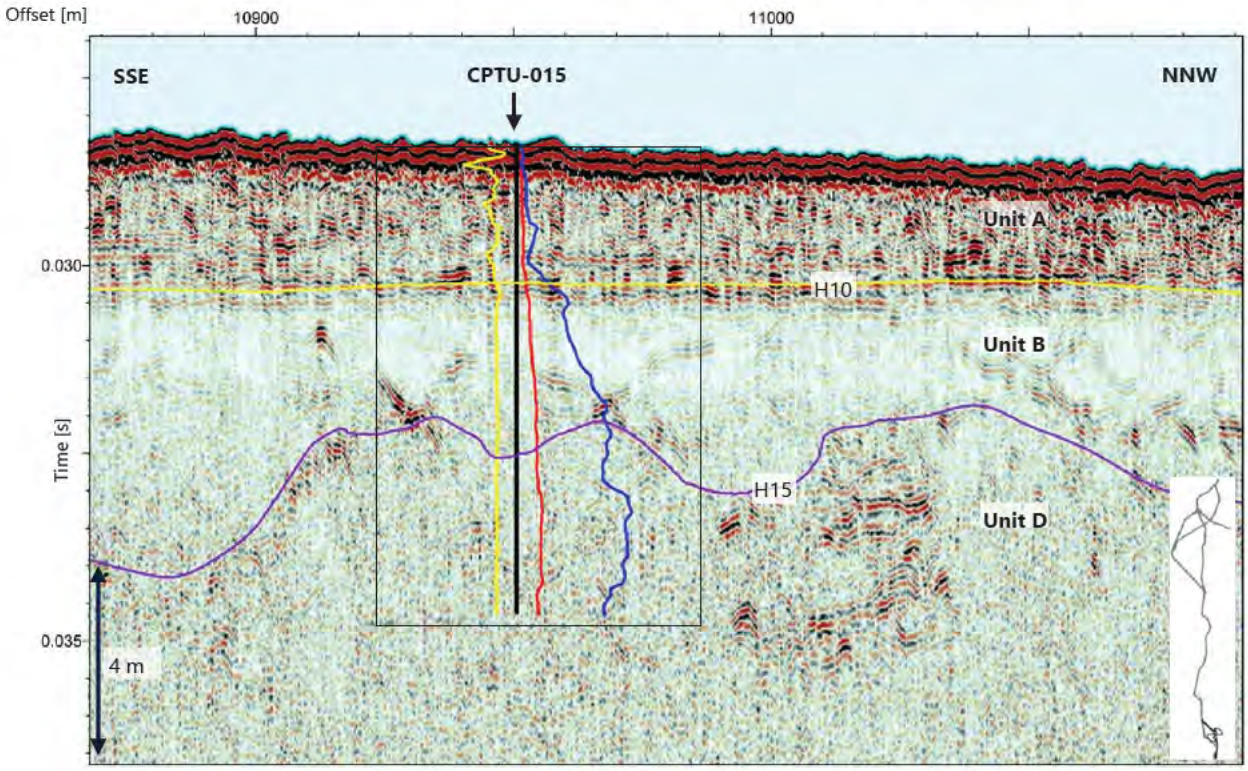


Figure 5.9: SBP data example of route section Export Route East MT. (Line SBP_TA3C2015P1) *Width of the CPT boxes show cone resistance values (blue curve) within range of 0 to 25 MPa, sleeve friction values (red curve) from 0 to 0.625 MPa and friction ratio (yellow curve) from 0 to 4 %.*

6. Export Route West HDD

6.1 Export Route West HDD Location

The location of the Export Route West HDD section is shown in Figure 6.1. This section of the route has a length of 31.0 km.

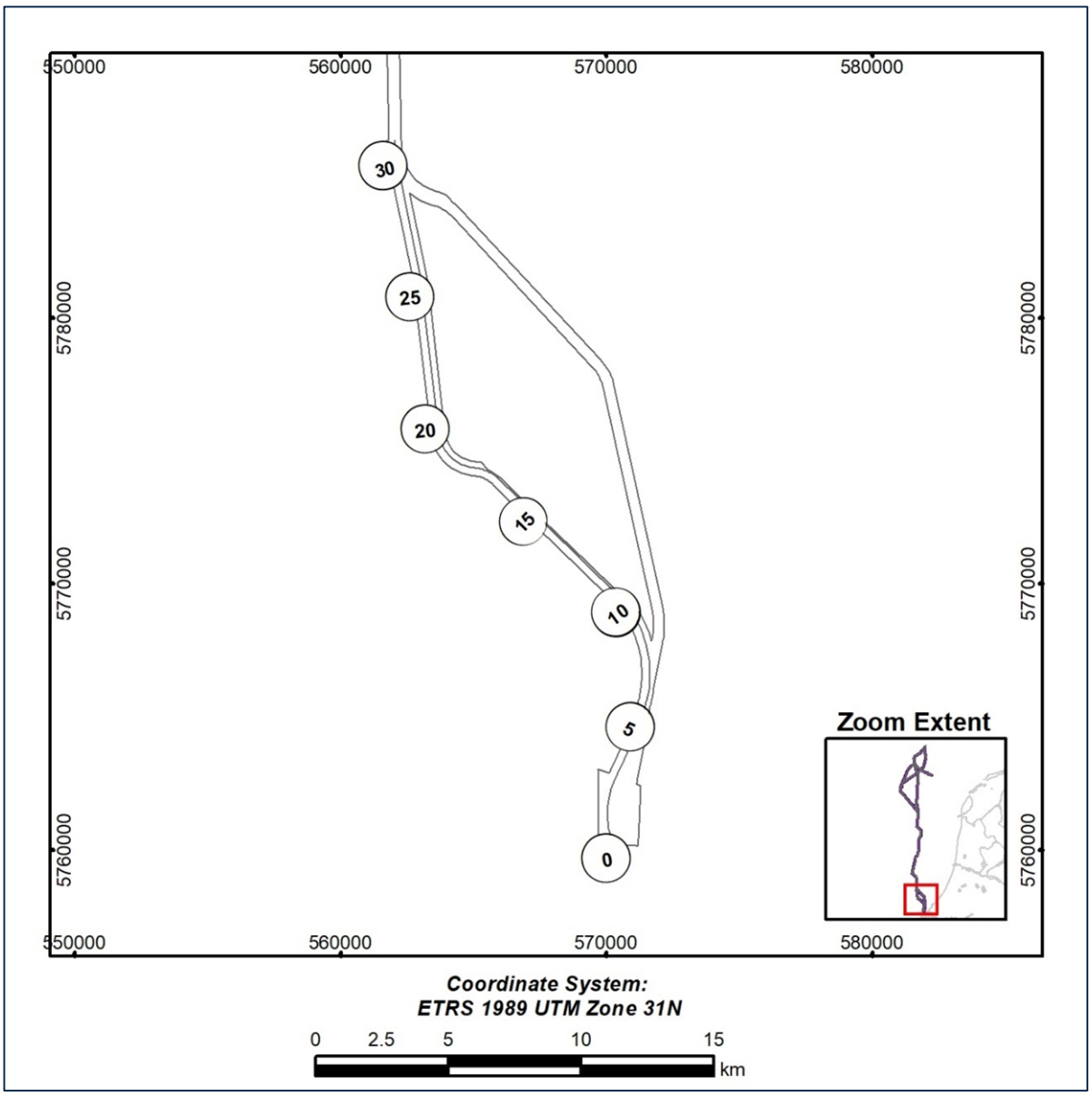


Figure 6.1: Location of the route section Export Route West HDD.

6.2 Results

6.2.1 Bathymetry

The water depth within Section Export Route West HDD ranges between 3.0 m and 24.0 m. An overview of the bathymetry is given in Figure 6.2.

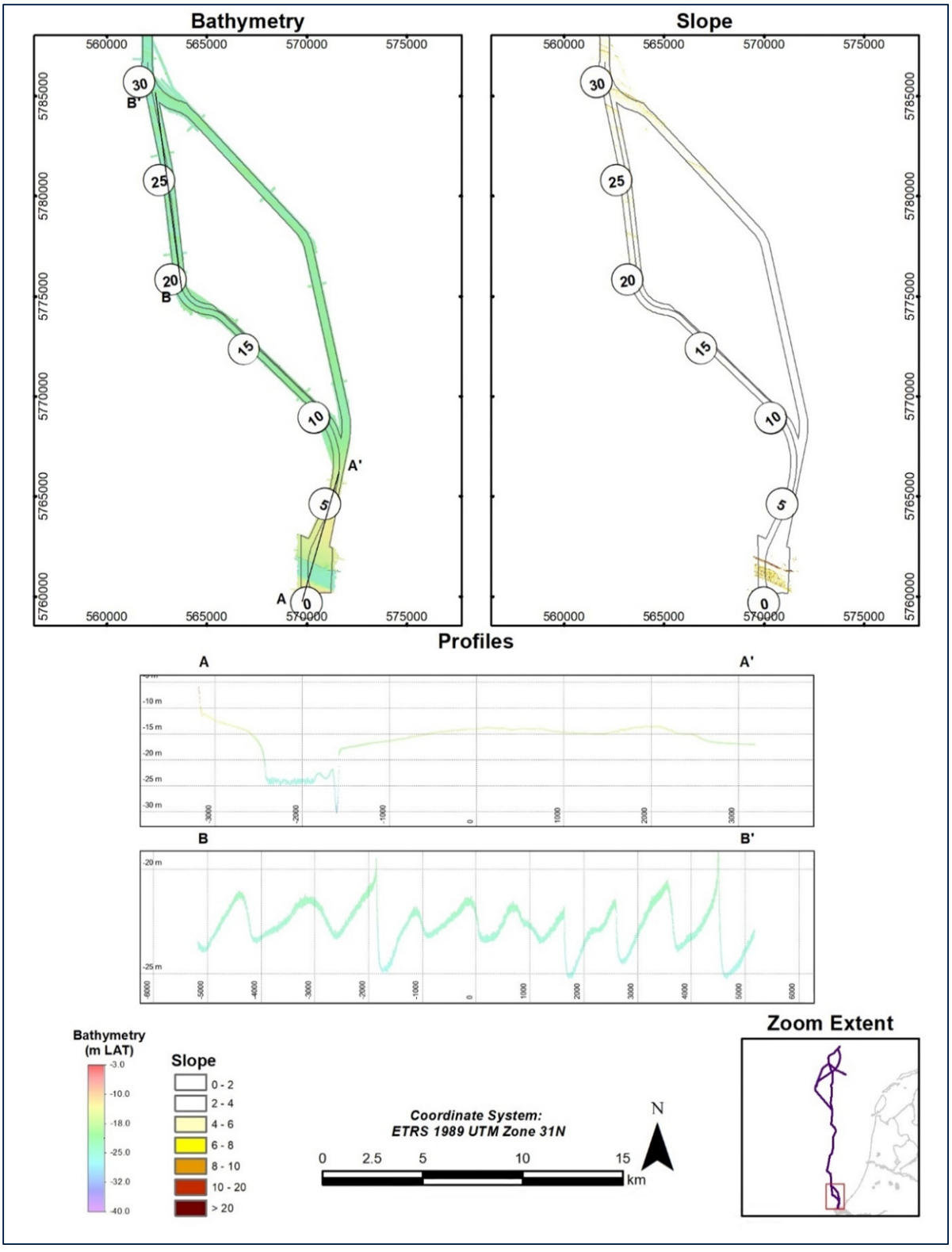


Figure 6.2: Bathymetry along Export Route West HDD.

6.2.2 Seafloor Morphology

A strong correlation between sediment types and morphological type was observed in the Export Route West HDD section, although some small variations are possible. An overview of encountered sediments and seafloor features is given in Table 6.1.

Table 35: Sediment type with associated morphology in Export Route West HDD

Sediment Type	Morphological Type
Gravelly SAND	Area with numerous boulders/debris Area with occasional boulders/debris Irregular seafloor or featureless
Slightly gravelly SAND	Ripples, megaripples and sand waves Irregular seafloor Cable trench (HKZ)
SAND	Featureless Irregular seafloor Navigation Channel / Maasmond Kanaal Wreck area
Rock armour	Rock armour

Figure 6.3 to Figure 6.5 show the first 3 KPs of the route section Export Route East MT.

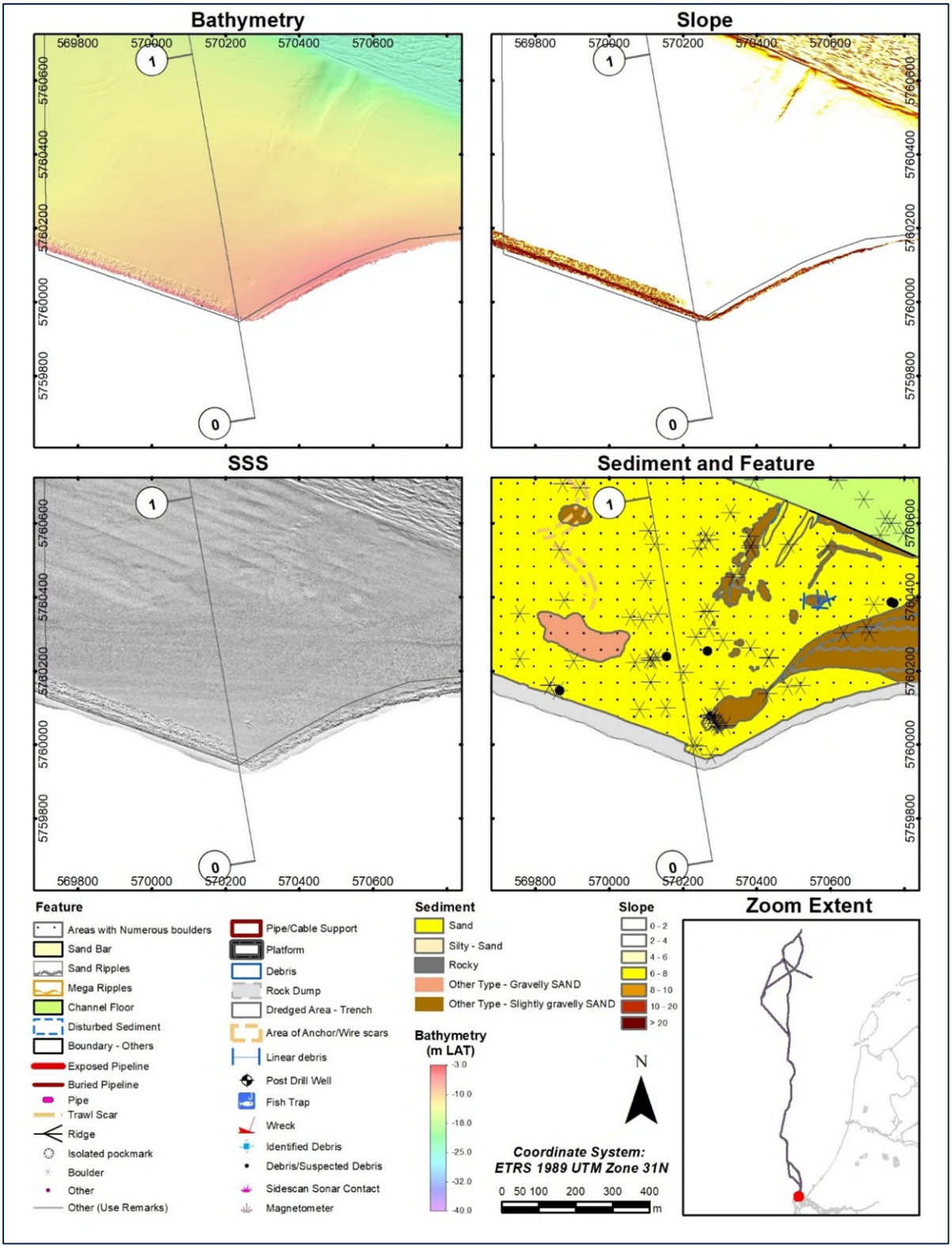


Figure 6.3: Overview of the sediments and morphology in Export Route West HDD: KP 0.0 to KP 1.0.

In the nearshore area, between KP 1.0 and KP 2.0, the main morphological feature is the dredged Maasmond Kanaal (navigation channel) with its dredging scour marks.

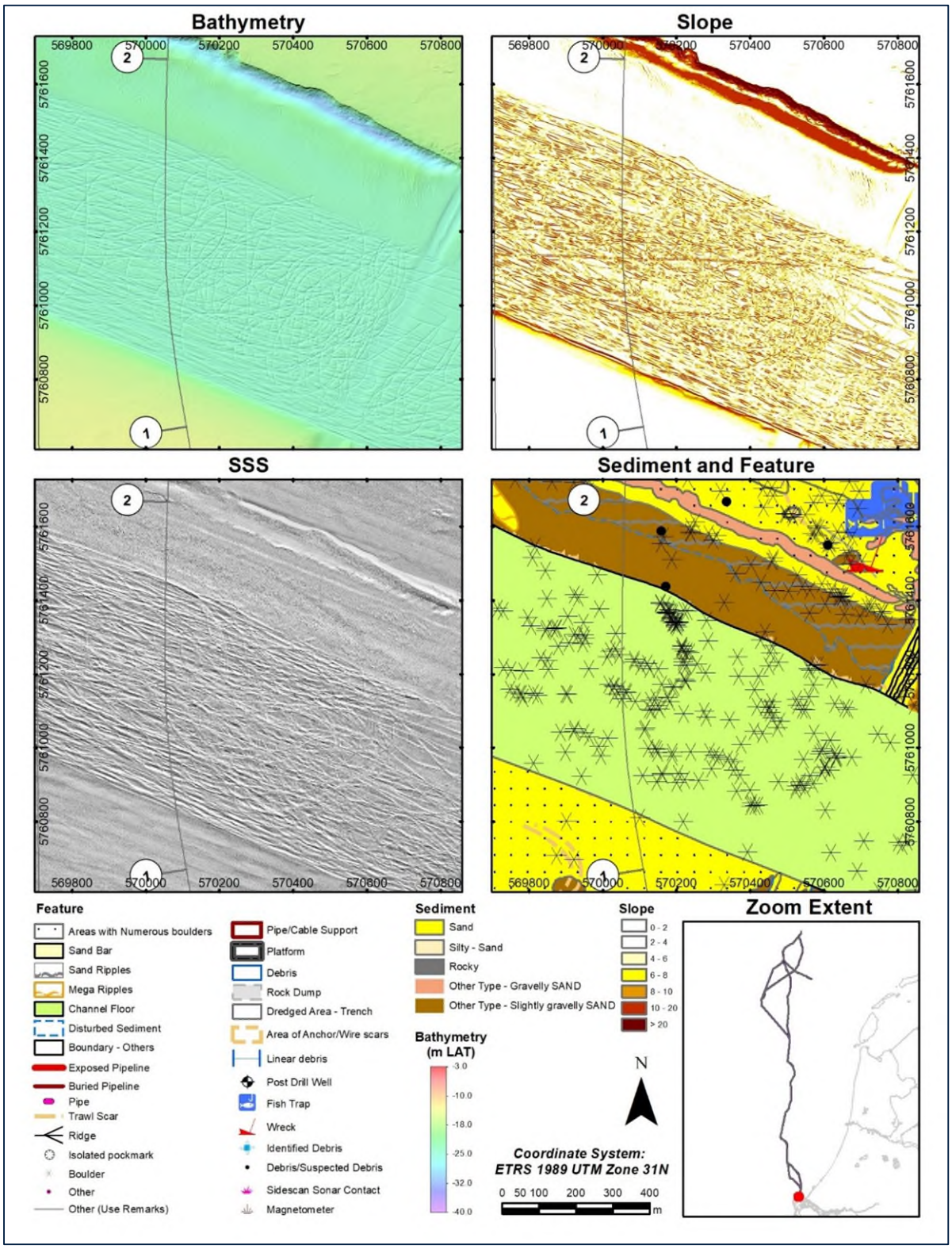


Figure 6.4: Overview of the sediments and morphology in Export Route West HDD: KP 1.0 to KP 2.0.

Between KP 2.0 and KP 3.0, an area with numerous boulders / debris and sediment dumping features is visible (Figure 6.5). At KP 2.4 of the section, and 0.4 km east from the centreline there is a debris wreck area identified.

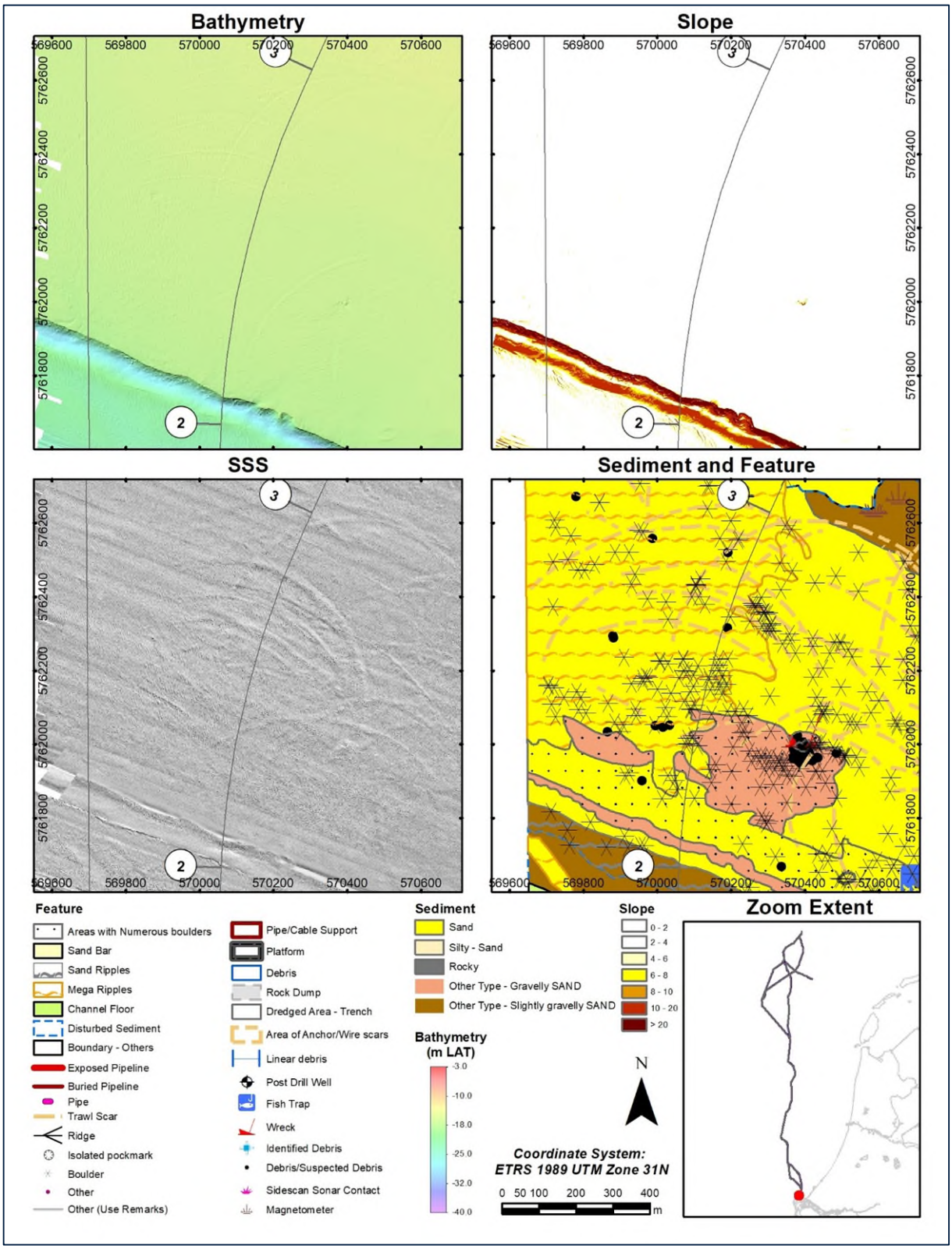


Figure 6.5: Overview of the sediments and morphology in Export Route West HDD: KP 2.0 to KP 3.0.

Between KP 12.0 and KP 13.0, a change of sediment type from a featureless SAND area to slightly gravelly SAND with ripples (Figure 6.6). From KP 12.5 till the end of this section the prevalent sediment is classified as slightly gravelly SAND with bedforms such as ripples, megaripples and sand waves.

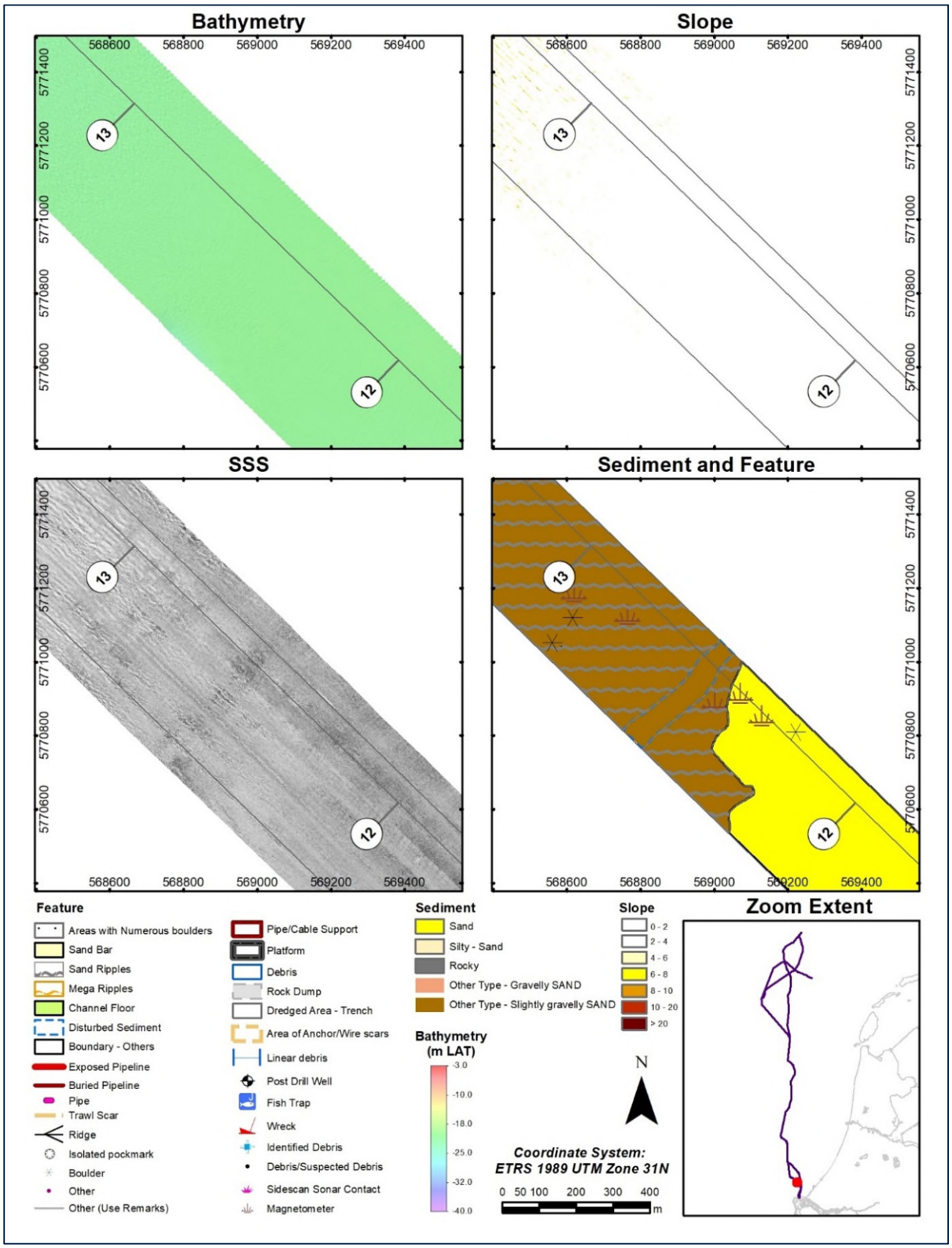


Figure 6.6: Overview of the sediments and morphology in Export Route West HDD: KP 12.0 to KP 13.0.

Between route sections Export Route East MT and Export Route West HDD, approximately 0.5 km from both sections, at KP 2.0, an unknown circular feature has been identified (Figure 6.7). This feature has a length of 47.7 m, a width of 24.8 m and a maximum depth of 0.54 m.

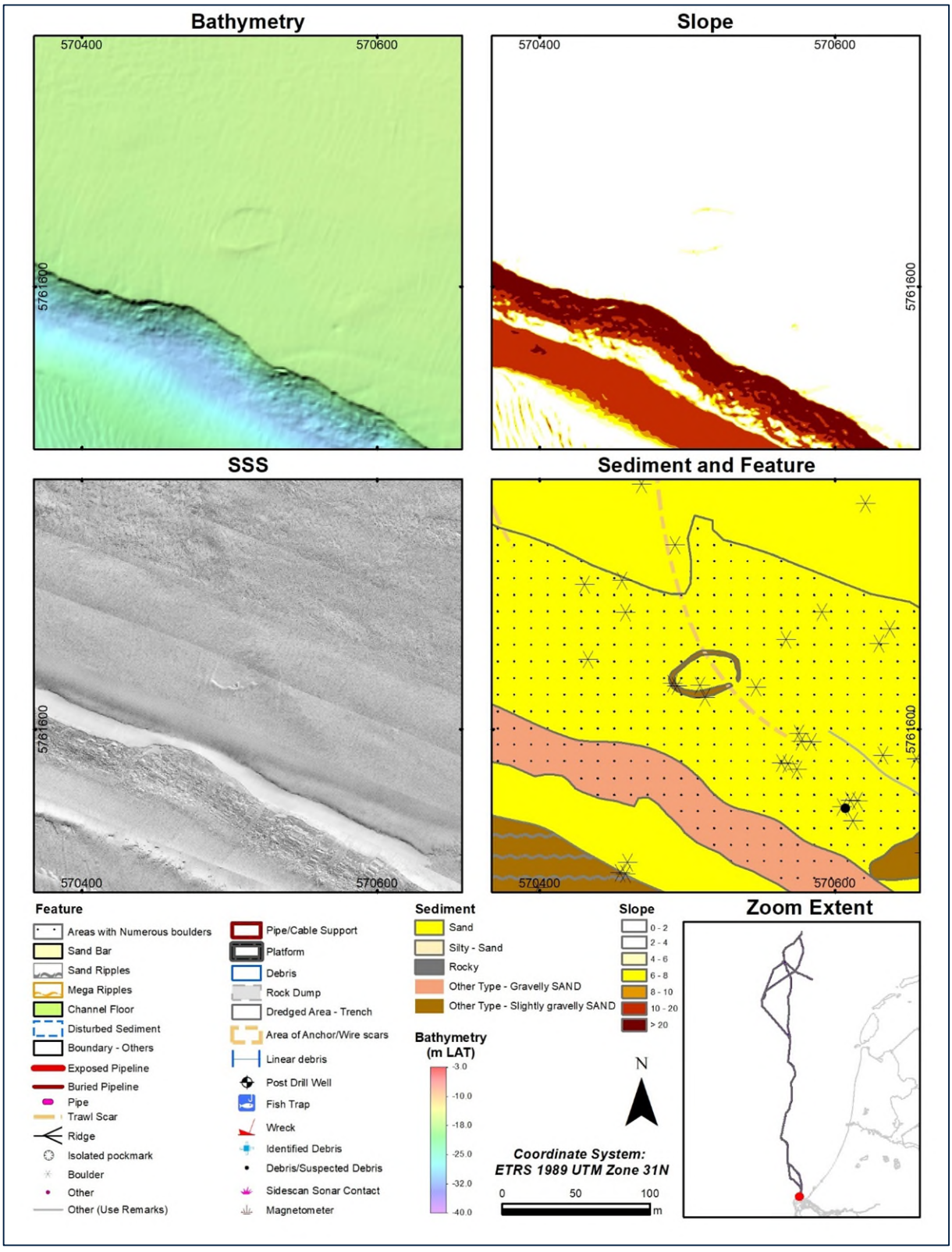


Figure 6.7: Overview of the sediments and morphology in Export Route West HDD: KP 2.0, unknown circular feature.

6.2.3 Seafloor Features and Contacts

Seafloor features and contacts were identified from one or more of the SSS, MBES, MAG and SBP sensors and cross-correlated, where possible.

Table 6.2 summarizes the quantities of contacts picked. The survey extent for each sensor varied and contacts were picked within the survey boundary of each sensor and cross-correlated where multiple datasets were available.

Table 36: Summary of seafloor contacts in Export Route West HDD

Sensor	Contact Classification	Quantity
SSS/MBES/MAG Point Features	Boulder	1885
	Debris	25
	Suspected debris	80
	Wreck	1
	Magnetic anomalies	651
SSS/MBES/MAG Linear Features	Possible fishing gear	3
	Mound ridge	2
	Scour	6460
	Telecommunication cable	1
	Buried pipeline	1
	Magnetic linear feature	4

8 targets cross correlate between sensors in section Export Route West HDD (Table 6.3).

Table 37: Summary of cross correlating seafloor contacts in Export Route West HDD

Section	SSS Target Name	MAG Target Name	Description
Near shore Area (Export Route West HDD)	BB_FS_SSS_0593	BB_FS_MAG_0222	Boulder
Near shore Area (Export Route West HDD)	BB_FS_SSS_0607	BB_FS_MAG_0247	Boulder
Near shore Area (Export Route West HDD)	BB_FS_SSS_0642	BB_FS_MAG_0274	Suspected debris
Near shore Area (Export Route West HDD)	BB_FS_SSS_0884	BB_FS_MAG_0567	Boulder
Near shore Area (Export Route West HDD)	BB_FS_SSS_0916	BB_FS_MAG_0605	Boulder
Near shore Area (Export Route West HDD)	BB_FS_SSS_0929	BB_FS_MAG_0691	Boulder
Near shore Area (Export Route West HDD)	BB_FS_SSS_0946	BB_FS_MAG_0710	Boulder
Near shore Area (Export Route West HDD)	BB_FS_SSS_0678	BB_FS_MAG_0298	Wreck

An area of numerous boulders / debris was identified between KP 19.0 and KP 28.0 (Figure 6.8).

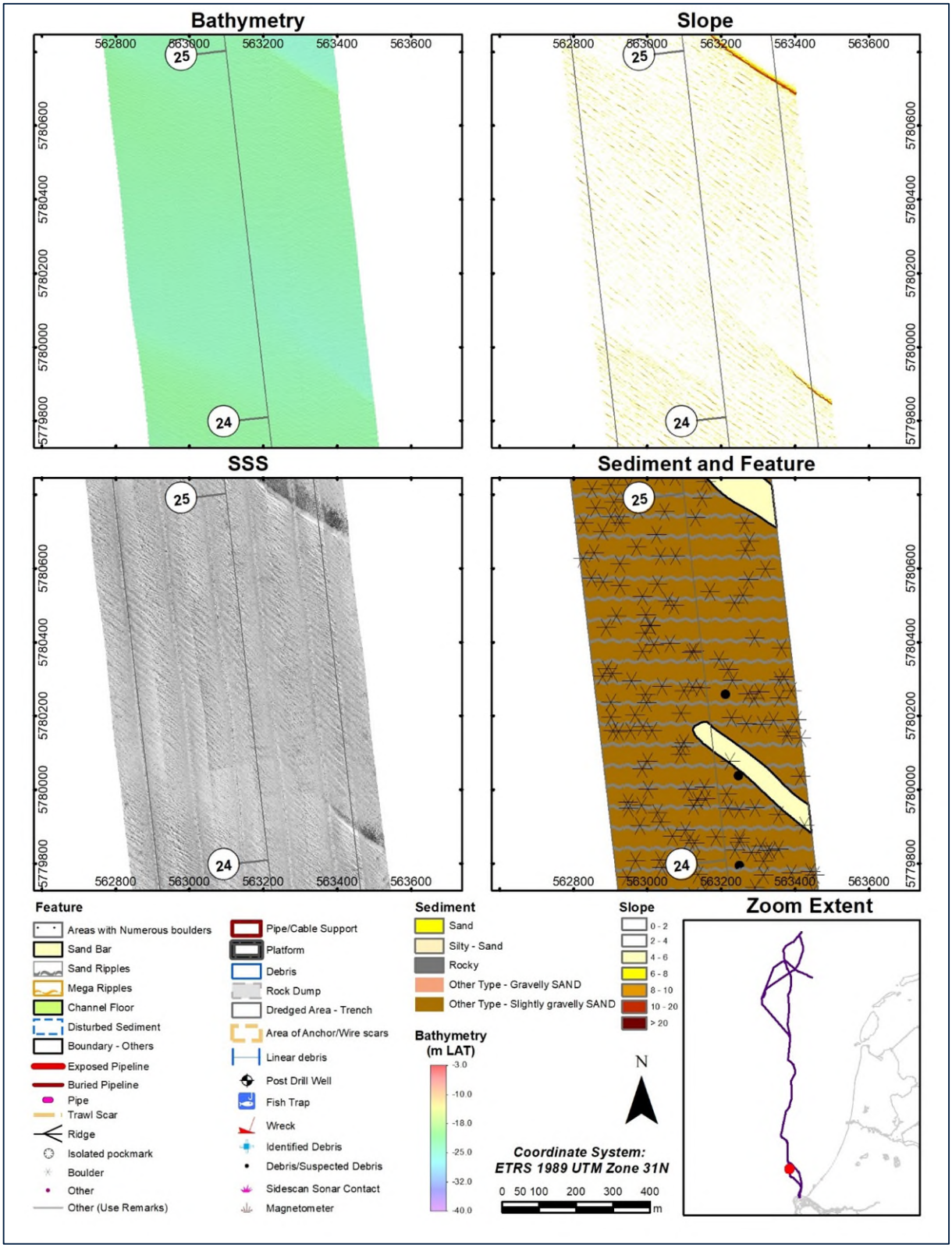


Figure 6.8: Example of area of boulders in Export Route West HDD.

Between KP 20 and KP 21 of the Export Route West HDD, a buried pipeline was identified (Table 5.3 and Figure 6.9).

Table 38: Summary of pipeline and cable in Export Route West HHD

Contact ID	Pipeline Name	Comment
Pipeline (PL0106_PR)	P18-A to P15-D 16-inch gas / 3-inch methanol pipeline bundle	Buried (1 segment)
Telecommunication cable (KB0002)	Concerto 1E	Buried (1 segment) (slightly visible in the magnetometer data)

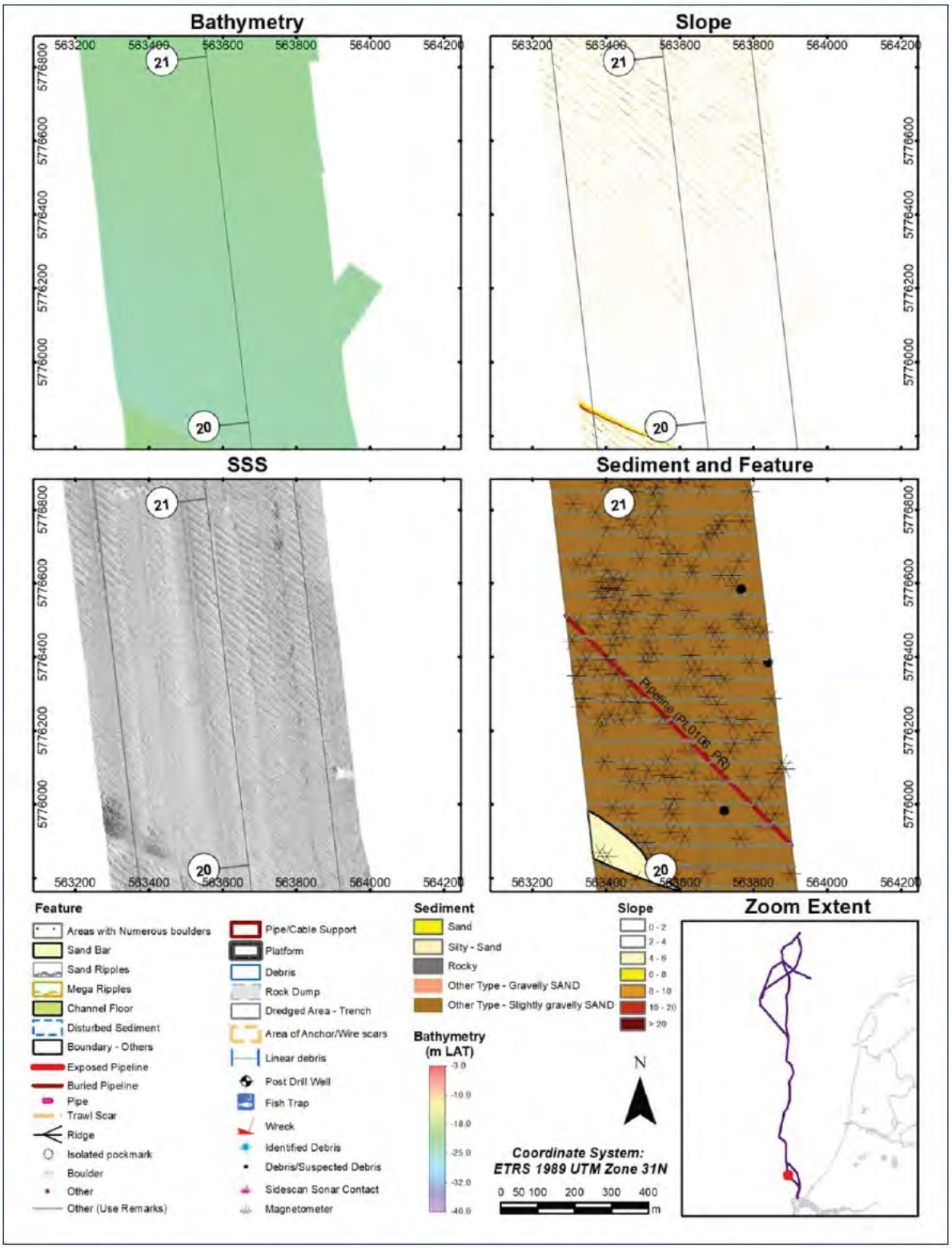


Figure 6.9: Example of area of boulders in Export Route West HDD: KP 20.0 to K9 21.0.

6.2.4 Magnetometer Contacts

651 magnetic contacts were found at the time of the geophysical scope (single MAG survey) in Export Route West HDD. The magnetometer anomalies range between 1.1 nT and 1213.1 nT. The highest magnetic amplitude is associated with the encountered pipeline. Most of the magnetic anomalies are located in the nearshore area, between KP 0.5 and KP 3.0 and are probably related to the anthropogenically altered area close to the port of Rotterdam.

6.2.5 Sub-seafloor Geology

Units DS, A, B, D and G are present in Export Route West HD (Figure 6.10).

Unit A is present basically in the entire section, except in the Maasmond Kanaal, where the top unit consists of disturbed sediments (Unit DS) and Unit A was removed during dredging activities. Between KP 0.3 and KP 1.1 Unit A was not observed, due to the acoustic blanking that hinder the interpretation. Unit A is characterized by chaotic in the nearshore area to semi-transparent seismic facies, with locally point reflections further offshore. The maximum thickness of Unit A in this section is approximately 4 m.

Unit B is present across the entire section. Between KP 0.0 to KP 1.1 it is not observed due to the acoustic blanking that hinder the interpretation. The unit has in general transparent to semi-transparent seismic character. Between approximately KP 2.0 and KP 7.5 the unit exhibits mostly layered facies with flat to inclined parallel reflectors. Internal buried channels with layered infill were observed in this unit locally.

Unit B is underlain by Unit D (interpreted to be present from approximately KP 14.8) and Unit G. Unit D and G exhibit structureless acoustically transparent to semi-transparent seismic character in this section.

High amplitude anomalies in Unit G were interpreted between KP 20.5 and KP 21.0, at approximately KP 23, between KP 25.6 and KP 27.0 and between KP 30.1 and KP 30.8. These negative amplitude events most likely represent laminae or thin bed of peat and/or organic-rich clay (peat level 3).

Table 6.5 provides lithology in the shallow sub-seafloor (within penetration depth of the SBP data), which is based on the seafloor CPT and VC geotechnical data acquired as part of this geophysical survey. Details of the geotechnical data can be found in report F197217-REP-006.

Table 39: Soil conditions in shallow sub-seafloor

Unit	Depth to Base [m BSF]	Lithology
DS	0 to 4.5	Very loose to very dense slightly silty fine and medium SAND
A	0.3 to 4.2	Very loose to very dense slightly silty fine and medium SAND with frequent shells and shell fragments Locally low to medium strength slightly sandy CLAY, with closely spaced thin laminae of silt

Unit	Depth to Base [m BSF]	Lithology
B	2.2 to 9.2	Medium to very dense slightly silty fine and medium SAND with numerous shells and shell fragments, occasionally slightly gravelly Locally with medium to thick beds of extremely low to very low strength very dark grey sandy CLAY
Notes: BPD = below penetration depth of SBP data		

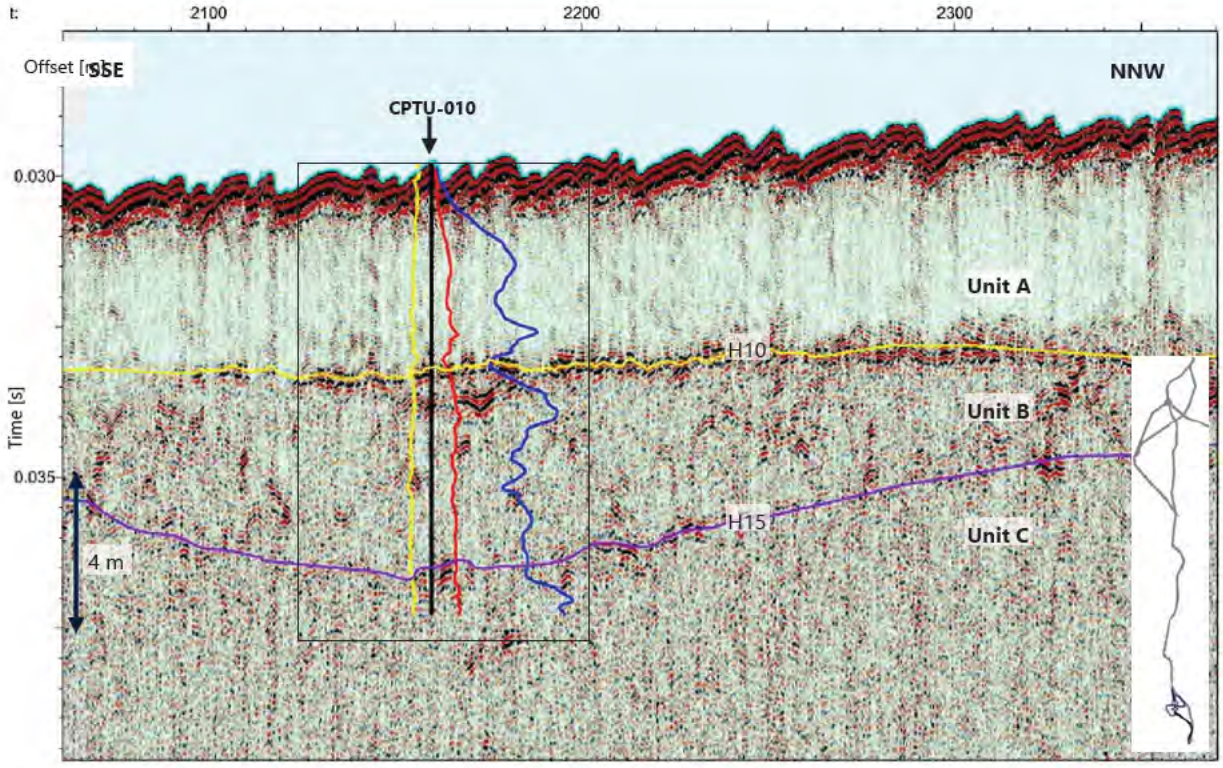


Figure 6.10: SBP data example of route section Export Route West HDD. (Line SBP_TA3D2079P2) *Width of the CPT boxes show cone resistance values (blue curve) within range of 0 to 25 MPa, sleeve friction values (red curve) from 0 to 0.625 MPa and friction ratio (yellow curve) from 0 to 4 %.*

7. Section A-Alt

7.1 Section A - Alt Location

The location of the route Section A - Alt is shown in Figure 7.1. This section of the route has a length of 94 km.

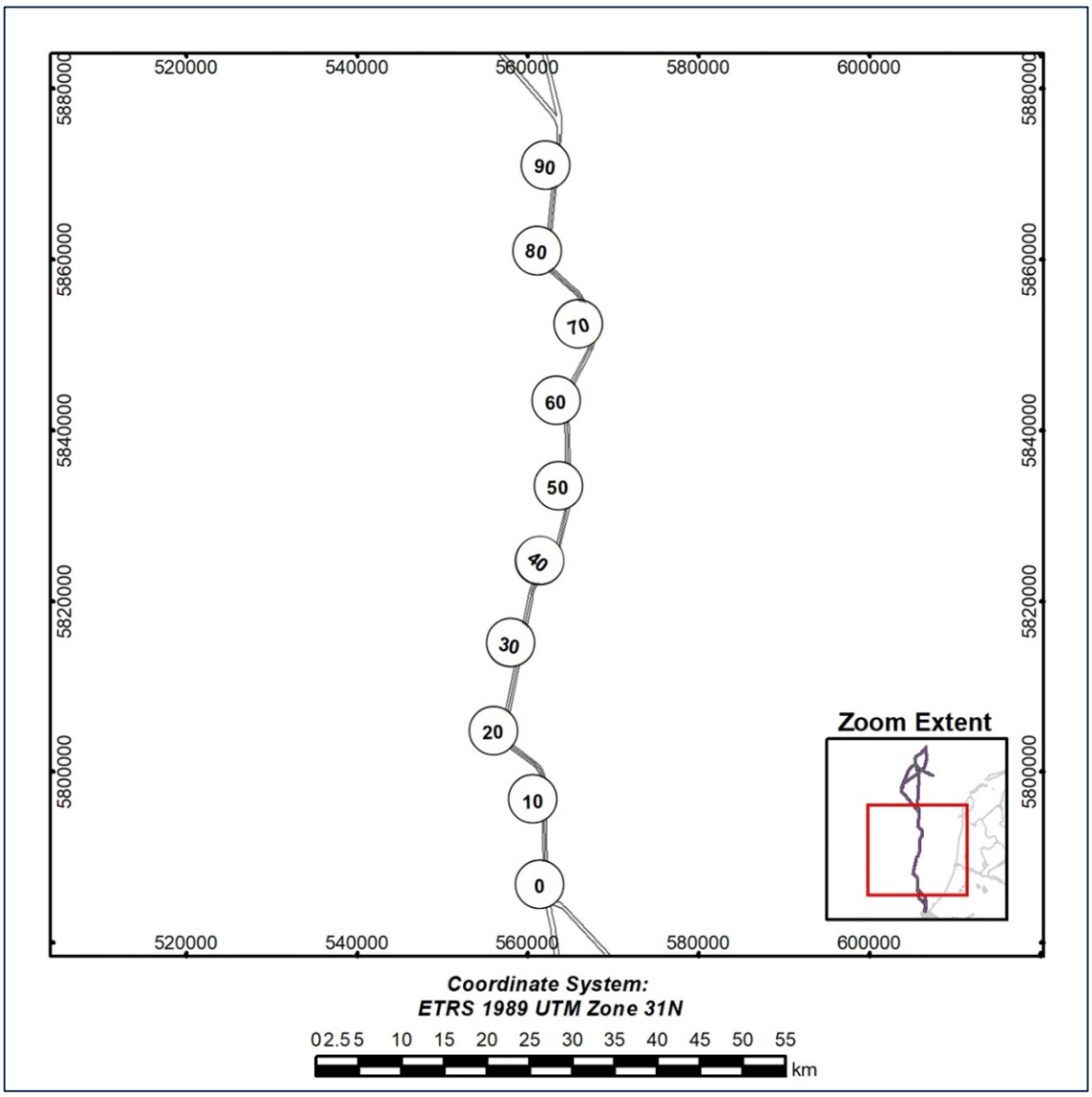


Figure 7.1: Location of the route section A – Alt.

7.2 Results

7.2.1 Bathymetry

The water depth in route Section A-Alt ranges between 24.0 m and 25.0 m. An overview of the bathymetry is given in Figure 7.2.

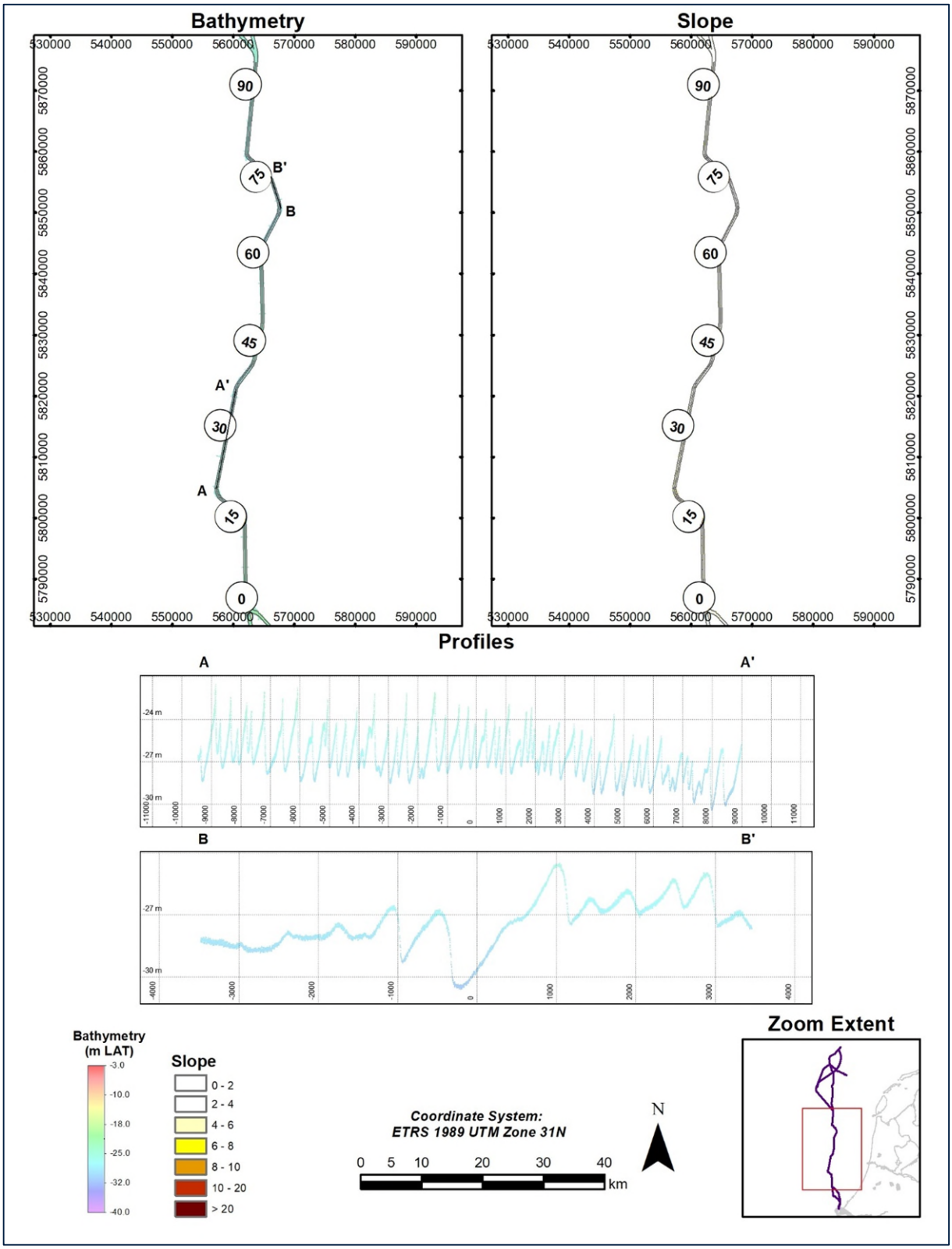


Figure 7.2: Bathymetry along the route Section A-Alt.

7.2.2 Seafloor Morphology

Overall, a strong correlation between sediment type and morphological type was observed, although some small variation is possible. An overview is given in Table 7.1 and Figure 7.3.

Table 40: Sediment type with associated morphology in route section A-Alt

Sediment Type	Morphological Type
Slightly gravelly SAND	Ripples or megaripples and sand waves

Figure 7.3 and Figure 7.4 show data examples of the route Section A – Alt. This area is characterised mostly by ripples, megaripples and sand waves.

The sand waves are symmetrical, with a northwest-southeast orientation, a wavelength ranging between 100 m and 600 m (on average 350 m), and an average height of 4.0 m.

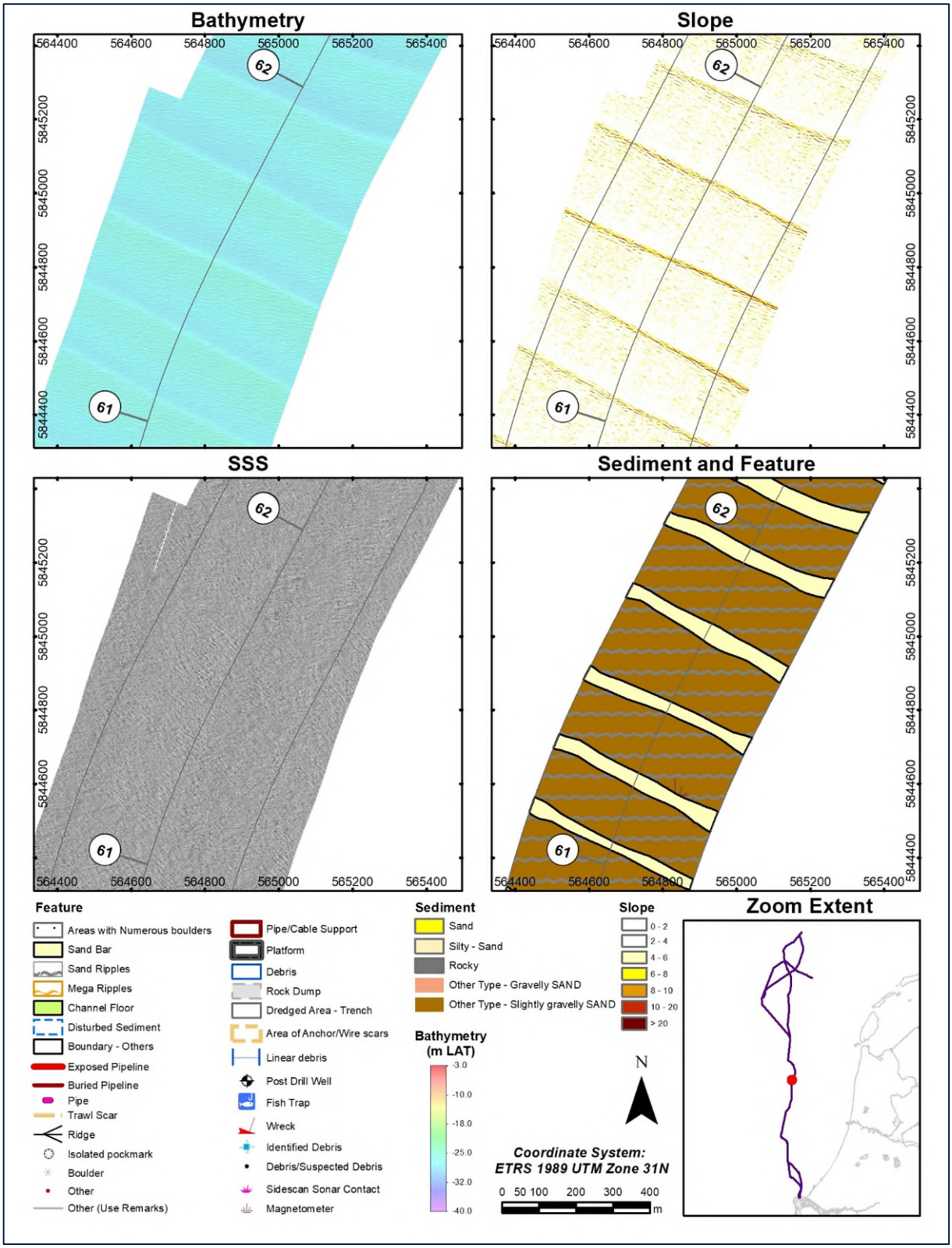


Figure 7.3: Overview of the sediments and morphology in route section A-Alt: KP 61.0 to KP 62.0.

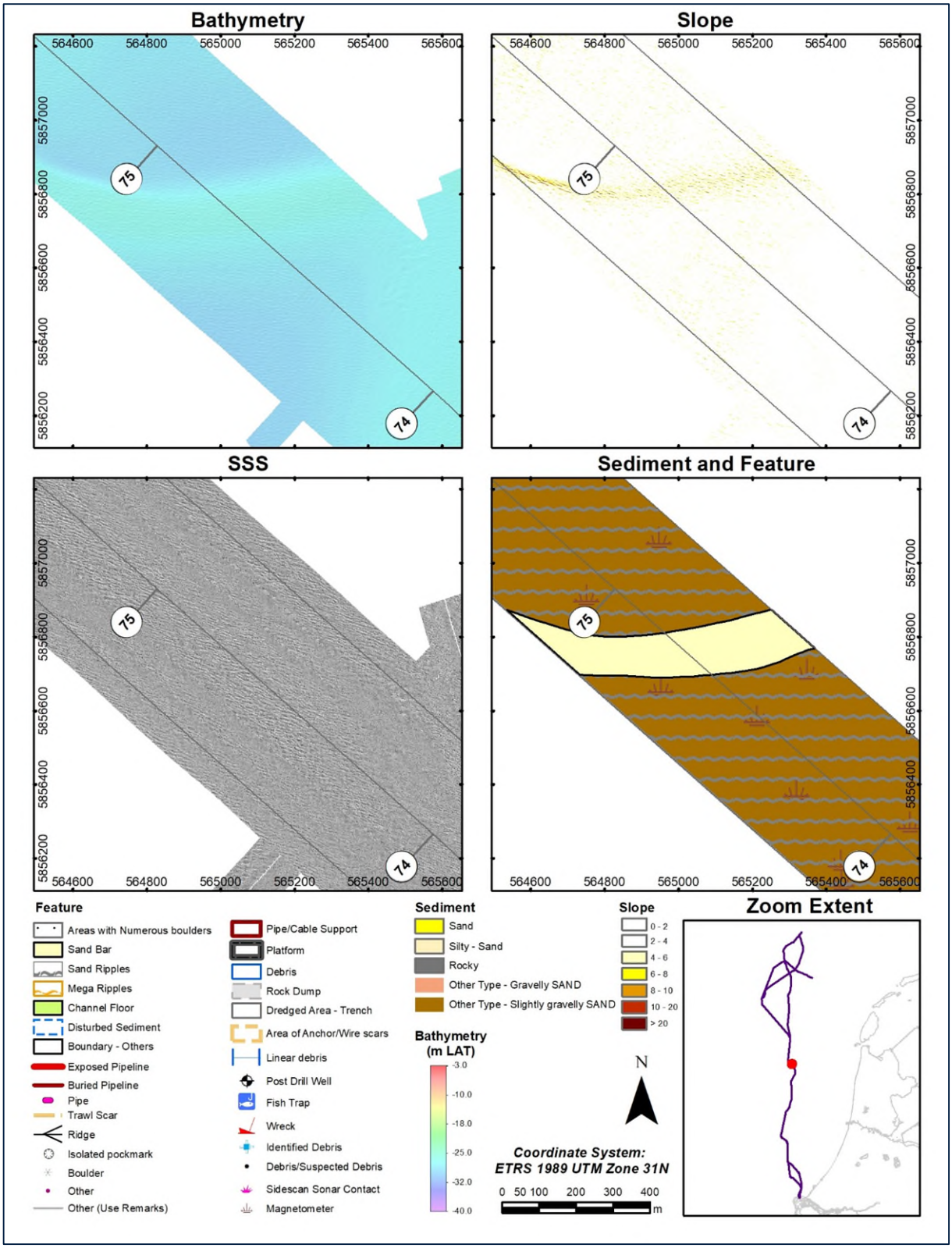


Figure 7.4: Overview of the sediments and morphology in route section A-Alt: KP 74.0 to KP 75.0.

7.2.3 Seafloor Feature and Contacts

Seafloor features and contacts were identified from one or more of the SSS, MBES, MAG and SBP sensors and cross-correlated where possible.

Table 7.2 summarises the quantities of contacts picked in Section A - Alt. The survey extent for each sensor varied and contacts were picked within the survey boundary of each sensor and cross-correlated where multiple datasets were available. No targets cross correlate between sensors in this section of the route.

Table 41: Summary of seafloor contacts in route section A-Alt

Sensor	Contact Classification	Quantity
SSS/MBES/MAG Point Features	Boulder	11
	Debris	13
	Suspected debris	37
	Magnetic anomalies	271
SSS/MBES/MAG Linear Features	Fishing gear	1
	Telecommunication cable	4
	Buried pipeline	5
	Magnetic linear feature	14

Five (5) buried pipelines and four (4) telecommunication cables were identified. Table 7.3 provides all the encountered and identified pipeline and cables.

Table 42: Summary of pipeline and telecommunication cables in route section A - Alt

Contact ID	Pipeline/Cable Name	Comment
Pipeline (PL0228_PR)	Q13a-A to P15-C 8-inch oil pipeline	Buried, KP 3.7
Mag Linear Feature	Q10 to P15-D pipeline	Buried, KP 18.0
Telecom Cable (KB0045)	Circe North	Buried, KP 19.6
Telecom Cable (KB0003)	Concerto 1 N	Buried, KP 20.5
Pipeline (PL0084_PR/HS)	P12-C to P12-SW 8-inch gas / 3-inch glycol pipeline bundle (abandoned)	Buried, KP 22.0
Telecom Cable (KB0015)	Rembrandt 1	Buried, KP 45.7
Telecom Cable (KB0067)	UK - Netherlands 14	Buried, KP 55.4
Pipeline (PL0148_PR)	Q4-A to P6-A 14-inch gas pipeline	Buried, KP 66.2
Pipeline (PL0109_PR)	Horizon to Helder-A 10-inch oil pipeline	Buried, KP 69.4
Pipeline (PL0176_PR)	Balgzand to Bacton	Buried, KP 92.5

Figure 7.5, Figure 7.6 and Figure 7.7 show data examples of encountered pipelines in in this section of the route.

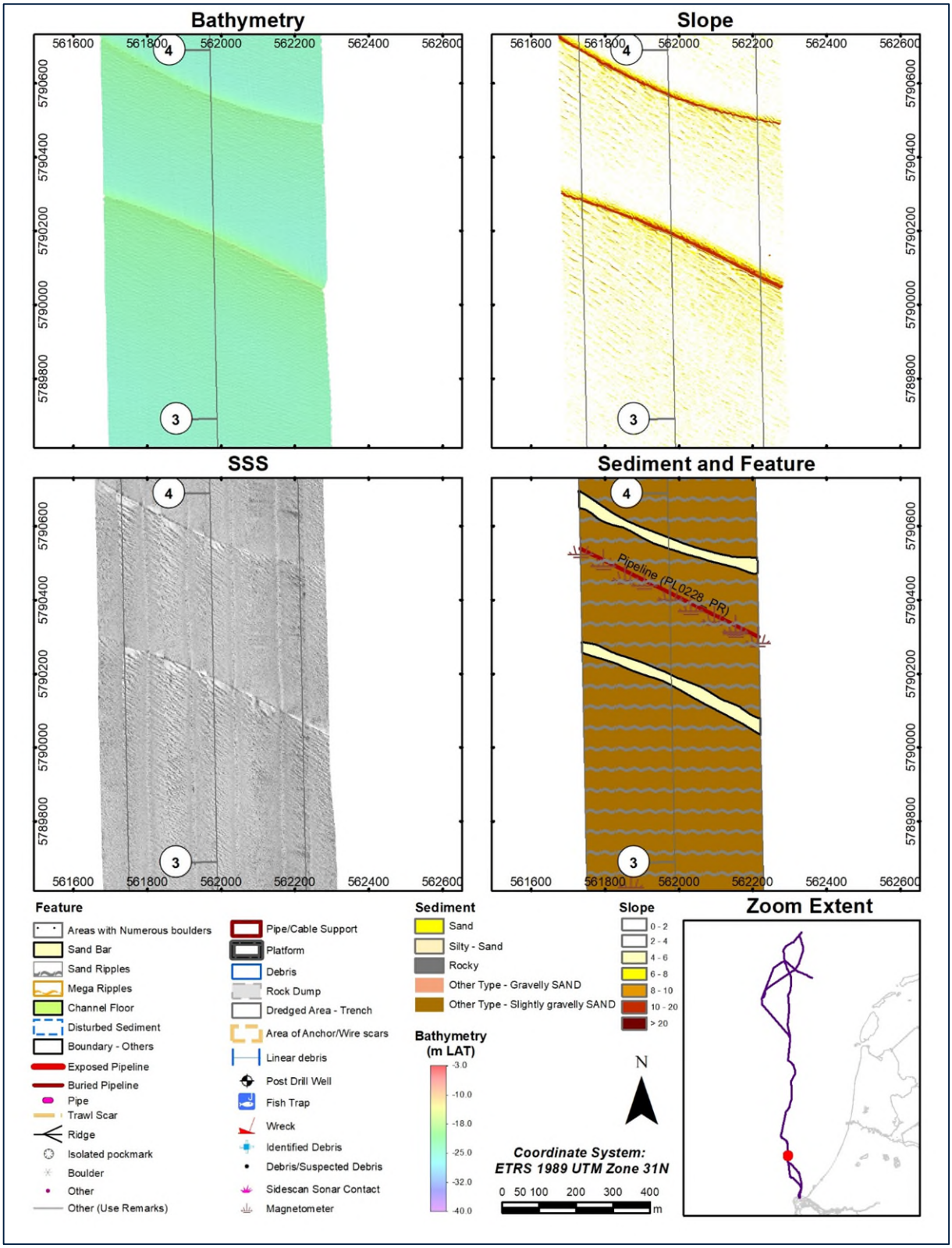


Figure 7.5: Overview of the sediments and morphology in route section A-Alt: KP 3.0 to KP 4.0, buried pipeline.

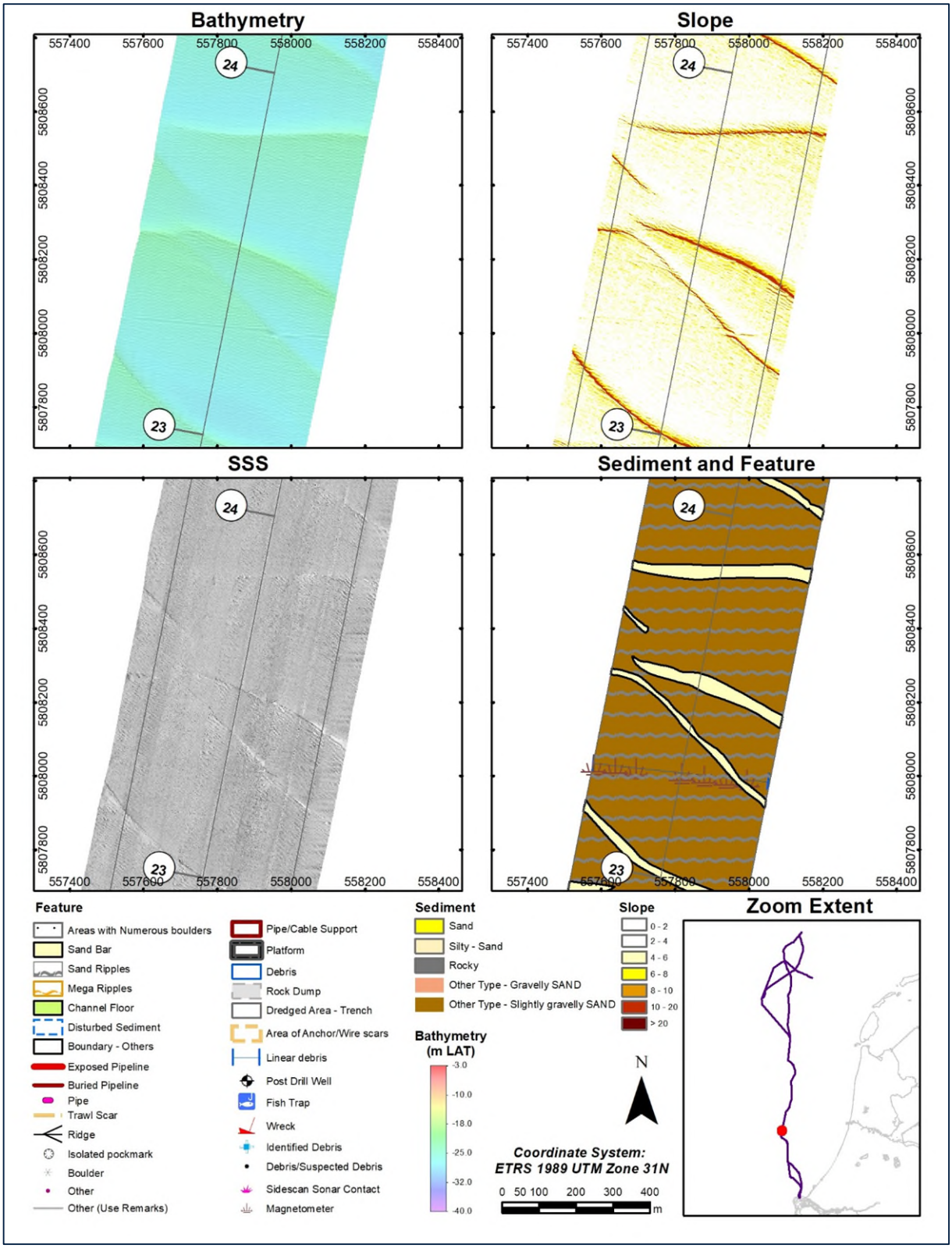


Figure 7.6: Overview of the sediments and morphology in route section A-Alt: KP 23.0 to KP 24.0, buried cable.

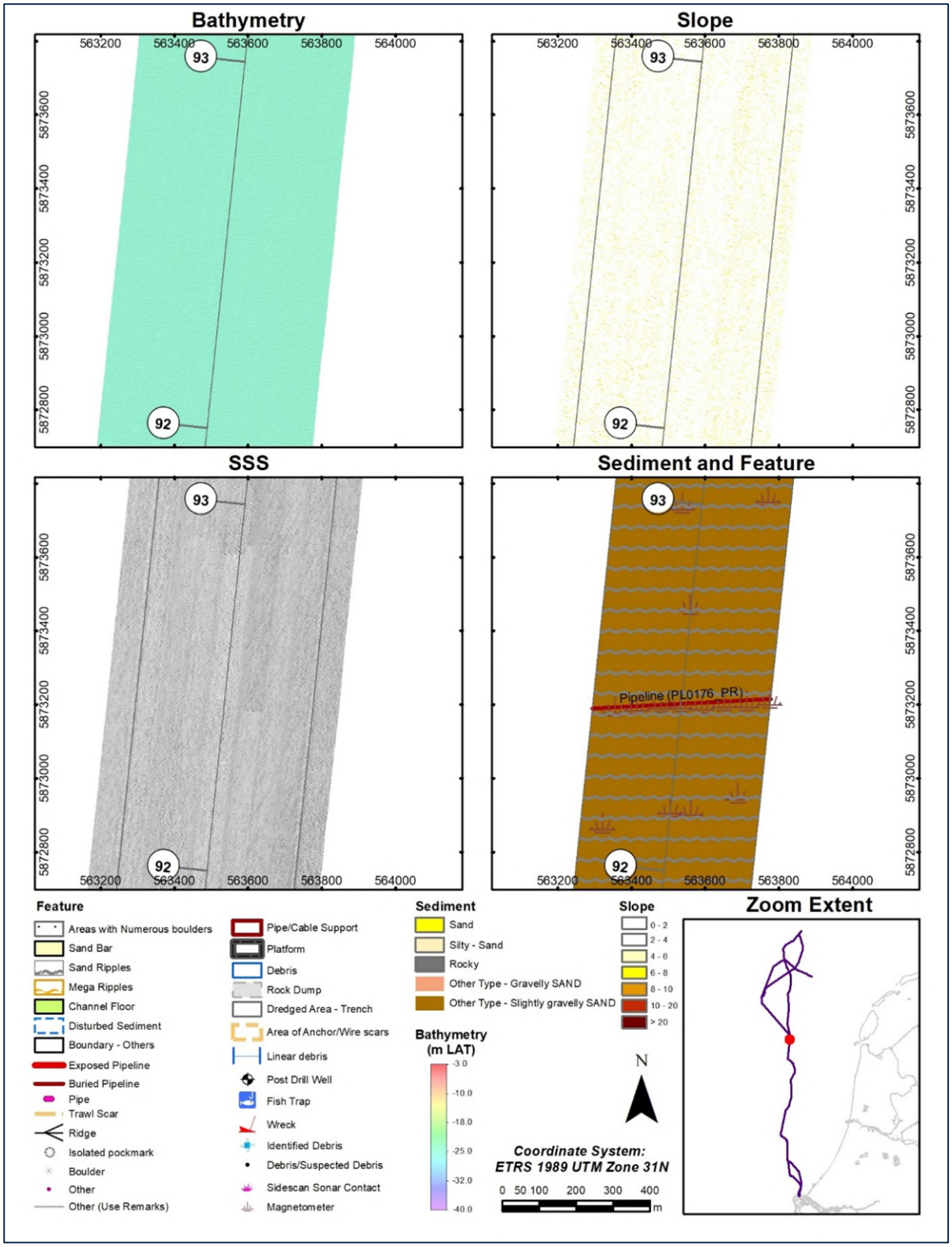


Figure 7.7: Overview of the sediments and morphology in route section A-Alt: KP 92.0 to KP 93.0, buried pipeline.

7.2.4 Magnetometer Contacts

271 magnetic contacts were found at the time of the geophysical scope (single MAG survey) in route Section A – Alt. The magnetometer anomalies range between 5.0 nT and 2966.4 nT. The highest magnetic amplitudes are associated with the encountered pipelines.

7.2.5 Sub-seafloor Geology

Units A, B, C, D, F and G are present in the route Section A-Alt (Figure 7.8).

Unit A is present in the entire section. It is characterized by acoustically transparent and semi-transparent seismic facies. Rarely, high amplitude reflectors of limited extent were observed in this unit. The maximum thickness of Unit A in this section is approximately 7 m.

Unit B is present across the entire section. On the SBP data, between KP 0.0 to KP 59.0 the base of the unit is observed locally and for the large part it is below the penetration depth of the data. The unit exhibits transparent to semi-transparent seismic character. Internal buried channels with layered infill were observed in this unit at approximately KP 23.5 to KP 59. High negative amplitude anomalies were also interpreted in this unit, most likely represent laminae or thin bed of peat and/or organic-rich clay (peat level 1). The maximum thickness of Unit A in this section is approximately 10 m.

Unit C is present between KP 42.0 to KP 94.0. This unit exhibits layered facies with low to high-amplitude parallel reflectors. High negative amplitude anomalies were also interpreted in this unit, most likely represent laminae or thin bed of peat and/or organic-rich clay (peat level 2). Maximum thickness of this unit is approximately 35 m.

Unit D is present across the entire section, but from KP 78.0 to KP 94.0 only in patches. It is acoustically transparent to semi-transparent and structureless. Maximum thickness of this unit in Section A-Alt is approximately 10 m.

Unit F is interpreted between KP 74.5 to KP 78.0. The basal reflector of this unit forms U-shaped channel with seismically transparent infill. Maximum thickness of this unit is approximately 90 m.

Unit G is present across the entire section. It exhibits transparent and semi-transparent seismic character. High negative amplitude anomalies were also interpreted in this unit (peat level 3).

Table 7.4 provides lithology in the shallow sub-seafloor (within penetration depth of the SBP data), which is based on the seafloor CPT and VC geotechnical data acquired as part of this geophysical survey. Details of the geotechnical data can be found in report F197217-REP-006.

Table 43: Soil conditions in shallow sub-seafloor

Unit	Depth to Base [m BSF]	Lithology
A	0.5 to 7.0	Very loose to very dense slightly silty fine and medium SAND with frequent shells and shell fragments
B	0.8 to 10.7	Medium to very dense slightly silty fine and medium SAND, occasionally with shells and shell fragments Locally low to high strength slightly sandy CLAY

Unit	Depth to Base [m BSF]	Lithology
C	BPD	Very loose to loose very silty fine and medium SAND with occasional pockets of organic matter Locally low strength to high strength very slightly sandy CLAY with medium spaced very thin beds of sand
Notes: BPD = below penetration depth of SBP data		

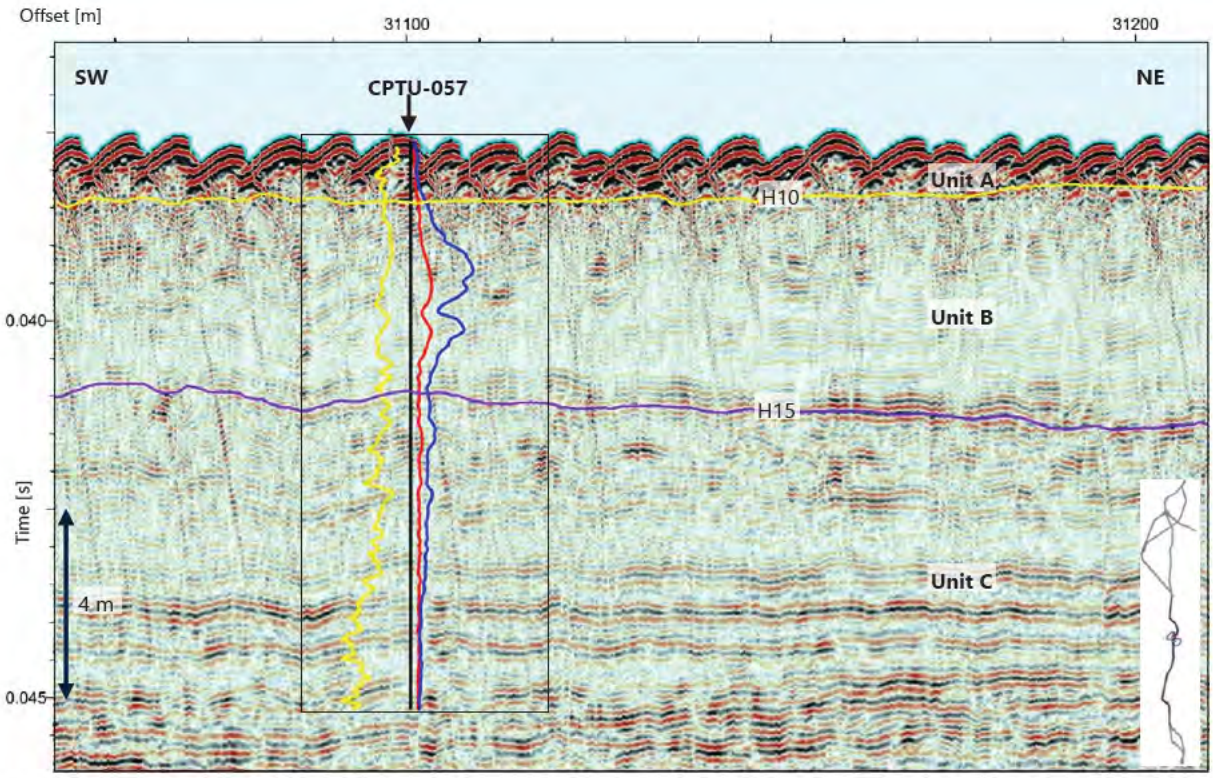


Figure 7.8: SBP data example of route section Alt-A. (Line SBP_TA3E2130P1) *Width of the CPT boxes show cone resistance values (blue curve) within range of 0 to 25 MPa, sleeve friction values (red curve) from 0 to 0.625 MPa and friction ratio (yellow curve) from 0 to 4 %.*

8. Section B

8.1 Section B Location

The location of the route Section B is showed in Figure 8.1. This section of the route has a length of 57.8 km.

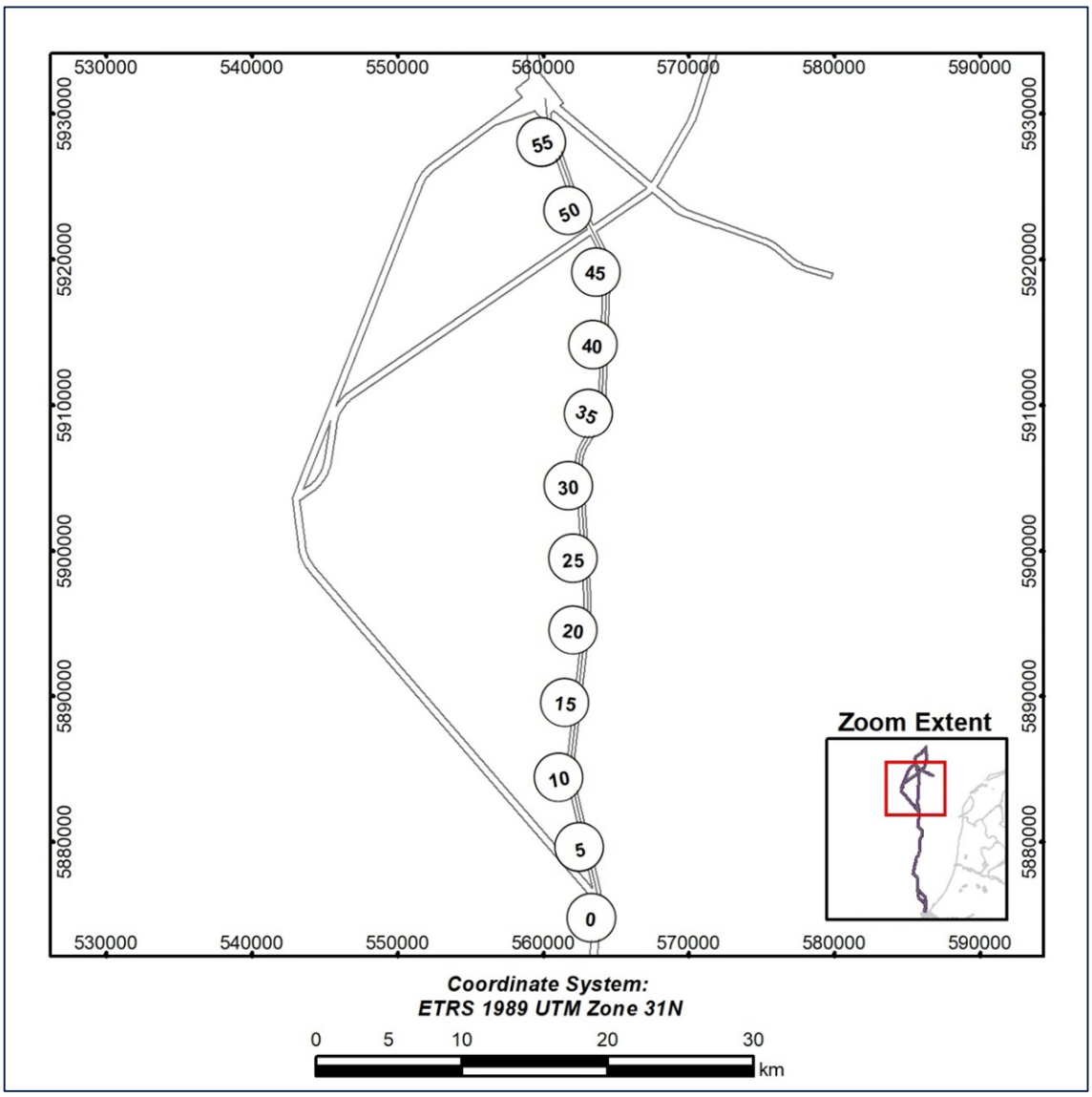


Figure 8.1: Location of the route section B.

8.2 Results

8.2.1 Bathymetry

The water depth in route Section B ranges between 25.0 m and 30.5 m. An overview of the bathymetry is given in Figure 8.2.

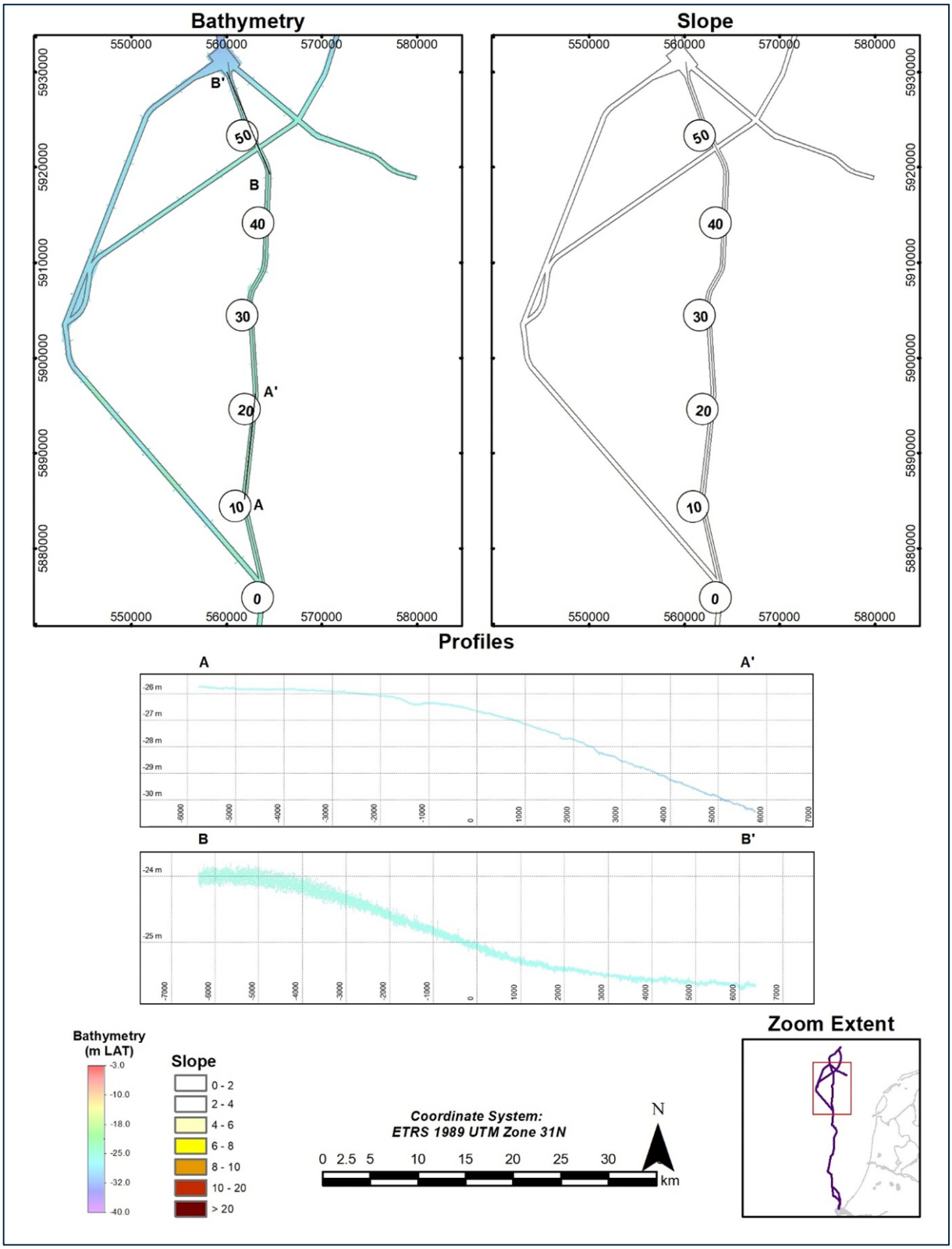


Figure 8.2: Bathymetry along the route section B.

8.2.2 Seafloor Morphology

A strong correlation between sediment type and morphological type was observed, although some small variation is possible. An overview is given in Table 8.1 and Figure 8.7 and Figure 8.8.

Table 44: Sediment type with associated morphology in route section B

Sediment Type	Morphological Type
Slightly gravelly SAND	Ripples, megaripples
SAND	Featureless

Between KP 0.0 and KP 17.5 and between KP 23.5 and KP 28.3, sediment was classified as slightly gravelly SAND with ripples and megaripples. The rest of Section B was classified as featureless SAND.

Figure 8.3 and Figure 8.4 show data examples of the sediment type and seafloor feature found in Section B.

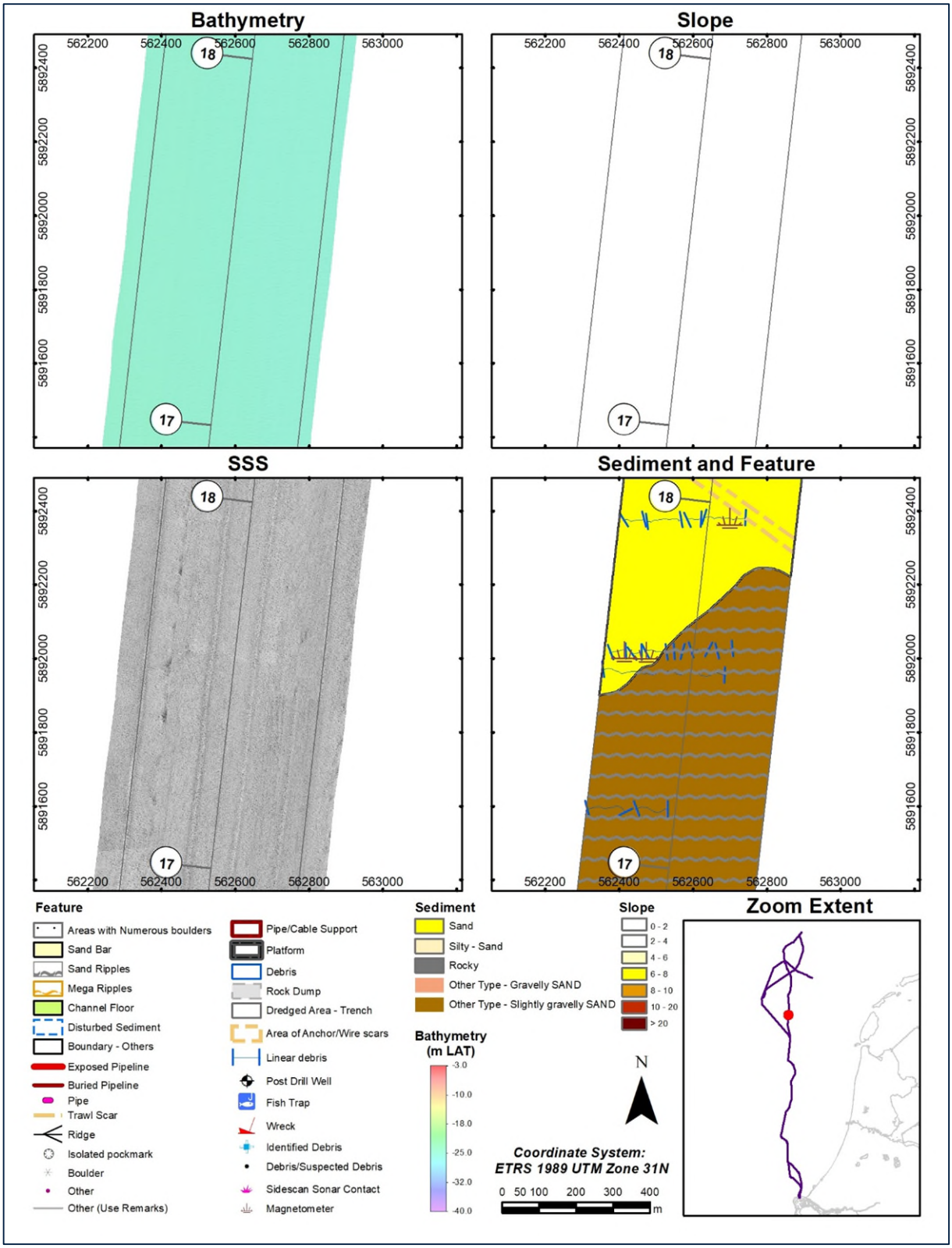


Figure 8.3: Overview of the sediments and morphology in route section B: KP 17.0 to KP 18.0.

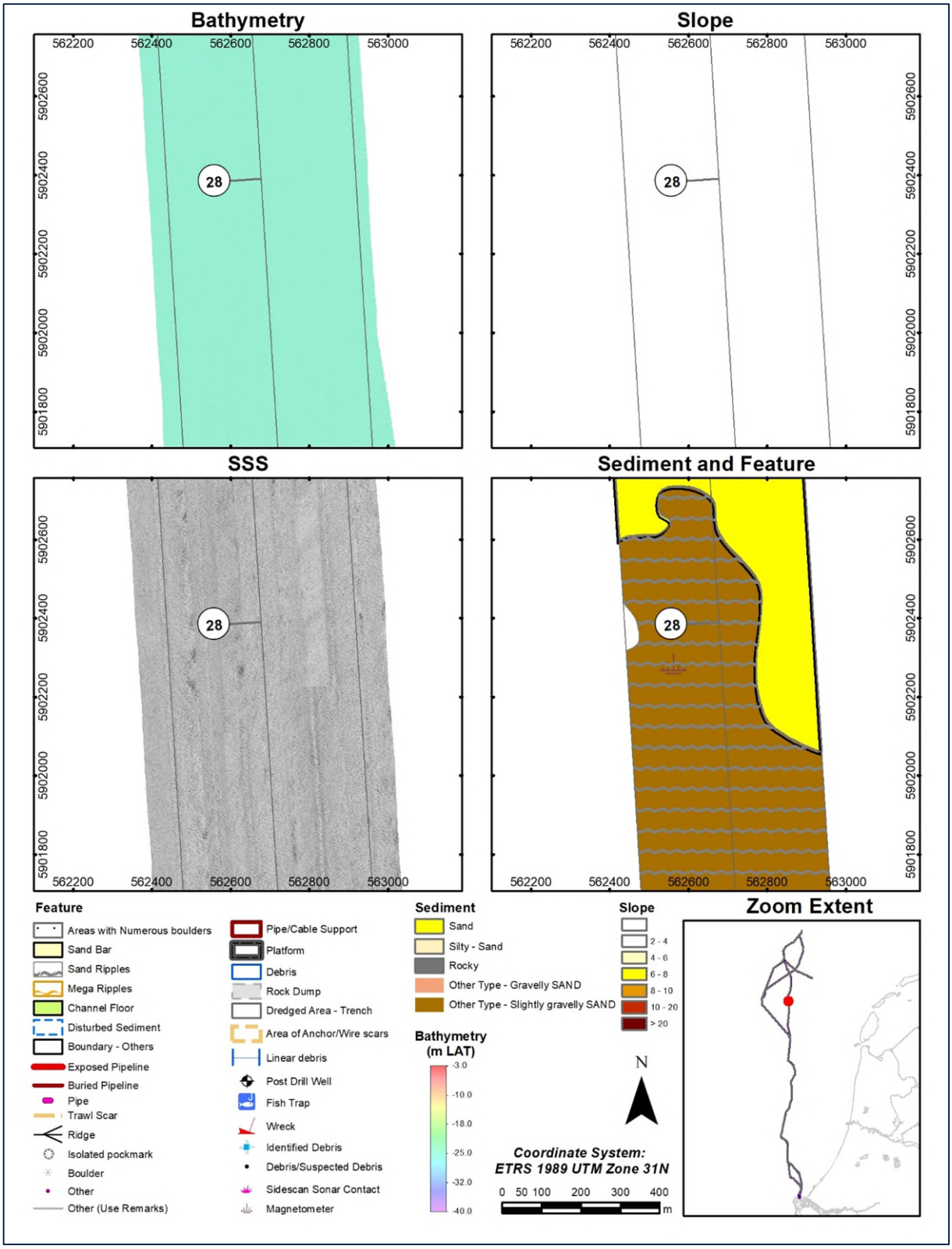


Figure 8.4: Overview of the sediments and morphology in route section B: KP 28.0.

8.2.3 Seafloor Features and Contacts

Seafloor features and contacts were identified from one or more of the SSS, MBES, MAG and SBP sensors and cross-correlated, where possible.

Table 8.2 summarizes the quantities of contacts picked. The survey extent for each sensor varied and contacts were picked within the survey boundary of each sensor and cross correlated where multiple datasets were available. No targets cross correlate between sensors in this section of the route.

Table 45: Summary of seafloor contacts in route section B

Sensor	Contact Classification	Quantity
SSS/MBES/MAG Point Features	Debris	34
	Depression pockmark	1
	Fishing gear	2
	Exposed pipe	4
	Seabed mound	39
	Suspected debris	7
	Magnetic anomalies	133
SSS/MBES/MAG Linear Features	Fishing gear	2
	Possible fishing gear	39
	Large trawl scour	24
	Mound ridge	18
	Exposed pipeline	1 (3 segments exposed, 4 segments buried)
	Buried pipeline	7

Figure 8.5 shows two (2) seafloor contacts classified as possible fishing gears were identified at KP 25.0.

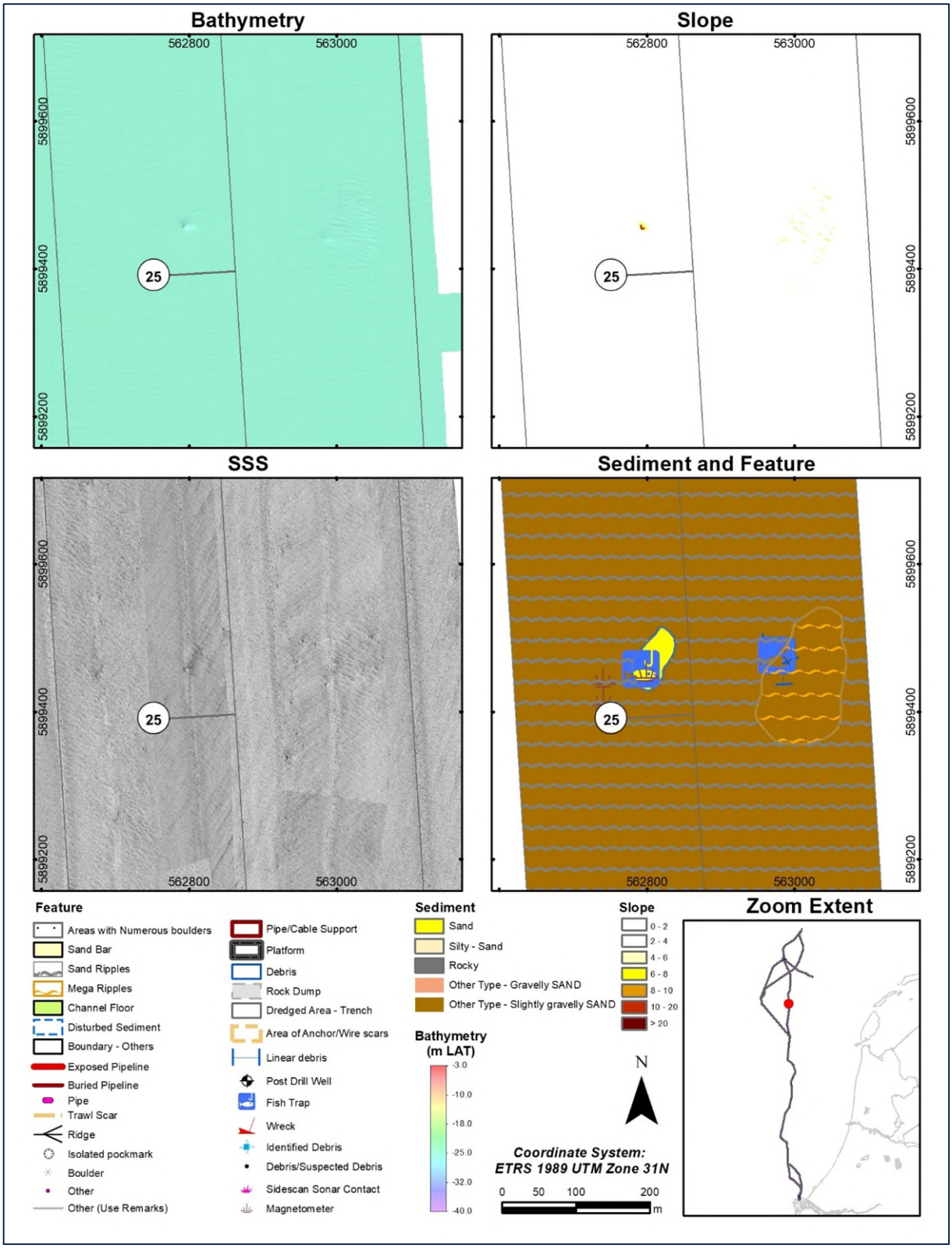


Figure 8.5: Overview of the sediments and morphology in route section B: KP 25.0, possible fishing gears.

Several buried pipelines were observed (Table 8.3 and Figure 8.6, Figure 8.7 and Figure 8.8).

Table 46: Summary of pipelines in route section B

Contact ID	Pipeline Name	Comment
Pipeline (PL0032_PR)	P6-A to L10-AR 20-inch gas pipeline	Buried, KP 8.7
Pipeline (PL0030_PR)	NAM_K15-FB-1 to Den Helder	Buried, KP 20.5
Pipeline (PL0004_PR)	K13-A to Den Helder 36-inch gas pipeline	Buried, KP 26.1
Pipeline (PL0062_PR)	K14-FA-1C TO K15-FA-1 18-inch pipeline	Buried, KP 26.2
Pipeline (PL0063_PR)	K12-BP to L10-AR 18-inch pipeline	Buried, KP 38.0
Pipeline (PL0029_HS)	K12-A to L10-AP 14/2-inch bundle	Buried, KP 48.7
Pipeline (PL0056_PR)	K12-E to K12-C 10-inch pipeline	Buried, KP 50.8
Pipeline (PL0142_PR)	D15-FA to L10-AC 36-inch pipeline	Partially buried and partially exposed, KP 53.4

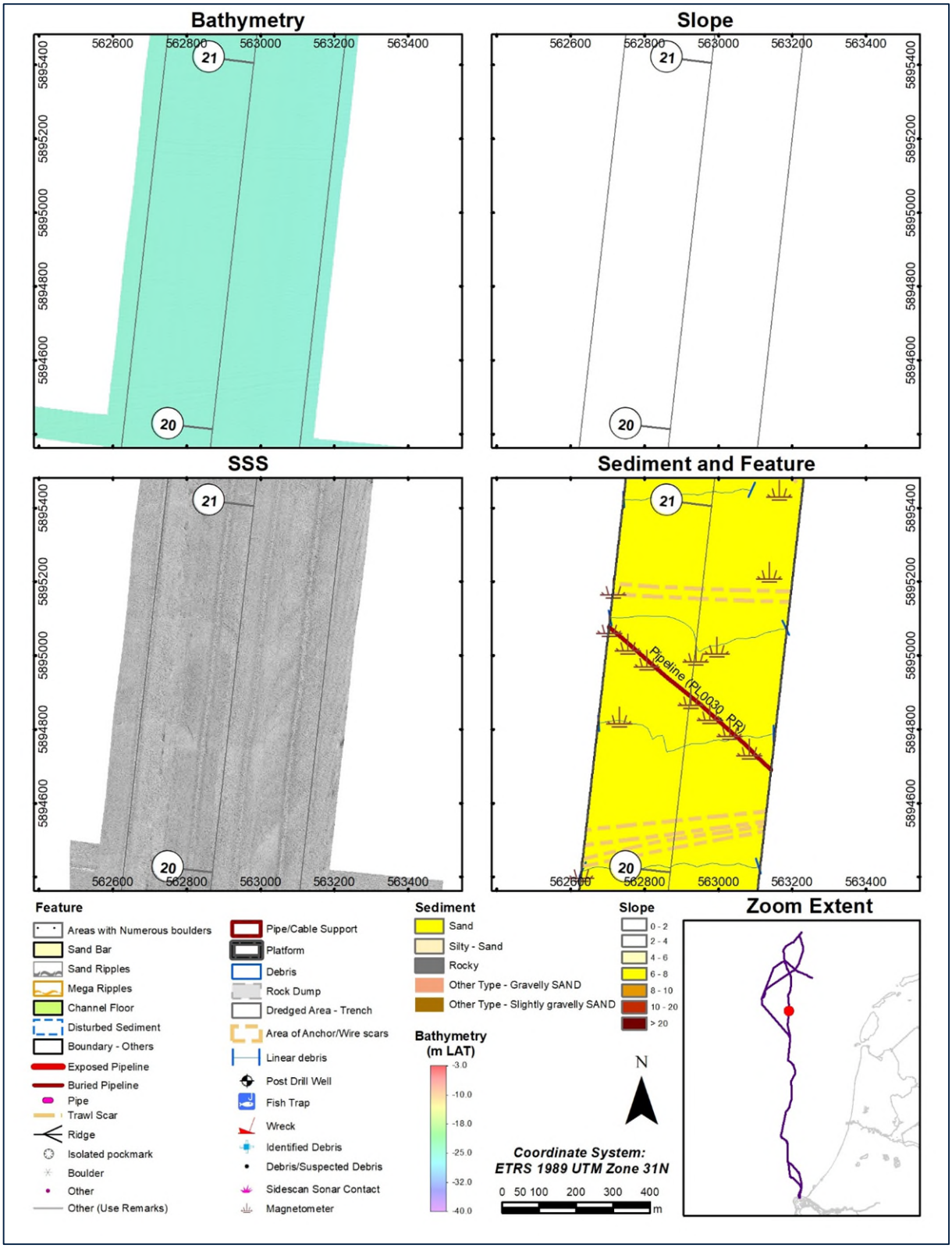


Figure 8.6: Overview of the sediments and morphology in route section B: KP 20.0 to KP 21.0, buried pipeline.

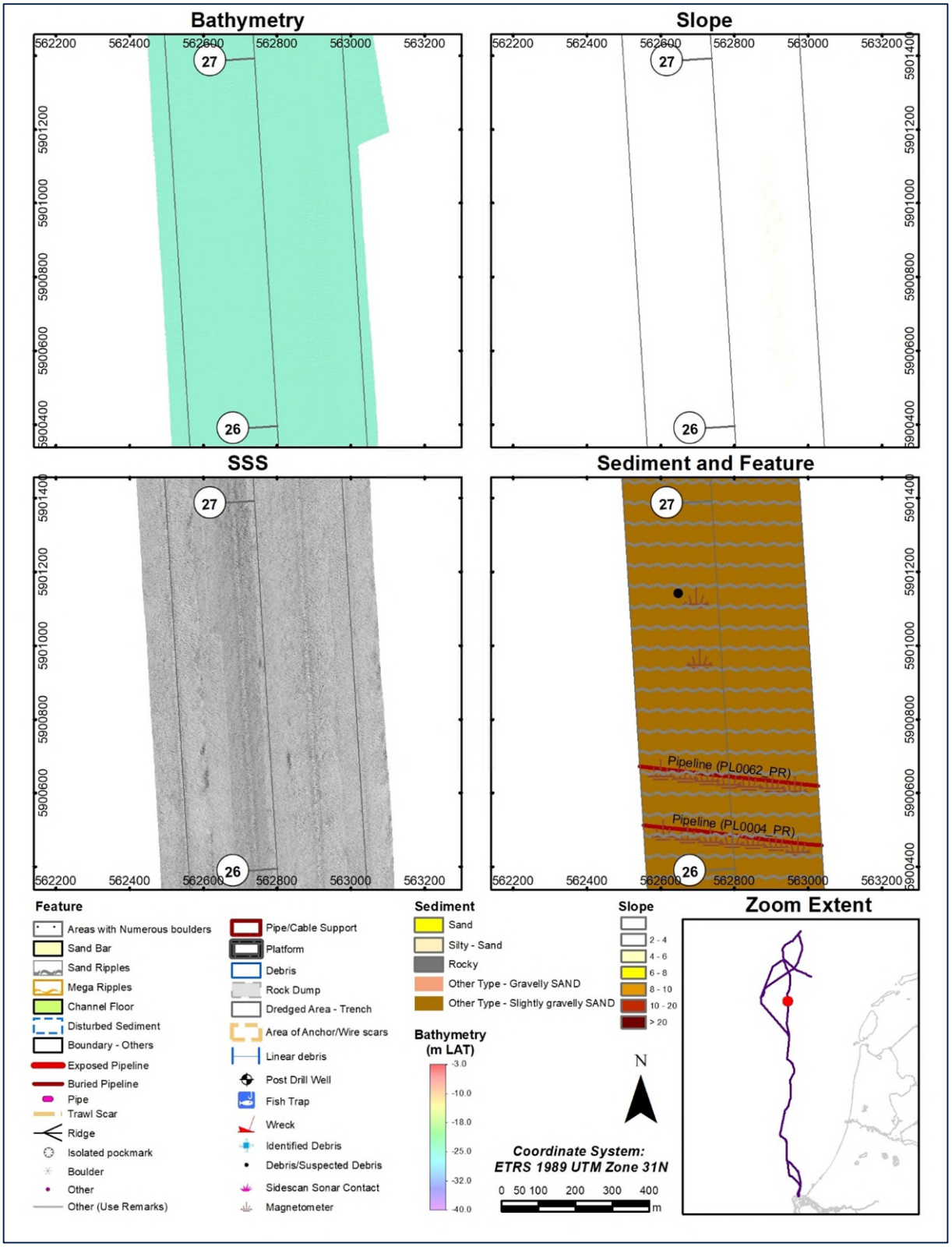


Figure 8.7: Overview of the sediments and morphology in route section B: KP 26.0 to KP 27.0, buried pipelines.

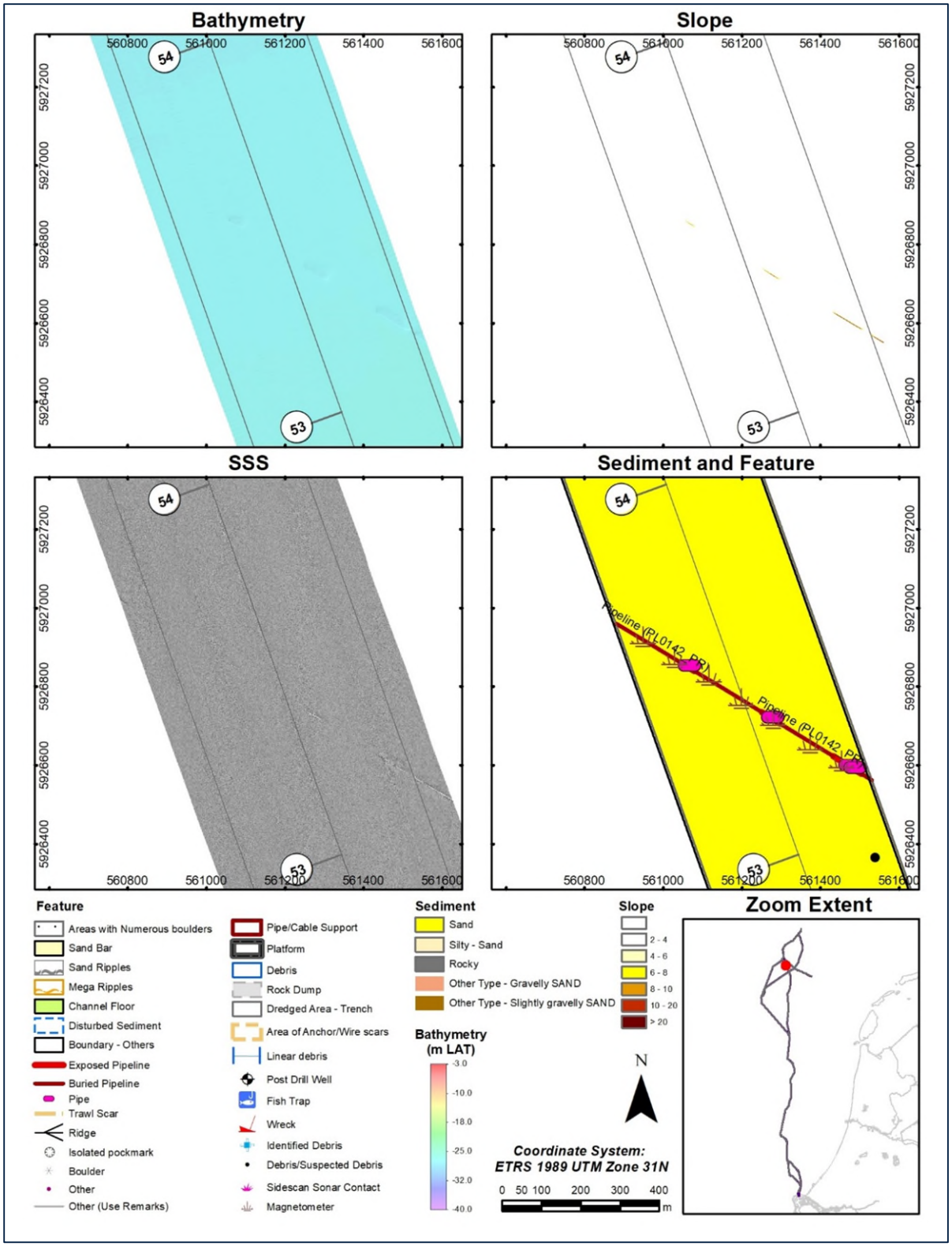


Figure 8.8: Overview of the sediments and morphology in route section B: KP 53.0 to KP 54.0, partially exposed pipeline.

8.2.4 Magnetometer Contacts

In Section B, 133 magnetic contacts were found at the time of the geophysical scope (single MAG survey). The magnetometer anomalies range between 5.2 nT and 7064.6 nT. The highest magnetic amplitudes are associated with the encountered pipelines.

8.2.5 Sub-seafloor Geology

Units A, B, D, E, F and G are present in the route Section B (Figure 8.9).

Unit A is present in the entire section. Between KP 0.0 to KP 40.0 the unit is characterized by a chaotic and semi-transparent seismic character. Between KP 40.0 to KP 57.8 it is acoustically transparent. The maximum thickness of this unit in this section is approximately 3 m.

Unit B is present across the entire section. On the SBP data, the seismic character is semi-transparent and structureless, locally where the base is channelised the infill is structured, with medium-amplitude subparallel reflectors. On the 2D-UHRS, high amplitude negative anomalies were observed at the base of this unit, which represent laminae or thin bed of peat and/or organic-rich clay (peat level 1). The maximum thickness Unit B in this section is approximately 9 m.

Unit C is present across the entire section, except between KP 51.8 and the end of the section, where it is interpreted to be absent. The unit is characterized by locally transparent /structureless to layered facies, with medium to high amplitude parallel reflectors, which are locally irregular, discontinuous, and forming small channels. High negative amplitude reflectors are common in this unit, which most likely represent laminae or thin bed of peat and/or organic-rich clay (peat level 2). The thickness varies, on average it is approximately 5 m, the maximum reaches approximately 10 m.

Unit D is present in the entire section. Its seismic character is transparent to semi-transparent, with locally internal erosion surfaces. The maximum thickness of the Unit D in this section is approximately 15 m.

Unit E is present between KP 31.5 to KP 57.8. The unit is characterised by semi-transparent and structureless facies. The maximum thickness of this unit in this section is approximately 20 m.

Unit F (infill of glacial valley) is present between KP 41.9 to KP 51.7.

Table 8.4 provides lithology in the shallow sub-seafloor (within penetration depth of the SBP data), which is based on the seafloor CPT and VC geotechnical data acquired as part of this geophysical survey. Details of the geotechnical data can be found in report F197217-REP-006.

Table 47: Soil conditions in shallow sub-seafloor

Unit	Depth to Base [m BSF]	Lithology
A	0.7 to 3.3	Very loose to very dense slightly silty to silty fine and medium SAND with frequent shells and shell fragments
B	2.4 to 11.1	Medium to very dense slightly silty fine and medium SAND with frequent shells and shell fragments Locally clayey fine and medium SAND

Unit	Depth to Base [m BSF]	Lithology
C	BPD	Thickly Interbedded Low to medium strength sandy clayey SILT and medium strength CLAY Occasionally medium dense to dense slightly silty fine and medium SAND with extremely closely to very closely spaced thin laminae to medium beds of peat and clay
D	BPD	Loose to medium dense slightly silty to silty fine and medium SAND
Notes: BPD = below penetration depth of SBP data		

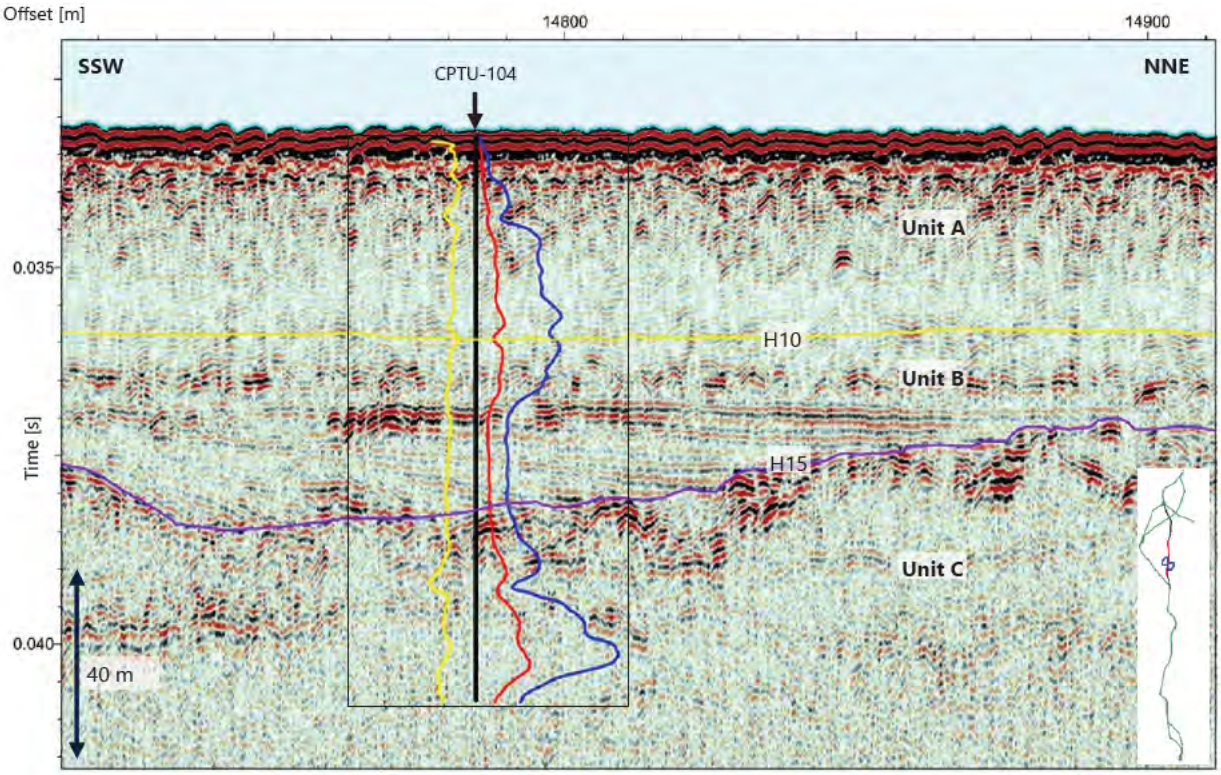


Figure 8.9: SBP data example of route section B. (Line SBP_ TA3F2184P2) *Width of the CPT boxes show cone resistance values (blue curve) within range of 0 to 25 MPa, sleeve friction values (red curve) from 0 to 0.625 MPa and friction ratio (yellow curve) from 0 to 4 %.*

9. Section C

9.1 Section C Location

The location of the Section C is showed in Figure 9.1. This section of the route has a length of 26.8 km and runs from the Hub Area to Platform LA4.

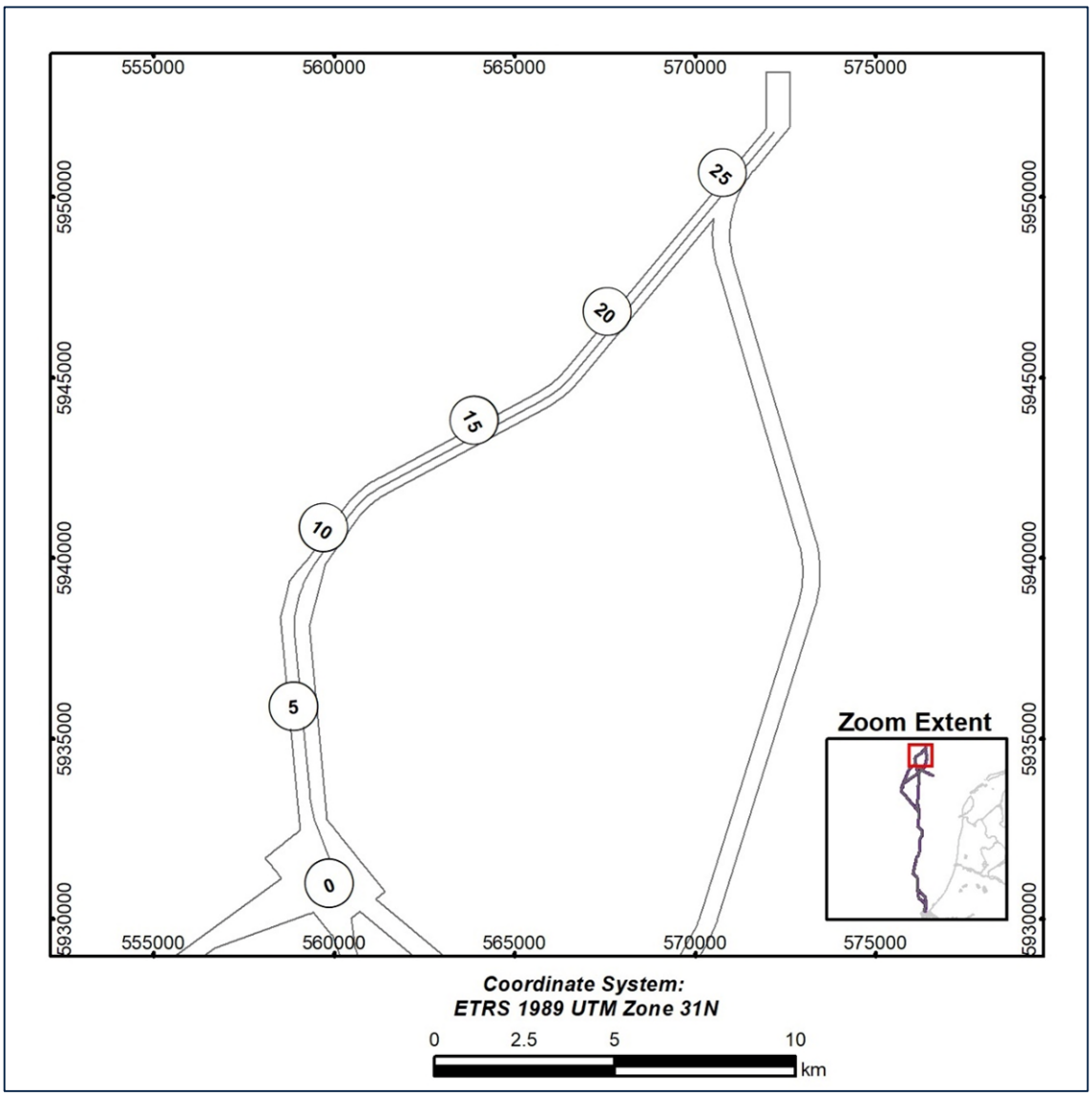


Figure 9.1: Location of the route section C.

9.2 Results

9.2.1 Bathymetry

The water depth in route Section C ranges between 31.0 m and 39.5 m. An overview of the bathymetry is given in Figure 9.2.

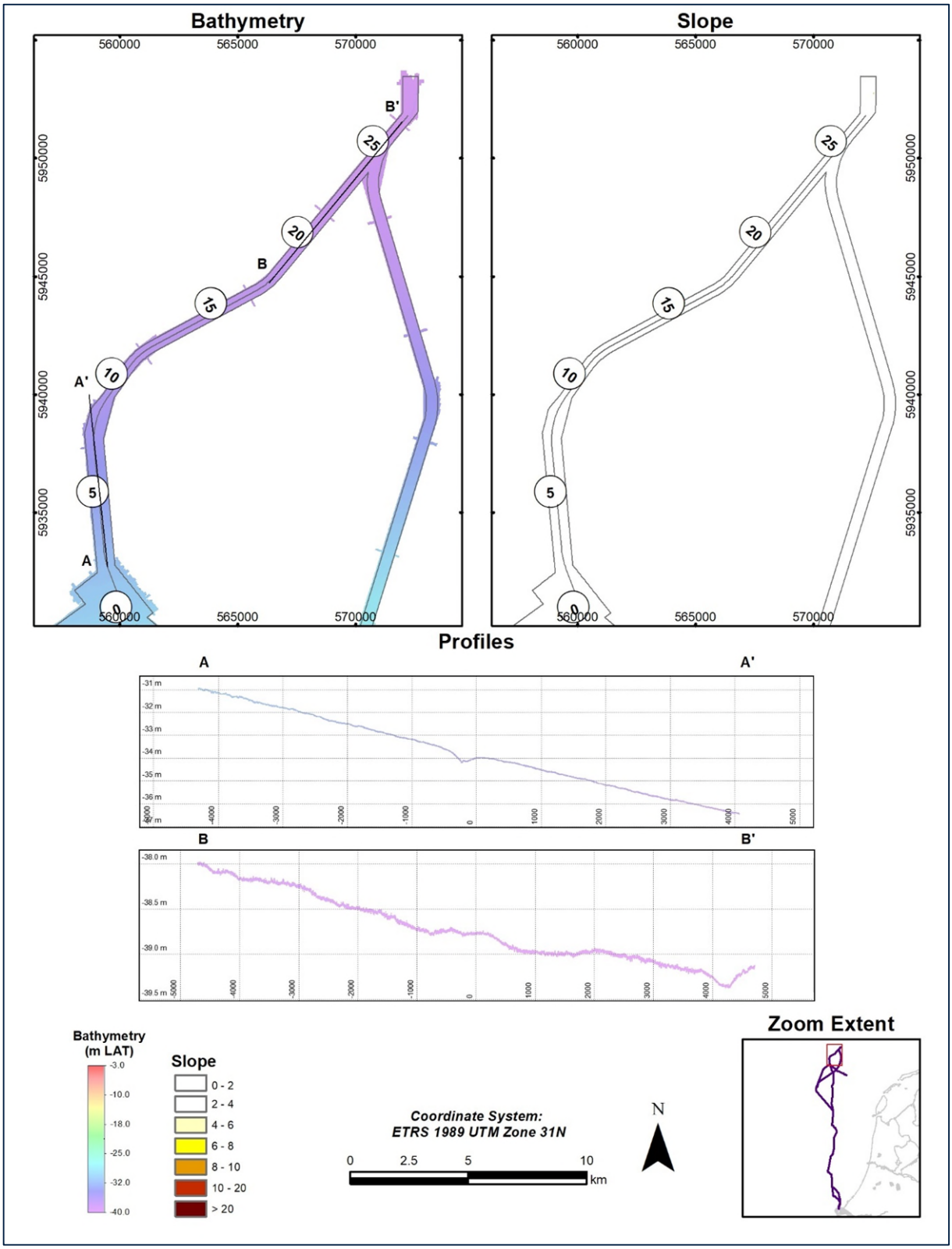


Figure 9.2: Bathymetry along the route section C.

9.2.2 Seafloor Morphology

Overall, a strong correlation between sediment type and morphological type was observed, although some small variation is possible. An overview is given in Table 9.1.

Table 48: Sediment type with associated morphology in route section C

Sediment Type	Morphological Type
Gravelly SAND	Patchy coarse sediments
Silty (muddy) SAND	Patchy fine sediments
SAND	Featureless, trawl marks area

The seafloor in Section C is mostly featureless with SAND as primary sediment. Between KP 2.5 and KP 5.5 two areas of gravelly SAND (patchy coarse sediments) have been identified. Isolated trawl marks have been found as well. From KP 20.0 to the Platform L4A there is a change in sediment type observed, which becomes silty (muddy) SAND (Figure 9.6).

9.2.3 Seafloor Features and Contacts

Seafloor features and contacts were identified from one or more of the SSS, MBES, MAG and SBP sensors and cross-correlated where possible.

Table 9.2 summarises the quantities of contacts picked. The survey extent for each sensor varied and contacts were picked within the survey boundary of each sensor and cross correlated where multiple datasets were available. No targets cross correlate between sensors in this section of the route.

Table 49: Summary of seafloor contacts in route section C

Sensor	Contact Classification	Quantity
SSS/MBES/MAG Point Features	Boulder	148
	Depression pockmark	5
	Mattress	2
	Seabed mound	3
	Suspected debris	83
	Wreck	1
	Magnetic anomalies	118
SSS/MBES/MAG Linear Features	Exposed pipeline	3 (2 segments belonging to the same pipeline)
	Buried pipeline	8 (several segments belonging to the same pipelines)
	Magnetic linear feature	1

A wreck was identified at KP 4.5 of this route section (Figure 9.3).

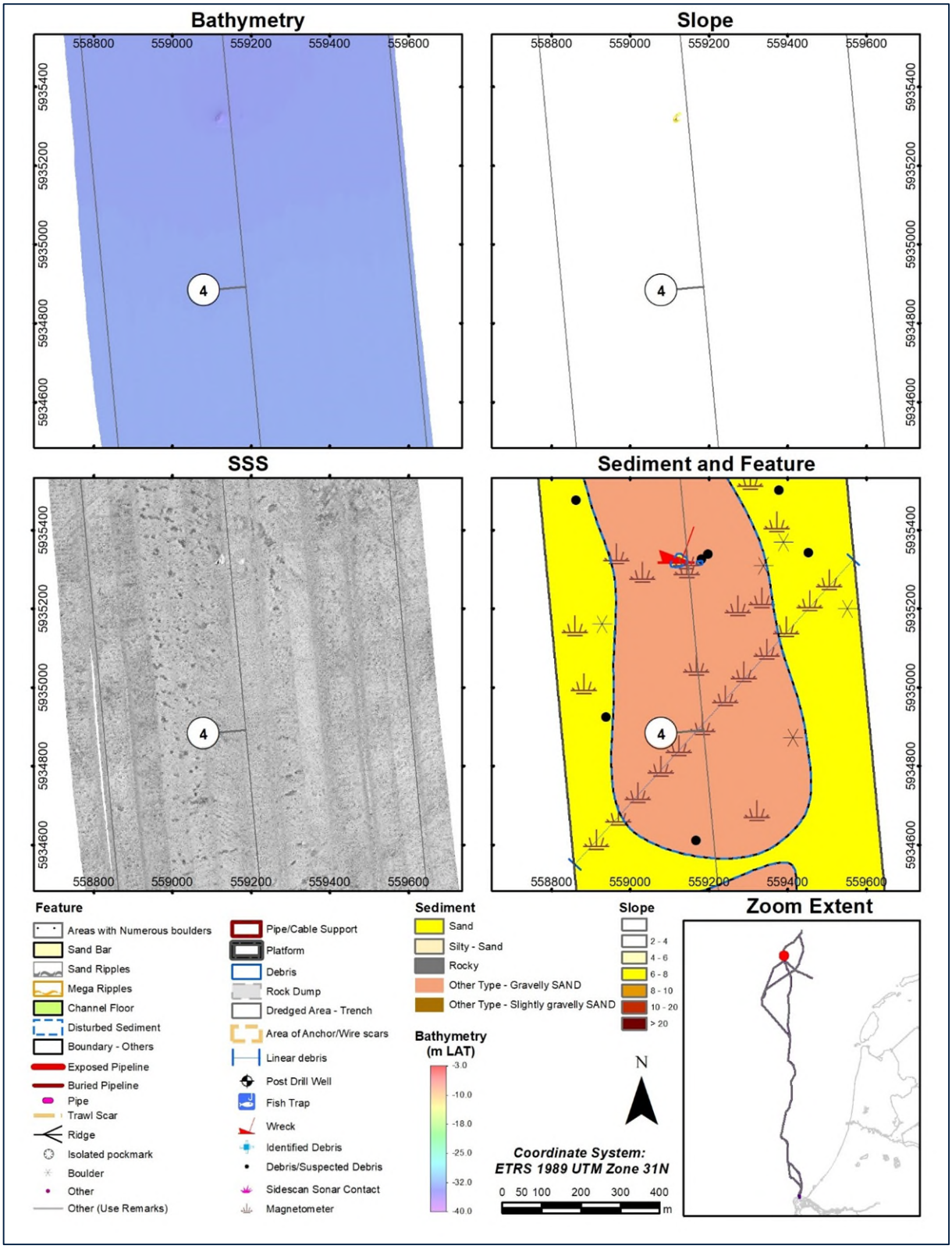


Figure 9.3: Overview of the sediments and morphology in route section C: KP 4.5.

Two (2) exposed segments of a pipeline and two (2) mattresses were identified near Platform L4A (Figure 9.4).

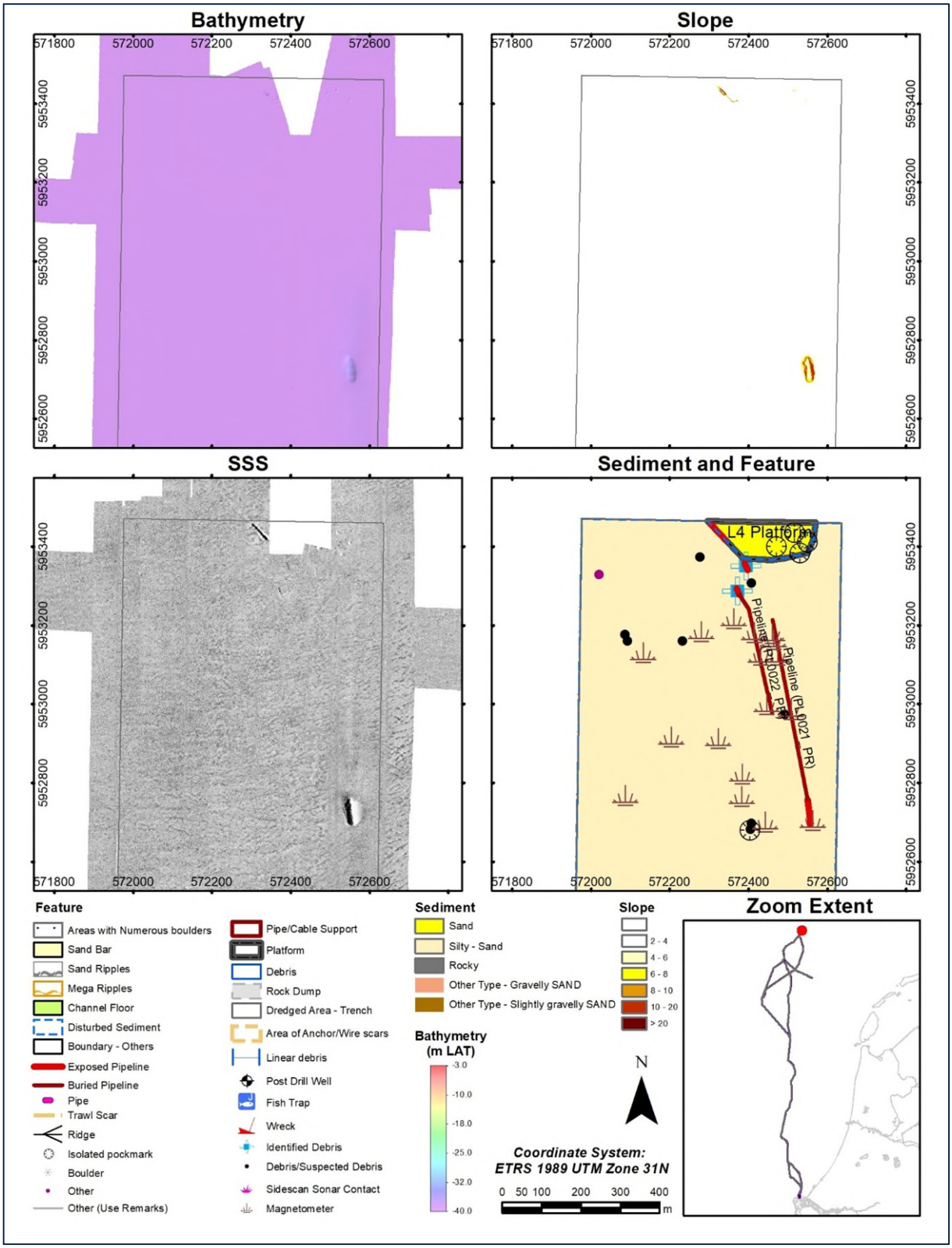


Figure 9.4: Overview of the sediments and morphology in route section C, near Platform L4A.

In Section C, five (5) pipelines and one (1) possible cable have been identified. One of the observed pipelines has two exposed segments in the proximity of the Platform L4A (Table 9.3, Figure 9.5, Figure 9.6 and Figure 9.7).

Table 50: Summary of pipelines in route section C

Contact ID	Pipeline Name	Comment
Pipeline (PL0064_PR)	K9c-A to L10-AR 16-inch pipeline	Buried, KP 9.7
Pipeline (PL0047_PR)	L4-B to L7-A 10.75-inch pipeline	Buried, KP 19.2
Pipeline (PL0048_PR)	L4-B to L7-A 3.5-inch pipeline	Buried, KP 19.3
Pipeline (PL0022_PR)	L4-A TO L7-P 3.5-inch pipeline (abandoned)	Buried (2 segments) (No KP information available)
Pipeline (PL0021_PR)	L4-A to L7-P 12.75-inch pipeline (abandoned)	2 Segments Exposed 1 Segment buried (No KP information available)
Magnetic linear feature (possible cable)	No available background information	Buried, KP 4

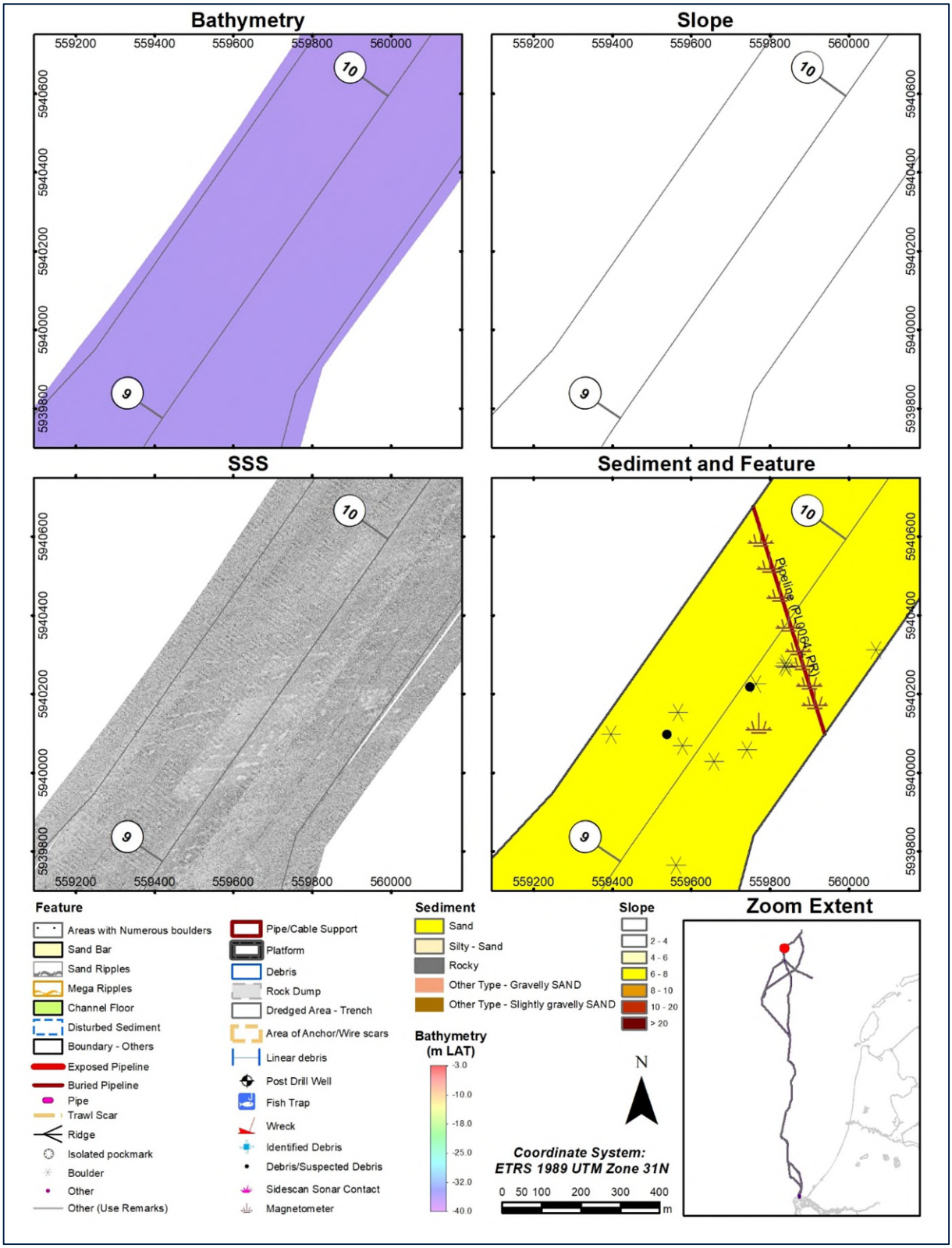


Figure 9.5: Overview of the sediments and morphology in route section C: KP 9.0 to KP 10.0; identified pipeline.

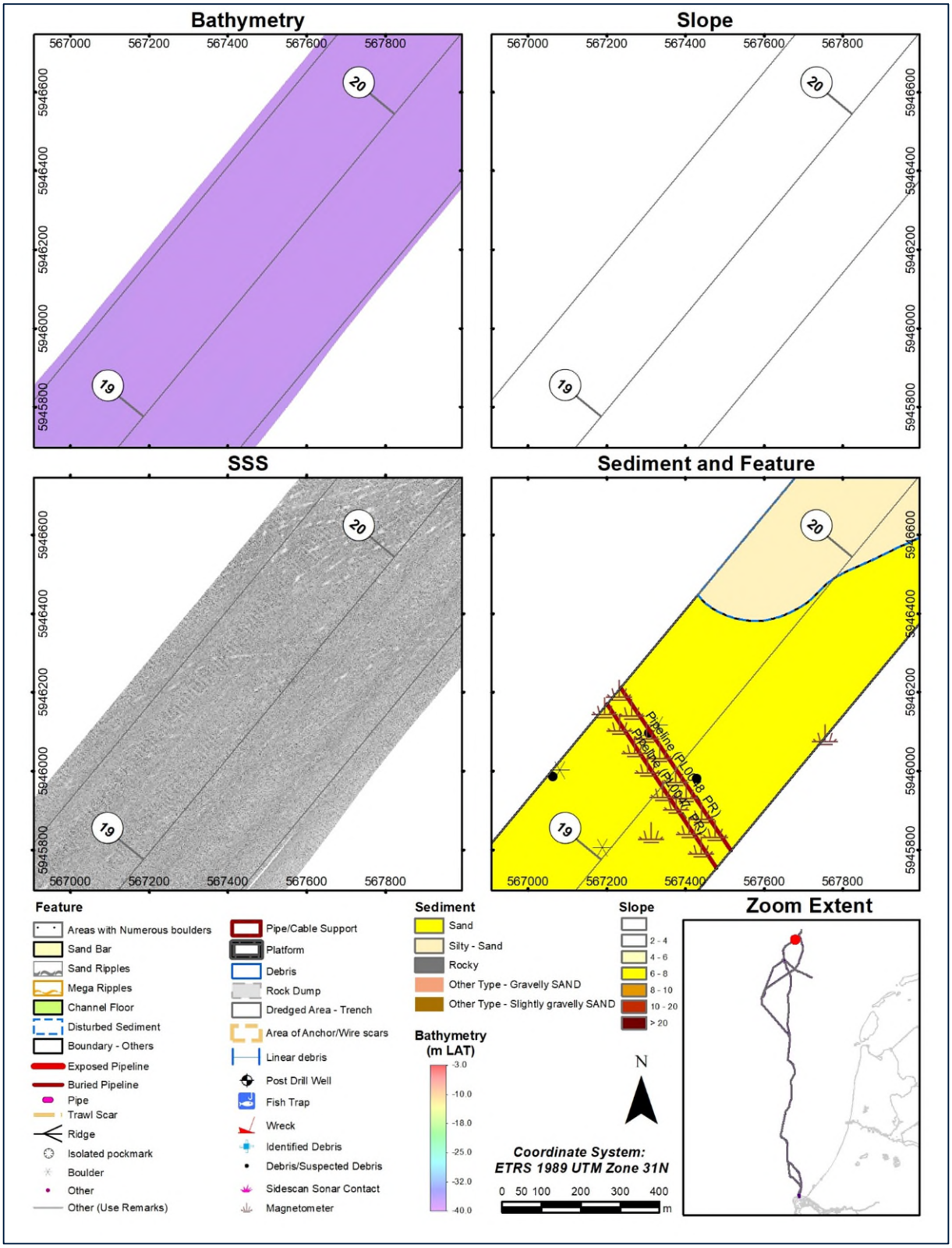


Figure 9.6: Overview of the sediments and morphology in section C: KP 19.0 to KP 20.0, identified pipelines.

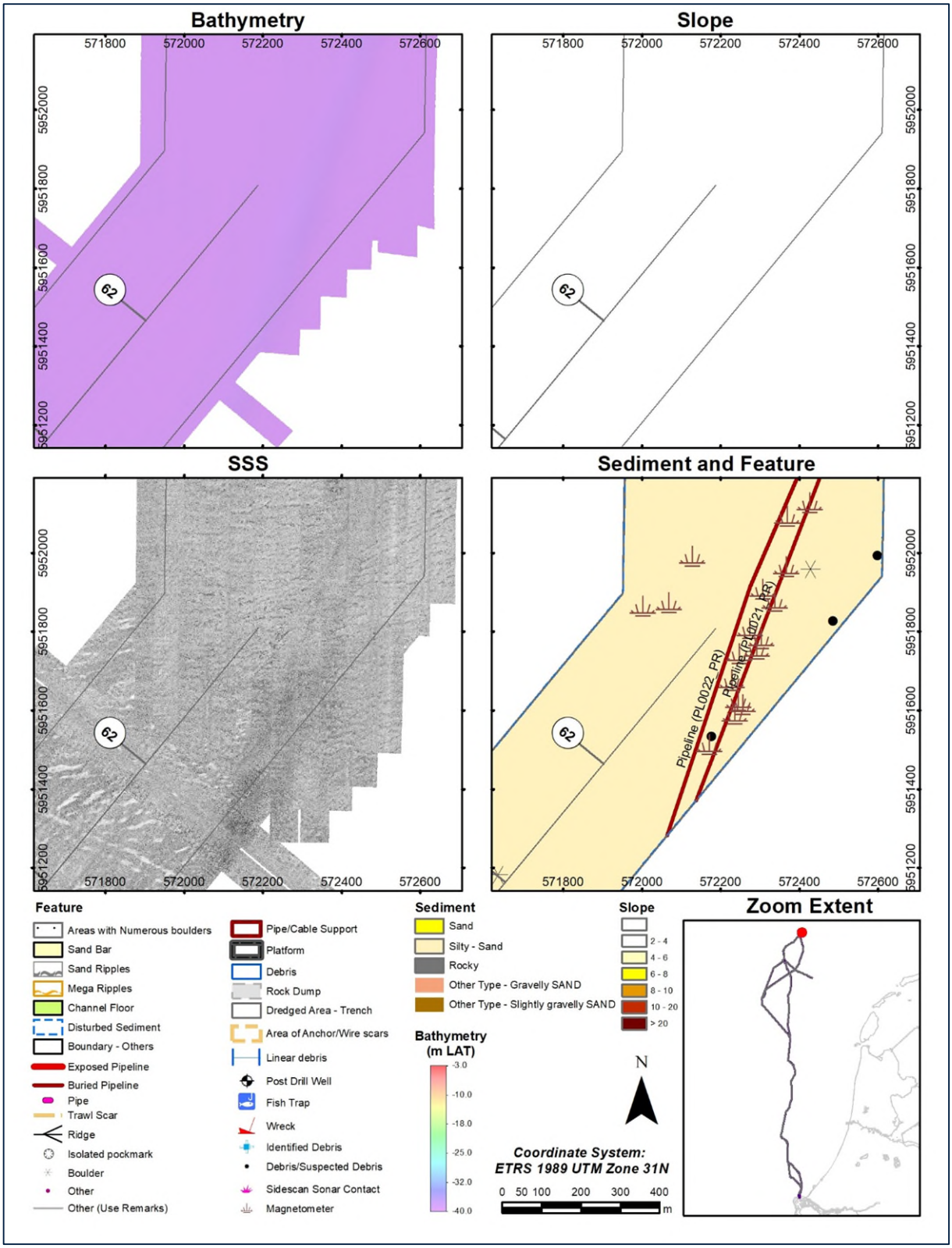


Figure 9.7: Overview of the sediments and morphology in section C: KP 62.0, buried pipelines.

9.2.4 Magnetometer Contacts

118 magnetic contacts were found at the time of the geophysical scope (single MAG survey) in route Section C. The magnetometer anomalies range between 5.1 nT and 3529.9 nT. The highest magnetic amplitudes are associated with the encountered pipelines.

9.2.5 Sub-seafloor Geology

Units A, B, D, E, F and G are present in the route Section C (Figure 9.8).

Unit A is present in the entire section. From KP 0.0 to KP 5.5 this unit is acoustically transparent. This changes between KP 5.5 to KP 26.8 with the upper half of the unit being acoustically semi-transparent with low to medium-amplitude parallel reflectors while the lower half of the unit remains acoustically transparent. The maximum thickness this unit in this section is approximately 3 m.

Unit B is present across the entire section. On the SBP data, the unit is characterized by layered facies, of medium to high amplitude parallel reflectors. In the initial part of this route section, the lower part of the unit is acoustically transparent. The transparent interval thins towards the north and from approximately KP 11.5 the entire unit has layered facies. Locally, the base is channelized. The infill of the channels at the base is structured or chaotic, with high amplitude reflectors. The maximum thickness Unit B in this section is approximately 7 m.

Unit D is present in the entire section. Its seismic character is transparent to semi-transparent, with parallel to sub parallel internal reflectors, marking erosion surfaces. Locally, channels and negative high amplitude anomalies were also interpreted in this unit (peat level 2). The maximum thickness of the Unit D in this section is approximately 15 m.

Unit E is present in the entire section. Acoustically it is semi-transparent and structureless. Locally high negative amplitude anomalies were also interpreted (peat level 3). The maximum thickness of this unit in this section is approximately 20 m.

Unit F (infill of glacial valley) is present between KP 24.6 to KP 26.5.

Table 9.4 provides lithology in the shallow sub-seafloor (within penetration depth of the SBP data), which is based on the seafloor CPT and VC geotechnical data acquired as part of this geophysical survey. Details of the geotechnical data can be found in report F197217-REP-006.

Table 51: Soil conditions in shallow sub-seafloor

Unit	Depth to Base [m BSF]	Lithology
A	0.8 to 3.2	Very loose slightly clayey fine SAND with frequent shells and shell fragments Locally silty fine SAND
B	1.2 to 7.5	Medium to very dense slightly silty fine and medium SAND Frequently a very thin to thick bed of very low to high strength slightly sandy CLAY
D	BDP	Medium to very dense slightly silty to silty fine and medium SAND
Notes: BPD = below penetration depth of SBP data		

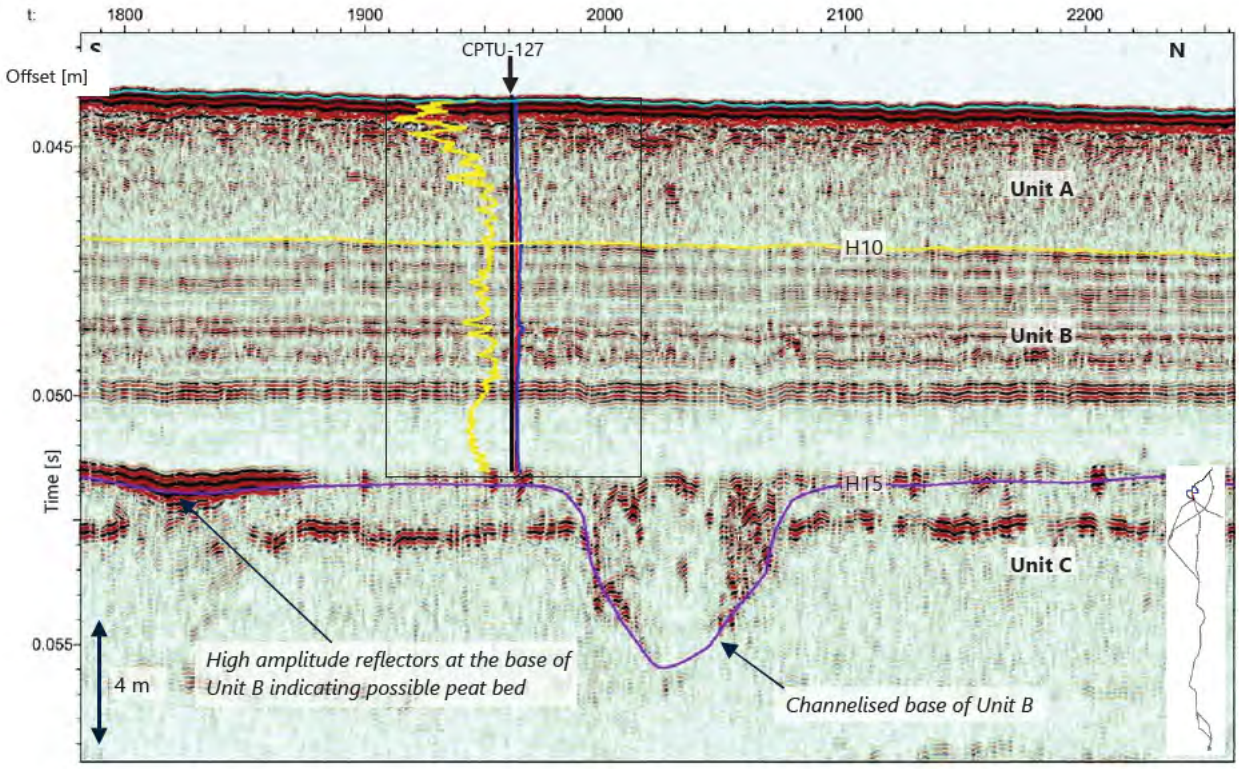


Figure 9.8: SBP data example of route section C. (Line SBP_TA3H23321P1_1) *Width of the CPT boxes show cone resistance values (blue curve) within range of 0 to 25 MPa, sleeve friction values (red curve) from 0 to 0.625 MPa and friction ratio (yellow curve) from 0 to 4 %.*

10. Section D

10.1 Section D Location

The location the route Section D is shown in Figure 10.1. This section of the route has a length of 33.8 km.

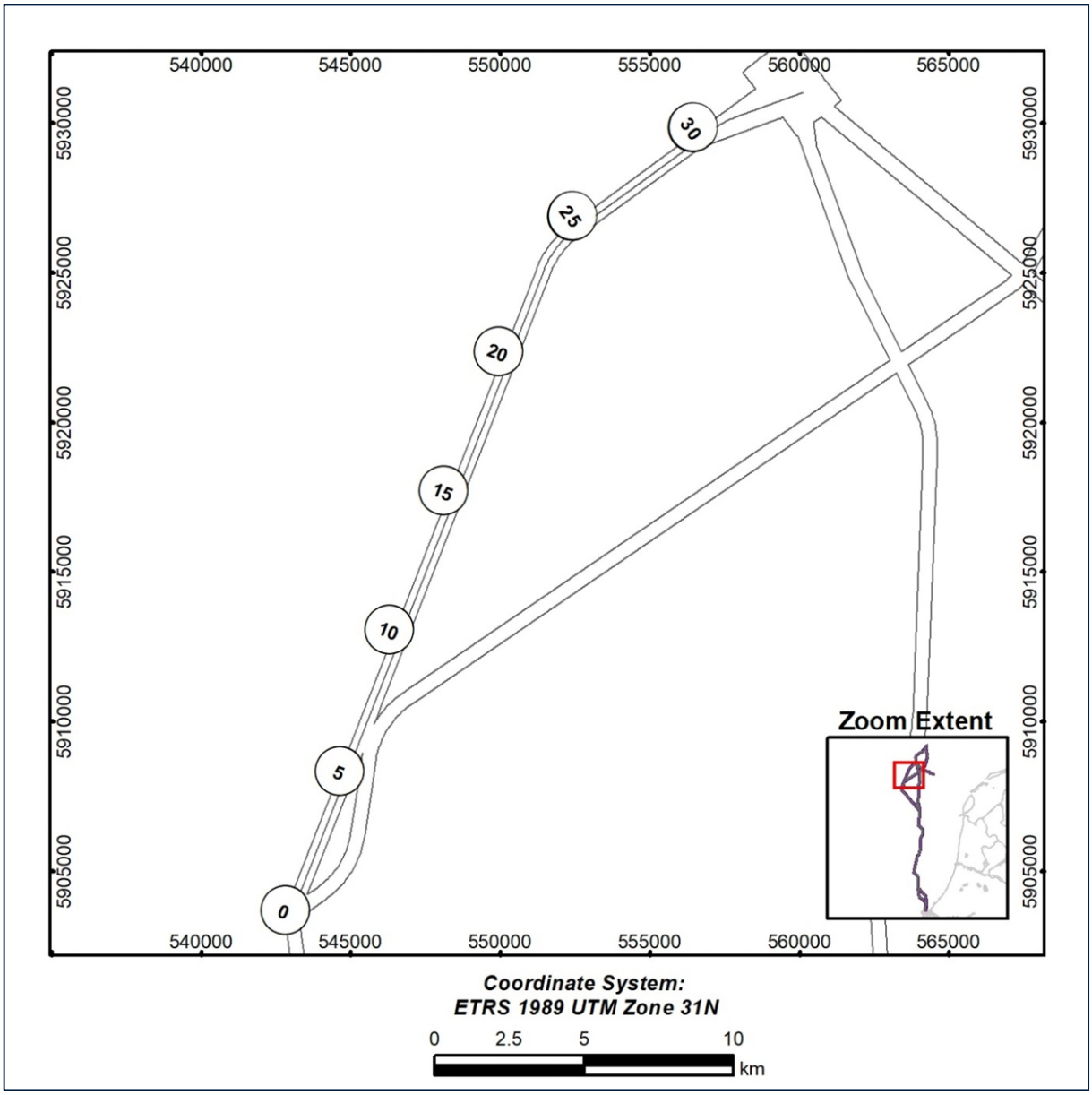


Figure 10.1: Location of the route section D.

10.2 Results

10.2.1 Bathymetry

The water depth in route Section D ranges between 29.5 m and 31.0 m. An overview of the bathymetry is given in Figure 10.2.

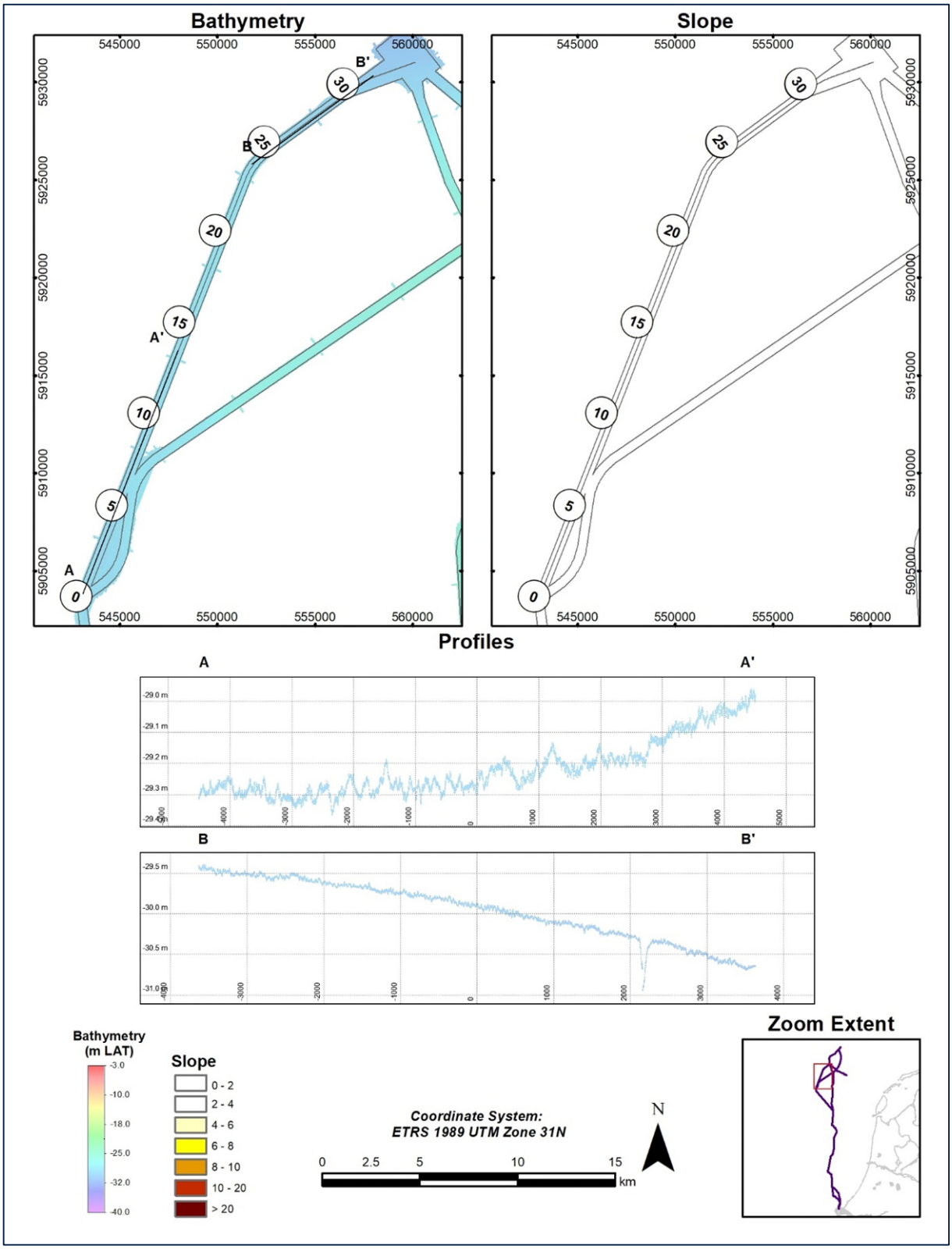


Figure 10.2: Bathymetry along the route section D.

10.2.2 Seafloor Morphology

A strong correlation between sediment types and morphological type was observed, although some small variation is possible. An overview is given in Table 10.1.

Table 52: Sediment type with associated morphology in route section D

Sediment Type	Morphological Type
Silty (muddy) SAND	Patchy fine sediments
SAND	Featureless, trawl marks area

Between KP 0.0 and KP 29, the dominant sediment is SAND, between KP 29.0 and KP 32.5 the sediment is classified as silty (muddy)SAND, between KP 32.5 and the end of the section (Hub Area) the sediment type is mostly SAND with isolated trawl marks.

10.2.3 Seafloor Features and Contacts

Seafloor features and contacts were identified from one or more of the SSS, MBES, MAG and SBP sensors and cross-correlated where possible.

Table 10.2 summarises the quantities of contacts picked. The survey extent for each sensor varied and contacts were picked within the survey boundary of each sensor and cross-correlated where multiple datasets were available. Three targets cross correlate between sensors.

Table 53: Summary of seafloor contacts in route section D

Sensor	Contact Classification	Quantity
SSS/MBES/MAG Point Features	Boulder	251
	Debris	9
	Magnetic anomalies	117
SSS/MBES/MAG Linear Features	Fishing gear	1
	Exposed pipeline	1 partially exposed (2 segments) and partially buried (1 segment)
	Buried pipeline	1

Table 10.3 shows the 3 targets that were cross correlated between sensors in Section D.

Table 54: Summary of cross correlating seafloor contacts in route section D

Section	SSS Target Name	MAG Target Name	Description
Section D	BK_FSEA_SSS_0084	BK_FSEA_MAG_0090	Debris
Section D	BK_FSEA_SSS_0086	BK_FSEA_MAG_0133	Debris
Section D	BK_FSEA_SSS_0163	BK_FSEA_MAG_0093	Debris

An example of a SSS/MBES target with a length of 2.5 m correlated with a MAG anomaly of 4576.5 nT, found at KP 19.8 of Section D, is shown in Figure 10.3. The distance between the target and the route is 63 m.

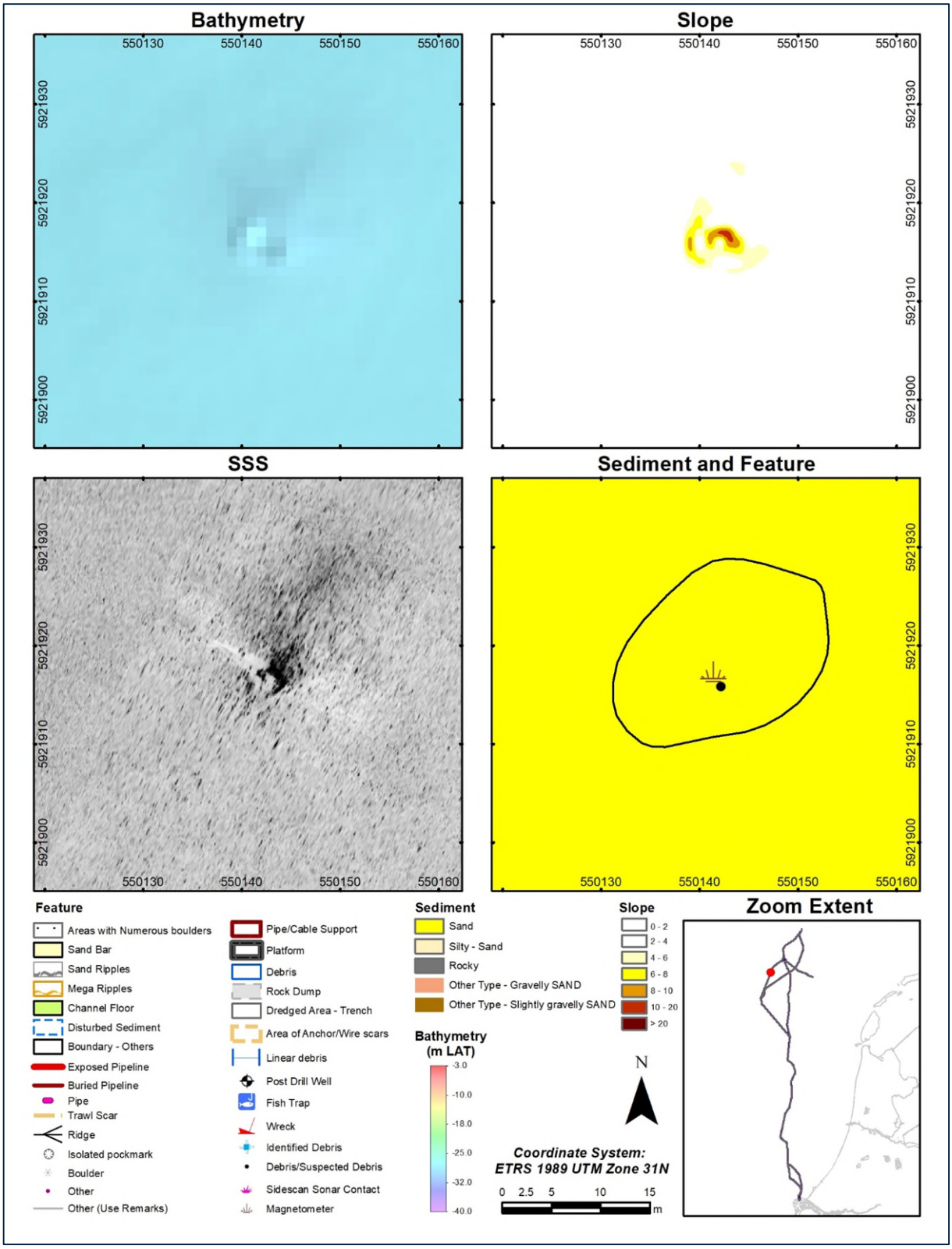


Figure 10.3: Example cross-correlated target found in route section D.

Two (2) pipelines were identified, one (1) buried and one (1) partially buried and partially exposed in this section of the route (Table 10.4 and Figure 10.4).

Table 55: Summary of pipelines in route section D

Contact ID	Pipeline Name	Comment
Pipeline (PL0119_PR)	K11-B to K12-C 14/2-inch pipeline bundle (abandoned 2005)	Buried, KP 21.1
Pipeline (PL0142_PR)	D15-FA to L10-AC 36-inch dry gas pipeline	Partially buried (1 segment), partially exposed (2 segments), KP 30.1

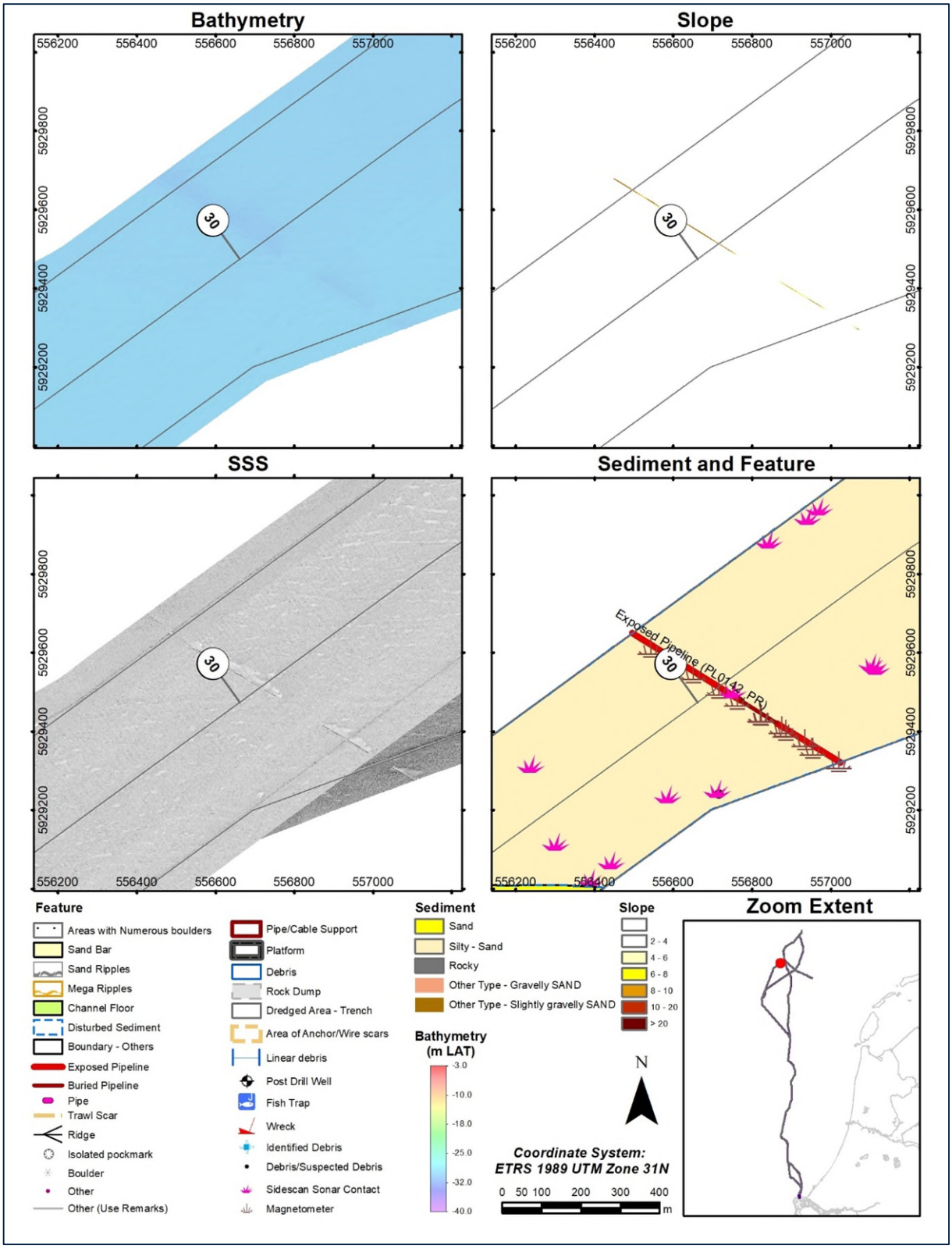


Figure 10.4: Example of partially buried and partially exposed pipeline in route section D.

10.2.4 Magnetometer Contacts

117 magnetic contacts were found at the time of the geophysical scope (single MAG survey) in route Section D. The magnetometer anomalies range between 5.1 nT and 7221.3 nT. The highest magnetic amplitudes are associated with the encountered pipelines

10.2.5 Sub-seafloor Geology

Units A, B, C, D, E, F and G are present in the route Section D (Figure 10.5).

Unit A is present in the entire section. It characterized by acoustically transparent seismic character. The maximum thickness of this unit in this section is approximately 3 m.

Unit B is present across the entire section. On the SBP data, the seismic character is chaotic between KP 0.0 and KP 10.0, acoustically transparent between KP 10.0 and KP 21.0, and from KP 21.0 till the end of the route section layered seismic facies with low to medium-amplitude parallel reflectors. Where the base is channelised, the infill is chaotic or structured, with high amplitude reflectors. At the base of this unit high amplitude anomalies were observed, which may represent laminae or thin bed of peat and/or organic-rich clay (peat level 1). The maximum thickness of this unit in this section is approximately 5 m.

Unit C is present between KP 0.0 and KP 20.4. The unit exhibits mostly transparent/ structureless facies in this section, locally there are internal high amplitude semi-horizontal reflectors observed, especially towards the north. The thickness increases to the north and reaches maximum thickness of approximately 10 m.

Unit D is present between KP 4.0 and KP 28.9, between KP 31.5 and the end of the section. Its seismic character varies from acoustically transparent to bedded, with parallel reflectors. Locally, negative high amplitude anomalies were also interpreted (peat level 2). The maximum thickness of the Unit D in this section is approximately 15 m.

Unit E is present in the entire section. Acoustically it is transparent to semi-transparent and structureless. The maximum thickness of this unit in this section is approximately 20 m.

Unit F (infill of glacial valley) is present between KP 27.9 to KP 29.1.

Table 10.5 provides lithology in the shallow sub-seafloor (within penetration depth of the SBP data), which is based on the seafloor CPT and VC geotechnical data acquired as part of this geophysical survey. Details of the geotechnical data can be found in report F197217-REP-006.

Table 56: Soil conditions in shallow sub-seafloor

Unit	Depth to Base [m BSF]	Lithology
A	0.8 to 2.9	Very loose to medium dense silty fine and medium SAND, with occasional shells and shell fragments
B	1.3 to 9.0	Medium dense to dense slightly silty to silty fine and medium SAND with occasional shells and shell fragments Locally with thick beds of low to medium strength slightly sandy clayey SILT with closely spaced thin to thick laminae of sand, with closely spaced thin laminae of peat
C	BPD	Medium dense to dense silty to very silty fine and medium SAND
D	BPD	Low strength to high strength CLAY

Unit	Depth to Base [m BSF]	Lithology
Notes: BPD = below penetration depth of SBP data		

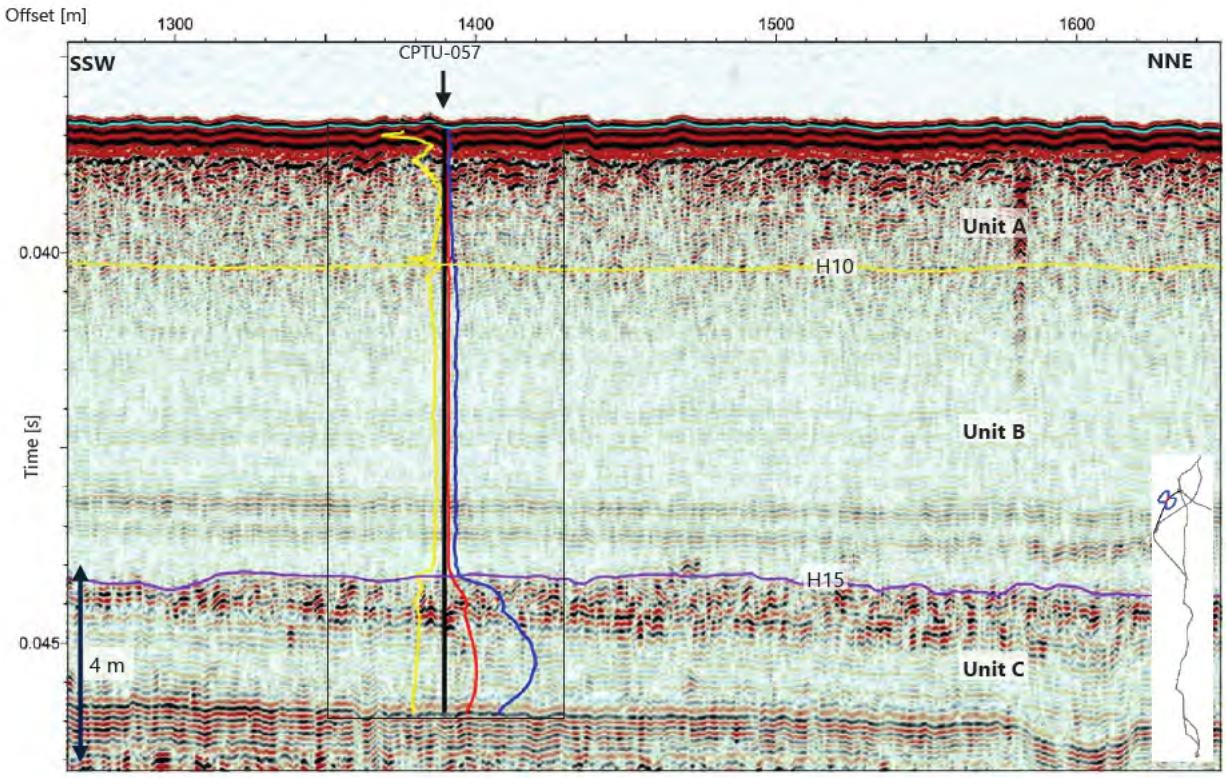


Figure 10.5: SBP data example of route section D. (Line SBP_TA3K2305P1_5) Width of the CPT boxes show cone resistance values (blue curve) within range of 0 to 25 MPa, sleeve friction values (red curve) from 0 to 0.625 MPa and friction ratio (yellow curve) from 0 to 4 %.

11. Section E Alternative

11.1 Section E Alternative Location

The location of the route Section E Alternative is shown in Figure 11.1. This section of the route has a length of 23.5 km.

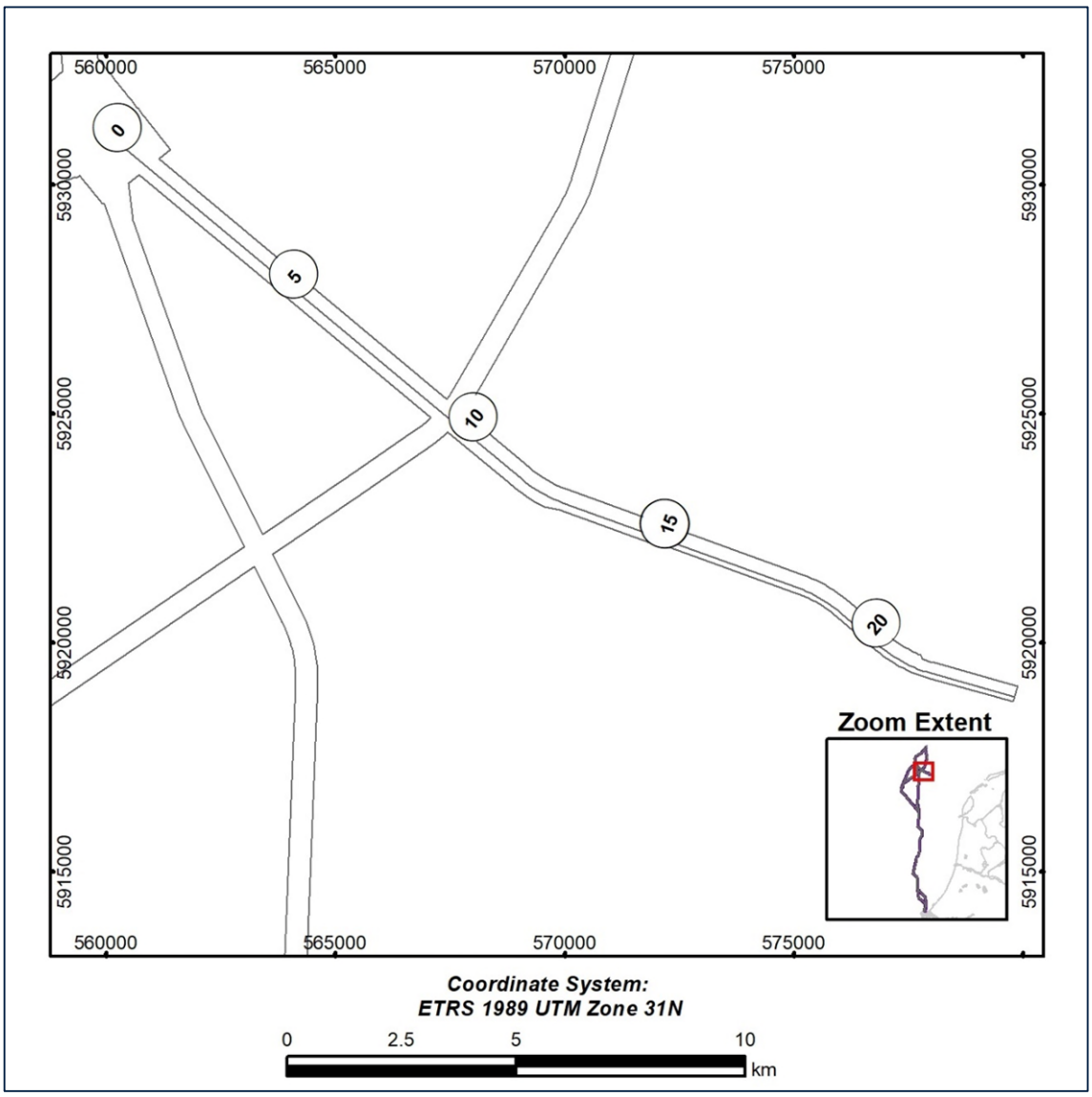


Figure 11.1: Location of the route section E Alternative.

11.2 Results

11.2.1 Bathymetry

The water depth in route Section E Alternative ranges between 26.0 m and 30.5 m. An overview of the bathymetry is given in Figure 11.2.

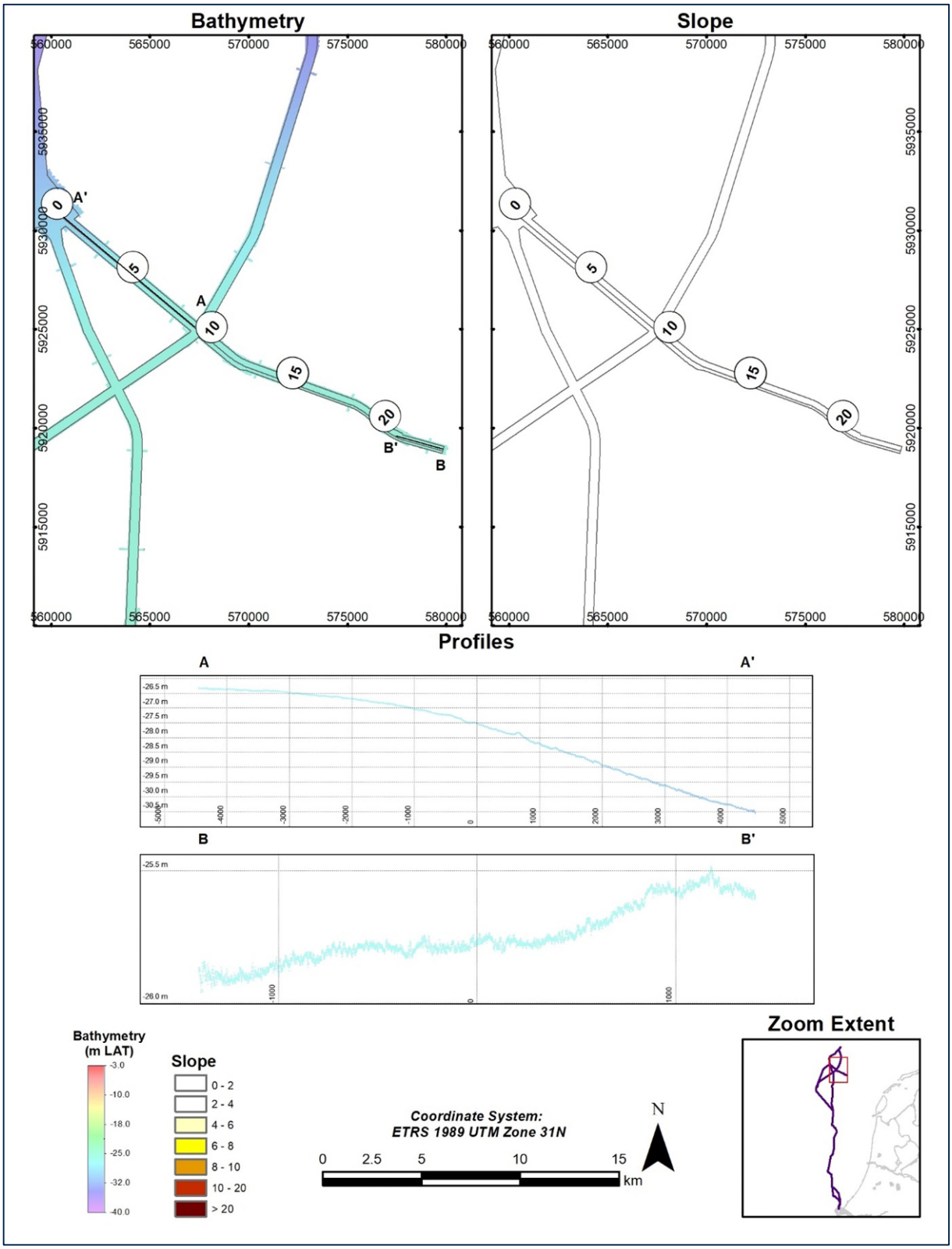


Figure 11.2: Bathymetry along the route section E Alternative.

11.2.2 Seafloor Morphology

A strong correlation between sediment types and morphological type was observed, although some small variation is possible. An overview is given in Table 11.1.

Table 57: Sediment type with associated morphology in route section E Alternative

Sediment Type	Morphological Type
Slightly gravelly SAND	Ripples
SAND	Featureless

From KP 0.0 to KP 22.0 the dominant sediment has been classified as SAND mostly featureless, from KP 22.0 till the end of Section E Alternative an area of sightly gravelly SAND with ripples has been identified.

11.2.3 Seafloor Features and Contacts

Seafloor features and contacts were identified from one or more of the SSS, MBES, MAG and SBP sensors and cross-correlated where possible.

Table 11.2 summarises the quantities of contacts picked. The survey extent for each sensor varied and contacts were picked within the survey boundary of each sensor and cross correlated where multiple datasets were available. No targets cross-correlate in this section of the route.

Table 58: Summary of seafloor contacts in route section E Alternative

Sensor	Contact Classification	Quantity
SSS/MBES/MAG Point Features	Debris	34
	Suspected debris	2
	Wreck	1
	Magnetic anomalies	41
SSS/MBES/MAG Linear Features	Exposed pipeline	1 partially exposed and partially buried pipeline
	Buried pipeline	4
	Magnetic linear feature	1

A wreck was found at KP 20.0 of the route Section E Alternative (Figure 11.3). The wreck is located approximately 220 m from the route.

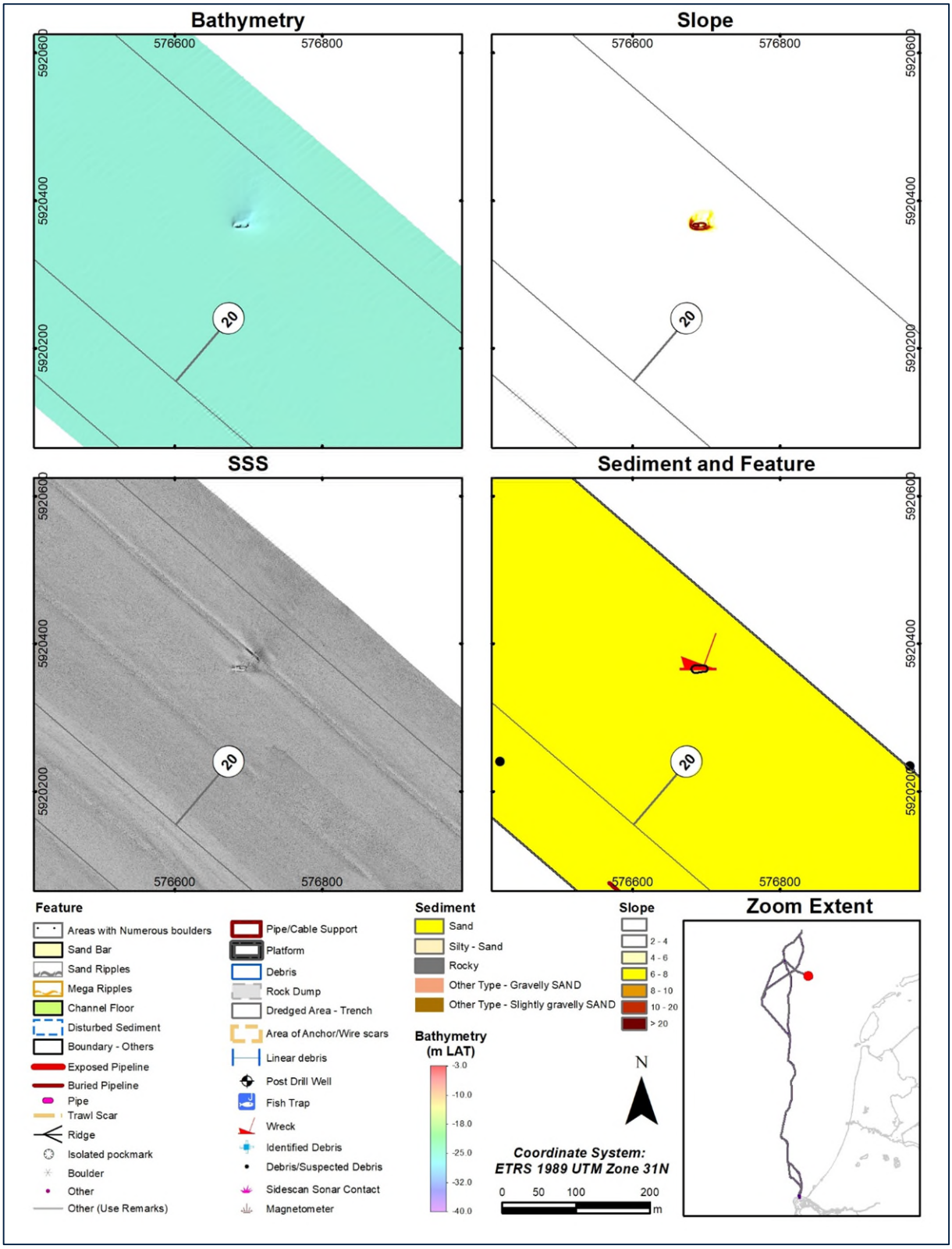


Figure 11.3: Example of wreck found in route section E Alternative.

Five (5) pipelines and one (1) possible cable were identified in route Section E Alternative (Table 11.3). One of the identified pipelines is partially exposed.

Table 59: Summary of pipeline in route section E Alternative

Contact ID	Pipeline Name	Comment
Pipeline (PL0064_PR)	K9c-A to L10-AR 16-inch dry gas pipeline	Buried, KP 18
Pipeline (PL0068_PR)	L10-S3 to L10-AP 6/2-inch pipeline bundle (abandoned 2005)	Buried KP 20, 21
Pipeline (PL0067_HS)	L10-L to L10-AP 10-inch gas / 2-inch methanol pipeline bundle	Partially buried (2 Segments) and partially exposed (1 segment), KP 22.5
Pipeline (PL0012_PR)	L7-P to L10-A 16-inch dry gas pipeline	Buried, KP 22.5
Pipeline (PL0002_HS)	L10-B to L10-AD 10-inch gas / 2-inch methanol pipeline bundle	Buried, KP 22.8
Mag Linear Feature (Possible cable)	Not present in the background database	Buried, KP 23.4

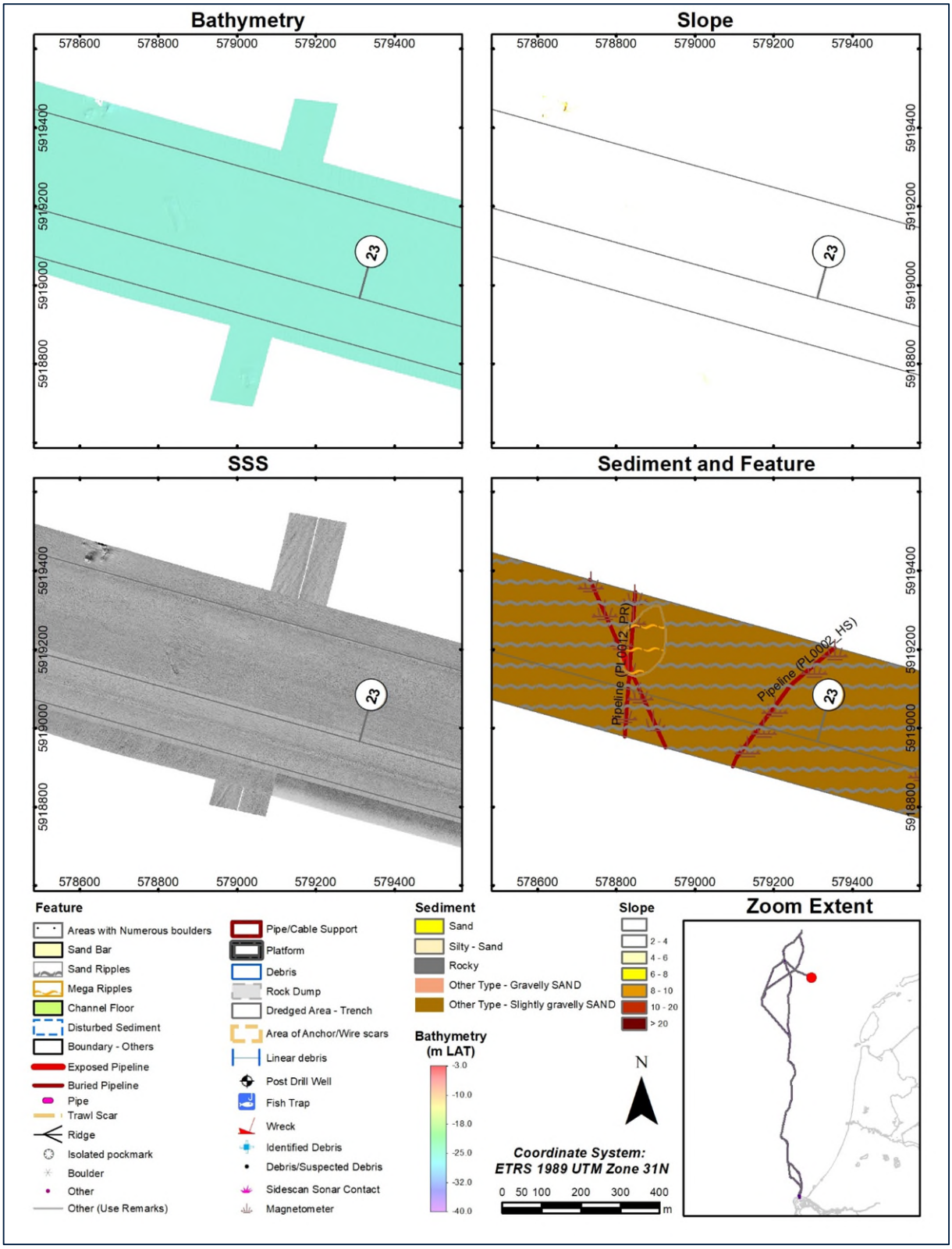


Figure 11.4: Example of pipelines found in route section E Alternative.

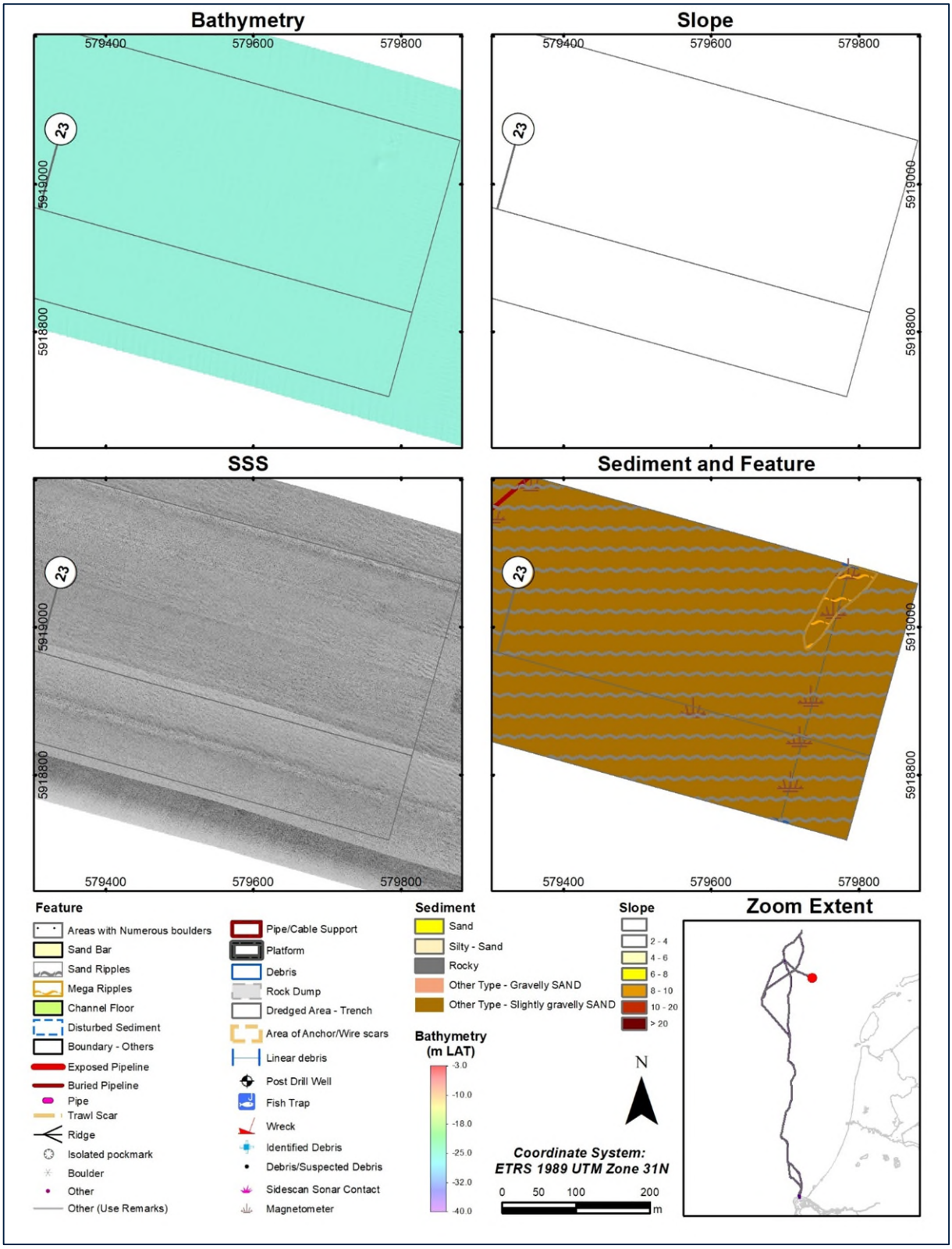


Figure 11.5: Example of possible cable found in route section E Alternative: KP 23.4.

11.2.4 Magnetometer Contacts

41 magnetic contacts were found at the time of the geophysical scope (single MAG survey). in route section E Alternative. The magnetometer anomalies range between 7.4 nT and 3424.2 nT. The highest magnetic amplitudes are associated with the encountered pipelines.

11.2.5 Sub-seafloor Geology

Units A, B, C, D, E and F are present in route Section E Alternative (Figure 11.6).

Unit A is present in the entire section. It has transparent seismic character. From approximately KP 12.0 the unit shows locally chaotic intervals and undulating internal erosion surfaces marked by medium amplitude reflectors. The maximum thickness of this unit in this section is approximately 3 m.

Unit B is present across the entire section. The unit has predominantly acoustically transparent seismic character. Between KP 11.0 and KP 15.5, locally intervals with chaotic facies with high amplitude reflections are present. The base is locally channelised. Their infill is structured, with medium to high amplitude sub parallel reflectors. The maximum thickness of this unit in this section is approximately 6 m.

Unit C is present between KP 8.5 to KP 23.5. It exhibits semi-transparent seismic character, with locally internal high amplitude negative reflectors of various extent. These reflectors represent laminae or thin bed of peat and/or organic-rich clay. The maximum thickness of this unit in this section is approximately 4 m.

Unit D is present in the entire section. Its seismic character is semi-transparent with internal erosion surfaces marked by undulating medium to high amplitude reflectors. Locally, internal channels and negative high amplitude anomalies indicating peat were observed in this unit. The maximum thickness of the Unit D in this section is approximately 20 m.

Unit E is present in the entire section. Acoustically it is transparent to semi-transparent and structureless.

Unit F (glacial valley infill) is present locally between KP 2.5 and KP 22.7.

Table 11.4 provides lithology in the shallow sub-seafloor (within penetration depth of the SBP data), which is based on the seafloor CPT and VC geotechnical data acquired as part of this geophysical survey. Details of the geotechnical data can be found in report F197217-REP-006.

Table 60: Soil conditions in shallow sub-seafloor

Unit	Depth to Base [m BSF]	Lithology
A	2.3 to 2.8	Very loose to loose silty fine and medium SAND with occasional shells and shell fragments
B	3.9 to 10.9	Loose to dense slightly silty to very silty fine and medium SAND with occasional shells and shell fragments
C	BPD	Medium dense slightly silty to very silty fine and medium SAND Locally with a medium bed of sandy SILT Locally with a medium bed of medium strength CLAY
Notes: BPD = below penetration depth of SBP data		

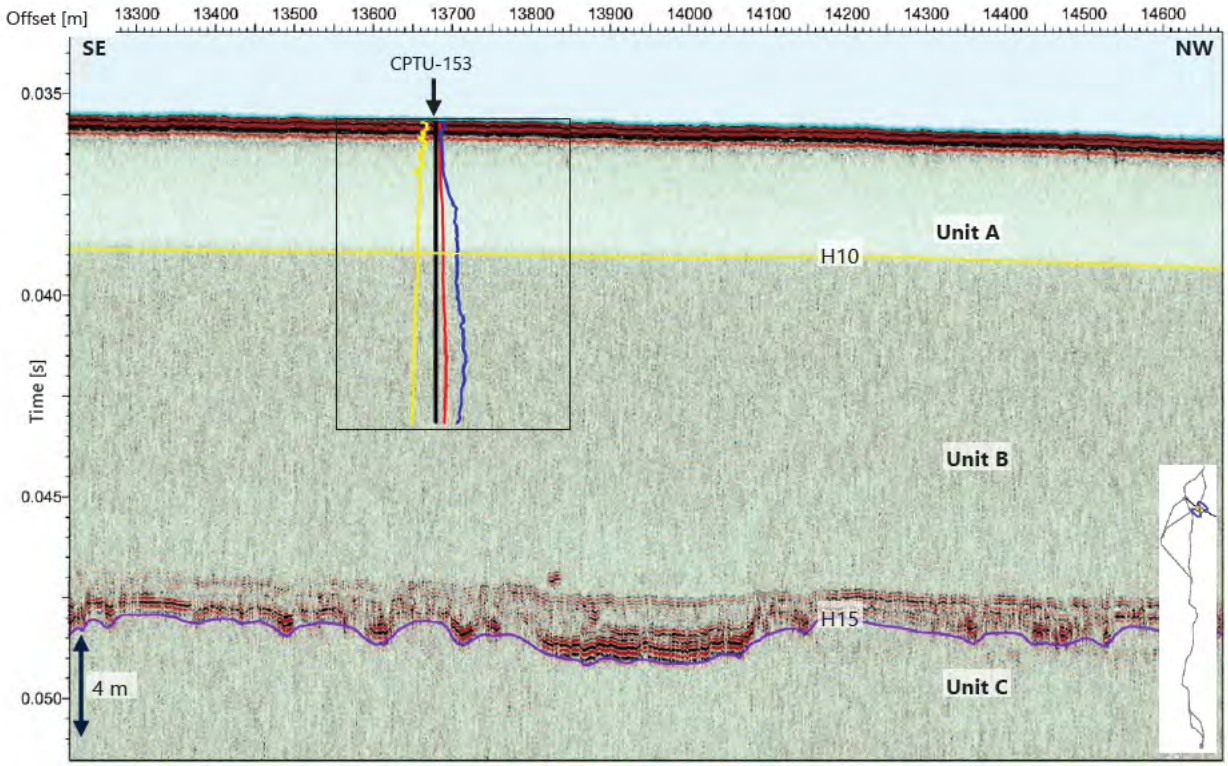


Figure 11.6: SBP data example of route section E Alternative. (Line SBP_TA3N2365P1) Width of the CPT boxes show cone resistance values (blue curve) within range of 0 to 25 MPa, sleeve friction values (red curve) from 0 to 0.625 MPa and friction ratio (yellow curve) from 0 to 4 %.

12. Section F

12.1 Section F Location

The location of in route Section F is shown in Figure 12.1. This section of the route has a length of 36.3 km.

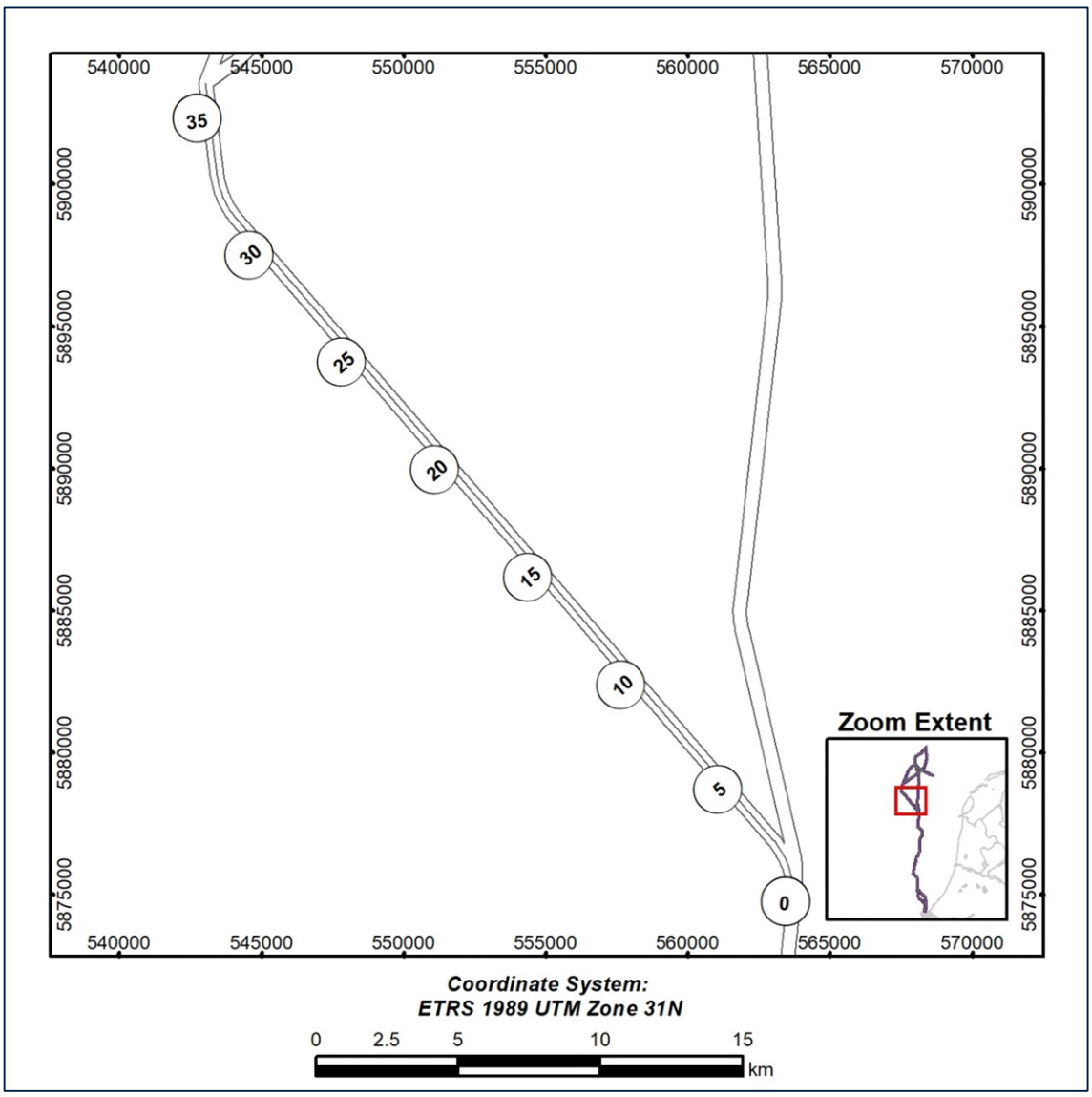


Figure 12.1: Location of the route section F.

12.2 Results

12.2.1 Bathymetry

The water depth in route Section F ranges between 24.0 m and 30.0 m. An overview of the bathymetry is given in Figure 12.2.

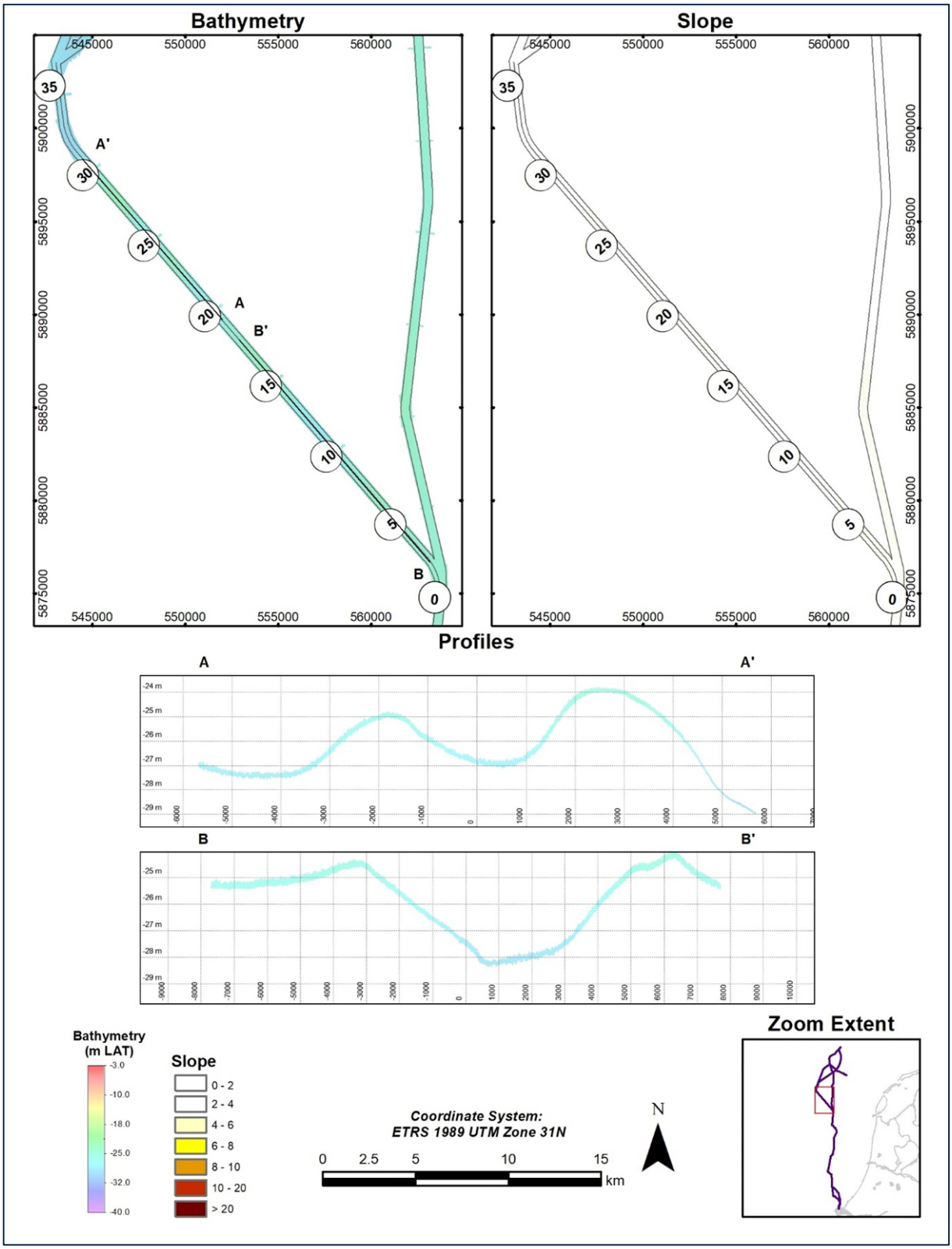


Figure 12.2: Bathymetry along the route section F.

12.2.2 Seafloor Morphology

A strong relation between sediment type and morphological type was observed, although some small variation is possible. An overview is given in Table 12.1.

Table 61: Sediment type with associated morphology in route section F

Sediment Type	Morphological Type
Slightly gravelly SAND	Ripples or megaripples and sand waves
SAND	Featureless

From KP 0.0 to KP 29.7 the dominant sediment was classified as slightly gravelly SAND with ripples, megaripples and sand waves. From KP 29.7 till the end of the section the sediments were classified as SAND mostly featureless. Figure 12.3 shows the sediment and morphology transition at KP 29.7.

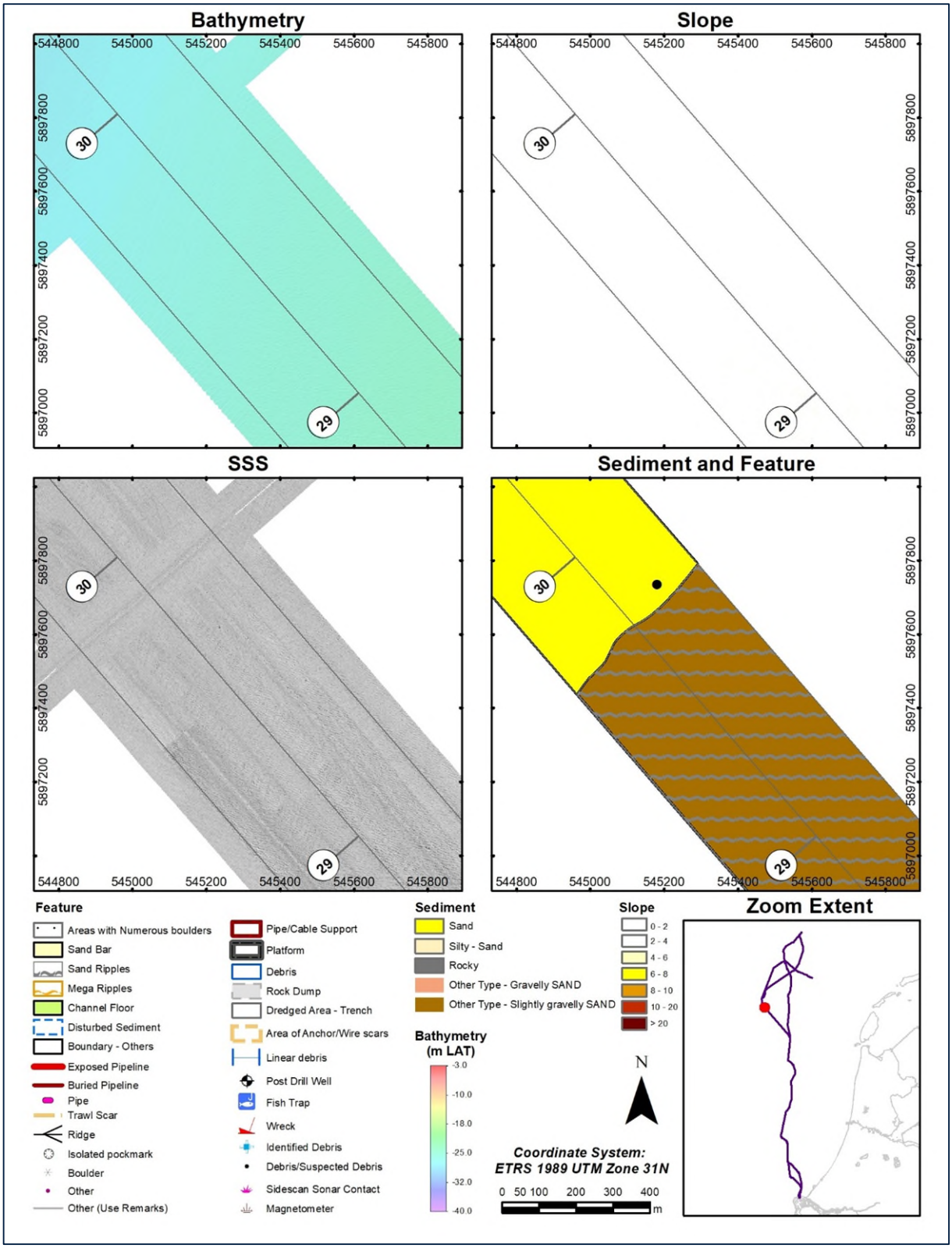


Figure 12.3: Overview of the sediments and morphology transition in rote section F: KP 29.0 to KP 30.0.

12.2.3 Seafloor Features and Contacts

Seafloor features and contacts were identified from one or more of the SSS, MBES, MAG and SBP sensors and cross correlated where possible.

Table 12.2 summarises the quantities of contacts picked. The survey extent for each sensor varied and contacts were picked within the survey boundary of each sensor and cross-correlated where multiple datasets were available. No targets cross correlate between sensors in this section of the route.

Table 62: Summary of seafloor contacts in route section F

Sensor	Contact Classification	Quantity
SSS/MBES/MAG Point Features	Boulder	10
	Debris	12
	Magnetic anomalies	70
SSS/MBES/MAG Linear Features	Debris	1
	Large trawl scour	16
	Buried pipeline	4

Four (4) buried pipelines were identified in route Section F (Table 12.3, Figure 12.4 and Figure 12.5).

Table 63: Summary of pipeline in route section F

Contact ID	Pipeline Name	Comment
Pipeline (PL0032_PR)	P6-A to L10-AR 20-inch gas pipeline	Buried, KP 5.8
Pipeline (PL0004_PR)	K13-A to Den Helder 36-inch gas pipeline	Buried, KP 36.2
Pipeline (PL0062_PR)	K14-FA-1C to K15-FA-1 18-inch pipeline	Buried, KP 36.3
Pipeline (PL0130_PR)	K14-FA-1 to K15-FB-1 pipeline	Buried, KP 36.35

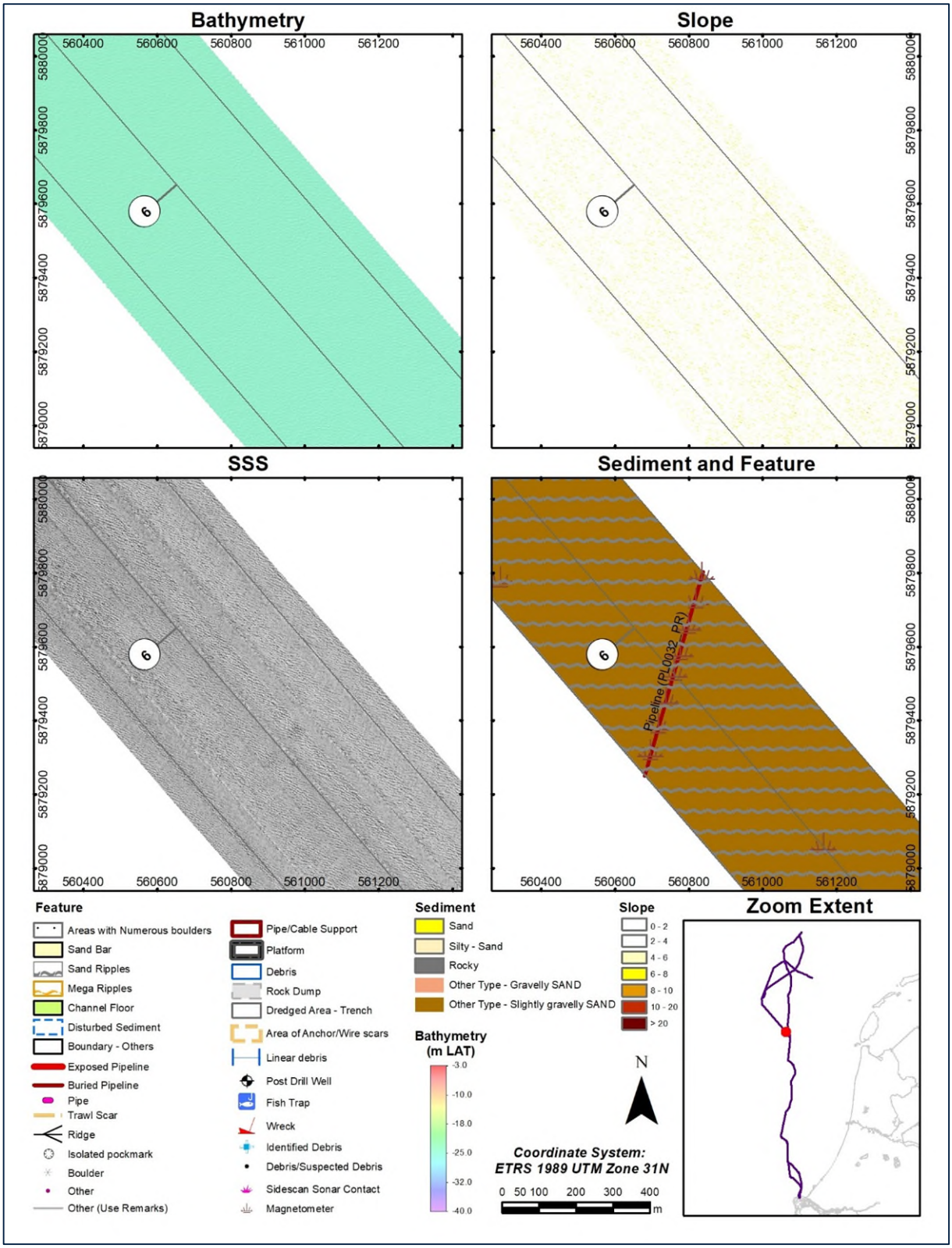


Figure 12.4: Example of pipeline crossing in route section F: KP 6.0.

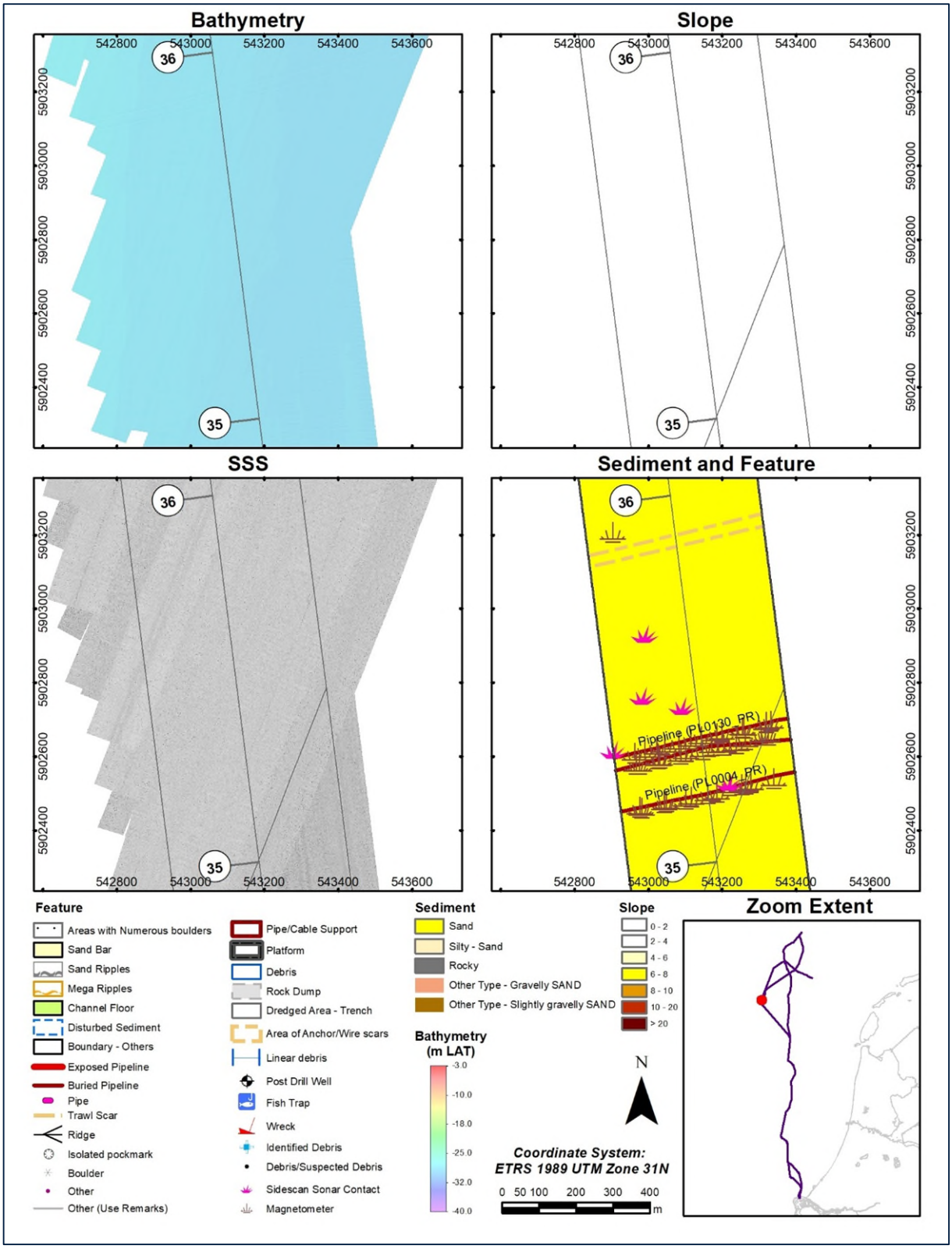


Figure 12.5: Example of pipelines crossing the route section F: KP 35.0 to KP 36.0.

12.2.4 Magnetometer Contacts

70 magnetic contacts were found at the time of the geophysical scope (single MAG survey) in route section F. The magnetometer anomalies range between 13.7 nT and 3983.8 nT. The highest magnetic amplitudes are associated with the encountered pipelines.

12.2.5 Sub-seafloor Geology

Units A, B, C, D, F and G are present in route Section F (Figure 12.6).

Unit A is present in the entire section. It has transparent seismic character. The maximum thickness of this unit in this section is approximately 5 m.

Unit B is present across the entire section. The unit is predominantly acoustically transparent. The base is locally channelised, with the infill characterised by layered character with high amplitude reflectors. At the base, locally high amplitude reflectors were observed, which represent laminae or thin bed of peat and/or organic-rich clay (peat level 1). The maximum thickness of this unit in this section is approximately 5 m.

Unit C is present in the entire section. It exhibits semi-transparent to chaotic seismic character, with local high amplitude negative reflectors, indicating laminae or thin bed of peat and/or organic-rich clay (peat level 2). The maximum thickness of this unit in this section is approximately 4 m.

Unit D is present in the entire section. Its seismic character changes along the route. Between KP 0.0 to KP 11.0 it is mainly acoustically transparent, between KP 11.0 and KP 27.0 it is bedded in the upper part and from approximately KP 27.0 the entire unit shows bedded facies with medium amplitude parallel reflectors. Locally, the base is channelised and high amplitude negative short reflectors were observed (peat level 2). The maximum thickness of the Unit D in this section is approximately 20 m.

Unit F (glacial valley infill) is present between KP 2.7 and KP 6.4, between KP 8.4 and KP 10.0, between KP 26.9 and KP 27.3 and between KP 28.4 and KP 31.7.

Table 12.4 provides lithology in the shallow sub-seafloor (within penetration depth of the SBP data), which is based on the seafloor CPT and VC geotechnical data acquired as part of this geophysical survey. Details of the geotechnical data can be found in report F197217-REP-006.

Table 64: Soil conditions in shallow sub-seafloor

Unit	Depth to Base [m BSF]	Lithology
A	0.7 to 4.7	Very loose to medium dense slightly silty fine and medium SAND
B	1.6 to 6.5	Medium to very dense slightly silty to very silty fine and medium SAND with occasional shells and shell fragments Locally with a medium to high strength slightly sandy clayey SILT
C	BPD	Very loose to very dense silty fine SAND with Locally with very closely to closely spaced thin laminae of peat Locally with a medium bed of medium to high strength CLAY
D	BPD	Low to high strength silty CLAY
Notes: BPD = below penetration depth of SBP data		

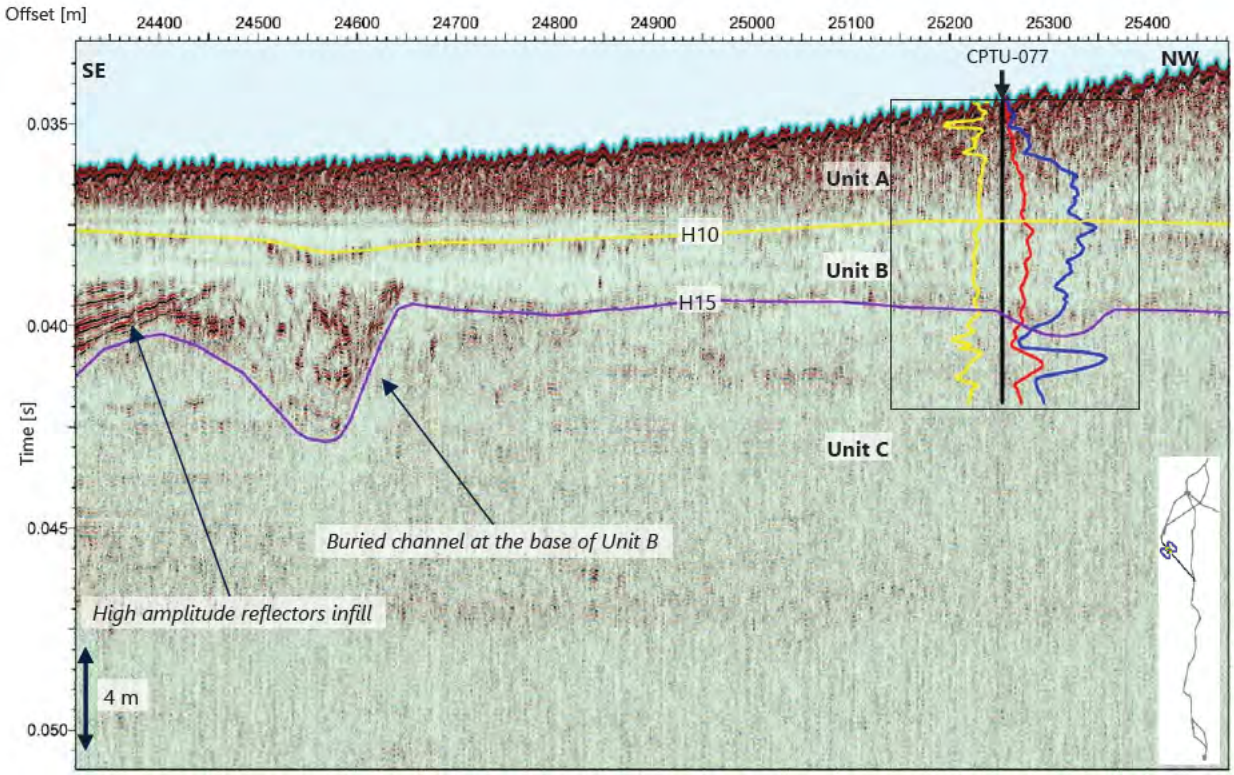


Figure 12.6: SBP data example of route section F. (Line SBP_TA3J2262P1) Width of the CPT boxes show cone resistance values (blue curve) within range of 0 to 25 MPa, sleeve friction values (red curve) from 0 to 0.625 MPa and friction ratio (yellow curve) from 0 to 4 %.

13. Section K14-L4A

13.1 Section K14-L4A Locations

The location of in route Section K14-L4A is shown in Figure 13.1. This section of the route has a length of 62.4 km.

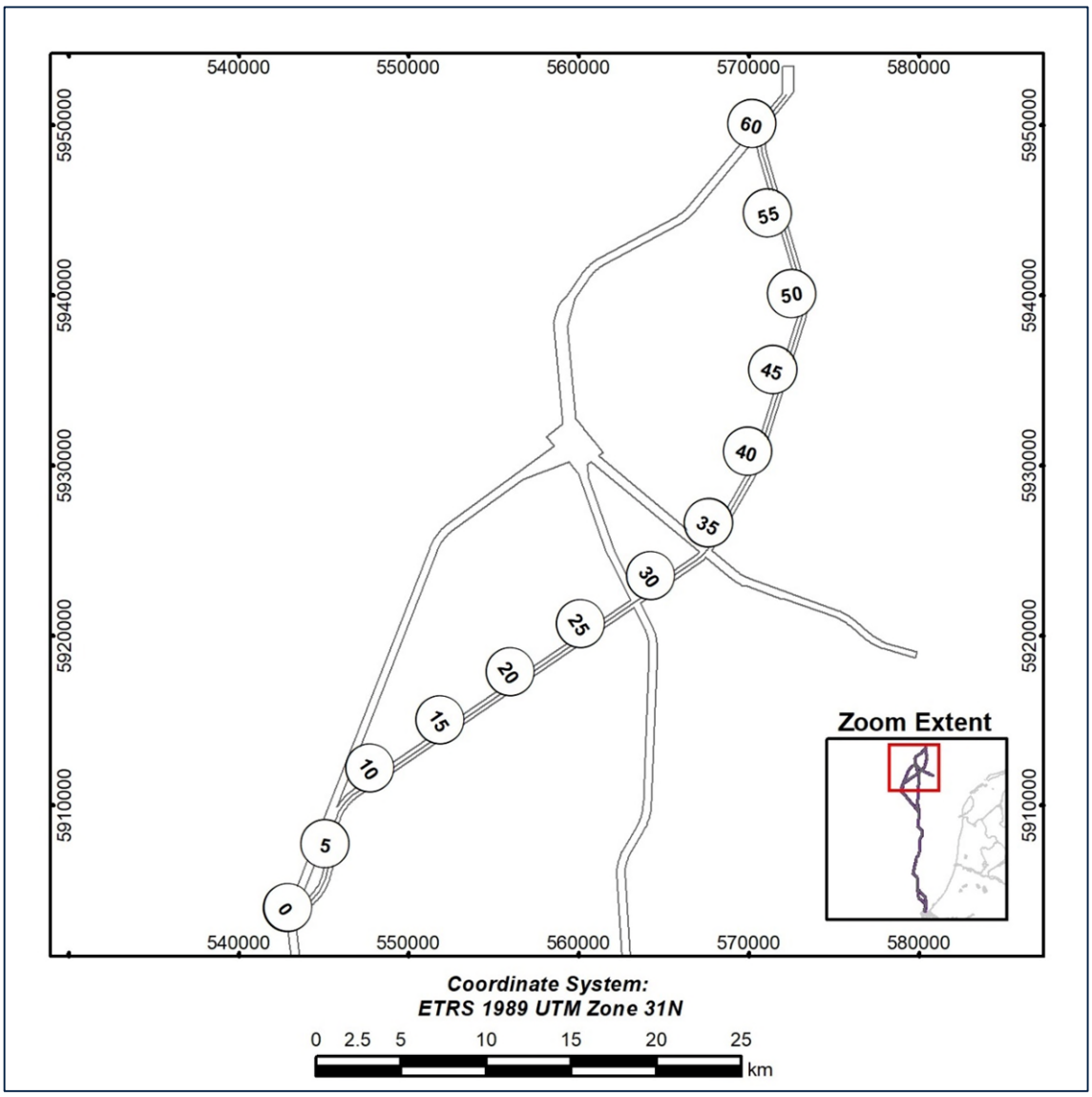


Figure 13.1: Location of the route section K14-L4A.

13.2 Results

13.2.1 Bathymetry

The water depth in route Section K14-L4A ranges between 26.0 m and 39.5 m. An overview of the bathymetry is given in Figure 13.2.

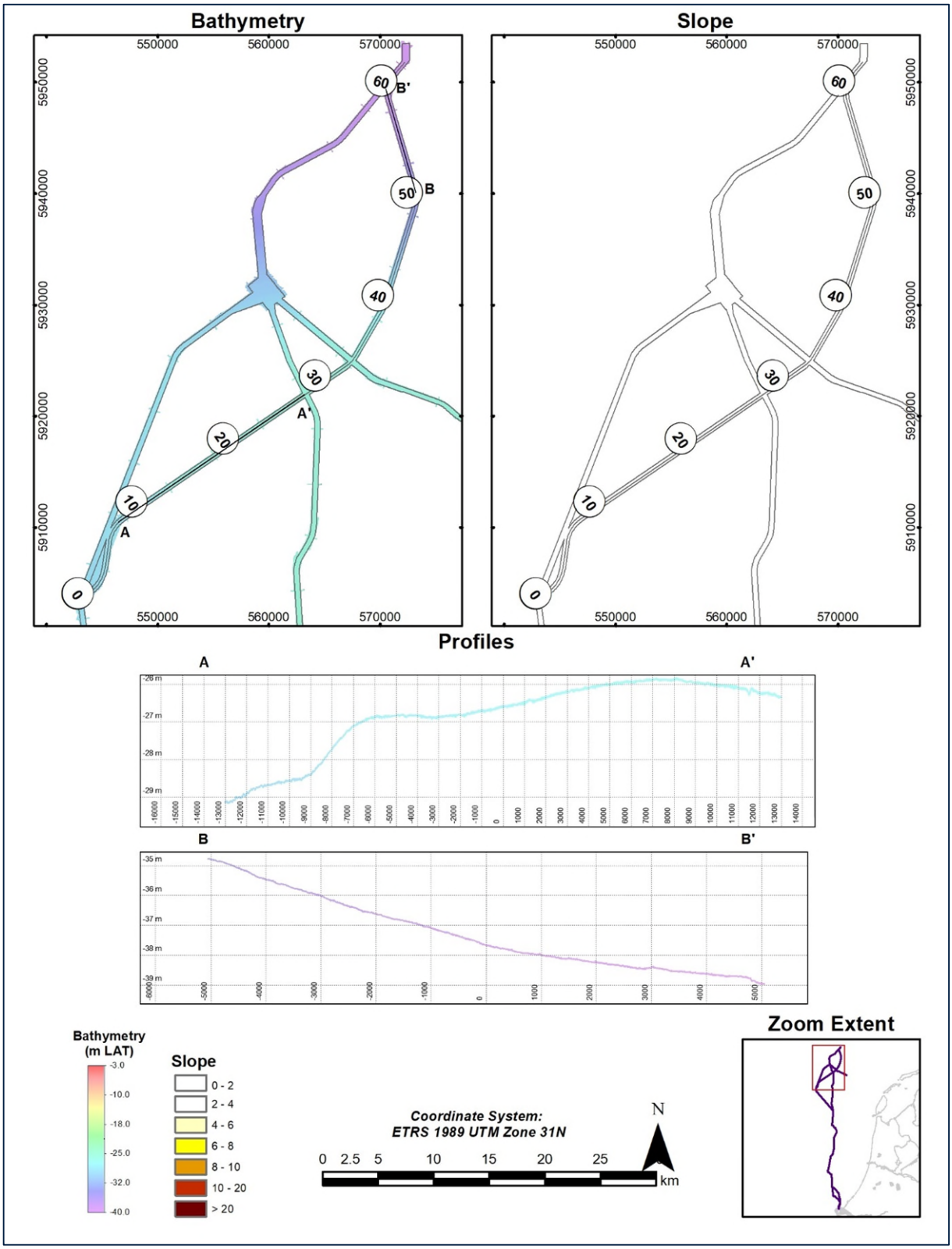


Figure 13.2: Bathymetry along the route section K14-L4A.

13.2.2 Seafloor Morphology

A strong correlation between seafloor sediment types and morphological type was observed, although some small variation is possible. An overview of the encountered sediment and features is given in Table 13.1.

Table 65: Sediment type with associated morphology in route section K14-L4A

Sediment Type	Morphological Type
Gravelly SAND	Patchy coarse sediments
Silty (muddy) SAND	Patchy fine sediments
SAND	Featureless, area with trawl marks

From KP 0.0 to KP 50.0 the route is characterised by sandy sediments with trawl marks. Between KP 50.0 and KP 58.0 there are sandy sediments with occasional patchy (fine and coarse) sediments. Figure 13.3 shows an example of sediments transition in this section of the route.

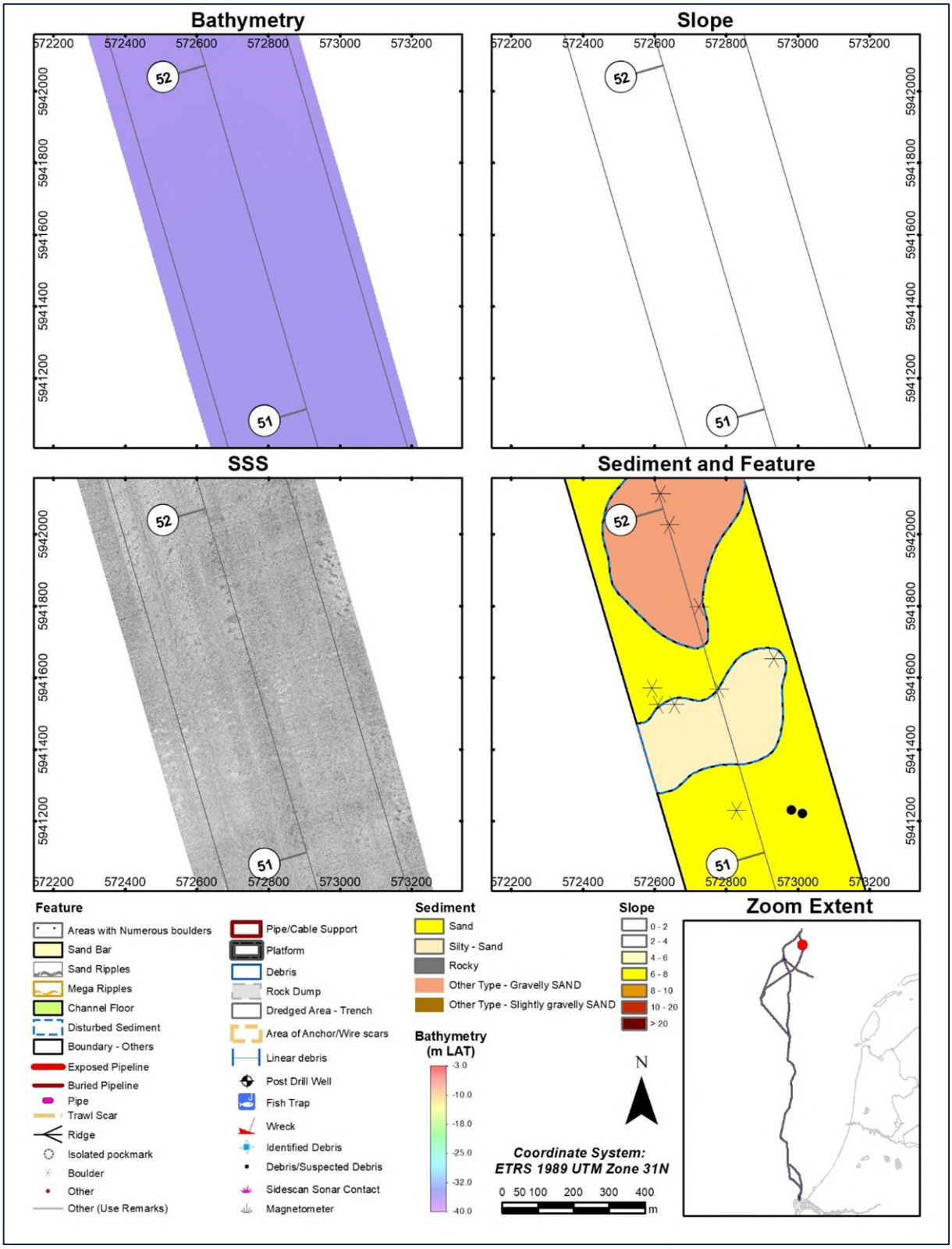


Figure 13.3: Overview of the sediments and morphology in route section K14-L4A: KP 51 to KP 52.

13.2.3 Seafloor Features and Contacts

Seafloor features and contacts were identified from one or more of the SSS, MBES, MAG and SBP sensors and cross-correlated where possible.

Table 13.2 summarises the quantities of contacts picked. The survey extent for each sensor varied and contacts were picked within the survey boundary of each sensor and cross-correlated where multiple datasets were available. No targets cross correlate between sensors in this section of the route.

Table 66: Summary of seafloor contacts in route section K14-L4A

Sensor	Contact Classification	Quantity
SSS/MBES/MAG Point Features	Boulder	129
	Debris	2
	Seabed mound	56
	Suspected debris	285
	Magnetic anomalies	132
SSS/MBES/MAG Linear Features	Possible debris	1
	Mound Ridge	1
	Unknown linear feature	1
	Buried pipeline	6
	Magnetic linear feature	1

Figure 13.4 shows the interpreted magnetic linear feature at KP 52.6.

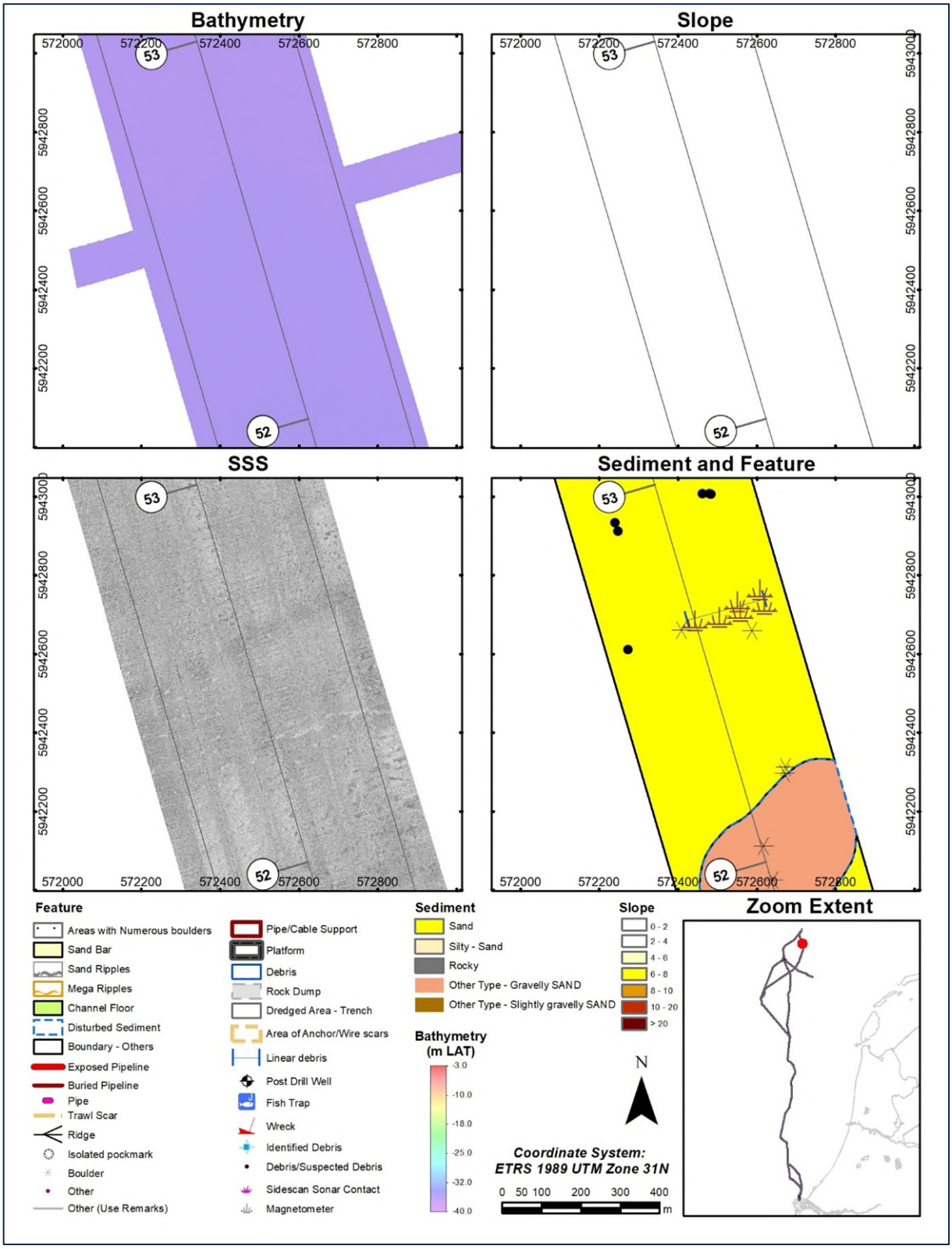


Figure 13.4: Overview of the magnetic linear feature interpreted in route section K14-L4A: KP 52.6.

Six (6) buried pipelines were identified in route Section K14-L4A (Table 13.3, Figure 13.5 and Figure 13.6).

Table 67: Summary of pipelines in route section K14-L4A

Contact ID	Pipeline name	Comment
Pipeline (PL0029_HS)	K12-A to L10-AP 14/2-inch bundle	Buried, KP 29.0
Pipeline (PL0055_HS)	SIDE-TAP KP 12.4 to K12-E 2-inch pipeline	Buried, KP 29.0
Pipeline (PL0142_PR)	D15-FA to L10-AC 36-inch pipeline	Buried, KP 31.7
Pipeline (PL0064_PR)	K9c-A to L10-AR 16-inch pipeline	Buried, KP 36.2
Pipeline (PL0049_PR)	L7-A to L7-P 10.75-inch pipeline	Buried, KP 48.0
Pipeline (PL0050_HS)	L7-A to L7-P 3.5-inch pipeline	Buried, KP 48.1

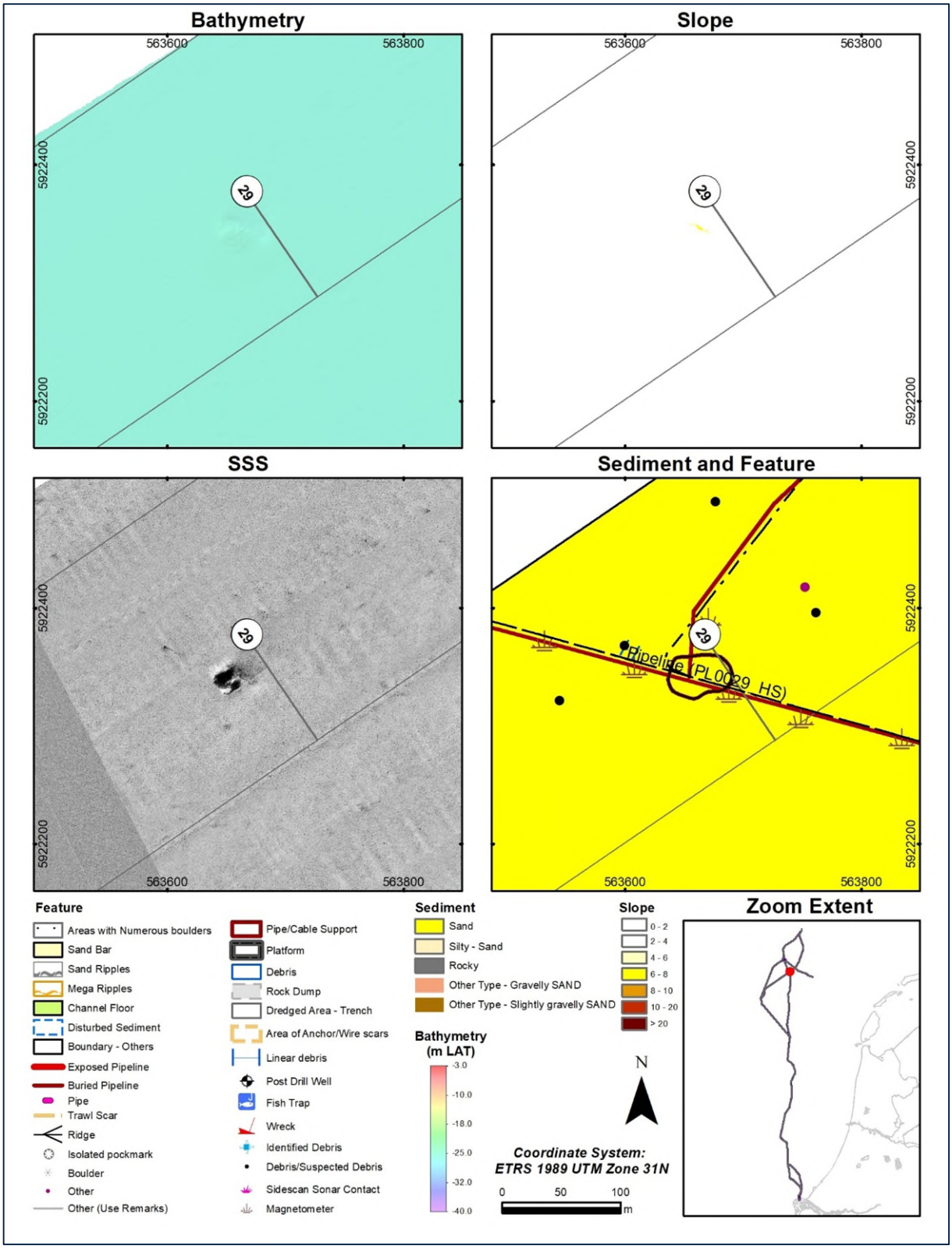


Figure 13.5: Pipelines conjunction encountered in route section K14-L4A: KP 29.0.

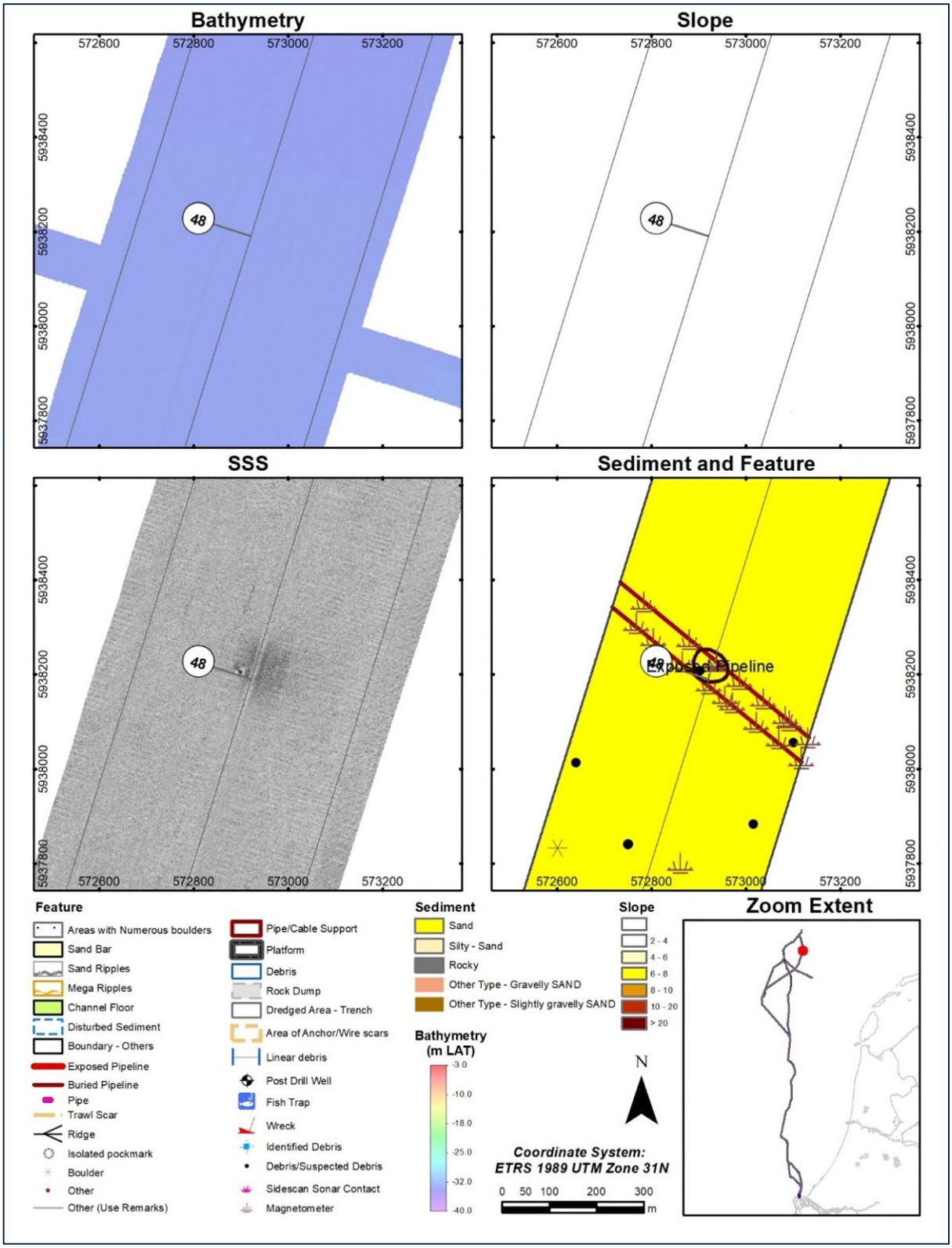


Figure 13.6: Pipelines encountered in route section K14-L4A: KP 48.0.

13.2.4 Magnetometer Contacts

132 magnetic contacts were found at the time of the geophysical scope (single MAG survey) in route Section K14-L4A. The magnetometer anomalies range between 5.1 nT and 2892.0 nT. The highest magnetic amplitudes are associated with the encountered pipelines.

13.2.5 Sub-seafloor Geology

Units A, B, C, D, E and G are present in the route Section K14-L4A (Figure 13.7).

Unit A is present in the entire section, characterized by homogenous acoustically semi-transparent seismic facies. The average thickness is 1.2 m between KP 0.0 and KP 21.0, between KP 21.0 and KP 52.0 it is approximately 2.5 m and further it gradually decreases towards the north.

Unit B is present across the entire section. On the SBP data, the unit is in general characterized by layered seismic facies, with low to high amplitude semi-horizontal to inclined reflectors. Between KP 0.0 and KP 9.0, the unit is relatively thin with chaotic seismic facies. From approximately KP 9.0, internal erosion surfaces are present. The upper part is in general more acoustically transparent with vague reflectors and the lower part with medium to high amplitude reflectors. Between KP 23.0 and KP 32.0, the lower part of the unit is structureless (chaotic) with point reflections. From KP 44.5 the unit exhibits entirely high amplitude parallel reflectors.

Unit C is present between approximately KP 0.0 and KP 38.5. The unit exhibits structureless and semi-transparent internal seismic facies in this section. Between KP 16.0 and KP 22.0, common local high amplitude negative reflectors are observed, pointing to possible pockets or beds of peat. The base is marked mostly by positive amplitude reflector.

Unit D is present in the entire route section and exhibits layered facies with low to high-amplitude parallel reflectors and locally transparent intervals. The base is locally channelised, also negative high amplitude short reflectors were observed at the base pointing to possible peat.

Unit E is absent between KP 0.0 and KP 3.1 and between KP 43.6 and KP 49.2. Unit G is present in the entire route section. Both units show similar chaotic seismic facies.

Unit F (glacial valley infill) is present between KP 28.3 and KP 31.4, between KP 33.9 and KP 35.5, between KP 36.9 and KP 37.8, between KP 43.3 and KP 46.1, between KP 60.4 and KP 62.1.

Table 13.4 provides lithology in the shallow sub-seafloor (within penetration depth of the SBP data), which is based on the seafloor CPT and VC geotechnical data acquired as part of this geophysical survey. Details of the geotechnical data can be found in report F197217-REP-006.

Table 68: Soil conditions in shallow sub-seafloor

Unit	Depth to Base [m BSF]	Lithology
A	0.4 to 2.8	Very loose to loose slightly silty to silty fine and medium SAND with occasional shells and shell fragments Locally very loose clayey fine SAND

Unit	Depth to Base [m BSF]	Lithology
B	1.2 o 10.7	Medium to very dense slightly silty to very silty fine and medium SAND with occasional shells and shell fragments Locally with a thin bed of firm PEAT Locally with a thin to very thick bed of low strength sandy CLAY

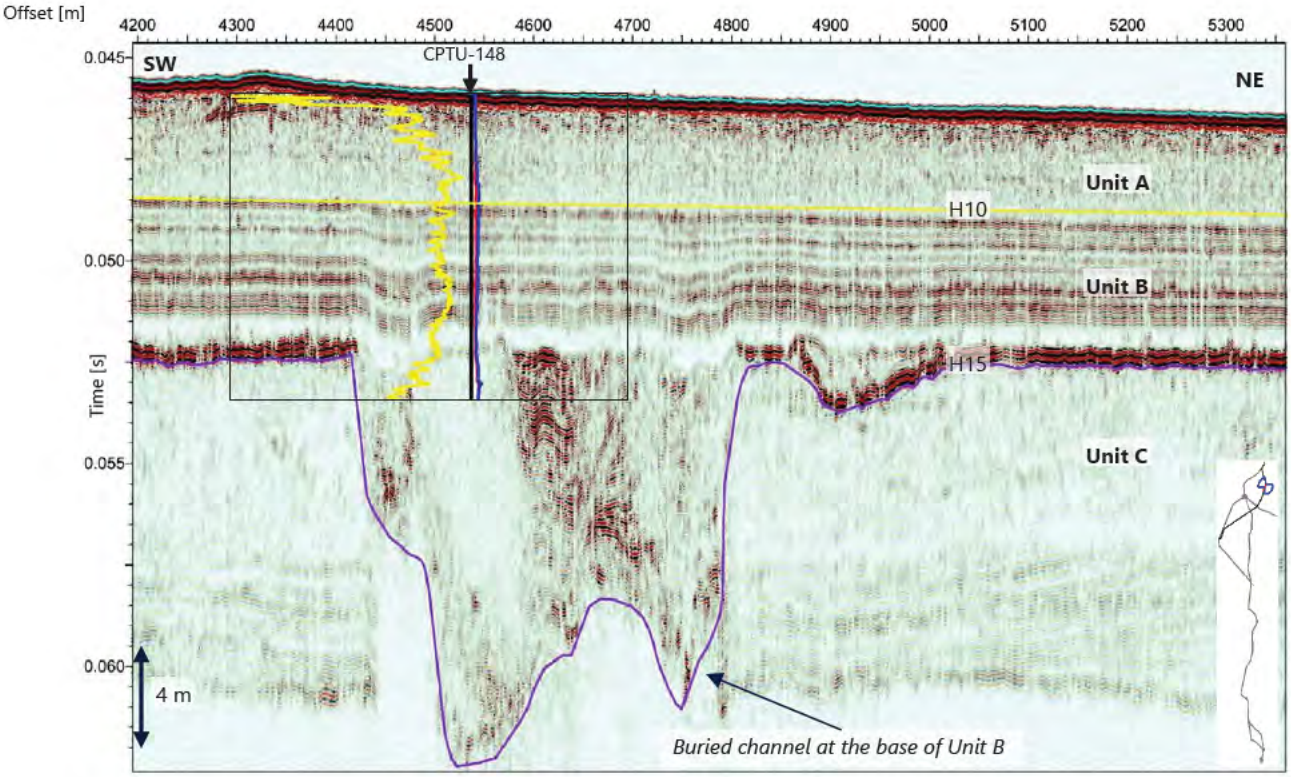


Figure 13.7: SBP data example of route section K14-L4A. (Line SBP_TA3M2320P1_3) Width of the CPT boxes show cone resistance values (blue curve) within range of 0 to 25 MPa, sleeve friction values (red curve) from 0 to 0.625 MPa and friction ratio (yellow curve) from 0 to 8 %.

14. Hub Area

14.1 Hub Area Locations

The location of the Hub Area is shown in Figure 14.1.

The Hub Area is approximately 5.3 km^2 in size, situated in the crossing between route Section B, Section C, Section D and Section E Alternative.

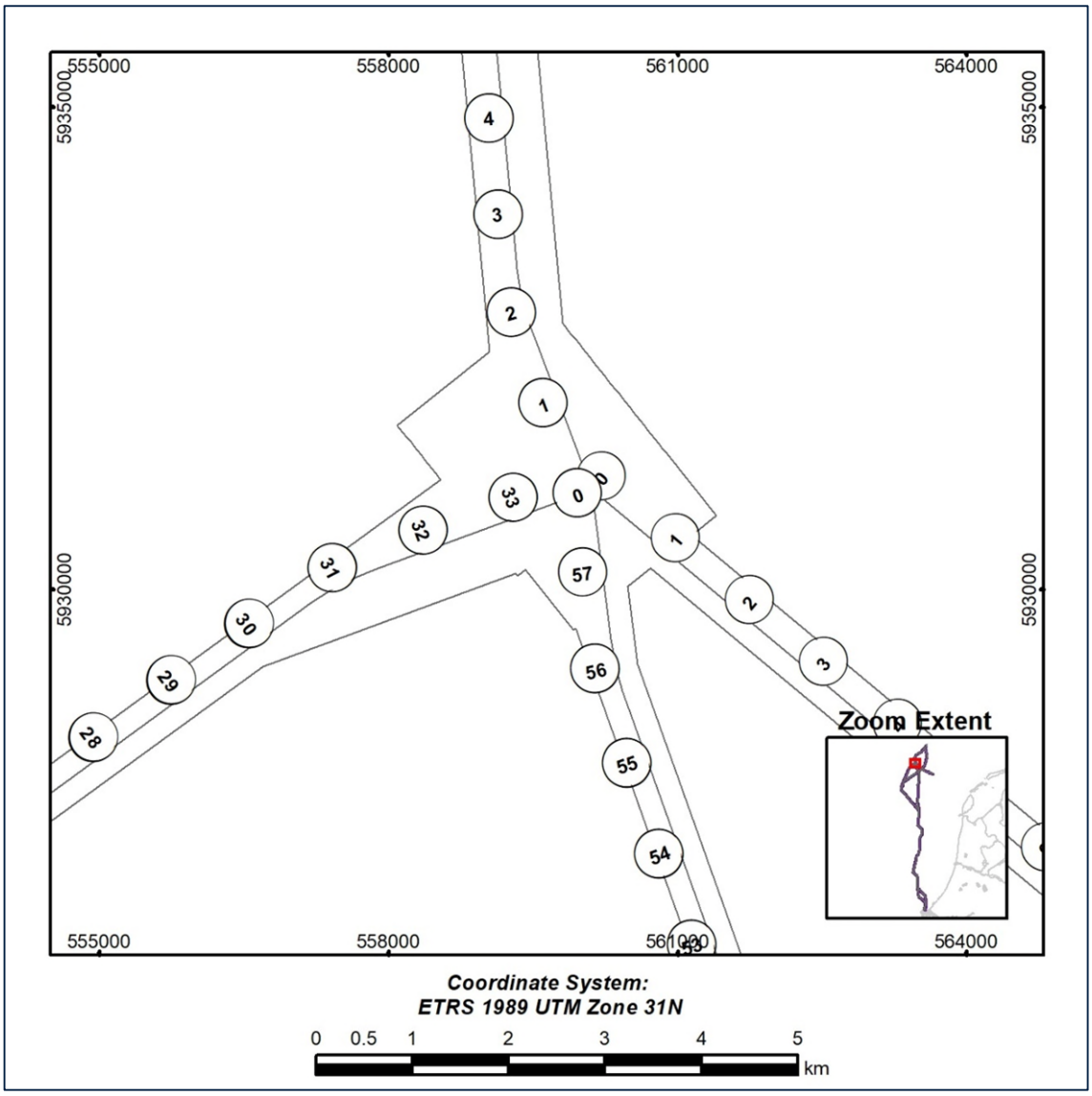


Figure 14.1: Location of the Hub Area.

14.2 Results

14.2.1 Bathymetry

The water depth within Hub Area ranges between 30.0 m and 31.5 m. An overview of the bathymetry is given in Figure 14.2

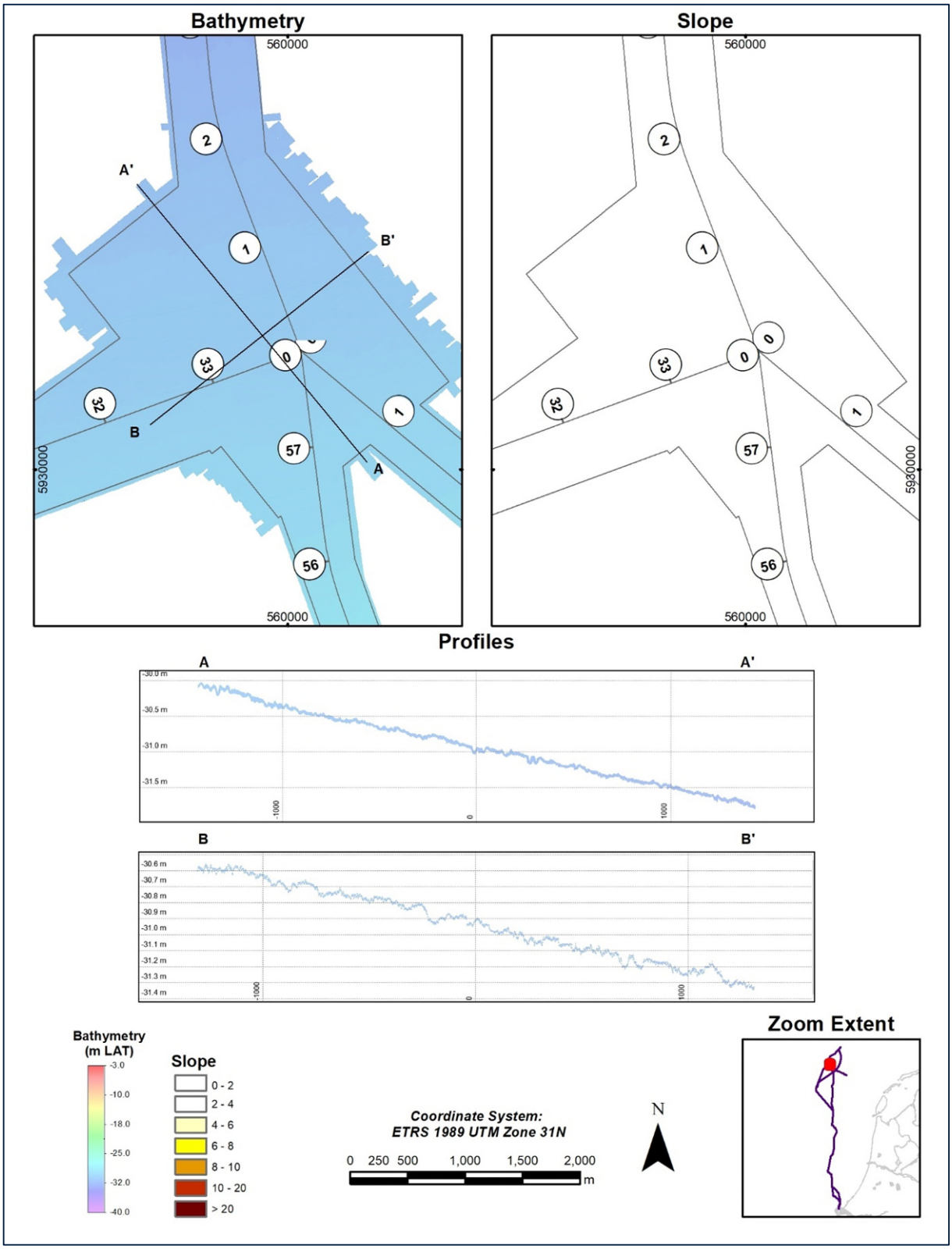


Figure 14.2: Bathymetry in the Hub Area.

14.2.2 Seafloor Morphology

No morphological features were identified in the Hub Area. The main sediment type has been classified as SAND with trawl marks. An overview of the sediment and the morphology in the Hub Area is given in Figure 14.3.

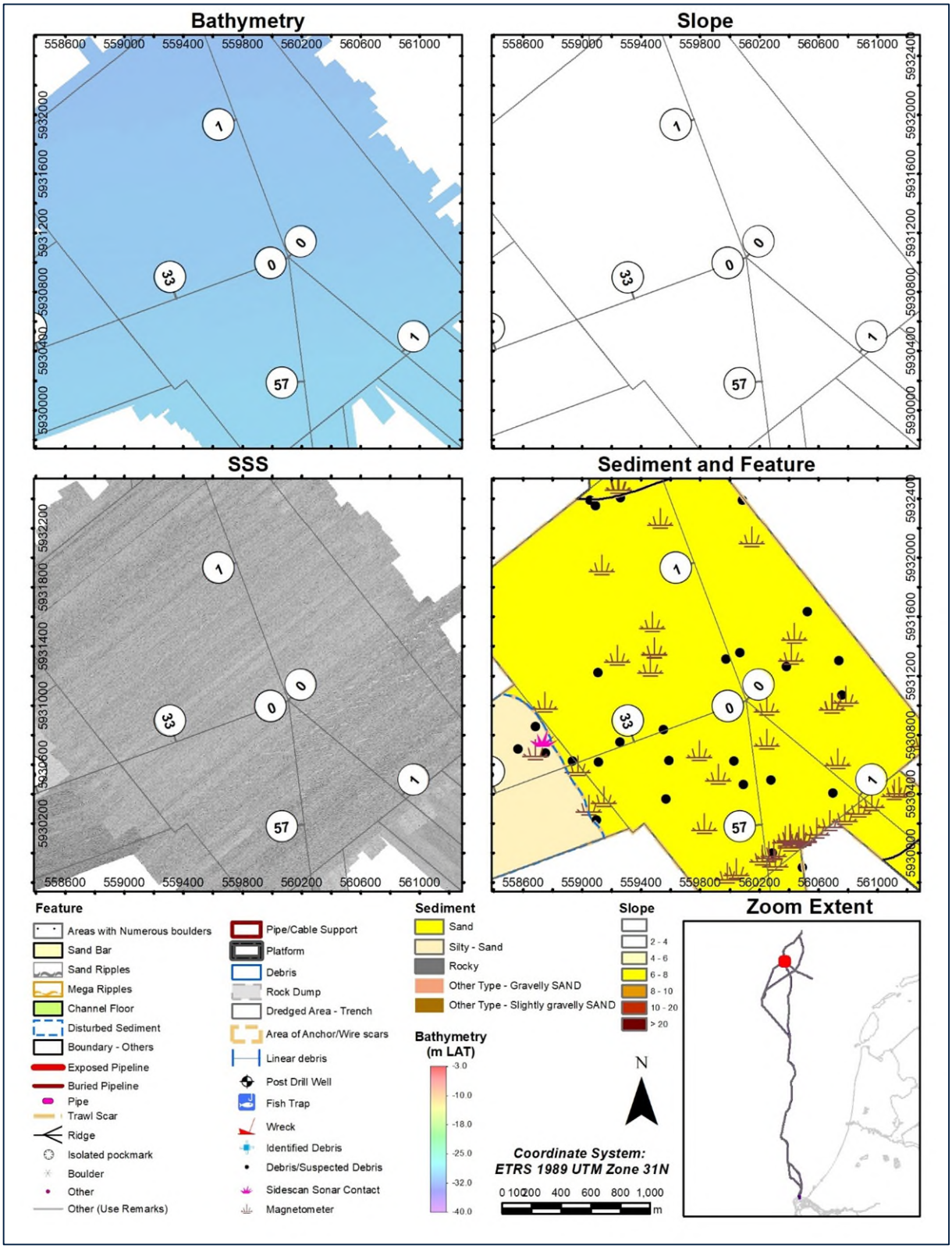


Figure 14.3: Overview of the sediments and morphology in the Hub Area.

14.2.3 Seafloor Features and Contacts

Seafloor features and contacts were identified from one or more of the SSS, MBES, MAG and SBP sensors and cross-correlated where possible.

Table 14.1 summarises the quantities of contacts picked. The survey extent for each sensor varied and contacts were picked within the survey boundary of each sensor and cross-correlated where multiple datasets were available. No targets cross correlate between sensors in this section of the route.

Table 69: Summary of seafloor contacts in the Hub Area

Sensor	Contact Classification	Quantity
SSS/MBES/MAG Point Features	Debris	19
	Suspected debris	3
	Magnetic anomalies	38

No linear features and no pipelines are crossing the Hub Area.

14.2.4 Magnetometer Contacts

In the Hub Area, 38 magnetic contacts were found at the time of the geophysical scope (single MAG survey). The magnetometer anomalies range between 6.0 nT and 591.0 nT. The highest magnetic amplitudes are associated with buried suspected debris (Figure 14.4)

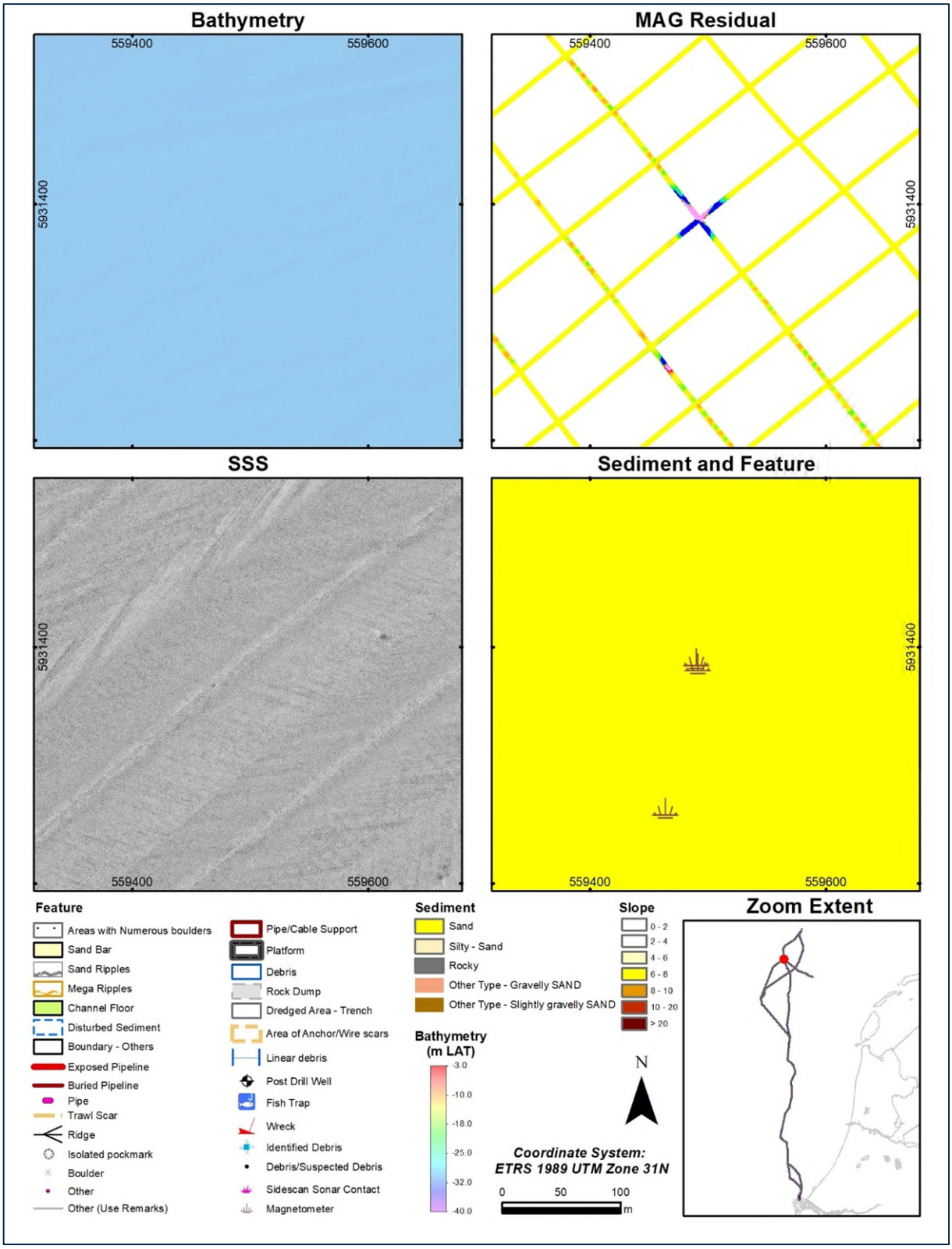


Figure 14.4: Position of the largest MAG contact in the Hub Area (MAG residual scale +/- 5 nT).

14.2.5 Sub-seafloor Stratigraphy

Units A, B, D, E and G are present in the Hub Area (Figure 14.5).

Unit A is present in the entire section. It has transparent seismic character. The average thickness of this unit in this route section is approximately 2.5 m.

Unit B is present across the entire section. This unit has a semi-transparent seismic character with low to medium-amplitude parallel to sub parallel reflectors. The base of this unit is locally channelised. Their infill is structured, with medium to high amplitude reflectors. Locally at the base, high amplitude short reflectors were observed, which represent laminae or thin bed of peat and/or organic-rich clay (peat level 1). The maximum thickness of this unit in this section is approximately 5 m.

Unit D is present in the entire section. Its seismic character is transparent to semi-transparent, with internal erosion surfaces, marked by inclined reflectors. Locally, channels and high negative amplitude anomalies were also interpreted (peat level 2). The maximum thickness of the Unit D in this section is approximately 20 m.

Unit E and G is present in the entire section. Both units show similar chaotic seismic facies.

Table 14.2 provides Lithology for the HUB Area based on the seafloor CPT and VC geotechnical data acquired as part of this geophysical survey. Details of the geotechnical data can be found in report F197217-REP-006.

Table 70: Soil conditions in sub-seafloor

Unit	Depth to Base [m BSF]	Lithology
A	1.5 to 3.3	Very loose clayey fine and medium SAND with occasional shells and shell fragments
B	5.8 to 9.6	Very loose clayey fine and medium SAND with occasional shells and shell fragments Locally with medium bed of very low to low strength sandy CLAY
D	17.3 to 19.0	Dense to very dense SAND
E	27.5 to 31.6	Dense to very dense SAND Locally with medium spaced thin to medium beds of CLAY

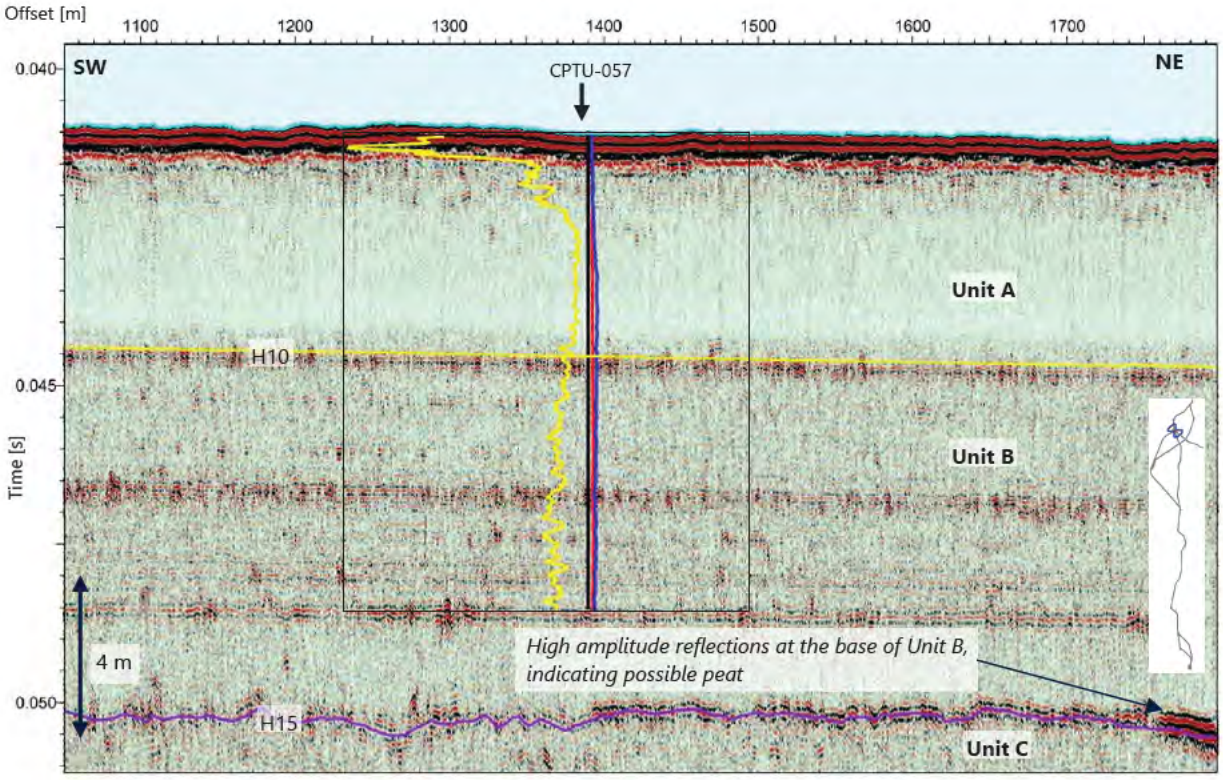


Figure 14.5: SBP data example of the Hub Area. (Line SBP_TA3P2428P1) Width of the CPT boxes show cone resistance values (blue curve) within range of 0 to 25 MPa, sleeve friction values (red curve) from 0 to 0.625 MPa and friction ratio (yellow curve) from 0 to 8 %.

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Appendix A

Guidelines on the Use of the Report

This report (the "Report") was prepared as part of the services (the "Services") provided by Fugro for its client (the "Client") and in accordance with the terms of the relevant contract between the two parties (the Contract") and to the extent to which Fugro relied on Client or third-party information as was set out in the Contract.

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Appendix B

Alignment charts

B.1 Export Route

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RAPPORT

Zeebodem, inclusief morfologie, archeologie en niet gesprongen explosieven

MER Aramis CO2 transportinfrastructuur

Klant: Aramis

Referentie: ARM-PFE-B10-ENV-EIA-2025
Status: Definitief/01
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ARAMIS

CCS-ARAMIS Project
Environment Impact Assessment – Baseline report

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1 Inleiding

Voor u ligt het detailrapport over zeebodem, onderdeel van het bij het MER Aramis initiatief.

Dit detailrapport heeft betrekking op het milieuthema zeebodem. Hierbij zijn de mogelijke effecten op de morfologie beschreven, inclusief de archeologie. De effecten op de landbodem zijn in een aparte rapportage weergegeven.

Dit detailrapport bevat een gedetailleerde beschrijving en beoordeling van de effecten van alle onderdelen van het Aramis initiatief, en een globale beschrijving en beoordeling van de effecten van onderdelen die niet tot het Aramis initiatief behoren, maar wel tot de CCS-keten.

1.1 Korte introductie van het Aramis initiatief

Integrale Aramis CCS-keten

Om de klimaatdoelstellingen te behalen, is er behoefte aan additionele transportinfrastructuur voor CO_2, waarmee meerdere opslaglocaties op zee worden ontsloten voor verschillende industriële emissiebronnen. Het Aramis initiatief speelt in op die behoefte door een nieuwe integrale en open CCS-keten mogelijk te maken. Het Aramis initiatief vormt een onderdeel van deze CCS-keten en bestaat uit de aanleg en exploitatie van een open CO_2-transportinfrastructuur. Het Aramis initiatief wordt in de rapportage dan ook wel aangeduid als Aramis CO_2-transportinfrastructuur. Samen met de afvanginfrastructuur en opslaginfrastructuur vormt dit de integrale CCS keten met onderstaande samenhangende onderdelen (zie figuur 1-1).

CO_2-afvanginfrastructuur

1 CO_2-afvang bij industrie, en geschikt maken voor transport;

2 CO_2-transport naar het verzamelpunt op de Maasvlakte, middels de Porthos landleiding of per schip;

CO_2-transportinfrastructuur (Aramis initiatief)

3 CO_2-verzamelpunt op de Maasvlakte met een compressorstation en een terminal.

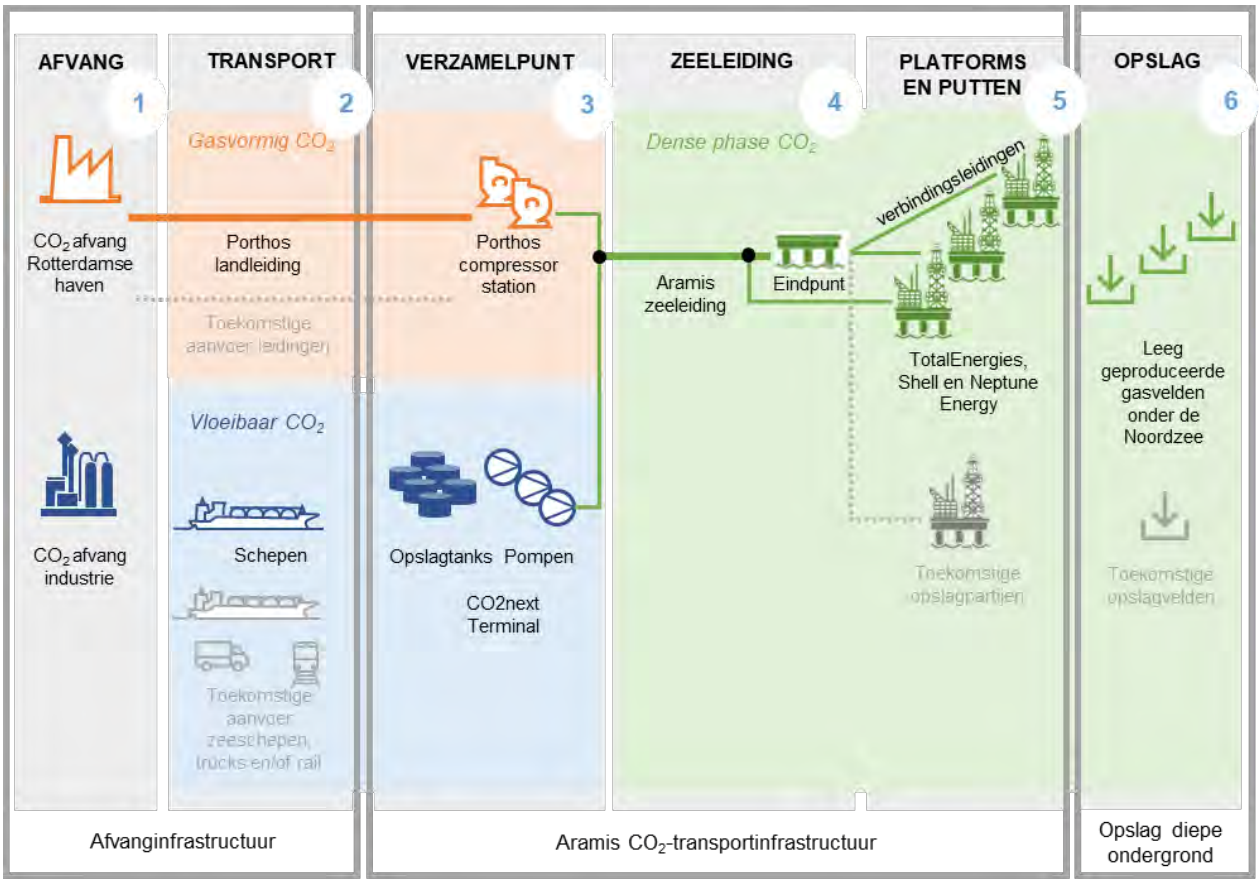
- Het compressorstation ontvangt gasvormig CO_2 dat aangevoerd wordt per landleiding (via de Porthos-landleiding) en brengt het op druk voor het transport per zeeleiding;
- De terminal ontvangt vloeibaar CO_2 aangevoerd per schip. De terminal locatie bevat steigers, opslagtanks voor tijdelijke opslag van CO_2 en hogedrukpompen voor levering aan de zeeleiding. CO_2 uit het compressorstation en vanaf de terminal komen samen in de CO_2-zeeleiding;

4 CO_2-transport door de centrale CO_2-zeeleiding naar het distributieplatform op de Noordzee. Dit platform is uitgerust met een verdeelstation voor toevoer van CO_2 naar de verschillende platforms. Er zijn tevens connectiepunten in de zeeleing waar vandaan CO_2 aan platforms geleverd kan worden;

5 CO_2-injectie: via verbindingsleidingen komt de CO_2 vanaf de zeeleiding bij injectieplatform. Middels putten bij deze platforms wordt CO_2 geïnjecteerd in leeg geproduceerde gasvelden in de diepe ondergrond van de Noordzee.

CO_2-opslag diepe ondergrond

6 CO_2-opslag: permanente CO_2 opslag in de diepe ondergrond.



Figuur 1-1. Overzicht van de integrale CCS-keten met daarin de componenten die onderdeel zijn van de voorgenomen activiteit, namelijk: transport per schip, terminal CO2next, uitbreiding compressorstation Porthos, zeeleiding met eindpunt en connectiepunten, aansluitleidingen en platforms

Het Aramis initiatief

Het Aramis initiatief heeft als doel het verzamelpunt (onderdeel 3), de zeeleiding (onderdeel 4) en de injectie (onderdeel 5) te realiseren. Hiervoor wordt door het Aramis consortium (bestaande uit Shell, TotalEnergies, Gasunie en EBN) samengewerkt met CO2next (voor de terminal) en Porthos (voor het compressorstation). De opslag vindt plaats vanaf de platforms van Shell, TotalEnergies en Neptune Energy.

De afvang (onderdeel 1) en transport van CO_2 naar het verzamelpunt (onderdeel 2) vallen buiten het Aramis initiatief[1]. In het MER worden deze aspecten wel benoemd en op hoofdlijnen beschreven, omdat ze integraal onderdeel uitmaken van de integrale Aramis CCS keten.

De opslag in de diepe ondergrond (onderdeel 6) valt eveneens buiten het initiatief. Voor de diepe ondergrond gelden geen milieuregels. De mogelijke gevolgen van opslag in de diepe ondergrond wordt echter wel apart beschreven in het MER middels de deelrapporten opslag diepe ondergrond.

Bij de aanleg van Aramis wordt rekening gehouden met toekomstige uitbreiding met meer leveranciers van CO_2 en meer opslagpartijen. In eerste instantie wordt vergunning aangevraagd voor een startsituatie en de eerste uitbreidingssituatie. Dit wordt in het MER getoetst. Toekomstige initiatieven *na* de eerste uitbreidingssituatie behoren niet tot de vergunningaanvraag maar worden in het MER wel (globaal) beschreven.

[1] *Een deel van de schepen die CO_2 leveren aan de terminal is afkomstig van Aramis-initiatiefnemers.*

De ingebruikname verwachten de Aramis initiatiefnemers in 2028, waarbij tegelijk al de eerste activiteiten zoals beschreven in de eerste uitbreidingsituatie kunnen starten. Voor het bereiken van de maximale doorvoercapaciteit is enkele jaren later als uitgangspunt in het MER aangehouden.

Een uitgebreide beschrijving van het Aramis initiatief is opgenomen in het deelrapport technische beschrijving en het samenvattend hoofdrapport MER (zie figuur 1-3).

1.2 Korte introductie op het milieuthema zeebodem

1.2.1 Zeebodem

Effecten op de zeebodem treden op als gevolg van ingrepen in de bodem tijdens de aanleg van de transportleiding op zee. Ook kunnen effecten optreden door verontreinigingen tijdens de gebruiksfase of bij calamiteiten. De toetsing voor de zeebodem is uitgevoerd middels een bureaustudie, gebaseerd op survey informatie en beschikbare informatie.

1.2.2 Relevante fases

Het MER bestudeert die aspecten van een activiteit die de fysieke leefomgeving kunnen beïnvloeden. De milieueffecten van de alternatieven en varianten voor het thema zeebodem worden beschreven. Daarbij wordt onderscheid gemaakt tussen de aanlegfase en gebruiksfase, en worden de mogelijke effecten van een incident beschreven; namelijk:

- De aanlegfase bestaat uit de aanleg van de boortunnel (tunnel of Direct pipe), uitbaggeren van de bodem, plaatsen van de zeeleiding en aansluitleidingen naar de platforms op de zeebodem of ingraven in de zeebodem, plaatsen van de nieuwe platforms en boren van nieuwe putten.
- De gebruiksfase bestaat uit de start-up en shutdown van de transportleiding waarbij de druk en temperatuur van CO_2 in de buisleiding zal toenemen en afnemen. Gedurende de normale gebruiksfase (de periode tussen start-up en shutdown) wordt een constante druk en temperatuur aangenomen.

In de eerste fase van de m.e.r.-procedure voor het Aramis initiatief is afgebakend welke onderwerpen binnen dit thema relevant zijn om te onderzoeken en hoe. Dit is beschreven in de Notitie Reikwijdte en Detailniveau die 18 november 2022 definitief is vastgesteld door de Minister voor Klimaat en Energie.

1.2.3 Relevante milieuaspecten

Voor het milieuthema zeebodem zijn de volgende milieuaspecten relevant:

- Morfologie, bodemberoering;
- Vertroebeling van het water ten gevolge van de graafwerkzaamheden;
- Archeologie, verstoring archeologische waarden en wrakken;
- Ontplofbare Oorlogsresten (OO, voorheen Niet Gesprongen Explosieven (NGE)), verstoring;
- Bodemkwaliteit, specifiek bodemtemperatuur.

Dit detailrapport beschrijft bovenstaande milieueffecten. Effecten op de zeeleiding door bijvoorbeeld vissersnetten wordt hier niet meegenomen, maar zijn beschreven in Detailrapport Nautische Veiligheid (Deelrapport Milieueffecten, bijlage 14). Ook de impact van de vertroebeling op de natuur en ecologie is niet meegenomen in dit detailrapport, maar wordt beschreven in de Detailrapporten Ecologie (Deelrapport

Milieueffecten, bijlage 5 Passende Beoordeling en Deelrapport Milie/ueffecten, bijlage 8 Natuurtoets Soorten).

1.2.4 Relevante alternatieven en varianten

In het MER zijn verschillende alternatieven en varianten onderzocht. Tabel 1.1 toont de voor Zeebodem aspecten relevante alternatieven en varianten.

Alternatieven	Voorgenomen activiteit	Alternatief
Kruising Maasgeul	Tunnel vanaf haaienvin bij Edisonbaai	Direct pipe (DP) nabij kruising Porthos leiding
Routing van de Zeeleiding	Westelijke route langs K14 platform West 2	Westelijke route langs K14 platform West 1 Alternatief 3 Centrale route
Varianten		**Variant**
Type hub op zee	Platform installatie voor knooppunten	Knooppunt op zeebodem

Tabel 1.1 - Relevante alternatieven en varianten voor het aspect Morfologie (Zeebodem)

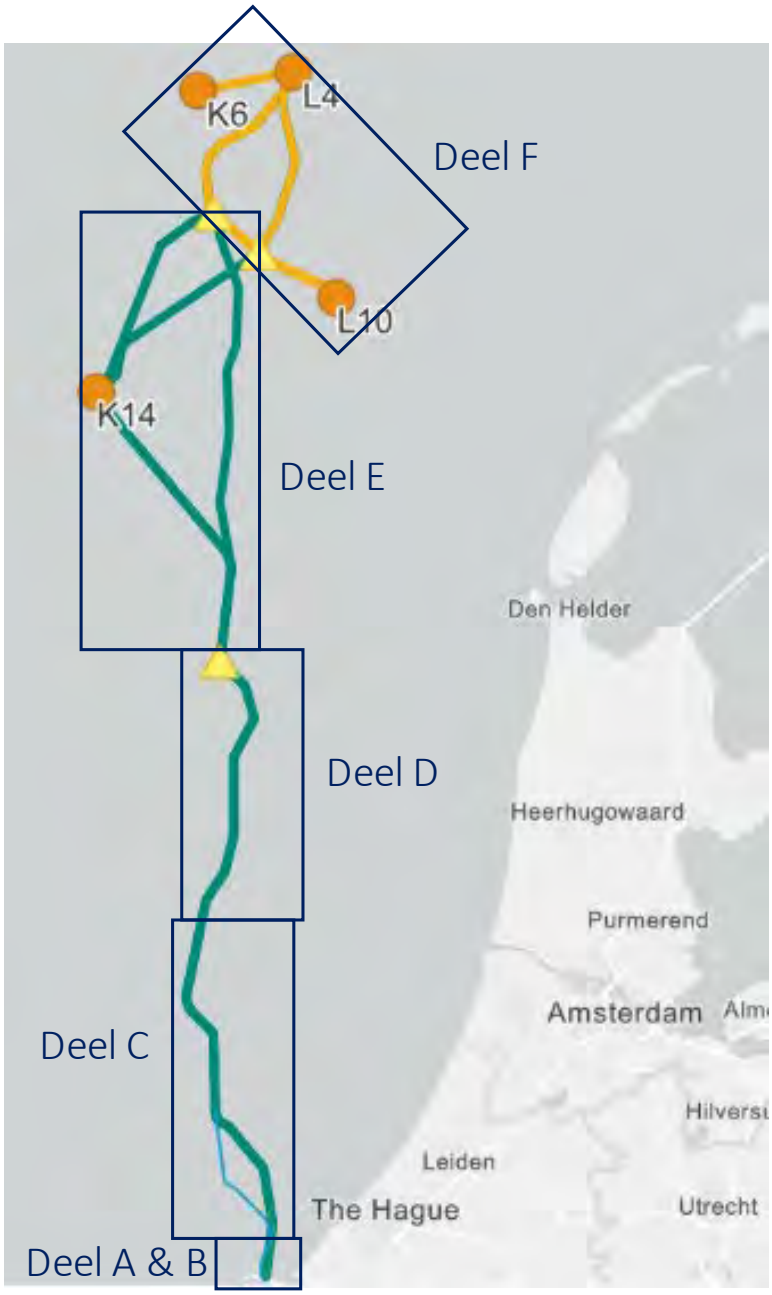
De verschillen in de routes van de alternatieven zijn klein, maar kunnen er wel voor zorgen dat de impact op de zeebodem net anders beoordeeld wordt. Het verschil in de routes is als volgt aan te geven:

- De route van alternatief West 1 loopt aan de noordkant en zuidkant door een puntje van toekomstig windpark Lagelander
- De route van alternatief West 2 loopt alleen aan de zuidkant door het puntje van toekomstig windpark Lagelander
- De route van alternatief 3 loop midden door toekomstig windpark Lagelander

In de beoordeling van de effecten wordt rekening gehouden met de wijze van realisatie van de pijpleiding. Hiervoor is de route opgedeeld in 6 delen. In Figuur 1-2 zijn de routes van alle varianten in één figuur weergegeven met daarbij de aanduiding van de 6 delen.

Deel	Wijze realisatie pijpleiding	Traject
A – Kruising Maasgeul	Direct pipe	0 – 2 km
B – Kruising Maasgeul	Tunnel	0 – 3 km
C – Zeeleiding Nearshore	Leggen en ingraven	2/3 – 70 km
D – Zeeleiding Offshore	Leggen (mogelijk ingraven)	70 – 153,4 km
E – Zeeleiding Offshore Noord naar D-HUB	Leggen (mogelijk ingraven)	153,4 – 200 km
F – D-HUB naar operators	Leggen (mogelijk ingraven)	

Tabel 1.2 – Aanduiding onderdelen van de zeeleiding vanaf de kruising met de Maasgeul.



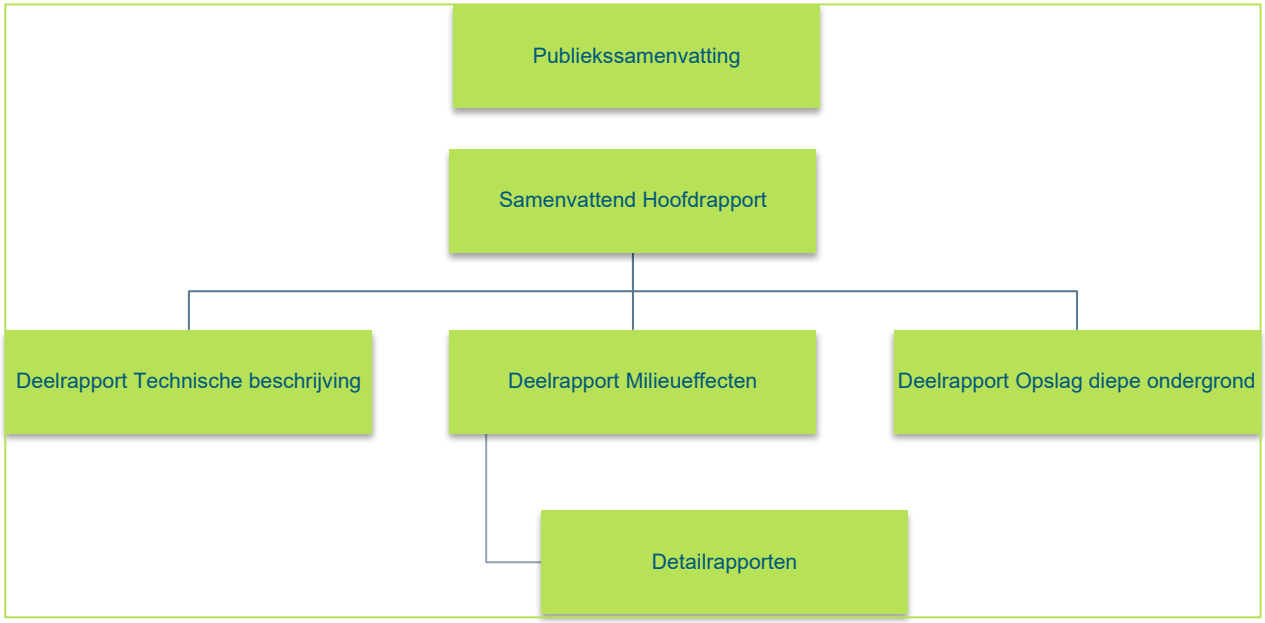
Figuur 1-2 - Tracés van de Zeeleiding uit voornemen en alternatieven in een gecombineerde figuur. De leiding van L4A naar K6-C en het platform K6-C is inmiddels geen onderdeel meer van het MER.

1.3 Opbouw van het MER en dit detailrapport

Voor het Aramis initiatief is een gecombineerd Plan-/ProjectMER opgesteld. Figuur 1-3 geeft de rapportagestructuur van het MER Aramis. Het MER bestaat uit een Samenvattend Hoofdrapport, voorzien van een Publiekssamenvatting. Ter onderbouwing van het Samenvattend Hoofdrapport zijn deelrapporten opgesteld. Dit betreft het deelrapport Technische beschrijving van Aramis, het deelrapport Milieueffecten met daarbij de onderliggende technische detailstudies en de deelrapporten Opslag diepe ondergrond.

Doordat CO_2 in meerdere geologische voorkomens wordt opgeslagen, zijn er voor de opslag diepe ondergrond meerdere deelrapporten opgesteld.

Het voorliggende rapport is het detailrapport Zeebodem. De bevindingen uit dit detailrapport zijn opgenomen in het Deelrapport Milieueffecten, en op hoofdlijnen in het Samenvattend Hoofdrapport.



Figuur 1-3 - Overzicht rapportagestructuur MER Aramis

Opbouw van dit detailrapport

Dit detailrapport beschrijft in het volgende hoofdstuk allereerst welk kader van beleid, wet- en regelgeving van toepassing is voor het thema bodem. In hoofdstuk 3 is toegelicht hoe het onderzoek is uitgevoerd en hoe de effecten zijn beoordeeld. De referentiesituatie is in hoofdstuk 4 beschreven. De referentiesituatie is de situatie die ontstaat op grond van de huidige situatie en alle relevante autonomie ontwikkelingen die verwacht worden in het studiegebied. Het dient als vergelijkingsbasis voor het bepalen van de milieueffecten. In de hoofdstukken 5, 6 en 7 zijn de milieueffecten beschreven en beoordeeld, voor de gebruiksfase, tijdens de aanleg en ontmanteling, en tijdens onderhoudswerkzaamheden en onvoorziene situaties. Hoofdstuk 8 gaat op globaal niveau in op de effecten van alle ketenonderdelen die niet binnen de scope vallen van het Aramis initiatief, maar hier wel mee samenhangen. Tevens is hier ingegaan op de mogelijke cumulatieve effecten. Hoofdstuk 9 bevat een opsomming van alle ontbrekende informatie voor het milieuthema bodem en een voorstel voor hoe de effecten op bodem gemonitord kunnen worden. Tot slot bevat hoofdstuk 10 de samenvatting van bevindingen en de toetsing aan de wet- en regelgeving.

2 Beleid, wet- en regelgeving

Dit hoofdstuk beschrijft welk beleid en welke wet- en regelgeving relevant is voor het Aramis initiatief voor het thema Zeebodem. Dit maakt duidelijk binnen welke randvoorwaarden het Aramis initiatief tot stand moet komen.

2.1 Internationaal

De grenzen van het Nederlandse deel van de Noordzee hebben bestuurlijke en juridische betekenis, maar het gebruik, de natuur en het ecosysteem zijn grensoverschrijdend. Het beleid voor de Noordzee wordt in hoge mate bepaald door internationale kaders. Het **VN-Zeerechtverdrag (UNCLOS)** is het alomvattende juridische kader voor het gebruik van zeeën en oceanen. Een aantal verdragen, waarbij Nederland partij is, en samenwerkingsverbanden kan worden gezien als een nadere uitwerking van de algemene regels vervat in het VN-Zeerechtverdrag (Programma Noordzee 2022-2027, p.16-17).

Op **mondiaal en regionaal niveau** worden diverse afspraken gemaakt over zeegebonden activiteiten, veiligheid, en de bescherming van het zeemilieu. De belangrijkste samenwerkingsverbanden en verplichtingen die relevant zijn voor het aspect Zeebodem binnen het Aramis project (Programma Noordzee 2022-2027, p.16-17): het Oceanenbeleid afspraken in het kader van de Internationale Maritieme Organisatie (IMO), het Verdrag van Londen en het daarbij behorende London Protocol van 1996, en tot slot het Verdrag van Valletta (Verdrag van Malta in relatie tot Archeologie).

Op **Europees niveau** zijn in het bijzonder de Kaderrichtlijn Water (KRW), Kaderrichtlijn Mariene Strategie (KRM), Richtlijn Maritieme Ruimtelijke Planning (MSP) en het Gemeenschappelijk Visserijbeleid (GVB) relevant voor dit detailrapport. Dit geldt ook voor de Oslo Parijs Conventie voor de bescherming van het mariene milieu in het Noord-Oost Atlantische gebied, inclusief de Noordzee (OSPAR), veelal via KRM-implementatie. Kenmerkend voor OSPAR is de uitwerking in aparte strategieën voor: eutrofiëring, milieugevaarlijke stoffen, olie, zwerfvuil en radioactiviteit.

Voor de **Noordzeelanden** is de Politieke Verklaring van Noordzee-energieministers (The North Seas Energy Cooperation 2020-2023, als vervolg op de verklaring 2016-2019) ter versterking van de samenwerking bij de ontwikkeling van offshore duurzame energie, met onder andere aandacht voor ruimtelijke planning en ecologie, relevant. Ook relevant is de samenwerking (The North Sea Region Maritime Spatial Planning Collaboration Group, 2021) op grond van artikel 11 uit de Europese Richtlijn Maritieme Ruimtelijke Planning tussen Noordzeelanden ten behoeve van afstemming ter bevordering van grensoverschrijdende coherentie tussen plannen.

2.2 Nationaal

2.2.1 Waterbodem

Omgevingswet (2024)
De wet regelt de omzetting in Nederlands recht van de waterkwaliteitsdoelstellingen van de KRW, inclusief de doelstellingen van de Grondwaterrichtlijn uit 2006 en de bovengenoemde Europese Richtlijn Prioritaire stoffen. De doelstellingen voor de goede chemische toestand en de goede ecologische toestand voor oppervlaktewaterlichamen en grondwaterlichamen worden hiermee vastgelegd in de vorm van milieukwaliteitseisen. Daarnaast regelt de wet het beheer van oppervlaktewater en grondwater en verbetert ook de samenhang tussen waterbeleid en de fysieke leefomgeving. De in de Omgevingswet opgenomen doelstellingen vormen een uitwerking van de grondwettelijke opdracht aan de overheid om zorg te dragen voor de bewoonbaarheid van het land en de bescherming en verbetering van het leefmilieu. Verdere uitwerking vindt plaats in het Besluit activiteiten leefomgeving, het Besluit kwaliteit leefomgeving en het Omgevingsbesluit, bijvoorbeeld in normen en eisen. Zo zijn waterbeheerders

verplicht te voldoen aan een aantal belangrijke waterkwaliteitseisen. Voor de oppervlaktewaterkwaliteit gelden chemische en ecologische kwaliteitsnormen. Voor de grondwaterkwaliteit gelden alleen chemische kwaliteitsnormen. Voor waterkwaliteitsnormen verwijst de wet naar stoffenlijsten en normen die zijn vastgelegd in de wet zelf, de Kaderrichtlijn Water en de Grondwaterrichtlijn.

Nationaal Waterprogramma (2022-2027)
In een nationaal waterprogramma (voorheen waterplan) zijn de hoofdlijnen vastgelegd van het nationale waterbeleid en de uitvoering ervan in de Rijkswateren en -vaarwegen. De wettelijke doelstellingen en normen van de gewenste ontwikkeling, werking en bescherming die nodig is voor de watersystemen zijn vastgelegd in het **Nationale Waterprogramma (NWP)**. Deze wordt elke zes jaar herzien. Met dit Nationaal Waterprogramma voldoet Nederland aan de Europese eisen die voortvloeien uit de Kaderrichtlijn Water (KRW), de Richtlijn Overstromingrisico's (ROR) en de Kaderrichtlijn Mariene Strategie (KMS). Het NWP 2022-2027 is vastgesteld op 18 maart 2022. Hierin is o.a. het volgende opgenomen over CO_2-opslag: *Voldoende ruimte voor opslag van CO_2 in lege olie- en gasvelden of in ondergrondse waterhoudende bodemlagen (aquifers). Dit als tijdelijk instrument tijdens het verloop van de transitie naar een volledig duurzame energievoorziening"* (p.214).

Een belangrijk onderdeel van het NWP is het Programma Noordzee. Het Akkoord voor de Noordzee (tussen het Rijk en betrokken belangenorganisaties), de internationale beleidsontwikkelingen en de Nationale Omgevingsvisie (NOVI) vormen de basis voor de beleidsvoornemens die in het Programma Noordzee 2022-2027 zijn uitgewerkt. Voor het aspect Zeebodem zijn de volgende beleidsvoornemens relevant:

- Voor scheepvaart is opgenomen een verbeterde voorwasprocedure ter voorkoming van persistente drijvende stoffen in het milieu.
- Voor kabels en leidingen is een beoordelingsmethode voor de verwijderingsplicht ontwikkeld, met leidende criteria voor hinder voor ander gebruik, veiligheid, milieueffecten en kosten. Indien de kabels en leidingen mogen blijven liggen, worden deze schoon en veilig achtergelaten.

Ruimtelijke samenhang windparken en mijnbouwactiviteiten op de Noordzee[2]
Minister Jetten (Klimaat en Energie) heeft de kamer in mei 2023 geïnformeerd over de conflicterende ruimtevraag op de Noordzee, de ruimtelijke samenhang van de energie-activiteiten (windenergie, mijnbouw, CO_2-opslag en waterstof) op de Noordzee. De ruimte is hier is een schaars goed op de steeds voller wordende Noordzee. Een Noordzee waar bovendien ook ruimte moet zijn voor de transities naar een duurzame voedselvoorziening en naar een ecologisch gezonde Noordzee. De verdeling van de ruimte op de Noordzee wordt primair geregeld in het Programma Noordzee 2022-2027, dat onderdeel is van het Nationaal Waterprogramma 2022-2027. In deze Rijksstructuurvisie is voor windenergie op zee ruimte gereserveerd voor de periode tot en met 2031. Tevens heeft het kabinet hierin aangekondigd dat er een Partiële Herziening (een tussentijdse wijziging) komt van datzelfde Programma Noordzee. Bij de voorbereiding van de Partiële Herziening en ook in de uitvoering van de huidige routekaart windenergie op zee voor de periode tot en met 2031 zijn er knelpunten geconstateerd om de windparken als mijnbouwactiviteiten op zee in te passen. Ook met het inpassen van (voorgenomen) scheepvaartroutes. De knelpunten worden op dit moment onderzocht. Met de publicatie van de Partiële Herziening zal duidelijk zijn of deze knelpunten het Aramis project raken.

[2] *Kamerbrief van Minister Jetten, d.d. 17 mei 2023*

2.2.2 Archeologie

In de **Visie Erfgoed en Ruimte (2011)** is als doelstelling voor de Noordzee opgenomen om het cultureel erfgoed goed te positioneren bij ruimtelijke ontwikkelingen op de Noordzee. Het rijksbeleid is gebaseerd op de uitgangspunten van het **Verdrag van Valetta** (1992) (ook wel verdrag van Malta genoemd), dat strekt tot bescherming van het archeologische erfgoed als bron van het Europese gemeenschappelijke geheugen en als middel voor geschiedkundige en wetenschappelijke studie. In het bijzonder gaat het om:

- het streven naar het zoveel mogelijk behouden van archeologische waarden in de bodem (in situ),
- een meldplicht voor archeologische vondsten,
- het meewegen van het archeologisch belang in de ruimtelijke ordening en
- het waarborgen dat milieueffectrapportages en de daaruit voortvloeiende beslissingen rekening houden met archeologische vindplaatsen en hun context.
- Tenslotte is het uitgangspunt dat de kosten voor het benodigde archeologisch onderzoek aan de verstoorder worden doorberekend (het 'verstoorder betaalt'-principe).

NOVI (2020)
Ook de **Nationale Omgevingsvisie (NOVI**) (2020) noemt het behoud en versterken van cultureel erfgoed als nationaal belang. Het archeologische erfgoed in en op de zeebodem maakt hier deel van uit. Het beleid is dat het archeologisch erfgoed zoveel mogelijk in de bodem (in situ) behouden blijft. Door archeologische vindplaatsen vroegtijdig te inventariseren, kunnen in de Noordzee in-situ behoud en ruimtelijke ontwikkelingen meestal goed samengaan. Als in-situ-behoud niet mogelijk blijkt, kan het de voorkeur hebben om de archeologische vindplaats op te graven en zodoende de informatiewaarde ervan veilig te stellen (Aanvullend ontwerp Programma Noordzee 2022-2027).

Erfgoedwet (2016)
Voor de territoriale zee en de aansluitende zones is met name hoofdstuk 5 van de Erfgoedwet – dat ziet op de archeologische monumentenzorg – van belang. Het uitgangspunt hiervan is een opgravingsverbod. Waarbij de definitie van opgraving als volgt luidt: "*als handelingen te verrichten met betrekking tot het opsporen, onderzoeken of verwerven van cultureel erfgoed of onderdelen daarvan, waardoor verstoring van de bodem, of verstoring of gehele of gedeeltelijke verplaatsing of verwijdering van een archeologisch monument of cultureel erfgoed onder water optreedt. Opgravingen kunnen slechts worden uitgevoerd met een certificaat dat op aanvraag wordt verstrekt door een instelling die door de Minister van OC&W hiertoe is aangewezen*."

Het **Mijnbouwbesluit** bepaalt dat indien bij mijnbouwactiviteiten op het continentaal plat een (vermoedelijk) archeologisch monument[3] wordt gevonden of een archeologische vondst[4] wordt aangetroffen, artikel 5.10 van de Erfgoedwet van toepassing is en dat de artikelen 56, 58, eerste lid, en 59 van de Monumentenwet 1988, zoals die wet luidde voor inwerkingtreding van de Erfgoedwet, van overeenkomstige toepassing zijn.

[3] *Als bedoeld in artikel 1.1 van de Erfgoedwet.*
[4] *Als bedoeld in artikel 1.1 van de Erfgoedwet.*

Binnen de territoriale zee en aansluitende zone (het gebied buiten de territoriale wateren tot 24 zeemijlen) geldt dat voor het opgraven van archeologische monumenten, waaronder wrakken vallen, een opgravingsvergunning verplicht is.

De opgravingsvergunning is verplicht op grond van artikel 45 t/m 47a van de Monumentenwet 1988. Verder geldt vanuit de Monumentenwet 1988 de verplichting dat bij de uitvoering van werken aangetroffen zaken, waarvan redelijkerwijs vermoed kan worden dat deze van cultuurhistorisch belang zijn, worden gemeld aan de RCE. Voor wrakken met een cultuurhistorische waarde moet een nadere afweging worden gemaakt, alvorens ze worden geborgen of geruimd. Bij deze afweging zijn de uitgangspunten van de annex van de UNESCO Verdrag voor de Bescherming van Onderwatererfgoed sturend. Dit verdrag heeft tot doel om plundering van archeologisch erfgoed onder water, veelal scheepwrakken, tegen te gaan. Naast een juridisch instrument is met name het mechanisme voor internationale samenwerking dat het Verdrag biedt, van belang. Verder verplichten het verdrag van Malta en het UNESCO-verdrag Nederland ertoe om in het toepassingsgebied van het verdrag bij economische activiteiten die onder hun jurisdictie vallen het onderwater cultureel erfgoed te beschermen en negatieve gevolgen te mitigeren.

Momenteel onderzoekt het kabinet stappen om te komen tot ratificatie van het UNESCO-verdrag voor de Bescherming van Onderwatererfgoed.
www.noordzeeloket.nl d.d. 20/4/2023

Kwaliteitsnorm Nederlandse Archeologie
In de **Kwaliteitsnorm Nederlandse Archeologie** (KNA) wordt verwezen naar een aantal leidraden op plekken waar deze een relevante aanvulling vormen in de toepassing van methoden en technieken. Leidraden kunnen beschouwd worden als een ‘best practice’ voor specifieke onderdelen binnen het archeologisch onderzoek. KNA Waterbodems, versie 4.1 beschrijft alle procedures en eisen voor het archeologisch onderzoeksproces die relevant zijn voor het leggen van de Zeeleiding.

2.2.3 Explosieven (Ontplofbare Oorlogsresten)

In de landelijke wet- en regelgeving van toepassing omtrent bodem (bescherming), wordt in plaats van de term niet-gesprongen explosieven (NGE) de term conventionele explosieven (CE) gebruikt.

Landelijke wet- en regelgeving
In artikel 4.10 van het Arbeidsomstandighedenbesluit uit 1997 is bepaald dat **bedrijven** die werkzaamheden verrichten omtrent het opsporen, benaderen en ruimen van niet gesprongen explosieven **certificering plichtig zijn**. Certificatie van opsporingsbedrijven vindt plaats op basis van het zogenoemde werkveldspecifieke certificatieschema voor het Systeemcertificaat Opsporen Conventionele Explosieven (WSCS-OCE).

Deze regel treedt in werking zodra er inschattingen gemaakt gaan worden van risico's en de vervolgstappen (zoals het benaderen van een explosief). Deze regelgeving is nog niet van toepassing als er een eerste inschatting gemaakt wordt van de trefkans op niet-gesprongen explosieven in de bodem. Het doen van een historisch feitenrelaas (zoals de provinciale signaleringskaart) is niet gebonden aan de landelijke regels, zoals het WSCS-OCE dat wel is.

Rol van de provincie
De provincie heeft geen formele rol (op het gebied van vergunningen, toezicht en handhaving) ten aanzien van niet-gesprongen explosieven. Door het opstellen van de signaleringskaart heeft de provincie faciliterend opgetreden richting gemeenten en initiatiefnemers van ruimtelijke ontwikkelingen. Door de provincie is dan ook geen specifiek beleid opgesteld voor de omgang met niet-gesprongen explosieven.

Rol van de gemeente als bevoegd gezag
Bij het opsporen en ruimen van niet-gesprongen explosieven is de openbare orde en veiligheid het bepalende uitgangspunt. De burgemeester is op grond van artikel 172 van de Gemeentewet belast met de handhaving daarvan. Aan hem staan daartoe diverse bevoegdheden ter beschikking, waaronder het geven van noodbevelen en het vaststellen van een noodverordening. De beslissing om in een concrete situatie al dan niet over te gaan tot het opsporen en ruimen van explosieven is dus de bevoegdheid van de burgemeester. Er geldt overigens geen verplichting om over te gaan tot opsporing en ruiming. Dit hangt af van het concrete geval en dat wordt vooral beoordeeld in relatie tot het huidige en toekomstige gebruik van het gebied.

Er kunnen op hoofdlijnen twee aanleidingen worden genoemd voor het uitvoeren van een vooronderzoek naar Ontplofbare Oorlogsresten (OO) en vervolgens het opsporen en ruimen van OO, namelijk:

- **Spontane vondst van een OO**, bijvoorbeeld tijdens het graven bij werkzaamheden. De spontane vondst van een OO moet worden gemeld bij de Kustwacht. De Kustwacht besluit afhankelijk van de situatie ter plaatse of de Explosieven Opruiming Dienst (EOD, Defensie) gewaarschuwd moet worden. De EOD bepaald op basis van onderzoek ter plaatse welke maatregelen er worden genomen en zal dat vervolgens afstemmen met de burgemeester en de politie.
- Het **vermoeden** dat in een bepaald gebied niet gesprongen explosieven in de (water) bodem zitten, meestal in combinatie met bijvoorbeeld bouwplannen in dat gebied. In dat geval wordt er altijd gestart met een **vooronderzoek**, zo nodig gevolgd door de opsporing en ruiming van OO. Het verrichten van vroegtijdig vooronderzoek is zowel van belang voor de veiligheid, maar ook om te voorkomen dat op een later moment grote vertraging in bijvoorbeeld bouwprojecten optreedt.

3 Beschrijving onderzoeks- en beoordelingsmethodiek

Dit hoofdstuk beschrijft de aanpak waarmee de milieueffecten worden bepaald en beoordeeld.

3.1 Onderzoeksmethodiek

Vanuit de MER beoordelingsmethodiek is informatie nodig over:

- de referentiesituatie; dat is de huidige situatie plus autonome ontwikkelingen (bijvoorbeeld aan de hand van scenario's en reeds vergunde projecten) en
- een inschatting op basis van 'expert judgement' (kwalitatief) en/of op basis van survey informatie welke invloed het voornemen zal hebben op de referentiesituatie.

In Tabel 3.1 zijn de relevante criteria en aspecten opgenomen voor de Zeebodem.

Tabel 3.1 - Overzicht relevante milieuaspecten Zeebodem

Milieu aspect	Fase	Wijze
Morfologie	Aanleg Gebruik	'Expert judgement' op het morfologische aspect en kwalitatief oordeel op basis van (bureau)studies
Vertroebeling	Aanleg	Kwantitatief als input voor kwalitatief oordeel ecologie
Archeologie	Aanleg	'Expert judgement' en kwalitatief oordeel op basis van survey rapporten
NGE (OO)	Aanleg	'Expert judgement' en kwalitatief oordeel op basis van survey rapporten
Bodemtemperatuur	Gebruik	Kwantitatief als input voor kwalitatief oordeel ecologie

3.2 Beoordelingsmethodiek

Wijze van bepalen en beoordelen van effecten
In een milieueffectrapportage worden de milieueffecten van een voornemen in beeld gebracht en beoordeeld. De effecten bepalen we veelal door de toekomstige situatie die ontstaat door het voornemen te vergelijken met de situatie die ontstaat zonder het voornemen, ook wel de referentiesituatie genoemd. Aan het verschil tussen die twee situaties, het effect, wordt een kwalitatief oordeel toegekend. Hierbij passen we een zeven punts scoreschaal toe van plussen en minnen zoals hieronder voor elk beoordelingscriterium weergegeven. Op die manier worden de effecten voor alle relevante milieuthema's op basis van 'expert judgement' bepaald en beoordeeld.

De beoordeling voor de zeebodem is op basis van de volgende criteria uitgevoerd:

- **Morfologie**: De effecten van de aanwezigheid van de leiding op de morfologie van de zeebodem en de effecten van de bodemberoering op de bodem en daarmee de morfologie.
- **Vertroebeling**: Door bodemberoering komt sediment in de waterkolom, wat vertroebeling tot gevolg kan hebben. De mate waarin dit gebeurt wordt met dit criterium bepaald.
- **Archeologie**: De mate van verstoring op archeologische aspecten, zoals bijvoorbeeld scheepswrakken
- **NGE (OO)**: De mate van verstoring, dan wel het risico, op niet gesprongen explosieven.
- **Bodemkwaliteit**: De mate waarop de voorgenomen activiteit qua temperatuur invloed heeft op de bodemkwaliteit

Onderstaande tabel geeft de maatlat weer voor de effectbeoordeling van de vijf criteria.

Effect	Omschrijving	Operationalisering effectscores				
		Morfologie	*Vertroebeling*	*Archeologie*	*NGE (OO)*	*Bodemkwaliteit*
		Aanlegfase	*Aanlegfase*	*Aanlegfase*	*Aanlegfase*	*Gebruiksfase*
+ + +	Sterk positief effect, groot van omvang en zodanig dat een overschrijding van normen wordt opgeheven	n.v.t	n.v.t	n.v.t	n.v.t	n.v.t
+ +	Positief effect, relatief groot of in een kritische periode of gebied	n.v.t	n.v.t	n.v.t.	n.v.t.	n.v.t.
+	Licht positief effect, relatief beperkt, tijdelijk of lokaal	n.v.t	n.v.t	n.v.t	Netto neemt het risico af doordat explosieven die worden gevonden worden verwijderd.	n.v.t
0	Geen effect	Geen relevante verandering van het bodemreliëf en verstoring bodemopbouw.	Geen effect	Geen effect	Geen effect	Geen effect
-	Licht negatief effect, relatief beperkt, tijdelijk of lokaal	Verandering van het bodemreliëf en verstoring bodemopbouw.	Lichte toename van concentraties sediment in het water.	Geringe kans op verstoring archeologische waarden	Niet uit te sluiten dat er nog explosieven aangetroffen worden.	Temperatuurtoename van meer dan 2 graden op 1 meter van de buisleiding.
- -	Negatief effect, relatief groot of in een kritische periode of gebied, onderzoek mitigerende maateregelen nodig	Grote verandering van het bodemreliëf en zware verstoring bodemopbouw	Matige toename van concentraties sediment in het water.	Kans verstoring archeologische waarden, vooronderzoek nodig	Onderzoek is nodig omdat er vrij zeker explosieven kunnen voorkomen.	Temperatuurtoename van meer dan 2 graden op meer dan 1 meter van de buisleiding.
- - -	Zeer negatief effect, zodanig dat milieueffect zonder mitigerende maatregelen buiten de normen van regelgeving en beleid valt	Zeer grote verandering van het bodemreliëf en zware verstoring bodemopbouw	Grote toename van concentraties sediment in het water en mogelijke invloed op natuurwaarden.	Zeker verstoring archeologische waarden, mitigatie nodig	Te groot risico vanwege aanwezige explosieven.	De temperatuurtoename leidt tot mobilisatie van eventueel aanwezige mobiele verontreinigingen.
Nvt	Niet van toepassing					

4 Beschrijving referentiesituatie

In een milieueffectrapportage worden de milieueffecten van een voornemen in beeld gebracht en beoordeeld. De effecten bepalen we veelal door de toekomstige situatie die ontstaat door het voornemen te vergelijken met de situatie die ontstaat zonder het voornemen, ook wel de referentiesituatie genoemd. Aan het verschil tussen die twee situaties, het effect, wordt een kwalitatief oordeel toegekend. Dit hoofdstuk beschrijft allereerst de huidige situatie voor de verschillende beoordelingscriteria voor het thema bodem. Vervolgens beschrijft het welke situatie ontstaat als gevolg van alle autonome ontwikkelingen; de referentiesituatie.

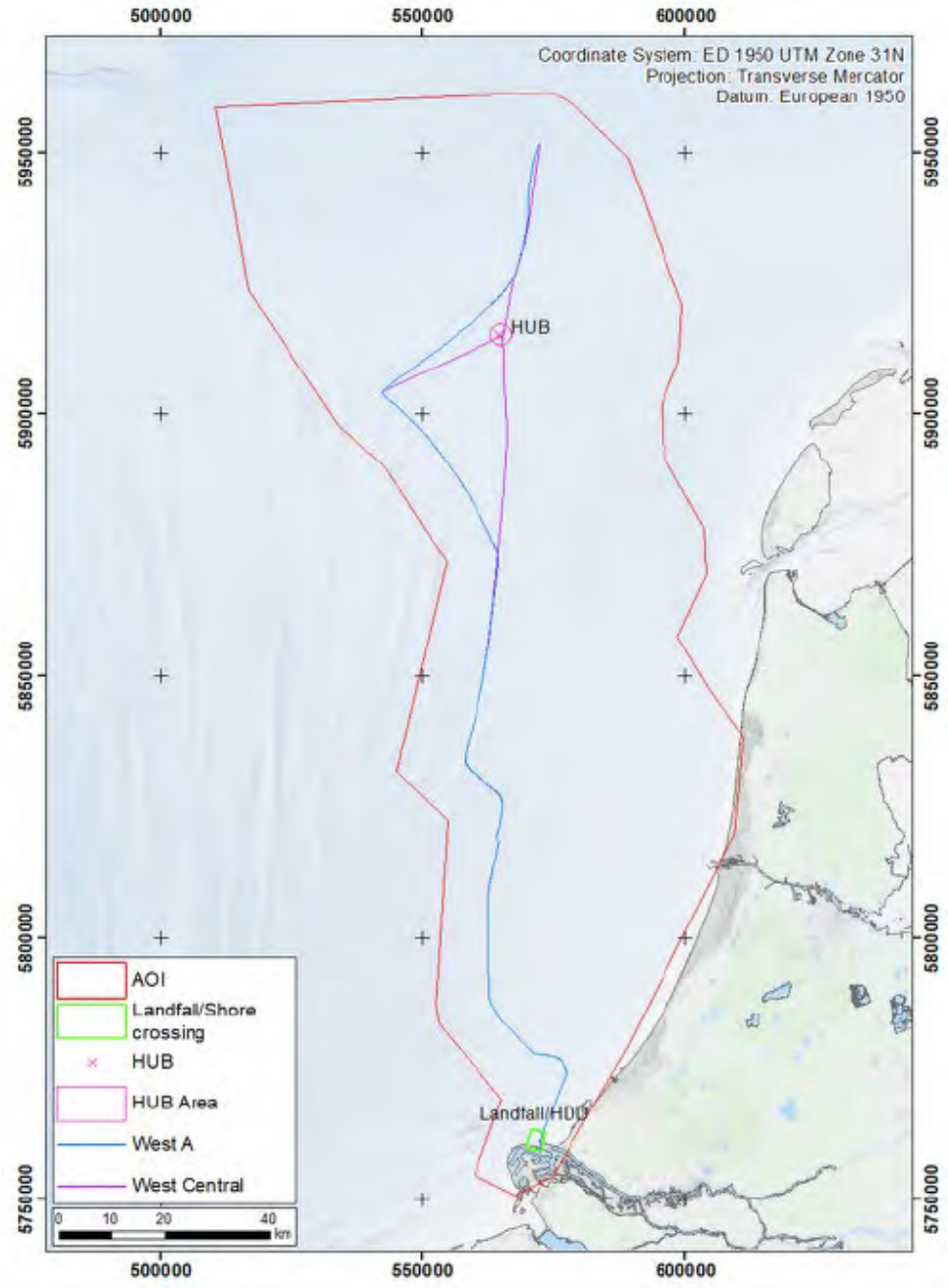
4.1 Beschikbare informatie

Voor het aspect Zeebodem is de huidige situatie in kaart gebracht, alsmede autonome ontwikkelingen en relevante overige projecten in het studiegebied. Het studiegebied is weergegeven in Figuur 4-1 (aangeduid met de code AOI). Het onderzoek naar de huidige situatie bestaat uit een bureaustudie en geofysisch onderzoeken binnen het studiegebied, zowel dicht bij de kust als verder op zee. De volgende survey rapporten zijn gebruikt:

- **Aramis Pipeline Routing Desktop Study** - Expected Site Conditions, Consultancy Report (R201644 03 | 10 February 2022 | Fugro)
- **Nearshore Geophysical Survey Results**, Processing and Results Report – Seeker (F197217-REP-RES 02 | 9 November 2022 | Fugro)
- **Geophysical Survey Results Report,** Geophysical and Geotechnical Site Investigation (F197217-REP-001 | 03 | 8 December 2023 | Fugro)
- **An archaeological assessment of geophysical survey data**, **22A030-01 | version 3.0 final | 31-08-2023 |** Periplus Archeomare
- Route selection document including aspects as morphology, safety.

Bovenstaande studies zijn door Fugro France SAS en Periplus uitgevoerd, in opdracht van TotalEnergies, en zijn voor deze rapportage geïnterpreteerd en samengevat. Op basis van deze gegevens is de referentiesituatie inzichtelijk gemaakt en is op basis van ‘expert judgement’ een inschatting gemaakt van de verwachte milieueffecten.

Bureaustudie (Aramis Pipeline Routing Desktop Study)
In de bureaustudie is gekeken naar de locatie specifieke condities van de zeebodem en de ondergrond van het studiegebied. De resultaten zijn gebaseerd op beschikbare data van het studiegebied waarvan de regionale geologische achtergrond is bepaald, maar ook van een ruimer gebied daaromheen (zie Figuur 4-1). Hierdoor is er een beter begrip van de mogelijke of geïdentificeerde geologische kenmerken of processen die in het gebied kunnen worden verwacht. Daarnaast is informatie over het gebruik van het gebied, zowel huidige of activiteiten in het verleden, en bestaande objecten in diverse kaarten gevisualiseerd. Deze gegevens zijn bestudeerd om de verschillende geologische kenmerken, stratigrafische eenheden, geotechnische parameters en beperkingen (geologisch en locatiegebruik) inzichtelijk te maken. Hierbij is onderscheid gemaakt in het gebied van de kust waar de toekomstige transportleiding zal aanlanden, het zeegebied waar de toekomstige HUB zal komen.



Figuur 4-1 - Studiegebied aspect Zeebodem (Rode lijn = AOI)

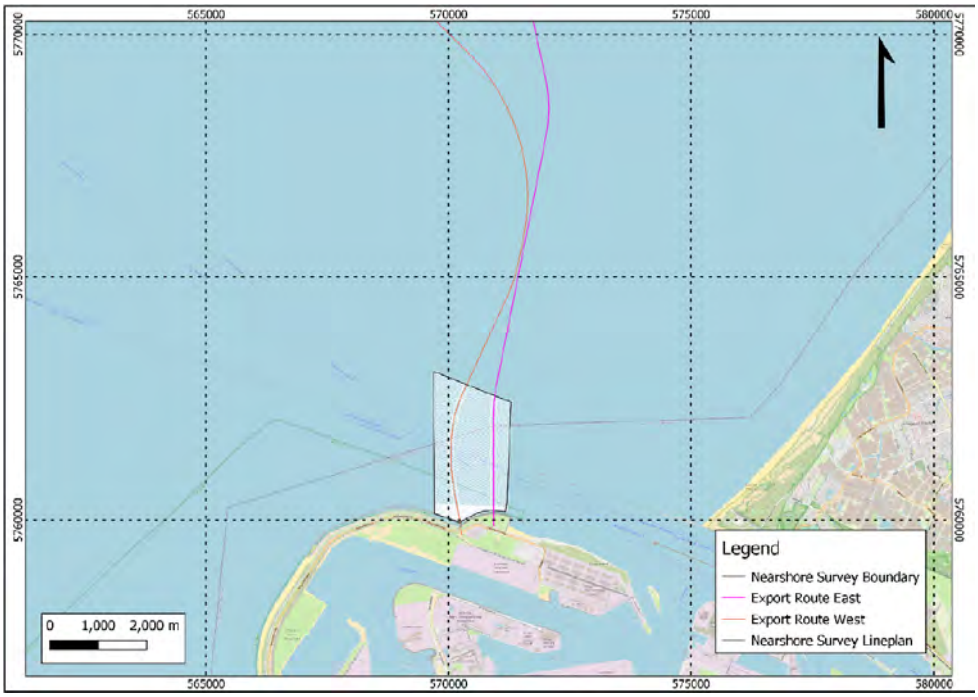
De geotechnische parameters zijn voornamelijk afgeleid op basis van openbare informatie en ervaring van Fugro. De volgende data is gebruikt:

- Geografische informatie over het studiegebied van TotalEnergies
- Interne database, zoals:
  - Informatie over regionale geologie
  - Algemene geotechnische data
  - Data van eerdere geotechnische en geofysische onderzoeken
- Openbare data (o.a. ruimtelijke data):
  - O.a. EMODnet, Rijkswaterstaat, Noordzeeloket, RVO, DINOloket
- Gepubliceerde rapporten voor geologische informatie

De rapportage geeft een beschrijving van de regionale geologie, de specifieke locatie condities en er wordt aandacht besteed aan de identificatie van mogelijk ontbrekende gegevens of gebieden met onzekerheden om aanbevelingen op te stellen voor toekomstige geofysische en geotechnische locatie specifieke onderzoeken.

In bijlage C van de bureaustudie, is de bureaustudie voor NGE's (OO) opgenomen. Deze studie is uitgevoerd door REASeuro op basis van historische gegevens om te bepalen of en in welke mate de kans aanwezig is dat er NGE's in het interessegebied bevinden. De Noordzee was immers het toneel van verschillende oorlog gerelateerde gebeurtenissen tijdens WO I en WO II. Hieronder vallen het zinken van een groot aantal schepen en vliegtuigen, bombardementen door vliegtuigen, zeeslagen en de aanwezigheid van mijnenvelden, militaire oefengebieden en munitiestortplaatsen. Als gevolg van deze gebeurtenissen kunnen NGE's zich in het interessegebied bevinden. De historische bureaustudie leidt tot de conclusie dat de aanwezigheid van NGE's binnen het hele interessegebied varieert van zeker tot verwaarloosbaar, afhankelijk van het type NGE in kwestie. Met name de aanwezigheid van NGE's als gevolg van mijnenvelden, luchtoorlog en het dumpen van munitie wordt als zeker beschouwd. Daarom is er een groot risico dat er NGE's worden aangetroffen binnen het interessegebied.

Geofysisch onderzoek Maasgeul (Nearshore Geophysical Survey Results)
Naast de bureaustudie heeft Fugro ook geofysisch onderzoek op locatie uitgevoerd middels onderzoeksschip Seeker om gedetailleerde informatie te verkrijgen. Het betrof hier een kleiner gebied dan wat is onderzocht voor de bureaustudie, Figuur 4-2.



Figuur 4-2 – Onderzoeksgebied geofysisch onderzoek Furgo (figuur 1.1 Nearshore Geophysical Survey Results)

Voor het gebied dicht bij de kust is het onderzoek verdeeld in de volgende elementen:

- Geofysisch (multibeam echosounder (MBES), side scan sonar (SSS), sub-bottom profiler (SBP) en single magnetometer (MAG));
- Niet-ontplofte munitie (UXO) (magnetische gradiëntmeter);
- 2D-seismiek met ultrahoge resolutie (UHRS);

- Refractie-seismiek en meerkanaalsanalyse van oppervlaktegolven (MASW).

De geofysische metingen zijn tussen 12 juli 2022 en 15 oktober 2022 uitgevoerd. Vervolgens zijn de metingen geanalyseerd en uitgewerkt in de rapportage voor de vier onderzochte elementen om een interpretatie te geven aan de bathymetrie, de karakteristieken van de zeebodem, zoals de morfologie (bedvormen en objecten) en het type sediment. Daarnaast zijn de observaties van de ondergrond van de zeebodem ook gerelateerd/geïnterpreteerd aan het geologische overzicht dat middels de bureaustudie is verkregen.

Geofysisch en geotechnisch onderzoek Noordzee (Geophysical Results Report)
Voor de gehele beoogde routes van de transportleiding is ook een geofysisch onderzoek uitgevoerd door Fugro, middels de onderzoeksschepen Discovery, Seeker en Searcher. Het onderzoek is uitgevoerd in de periode tussen Juli 2022 en Januari 2023.

Het onderzoeksrapport geeft de resultaten van het geofysisch onderzoek en de interpretatie van de voorgestelde 500m brede transportleidingcorridors en een offshore distributie hub met een straal van 2 km. De resultaten bevatten:

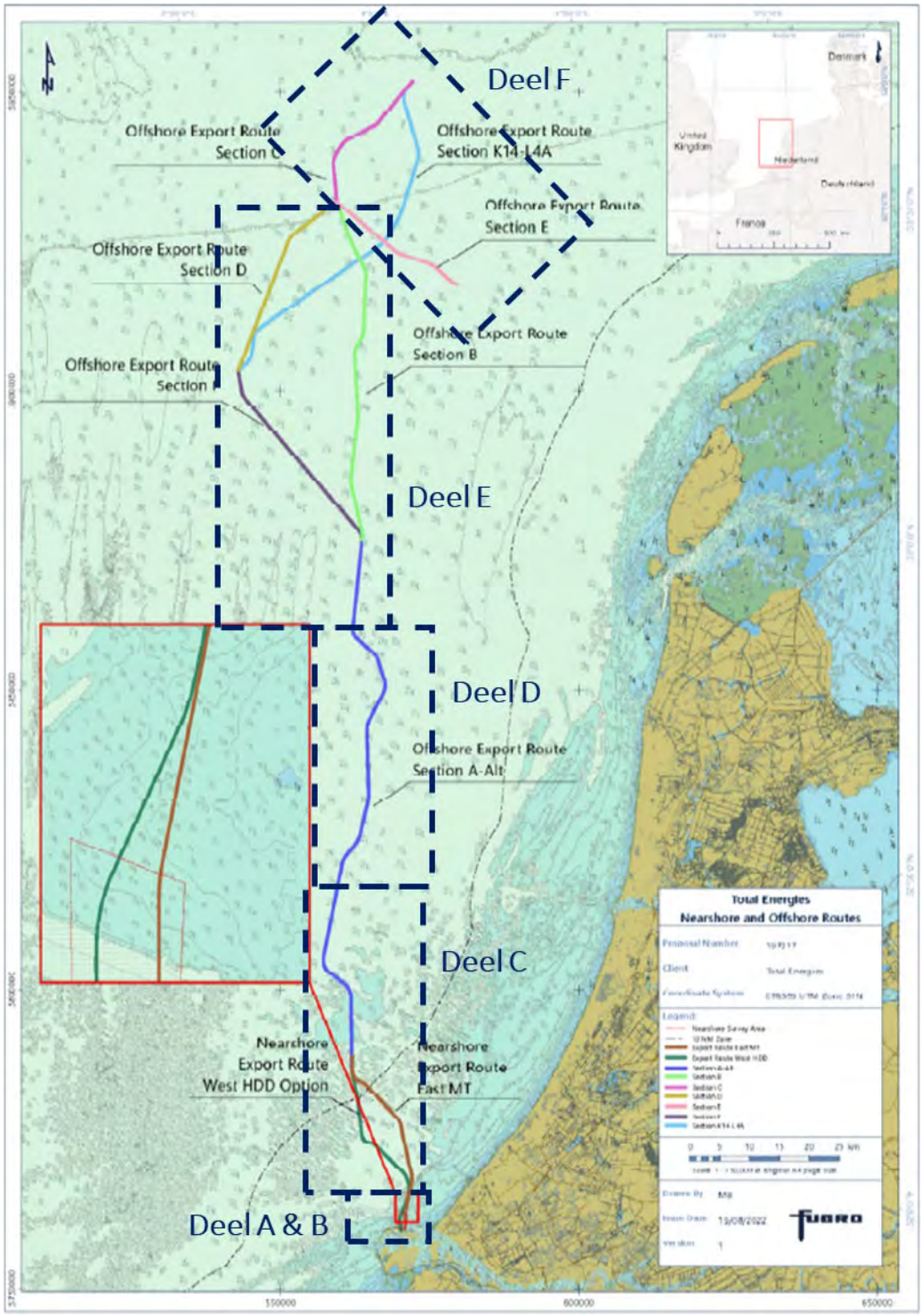
- Multibeam echosounder (MBES) gegevens voor een nauwkeurige bathymetrie om waterdiepten, zeebodemmorfologie en zeebodemgradiënt te bepalen;
- Hoge-resolutie side scan sonar (SSS) gegevens om de kenmerken van de zeebodem te bepalen, mogelijke aanwezigheid van keien, zeebodemsedimenten, objecten/puin en voorwerpen die van invloed kunnen zijn op de installatie van funderingen en transportleidingen;
- Magnetometer (MAG) gegevens over de locatie om eventuele metalen objecten / puin voorwerpen;
- Hoge-resolutie sub-bottom profiler (SBP) en 2D-UHRS gegevens om de subbodem te bepalen omstandigheden die van invloed kunnen zijn op de installatie van funderingen en transportleidingen, zoals ondiepe geologie, geologische kenmerken en geohazards.

Het onderzochte gebied is (door Fugro) verdeeld in 10 verschillende secties:

- Nearshore Export route East tunnel
- Nearshore Export Route West Direct Pipe Option
- Offshore Export Route Section A-Alt
- Offshore Export Route Section B
- Offshore Export Route Section C
- Offshore Export Route Section D
- Offshore Export Route Section E
- Offshore Export Route Section F
- Offshore Export Route Section K14-L4A
- Hub Area(s)

Deze 10 *secties* zijn anders dan de 6 *delen* die worden gehanteerd in de beoordeling. In Figuur 4-3 is de afbeelding van Fugro gecombineerd met de 6 delen.

De metingen voor dit onderzoek zijn geanalyseerd en uitgewerkt in de rapportage voor de verschillende secties om een interpretatie te geven aan de bathymetrie, de karakteristieken van de zeebodem, zoals de morfologie (bedvormen en objecten) en het type sediment. Daarnaast zijn de observaties van de ondergrond van de zeebodem ook gerelateerd/geïnterpreteerd aan het geologische overzicht dat middels de bureaustudie is verkregen.



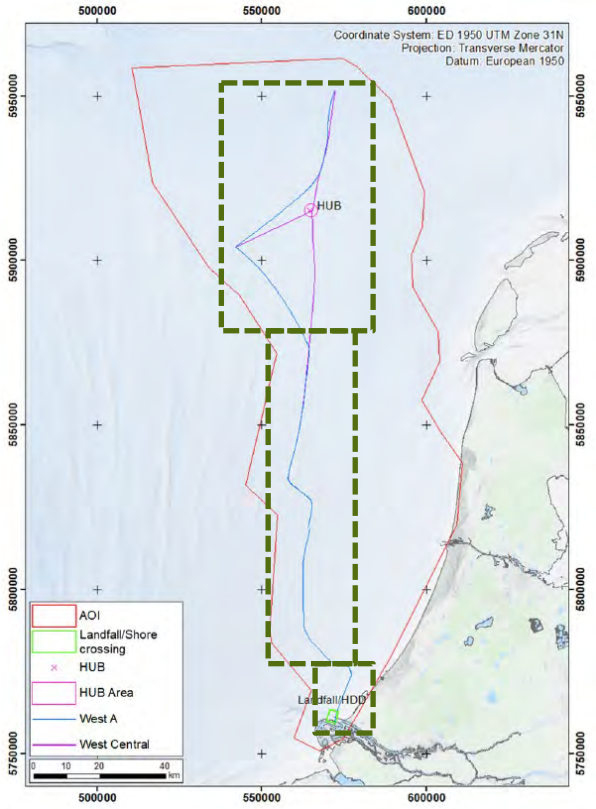
Figuur 4-3 – Overzicht secties onderzoeksgebied (figuur 0.1 uit Geophysical Results Report) inclusief de aanduiding van de delen uit de beoordeling (donkerblauw gestreept)

4.2 Huidige situatie

In de bureaustudie en surveys (zie ook paragraaf 4.1) is de huidige situatie onderzocht voor de zeebodem in het projectgebied. Het gebied waar de transportleiding komt te liggen is wat betreft bodemreliëf in drie gebieden op te delen die onderscheidend zijn, namelijk:

1. Zeebodem
    a. Ondiep continentaal plat met een complexe samenstelling van ritmische bedvormen;
    b. Relatief diepe zone met beperkte dynamiek;
2. Kustzone (kruising Maasgeul).

Figuur 4-4 toont deze gebieden. In de volgende paragrafen zijn de bathymetrie (Hoofdstuk 4.2.1) en de samenstelling en kenmerken (Hoofdstuk 4.2.2) ervan beschreven. In Hoofdstuk 4.2.3 is de zeestroming en het slibpercentage in het zeewater beschreven.



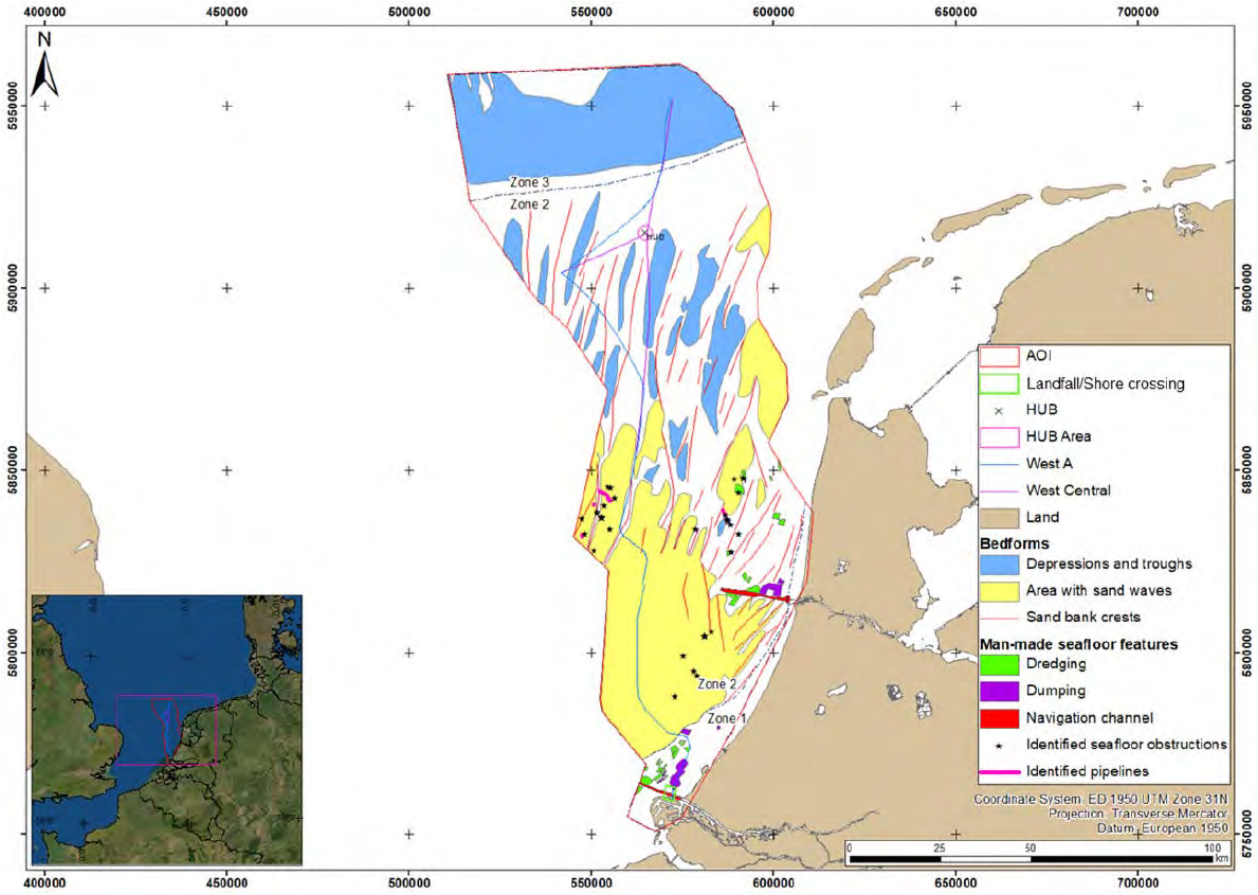
Figuur 4-4 – Gebieden onderscheidend voor Bodemreliëf

4.2.1 Bathymetrie (Bodemreliëf)

Zeebodem

De **waterdiepte** op de route van de zeeleiding varieert van 0 tot circa 39,5 m t.o.v. LAT (Lowest Astronomical Tide). De helling van de bodem is over het grote gedeelte minder dan 1°, maar kan lokaal oplopen tot 30° zijn gerelateerd aan antropogene kenmerken (zoals navigatiekanalen, baggergebieden, losgebieden en scheepswrakken) en toppen van zandbanken. In het algemeen wordt de zeebodem dieper richting het westen tot westnoordwesten, loodrecht op de kust. Gemiddeld gezien is de waterdiepte van de zeebodem 25 m t.o.v. LAT.

Kijkend naar de **morfologie** zijn er drie kenmerkende en onderscheidende zones voor de zeebodem aan te wijzen (Figuur 4-5): 1) een kustzone bedekt door een complexe samenstelling van ritmische beddingvormen, 2) een ondiep continentaal plat met een complexe samenstelling van ritmische beddingvormen, 3) een relatief diep gebied met beperkte dynamiek.



Figuur 4-5 – Kaart met de 3 zones in het interessegebied (figuur 4.17 Fugro deskstudie)

Verschillende bodemvormen zijn waargenomen in de zones: zandbanken, zandgolven, megaripples en ripples. Deze bodemvormen zijn door Deltares geclassificeerd (2016, 2019 en 2020), als onderdeel van morfodynamische bureaustudies ter ondersteuning van de ontwikkeling van de windparken. De classificatie houdt rekening met verschillende parameters, die het resultaat zijn van de complexe interactie tussen hydrodynamica, korrelgrootte en karakter van het sediment, sedimenttransport en morfologie. Samengevat zijn de belangrijkste kenmerken voor de bodemtypen opgenomen in Tabel 4.1.

Tabel 4.1 Overzicht waargenomen bodemvormen

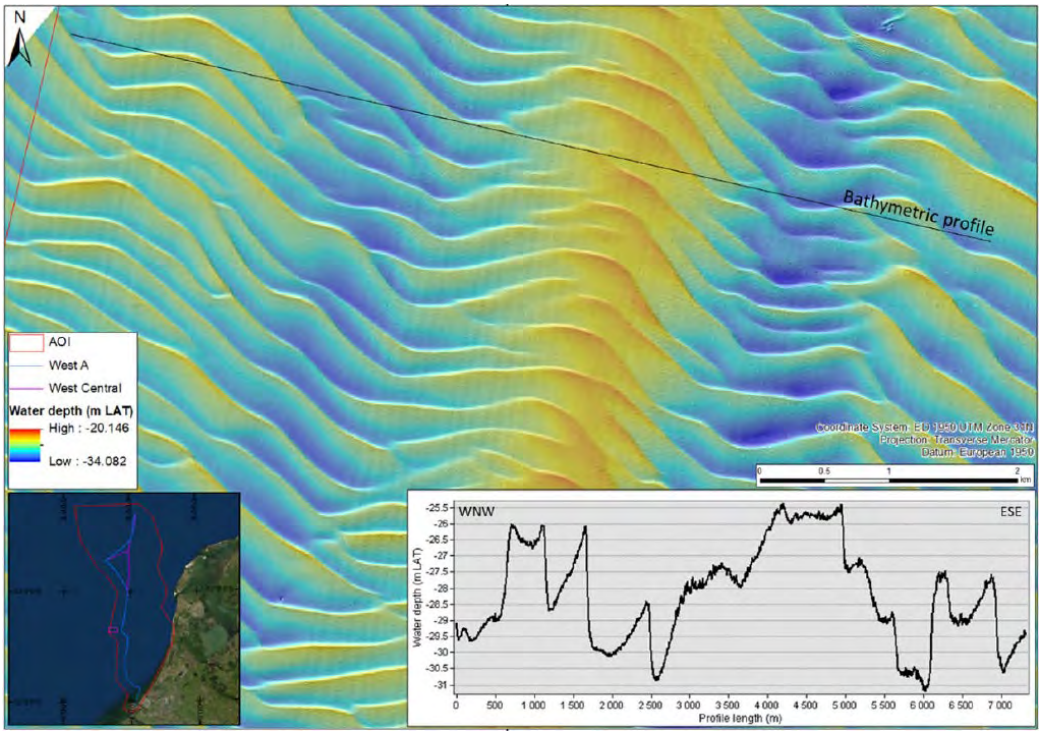
Type	Golflengte [m]	Golfhoogte [m]	Oriëntatie	Dynamiek (tijdschaal)
Zandbank	3000 – 10000	2,5 – 8	N-S – NNO-ZZW	0-10+ m/jaar
Zandgolf	120 – 1750	0,5 – 6	NW-ZO – WNW-OZO	1-10 m/jaar
Megaripple	4 – 20	0,1 – 0,4	NW-ZO – WNW-OZO	Maand(en)

Zandbanken vormen langgerekte ruggen (sub-)parallel aan de getijrichting. In dit gebied zorgt dat voor een N-Z tot NNO-ZZW oriëntatie van de zandbanken. De kammen zijn tientallen kilometerslang met een symmetrisch dwarsprofiel en liggen enkele kilometers uit elkaar. Ze zijn gemiddeld 10 m hoog. De zandbanken zijn ongeveer parallel aan de getij stroomrichting georiënteerd (Hulscher et al., 1993). Dicht bij de kust kunnen ze meer schuin op de getijdenstroom georiënteerd zijn (Calvete et al., 2001). De zandbanken dichter bij de kust worden geclassificeerd als getijdenkammen (van Dijk et al., 2012). De vorming van zandbanken kan grofweg in twee categorieën worden verdeeld (Dyer en Huntley, 1999):

- relictkenmerken, overgebleven na postglaciale zeespiegelstijging;
- nieuw gevormd, in het huidige hydrodynamische regime.

De offshore zandbanken zijn mogelijk gevormd tijdens het vroege Holoceen en de getijdenruggen zijn mogelijk recenter gevormd. De vorming van getijdenruggen houdt verband met getijdenstromingen in een door getijden gedomineerde kustboezem (Ashley, 1990).

De zandbanken komen met name in het noordelijke deel (zone 2) van het beoogde tracé voor.

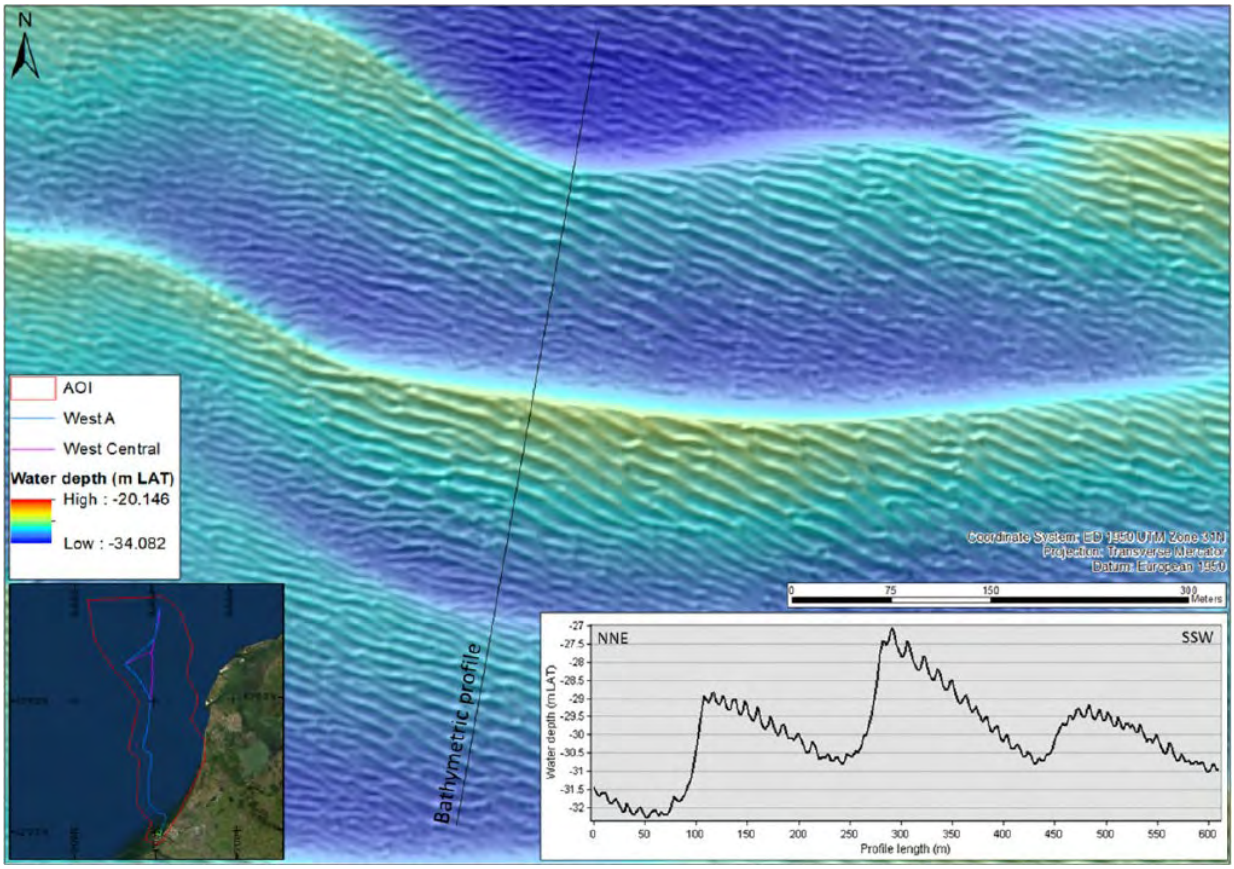


Figuur 4-6 – Voorbeeld van zandbanken (N-Z) met daarop zandgolven (W-O) in het windenergiegebied Hollandse Kust (west) zoals afgebeeld op MBES bathymetrie data. Een bathymetrisch profiel is gegeven loodrecht op de zandbanken. (figuur 4.18 Fugro bureaustudie)

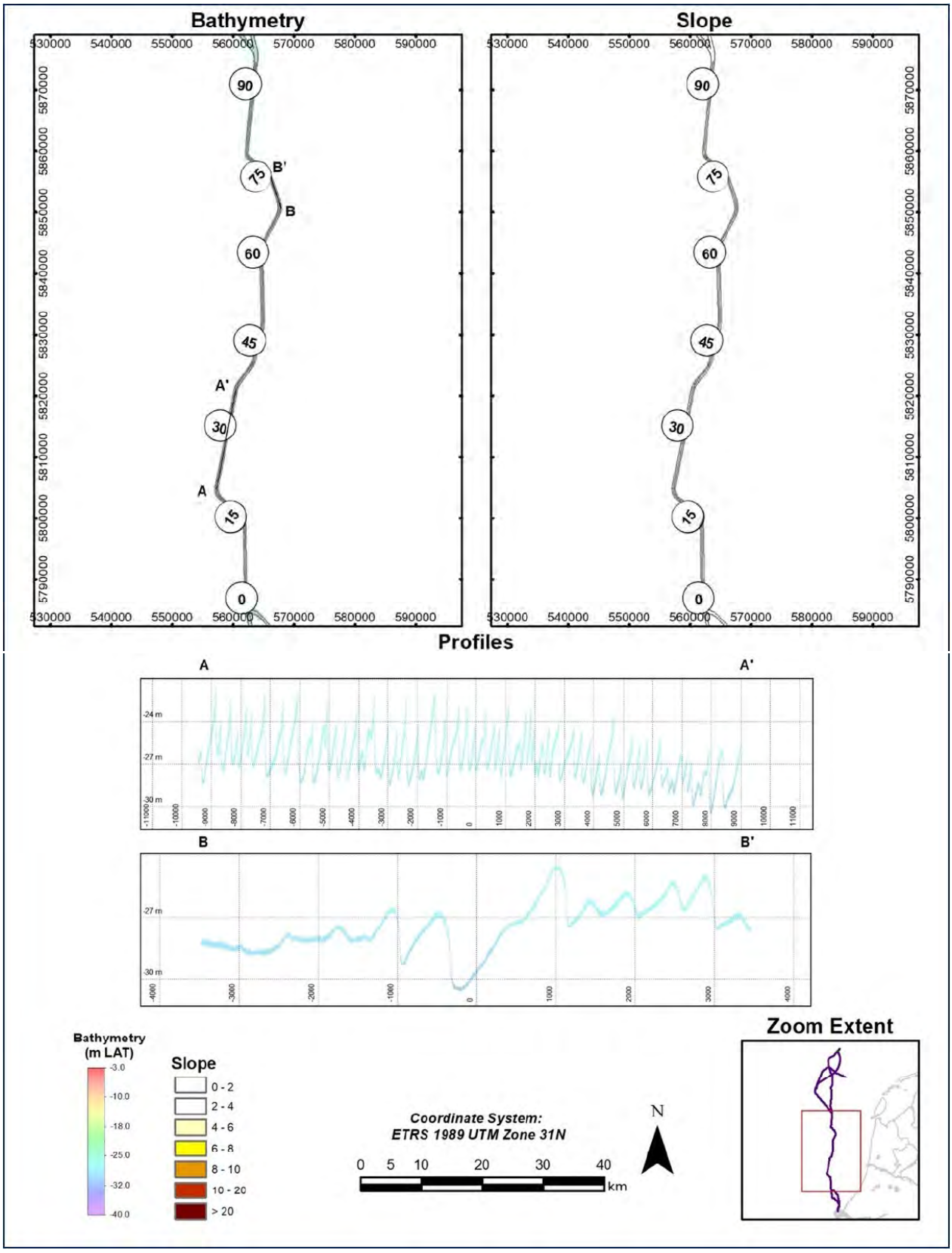
De positie van de noord-zuid georiënteerde zandbanken is redelijk stabiel. Van der Meulen et al. (2004) rapporteerden een migratiesnelheid voor zandduinen van meer dan 20 m/jaar nabij Texel, met typische migratiesnelheden die afnemen in zuidelijke richting tot een stationair (0 – 3 m/jaar) veld nabij de ingang van de Rotterdamse haven. Deltares onderzocht de migratiesnelheid van zandduinen in het gebied van windpark Prinses Amalia en concludeerde dat de duinen in dit gebied ongeveer 4 m/jaar migreren.
Om de migratiesnelheid van zandduinen in de zone van windpark Ijmuiden Ver te beoordelen, is een vergelijking gemaakt van multibeamgegevens die 30 dagen na elkaar zijn verkregen. In deze korte periode was een duin twee meter gemigreerd en was de vorm van het duin veranderd[5].

[5] *Document 22A030-01 Aramis pipeline – an archaeological assessment of geophysical survey data*

Zandgolven liggen op de zandbanken en worden waargenomen in waterdieptes van ongeveer 20 tot 30 m LAT. De kammen van de zandgolven zijn NW-ZO tot WNW-ZO georiënteerd, ongeveer loodrecht op de zandbanken (en daarmee dus loodrecht op de getijdestroom). De golflengte varieert tussen ongeveer 120 m en 1750 m, terwijl de golfhoogte varieert tussen 0,5 m en 4 m. De zandgolven hebben typisch een asymmetrisch profiel met een steile lijzijde in de richting van de voortplanting. Deze morfologie impliceert dat de overheersende trekrichting noord-noord-oost is. Het dominante getij is immers vloed. Zandgolven ontstaan door getijdenstroming en kunnen tot 25% van de waterdiepte bedragen (McCave, 1971), en hebben golflengten in de orde van honderden meters (Ashley, 1990; van Dijk & Kleinhans, 2005; Deltares, 2016). Figuur 4-7 en Figuur 4-8 geven voorbeelden van zandgolven.



Figuur 4-7 – Voorbeeld van zandgolven (W-O) met megaripples in het windenergiegebied Hollandse Kust (west) zoals afgebeeld op MBES bathymetrie data. Een bathymetrisch profiel is gegeven loodrecht op de zandgolven. (figuur 4.19 Fugro bureaustudie)



Figuur 4-8 – Zeebodem sectie A-Alt met zandgolven (Fugro rapport)

Megaripples zijn kleinschalige bodemkenmerken met lengtes van enkele meters en hoogtes tot enkele decimeters. De tijdschaal van de dynamiek ligt in de orde van maanden. De megaripples zijn overal in het gebied te vinden, liggen op de zandgolven en zijn op dezelfde manier georiënteerd. Ze hebben een golflengte van ongeveer 4 m tot 20 m, met hoogtes tussen 0,1 m en 0,4 m.

Ripples zijn de kleinste bodemvormen, met afmetingen in de orde van centimeters. Vanwege hun beperkte omvang kunnen ze niet worden waargenomen in de bathymetriegegevens. Ze liggen boven op de megaripples en zijn op dezelfde manier georiënteerd. Vanwege hun geringe omvang zijn ripples niet van belang voor het ontwerp van offshore-transportleidingen. Ze zijn echter wel relevant voor de ruwheid van de zeebodem en het sedimenttransport in het gebied (Deltares, 2020).

Troggen en depressies

Troggen houden verband met de aanwezigheid van de zandbanken in gebieden die niet door zandgolven worden beïnvloed (dieper dan 28 m LAT). Deze troggen kunnen 4 tot 6 m diep zijn en zijn langgerekt in N-Z-richting (parallel aan de zandbanken). Waar zandgolven aanwezig zijn, zijn deze troggen waarschijnlijk later opgevuld met sedimenten door de vorming en evolutie van de zandgolven. De zeebodem binnen de troggen lijkt op de bathymetrie van EMODnet glad en regelmatig. De troggen komen alleen voor in zone 2 van het interessegebied, zoals gekarteerd in Figuur 4-5.

Bovendien wordt de noordelijke depressie (zone 3) gekenmerkt door een gladde zeebodem en is op de resolutie van de EMODnet-bathymetrie geen beddingvorm afgebeeld. Dit houdt waarschijnlijk verband met de plotselinge toename van de waterdiepte (van 30 m LAT tot 42 m LAT).

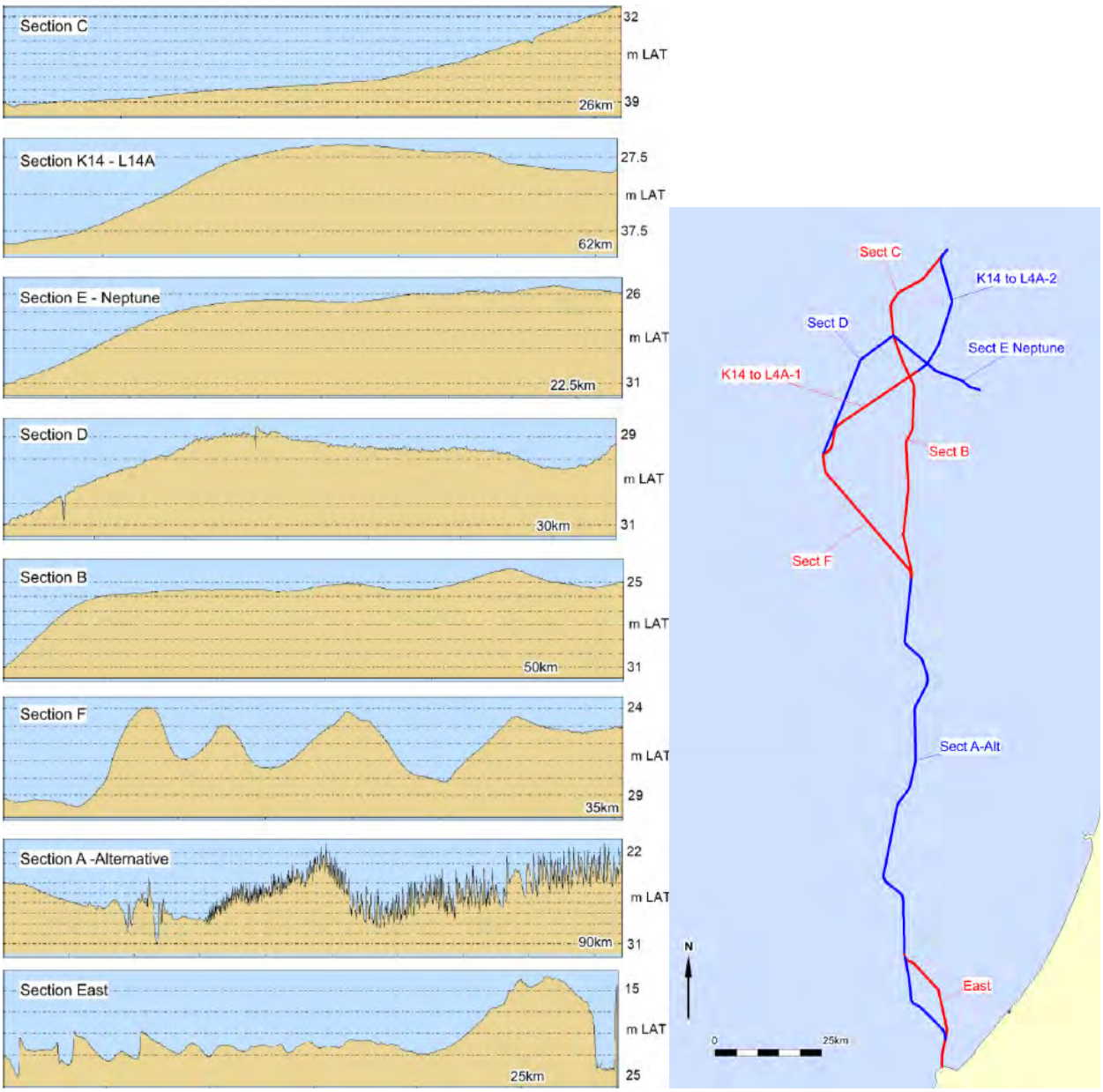
Overzicht morfologische typen per sectie

In onderstaand overzicht is per sectie aangegeven wat de lengte is, de diepte, welk sediment type en welk morfologisch type op dat traject aanwezig is. Bij het archeologisch onderzoek zijn ook geofysische metingen uitgevoerd door Fugro. Periplus heeft deze data gebruikt voor het archeologisch onderzoek. Daarnaast heeft zij de bodemdata geplot als profielen. De zeebodem profielen zijn voor de verschillende secties langs het traject gemaakt. Deze zijn in Figuur 4-9 weergegeven. In deze profielen zijn de morfologische typen, beschreven in voorgaande paragrafen, duidelijk zichtbaar.

Tabel 4.2 – Overzicht morfologische kenmerken per sectie

Sectie	Lengte traject [km]	Diepte [m LAT]	Sediment type	Morfologisch type
East MT	30,5	3,0-24,0	Grindig ZAND; licht grindig ZAND; ZAND; stenen	Keien/puin, onregelmatige zeebodem of zonder kenmerken; ripples, megaripples, zandgolven; kabelgeul (HKZ); Maasmondkanaal; stenen
West DP	31	3,0-24,0	Kiezelhoudend ZAND; licht grindig ZAND; ZAND; stenen	Keien/puin, onregelmatige zeebodem of zonder kenmerken; ripples, megaripples, zandgolven; kabelgeul (HKZ); Maasmondkanaal; stenen
A – Alt	94	22,0-30,0	licht grindig ZAND	ripples, megaripples, zandgolven (golflengte 100-600m, gemiddelde hoogte 4,0m)
B	57,8	25,0-30,5	licht grindig ZAND; ZAND	ripples, megaripples,structuurloos/kenmerkloos (featureless)
C (Hub Area – LA4)	26,8	31,0-39,5	Grindig ZAND; siltig (modderig) ZAND; ZAND	Verspreid voorkomende grove sedimenten; verspreid fijn sediment;

Sectie	Lengte traject [km]	Diepte [m LAT]	Sediment type	Morfologisch type
				structuurloos/kenmerkloos (featureless) en sleepnetmarkeringen
D	33,8	29,5-31,0	siltig (modderig) ZAND; ZAND	verspreid fijn sediment; structuurloos/kenmerkloos (featureless) en sleepnetmarkeringen
E Alternative	23,5	26,0-30,5	licht grindig ZAND; ZAND	Ripples; structuurloos/kenmerkloos (featureless)
F	36,3	24,0-30,0	licht grindig ZAND; ZAND	ripples, megaripples, zandgolven structuurloos/kenmerkloos (featureless)
K14-L4A	62,4	26,0-39,5	Grindig ZAND; siltig (modderig) ZAND; ZAND	Verspreid voorkomende grove sedimenten; verspreid fijn sediment; structuurloos/kenmerkloos (featureless) en sleepnetmarkeringen
Hub Area	5,3 km^2	30,0-31,5	ZAND	Geen morfologische kenmerken, wel sleepnetmarkeringen



Figuur 4-9 – Zeebodem profielen per sectie van noord naar zuid) en het overzicht van de secties (rechts) (bron: Periplus rapport, figuur 4 en 5)

Objecten

In het gebied waar de transportleiding komt te liggen zijn diverse gebieden en objecten geïdentificeerd, zoals scheepvaartroutes en aanvaarroutes naar havens, ankergebieden, windparken (bestaande en in ontwikkeling), bagger gebieden, militaire oefenterreinen, natuurgebieden, visgebieden, platforms, transportleidingen, kabels (elektra en data).

Bodem dynamiek

De dynamische bodemvormen (zandbanken, zandgolven en (mega)ripples) worden onder invloed van (getijden)stroming gevormd en in beweging zijn. De zandgolven en zandbanken hebben afmetingen die van invloed zijn op het ontwerp van de fundering voor de leidingen, terwijl (mega)ripples worden geacht geen significante invloed te hebben. De zandbanken worden beschouwd als stationair gedurende de

levensduur van een transportleiding, terwijl de zandgolven kunnen migreren met een snelheid tot tientallen meters per jaar (van Dijk & Kleinhans, 2005; Dorst et al., 2009; van Santen et al., 2011) en tijdens de levensduur van een transportleiding verticale variaties in de zeebodem op meterslange schaal veroorzaken. Indien zandgolven worden weggebaggerd, worden ze binnen enkele jaren weer gevormd.

Typische migratiesnelheden van zandgolven in de zuidelijke Noordzee liggen tussen 1 m/jaar en 10 m/jaar en in uitzonderlijke gevallen, zoals bijvoorbeeld in kustgebieden, tot 20 m/jaar (Deltares, 2020). De zandgolfmorfologie geeft aan dat de dominante migratierichting in de Noordzee naar het noordnoordoosten is. De migratiesnelheden van zandgolven variëren ruimtelijk en in de tijd. In het algemeen migreren zandgolven in ondieper water, bijvoorbeeld bovenop de zandbanken, sneller dan in de diepere delen en lokaal worden migratiesnelheden tot 9,0 m/jaar waargenomen (Deltares, 2019).
De migratieafstand kan toenemen in het geval van stormen of uitzonderlijke weersomstandigheden. Winterstormgebeurtenissen kunnen de morfologie van zandgolven veranderen. Zo kan sediment van de top naar de trog worden getransporteerd, waardoor de hoogte van de bedvormen lokaal afneemt. Bovendien kunnen megakolken en rimpelingen worden gladgestreken. Deze kleinschalige bedvormen zullen weer verschijnen zodra het ritmische stromingsregime is hersteld (Deltares, 2016).

Maasgeul (Nearshore Geophysical Survey Results, 9 November 2022)
De **waterdiepte** in het Landfall/Shore crossing-gebied varieert van 1,83 m tot 31,98 m t.o.v. LAT. Het belangrijkste bathymetrische kenmerk in dit gebied is het relatief diepe navigatiekanaal (Maasmondkanaal). Het navigatiekanaal is 833 m breed en heeft een maximale diepte van 31,98 m LAT. Aan de zuidkant is de gemiddelde diepte 24,50 m LAT en wordt de bodem doorkruist door verschillende baggersporen. Vanaf de kust tot aan het gebaggerde Maasmond kanaal neemt de bodem geleidelijk af van 1,83 m tot 24,50 m LAT. Vanaf het kanaal verder offshore neemt de bodem geleidelijk toe van 18,50 m LAT naar 16,10 m LAT. Het zuidelijke en het noordelijke deel van het gebaggerde Maasmondkanaal wordt doorsneden door een overwegend vlakke zeebodem met plaatselijk gebieden met bodemvormen (zoals ripples, megaripples en zandgolven) en enkele gebieden met een onregelmatige zeebodem. Het grootste deel van het kustgebied wordt gekenmerkt door lichte zeebodemhellingen van 1° tot 3°. In de nabijheid van het gebaggerde Maasmondkanaal bedraagt de helling meer dan 10°. De bathymetriegegevens tonen duidelijk de gebaggerde geulen van de recent geplaatste HKZ-kabels (Kabel van windgebied HK (zuid) naar Maasvlakte).

Morfologie: Het kustgebied maakt deel uit van een dynamisch landschap waar Quartaire formaties door verschillende geologische processen zijn gevormd en tot op de dag van vandaag door mariene omstandigheden worden gemodelleerd. Zeestromingen hebben oppervlakkige sedimenten gemobiliseerd en herverdeeld, waardoor bodemvormen van verschillende schalen zijn ontstaan die verschillende orden van grootte en erosiefuncties vertegenwoordigen.
De volgende morfologische kenmerken werden geïdentificeerd in het kustgebied:

- Bedvormen (ripples, megaripples en zandgolven)
- Onregelmatige zeebodem
- Gebied met talrijke keien/puin
- Gebied met incidentele keien/puin

In het kustgebied bij de Maasgeul zijn twee typen bedvormen geïdentificeerd;

1. Megaripples en zandgolven
2. Ripples

Deze bodemvormen ontstaan door de werking van bodem- en getijdenstromingen, die de zeebodemsedimenten herverdelen.

4.2.2 Samenstelling en kenmerken zeebodem

Sediment type
De typen sediment die voorkomen op de zeebodem in het interessegebied zijn op basis van MBES en SSS bepaald, met behulp van akoestische kenmerken, zoals algemeen patroon, ruwheid en reflectiviteit. De volgende vier typen zijn geïdentificeerd: (1) grindig ZAND; (2) licht grindig ZAND; (3) siltig (modderig) ZAND; (4) ZAND.

Objecten op de zeebodem
Tijdens de survey (Geophysical Survey Results Report, 8 December 2023) zijn de volgende objecten geïdentificeerd:

- 4 wrakgebieden
- Diverse transportleidingen die het beoogde tracé kruisen. Sommige transportleidingen liggen gedeeltelijk bloot en gedeeltelijk begraven, maar de meeste transportleidingen liggen begraven.
- 159 contacten zijn geclassificeerd als puin, 517 contacten zijn geclassificeerd als vermoedelijk puin
- Bodembescherming (2 matrassen) in de buurt van het platform L4A
- 3110 zwerfstenen
- Gevechtstuigsporen, sleepnetsporen
- 2748 magnetische anomalieën zijn opgepikt.

Binnen het onderzochte gebied (Periplus Archeomare, 2023) is aan in **totaal 8 contacten een archeologische verwachting** toegekend. De contactpunten zijn in het overzicht in Tabel 4.3 weergegeven. Drie contacten vallen binnen de 100 meter contour. Deze zijn in Tabel 4.3 dikgedrukt weergegeven en op de kaart in Figuur 4-10 met rode punten aangeduid. In overeenstemming met de Nederlandse wet- en regelgeving mogen er geen bodemberoeringen worden uitgevoerd binnen 100 meter van elk van deze locaties. Indien er werkzaamheden plaatsvinden binnen 100 meter van een potentiële archeologische vindplaats, wordt in overleg met Rijkswaterstaat en de Rijksdienst voor het Cultureel Erfgoed (RCE) per geval bekeken of de 100 meter afstand behouden blijft.

Tabel 4.3 – Contactpunten binnen onderzochte gebied (Periplus, 2023, p. 5)

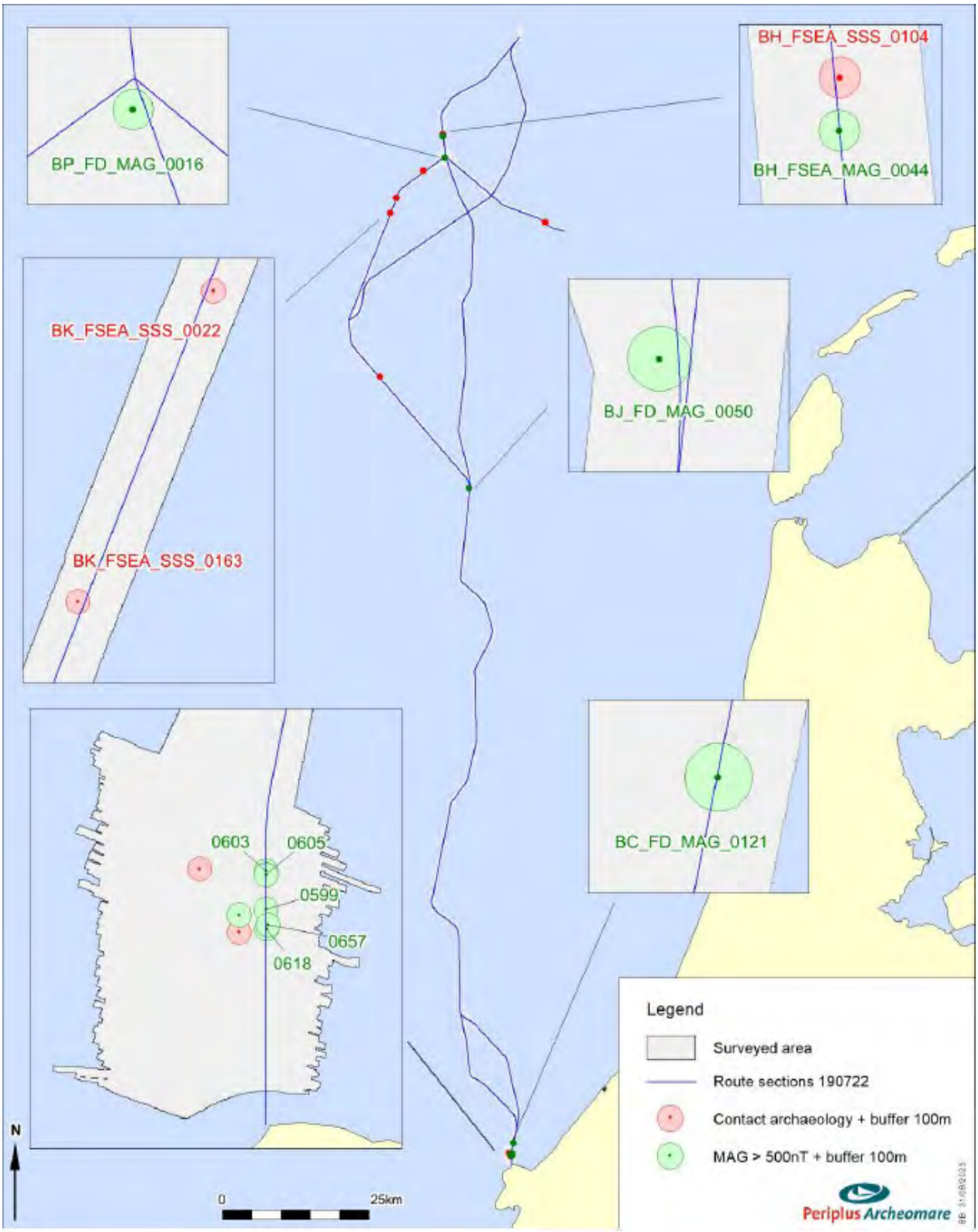
Feature	NCN	Easting	Northing	Route section	Distance
BK_FSEA_SSS_0022	-	551288	5924521	D	**+50**
BK_FSEA_SSS_0179	-	555839	5929168	D	-240
BJ_FD_SSS_0015	-	548443	5894128	F	+230
BB_FS_SSS_0683	219	570384	5762003	East	-540
BH_FSEA_SSS_0104	531	559172	5935317	C	**+25**
BK_FSEA_SSS_0163	967	550165	5921956	D	**-56**
BN_FD_SSS_0025	945	576689	5920367	E Neptune	+220
BB_FS_SSS_0433	-	570711	5761481	East	-210

Er zijn in totaal **2748 magnetische anomalieën** waargenomen. Op 10 locaties zijn magnetische anomalieën met een piek-tot-piekwaarde van meer dan 500 nT in kaart gebracht die niet in verband kunnen worden gebracht met bekende objecten zoals transportleidingen of kabels en die van potentieel archeologisch belang kunnen zijn. De anomalieën zijn in het overzicht in weergegeven Tabel 4.4. Negen van de tien contacten vallen binnen een straal van 100 meter van de voorgestelde route. Dit zijn de dikgedrukte locaties in de tabel en de groene punten op de kaart in Figuur 4-10. De objecten die deze

anomalieën veroorzaken, zijn niet zichtbaar op side scan sonar- of multibeambeelden en worden daarom beschouwd als begraven in de zeebodem. Deze objecten kunnen, behalve archeologische objecten, puin, NGE, verloren ankers, et cetera zijn. Zolang de aard van deze objecten niet is vastgesteld, worden de objecten geacht van potentieel archeologisch belang te zijn.

Tabel 4.4 – Anomalieën met meer van 500 nT met een potentieel archeologisch belang (Periplus, 2023, p. 6)

Target	E	N	nT	Section	Distance
BAB_FS_UXO_0010	570711	5761625	808	East	-210
BAB_FS_UXO_0599	570931	5761671	514	East	+5
BAB_FS_UXO_0603	570932	5761987	2312	East	+8
BAB_FS_UXO_0605	570933	5761957	1158	East	+8
BAB_FS_UXO_0618	570936	5761510	729	East	+11
BAB_FS_UXO_0657	570948	5761543	1348	East	+22
BC_FD_MAG_0121	571170	5763666	666	East	+4
BH_FSEA_MAG_0044	559169	5935057	578	C	-2
BJ_FD_MAG_0050	563642	5875159	2089	F	-59
BP_FD_MAG_0016	559490	5931390	591	B	-60



Figuur 4-10 – Kaart met de locaties van potentiële archeologisch belang. Rood zijn de contacten en groen de anomalieën.

Geologische kenmerken in de diepere zeebodem

In de survey (Geophysical Survey Results Report, 8 December 2023) zijn met behulp van SBP en 2D-UHRS gegevens geologische kenmerken onderzocht, die vertaald kunnen worden naar een seismostratigrafische eenheid voor de diepere zeebodem. Zie Tabel 4.5.

Tabel 4.5 – Seismostratigrafische eenheden voor de diepere zeebodem

Eenheid	Beschrijving
A	Aanwezig over de hele route. Het lijkt akoestisch transparant te zijn. Plaatselijk werden hoge amplitude interne puntreflecties of korte reflectoren waargenomen. In de grotere zandgolven werden plaatselijk zwakke pro gradatie structuren waargenomen. De eenheid wordt geïnterpreteerd als afgezet in een open mariene omgeving in reactie op de mariene transgressie tijdens het Laat-Holoceen en behoort tot de zuidelijke Bocht Formatie
B	Aanwezig in de hele route, behalve in het Maasmondkanaal. De eenheid heeft een seismisch karakter, variërend van semi-transparant tot chaotisch met talrijke discontinue en vaak onder een grote hoek geplaatste middelhoge tot hoge amplitude weerkaatsingen. In de eenheid zijn interne geulen en geulen aan de basis met verschillende afmetingen waargenomen. De vulling van de kanalen is variabel, maar meestal goed gelaagd en met weerkaatsingen met hoge amplitude. Hoge negatieve amplitudeanomalieën komen vaak voor in deze eenheid, vooral in het noordelijke deel van het traject, die mogelijk lagen veen en/of organisch rijke klei voorstellen. De eenheid wordt geïnterpreteerd als vroeg-Holocene kust- en getijdenafzettingen en behoort mogelijk tot de Naaldwijk Formatie. Plaatselijk kan de eenheid afzettingen van de Formatie van Boxtel bevatten en vooral in het zuidelijke en zuid-centrale deel van de route behoort een groot deel van deze eenheid mogelijk tot de Kreftenheye Formatie. Het onderscheid tussen deze formaties is moeilijk vanwege de vergelijkbare bodemgesteldheid (overwegend zand). In het kustgebied liggen de afzettingen van de Kreftenheye Formatie onder de basis van de geïnterpreteerde Naaldwijk Formatie.
C	Aanwezig in het centrale en gedeeltelijk in het noordelijke deel van de route. De eenheid wordt voor het grootste deel van de route gekenmerkt door beddingrijke seismische facies, bestaande uit parallelle weerkaatsingen. Plaatselijk, in het bovenste deel van de eenheid, werden structuurloze, semi-transparante intervallen waargenomen. In het noordoostelijke deel van het traject wordt de eenheid gekenmerkt door algemene semi-transparante seismische facies met lokale negatieve weerkaatsingen met hoge amplitude (2D-UHRS) van verschillende omvang. De hoge amplitude weerkaatsingen kunnen duiden op lagen met zakken veen en/of organische klei. De gelaagde aard van de eenheid zal naar verwachting correleren met afwisseling van zand en klei en lokale veenbedden. De eenheid wordt geïnterpreteerd als afgezet in een reeks kustmilieus (estuariën), getijdenvlakten of lagunes en komt overeen met het Bruine Bank Lid.
D	Aanwezig over de hele route, met uitzondering van een klein deel van de route (ongeveer 15 km) in het centrale deel en in het meest zuidelijke deel. De eenheid heeft over het algemeen een structuurloos en semi-transparant akoestisch karakter. Plaatselijk zijn er gelaagde intervallen, interne erosieoppervlakken die worden gemarkeerd door sterke hellende weerkaatsingen of die brede kanaalachtige kenmerken vormen. Inwendige begraven geulen zijn plaatselijk aanwezig. Unit D bestaat naar verwachting voornamelijk uit zand, met zeer plaatselijk klei- of veenafwisseling, afgezet in open zee- en getijdenmilieus. Men denkt dat de eenheid behoort tot de Eem Formatie.
E	Alleen aanwezig in het noordelijke deel van de route. Wordt gekenmerkt door akoestisch transparante tot semi-transparante en structuurloze seismische facies. Unit D bestaat naar verwachting voornamelijk uit zand, afgezet in open mariene en getijdenmilieu. De eenheid behoort vermoedelijk tot de Egmond bodemformatie.
F	Plaatselijk aanwezig in de noordelijke helft van de route. De eenheid vormt de opvulling van diep insnijdende U-vormige kanaalachtige kenmerken met steile flanken. Ze snijden in de onderliggende eenheid G en bereiken plaatselijk diepten onder de penetratie van de 2D-UHRS gegevens. Dergelijke kenmerken in dit deel van de Noordzee worden beschouwd als glaciale tunnelvalleien. De eenheid bestaat naar verwachting voornamelijk uit klei met frequent (siltig) zand interbeds

Eenheid	Beschrijving
	afgezet in glaciale, glaciofluviale en glaciolacustriene omgevingen. Deze afzettingen worden geïnterpreteerd als behorend tot de Peelo Formatie. Het interne karakter wordt over het algemeen gekenmerkt door semi-transparante tot chaotische seismische facies. Vaak, vooral in het bovenste deel, discontinue, onregelmatige en golvende/geplooide weerkaatsingen van gemiddelde tot hoge amplitude waargenomen.
G	De diepste eenheid die is waargenomen in de seismische gegevens binnen de diepte van belang en is aanwezig over het hele traject. De basis van deze eenheid ligt buiten de penetratiediepte van de 2D-UHRS. Het interne akoestische karakter van de eenheid is complex, van half doorzichtig tot chaotisch, met plaatselijk discontinue weerkaatsingen, interne erosieoppervlakken en verschillende interne kanalen. Deze complexiteit is het gevolg van de aard van het afzettingsmilieu van deze eenheid (fluviatiel tot deltaïsch) en postdepositionele processen zoals glaciale activiteit, inclusief erosie en mogelijk vervorming. De eenheid bestaat naar verwachting voornamelijk uit zand met af en toe klei en silt tussenlagen en plaatselijk dunne veenbedden. De eenheid komt volgens de interpretatie overeen met de Yarmouth Roads Formatie.

Naast de seismostratigrafische eenheden zijn er ook andere geologische kenmerken in de diepere zeebodem geïdentificeerd. Deze zijn weergegeven in Tabel 4.6.

Tabel 4.6 – Geologische kenmerken in de zeebodem

Begraven geulen	In de bodem begraven geulen en geulen aan het bodemoppervlak werden waargenomen in alle eenheden behalve eenheid A. Begraven geulen in eenheid B werden in kaart gebracht op basis van SBP-gegevens. Deze kanalen bevinden zich vaak aan de bovenkant van de eenheid, zijn NW-ZO georiënteerd en hebben een beperkte omvang. Ze hebben vaak een gelaagde invulling. De basis van eenheid B, C en D is plaatselijk gekanaliseerd. De basis van eenheid F vormt de diep ingesneden glaciale tunneldalen. Nabij de top van eenheid F zijn plaatselijk beddingvormige, kanaalachtige reflectoren waargenomen. Deze kenmerken lijken een laat stadium te vertegenwoordigen van de opvulling van deze tunnelvalleien die mogelijk plaatsvond in een lacustrien milieu.
Veen	Veenlagen zijn geïdentificeerd op drie stratigrafische niveaus: *veen niveau 1* geassocieerd met eenheid B, *veen niveau 2* geassocieerd met eenheid C, D en E, *veen niveau 3* geassocieerd met eenheid F en G. Veen komt het meeste voor in het noordelijke deel van het traject, met uitzondering van veen niveau 3. Dat is aanwezig langs het gehele traject, maar de verspreiding daarvan is zeer beperkt.
Ondiep gas	In het nabijgelegen kustgebied zijn er mogelijk gas/vloeistof geladen sedimenten waargenomen. De aanwezigheid hiervan kan niet volledig worden uitgesloten.
Keien en grind	In de survey zijn mogelijk keien of grof grind geïdentificeerd, echter, dit kan ook het resultaat zijn van andere factoren. Gezien de geologische setting (d.w.z. de verwachte aanwezigheid van periglaciale en glaciale sedimenten) kunnen keien en keien worden verwacht langs de Aramis-route. Daarom hun aanwezigheid niet worden uitgesloten.
Glaciale deformatie	Glaciale deformatie komt typisch tot uiting in seismische gegevens als chaotische interne weerkaatsingen, hellende afschuifvlakken, vervormde en geplooide lagen en verstoring van de oorspronkelijke interne structuur. Bewijzen van mogelijke vervorming werden waargenomen in eenheid G, vooral in de nabijheid van glaciale tunneldalen (eenheid F). Men denkt dat deze kenmerken verband houden met de Elsteriaanse ijstijd.
Gewelven/ breuken	Gewelven werden niet eenduidig geïdentificeerd in de seismische reflectiegegevens. De aanwezigheid van breuken kan echter niet worden uitgesloten.

4.3 Autonome ontwikkelingen

De Noordzee is een drukke zee met diverse activiteiten nu en in de toekomst. Ten aanzien van de bodem, of in relatie tot de bodem zijn de volgende ontwikkelingen relevant.

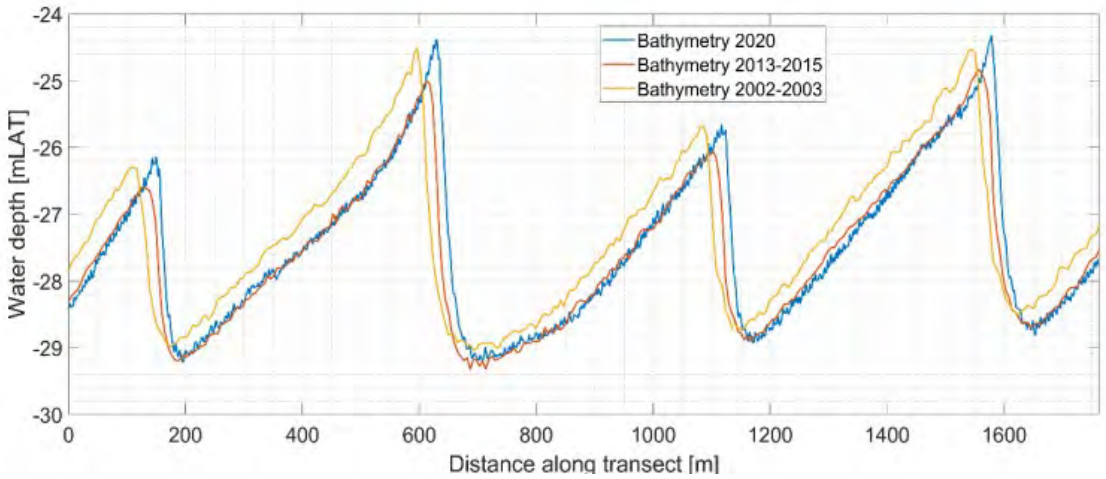
4.3.1 Ontwikkelingen bodem

De zeebodem op de Noordzee heeft verschillende kenmerken, waaronder zandbanken en zandgolven. Deze bodemkarakteristieken kennen dynamiek en migreren in de loop van de jaren. Deze dynamiek is niet voor elk gebied op de Noordzee hetzelfde. De typische migratiesnelheden van zandgolven in de zuidelijke Noordzee liggen tussen 1 m/jaar en 10 m/jaar en in uitzonderlijke gevallen, zoals bijvoorbeeld in kustgebieden, tot 20 m/jaar (Deltares, 2020). Een belangrijk aspect is dat er een ruimtelijke variatie is van migratiesnelheden.

Voor windenergiegebied Ijmuiden Ver, dat ten westen van het beoogde transportleiding tracé ligt, is door Deltares een onderzoek uitgevoerd [*Morphodynamics for Ijmuiden Ver Wind Farm Zone, Deltares, January 2023*]. De conclusies in dat onderzoek geven een beeld van wat er aan dynamische ontwikkelingen op de zeebodem voor komt:

- Grote noord-zuid georiënteerde zandbanken met hoogte verschillen van enkele meters tot 10 meter.
- Sedimenttransport voornamelijk door getij, meteorologische omstandigheden slechts tijdelijk effect; netto transport naar NNO in lijn met dominante getijdenstromingen (IJVER)
- Zandgolven migreren tussen 0,4m/jaar en 2,7m/jaar

In Figuur 4-11 is deze migratie inzichtelijk gemaakt. De gele lijn laat de zeebodem zien van 2002-2003 en de blauwe lijn de zeebodem van 2020. Hier is te zien dat de zandgolf ca. 40 meter is verplaatst gedurende een kleine 20 jaar.



Figuur 4-11 – Voorbeeld van de zeebodem van zuid-zuidwest tot noord-noordoost (Figuur 4.9 Deltares rapport)

4.3.2 Ontwikkelingen windparken

Voor 2030 worden er diverse windenergiegebieden op de Noordzee ontwikkelt, maar ook voor de periode daarna heeft de Nederlandse overheid haar ambities gezet. Hieronder valt o.a. het voorgenomen windenergiegebieden Lagelander. Verschillende varianten van het transportleidingtracé voor Aramis doorkruist dit toekomstige windenergiegebied. De exacte invulling van de windenergiegebieden zijn nog niet bepaald, maar vast staat dat er windturbines komen die met vele kabels worden verbonden om vervolgens de energie aan land te krijgen.

5 Milieueffecten tijdens gebruiksfase

Dit hoofdstuk gaat per Aramis onderdeel in op de effecten op het thema Zeebodem, zoals die verwacht worden tijdens het gebruik van de CCS-keten. Daarbij wordt onderscheid gemaakt naar de startsituatie en eerste uitbreidingssituatie, die alle twee onderdeel zijn van het Aramis initiatief. Tevens bevat het hoofdstuk een doorkijk naar de effecten die verwacht worden in de eindfase, hoewel dit strikt gezien niet tot het Aramis initiatief behoort.

De milieuaspecten tijdens de gebruiksfase bij het thema zeebodem zijn:

- **Morfologie**: De effecten van de aanwezigheid van de leiding op de morfologie van de zeebodem.
- **Bodemkwaliteit**: De mate waarop de voorgenomen activiteit qua temperatuur invloed heeft op de bodemkwaliteit.

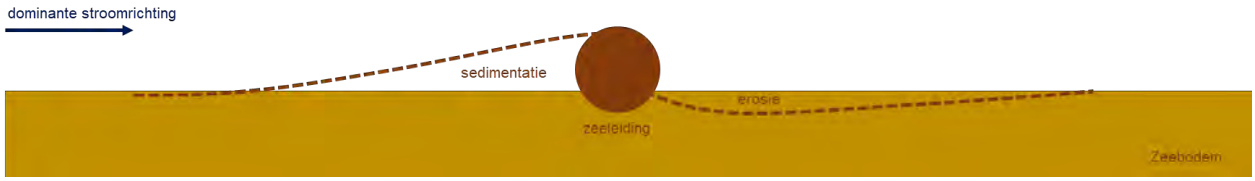
In deze fasen is niet van toepassing:

- **Vertroebeling**: Door bodemberoering komt sediment in de waterkolom, wat vertroebeling tot gevolg kan hebben. De mate waarin dit gebeurt wordt met dit criterium bepaald.
- **Archeologie**: De mate van verstoring op archeologische aspecten, zoals bijvoorbeeld scheepswrakken.
- **NGE (OO)**: De mate van verstoring, dan wel het risico, op niet gesprongen explosieven.

5.1 Morfologie

In paragraaf 4.2.1 is de morfologische dynamiek beschreven; aanwezigheid van verschillende bodemtypen (zandbanken, -golven en megaripples) en hoe deze in de tijd veranderen. Tijdens de gebruiksfase zal de zeeleiding in of op de zeebodem liggen. Grootschalige bodemberoering zal niet plaatsvinden, evenals een effect op de grootschalige morfologie. Alleen zeer lokaal kunnen veranderingen optreden door de aanwezigheid van een obstakel (de zeeleiding) op de bodem.

Daar waar de zeeleiding op de bodem ligt, of half ingegraven is, is er een verstoring van de zeebodem. Er ligt immers een object op de bodem. Op de zeebodem is er een geringe stroomsnelheid van het water, die zandkorrels met zich voort kan bewegen. Wanneer deze stroming dominant is in een bepaalde richting, kan deze ervoor zorgen dat aan de ene kant van de leiding de bodem wat sedimenteert en aan de andere kant erodeert. Dit verschijnsel is zeer gering én treedt op in geval van een sterk dominante richting. Daarnaast tast het de integriteit van de leiding niet aan; het is niet erg wanneer dit optreedt.
Wanneer de stroming van meerdere richtingen komt, wordt dit effect alleen maar minder of houdt het zich in balans waardoor er geen verschil is met de referentiesituatie. Het principe van dit verschijnsel is ter verduidelijking in onderstaande figuur weergegeven.



Figuur 5-1 - Principe van lokale bodemverandering rondom de zeeleiding

5.1.1 Effectbeoordeling morfologie

De beschreven lokale morfologie is kleinschalig. De zeeleiding heeft daar eigenlijk geen invloed op. De minimale invloed die er zou kunnen zijn in het geval dat de zeeleiding op de bodem ligt (en niet is ingegraven), is verwaarloosbaar klein.

De zeeleiding heeft geen effect op de (lokale) morfologie tijdens de gebruiksfase, ongeacht de wijze van realiseren van de zeeleiding. De beoordeling is daarom neutraal gescoord voor alle trajecten en varianten.

Tabel 5.1 - Effectbeoordeling Morfologie in de gebruiksfase (Deel A en B)

Criteria	Aspect	Kruising Maasgeul	
		Tunnel (Deel B)	Direct Pipe (Deel A)
Water	Morfologie	0	0

Tabel 5.2 - Effectbeoordeling Morfologie in de gebruiksfase (Deel C en D)

Criteria	Aspect	Zeeleiding leggen (Deel D)	Zeeleiding ingraven en leggen (Deel C)
Water	Morfologie	0	0

Tabel 5.3 - Effectbeoordeling Morfologie in de gebruiksfase (Deel E en F)

Criteria	Aspect	Zeeleiding leggen (Deel E)		Zeeleiding leggen (Deel F)
		Knooppunt op zeebodem	Platform installatie voor knooppunten	
Water	Morfologie	0	0	0

Tabel 5.4 - Effectbeoordeling Morfologie in de gebruiksfase voor de alternatieven

Criteria	Aspect	Alternatief 1 (West 1)		Alternatief 2 (West 2)		Centrale route
		1A	1B	2A	2B	3
Water	Morfologie	0	0	0	0	0

5.2 Bodemkwaliteit

Door afgifte van warmte op de omgeving door de zeeleiding zal de bodemtemperatuur lokaal verhogen, wat invloed kan hebben op de bodemkwaliteit. Deze invloed neemt af naarmate de Zeeleiding verder offshore ligt en tevens op grotere afstand van de leiding. De effecten treden alleen op tijdens het gebruik van de buisleiding. Tijdens de aanleg komt er geen warmte vrij. De temperatuur van de bovenste lagen van de zeebodem varieert met de temperatuur van het zeewater. Het zeewater varieert van temperatuur met gemiddeld 6 °C in februari en 19 °C in augustus[6]. In de (diepere) bodemlagen is de temperatuur constanter en fluctueert de temperatuur minder.
Er zijn twee zaken die invloed hebben op de inlaattemperatuur van de zeeleiding. De temperatuur van de stroom afkomstig van CO2next en de temperatuur afkomstig van de compressoren van Aramis. Hiermee rekening houdende is aangenomen dat de inlaattemperatuur van de zeeleiding tussen 30 en 65 °C bedraagt.

Bij aankomst op het d-hub platform (Deel E) is de temperatuur gelijk aan de water- en bodemtemperatuur ter plaatse. Tot welke afstand en op hoeveel meter van de zeeleiding de watertemperatuur wordt beïnvloed hangt af van meerdere factoren:

- pijpdiameter,
- wanddikte,
- coating,

[6] *F197217-REP-ENV-001-R02_Environmental-Desk-Top-Study, page 39*

- lengte,
- inlaattemperatuur,
- doorstroom volume CO2,
- bodem- en zeetemperatuur.

Omdat deze informatie nog niet nauwkeurig genoeg was ten tijde van publicatie van dit rapport is het aspect Bodemtemperatuur opgenomen Hoofdstuk 9 Leemten in kennis.

5.2.1 Effectbeoordeling bodemkwaliteit

In Deel A en B bevindt de zeeleiding zich onder het diepste gedeelte van de vaargeul. De afstand van de kern van de leiding tot aan het bodemoppervlak is daarom veel groter. Aan het bodemoppervlak zal er qua temperatuur geen effect meer zijn op de bodem. Het effect is nauwelijks meetbaar en wordt daarom neutraal gescoord (0).

Tabel 5.5 - Effectbeoordeling Temperatuurtoename in de gebruiksfase (Deel A en B)

Criteria	Aspect	Kruising Maasgeul	
		Tunnel (Deel B)	Direct Pipe (Deel A)
Water	Temperatuurtoename	0	0

In Deel C wordt de leiding ingegraven en gelegd. In Deel D, E en F wordt de leiding gelegd. Door de reeds afgelegde afstand zal de temperatuur in de leiding vanaf deze delen ongeveer gelijk zijn aan de omgevingstemperatuur. Het effect op de zeebodem (voornamelijk deel D) en zeewater (voornamelijk de latere delen waar de leiding wordt gelegd) wordt daarom neutraal gescoord (0).

Tabel 5.6 - Effectbeoordeling Temperatuurtoename in de gebruiksfase (Deel C en D)

Criteria	Aspect	Zeeleiding leggen (Deel D)	Zeeleiding ingraven en leggen (Deel C)
Water	Temperatuurtoename	0	0

Tabel 5.7 - Effectbeoordeling Temperatuurtoename in de gebruiksfase (Deel E en F)

Criteria	Aspect	Zeeleiding leggen (Deel E)		Zeeleiding leggen (Deel F)
		Knooppunt op zeebodem	Platform installatie voor knooppunten	
Water	Temperatuurtoename	0	0	0

De afzonderlijke delen worden allemaal neutraal gescoord. Voor de verschillende alternatieven zijn geen verschillen en is de beoordeling neutraal voor alle alternatieven.

Tabel 5.8 - Effectbeoordeling Temperatuurtoename in de gebruiksfase voor de alternatieven

Criteria	Aspect	Alternatief 1 (West 1)		Alternatief 2 (West 2)		Centrale route
		1A	1B	2A	2B	3
Water	Temperatuurtoename	0	0	0	0	0

6 Milieueffecten tijdens aanleg en ontmanteling

Dit hoofdstuk gaat per Aramis onderdeel in op de effecten op het thema Zeebodem, zoals die verwacht worden tijdens de aanleg en de ontmanteling van de CCS-keten. Waar nodig wordt onderscheid gemaakt naar de startfase en de eerste uitbreidingsfase. Tevens bevat het hoofdstuk een doorkijk naar de effecten die verwacht worden voor de eindfase.

De milieuaspecten tijdens de aanlegfase en ontmanteling bij het thema zeebodem zijn:

- **Morfologie**: De effecten van de bodemberoering op de bodem en daarmee de morfologie.
- **Vertroebeling**: Door bodemberoering komt sediment in de waterkolom, wat vertroebeling tot gevolg kan hebben. De mate waarin dit gebeurt wordt met dit criterium bepaald.
- **Archeologie**: De mate van verstoring op archeologische aspecten, zoals bijvoorbeeld scheepswrakken.
- **NGE (OO)**: De mate van verstoring, dan wel het risico, op niet gesprongen explosieven (ontplofbare oorlogsresten).

In deze fasen is niet van toepassing:

- **Bodemkwaliteit**: De mate waarop de voorgenomen activiteit qua temperatuur invloed heeft op de bodemkwaliteit.

6.1 Morfologie

6.1.1 Invloed morfologie op de leiding

De aanwezige morfologische typen (zandbanken, zandgolven en megaripples) zijn beschreven in paragraaf 4.2.1. Deze bodemtypen zijn dynamisch en door de veranderingen en verplaatsingen daarvan, kan dat negatieve invloed hebben op de zeeleiding en de stabiliteit daarvan. Op hoofdlijnen zijn twee verschillende effecten te beschrijven:

- *Zijwaartse druk op de leiding*: Dit is met name wanneer de leiding op de bodem ligt en niet is ingegraven. In de loop van de tijd kan dit negatieve invloed hebben op de stabiliteit van de zeeleiding. De zijwaartse beweging van de zandbanken kan de leiding ‘opzij duwen’ met zelfs, in theorie, een mogelijke breuk tot gevolg.
- *Hoogteverschillen*: De zandgolven met de steile lijzijde die in de loop van de tijd veranderen, kunnen de bodem onder de zeeleiding veranderen en met de grote hoogteverschillen ook resulteren in een breuk van de leiding.

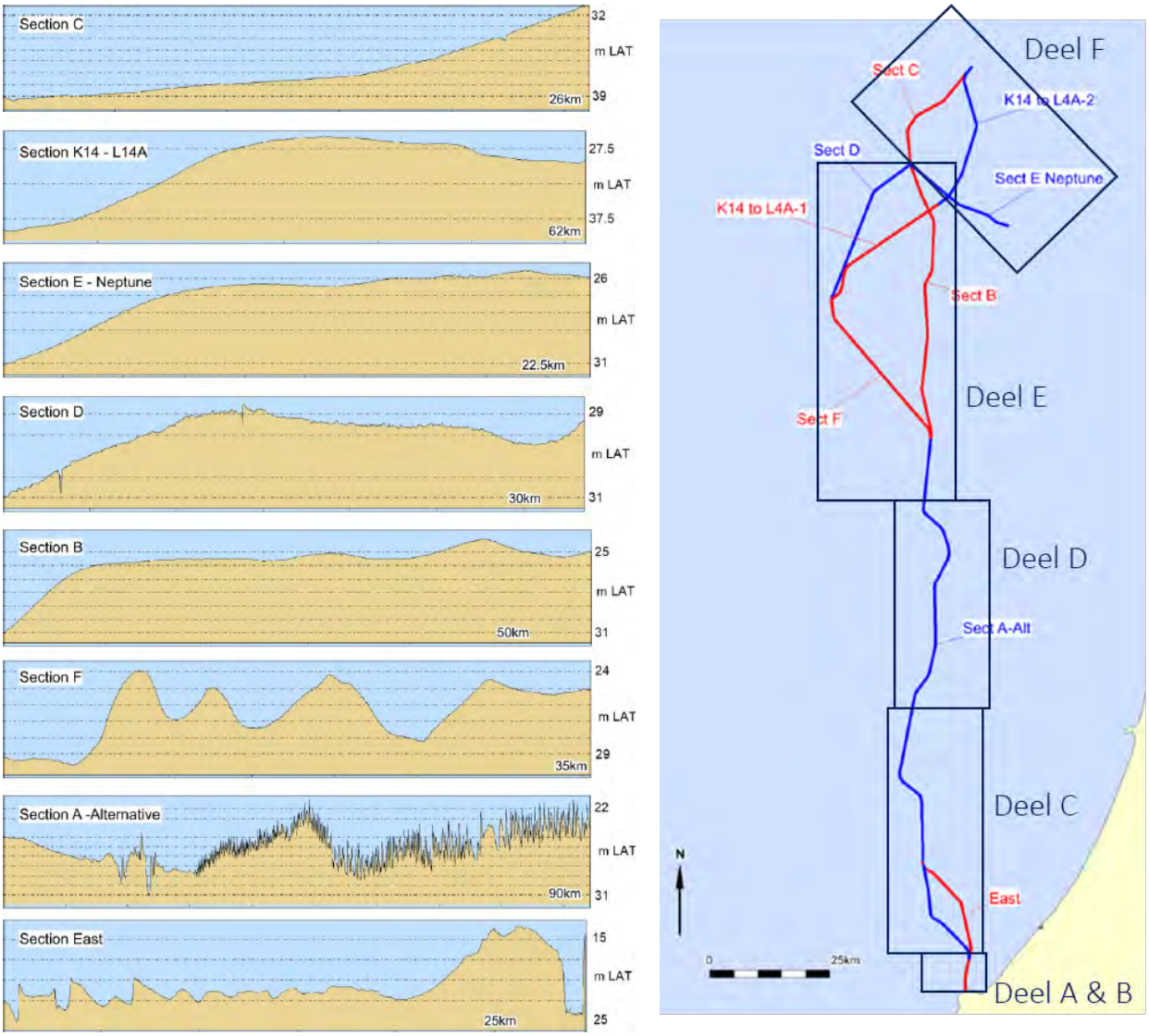
De invloed van de morfologie op de zeeleiding is geen onderdeel van de effectbeoordeling. Echter, deze principes dienen meegenomen te worden in het ontwerp en de realisatie van de leiding om de integriteit van de leiding te waarborgen.

6.1.2 Invloed bodemberoering op de morfologie

De invloed van de leiding op de morfologie wordt bepaald door de bodemberoering. Voor het realiseren van de leiding wordt de leiding ingegraven of op de bodem gelegd. Hiervoor zal er gegraven worden en op sommige locaties enkele meters, om onder het dynamische profiel van de zeebodem te komen. Op die manier ondervindt de leiding niet de effecten van de migrerende zandbanken en -golven, zoals beschreven in de vorige paragraaf.

6.1.3 Effectbeoordeling morfologie

Het Fugro rapport hanteert een verdeling in *secties* en in de beoordeling wordt er naar 6 *delen* gekeken. In onderstaande Figuur 6-1 zijn de zeebodemprofielen per sectie aangegeven met daarbij een kaart waarop zowel de sectie indeling als de delen voor de beoordeling zijn weergegeven. In Tabel 6.1 is dit ook in tabelvorm weergegeven.



Figuur 6-1 - Zeebodem profielen per sectie van noord naar zuid) en het overzicht van de secties met de aanduiding van de delen (rechts) (bron: Periplus rapport, figuur 4 en 5 (welke is aangevuld met de delen))

Tabel 6.1 - Vergelijking sectienummering gehanteerde kaarten

Indeling *delen*	Indeling *secties*
Deel A – Direct Pipe	Eerste stuk van sectie A - Alt (2 km)
Deel B – Tunnel	East
Deel C – Ingraven en leggen	Tweede stuk van sectie A-Alt (tot 70km)
Deel D – Leggen (indien nodig ingraven)	Derde stuk sectie A-Alt (70 – D-Hub 153,4 km)
Deel E – Leggen (indien nodig ingraven)	B, F, D, K14 to L4A-1
Deel F – Leggen (mogelijk ingraven)	C, K14 to L4A-2, E-Neptune

In Deel A en B zal de zeeleiding onder de Maasgeul door lopen, via een tunnel of direct pipe. In beide gevallen ligt de leiding voldoende diep onder de vaargeul en onder de zeebodem. De zeebodem en de morfologie worden hierdoor niet beïnvloed. De beoordeling voor deze delen is daarom neutraal (0).

Tabel 6.2 - Effectbeoordeling Morfologie in de aanlegfase (Deel A en B)

Criteria	Aspect	Kruising Maasgeul	
		Tunnel (Deel B)	Direct Pipe (Deel A)
Water	Morfologie	0	0

Zoals in Figuur 6-1 en Tabel 6.1 is te zien, komen Deel C en D overeen met de sectie “A-Alt”. Dit gebied kenmerkt zich door significante zandgolven en in het noordelijke deel ook zandbanken die dynamisch bewegen. Deze bewegingen zijn dynamisch genoeg om in potentie een effect te kunnen hebben op de stabiliteit van de zeeleiding. In het ontwerp dient hier rekening mee gehouden te worden. Een optie is om deze zeeleiding onder het dynamische profiel in te graven, zodat deze effecten niet op kunnen treden. Hiervoor dient er wel op sommige trajecten diverse meters diep gegraven te worden. Dit geldt voor deel C. Deze bodemberoering zorgt voor een minimale aanpassing van de zeebodem die van tijdelijke aard is. Immers, de leiding wordt ook weer afgedekt. Deze bodemberoering zal geen invloed hebben op de grootschalige morfologie; de zandbanken en zandgolven zullen hierdoor niet anders verplaatsen. De score is daarom neutraal (0) voor deel C. De zeeleiding in deel D wordt gelegd, evenals een deel van deel C. In het ontwerp en de realisatie dient rekening gehouden te worden met de verplaatsingen van de zandbanken en de zandgolven, die invloed kunnen hebben op de zeeleiding. De zeeleiding zelf - en de minimale bodemberoering die plaatsvindt bij het leggen - heeft geen effect op de morfologie. Ook hier geldt dat de zandbanken en zandgolven hierdoor niet anders zullen verplaatsen. De score voor deel D is daarom ook neutraal (0).

Tabel 6.3 - Effectbeoordeling Morfologie in de aanlegfase (Deel C en D)

Criteria	Aspect	Zeeleiding leggen (Deel D)	Zeeleiding ingraven en leggen (Deel C)
Water	Morfologie	0	0

De leiding wordt op de zeebodem gelegd van de inlaat naar de Hub area (deel E) en niet ingegraven. Er vindt niet tot nauwelijks bodemberoering plaats. Daarnaast is de morfologische dynamiek in dit gebied ook zeer beperkt. Er is daarmee geen effect op de morfologie en wordt daarom neutraal gescoord (0). Dit geldt ook voor Deel F. Hier is de bodem nauwelijks dynamisch en is het bodemprofiel redelijk vlak en glad. Het leggen van de zeeleiding zal hier ook geen invloed hebben op de morfologie. Ook hier is de beoordeling daarom neutraal (0).

Tabel 6.4 - Effectbeoordeling Morfologie in de aanlegfase (Deel E en F)

Criteria	Aspect	Zeeleiding leggen (Deel E)		Zeeleiding leggen (Deel F)
		Knooppunt op zeebodem	Platform installatie voor knooppunten	
Water	Morfologie	0	0	0

De effectbeoordeling is voor alle delen neutraal gescoord. Voor de verschillende alternatieven is dit ook het geval. Er vindt beperkte bodemberoering plaats, waarbij geen effect te verwachten is op de morfologie tijdens de aanlegfase.

Tabel 6.5 - Effectbeoordeling Morfologie in de aanlegfase voor de alternatieven

Criteria	Aspect	Alternatief 1 (West 1)		Alternatief 2 (West 2)		Centrale route
		1A	1B	2A	2B	3
Water	Morfologie	0	0	0	0	0

6.2 Vertroebeling

Effecten op de zeebodem heeft betrekking op het aspect **vertroebeling**. Vertroebeling is een gevolg van in een ingreep op:

- op het bodemreliëf,
- bodemberoering én
- verandering van bodemkwaliteit/temperatuur.

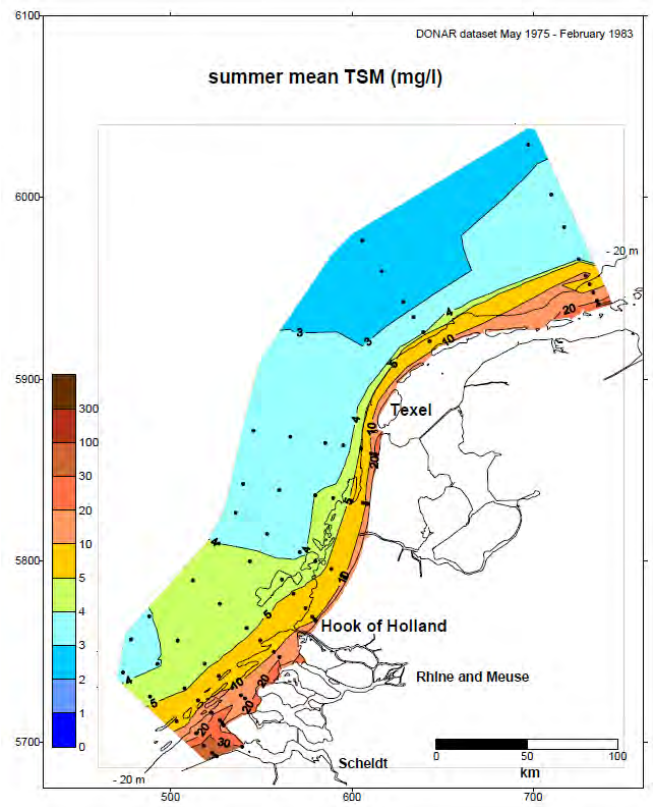
Het trenchen van de zeeleiding veroorzaakt mogelijk sedimentverschuivingen waarbij voedingsstoffen en schadelijke stoffen kunnen vrijkomen. Dit wordt **vertroebeling** genoemd. De effecten komen voornamelijk via de voedselketen tot uiting, omdat primair de prooidieren worden getroffen. De zoogdieren staan aan de top van de marine voedselketen en worden als gevolg van bioaccumulatie (het ophopen van toxische stoffen in de voedselketen) bijzonder bedreigd door giftige stoffen in het milieu. Door de werveling van het sediment tijdens de aanleg ontstaan vertroebelingspluimen die bijvoorbeeld de oriëntering van jagende, via sonar navigerende bruinvissen kunnen belemmeren. In de zuidelijke Noordzee bestaat echter een aanzienlijke natuurlijke vertroebeling die wordt veroorzaakt door plankton, door de wind en door de getijden.

6.2.1 Vertroebeling bij aanleg van de Zeeleiding

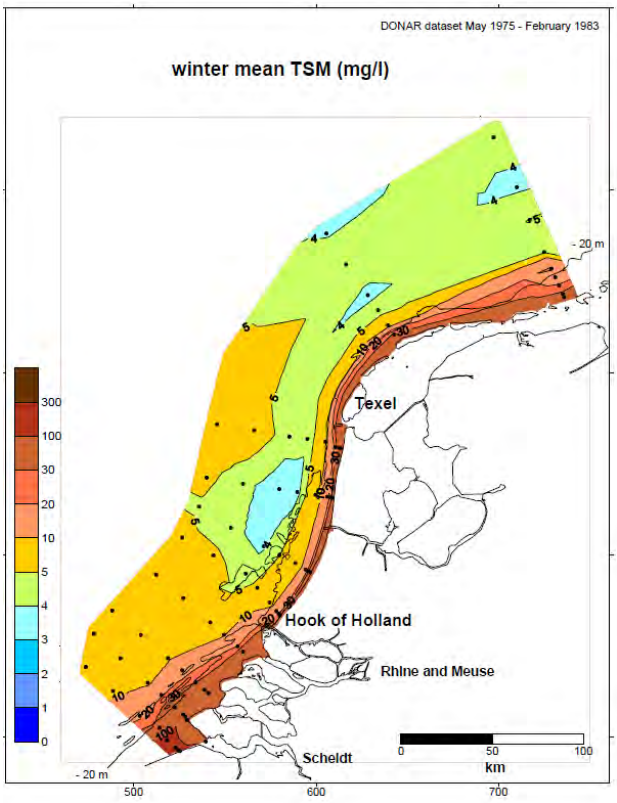
Zeestroming en slibpercentage in het water (vertroebeling)
Bij de aanleg van de zeeleiding wordt sediment van de zeebodem gebaggerd om de leiding te begraven en er wordt gebruik gemaakt van trenching gereedschap. Bij het baggeren en trenchen komt sediment en slib in suspensie wat gevolgen kan hebben voor het ecosysteem.

In deze studie zijn de concentraties van sediment dat in suspensie komt en de hoeveelheid sedimentatie benaderd met een gesimplificeerd model. De verspreiding van het sediment dat in suspensie komt is benaderd aan de hand van de getijdestroming en de valsnelheden van het fijne sediment.

De verhoging in sedimentconcentraties door het aanleggen van de zeeleiding worden vergeleken met de achtergrondconcentratie in de Noordzee van 3 tot 100 mg/L (Suijlen & Duin, 2002). Figuur 6-2 en Figuur 6-3 geven kaarten van de gemiddelde sedimentconcentraties in de Noordzee voor de zomer en winter. Over het algemeen is de sedimentconcentratie dichter bij de kust duidelijk hoger dan verder van de kust.



Figuur 6-2 - Zomergemiddelden van totale zwevende sediment concentraties nabij het oppervlak (1 mei – 31 oktober) (Suijlen & Duin, 2002).



Figuur 6-3 - Wintergemiddelden van totale zwevende sediment concentraties nabij het oppervlak (1 december – 31 maart) (Suijlen & Duin, 2002).

Werkzaamheden

De volgende alinea's beschrijven de werkzaamheden bij het aanleggen van de zeeleiding die vertroebeling en bodemberoering kunnen veroorzaken.

Kruising Maasgeul

Voor het kruisen van de Maasgeul zijn twee alternatieven onderzocht: tunnel (of mogelijk segmented tunnel) en direct pipe, ieder met een eigen route. In Figuur 6-4 zijn beide routes weergegeven. Bij het tunnelalternatief wordt onder de zeewering en Maasgeul doorgeboord over een afstand van circa 2 kilometer. Bij Direct pipe wordt onder de zeewering geboord over een lengte van circa 600 meter en vervolgens een sleuf gebaggerd in de Maasgeul voor de kruising van de Maasgeul. Dit leidt tot een grotere hoeveelheid bagger, zoals blijkt uit onderstaande gegevens:

1. Direct pipe een baggervolume van ongeveer 708.000 m^3
2. Tunneling een baggervolume van ongeveer 2.020 m^3

Bij het baggeren komt sediment in suspensie dat zorgt voor vertroebeling in het water. De stroming op dit punt is complex en wordt beïnvloed door getijdestroming, afvoer van de Nieuwe Waterweg en de aanwezigheid van de Maasvlakte 2. Op dit deel van de Nieuwe Waterweg wordt al veel gebaggerd om de toegang tot de haven van Rotterdam bevaarbaar te houden.



Figuur 6-4 - Alternatieve routes van de nearshore zeeleiding en kruising van de Maasgeul.

Aanleg zeeleiding
Ten noorden van de Maasgeul wordt de zeeleiding via een schip waar mogelijk op de zeebodem geplaatst. Op verschillende locaties wordt de zeeleiding ingegraven, dit gebeurt bij het kruisen van vaarroutes en leidingen, bij een kleine waterdiepte en mogelijk bij een onstabiel zeebed. De totale ingegraven lengte bedraagt naar verwachting circa 110 kilometer. De eerste 65 kilometer wordt ingegraven vanwege de kleine waterdiepte. Het gelegde deel van de zeeleiding bevat meerdere kruisingen met bestaande infrastructuur op de zeebodem, naar verwachting gaat dit om circa 45 kruisingen van gemiddeld 150 meter. Er kan lokaal vertroebeling optreden bij deze kruisingen, maar dit gaat om kleine hoeveelheden en is niet meegenomen in deze studie.

Uitgangspunten
Bij het bepalen van de vertroebeling door bodemberoering zijn een aantal aannames gedaan die in dit hoofdstuk zijn beschreven.

Aanleg zeeleiding
Bij het ingegraven deel van de zeeleiding wordt gebruik gemaakt van een trencher. Deze machine graaft een trapeziumvormige sleuf waar de zeeleiding in zakt en bedekt de leiding vervolgens met het verplaatste zand. De trapeziumvormige sleuf heeft een diepte van 2 meter en is aan de bovenkant 6 meter breed en aan de onderkant 2 meter breed. De dwarsdoorsnede heeft dus een oppervlak van 8 m². Voor berekening van de vertroebeling wordt ervan uitgegaan dat 25% van het verplaatste sediment in suspensie komt op een hoogte van gemiddeld 1 meter vanaf de zeebodem. Dat betekent dat er 2 m^3 sediment per meter geullengte in suspensie komt. Bij het bepalen van de vertroebeling wordt uitgegaan van een snelheid van de trencher van 2.1 meter per minuut.

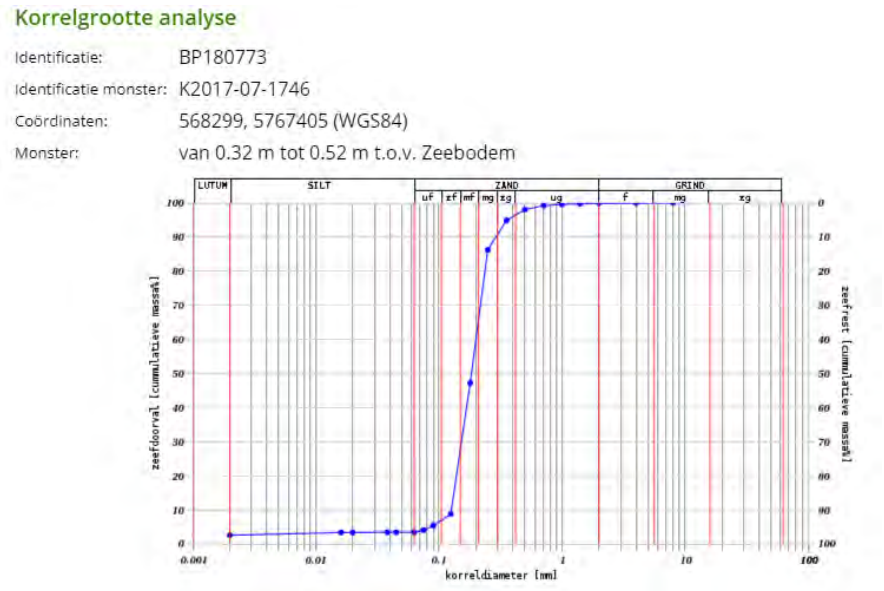
Bodemsamenstelling

De bodemsamenstelling is van belang om te bepalen hoeveel fijn sediment er in suspensie komt. Grof sediment (grof zand en grind) zakt vrijwel direct naar de zeebodem neer en is daarom niet van belang voor de vertroebeling. De bodemsamenstelling is gebaseerd op een korrelgrootteanalyse dichtbij het tracé van de zeeleiding. Figuur 6-5 geeft een overzicht van de korrelgrootteanalyse. Op basis van deze analyse is de bodemsamenstelling opgedeeld in 4 fracties fijn sediment. De aangenomen waardes staan in Tabel 6.6. De valsnelheden zijn berekend met vergelijking 1 (Ieperen, 1987). Het matig fijne zand en grove zand maakt ongeveer 80% van de bodem uit, en heeft een valsnelheid tussen de 27 en 60 mm/s en slaat dus relatief snel neer op de bodem. Dit zorgt ervoor dat binnen ongeveer 10 meter van de zeeleiding bodemberoering ontstaat door het neerslaan van het grove zand. De grove fracties worden verder niet meegenomen met het bepalen van de pluim.

$$w = \frac{1}{24.42} \cdot \frac{\Delta \cdot g \cdot D^2}{\nu} \qquad \text{Eq 1}$$

- w = valsnelheid [m/s]
- Δ = relatieve dichtheid = 1.65
- g = gravitatie versnelling =9.81 [m/s^2]
- D = korreldiameter [m]

V = kinematische viscositeit water =10^{-6} [m^2/s]



Figuur 6-5 - Korrelgrootte analyse van de bodem in de Noordzee, dicht bij het tracé van de zeeleiding. (DINOloket)

Tabel 6.6 - Overzicht van het fijne sediment in de bodem en de eigenschappen

Soort sediment	Aandeel gewicht [%]	Korrelgrootte [mm]	Val snelheid [mm/s]
Zeer fijn zand	3	0,1	6,63
Uiterst fijn zand	3	0,07	3,25
Silt	1	0,01	0,066
Klei	2,5	0,001	0,00066

Sediment transport

Het sediment dat in suspensie komt wordt vervoerd door de stroming van het getij. Langs de Nederlandse westkust loopt de getijdestroming vrijwel parallel langs de kustlijn. In het projectgebied is de getijdestroming ongeveer richting het noordoosten bij vloed en richting het zuidwesten bij eb. Bij het gesimplificeerde model wordt aangenomen dat de richting van de eb- en vloedstroming over de hele zeeleiding gelijk is en in tegengestelde richting. Er is aangenomen dat de richting van het getij 50 graden is ten opzichte van het noorden en dat de stroomsnelheid een amplitude heeft van 0,7 m/s7. Daarnaast wordt het getijdesignaal benaderd met een sinusgolf met een periode van 12 uur. Dit resulteert in de volgende benodigde parameters:

- Een gemiddelde stroomsnelheid tijdens een halve periode van 0,446 m/s
- De maximum afgelegde afstand van de waterkolom tijdens een halve periode 9.625 m,

De afstand die het sediment aflegt, hangt af van de hoogte van de pluim, de valsnelheid en de stroomsnelheid van het getij. Grover sediment zal binnen een halve periode op de bodem neerslaan, terwijl fijner sediment langer in suspensie blijft en daardoor op en neer beweegt met het getij. De maximum afgelegde afstanden van de verschillende soorten sediment is berekend met onderstaande formule en de resultaten worden weergegeven in Tabel 6.7.

$$Max\ afstand = min\left(\frac{h_{pluim}}{w} \cdot v_{gem};\ \ 9625\right) \qquad \textbf{Eq 2}$$

- w = valsnelheid [m/s]
- h_{pluim} = gemiddelde hoogte van de pluim =1 [m]
- v_{gem} = gemiddelde stroomsnelheid getij =0,446 [m/s]

Tabel 6.7: Maximum afgelegde afstanden van de verschillende soorten sediment voor het neerslaan op de bodem

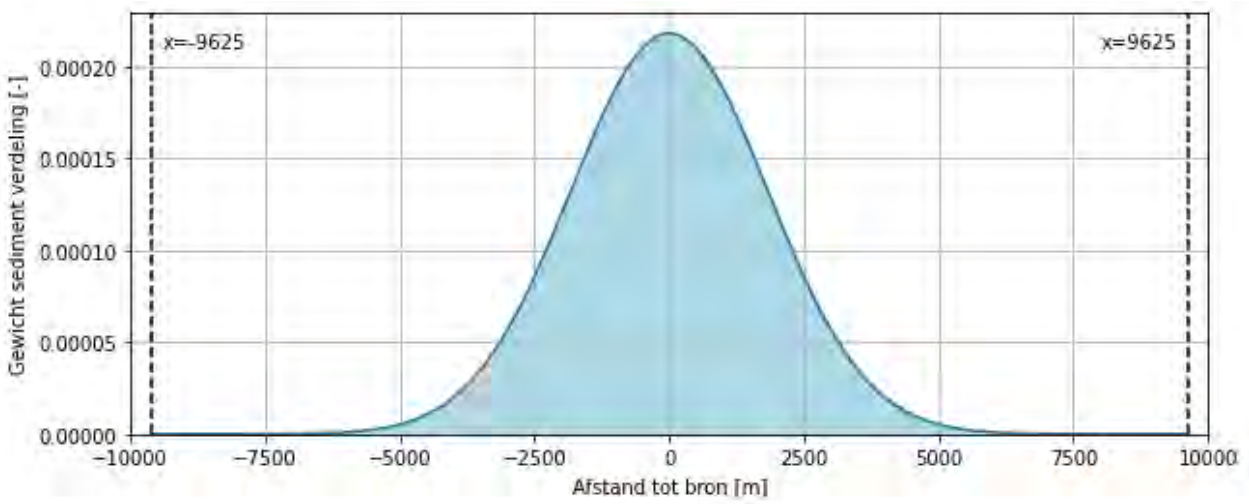
Soort sediment	Berekende afstand [m]	Gebruikte afstand [m]
Zeer fijn zand	67,3	67,3
Uiterst fijn zand	137,2	137,2
Silt	6757,6	6757,6
Klei	675757,6	9625

Een fit van een normale verdeling op de concentraties en afstanden is gebruikt om de ruimtelijke verdeling van het fijne sediment te modelleren en wordt weergegeven in Figuur 6-6. Vervolgens is over het hele tracé van de zeeleiding het sediment verdeeld met deze verdeling in verschillende tijdstappen, waarbij het totaal te verdelen sediment gelijk was aan het product van de tijdstap en de bronterm. Met deze methode wordt een gemiddelde verdeling van het sediment berekend, maar in werkelijkheid kunnen de maximumwaarden hoger zijn. De verdeling van het sediment hangt af van het moment waarop getrencht wordt en de op dat moment optredende stroomrichting en snelheid.

[7] *Voor de benadering van het sediment transport is een stroomsnelheid van 0,7m/s aangehouden. Dit is de stroomsnelheid aan de kust. Verder offshore en bij de HUB kan deze lager zijn. Dit betekent dat het sediment dichterbij het tracé neerslaat. De sedimentatie dikte zal daarmee hoger zijn. Het gebied waar sediment neerslaat is in deze benadering dus groter dan in werkelijkheid zal optreden in het gebied buiten de kuststrook. De hoeveelheid sediment die in suspensie wordt gebracht blijft hetzelfde, deze is niet afhankelijk van de stroomsnelheid.*

Tabel 6.8: Overzicht van de parameters voor de bepaling van de vertroebeling.

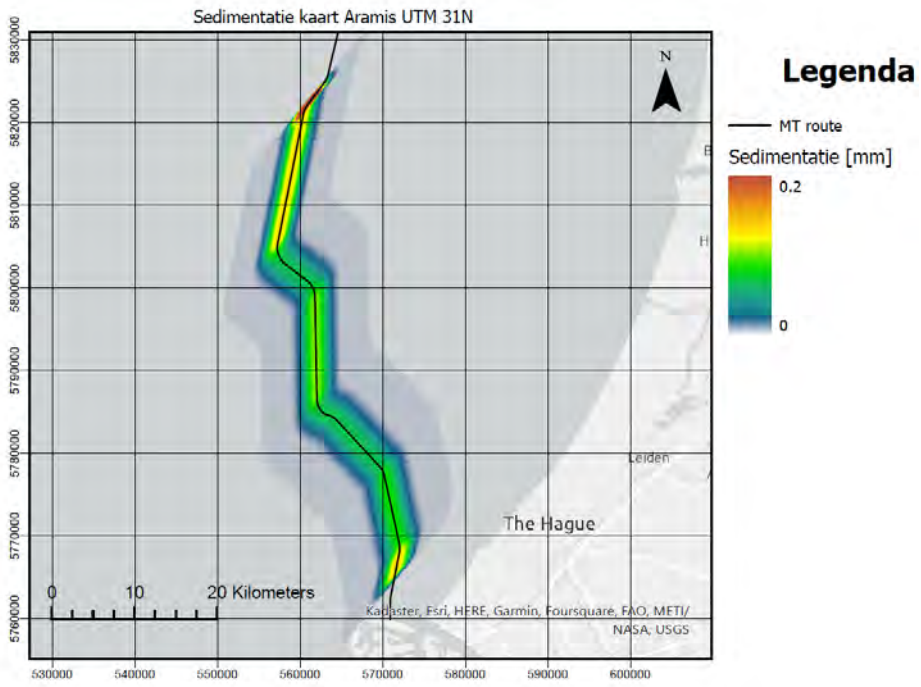
Overzicht bodemberoering en vertroebeling	
Lengte trace [m]	65.080
Breedte trencher [m]	6
Oppervlak omgewoelde bodem [m^2]	390.480
Volume sediment in suspensie per m trace [m^3/m]	2
Totaal volume sediment in suspensie [m^3]	130.160
Snelheid trencher [m/s]	0,035
Volume per seconde [m^3/s]	0,07
Dichtheid bodem [kg/m^3]	1860
Gewicht per seconde [kg/s]	130,2
Gewicht fijn sediment per seconde [kg/s]	12,4



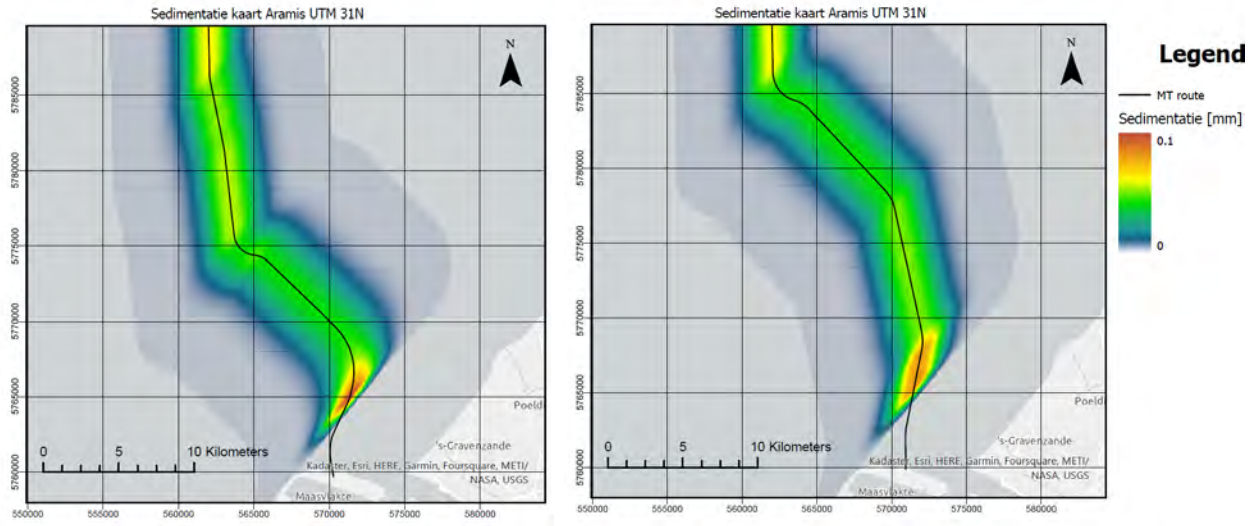
Figuur 6-6 - Verdeling van het sediment in de stroomrichting, gebaseerd op de gemiddelde stroomsnelheid en valsnelheden van de fijne sediment fracties.

Resultaten

Figuur 6-7 toont het ruimtelijk beeld met sedimentatie waardes voor het fijne sediment voor het aanleggen van de zeeleiding tot KP70. De analyse is uitgevoerd voor beide routes, Direct Pipe en Tunnel, en de sedimentatie rond de Maasgeul voor beide alternatieven is weergegeven in Figuur 6-8 en Figuur 6-9. Het aandeel fijn sediment is laag (9.5%) en de hoeveelheid sediment die in suspensie is gebracht is klein ten opzichte van het gebied waarover dit is verspreid, de maximum sedimentatie waardes blijven daarom ook laag (0.2 mm). De sedimentatiewaarden zijn mede afhankelijk van de oriëntatie van het tracé ten opzichte van de richting van de getijdestroming: de hogere sedimentatiewaardes treden op locaties waar het tracé meer in dezelfde richting gaat als de getijdestroomrichting.



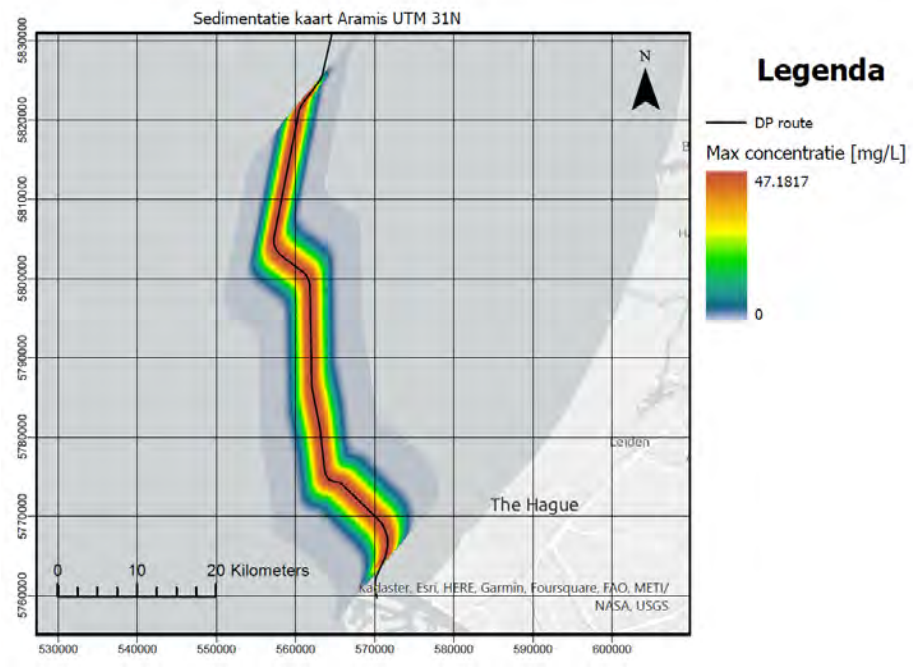
Figuur 6-7 - Kaart van de sedimentatie waardes voor de tunnel route.



Figuur 6-8 - Sedimentatie rond de Maasgeul voor de Direct pipe route.

Figuur 6-9 - Sedimentatie rond de Maasgeul voor de Tunnel route.

De maximum sedimentconcentratie, weergegeven in Figuur 6-10, treedt op vlak langs het tracé van de zeeleiding. Dit komt voornamelijk door het grovere sediment en deze deeltjes slaan ook weer snel neer op de zeebodem. De sedimentconcentraties verder van de zeeleiding zijn een stuk lager en zijn vergelijkbaar met de achtergrondconcentratie van 3-100 mg/L. De kaarten tonen alleen het fijne sediment; niet het grotere aandeel zand dat binnen 10 meter van de zeeleiding neerslaat. De bodem die hierdoor beroerd wordt heeft een oppervlakte van ongeveer 130 hectare (2x10 meter breed en 65.000 meter lang).



Figuur 6-10 - Maximum opgetreden concentraties langs het tracé van de zeeleiding.

6.2.2 Effectbeoordeling vertroebeling

In deze studie is een inschatting gemaakt van de toename in sedimentatie en sedimentconcentratie als gevolg van de aanleg van de zeeleiding van het Aramis initiatief. De resultaten laten zien dat als gevolg van het relatief kleine aandeel fijn sediment in de zeebodem de sedimentconcentraties en sedimentaties relatief laag blijven. De eventuele invloed van vertroebeling op natuurwaarden is opgenomen in de ecologische studies.

Vertroebeling aanlegfase

Voor het kruisen van de Maasgeul (deel A en B) worden twee opties overwogen, direct pipe en tunnel. De kruising van de Maasgeul heeft bij:

1. Direct pipe een baggervolume van ongeveer 708 000 m^3 heeft een licht negatief effect (-).
2. Tunnel een baggervolume van ongeveer 2020 m^3 heeft een neutraal effect (0).

Bij het baggeren komt sediment in suspensie dat zorgt voor vertroebeling in het water. De stroming op dit punt is complex en wordt beïnvloed door getijde stroming, afvoer van de Nieuwe waterweg en de aanwezigheid van Maasvlakte 2.

Tabel 6.9 - Effectbeoordeling Vertroebeling in de aanlegfase (Deel A en B)

Criteria	Aspect	Kruising Maasgeul	
		Tunnel (Deel B)	Direct Pipe (Deel A)
Water	Vertroebeling	0	-

Voor deel C is het effect op de vertroebeling van water licht negatief (-) in geval van de spuitlans. Door het kleine aandeel fijn sediment blijven de concentraties en sedimentatie hoeveelheden laag. De achtergrondconcentraties in de Noordzee variëren tussen de 3 tot 100 mg/L. Rond de zeeleiding zal deze concentratie voor een korte periode toenemen, maar de grovere fracties slaan snel neer op de bodem. Het fijnste sediment zal langer in suspensie blijven, maar ook over een groot gebied verspreiden en

daarom relatief lage concentraties hebben. De hoeveelheid sedimentatie heeft een maximum van 0,2 mm, wat maar op een relatief klein oppervlak optreedt. De sedimentatie in het grootste deel van het beroerde gebied zal verwaarloosbaar klein zijn. De sedimentatie van grof sediment is niet gemodelleerd, omdat is aangenomen dat dit type sediment binnen 10 meter naast de zeeleiding neerslaat. Vanuit het aspect morfologie zijn geen mitigerende maatregelen nodig.

In de variant 'overvloeien' wordt de leiding begraven door met hogedruk het zand weg te spoelen, zodat de leiding in de bodem zakt (-). De sedimentpluim wordt hierdoor wat hoger, waardoor het gebied waarover de grovere fracties verspreiden iets groter wordt. Daarnaast komt er ook per meter meer sediment in suspensie dan in het geval van de spuitlans.

Voor een deel van Sectie C en Secties D, E en F wordt de Zeeleiding gelegd. In dit deel worden van tevoren rectificerende maatregelen genomen zoals pre-sweeping in geval van bijvoorbeeld zandgolven d.m.v. baggeren. Indien eventuele freespans nog te lang en te hoog zijn (zelfs na pre-sweeping) kunnen deze delen van de Zeeleiding nog extra ondersteuning krijgen door "rockdumpen". Het effect van dergelijke maatregelen op vertroebeling is verwaarloosbaar klein.

Tabel 6.10 - Effectbeoordeling Vertroebeling in de aanlegfase (Deel C en D)

Criteria	Aspect	Zeeleiding leggen (Deel D en Deel C)	Zeeleiding ingraven (Deel C)	
			Voorgenomen activiteit Spuitlans	Variant 1 Overvloeien
Water	Vertroebeling	0	-	-

Tabel 6.11 - Effectbeoordeling Vertroebeling in de aanlegfase (Deel E en F)

Criteria	Aspect	Zeeleiding leggen (Deel E)		Zeeleiding leggen (Deel F)
		Knooppunt op zeebodem	Platform installatie voor knooppunten	
Water	Vertroebeling	0	0	0

Tabel 6.12 - Effectbeoordeling Vertroebeling in de Aanlegfase voor de alternatieven

Criteria	Aspect	Alternatief 1 (West 1)		Alternatief 2 (West 2)		Centrale route
		1A	1B	2A	2B	3
Water	Vertroebeling	0	0	0	0	0

Mitigerende maatregelen
Vanuit het aspect Vertroebeling zijn geen mitigerende maatregelen nodig. De eventuele invloed van vertroebeling op natuurwaarden is opgenomen in de ecologische studies.

6.3 Archeologie

6.3.1 De AMZ - Cyclus

Het werkproces archeologie, ook wel het proces van Archeologische Monumentenzorg (AMZ) genoemd, verloopt in de regel in verschillende stappen of fasen. Elke stap of fase eindigt met een afweging of er voldoende informatie is verzameld om een afgewogen beslissing te kunnen nemen over eventuele vervolgacties. In het proces worden de volgende hoofdprocessen onderscheiden voor onderzoek op land- en waterbodems:

- bureauonderzoek;

- inventariserend veldonderzoek;
- archeologische begeleiding (alleen waterbodems);
- opgraven;
- fysiek beschermen/behoud in situ

Aan de hand van een bureauonderzoek wordt bepaald of er sprake kan zijn van archeologische waarden in een gebied. Met een inventariserend veldonderzoek wordt vervolgens gekeken of er archeologische waarden aanwezig zijn. Meestal gebeurt dit in de vorm van een verkennend booronderzoek. Als er sprake is van een vindplaats vindt de waardering daarvan meestal plaats in de vorm van een proefsleuvenonderzoek.

Bij waterbodems vindt de inventarisatie plaats in de vorm van een opwaterfase en een onderwaterfase. Hierbij wordt gebruik gemaakt van bijvoorbeeld sonar technieken, eventueel gevolgd door inventariserend duikonderzoek. De inventarisatie bij land- en waterbodems wordt afgerond met een waardering en een (selectie)advies aan de bevoegde overheid. Meestal is dit een gemeente. In de praktijk bestaat het selectieadvies uit drie keuzemogelijkheden:

1 Behouden in situ (fysiek beschermen)
2 Vrijgeven
3 Opgraven

6.3.2 Positie onderzoek MER in AMZ cyclus

De huidige analyse (Periplus Archeomare, 2023) van geofysische onderzoeksresultaten is de tweede en volgende stap in de AMZ-cyclus, volgend op de bureaustudie. Het doel van deze beoordeling was om de op bureaustudie gebaseerde verwachting voor archeologische overblijfselen in het gebied te testen. De verwachting omvat resten van aan de scheepvaart gerelateerde objecten (wrakken), vliegtuigen uit de Tweede Wereldoorlog en prehistorische nederzettingen.

Periplus Archeomare adviseert verder archeologisch onderzoek uit te voeren dat zich richt op het ontstaan en de integriteit van paleolandschappen langs de trajecten van de Aramis-route. Dit voor algemene archeologische onderzoeksdoeleinden.

Zulk onderzoek omvat een inventarisatie van veldonderzoek door middel van vibrocore-bemonstering conform de Nederlandse Kwaliteitsnorm Archeologie (KNA Waterbodems 4.1). Er wordt een geotechnische campagne uitgevoerd om een geologisch model te genereren van de ondergrond van de zeeleiding route en om de fysische eigenschappen van de aanwezige sedimentlagen te bepalen. Het verdient aanbeveling om een aantal vibrocore-locaties aan te wijzen waar sedimentmonsters worden verzameld die uitsluitend worden gebruikt voor geo-archeologisch onderzoek.

De intacte monsters moeten door een (senior) prospector worden onderzocht en beschreven volgens de Standaard Boorbeschrijvingsmethode (SBB). Monsters worden geselecteerd en gestabiliseerd om te worden geanalyseerd door specialisten op het gebied van OSL- en radiokoolstofdatering, sedimentpetrografie, palynologie, micropaleontologie (foraminiferen, ostracoden, diatomeeën, et cetera), macroresten van planten en dieren en weekdieren om inzicht te krijgen in de ontwikkeling van landschappen in de tijd en de mate waarin deze paleolandschappen bewaard zijn gebleven.

Conform de Nederlandse Kwaliteitsnorm Archeologie (KNA Waterbodems 4.1) dient een Programma van Eisen (PvE) en/of Plan van Aanpak (PvA) te worden opgesteld. Dit PvE/PvA bevat de doelstelling, de onderzoeksstrategie en -methodiek, de kaders en de praktische uitvoering van het onderzoek, zodat het proces soepel verloopt en meervoudig gebruik van de verkregen data op uniforme wijze wordt

gerealiseerd. Het verdient aanbeveling om deze PvE/PvA ter goedkeuring voor te leggen aan het Bevoegd Gezag en de RCE. Na afronding van het inventariserend veldonderzoek, tijdens de aanleg van de Zeeleiding en bouw van D-Hub en platforms, kunnen gegevens worden verzameld dat – vanuit archeologisch oogpunt – waardevolle informatie op detailniveau oplevert. Het kan zeer nuttig zijn om deze informatie vanuit archeologisch oogpunt nader te onderzoeken. Het verdient aanbeveling om, nadat de plannen zijn uitgewerkt, in overleg met de RCE de mogelijkheden hiervoor te onderzoeken.

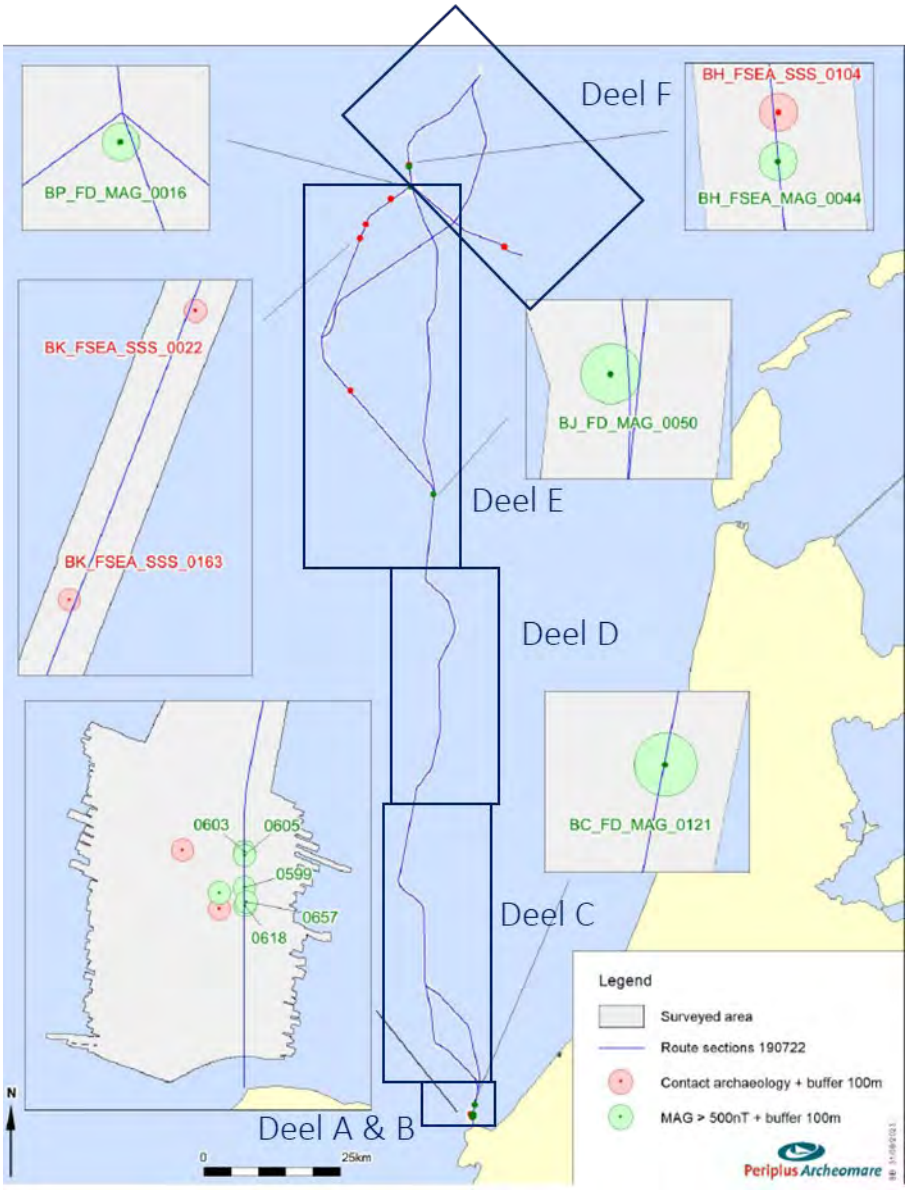
6.3.3 Effectbeoordeling Archeologie

In paragraaf 4.2.2 zijn de resultaten van de archeologische survey weergegeven en beschreven. Diverse contacten en anomalieën zijn tijdens de survey gevonden. De drie contacten en negen anomalieën met een mogelijke archeologische waarde die binnen een zone van 100 meter van de zeeleiding zijn gelegen, zijn relevant voor de effectbeoordeling. Deze locaties zijn in onderstaande tabel en in Figuur 6-11 weergegeven.

Tabel 6.13 - Overzicht contacten en anomalieën binnen een zone van 100 meter van de zeeleiding

Contacten	Aanwezig in deel
BK_FSEA_SSS_0022	E (sectie D in Fugro/Periplus survey)
BH_FSEA_SSS_0104	F (sectie C in Fugro/Periplus survey)
BK_FSEA_SSS_0163	E (sectie D in Fugro/Periplus survey)

Anomalieën	Aanwezig in deel
BAB_FS_UXO_0599	B (sectie East in Fugro/Periplus survey)
BAB_FS_UXO_0603	B (sectie East in Fugro/Periplus survey)
BAB_FS_UXO_0605	B (sectie East in Fugro/Periplus survey)
BAB_FS_UXO_0618	B (sectie East in Fugro/Periplus survey)
BAB_FS_UXO_0657	B (sectie East in Fugro/Periplus survey)
BC_FD_MAG_0121	B (sectie East in Fugro/Periplus survey)
BH_FSEA_MAG_0044	F (sectie C in Fugro/Periplus survey)
BJ_FD_MAG_0050	E (sectie F in Fugro/Periplus survey)
BP_FD_MAG_0016	F (sectie B in Fugro/Periplus survey)



Figuur 6-11 - Kaart met de locaties van potentiële archeologisch belang. Rood zijn de contacten en groen de anomalieën.

Voor Deel B zijn er 6 anomalieën gevonden met mogelijk Archeologische waarde. In Deel A zijn geen anomalieën en contacten vastgesteld.

Tabel 6.14 - Effectbeoordeling Archeologie in de aanlegfase (Deel A en B)

Criteria	Aspect	Kruising Maasgeul	
		Tunnel (Deel B)	Direct Pipe (Deel A)
Archeologie	Verstoring	-	0

Voor Deel C en D zijn er geen contacten en anomalieën gevonden met mogelijk Archeologische waarde.

Tabel 6.15 - Effectbeoordeling Archeologie in de aanlegfase (Deel C en D)

Criteria	Aspect	Zeeleiding leggen (Deel D)	Zeeleiding ingraven en leggen (Deel C)
Archeologie	Verstoring	0	0

Voor Deel E zijn er 2 contacten en 1 anomalie gevonden. Voor Deel F is er 1 contact gevonden en 2 anomalieën.

Tabel 6.16 - Effectbeoordeling Archeologie in de aanlegfase (Deel E en F)

Criteria	Aspect	Zeeleiding leggen (Deel E)		Zeeleiding leggen (Deel F)
		Knooppunt op zeebodem	Platform installatie voor knooppunten	
Archeologie	Verstoring	-	-	-

Bij alle varianten zijn contacten en anomalieën gevonden. De verschillen in aantallen zijn klein. Er is daarom geen onderscheid in de beoordeling.

Tabel 6.17 - Effectbeoordeling Archeologie in de aanlegfase voor de alternatieven

Criteria	Aspect	Alternatief 1 (West 1)		Alternatief 2 (West 2)		Centrale route
		1A	1B	2A	2B	3
Archeologie	Verstoring	-	-	-	-	-

Mitigerende maatregelen

Uit het onderzoek blijkt dat tijdens de installatie van de transportleiding archeologische objecten kunnen worden ontdekt die tijdens het geofysisch onderzoek volledig zijn begraven of niet als archeologisch object zijn herkend.

Daar waar de transportleiding te dicht bij een archeologisch waardevol object komt te liggen (binnen 100 meter), zal onderzoek moeten worden gedaan naar het verplaatsen van de ligging van de transportleiding. Indien dit niet mogelijk is, dan is het van belang middels nader onderzoek om vast te stellen of dat wel/niet archeologie is, eventueel met behulp van duikers. Tevens bestaat de mogelijkheid met Rijkswaterstaat en Rijksdienst voor Cultureel Erfgoed (RCE) te bespreken waar de 100 meter afstandsnorm verkleind kan worden, indien kan worden aangetoond dat leggen van transportleiding de bodem verder niet verstoord.

De volgende stap is om passief archeologisch toezicht te houden op basis van een goedgekeurd Programma van Eisen (PvE) (conform de Nederlandse Kwaliteitsnorm voor Archeologie – KNA Waterbodems 4.1). Dit PvE dient ter goedkeuring voorgelegd te worden aan Bevoegd Gezag en de RCE. Passief archeologisch toezicht houdt in dat een archeoloog niet aanwezig is tijdens de uitvoering van de werkzaamheden maar altijd op afroep beschikbaar is. Het opvolgen van dit advies voorkomt vertragingen tijdens de werkzaamheden wanneer onverhoopt archeologische resten worden aangetroffen. Volgens de Erfgoedwet is het verplicht deze bevindingen te melden aan de toezichthouder (Minister van OCW). Deze meldingsplicht moet contractueel ook worden opgenomen in het bestek van het werk.

6.4 NGE (OO, Ontplofbare Oorlogsresten)

De historische bureaustudie leidt tot de conclusie dat de aanwezigheid van NGE's binnen het hele interessegebied varieert van zeker tot verwaarloosbaar, afhankelijk van het type NGE in kwestie. Met name de aanwezigheid van NGE's als gevolg van mijnenvelden, luchtoorlog en het dumpen van munitie wordt als zeker beschouwd. Daarom is er een groot risico dat er NGE's worden aangetroffen binnen het interessegebied.

In paragraaf 4.2.2 zijn de resultaten van de archeologische surveys weergegeven en beschreven. Uit de survey volgt dat er op 10 locaties zijn magnetische anomalieën met een piek-tot-piekwaarde van meer dan 500 nT in kaart gebracht die niet in verband kunnen worden gebracht met bekende objecten zoals transportleidingen of kabels. De objecten die deze anomalieën veroorzaken, zijn niet zichtbaar op side scan sonar- of multi-beam beelden en worden daarom beschouwd als begraven in de zeebodem. In theorie kunnen deze objecten op deze 10 locaties NGE's zijn. Met dit uitgangspunt is de effectbeoordeling bepaald.

6.4.1 Effectbeoordeling NGE (OO)

Vanuit de survey zijn 10 onbekende objecten gevonden die binnen 100 meter van de zeeleiding liggen. De aanwezigheid van de onbekende objecten – en daarmee mogelijke NGE's – worden licht negatief beoordeeld. Het overzicht van de contacten en anomalieën is in Tabel 6.13 en Figuur 6-11 weergegeven. Voor Deel B zijn er 6 anomalieën gevonden. In Deel A zijn geen anomalieën en contacten vastgesteld.

Tabel 6.18 - Effectbeoordeling NGE in de aanlegfase (Deel A en B)

Criteria	Aspect	Kruising Maasgeul	
		Tunnel (Deel B)	Direct Pipe (Deel A)
NGE	Verstoring	-	0

Voor Deel C en D zijn er geen contacten en anomalieën gevonden.

Tabel 6.19 - Effectbeoordeling NGE in de aanlegfase (Deel C en D)

Criteria	Aspect	Zeeleiding leggen (Deel D)	Zeeleiding ingraven en leggen (Deel C)
NGE	Verstoring	0	0

Voor Deel E zijn er 2 contacten en 1 anomalie gevonden. Voor Deel F is er 1 contact gevonden en 2 anomalieën.

Tabel 6.20 - Effectbeoordeling NGE in de aanlegfase (Deel E en F)

Criteria	Aspect	Zeeleiding leggen (Deel E)		Zeeleiding leggen (Deel F)
		Knooppunt op zeebodem	Platform installatie voor knooppunten	
NGE	Verstoring	-	-	-

Bij alle varianten zijn contacten en anomalieën gevonden. De verschillen in aantallen zijn klein. Er is daarom geen onderscheid in de beoordeling.

Tabel 6.21 - Effectbeoordeling NGE in de aanlegfase voor de alternatieven

Criteria	Aspect	Alternatief 1 (West 1)		Alternatief 2 (West 2)		Centrale route
		1A	1B	2A	2B	3
NGE	Verstoring	-	-	-	-	-

7 Milieueffecten tijdens onderhoud en onvoorziene situaties

Dit hoofdstuk gaat in op de effecten die te verwachten zijn tijdens onderhoudswerkzaamheden en onvoorziene situaties.

Het onderhoud aan de leiding vindt plaats door:

- Intern onderzoek met behulp van pigging. Er wordt een instrument door de transportleiding gevoerd, die de wanddikte meet en zo aangeeft waar de wanddikte aangetast is.
- Extern onderzoek met behulp van een onderwatercamera wordt de leiding visueel gemonitord.

Onvoorziene omstandigheden
De onvoorziene omstandigheden die invloed kunnen hebben op de zeebodem zijn:

- Lekkage uit de transportleiding
- Beweging in de zeeleiding ten gevolge van de verplaatsing van zandbanken en zandgolven

In het gebied van het beoogde tracé van de transportleiding zijn zandbanken en zandgolven aanwezig, die dynamisch zijn en migreren. Dit heet regionale morfodynamiek. De typische migratiesnelheden van zandbanken variëren in de zuidelijke Noordzee, waarbij de ruimtelijke variatie een belangrijk aspect is. De dynamiek van de zandbanken kan een significante impact hebben op het ontwerpwerp van de transportleiding fundering en integriteit van de transportleiding. Door deze dynamiek kan de transportleiding op de ene plek sneller verschuiven dan op een andere plek. De spanningen en druk die hierdoor op de leiding komen, kunnen ervoor zorgen dat de leiding beschadigd of breekt.

Ook de dynamiek van de zandgolven (die loodrecht op de zandbanken staan) kan ervoor zorgen dat de leiding beschadigd of breekt. Dit heeft te maken met de vorm van de zandgolven. Deze kenmerken zich door een steile lijzijde. Wanneer de zandgolf zicht verplaatst waar een leiding ligt, kan dat ertoe leiden dat de leiding niet meer op de bodem ligt en erboven ‘hangt’ (freespan). Indien eventuele freespans nog te lang en te hoog zijn (zelfs na pre-sweeping) kunnen deze delen van de Zeeleiding nog extra ondersteuning krijgen door “rockdumpen”.

8 Milieueffecten buiten Aramis scope en cumulatie

Zoals eerder beschreven behoren sommige CCS-ketenonderdelen niet tot het Aramis initiatief. Het is belangrijk om van deze onderdelen op hoofdlijnen wel de milieugevolgen in beeld te brengen. Het betreft immers effecten die mede via het Aramis initiatief ontstaan. Door de effecten van deze onderdelen ook te beschouwen ontstaat een beeld van de gevolgen van de totale CCS keten. Omdat deze onderdelen niet door de Aramis initiatiefnemers worden ondernomen en omdat hierover slechts beperkt informatie beschikbaar is, worden deze milieugevolgen slechts op globaal niveau beschouwd.

De onderdelen buiten de Aramis scope hebben geen invloed op de zeebodem, vertroebeling, archeologie, niet gesprongen explosieven (Ontplofbare Oorlogsrechten) of de bodemtemperatuur.

9 Leemten in kennis en voorstel voor monitoring

Voor het Aramis project zijn in het voorliggende rapport de milieueffecten beschreven voor ‘Zeebodem’. Het gaat dan om de effecten op de Zeebodem gedurende vier beschouwde situaties (de referentiesituatie, gebruiksfase, aanleg & ontmanteling, onderhoud & onvoorziene omstandigheden). De effectbeschrijving is gebaseerd op de beschikbare informatie. In dit hoofdstuk wordt aangegeven met welke leemten in kennis rekening is gehouden en wordt een voorstel voor monitoring beschreven.

Morfologie
Dat de dynamiek van de morfologie een rol speelt en varieert op de Noordzee is in diverse onderzoeken vastgesteld. Echter, de exacte mate van migratie voor deze morfologietypen op de locatie van de toekomstige transportleiding is niet bekend. Bij nadere uitwerking, dienen in het ontwerp en uitvoering passende maatregelen te worden genomen voor deze dynamiek. En dient onderbouwd te worden met berekeningen op welke diepte de Zeeleiding geen relevante invloed meer kan hebben van regionale morfodynamiek.

Indien de leiding op de bodem wordt gelegd, of deels wordt begraven, dient er ook rekening gehouden te worden met de lokale morfodynamiek rondom de transportleiding. Dit betreft de erosie en sedimentatie aan lij- en loefzijde van de transportleiding. Sterke stroming langs of over de transportleiding kan zorgen voor freespans of verzakking van de leiding. Ook hiervoor dienen in de nadere uitwerking van het ontwerp en uitvoering passende maatregelen genomen te worden. Bijvoorbeeld door de zeeleiding extra ondersteuning te geven door “rockdumpen”.

Bodemkwaliteit
Door afgifte van warmte op de omgeving door de zeeleiding zal de bodemtemperatuur lokaal verhogen, wat invloed kan hebben op de bodemkwaliteit. In de beoordeling is aangegeven dat de verwachting van de impact van de temperatuur op de bodemkwaliteit neutraal te scoren is. Een berekening van de warmteafgifte dient nog uitgevoerd te worden om deze beoordeling te onderbouwen.

Archeologie
Als resultaat van de survey, zijn er contacten en anomalieën gevonden binnen 100 meter van de toekomstige leiding, die een mogelijke archeologische waarde kunnen hebben. Het is vanuit deze survey niet te zeggen of dit daadwerkelijk archeologische objecten zijn. De volgende te nemen stappen uit de AMZ-cyclus zullen meer duidelijkheid geven of deze contacten en anomalieën van archeologische waarde zijn:

- Nader onderzoek om vast te stellen of het object wel/niet van archeologische waarde is, eventueel met behulp van duikers;
- In overleg met RWS en RCE of de afstandsnorm van 100 meter verkleind kan worden;
- Passief archeologisch toezicht tijdens de uitvoering; een archeoloog op afroep die advies kan geven tijdens de uitvoering.

NGE (OO, Ontplofbare Oorlogsresten)
De 10 onbekende objecten die binnen 100 meter van de toekomstige zeeleiding zijn gevonden vanuit de survey, kunnen mogelijke NGE’s zijn. Op basis van de survey kan dit niet worden uitgesloten. In het vervolgtraject (in het verlengde van de FEED) zal er nader onderzoek gedaan moeten worden naar deze 10 onbekende objecten om te identificeren wat dit daadwerkelijk is. In geval van een explosief zal deze indien nodig worden verwijderd door de Explosieven Opruimingsdienst Defensie (EOD).

Tijdens de aanleg van de zeeleiding kan een spontane vondst niet worden uitgesloten. Als dit gebeurt zal de Kustwacht ingelicht moeten worden, die op haar beurt de (maritieme explosievenexperts van) Defensie inlicht om het explosief onschadelijk te maken en te verwijderen indien dat nodig is.

10 Samenvatting milieueffecten

10.1 Milieueffecten tijdens gebruiksfase

Morfologie

De invloed van de leiding op de morfologie wordt bepaald door de bodemberoering. Voor het realiseren van de leiding wordt de leiding ingegraven of op de bodem gelegd. Hiervoor zal er gegraven worden en op sommige locaties enkele meters, om onder het dynamische profiel van de zeebodem te komen. Op die manier ondervindt de leiding niet de effecten van de migrerende zandbanken en -golven.

Voor de verschillende delen wordt de invloed van de leiding op de morfologie neutraal gescoord (Tabel 10.1). Ongeacht de wijze van realiseren van de leiding. Voor de verschillende alternatieven is er op dit thema geen onderscheid (Tabel 10.2).

Tabel 10.1 - Effectbeoordeling Morfologie in de gebruiksfase voor de verschillende delen

Deel A Direct Pipe	Deel B Tunnel	Deel C Ingraven en leggen	Deel D Leggen	Deel E Leggen	Deel F Leggen
0	0	0	0	0	0

Tabel 10.2 - Effectbeoordeling Morfologie in de gebruiksfase voor de alternatieven

Alternatief 1 (West 1)		Alternatief 2 (West 2)		Centrale route
1A	1B	2A	2B	3
0	0	0	0	0

Bodemkwaliteit

Door afgifte van warmte op de omgeving door de zeeleiding zal de bodemtemperatuur lokaal verhogen, wat invloed kan hebben op de bodemkwaliteit. Voor Deel A en B bevindt de zeeleiding zich onder het diepste gedeelte van de vaargeul. De afstand van de kern van de leiding tot aan het bodemoppervlak is daarom veel groter. Aan het bodemoppervlak zal er qua temperatuur geen effect meer zijn op de bodem. Voor de overige delen zal de temperatuur van de leiding zijn afgenomen, vanwege de afgelegde afstand. De temperatuur in de leiding zal ongeveer gelijk zijn aan de omgevingstemperatuur. Er wordt geen impact op de bodemkwaliteit verwacht. Een berekening om dit te onderbouwen dient nog gemaakt te worden (zie ook Hoofdstuk 9 Leemten in kennis).

Voor de verschillende delen wordt de invloed van de temperatuur van de leiding op de bodemkwaliteit neutraal gescoord (Tabel 10.3). Voor de verschillende alternatieven is er op dit thema geen onderscheid (Tabel 10.4).

Tabel 10.3 - Effectbeoordeling Bodemkwaliteit in de gebruiksfase voor de verschillende delen

Deel A Direct Pipe	Deel B Tunnel	Deel C Ingraven en leggen	Deel D Leggen	Deel E Leggen	Deel F Leggen
0	0	0	0	0	0

Tabel 10.4 - Effectbeoordeling Bodemkwaliteit in de gebruiksfase voor de alternatieven

Alternatief 1 (West 1)		Alternatief 2 (West 2)		Centrale route
1A	1B	2A	2B	3
0	0	0	0	0

10.2 Milieueffecten tijdens aanleg en ontmanteling

Morfologie

De bodemberoering door de aanleg van de leiding (leggen of ingraven) zal geen invloed hebben op de grootschalige morfologie; de zandbanken en zandgolven zullen hierdoor niet anders verplaatsen. Voor alle delen wordt daarom de invloed neutraal gescoord.

Tabel 10.5 - Effectbeoordeling Morfologie in de aanlegfase voor de verschillende delen

Deel A Direct Pipe	Deel B Tunnel	Deel C Ingraven en leggen	Deel D Leggen	Deel E Leggen	Deel F Leggen
0	0	0	0	0	0

Tabel 10.6 - Effectbeoordeling Morfologie in de aanlegfase voor de alternatieven

Alternatief 1 (West 1)		Alternatief 2 (West 2)		Centrale route
1A	1B	2A	2B	3
0	0	0	0	0

Vertroebeling

Bij de aanleg van de zeeleiding komt sediment in suspensie dat zorgt voor vertroebeling in het water. Als gevolg van het relatief kleine aandeel fijn sediment in de zeebodem blijven de sedimentconcentraties en sedimentaties relatief laag. De eventuele invloed van vertroebeling op natuurwaarden is opgenomen in de ecologische studies. De verschillende delen worden beoordeeld met een licht negatief effect (-) of neutraal effect (0).

Tabel 10.7 - Effectbeoordeling Vertroebeling in de aanlegfase voor de verschillende delen

Deel A Direct Pipe	Deel B Tunnel	Deel C Ingraven	Deel C Leggen	Deel D Leggen	Deel E Leggen	Deel F Leggen
-	0	-		0	0	0

Tabel 10.8 - Effectbeoordeling Vertroebeling in de aanlegfase voor de alternatieven

Alternatief 1 (West 1)		Alternatief 2 (West 2)		Centrale route
1A	1B	2A	2B	3
0	0	0	0	0

Archeologie

Diverse contacten en anomalieën zijn tijdens de survey gevonden. De contacten en anomalieën met een mogelijke archeologische waarde die binnen een zone van 100 meter van de zeeleiding zijn gelegen, zijn relevant voor de effectbeoordeling. Daar waar de contacten en anomalieën zijn gevonden, wordt het effect licht negatief beoordeeld (-). Het effect is neutraal (0) beoordeeld als er geen contacten en/of anomalieën zijn gevonden.

Tabel 10.9 - Effectbeoordeling Archeologie in de aanlegfase voor de verschillende delen

Deel A Direct Pipe	Deel B Tunnel	Deel C Ingraven en leggen	Deel D Leggen	Deel E Leggen	Deel F Leggen
0	-	0	0	-	-

Tabel 10.10 - Effectbeoordeling Archeologie in de aanlegfase voor de alternatieven

Alternatief 1 (West 1)		Alternatief 2 (West 2)		Centrale route
1A	1B	2A	2B	3
-	-	-	-	-

NGE (OO)

Vanuit de survey zijn 10 onbekende objecten gevonden die binnen 100 meter van de zeeleiding liggen. De aanwezigheid van de onbekende objecten – en daarmee mogelijke NGE's – worden licht negatief beoordeeld (-)

Tabel 10.11 - Effectbeoordeling NGE in de aanlegfase voor de verschillende delen

Deel A Direct Pipe	Deel B Tunnel	Deel C Ingraven en leggen	Deel D Leggen	Deel E Leggen	Deel F Leggen
0	-	0	0	-	-

Tabel 10.12 - Effectbeoordeling NGE in de aanlegfase voor de alternatieven

Alternatief 1 (West 1)		Alternatief 2 (West 2)		Centrale route
1A	1B	2A	2B	3
-	-	-	-	-

11 Referentielijst

[1] J. Suijlen en R. Duin, „Atlas of near-surface total suspended matter concentrations in the Dutch coastal zone of the North Sea," Rijkswaterstaat, RIKZ, 2002.
[2] H. v. Ieperen, „The fall velocity of grain particles," Landbouwuniversiteit Wageningen, 1987

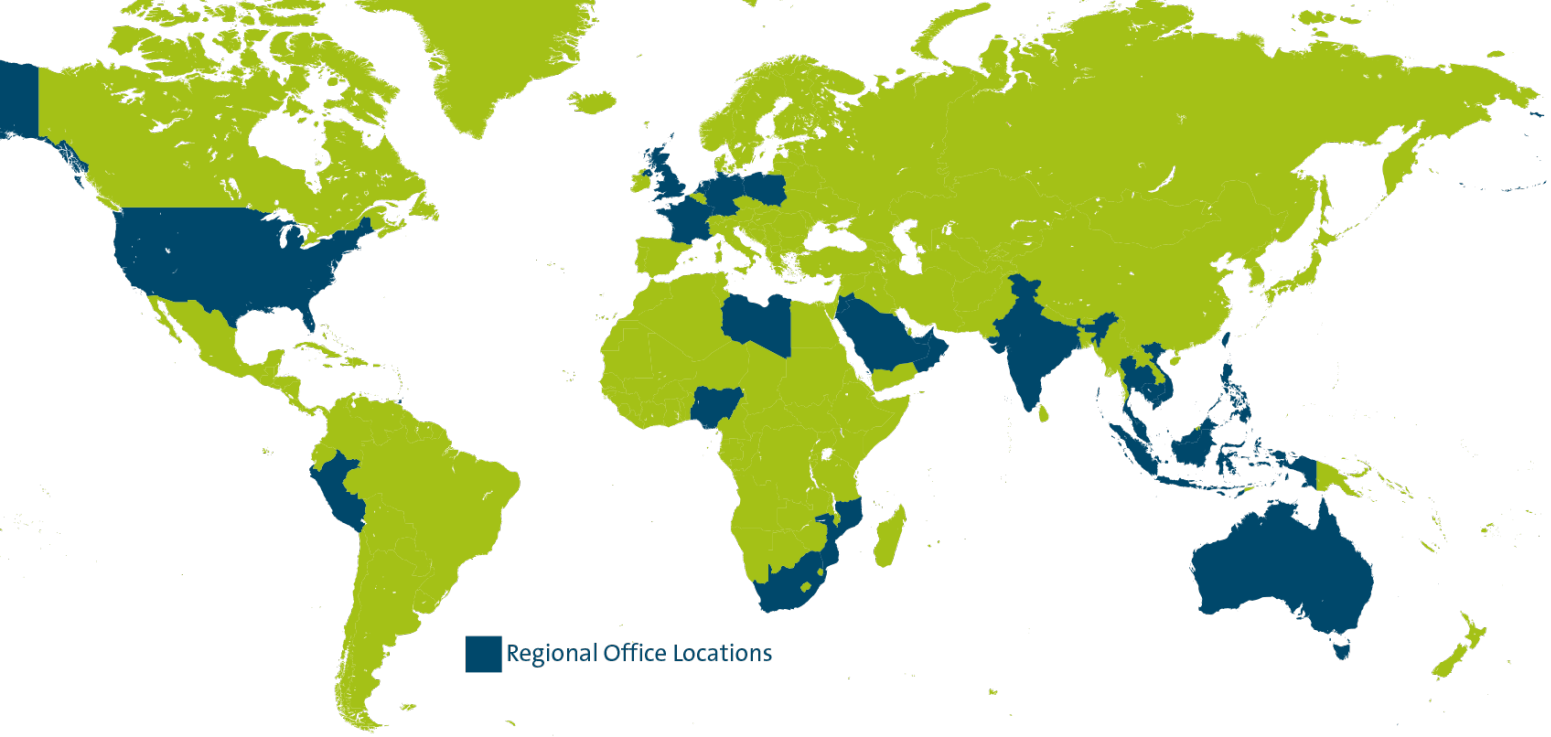
- **Aramis Pipeline Routing Desktop Study** - Expected Site Conditions, Consultancy Report (R201644 (03) | 10 February 2022)
- **Nearshore Geophysical Survey Results**, Processing and Results Report – Seeker (F197217-REP-RES 02 | 9 November 2022)
- **Geophysical Survey Results Report,** Geophysical and Geotechnical Site Investigation F197217-REP-001 | 03 | 8 December 2023
- **Document 22A030-01 Aramis pipeline – an archaeological assessment of geophysical survey data**, by Periplus Archeomare, 31-08-2023 (version 3.0 final) [goedgekeurd door RCE]
- Route selection document including aspects as morphology, safety.

12 Afkortingenlijst

DP	Direct Pipe
LAT	Lowest Astronomical Tide
NGE	Niet Gesprongen Explosief
OO	Ontplofbare Oorlogsresten
RCE	Rijksdienst voor het Cultureel Erfgoed

Lijst van afkortingen en begrippen

Woord	***Toelichting***
Aanleg	Plaatsen, installeren Aramis
Aramis	Dit initiatief
Bodemecosystemen	Het geheel en samenhang van alle dieren en planten in de bodem
CCS	Carbon Capture and Storage) (opslag van koolstofdioxide)
CO2	Koolstofdioxide (een broeikasgas)
EU	Europese Unie
Gebruiksfase	De situatie met Aramis aangelegd en in gebruik
Grondverzet	Graafwerkzaamheden in de grond en grondtransport
Immobiel	Zich niet verplaatsen; op dezelfde plek blijven
Incidenten	Niet voorziene gebeurtenissen, ongevallen en ongelukken
Infrastructuur	Wegen, kabels en leidingen zowel boven- als ondergronds, incl. platforms
Infrastructuurketen	Samengestelde installatie van aan elkaar verbonden onderdelen
Integraal systeem	Alles bij elkaar; Aramis als complete installatie
Interventiewaarde	Grens waarboven maatregelen (saneren) nodig is
Mobiel	Zich verplaatsen; niet op dezelfde plek blijven
Onderhoud	Inspectie, reinigen en zo nodig preventief vervangen van (delen van) Aramis
Ontmantelen	Opruimen en afvoeren van Aramis
Onvoorzien	Niet verwacht, geen rekening mee gehouden
Porthos	Een vergelijkbaar initiatief (zelfde technieken en doel)
Referentiesituatie	De situatie zonder Aramis
Verontreiniging	Stoffen die niet van nature voorkomen in het milieu met negatieve effecten



Royal HaskoningDHV is een onafhankelijk internationaal advies- en ingenieursbureau. We combineren 140 jaar engineering- en ontwerpexpertise met consultancy, software en technology diensten. We leveren hiermee toegevoegde waarde voor klanten en hebben een positieve impact op mensen en onze leefomgeving. Dat is onze drijfveer: Enhancing Society Together. Daar hoort bij dat we onszelf en anderen voortdurend uitdagen om bij te dragen aan duurzame oplossingen voor lokale en wereldwijde vraagstukken in de gebouwde omgeving en de industrie.

In onze snel veranderende wereld wordt de agenda bepaald door onder meer klimaatverandering, de digitale transformatie, een veranderende consumentenvraag en hybride werken. Met onze geïntegreerde duurzame oplossingen willen we bijdragen aan het bredere technologische en maatschappelijke plaatje.

Gesteund door de kennis en ervaring van meer dan 6.000 collega's werken we vanuit kantoren in meer dan 20 landen. We ondersteunen klanten om de transitie te maken naar een slimme en duurzame organisatie. We koppelen onze engineering- en ontwerpexpertise aan onze software- en technologische diensten om toegevoegde waarde te leveren voor onze klanten en de lifecycle van hun assets.

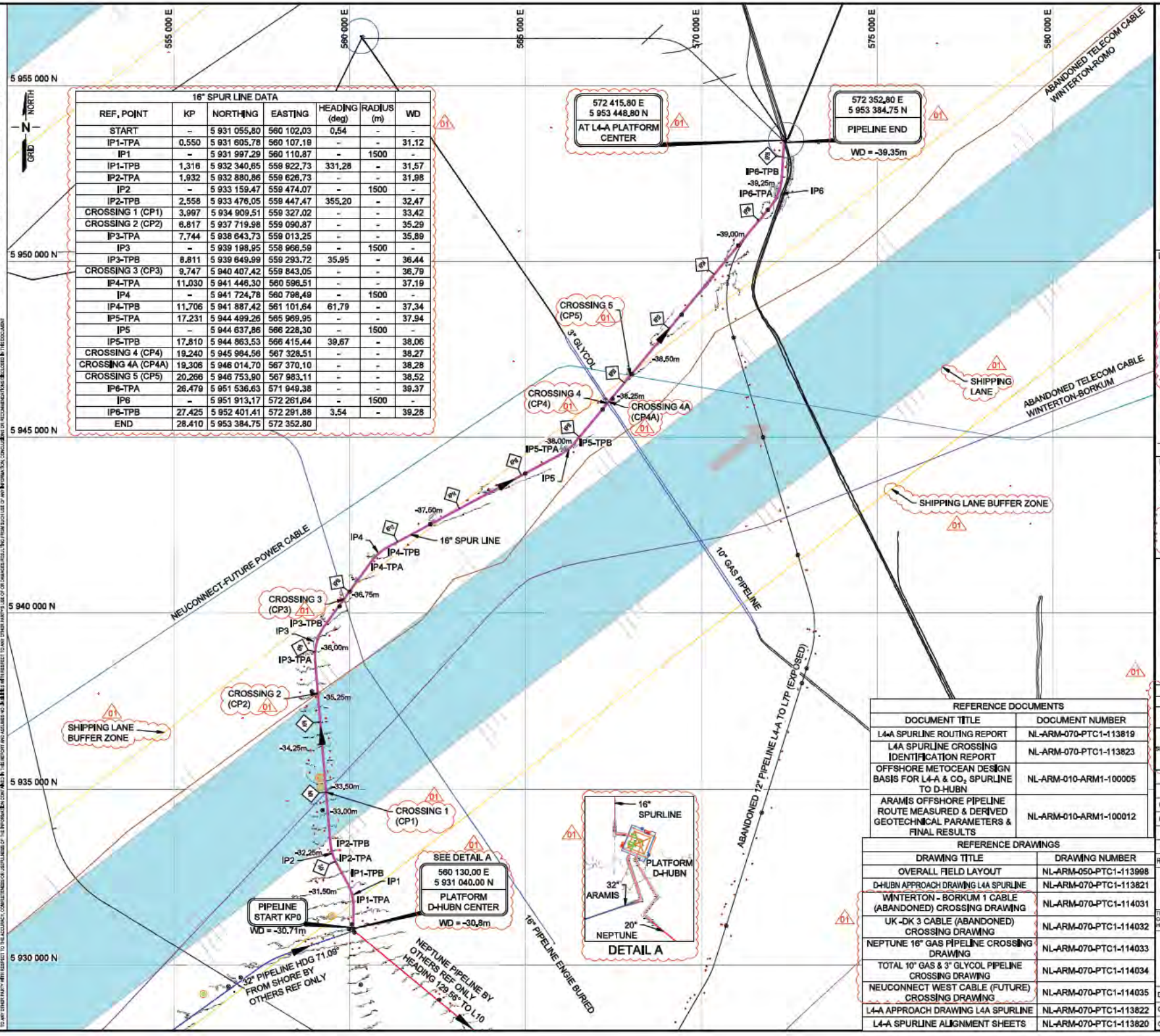
We zijn oprecht, handelen integer en transparant in al onze activiteiten, ook onze bedrijfsvoering Ons team is divers en inclusief. De veiligheid en het welzijn van mensen, in ons team en daarbuiten, staat onder alle omstandigheden voorop.

In projecten en initiatieven werken we actief samen met overheden en het bedrijfsleven, partners en stakeholders. We zien een belangrijke rol voor onszelf in innovatieve duurzame ontwikkeling en willen bijdragen aan een betere leefomgeving, nu en in de toekomst.

Ons hoofkantoor is gevestigd in Nederland en we hebben kantoren in Europa, Azie, Afrika, Australie en Amerika.

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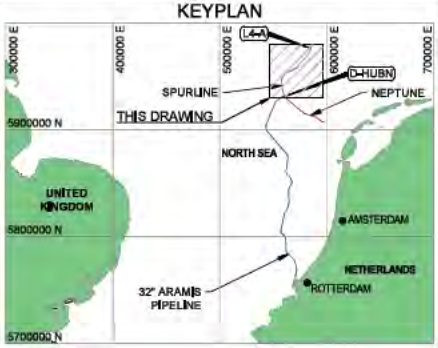
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16" SPUR LINE DATA

REF. POINT	KP	NORTHING	EASTING	HEADING (deg)	RADIUS (m)	WD
START	–	5 931 055,80	560 102,03	0,54	-	-
IP1-TPA	0,550	5 931 605,78	560 107,19	-	-	31,12
IP1	-	5 931 997,29	560 110,87	-	1500	-
IP1-TPB	1,316	5 932 340,65	559 922,73	331,28	-	31,57
IP2-TPA	1,932	5 932 880,86	559 626,73	-	-	31,98
IP2	-	5 933 159,47	559 474,07	-	1500	-
IP2-TPB	2,558	5 933 476,05	559 447,47	355,20	-	32,47
CROSSING 1 (CP1)	3,997	5 934 909,51	559 327,02	-	-	33,42
CROSSING 2 (CP2)	6,817	5 937 719,98	559 090,87	-	-	35,29
IP3-TPA	7,744	5 938 643,73	559 013,25	-	-	35,89
IP3	-	5 939 198,95	558 966,59	-	1500	-
IP3-TPB	8,811	5 939 649,99	559 293,72	35,95	-	36,44
CROSSING 3 (CP3)	9,747	5 940 407,42	559 843,05	-	-	36,79
IP4-TPA	11,030	5 941 446,30	560 596,51	-	-	37,19
IP4	-	5 941 724,78	560 798,49	-	1500	-
IP4-TPB	11,706	5 941 887,42	561 101,64	61,79	-	37,34
IP5-TPA	17,231	5 944 499,26	565 969,95	-	-	37,94
IP5	–	5 944 637,86	566 228,30	–	1500	–
IP5-TPB	17,810	5 944 863,53	566 415,44	39,67	-	38,06
CROSSING 4 (CP4)	19,240	5 945 964,56	567 328,51	-	-	38,27
CROSSING 4A (CP4A)	19,306	5 946 014,70	567 370,10	-	-	38,28
CROSSING 5 (CP5)	20,266	5 946 753,90	567 983,11	-	-	38,52
IP6-TPA	26,479	5 951 536,63	571 949,38	-	-	39,37
IP6	-	5 951 913,17	572 261,64	-	1500	-
IP6-TPB	27,425	5 952 401,41	572 291,88	3,54	-	39,28
END	28,410	5 953 384,75	572 352,80			

KEYPLAN



LEGEND

- 12m, 14m, 16m, 17m, 19m / 20m, 22m, 24m, 26m — MINIMUM DEPTH ZONE MARKS SHOWN TOWARDS DEPTH
- WRECKS 01
- SHIPPING LANE (WITH DIRECTION ARROW)
- BATHYMETRY (5m)
- ARCHAEOLOGICAL SITES
- DEBRIS
- 3rd PARTY PIPELINES
- ⊗ - CPTU/VC SAMPLE LOCATION
- CP - CROSSING POINT
- TP - TANGENT POINT
- IP - INTERSECTION POINT
- WD - WATER DEPTH
- FLOW DIRECTION
- KP - 2 Km KP MARKER
- 3rd PARTY CABLES (UNLESS STATED OTHERWISE)

NOTES:

1. ALL DIMENSIONS ARE IN METRES UNLESS NOTED OTHERWISE.
2. ALL HEADINGS ARE TAKEN CLOCKWISE FROM GRID NORTH IN DECIMAL DEGREES AND IN DIRECTION OF FLOW.
3. KP DIRECTION IS DEFINED BY FLOW DIRECTION D-HUBN TO L4-A.
4. D-HUBN PLATFORM HEADING 22,5° FROM TRUE NORTH (21.77 FROM GRID NORTH AT THE PLATFORM CENTER).
5. L4-A PLATFORM HEADING 24° FROM TRUE NORTH (23.11° FROM GRID NORTH AT THE PLATFORM CENTER). 01

REFERENCE DOCUMENTS

DOCUMENT TITLE	DOCUMENT NUMBER
L4-A SPURLINE ROUTING REPORT	NL-ARM-070-PTC1-113819
L4A SPURLINE CROSSING IDENTIFICATION REPORT	NL-ARM-070-PTC1-113823
OFFSHORE METOCEAN DESIGN BASIS FOR L4-A & CO_2 SPURLINE TO D-HUBN	NL-ARM-010-ARM1-100005
ARAMIS OFFSHORE PIPELINE ROUTE MEASURED & DERIVED GEOTECHNICAL PARAMETERS & FINAL RESULTS	NL-ARM-010-ARM1-100012

REFERENCE DRAWINGS

DRAWING TITLE	DRAWING NUMBER
OVERALL FIELD LAYOUT	NL-ARM-050-PTC1-113998
D-HUBN APPROACH DRAWING L4A SPURLINE	NL-ARM-070-PTC1-113821
WINTERTON - BORKUM 1 CABLE (ABANDONED) CROSSING DRAWING	NL-ARM-070-PTC1-114031
UK -DK 3 CABLE (ABANDONED) CROSSING DRAWING	NL-ARM-070-PTC1-114032
NEPTUNE 16" GAS PIPELINE CROSSING DRAWING	NL-ARM-070-PTC1-114033
TOTAL 10" GAS & 3" GLYCOL PIPELINE CROSSING DRAWING	NL-ARM-070-PTC1-114034
NEUCONNECT WEST CABLE (FUTURE) CROSSING DRAWING	NL-ARM-070-PTC1-114035
L4-A APPROACH DRAWING L4A SPURLINE	NL-ARM-070-PTC1-113822
L4-A SPURLINE ALIGNMENT SHEETS	NL-ARM-070-PTC1-113820

GEODETIC PARAMETERS

DATUM	EPSG CODE	25831	PROJECTION	NAME	UTM
	HORIZONTAL	ETRS 1989		ZONE	31 NORTH
	VERTICAL	LAT		CENTRAL MERIDIAN	3° EAST
	NAME	GRS 1980		LATITUDE OF ORIGIN	EQUATOR
SPHEROID	SEMI MAJOR AXIS	6 378 137,000		FALSE EASTING	500000m
	SEMI MINOR AXIS	6 356 752,314		FALSE NORTHING	0m
	INVERSE FLATTENING	298,257222101		SCALE FACTOR	0,9996

Rev.	Date	Status	Revision Description	Iss.	Check.	Appr.
01	29,05,24	IFD	ISSUED FOR DESIGN			
00	21.03.24	IFR	ISSUED FOR REVIEW			
B	26.02.24	IDC	INTER DISCIPLINE CHECK			
A	20.02.24	IR	INTERNAL REVIEW			

ARAMIS CCS

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ARAMIS DHUB-N TO L4-A SPURLINE ROUTE

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ARAMIS DEVELOPMENT

BB03 FLOW ASSURANCE STUDY REPORT

Identification page

Title: Aramis development – Flow Assurance study

Entity: [redacted] Location – Date: [redacted] 12/10/2023

Issued by	Verified by	Approved by
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Keywords (10 max.- other than title): Netherlands, Aramis, Offshore, CO_2 injection, CO_2 with impurities, complex network

Geographical references: Netherlands, Rotterdam, Dutch Continental Shelf, Aramis

Abstract:

The Aramis project is a cooperation between Shell, TotalEnergies, EBN and GasUnie. It aims to develop a CO_2 transportation infrastructure that can bring captured CO_2 from emitters to offshore storage sites on the Dutch Continental Shelf.
The first phase of the project is estimated to bring just over 5 MTPA transport capacity with a full growth case estimated at some 22 MTPA. The design life of the transport infrastructure will be 30 years for end-of-life activities.
A number of impurities are included in the CO_2 specification which could be of a great challenge when defining operating philosophies.

This document presents the steady state and transient thermo-hydraulic analysis performed for the injection of CO_2 with impurities through Aramis injection system and more specifically its trunkline.

The objectives of this report are:

- Determine steady state conditions to confirm the operability of the network while ensuring that the CO_2 remains in the dense phase.
- Support the preparation of an operating philosophy and relevant procedures and equipment for transient operations (first filling, depressurization, Etc.).

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1 GENERAL

1.1 Project presentation

The Aramis project is a cooperation between Shell, TotalEnergies, EBN and GasUnie. Aramis aims to develop a CO_2 transportation infrastructure (together with CO2next and Porthos) that can bring captured CO_2 from emitter to offshore storage sites on the Dutch Continental Shelf.

Where efficient and applicable, the infrastructure will be developed in a phased manner to match the supply of CO_2 (scalable approach). The first phase is estimated to bring just over 5 MTPA transport capacity with a full growth case estimated at some 22 MTPA. The design life of the transport infrastructure will be 30 years for end-of-life activities.

Once the Aramis system is established, it would unlock the majority of offshore storage capacities in the Dutch sector of the North Sea, allowing incremental emitter by emitter decarbonization through incremental storage development.

Aramis Transport Launching phase is targeting to inject a minimum of 5 MTPA average of CO_2 with an aspirational RFSU in Q1 2028 (first pick up of CO_2 at emitters) and first injection in reservoir in Q1 2027. Of the 5 MTPA about 2 MTPA will be transported by barges to the CO2next Terminal. Another 3 MTPA will tie into the yet to be constructed Porthos onshore pipeline (vapor phase) and the existing OCAP pipeline. These volumes will arrive at the Porthos compressor station and will be compressed into the offshore trunkline transporting the CO_2 to the storage sites. The compressors are assumed to be located at the premises of the Porthos compressor station. The injection split for the Launch phase is assumed to be 50/50% between the Shell and TotalEnergies storage fields.

Aramis, a cooperation between TotalEnergies, Shell, EBN and Gasunie, is incorporating, from the onset, a cross-border approach, providing a decarbonization solution for North-West Europe. Aramis will deliver through studies and through establishing agreements with other operators in the transport infrastructure such as Co2next and Porthos an end-to-end transport solution for CO_2 molecules from emitter to store.

The Aramis Transport CCS network, contains the following:

- **Shipping solution - studied by Aramis** - that will collect liquified CO_2 from new export terminals located in the North Sea Port area on both sides of the Westerschelde estuary.
- **A new receiving shipping terminal at Maasvlakte - studied by CO2next** (to be built and operated by CO2next)**:** Liquid CO_2 will be transported by coasters/barges from different industrial clusters located in the Northwest Europe region to a new receiving terminal and temporary storage in an onshore hub located at the Maasvlakte near Rotterdam.
- **Adding compressor capacity to the Porthos compressors station – studied jointly between Aramis and Porthos.** Compressed (gas phase) CO_2 volumes coming by onshore pipeline from Rotterdam and its hinterlands will be further compressed in a compressor station and combined with liquid CO_2 for transport through a new high-pressure, ambient-temperature offshore trunkline to the receiving offshore platforms.
- **A trunkline – studied by Aramis:** Aramis envisages a ~200 km oversized trunkline (dense phase) to the offshore platforms / blocks with tie-in points to cater for future growth and enable third-party access.

The scope for the ARAMIS common infrastructure is divided into Building Blocks (BB). Aramis partners have agreed to develop Building Blocks jointly or individually, see figure below (Ref. [1]).

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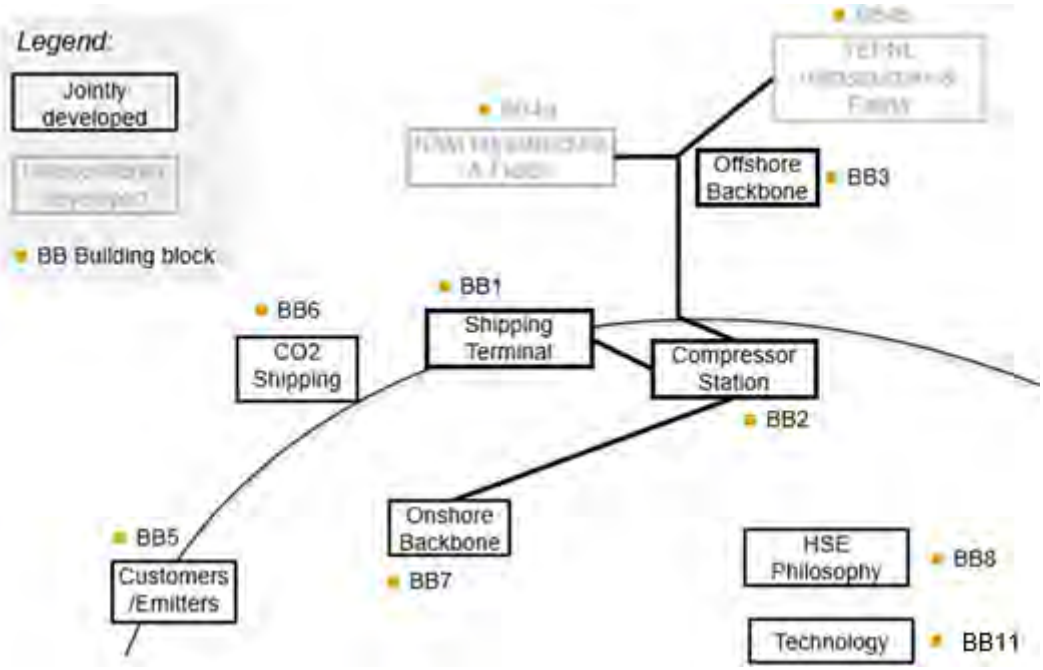


Figure 1-1: Aramis Transport Scope of Work

For the next phase (technical work until start of FEED) the technical work will be led by integrated ARAMIS teams with one company leading each block, as per below table:

	Description	Key focal point/Lead
BB01	Terminal	TotalEnergies
BB02	Compressor	Shell
BB03	Backbone	TotalEnergies
BB06	Shipping	Shell
BB08 A	Operations	Shell
BB08 B	HSSE	Shell / TotalEnergies combined
BB11	ICCS/Telecom	Shell / TotalEnergies combined

Table 1-1: Key focal point for each building block

1.2 Purpose of the document

This document presents the steady state and transient thermo-hydraulic analysis performed for the injection of CO_2 through Aramis trunkline.

The objectives of this report are:

- Determine steady state conditions to confirm the operability of the network while ensuring that the CO_2 remains in the dense phase
- Support the preliminary definition of an operating philosophy and procedures based on transient scenario analyses of key operations expected on field.

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1.3 Reference documents

1.3.1 Company documents

The following COMPANY documents are referenced in this document

Ref. [X]	Title	Issuer
Ref. [1]	Aramis Transport: Project premises Document	[redacted]
Ref. [2]	Aramis Project – Aramis BB03 Process Report	

Table 1-2: COMPANY documents

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2 EXECUTIVE SUMMARY

2.1 Introduction

Aramis project aims to develop a CO_2 transportation infrastructure that can bring captured CO_2 from emitters to offshore storage sites on the Dutch Continental Shelf. The infrastructure will be developed in a phased manner to match the supply of CO_2. The first phase is estimated to bring just over 5 MTPA transport capacity with a full growth case estimated at some 22 MTPA. The design life of the transport infrastructure will be 30 years for end-of-life activities.
A number of impurities are included in the CO_2 specification. The impurity level of several components, including H_2O, are directly linked to maintaining design integrity.

The injection system starts onshore at the Rotterdam port, goes through a 32'' OD trunkline subsea all the way to the K14 ILT/PLET where the take-off for SHELL wells occurs, before getting to the central platform D-HUBN (Also referred to as DHUB) at about 196 km from the inlet and 33 km from K14 ILT/PLET.

At the DHUB, a second take-off for Neptune wells (Platform L10) occurs. The remaining volume is injected in TotalEnergies area at about 26 km from the DHUB through a 24'' OD spurline. The TotalEnergies area, starts at the level of the PLEM and reaches first L4A platform. Only the trunkline and this part of the injected system are covered in this report.

This document presents the steady state and transient thermo-hydraulic analysis performed for the injection of CO_2 with impurities through Aramis injection system and more specifically its trunkline.

The objectives of this report are:

- Determine steady state conditions to confirm the operability of the integrated network while ensuring that the CO_2 remains in the dense phase. The number of steady state simulations has been optimized by selecting critical sizing years along the injection profiles and the inlet conditions. Only the base cases are presented in this section:

- **Base Case 1**: Max Flowrate of 22 MTPA – discharge pressure 180 barg – Inlet temperature 50°C, and considering subsequent reservoir pressure build-up,
- **Base Case 2**: Startup flowrate of 5 MTPA – discharge pressure 150 barg – Inlet temperature 50°C, with no pressure build-up at reservoir level.

- Support the preliminary definition of an operating philosophy and procedures based on transient scenario analyses of key operations expected on field. The injection case selected to perform transient analysis is 22 MTPA. The conducted transient simulations are listed here below:

- **Shutdown – Packing case 1:** Spurious closure of wells while the pumps are still in operation – 22 MTPA steady state as base case (Base Case 1)
- **Shutdown – Packing case 2**: Spurious closure of the Riser Isolation Valve (RIV) at the DHUB while the pumps are still in operation – 22 MTPA all the way to DHUB steady state as base case (Sensitivity Case 1).
- **Shutdown – Depacking**: Spurious shutdown of pumps while the wells are still open – 22 MTPA steady state as base case (Base Case 1).
- **Planned depressurization:** Shutdown of pumps while the wells are still open, then blowdown through the wells until the pressure in the transport line reaches 10 – 20 bar above highest WHSIP or 10 bar above pressure triggering two-phase flow, the wells are then closed, and

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depressurization continues through the Restricted orifices (RO) topside – 22 MTPA steady state as base case (Base Case 1).

- **Depressurization after unplanned abnormal shutdown – wells available:** Spurious closure of wells while the pumps are still in operation which would pack the line at highest pressure, then blowdown through one well, the furthest and having the lowest WHSIP (controlled depressurization) until the pressure in the transport line reaches 10 – 20 bar above this lowest WHSIP or 10 bar above pressure triggering two-phase flow – 22 MTPA steady state as base case (Base Case 1).
- **Depressurization after unplanned abnormal shutdown – wells not available:** Spurious closure of wells while the pumps are still in operation which would pack the line at highest pressure, then blowdown through the RO topsides – 22 MTPA steady state as base case (Base Case 1).

2.2 Results & Recommendations

The main outcomes of the present Flow Assurance study for BB03 are summarized here after:

2.2.1 Steady state results

- **22 MTPA peak rate**

Here after are presented the arrival conditions at each platform along with the flowrates for the 22 MTPA peak rate:

Platform	K14	DHUB	L10	TTE PLEM (3)
Arrival flowrate (MTPA)	8	14	6	8
Arrival flowrate (kg/s)	253.68	443.94	190.26	253.68
Arrival pressure (bara) (1)	137.96	135.18	133.79	136.43
Arrival pressure + topside pressure drop margin (2)	132.96	135.18	128.79	136.43
Temperature (°C)	19.2	17.06	16	16.33

Note:

1. The indicated arrival pressure includes a 10% margin on the pressure drop. Reference height +24 m / MSL except for TTE PLEM which is at -39 m / MSL,

2. The indicated arrival pressure includes both 10% margin on pressure drop and a 5 bar margin representative of topside pressure drop related to piping and chokes. Reference height +24 m / MSL except for TTE PLEM which is at -39 m / MSL,

3. For the peak rate only indicative results of the subsea manifold at 1.9 km from L4A platform and -39 m of water depth are presented

Table 2-1: Arrival conditions at key points of the injection system for 22 MTPA base case

From the present Flow Assurance study, it appears that the injection of 22 MTPA might be highly challenging at the end of life, therefore highlighting the strong effect of the pressure build-up observed in the reservoir during field life.

This is a major uncertainty that is difficult to unlock at this stage.

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- **5 MTPA start-up rate**

Here after are presented the arrival conditions at each platform along with the flowrates for the 5 MTPA start-up rate:

Platform	K14	DHUB	L4A
Arrival flowrate (MTPA)	2.5	2.5	2.5
Arrival flowrate (kg/s)	79.27	79.27	79.27
Arrival pressure (bara) (1)	146.49	146.47	146.26
Arrival pressure + topside pressure drop margin (2)	141.49	146.47	141.26
Temperature (°C)	16.96	16.62	15.5

Note:

1. The indicated arrival pressure includes a 10% margin on the pressure drop. Reference height +24 m / MSL,

2. The indicated arrival pressure includes both 10% margin on pressure drop and a 5 bar margin representative of topside pressure drop related to piping and chokes. Reference height +24 m / MSL.

Table 2-2: Arrival conditions at platforms for 5 MTPA base case

2.2.2 Transient simulations results

- **Shutdown – Packing Case 1**

This scenario consists in spurious closure of injection sites (Christmas Tree closure) while onshore pumps are still running.

Pressure build-up anticipated in transport pipeline for this shutdown scenario is presented here after. It is worth mentioning that a Pressure Protection System for the trunkline is supposed to be triggered at 200 barg.

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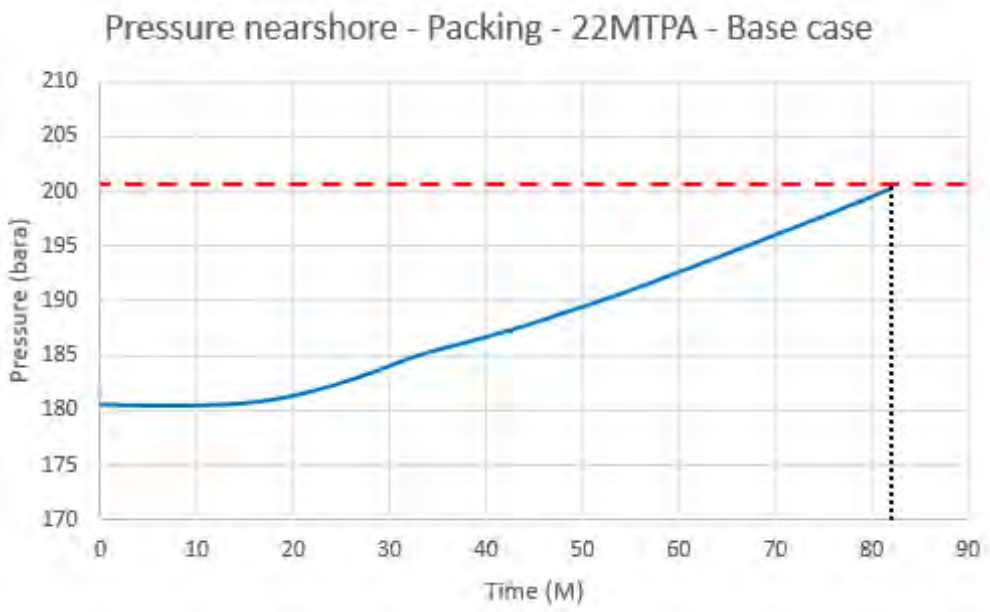


Figure 2-1: Pressure build-up in pipeline with shutdown at injection sites and no shutdown onshore – Base Case

The pressure build-up in the transport pipeline is relatively rapid because of the high initial steady state operating pressure. The higher is the pressure build-up in the reservoir due to CO_2 injection, then the faster is the packing of the transport pipeline. This means that at late life, packing of the trunkline will be faster than at early life conditions.

For the worst scenario (late life, 22 MTPA injection with reservoir pressure build-up), the Pressure Protection System alarm is triggered after 82 min of the unplanned shutdown, leaving enough time for the operators, the pipeline control or pipeline safety system to respond and to avoid a high pipeline shut-in pressure.

- **Shutdown – Packing Case 2**

This scenario consists in spurious closure of Riser Head valve at the central platform DHUB while onshore pumps are still running. This scenario is looked at as faster pressurization is anticipated due to the smaller volume of the pipeline.

Pressure build-up anticipated in transport pipeline for this shutdown scenario is presented here after.

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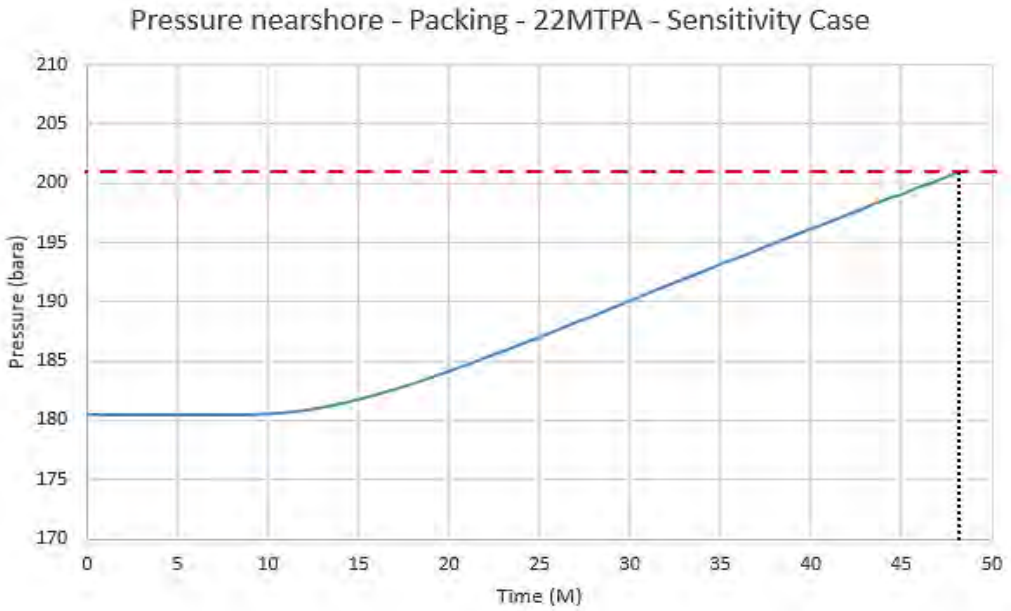


Figure 2-2: Pressure build-up in pipeline with RIV shutdown and no shutdown onshore – Sensitivity Case

As for packing case 1, worst conditions have been considered to define the shortest pressurization time for this sensitivity study, namely, late life conditions with pressurized reservoir and injection at 22 MTPA. For this scenario, the Pressure Protection System alarm is triggered after 48 min of the unplanned shutdown. Even though this case is most likely not to occur, the operators, the pipeline control or pipeline safety system should still have enough time to respond and to avoid a high pipeline shut-in pressure.

- **Shutdown – Depacking**

Transport pipeline blowdown into wells for such shutdown scenario is presented here after:

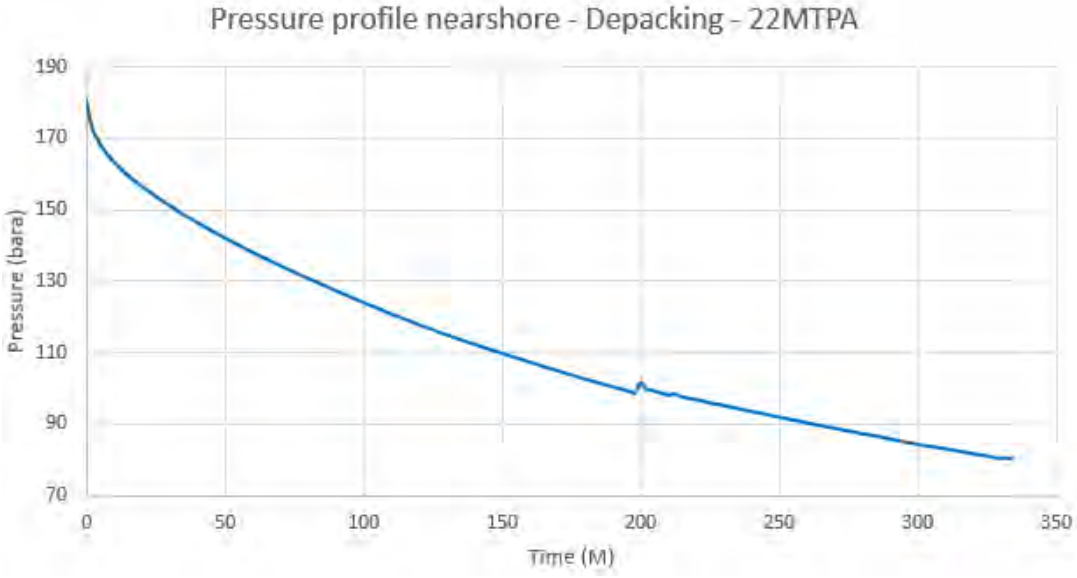


Figure 2-3: Transport pipeline blowdown into wells with shutdown onshore and no shutdown at injection sites

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As presented on figure above, the pressure in the transport pipeline decreases by approximately 0.3 bar / min. The present study also highlights that gas flashing is experienced after about 5 hours (300 min) following unplanned shutdown in the beginning of the transport pipeline between the Onshore and the Micro-Tunnel sections.

Those two-phases conditions in the transport pipeline are observed as soon as the Pressure @ Maasvlakte goes below 82 barg. Even with such conditions, operators and control system should have enough time to respond and avoid the appearance of gas pockets within transport pipeline. A pressure set point of 90 barg including a 10 bar margin over the critical point for Low Pressure Alarm should be respected at Maasvlakte terminal, after which the risks of two-phase flow become unavoidable.

Another outcome of the present study is that no crossflow phenomena between the different injection wells will be observed, at least, in the first 5 hours following unplanned shutdown event. The potential risk of cross flow between the different wells has not been further assessed as the injection network should already be in two-phase flow conditions, what should be avoided and can be considered as driving parameter in case of blowdown events.

- **Depressurization**

There is no specific operational requirement for depressurization of the subsea network in normal situation / shutdown. The potential scenarios that may impose a depressurization of the subsea system could be:

- Damage of the transport pipeline requiring repair and then blow-down of subsea system prior any intervention,
- Formation of a plug requiring blow-down to attempt remediating,
- Pipeline decommissioning,
- Operational issues at onshore plant requiring blow-down of the subsea system to control CO_2 release if any.

In the frame of this study, 3 main scenarios have been considered. They are summarized here below. All cases have been covered and deeply assessed. Nevertheless, in order to ease the reading of this report, it has been decided not to present all the cases as all the results are almost similar and proposed design complies with all requirements.

➢ Normal / Planned shutdown:

- Shutdown of the export pumps while the wells are still open in order to empty the pipeline as much as possible,
- When the pressure reaches 90 barg at Maasvlakte terminal and before triggering the two-phase flow, the blowdown through the wells is stopped,
- 1 hour waiting time for the preparation of venting operations,
- Vent through restricted orifice(s),

➢ Abnormal / Unplanned shutdown:

- Spurious closure of wells while the export pumps are still in operation,
- Packing of the transport pipeline at the highest pressure,

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- Blowdown operation into the furthest well having the lowest WHSIP (for better control of the depressurization activity, nevertheless number and location of wells still to be defined by Field Operations team – Single well or multi wells operation, acceptance of two-phase flow in well during blowdown, Etc.) until reaching the pressure set point of 90 barg at Maasvlakte terminal, or 10 bar above the lowest WHSIP
- After settle-out pressure in network is about 90 barg or 10 bar above the lowest WHSIP, well is shutdown, and vent through restricted orifice(s) initiated,

Because this case is similar to the planned shutdown with minor differences, only relative results will be presented.

- ➢ Abnormal / Unplanned shutdown with line packed and wells are not available,
- Representative scenario in case of hydrates plug before reaching the platforms,
- The export pumps are still in operation and the line is packed,
- 1 hour waiting time for the preparation of venting operations,
- Vent through restricted orifice(s).

This case has a very low probability of occurrence as wells should always be available, at least one, which means that blowdown and pressure reduction into transport pipeline should always be possible through the wells at first. Because this case is similar to the planned shutdown with minor differences, only relative results will be presented.

It is worth mentioning that when depressurizing the CO_2 to atmospheric conditions, extremely low temperatures are anticipated whatever the scenarios considered. Therefore, it is important to control the pressure in the transport pipeline during depressurization operations in order to comply with design temperatures of the transport pipeline. The control of the pressure during blow-down has been achieved by considering staggered depressurization sequence and by adjusting the diameter of the Restriction Orifices over depressurization sequence.

Since there is a high risk of ice formation around the pipe at very low temperatures and in order to take into account enough margin to cover the uncertainties related to *OLGA* software, the minimum considered temperature is 0°C. It is also worth mentioning that the depressurization simulations are very slow, and the temperature does not fall rapidly which means that the margin over the temperature could be relaxed as these calculations are not considered as fast transient.

The back pressure downstream Restriction Orifice should be also defined to avoid ice formation in the depressurization system. In the present study, and considering the phase diagram of CO_2, the pressure has been fixed at 7 bara (above triple point) to avoid ice formation and risk of plugging of depressurization lines. The transition from 7 bara to atmospheric conditions at vent and associated equipment should be developed by Process in accordance with Flow Assurance outcomes / recommendations presented in this report and to mitigate the risks of plugging of the depressurization network.

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After completion of the different analyses, proposed design of depressurization system consists in implementing 4 Restriction Orifices. This arrangement has been identified as the best compromise in order to avoid too low temperatures in transport pipeline with regard to design temperature and water icing risks, but also to shorten the duration of the depressurization sequence.

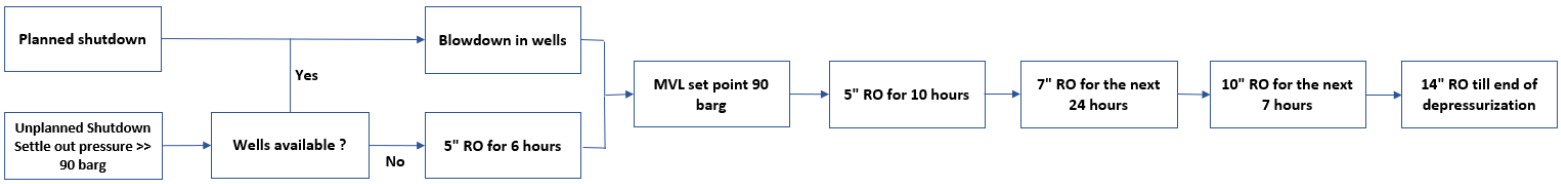


Figure 2-4: Depressurization sequence – Staggered Restriction Orifices

Proposed diameters of the Restriction Orifice are 5, 7, 10 and 14 inches for the depressurization of the BB03 trunkline. Those Restriction Orifices are used in sequence (the one after the other). The switch between the first and second Restriction Orifices occurs 10 hours after depressurization of first RO. 24 hours later, occurs the second switch. The third switch occurs 7 hours after depressurization of third RO. The minimum achieved bulk temperature is 1°C (for a few minutes) to which a 5°C margin should be applied to define the minimum design temperature of the pipeline.

The duration of the depressurization starting from a pressure set point of 90 barg at MVL lasts approximately 2 days and a half (58 hours).

Concerning the unplanned shutdown with wells available post packing of the line, the blowdown through the furthest well with the lowest WHSIP lasts a little more than 10 days until reaching the pressure set point of 90 barg. In the present study, the WHSIP of the considered well for blowdown operations being lower than 90 barg, the two-phase flow condition is driving the switch to Restriction Orifice to complete the depressurization of the injection network. Once the pressure set point is reached at MVL terminal, the proposed operating philosophy detailed above can be applied.

On the other hand, for the unplanned shutdown with line packing and wells not available, the procedure of the depressurization can start directly with a 5” RO (approximately 6 hours until reaching 90 barg at MVL then continue with 10 hours before switching to a bigger RO) and the steps detailed above can still be valid and applicable as the temperature can still be controlled and does not drop to very low values, respecting the 0°C threshold. The only possible difference with the planned shutdown sequence is that the first step of 5” RO can be longer than expected. Nevertheless, there is no risk of dropping to very low temperatures and ice formation around the pipe can be avoided.

Because of the isenthalpic phenomena during the liquid blow-down, the minimum expected temperature downstream the different Restriction Orifices is about -56°C. Those low temperatures should be experienced as long as liquid CO_2 will be observed downstream Restriction Orifice. A 20°C margin is then added to the minimum temperature leading to a design temperature of the topside piping of - 76°C.

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3 BASIS OF DESIGN

3.1 Software and margins

3.1.1 Thermodynamic software

Because of the relatively new topics in the industry dealing with pure CO_2 injection, it is admitted that the accuracy of the different available thermodynamic packages might be questionable. This is mainly due to the presence of the various impurities that affect the phase envelope of the CO_2.

For compatibility reasons between the thermodynamic and multiphase flow software, *Multiflash – commercial version - 7.1* was used to generate the fluids. The following models and adjustments were used:

- Thermodynamic model: SRK Advanced (RKSA in *Multiflash*) with CO_2 volume shift (VSRK=6.2x10^{-6}m^3/mol)
- Viscosity: Super TRAPP
- Thermal conductivity: Super TRAPP

3.1.2 Multiphase flow software

OLGA 2021.2.0 has been used as a reference for all thermo-hydraulic analyses (steady state and transient).

Due to the nature of the fluid and the presence of the impurities, a compositional tracking approach has been considered as base case for all Flow Assurance studies.

3.2 Environmental data

The ambient conditions are presented in the following table (Ref. [1]):

Ambient temperature (°C)		
Depth (m)	**Cold case (winter)**	**Warm case (summer)**
Air	-4.7	21.7
0	-0.5	21.1
1	4.0	16.0
30	4.0	16.0
50	4.0	16.0

Table 3-1: Ambient conditions

In a conservative approach, the warm case set of data is considered for thermo-hydraulic calculations since it maximizes the pressure losses.

No current has been accounted for on the external surface of the production pipe in the frame of this study (faster cooling effect during transient operations, almost no impact on trenched / buried

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sections in the steady state, slightly under conservative for exposed sections in the steady state but impact negligible on the final results).

3.3 Injection system description

The injection system starts onshore at the Rotterdam port, goes through a 32'' OD trunkline subsea all the way to the K14 ILT/PLET where the take-off for SHELL wells occurs, before getting to the central platform D-HUBN (Also referred to as DHUB) at about 196 km from the inlet and 33 km from K14 ILT/PLET. At the DHUB, a second take-off for Neptune wells (Platform L10) occurs. The remaining volume is injected in TotalEnergies area at about 26 km from the DHUB through a 24'' OD spurline. The TotalEnergies area starts at the level of the PLEM. The L4A platform is located at 1.9 km from the PLEM. The trunkline is also referred to as BB03.

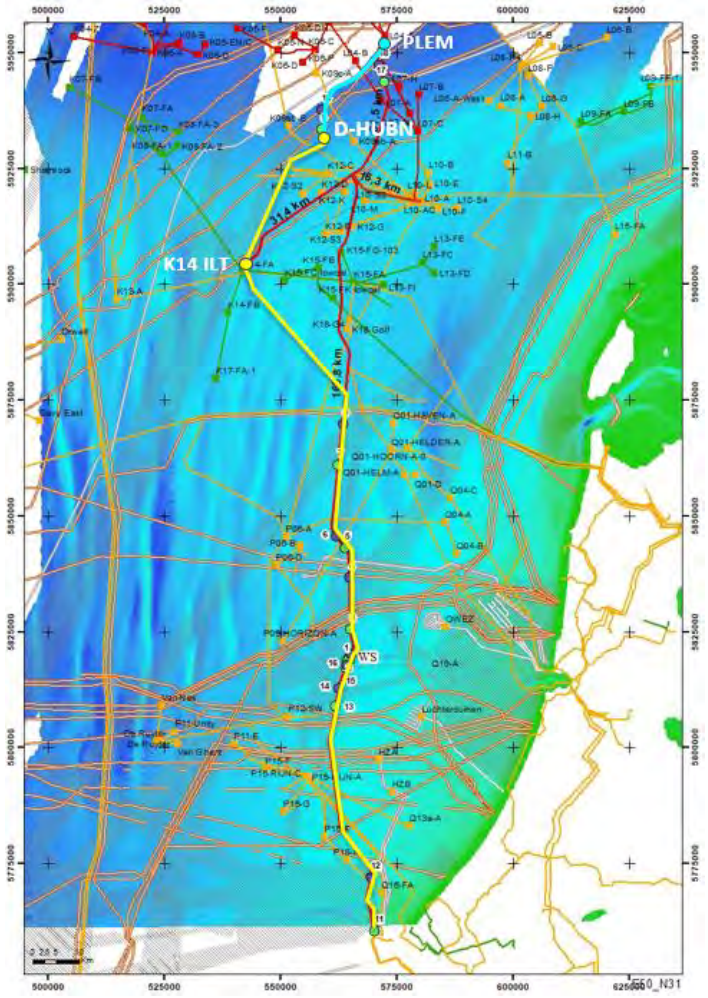


Figure 3-1: Aramis injection system

3.3.1 Injection system description

The following tables detail the characteristics of Aramis injection system (Ref. [1])

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Flowline	Length (km)	Outer diameter (in)	Internal diameter (mm)	Roughness (mm) (1)
Onshore to Maasvlakte terminal	1.92	32	755.6	0.045
Maasvlakte terminal to K14 ILT	160.95	32	755.6	0.045
K14 ILT to DHUB	33.5	32	755.6	0.045
DHUB to PLEM	26.2	24	565.1	0.045
K14 ILT to K14 platform	2	24	565.1	0.045
DHUB to L10 platform	20	24	565.1	0.045
PLEM to L04-A	1.88	24	565.1	0.045

Note:

1. The considered roughness is conservative and representative of the roughness after a few years in operation of the transport pipeline

Table 3-2: Injection system characteristics

3.3.2 Bathymetries

The figures here below present the elevation profile of each section of the main trunkline and the spurlines provided by the geospatial team.

The status of the transport pipeline at seabed (exposed, trenched, Etc.) has been added to the different figures. When there is no available information, the pipe is considered exposed. Should the transport pipeline be fully or partially buried on short sections, then no impact is anticipated on the results of the Flow Assurance study summarized in the present report.

3.3.2.1 Main trunkline

The coating of the transport pipeline at seabed is very different from a section to another due to several external constraints (shipping lanes, platform zone, micro-tunnel nearshore...). The length and position of each section are shared by pipeline specialists (Onshore and nearshore flowlines) and geospatial team (Shipping lanes). The platform zone is an extended area 500 m from platforms as defined in pipeline design code / standards.

At shore approach, the transport pipeline connection to onshore facilities is achieved through a drilled micro-tunnel.

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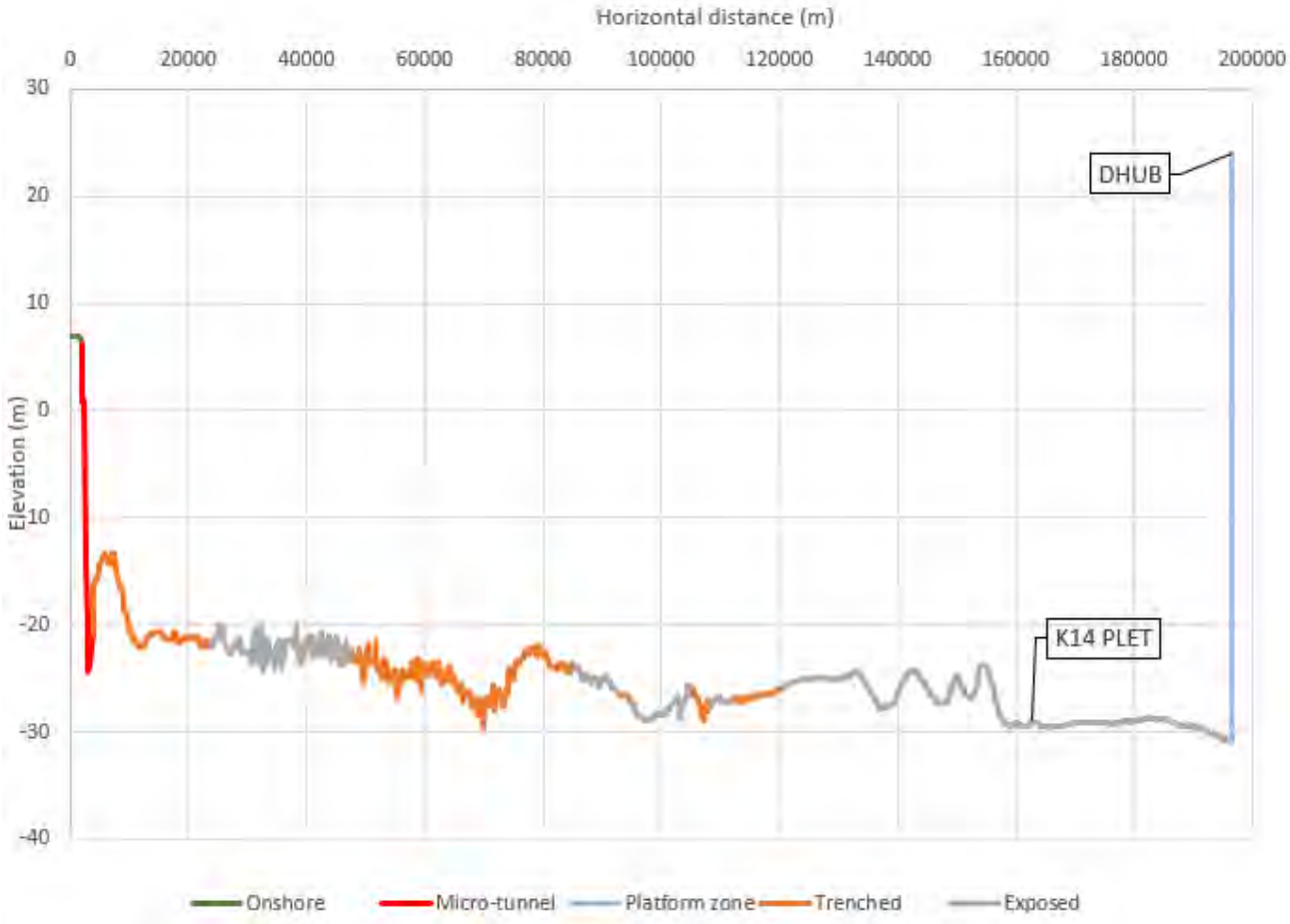


Figure 3-2: Trunkline - Onshore to DHUB pipeline bathymetries

The total measured length of the trunkline is about 198.3 km.

3.3.2.2 Main Spurlines

The main spurlines are part of the injection system. The pipe diameter is the main difference with the trunkline. The spurlines are listed here after:

- DHUB to L4A PLEM: Total measured length is about 26.2 km.
- L4A PLEM to L4A platform: Total measured length is about 1.9 km.
- K14 PLET to K14 platform: Total measured length is about 2 km.
- DHUB to L10 platform: Total measured length is about 20 km.

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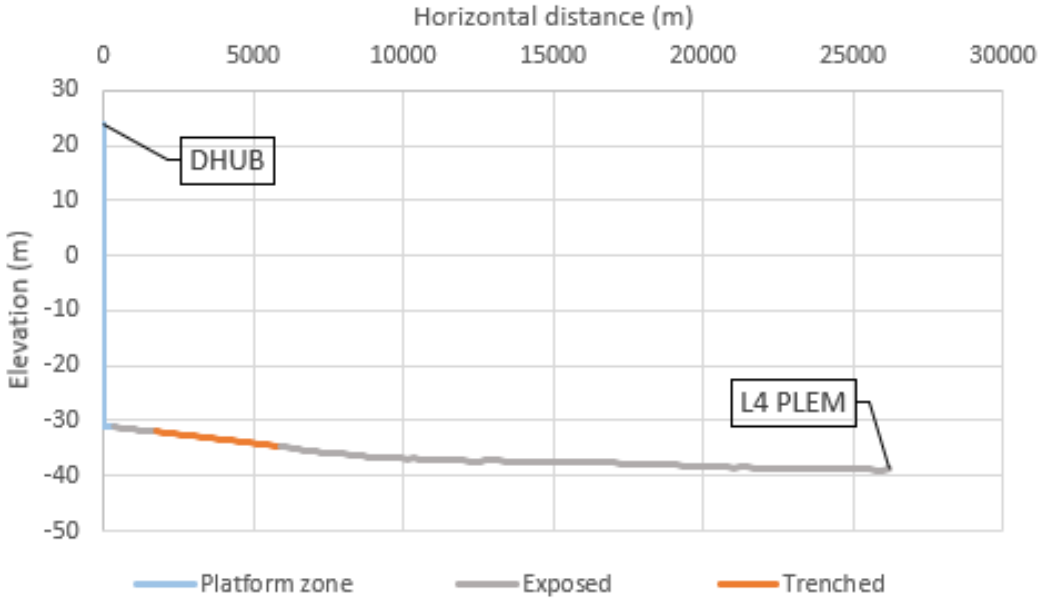


Figure 3-3: Section C (DHUB to L4A PLEM) pipeline bathymetries

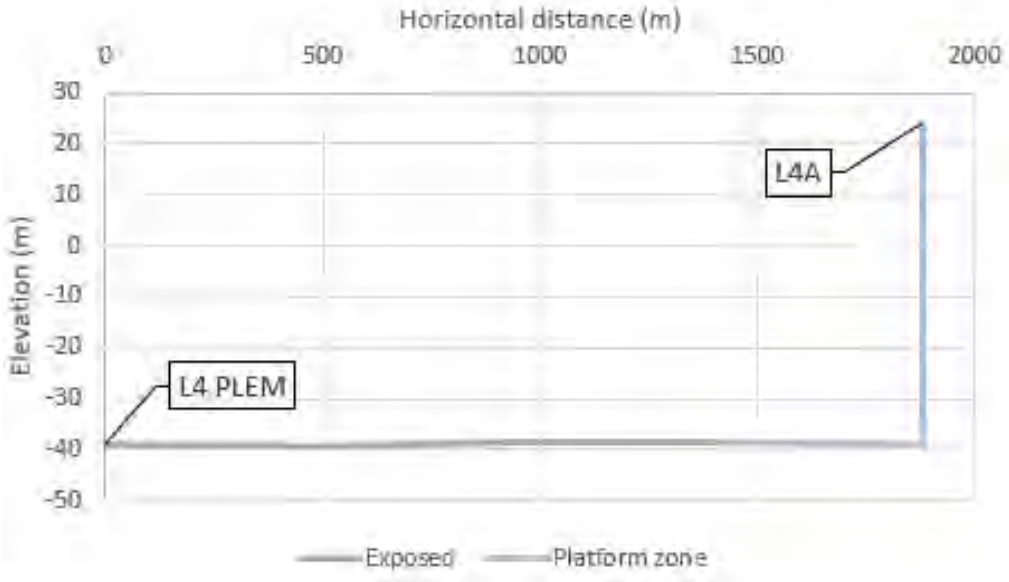


Figure 3-4: L4 PLEM to L4A platform pipeline bathymetries

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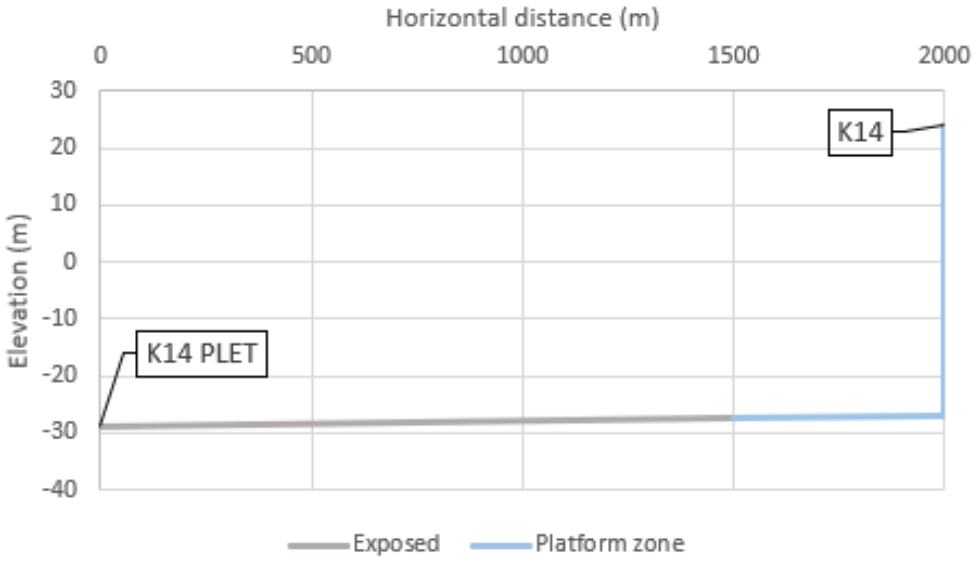


Figure 3-5: K14 PLET to K14 platform pipeline bathymetries

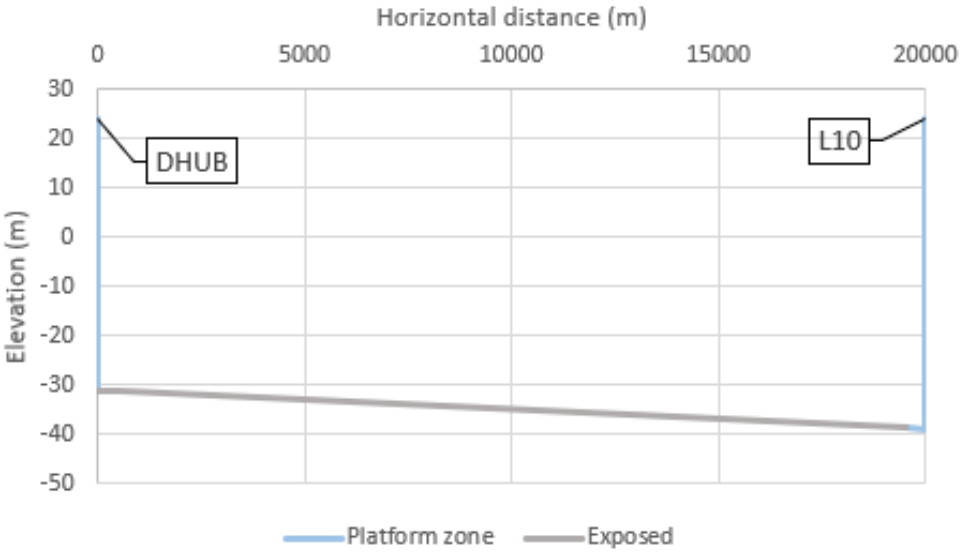


Figure 3-6: DHUB to L10 platform pipeline bathymetries

3.3.3 Cross sections of the flowlines

3.3.3.1 Main trunkline

The following table gives the cross section of the pipeline and risers considered for the study and the thermal properties of the different materials used in the analysis and as modelled in *OLGA*. These thermal properties are based on conservative values. Typically, the thermal conductivity is based on wet, aged values, while the density and heat capacity are based on initial conditions.

Different cross-sections for the transport pipeline will be observed along the pipe route due to the nature of soil, the presence of the micro-tunnel and several shipping lanes. In order to capture any potential impact of those different cross-sections during transient operations of the pipeline on the

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flowing temperature, a detailed modeling of the transport pipeline has been therefore developed in the *OLGA* model by implementing all the different cross sections.

Most of pipeline characteristics have been shared by the pipeline specialists. Should any information be missing, an assumption in then taken and discussed with the pipeline specialist.

It is worth mentioning that all burial depths have been recalculated by an internal tool (methodology almost similar to recommendation implemented in *OLGA User Manual*) that has been developed to estimate an equivalent thickness taking into account upper and lower layers of soil around the pipe. Because of the thickness of the equivalent layer, the density and heat capacity of the soil have been slightly modified to adjust the thermal inertia of the soil according to burial depth as per TotalEnergies internal practises in order not to over-estimate the Cool-Down time performance of the buried section. This should be revisited at next phase depending on the modelling approach considered for buried section modelling.

All pressure requirement calculations in the present Flow Assurance study are considering a transport pipeline roughness of 45 µm, which is conservative and representative of the roughness after few years in operations of the transport pipeline.

All the cross-sections included in the model are summarized in the different tables here below.

Buried – Onshore – 32'' OD						
Layer / Material	**ID**	**Thickness**	**OD**	**Conductivity**	**Density**	**Specific heat**
	mm	**mm**	**mm**	**(W/m.K)**	**(kg/m^3)**	**(J/kg.C)**
Carbon steel	755.64	28.6	812.8	45	7850	470
3LPP	812.8	3.0	818.8	0.22	900	1750
Concrete	818.8	150	1118.8	3	2500	960
Buried Sand	1118.8	2510.0 (1)	6138.72	1.8	1780	907.2
Note: **1**. The pipe has a burial depth of 1 m. The presented value is an equivalent thickness taking into account lower layer as well.						

Table 3-3: Cross sections & thermal properties of the Onshore section

Micro-tunnel – 32'' OD						
Layer / Material	**ID**	**Thickness**	**OD**	**Conductivity**	**Density**	**Specific heat**
	mm	**mm**	**mm**	**(W/m.K)**	**(kg/m^3)**	**(J/kg.C)**
Carbon steel	755.64	36.7	829.04	45	7850	470
3LPP	829.04	10	849.04	0.22	900	1750
Sea Water	849.04	3.7 (2)	856.36	0.6	1000	4180
Onshore rock	856.36	31174.5 (1)	63205.3	2.25	2300	850
Note: **1**. The pipe has a burial depth of 15 m. The presented value is an equivalent thickness taking into account lower layer as well. **2**. The thickness of the water layer has been calculated based on the volume of the drilled section						

Table 3-4: Cross sections & thermal properties of the micro-tunnel

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Shipping channels - trenched – 32'' OD						
Layer / Material	**ID**	**Thickness**	**OD**	**Conductivity**	**Density**	**Specific heat**
	mm	**mm**	**mm**	**(W/m.K)**	**(kg/m^3)**	**(J/kg.C)**
Carbon steel	755.64	28.6	812.8	45	7850	470
3LPP	812.8	3.0	818.8	0.22	900	1750
Concrete	818.8	130	1078.8	3	2500	960
Buried Sand	1078.8	1679.5 (1)	4437.85	1.8	1780	907.2
Note: **1**. The pipe has a burial depth of 0.6 m. The presented value is an equivalent thickness taking into account lower layer as well.						

Table 3-5: Cross sections & thermal properties of the shipping channels (trenched) – trunkline

Platform zones – 32'' OD						
Layer / Material	**ID**	**Thickness**	**OD**	**Conductivity**	**Density**	**Specific heat**
	mm	**mm**	**mm**	**(W/m.K)**	**(kg/m^3)**	**(J/kg.C)**
Carbon steel	755.64	30.2	816	45	7850	470
3LPP	816	3.0	822	0.22	900	1750
Concrete	822	150	1122	3	2500	960

Table 3-6: Cross sections & thermal properties of the platform zones – trunkline

Exposed pipes – 32'' OD						
Layer / Material	**ID**	**Thickness**	**OD**	**Conductivity**	**Density**	**Specific heat**
	mm	**mm**	**mm**	**(W/m.K)**	**(kg/m^3)**	**(J/kg.C)**
Carbon steel	755.64	28.6	812.8	45	7850	470
3LPP	812.8	3.0	818.8	0.22	900	1750
Concrete	818.8	150	1118.8	3	2500	960

Table 3-7: Cross sections & thermal properties of the exposed pipes – trunkline

3.3.3.1 Main Spurlines

Shipping channels - trenched – 24'' OD						
Layer / Material	**ID**	**Thickness**	**OD**	**Conductivity**	**Density**	**Specific heat**
	mm	**mm**	**mm**	**(W/m.K)**	**(kg/m^3)**	**(J/kg.C)**
Carbon steel	565.14	22.2	609.6	45	7850	470
3LPP	609.6	3.0	615.6	0.22	900	1750
Concrete	615.6	110	835.6	3	2500	960
Buried Sand	835.6	1147.6	3130.7	1.8	1780	907.2
Note: **1**. The pipe has a burial depth of 0.6 m. The presented value is an equivalent thickness taking into account lower layer as well.						

Table 3-8: Cross sections & thermal properties of the shipping channels (trenched) – Main spurlines

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Platform zones – 24'' OD						
Layer / Material	**ID**	**Thickness**	**OD**	**Conductivity**	**Density**	**Specific heat**
	mm	**mm**	**mm**	**(W/m.K)**	**(kg/m^3)**	**(J/kg.C)**
Carbon steel	565.14	23.8	612.8	45	7850	470
3LPP	612.8	3.0	618.8	0.22	900	1750
Concrete	618.8	100	818.8	3	2500	960

Table 3-9: Cross sections & thermal properties of the platform zones – Main spurlines

Exposed pipes – 24'' OD						
Layer / Material	**ID**	**Thickness**	**OD**	**Conductivity**	**Density**	**Specific heat**
	mm	**mm**	**mm**	**(W/m.K)**	**(kg/m^3)**	**(J/kg.C)**
Carbon steel	565.14	22.2	609.6	45	7850	470
3LPP	609.6	3.0	615.6	0.22	900	1750
Concrete	615.6	110	835.6	3	2500	960

Table 3-10: Cross sections & thermal properties of the exposed pipes – Main spurlines

3.4 CO_2 specifications – key assumptions

Two entry specifications are considered, one for CO_2 arriving by ship (liquid CO_2) and one for CO_2 arriving by vapor phase pipeline (gaseous CO_2). This section outlines entry specifications and design compositions for the respective building blocks.

The following limits on impurities are carried (Ref. [1]):

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Class	Component	Constraint	unit	value
	CO_2	larger than	mol%	balance
	H_2O	less than	ppmmol	30
inerts	N_2	less than	mol%	-
	O_2	less than	ppmmol	10
	H_2	less than	ppmmol	500
	Ar	less than	mol%	-
	CH_4	less than	mol%	-
	CO	less than	ppmmol	1200
	$O_2+N_2+H_2+Ar+CH_4+CO$	sum less than	ppmmol	2000
	NO_x	sum less than	ppmmol	10
sulphur	SO_x	sum less than	ppmmol	10
	H_2S	less than	ppmmol	5
	CarbonylSulphide	less than	ppmmol	-
	DimethylSulphide	less than	ppmmol	-
	H_2S + COS + SO_x + DMS	sum less than	ppmmol	-
Volatile organic components	Amine	less than	ppmmol	10
	Formaldehyde	less than	ppmmol	20
	Acetaldehyde	less than	ppmmol	20
	Aldehydes	sum less than	ppmmol	-
	carbolylic acids & amides	sum less than	ppmmol	-
	phosphorus-containing compounds	sum less than	ppmmol	-
	NH_3	less than	ppmmol	10
	Ethylene (C_2H_4)	sum less than	ppmmol	-
	H-Cyanide (HCN)	less than	ppmmol	-
	Total volatile organic compounds (excl. MeOH, EtOH, aldehydes)	sum less than	ppmmol	10
	Methanol	less than	ppmmol	40
	Ethanol	less than	ppmmol	20
Heavies	glycols (TEG)	sum less than		-
	C_{2+} (aliphatic hydrocarbons)	sum less than	ppmmol	-
	Aromatic Hydrocarbons	sum less than	ppmmol	-
Metals	Hg	less than	ppbmol	30
	Cadmium + Thalium	sum less than	ppbmol	30

Table 3-11: Aramis Liquid CO_2 - Specifications for CO_2 loaded in the CO_2 ships/barges

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Class	Component	Constraint	unit	value
	CO_2	larger than	mol%	95
	H_2O	less than	ppmmol	70(1)
inerts	N_2	less than	mol%	2.4
	O_2	less than	ppmmol	40
	H_2	less than	ppmmol	7500
	Ar	less than	mol%	0.4
	CH_4	less than	mol%	1
	CO	less than	ppmmol	750
	$O_2+N_2+H_2+Ar+CH_4+CO$	sum less than	ppmmol	40000
	NO_x	sum less than	ppmmol	5
sulphur	SO_x	sum less than	ppmmol	-
	H_2S	less than	ppmmol	5
	CarbonylSulphide	less than	ppmmol	0.1(2)
	DimethylSulphide	less than	ppmmol	1.1(2)
	H_2S + COS + SO_x + DMS	sum less than	ppmmol	20
Volatile organic components	Amine	less than	ppmmol	1
	Formaldehyde	less than	ppmmol	-
	Acetaldehyde	less than	ppmmol	0.2 (2)
	Aldehydes	sum less than	ppmmol	10
	carbolylic acids & amides	sum less than	ppmmol	1
	phosphorus-containing compounds	sum less than	ppmmol	1
	NH_3	less than	ppmmol	3
	Ethylene (C_2H_4)	sum less than	ppmmol	1(2)
	H-Cyanide (HCN)	less than	ppmmol	2
	Total volatile organic compounds (excl. MeOH, EtOH, aldehydes)	sum less than	ppmmol	10
	Methanol	less than	ppmmol	620
	Ethanol	less than	ppmmol	20
Heavies	glycols (TEG)	sum less than		Follow dew-point specs
	C_{2+} (aliphatic hydrocarbons)	sum less than	ppmmol	1200
	Aromatic Hydrocarbons	sum less than	ppmmol	0.1
Metals	Hg	less than	ppbmol	-
	Cadmium + Thalium	sum less than	ppbmol	-
Dew-point	Dew point (any liquid phase)	sum less than	°C (@ 20 bar)	-10 (3)

Table 3-12: Aramis Gaseous CO_2 - Specification for CO_2 loaded in the CO_2 pipeline

Notes

1. Specification maintained at 40 ppmmol as per OCAP spec. CO2 spec v 3.1 for Porthos infrastructure is 70 ppm.

2. Specification as per OCAP specification (OCAP-ME-20180307-JLi) and only applicable for emitters that will also flow via OCAP infrastructure.

3. Measured or predicted using CPA equation of state.

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A number of impurities are included in the overview without a specific limit to their content. Emitters agree to inform Aramis in case these components are expected in the CO_2 product at levels above 1 ppmmol. Aramis will then conduct a risk assessment study to understand the maximum amount that can be tolerated (Ref. [1]).

The Aramis design does not contain facilities to remove impurities above agreed values. The impurity level of several components, including H_2O, are directly linked to maintaining design integrity.

The design composition for phase behavior and thermophysical properties is derived as follows:

- Volatile organic components are modelled as Methanol
- C2+ is modelled as Ethane
- Components <= 1 ppmmol are ignored
- For pipeline, the nitrogen content is adjusted to meet the total inert spec. All other inert components are at their maximum allowable individual level.
- Sulphur oxides are modelled as SO_2.

Component	Amount (mol)
CO_2	95
H_2O	0.004
N_2	2.4
O2	0.004
H_2	0.75
AR	0.4
CH_4	1
CO	0.075
NO	0.003
NO_2	0.002
SO_2	0
H_2S	0.00511
NH_3	0.0003
HCN	0.0002
METHANOL	0.064
ETHANOL	0.002
ETHANE	0.12

Table 3-13: Final CO_2 specification

Due to the introduction of the impurities, the phase envelope is subject to be modified compared to initial specifications. The higher will be the impurities content in the specifications, the larger will be the phase envelope, therefore potentially triggering the risks to observe two-phases flow conditions in the transport system in case of low pressure. The effect of impurities may also impact the accuracy of the Flow Assurance outcomes in two phase operational area if any.

The figures here below summarize the phase envelope associated to the different specifications along with the Water Dew curve:

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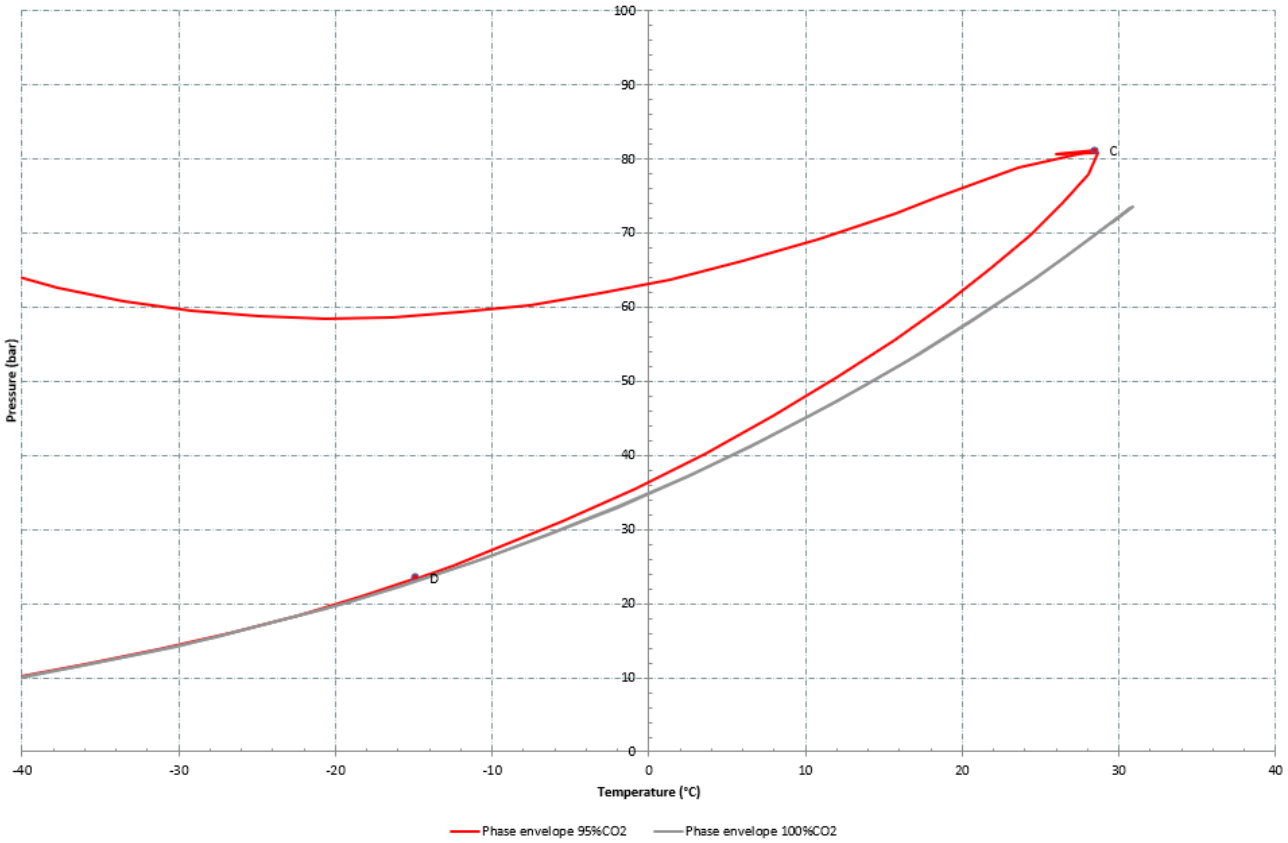


Figure 3-7: Comparisons of phase envelope between pure CO_2 & 95% CO_2 composition

As observed on the phase envelopes of pure CO_2 in comparison with CO_2 with impurities, the critical point of CO_2 fluid with impurities is higher than the one of pure CO_2 fluid (81.2 bar vs. 73.6 bar), making the fluid containing the impurities more conservative.

It is also worth mentioning that the introduction of impurities in the CO_2 specification affects the water solubility and therefore the water dew curve as those impurities will interact with water. This might increase the risks of appearance of free water and therefore the risks of corrosion.

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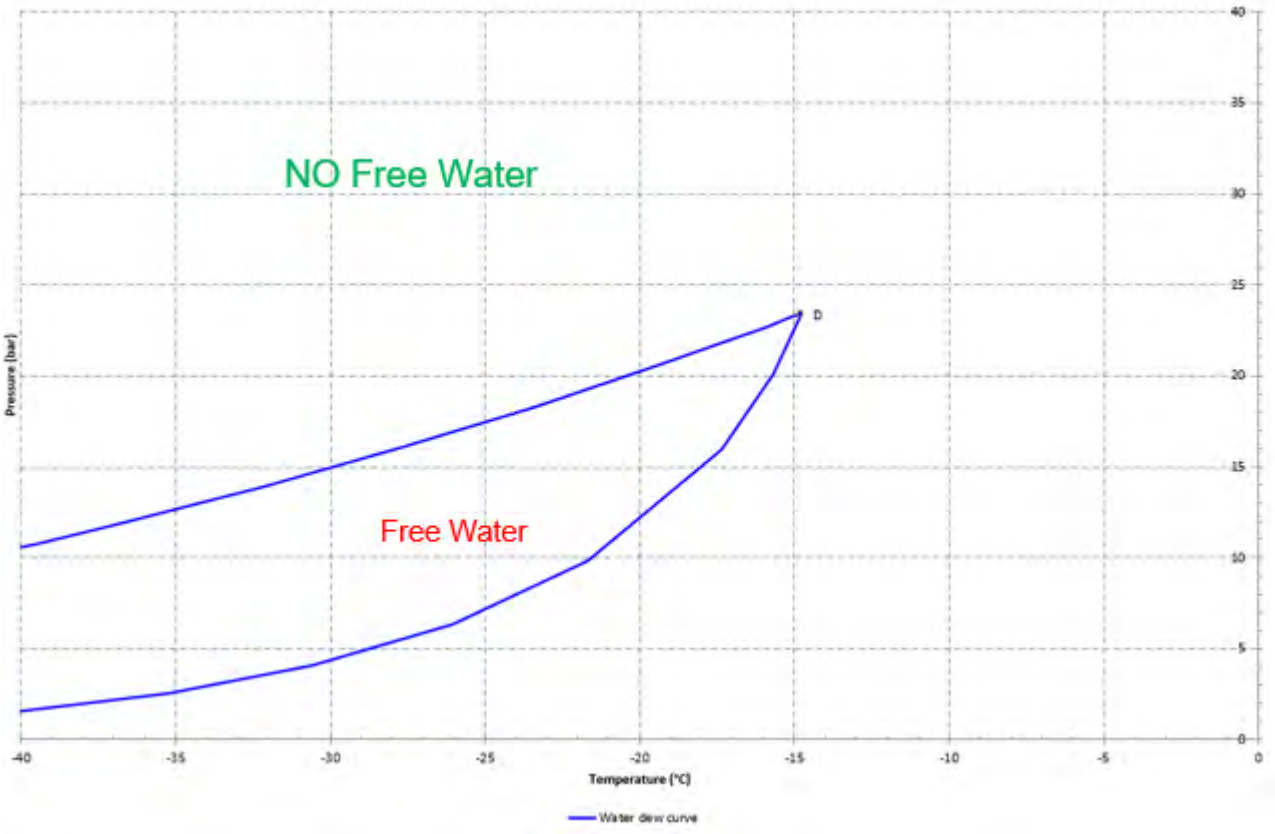


Figure 3-8: Water dew curve considering 95% CO_2 composition

According to liquid CO_2 specification and anticipated operating conditions in the injection system, there is no risk to observe free water, therefore mitigating the hydrates risks and the risks of corrosion in the system. Should the liquid CO_2 specification be revisited, then the risks to observe free water in the system should be updated accordingly.

Specific attention should be nevertheless paid during first filling operations of the trunkline with CO_2 as low pressure and low temperature might be observed during this specific operation, making operating conditions not so far from water dew curve with the latest proposed sequence by EBN (Appendix **Erreur ! Source du renvoi introuvable.**). This should be further evaluated at next phase of the project.

Due to CO_2 injection in an aquifer, hydrates risks could be triggered in the injection wells after “long” shutdown as the CO_2 stream should be saturated with higher water content than what is mentioned in the liquid CO_2 specification. The time for the CO_2 contained in the tubing to be saturated with water during shutdown is difficult to evaluate but risks cannot be neglected at this stage.

Such negative outcome imposes the implementation of specific operating procedure prior restarting wells as for instance bullheading of MEG within injection tubing before the opening of the Injection Choke valve in order to “dry” the fluid located at top part of the tubing.

In steady state operations, no hydrates risks are anticipated in the transport pipeline because of the low water content. Extremely low temperatures and low pressures have to be observed in the system before triggering any hydrates crystals formation, and those conditions are far from expected operating conditions of the transport system.

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3.5 Injection profile and inlet conditions

3.5.1 Injection profile

For this phase of the project, a peak injection rate of 22 MTPA is defined. Two take-offs of 8 MTPA at K14 PLET and 6 MTPA at the DHUB towards L10 platform should be taken into account. The rest is injected into TotalEnrgies area.

In addition to the 22 MTPA peak rate, a 5 MTPA flowrate is simulated as it gives more insights on early life injection with lower reservoir pressure. The following table indicates the flowrates associated to each platform:

		Rate	
Inlet	MTPA	**5**	**22**
	Kg/s	158.55	697.62
K14	MTPA	**2.5**	**8**
	Kg/s	79.27	253.68
DHUB	MTPA	**2.5**	**14**
	Kg/s	79.27	443.94
L10	MTPA		**6**
	Kg/s		190.26
TTE PLEM	MTPA	**2.5**	**8**
	Kg/s	79.27	253.68
L4A	MTPA	**2.5**	**-**
	Kg/s	79.27	-
Note: For the peak rate, the flowrate for L4A platform is not mentioned. In this case, indicative results of the subsea manifold at 1.9 km from L4A platform and -39 m of water depth will be presented			

Table 3-14: Injection profile for the sizing years

3.5.2 Inlet conditions

The different discharge pressure requirements for both sizing years along with the discharge temperature are presented in the following table:

	5 MTPA case	22 MTPA case
Pressure (barg)	150	180
Temperature (°C)	50	50

Table 3-15: Trunkline inlet conditions

It is worth to mention that these values are input data from CCS development team working on Aramis project and are representative of future operations on Aramis. It has also been decided to consider the warmest inlet temperature as a conservative approach for thermo-hydraulic calculations since it maximizes the pressure losses. Several sensitivities are conducted regarding the inlet conditions mostly for the design temperature determination explicated in the next sections.

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4 METHODOLOGY

4.1 Steady state

Steady state simulations have been performed for both peak rate and startup / early life flowrates with several inlet conditions using *OLGA 2021* for the base cases and an internal CO_2 spreadsheet developed by the Flow Assurance team in TotalEnergies and based on analytical model for pressure drop calculation for the sensitivity cases. This was possible thanks to the monophasic behavior of CO_2 transport in the network.

Concerning the *OLGA* simulations, it is worth mentioning that throughout the simulations, several parameters are assessed:

- Pressure and temperature at key points of the injection system including platforms and other focal arrival points,
- Flowrates throughout the injection system and target rates for each well,
- Injection wells chokes openings,
- The erosion velocity ratio as well as fluid velocities and flow regime inside the pipelines and riser.

For the calculations performed for this study using *OLGA*, and in order to capture the dynamic of the whole system, the entire injection system is modeled including the injection wells of TotalEnergies area. Only BB03 related information and results are presented in this report.

The number of thermo-hydraulic simulations has been optimized, mainly covering the following cases:

- Base Case 1: Max Flowrate of 22 MTPA – discharge pressure 180 barg – Inlet temperature 50°C
- Base Case 2: Startup / early life flowrate of 5 MTPA – discharge pressure 150 barg – Inlet temperature 50°C
- Sensitivity Case 1: Max Flowrate of 22 MTPA all the way to DHUB without any take-off at K14 PLET – discharge pressure 180 barg – Inlet temperature 50°C – Most likely not to occur but it was studied to evaluate the packing time.
- Sensitivity Case 2: Max Flowrate of 22 MTPA – discharge pressure 180 barg – Inlet temperature 65°C – Most likely not to occur but it was studied to define the design temperature of the trunkline.
- Sensitivity Case 3: Max Flowrate of 22 MTPA – discharge pressure 180 barg – Inlet temperature 56°C – This case was studied to further refine the design temperature of the trunkline, being less stringent.
- Sensitivity Case 4: Max Flowrate of 11 MTPA coming from Porthos – discharge pressure 180 barg vs 120 barg – Inlet temperature 65°C – This case was studied to further refine the design temperature of the trunkline being less stringent.

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4.2 Transient calculations

The injection case selected to perform transient analysis is 22 MTPA, which is the injection case with maximum flowrate, maximum operating pressure, maximum settle-out pressure, high reservoir pressurization, Etc. This injection scenario is used to determine the operating philosophies and key equipment for all transient operations while ensuring pipeline integrity with regards to design conditions, risks of ice formation, hydrates risks, Etc.

The following table lists the transient simulation cases and provides further details on each case:

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Transient operation	Sequence of operation	Verifications	Steady state initial case
Shutdown – Packing 1	1. Spurious closure of wells 2. Pumps still in operation	- Definition of the safe shutdown operation to avoid two-phases - Evaluation of the time for operators to react - Estimation of the hydrate and ice risk - Pressure, temperature & density profile evolution over time	22 MTPA base case
Shutdown – Packing 2	1. Closure of Riser Isolation Valve (RIV) upstream DHUB 2. Pumps still in operation		22 MTPA to DHUB with no take-off at K14 (sensitivity case 1)
Shutdown - Depacking	1. Spurious shutdown of pumps 2. Wells still open	- Determination of the minimum pressure and time required after shutdown to reach the vapor phase threshold pressure or crossflow between the injection wells	22 MTPA base case
Planned depressurization	1. Shutdown of pumps 2. Wells kept open 3. Blowdown through wells till reaching pressure in transport line 10 - 20 bar above highest WHSIP or 10 bar above pressure that triggers two phase flow. 4. Wells closed 5. Depressurization continued through RO topsides	- Procedure for planned depressurization offshore - Sequence in case of unplanned or emergency depressurization due to pipe blockage, collapse, Etc. - Restriction Orifice (RO) sizing - Depressurization flowrates to vent - Assess position of the depressurization system (onshore or offshore) - Accurate dynamic heat flow transfer modelling of the flowlines - Depressurization duration - Pressure and temperature profile vs time - Evaluation of hydrates and ice risks, high pressure drop / line blockage, free water & two-phase zone - Minimum temperature over the line	22 MTPA base case
Depressurization after unplanned abnormal shutdown - Wells available	1. Spurious closure of wells 2. Pumps still in operation 3. Packing of the transport pipeline at the highest pressure 4. Blowdown through furthest well presenting lowest WHSIP till reaching pressure in transport pipeline 10 - 20 bar above WHSIP or 10 bar above pressure that triggers two phase flow		22 MTPA base case
Depressurization after unplanned abnormal shutdown - Wells not available (Plug, Etc.)	1. Spurious closure of wells 2. Pumps still in operation 3. Packing of the transport pipeline at the highest pressure 4. Blowdown through RO topsides		22 MTPA base case

Table 4-1: Conducted transient simulations

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5 STEADY STATE RESULTS

In this section are presented the main results of the steady state simulations for the base case of Aramis project along with a number of sensitivity studies changing the inlet conditions in order to analyze the impact over the temperature and pressure profiles over the trunkline.

5.1 Base case

Pressure results considered for the validation of the production profile are based on simulations for warm conditions maximizing pressure drop along the pipeline.

Two different flowrates have been studied:

- Peak flowrate: 22 MTPA with 180 barg as inlet pressure
- Early life flowrate: 5 MTPA with 150 barg as inlet pressure

5.1.1 22MTPA scenario

5.1.1.1 Operating conditions against phase envelope

The pressure and temperature profiles along the transport pipeline route have been compared to phase envelope in order to identify any risk of two-phases flow conditions anywhere in the injection system.

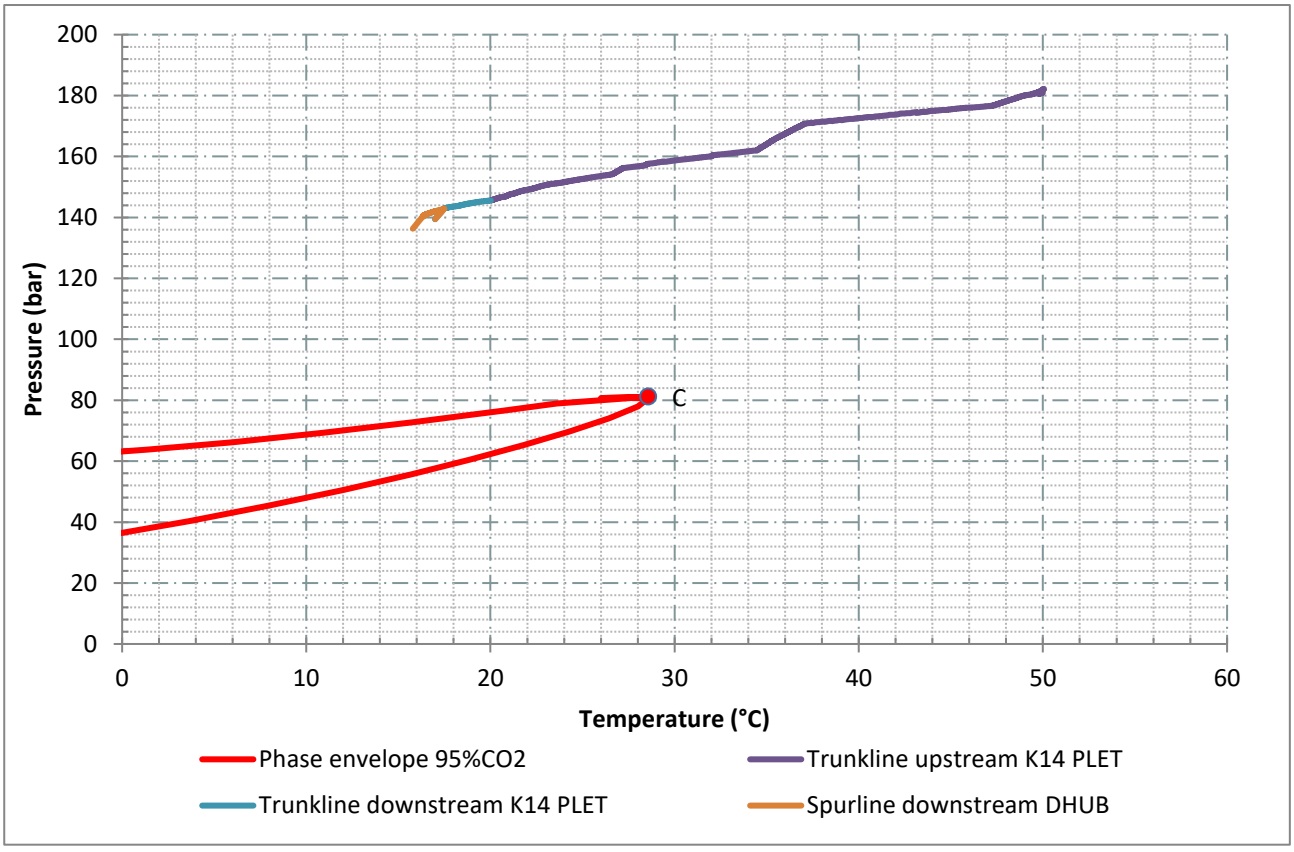


Figure 5-1: Operating conditions of transport pipeline at 22 MTPA against phase envelope

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As observed on previous figure, there is no risk to operate the transport pipeline in two-phase flow conditions at 22 MTPA. The operating conditions are always far from the phase envelope with more than 60 bar from the critical point including a 10 bar margin when applied.

5.1.1.2 Pressure Profile

Here after is presented the pressure profile (more details are presented in the appendix 9.1.1.1) along the trunkline of 32 in OD for 22 MTPA with a take-off of 8 MTPA at K14 PLET and the spurline of 24 in OD after take-off of 6 MTPA at DHUB for L10 platform. The results include a 10% margin on total pressure drop.

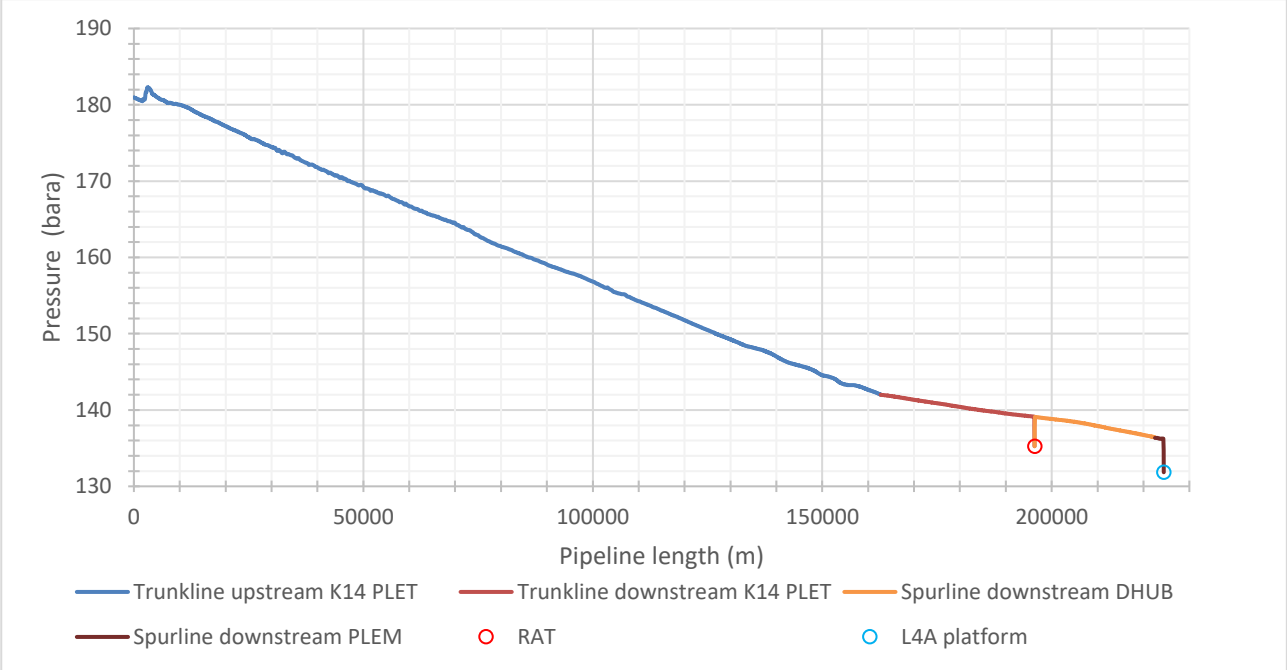


Figure 5-2: Pressure profile for the 22 MTPA case

As the figure indicates, with a 180 barg discharge pressure, the arrival pressure at K14 PLET is approximatively 141 barg and at top of DHUB 134.2 barg including the 10% margin on pressure drop. The arrival pressure at L4A platform is about 131 barg. Further indications on arrival pressures at platforms are presented in the following sections.

5.1.1.3 Temperature Profile

Here after is presented the temperature profile (more details are presented in the appendix 9.1.1.2) along the trunkline of 32 in OD for 22 MTPA with a take-off of 8 MTPA at K14 PLET and the spurline of 24 in OD after take-off of 6 MTPA at DHUB for L10 platform. The given results are for the warm case (summer conditions for ambient temperature and warmest temperature at inlet for a 22 MTPA flowrate).

As observed on the temperature profile, the arrival temperature at DHUB is about 17°C while the arrival temperature at top of L4A platform is about 15.8°C. It is worth mentioning that the fluid takes longer time than expected to be in thermal equilibrium with the seabed ambient temperature and that is due to the large flowrate, minimizing heat exchange with the ambient environment and the huge thermal inertia of the CO_2.

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From this temperature profile, it appears that the range of temperature expected at the different injection sites should follow the sea water seasonal temperatures, meaning that the arrival temperature should range between 4°C and 16°C, whatever the injection temperature at onshore terminal.

It is worth mentioning that with reduced flowrate, the thermal equilibrium with surrounding sea water will be reached sooner in the trunkline, not modifying the conclusion above with regards to arrival temperature at different offshore platforms.

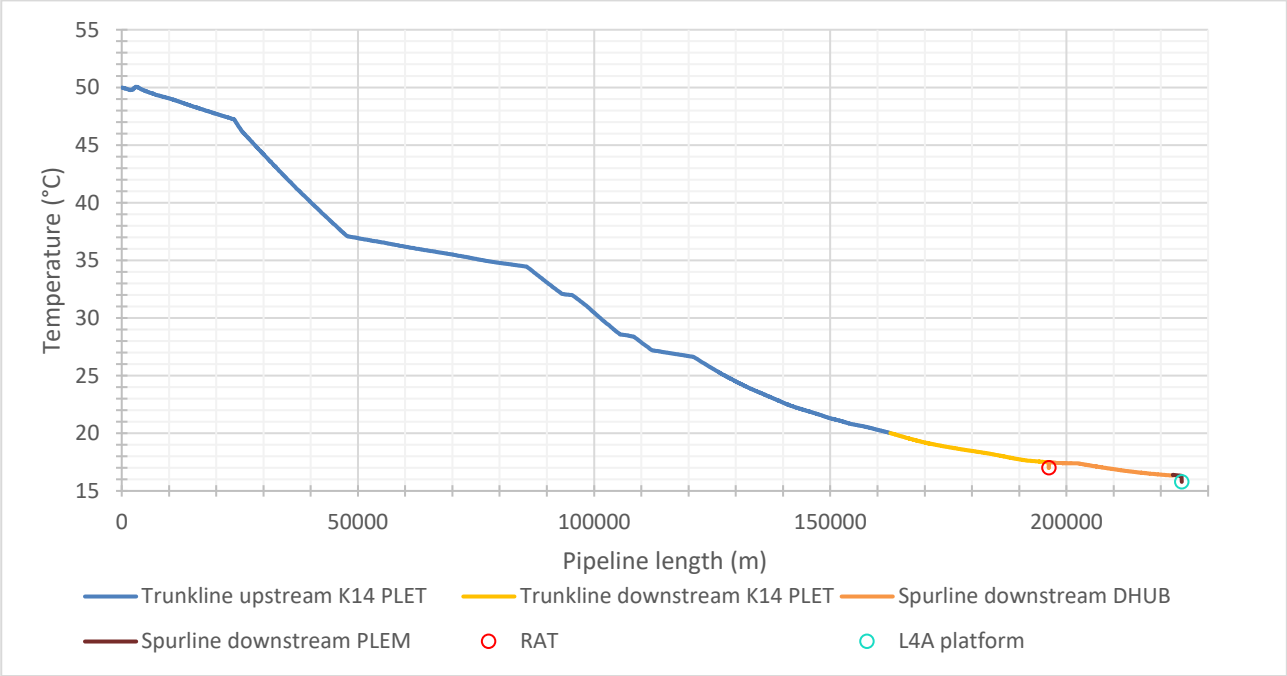


Figure 5-3: Temperature profile for the 22 MTPA warm case

5.1.1.4 Arrival conditions at platforms

Here after are presented the arrival conditions at each platform along with the reached flowrate.

From the present Flow Assurance study, it appears that the injection of 22 MTPA might be highly challenging at the end of life, therefore highlighting the strong effect of the pressure build-up observed in the reservoir during field life.

This is a major uncertainty that is difficult to unlock at this stage.

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Platform	K14	DHUB	L10	TTE PLEM (3)
Arrival flowrate (MTPA)	8	14	6	8
Arrival flowrate (kg/s)	253.68	443.94	190.26	253.68
Arrival pressure (bara) (1)	137.96	135.18	133.79	136.43
Arrival pressure + topside pressure drop margin (2)	132.96	135.18	128.79	136.43
Temperature (°C)	19.2	17.06	16	16.33

Note:

1. The indicated arrival pressure includes a 10% margin on the pressure drop. Reference height +24 m / MSL except for TTE PLEM which is at -39 m / MSL,

2. The indicated arrival pressure includes both 10% margin on pressure drop and a 5 bar margin representative of topside pressure drop related to piping and chokes. Reference height +24 m / MSL except for TTE PLEM which is at -39 m / MSL,

3. For the peak rate only indicative results of the subsea manifold at 1.9 km from L4A platform and -39 m of water depth are presented

Table 5-1: Arrival conditions at platforms for 22 MTPA base case

5.1.1.5 Fluid velocity and Erosional Velocity Ratio

The fluid velocity and the Erosional velocity ratio (EVR) over transport pipeline route at peak injection rate (22 MTPA) ranges:

- Trunkline upstream DHUB:
  - Minimum Fluid velocity ranges from 1.15 to 2.34 m/s,
  - Maximum EVR ranges from 0.28 to 0.49.

- Spurlines downstream DHUB & from K14 PLET to K14 platform:
  - Minimum Fluid velocity ranges from 0.77 to 1.21 m/s,
  - Maximum EVR ranges from 0.18 to 0.29.

No erosion neither deposition (if any precipitates, particles, solids, Etc.) issues are anticipated in the mentioned flowlines as both EVR and fluid velocities are within an acceptable limit.

5.1.2 5 MTPA scenario

5.1.2.1 Operating conditions against phase envelope

The pressure and temperature profiles along transport pipeline route and within injection wells have been compared to phase envelope in order to identify any risk of two-phases flow conditions anywhere in injection system.

As observed on the following figure, there is no risk to operate the transport pipeline in two-phase flow conditions at 5 MTPA. The operating conditions are always far from phase envelope with more than 60 bar from the critical point including a 10 bar margin when applied.

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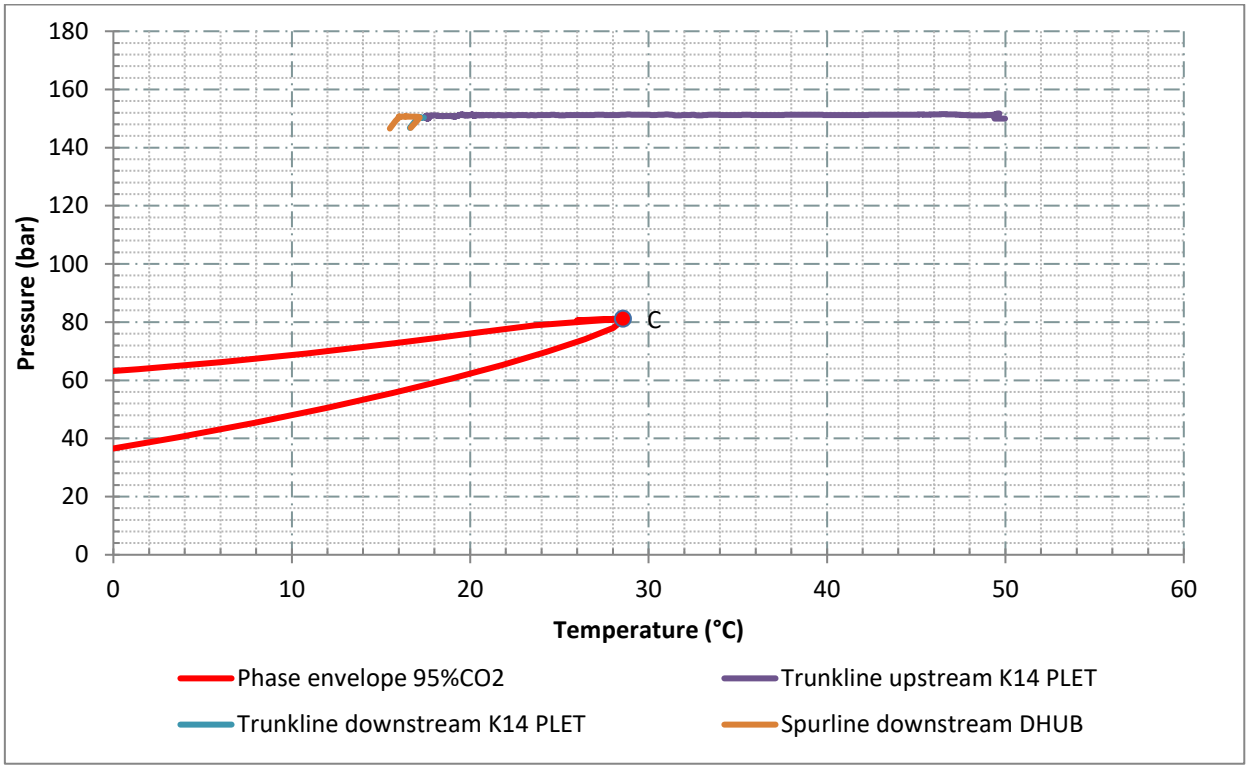


Figure 5-4: Operating conditions of transport pipeline at 5 MTPA against phase envelope

5.1.2.2 Pressure Profile

Here after is presented the pressure profile (More details are presented in the appendix 9.1.2.1) along the trunkline of 32 in OD for 5 MTPA with a take-off of 2.5 MTPA at K14 PLET and the spurline of 24 in OD downstream DHUB. The results include a 10% margin on total pressure drop.

As presented in the following figure, with a 150 barg discharge pressure, the arrival pressure at K14 PLET is approximatively 149.2 barg and at top of DHUB 145.4 barg including a 10% margin on pressure drop. The arrival pressure at L4A platform is about 145.1 barg. Further indications on arrival pressures at platforms are presented in the following sections.

Because of the low injection rate, there is almost no pressure drop into the injection system allowing reaching at injection platforms high delivery pressures. Those results are consistent.

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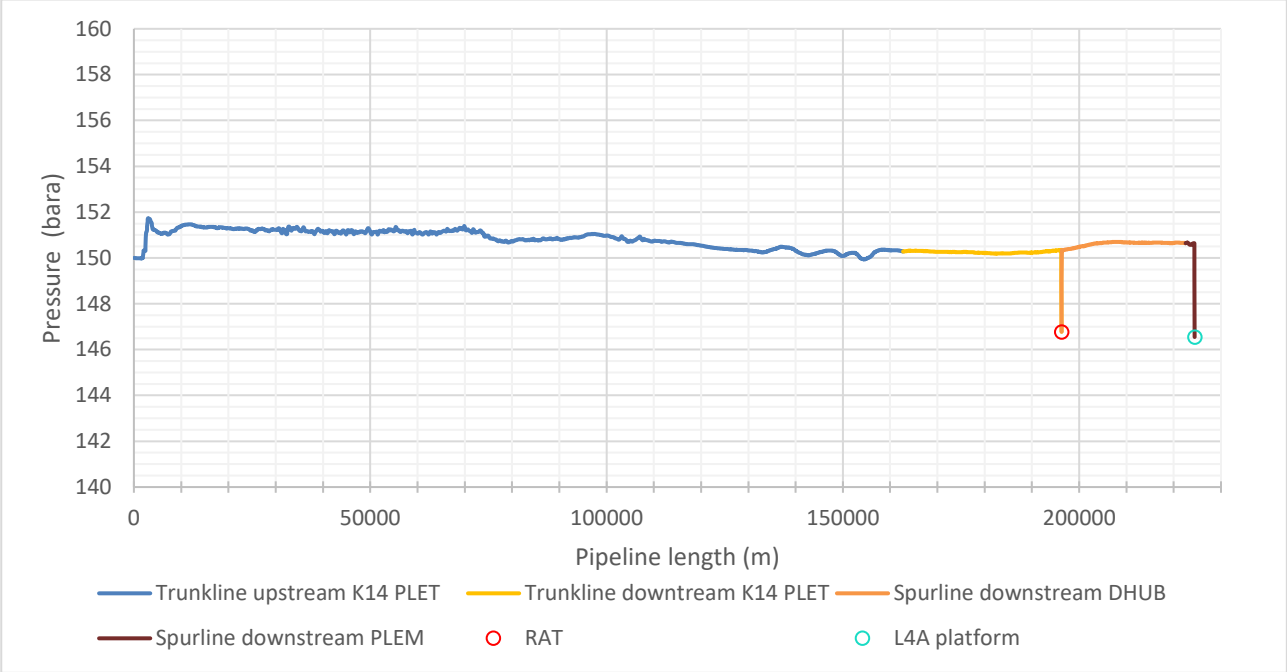


Figure 5-5: Pressure profile for the 5 MTPA case

5.1.2.3 Temperature Profile

Here after is presented the temperature profile (More details are presented in the appendix 9.1.2.2) along the trunkline of 32 in OD for 5 MTPA with a take-off of 2.5 MTPA at K14 PLET and the spurline of 24 in OD downstream DHUB. The given results are for the warm case (summer conditions for ambient temperature).

As observed on the temperature profile below, the arrival temperature at DHUB is about 16.7°C while the arrival temperature at top of L4A platform is about 15.5°C. Further indications on arrival temperatures at platforms are presented in the following sections.

As observed on the following figure, a fast thermal equilibrium with surrounding sea water is reached as soon as the CO_2 is reaching the first “exposed” section.

From this temperature profile, it appears that the range of temperature expected at the different injection platforms is unchanged compared to scenario of 22 MTPA and will follow the sea water seasonal temperatures, meaning that the arrival temperature should range between 4°C and 16°C, whatever the injection temperature at onshore terminal.

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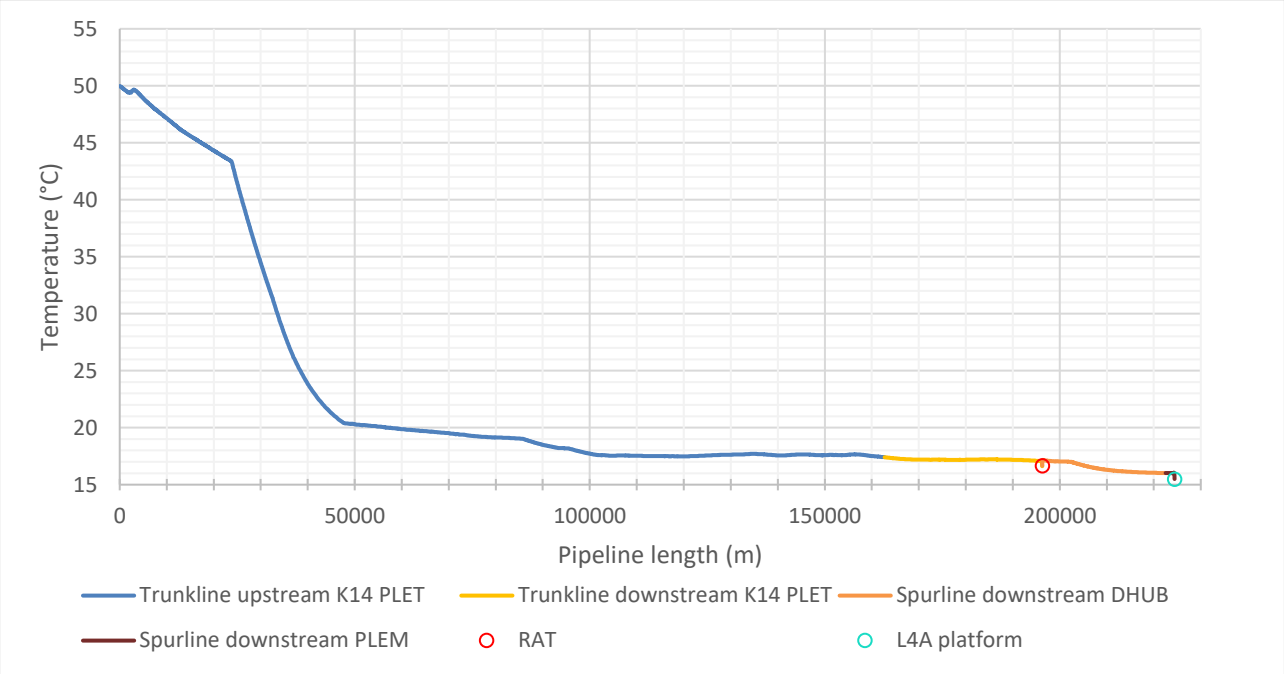


Figure 5-6: Temperature profile for the 5 MTPA warm case

5.1.2.4 Arrival pressures at platforms

Here after are presented the arrival conditions at each platform along with the reached flowrate:

Platform	K14	DHUB	L4A
Arrival flowrate (MTPA)	2.5	2.5	2.5
Arrival flowrate (kg/s)	79.27	79.27	79.27
Arrival pressure (bara) (1)	146.49	146.47	146.26
Arrival pressure + topside pressure drop margin (2)	141.49	146.47	141.26
Temperature (°C)	16.96	16.62	15.5

1. The indicated arrival pressure includes a 10% margin on the pressure drop. Reference height +24 m / MSL,

2. The indicated arrival pressure includes both 10% margin on pressure drop and a 5 bar margin representative of topside pressure drop related to piping and chokes. Reference height +24 m / MSL.

Table 5-2: Arrival conditions at platforms for 5 MTPA base case

5.1.2.5 Fluid velocity and Erosional Velocity Ratio

The fluid velocity and the Erosional Velocity Ratio (EVR) over transport pipeline route at 5 MTPA ranges:

- Trunkline upstream DHUB:
  - Minimum Fluid velocity ranges from 0.22 to 0.62 m/s,
  - Maximum EVR ranges from 0.05 to 0.12.

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- Spurlines downstream DHUB & from K14 PLET to K14 platform:
  - Minimum Fluid velocity ranges from 0.37 to 0.39 m/s,
  - Maximum EVR ranges around 0.09.

For the 5 MTPA case, all fluid velocities are expected to be low. This could induce deposition of particles, solids, etc. if any and enhanced Corrosion Under Deposits Phenomena. For early life conditions, it is recommended to further investigate those issues in the upcoming phases of the project, more specifically the presence of any particles, solids that may settle / accumulate into the injection lines because of the low velocities.

On the other hand, the EVR limit is respected in all the mentioned injection flowlines.

5.2 Sensitivity studies

Several steady state sensitivities studying the impact of the initial conditions were conducted using the CO_2 spreadsheet or *OLGA* model. The main reasons are:

- The evaluation of the required packing time of the trunkline with comparison to the base case (Sensitivity study 1)
- The definition and refining of the trunkline's design temperature (Sensitivity study 2, 3 and 4)

The list and the description of the sensitivity studies is as follows:

Case	Flowrate (MTPA)	Discharge pressure (barg)	Inlet temperature (°C)	Details
Sensitivity study 1 *OLGA model*	22 MTPA all the way to DHUB without any take-off at K14 PLET	180	50	22 MTPA all the way to DHUB without any take-off at K14 PLET
Sensitivity study 2 *CO_2 spreadsheet*	22	180	65 (1)	Most likely not to occur but it was studied to evaluate the design temperature of the trunkline
Sensitivity study 3 *CO_2 spreadsheet*	22	180	56 (2)	This case was studied in order to further refine the design temperature of the trunkline.
Sensitivity study 4 *CO_2 spreadsheet*	11 (3)	180 vs. 120	65	This case was studied in order to further refine the design temperature of the trunkline.

Note:

1. 65°C is the maximum temperature outlet of Porthos, also considered as the Maximum Operating Temperature (MOT) for Porthos flowrate (Ref. [2]).

2. 56°C is the maximum temperature of the mix of all fluids corresponding to a flowrate of 22 MTPA at the inlet of the trunkline (Ref. [2]).

3. 11 MTPA is the maximum flowrate coming from Porthos (Ref. [2]).

Table 5-3: List of conducted steady state sensitivity cases

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5.2.1 Sensitivity study 1

5.2.1.1 Pressure Profile

Here after is presented the pressure profile (More details are presented in the appendix 9.1.3.1) along the trunkline of 32 in OD for 22 MTPA with no take-off at K14 PLET. The results include a 10% margin on total pressure drop.

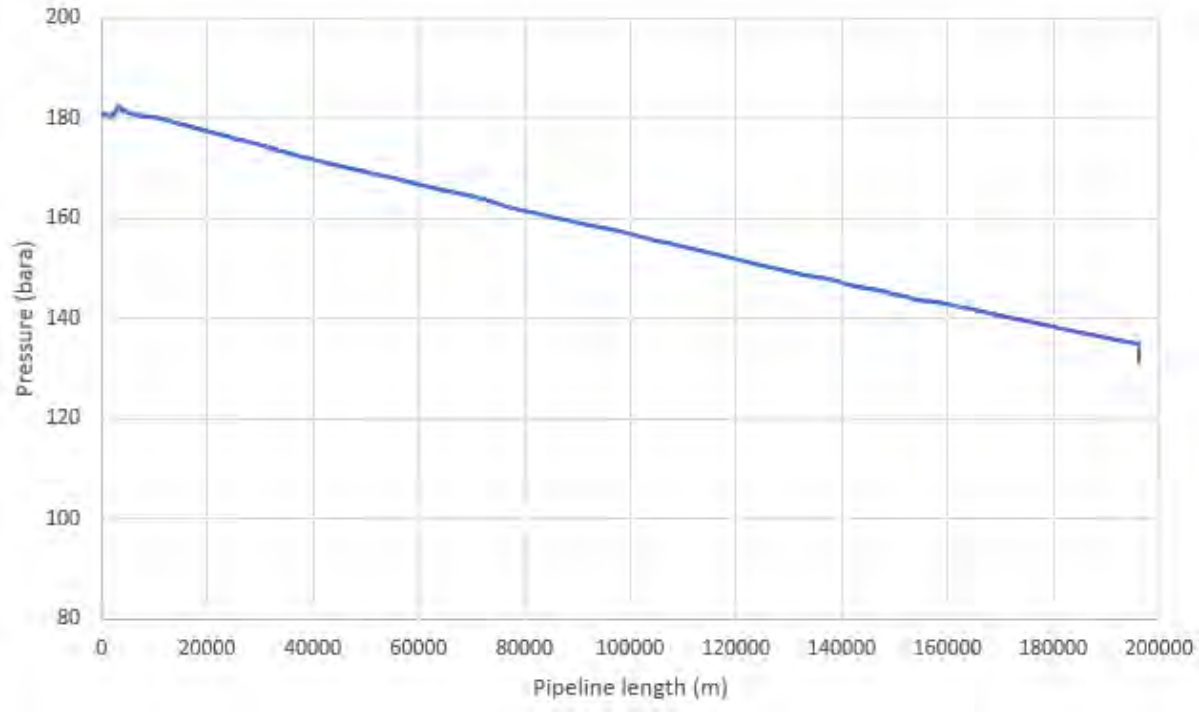


Figure 5-7: Pressure profile for the sensitivity study 1

As the figure indicates, with a 180 barg discharge pressure, the arrival pressure at top of DHUB is approximatively 130.1 barg including the 10% margin on pressure drop.

5.2.1.2 Temperature Profile

Here after is presented the temperature profile (More details are presented in the appendix 9.1.3.2) along the trunkline of 32 in OD for 22 MTPA with no take-off at K14 PLET.

As observed on the temperature profile, the arrival temperature at DHUB is about 17.3°C. It is worth reminding that the fluid takes longer time than expected to be in thermal equilibrium with the seabed ambient temperature and that is potentially due to the large flowrate minimizing the exchanges with the ambient environment and the huge thermal inertia of the CO_2.

From this sensitivity study, the expected range of arrival temperature at injection platforms remains unchanged compared to previous conclusions of the present report profile, namely this range will follow the sea water seasonal temperatures, meaning that the arrival temperature should oscillate between 4°C and 16°C, whatever the injection temperature at onshore terminal.

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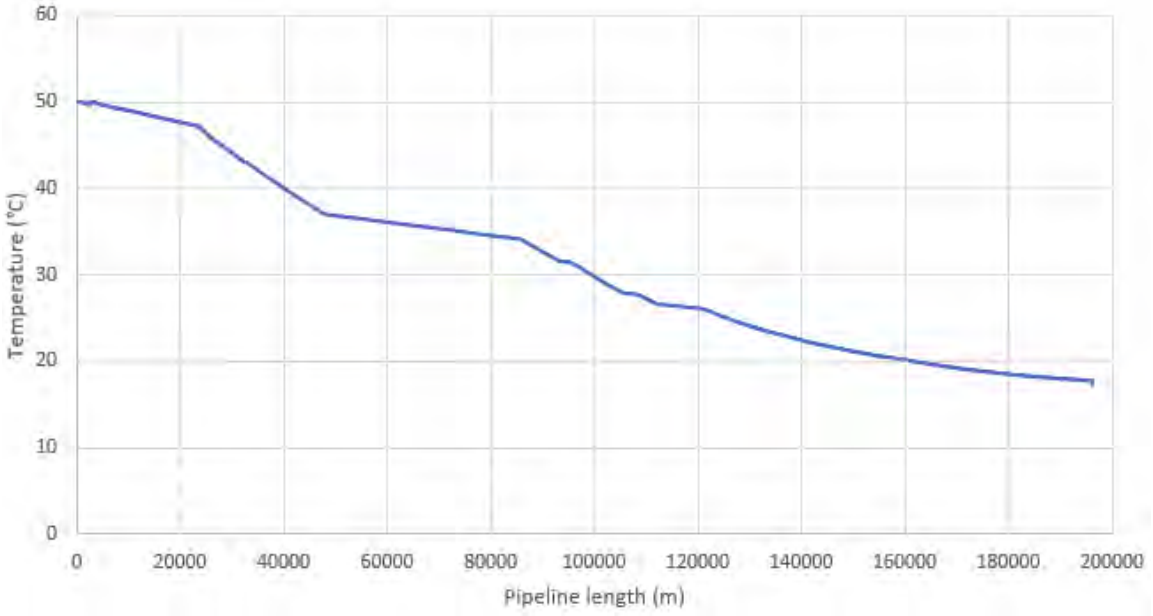


Figure 5-8: Temperature profile for the sensitivity study 1

5.2.2 Sensitivity study 2

5.2.2.1 Pressure Profile

Here after is presented the pressure profile (More details are presented in the appendix 9.1.4.1) along the trunkline of 32 in OD for 22 MTPA with a take-off of 8 MTPA at K14 PLET. The results include a 10% margin on total pressure drop.

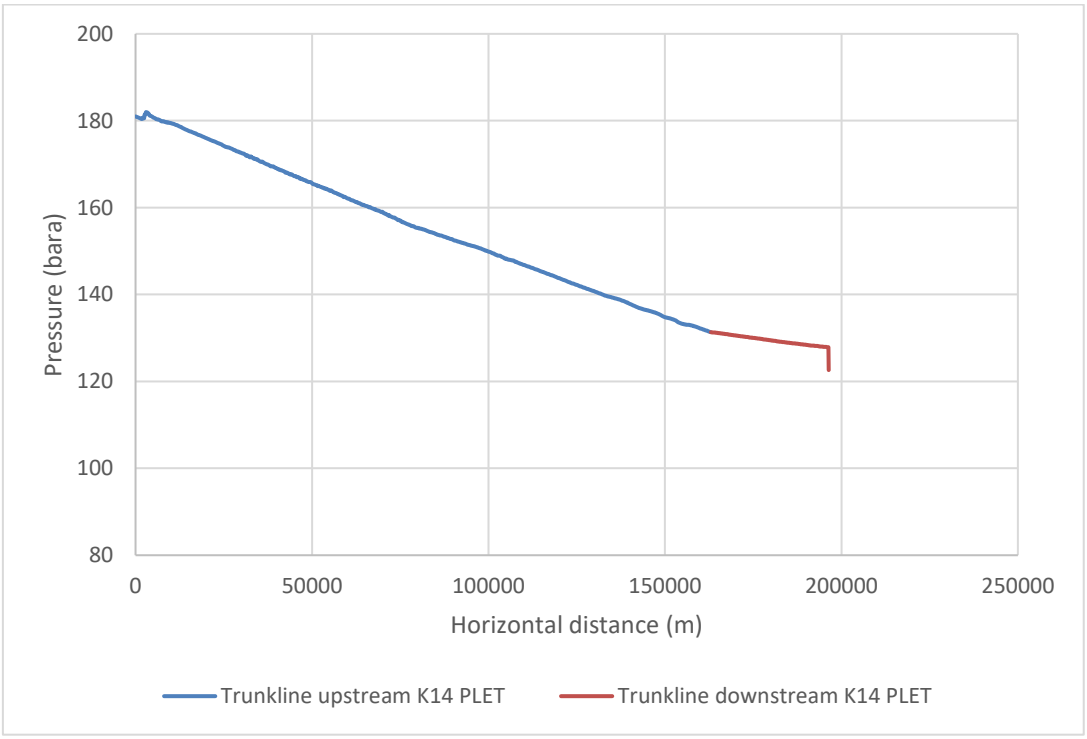


Figure 5-9: Pressure profile for the sensitivity study 2

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As the figure indicates, with a 180 barg discharge pressure, the arrival pressure at K14 PLET is approximatively 130.2 barg and at top of DHUB 121.6 barg including the 10% margin on pressure drop.

5.2.2.1 Temperature Profile

Here after is presented the temperature profile (More details are presented in the appendix 9.1.4.2) along the trunkline of 32 in OD for 22 MTPA with a take-off of 8 MTPA at K14 PLET. The given results are for the warm case (summer conditions for ambient temperature and 65°C at inlet for a 22 MTPA flowrate).

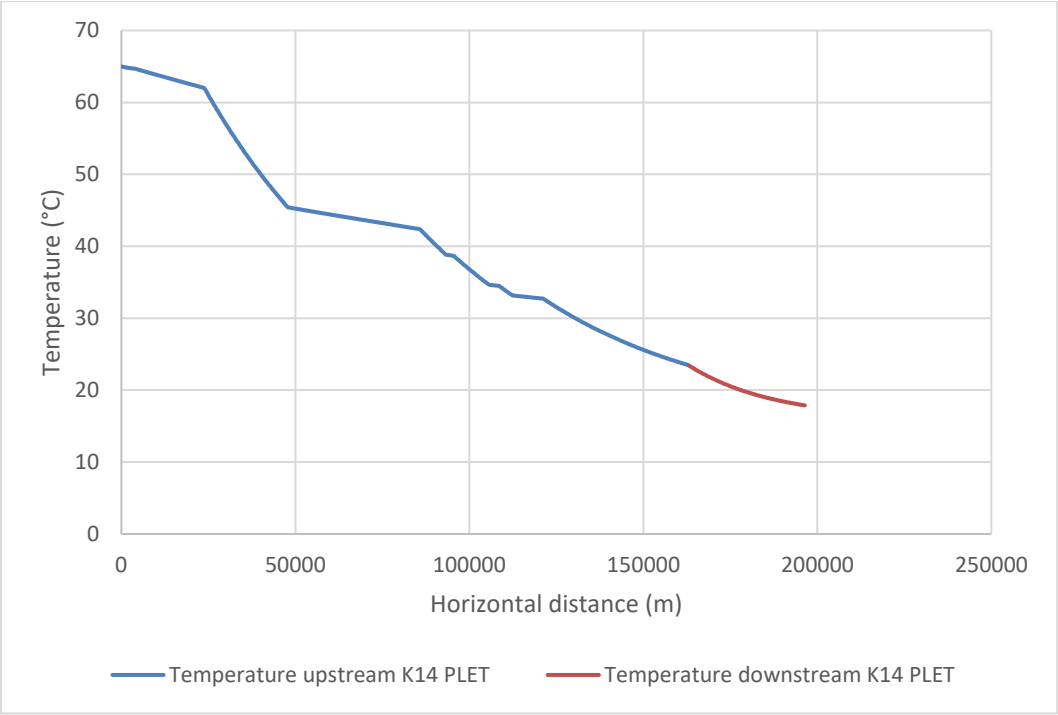


Figure 5-10: Temperature profile for the sensitivity study 2

As observed on the temperature profile, the arrival temperature at DHUB is about 17.9°C. It is worth reminding that the fluid takes longer time than expected to be in thermal equilibrium with the seabed ambient temperature and that is potentially due to the large flowrate minimizing the exchanges with the ambient environment and the huge thermal inertia of the CO_2.

5.2.3 Sensitivity study 3

This study has been conducted for the evaluation of the design temperature of the trunkline. All details are in the next section.

5.2.4 Sensitivity study 4

This study has been conducted for the evaluation of the design temperature of the trunkline. All details are in the next section.

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5.3 Trunkline design temperature

Since CO2next Liquid CO_2 (LCO_2) Terminal (BB01) and Porthos Compression Station (BB02) have different conditions in terms of flowrate, temperature and pressure, in this section several sensitivities regarding the inlet conditions of the trunkline are lead.

Other sensitivities related to the length of the sections presenting different pipe characteristics (burial, coating…) are also conducted in order to cover all uncertainties related to the installation, any change of pipeline configuration following seabed surveys, Etc. and to account for marine growth or any small layers of soils that could have been transported by the sea current and laid over the pipe, affecting therefore the thermal exchange with surrounding sea water temperature.

The aim being to minimize the heat transfer conditions in order to determine the maximum design temperature of the trunkline and define a spec break location after which the design temperature could be decreased.

The base cases covering the maximum flowrates in accordance with the maximum operating temperatures (MOT) were provided by process team (Ref. [2]) and are as follow:

- **Case 1**: 11 MTPA as maximum flowrate with a MOT of 65°C
- **Case 2**: 22 MTPA as maximum flowrate with a MOT of 56°C

5.3.1 Case 1

The sensitivities conducted over this case are listed below:

- Flowrate: 11 MTPA / MOT: 65°C / Discharge pressure 180 barg / No additional lengths over buried sections.
- Flowrate: 11 MTPA / MOT: 65°C / Discharge pressure 180 barg / +540 m over Onshore section.
- Flowrate: 11 MTPA / MOT: 65°C / Discharge pressure 180 barg / +600 m over Micro-Tunnel section.
- Flowrate: 11 MTPA / MOT: 65°C / Discharge pressure 180 barg / + 580 m over trenched section at the exit of the Micro-Tunnel.
- Flowrate: 11 MTPA / MOT: 65°C / Discharge pressure 180 barg / + 980 m over trenched section at the exit of the Micro-Tunnel.
- Flowrate: 11 MTPA / MOT: 65°C / Discharge pressure 180 barg / + 1580 m over trenched section at the exit of the Micro-Tunnel covering three additional lengths over the previously mentioned three buried sections.

Considering the most stringent temperature profiles, a sensitivity over the discharge pressure at the inlet has also been conducted. Giving that the lowest pressure switch (PSLL) is at 95 barg, and that any pressure lower that 120 barg at the inlet could trigger two-phase flow in the injection system, a pressure of 120 barg has been considered for this sensitivity.

- Flowrate: 11 MTPA / MOT: 65°C / Discharge pressure 120 barg / + 1580 m over trenched section at the exit of the Micro-Tunnel.
- Flowrate: 11 MTPA / MOT: 65°C / Discharge pressure 120 barg / + 980 m over trenched section at the exit of the Micro-Tunnel.

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5.3.2 Case 2

Considering the most stringent temperature profiles over case 1, the following sensitivities have been conducted over case 2:

- Flowrate: 22 MTPA / MOT: 56°C / Discharge pressure 180 barg / No additional lengths over buried sections.
- Flowrate: 22 MTPA / MOT: 56°C / Discharge pressure 180 barg / + 1580 m over trenched section at the exit of the Micro-Tunnel.
- Flowrate: 22 MTPA / MOT: 56°C / Discharge pressure 180 barg / + 980 m over trenched section at the exit of the Micro-Tunnel.

5.3.3 Trunkline design temperature study results

The following graph presents a comparison over all previously listed cases and sensitivities, including a 5°C margin:

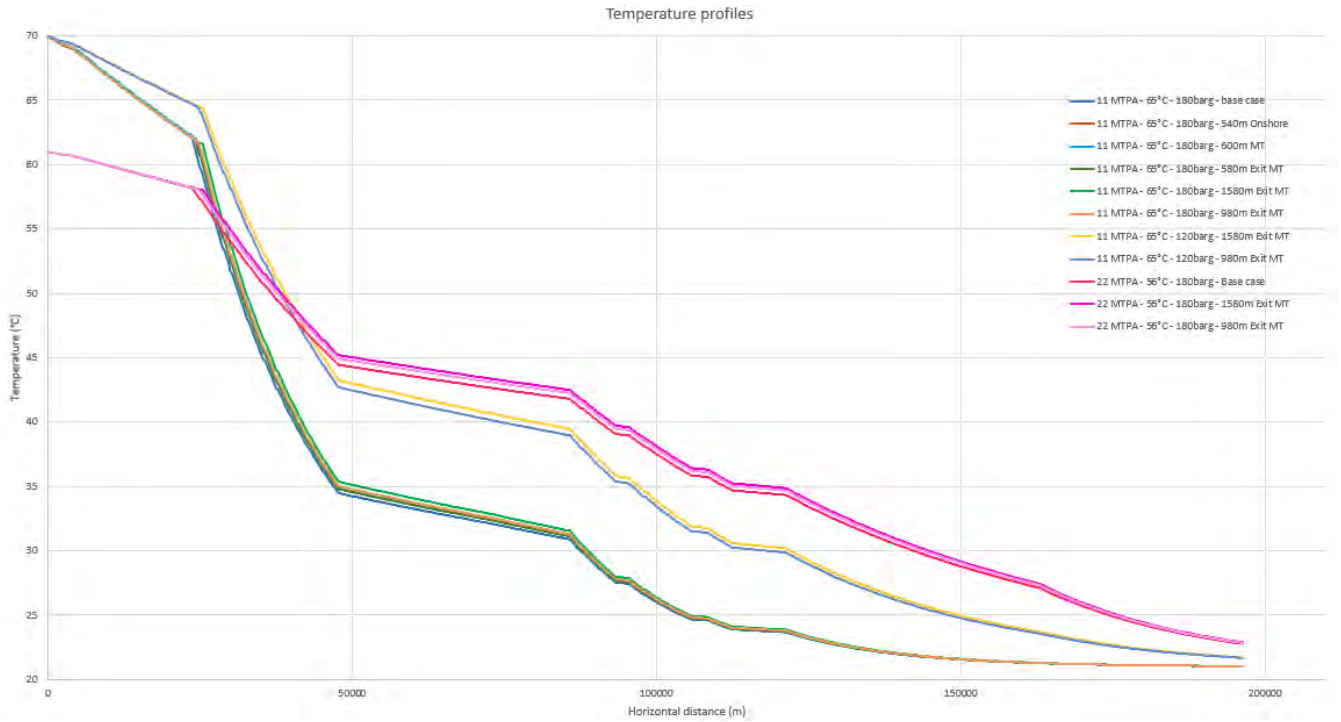


Figure 5-11: Temperature profiles for trunkline design temperature determination

As observed on the graph, the case where an 11 MTPA flowrate, a MOT of 65°C and a discharge pressure of 120 barg with a 1580 m of additional length over the buried sections all together presents the most stringent temperature profile for the first approximately 45 kilometers. The difference in the temperature profile over these first kilometers in both cases where a 980 m and 1580 m length of buried sections are added is very negligeable, meaning that any local adjustments of the pipeline configuration on the seabed will not affect the definition of the design temperature and the proposed spec break here after.

Over the rest of the trunkline, the case where a 22 MTPA flowrate, a MOT of 56°C and a discharge pressure of 180 barg with a 1580 m or 980 m of additional length over the buried sections all together presents the most stringent temperature profile.

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As a conservative approach, and considering a 5°C margin, it is recommended to set a design temperature of

- 70°C over the first 50 kilometers and
- 50°C for the rest of the trunkline up to the distribution hub (DHUB).

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6 TRANSIENT CALCULATION RESULTS

In this section are presented the main results of the transient calculations performed for Aramis phase 1 project.

6.1 Unplanned Shutdown – Packing & depacking phenomena

Shutdown simulations were performed for warm ambient conditions and for peak flowrate to assess the pressure and temperature profiles during the shutdown in order to define a safe shutdown operation to avoid 2-phases flow or crossflow between the injection wells and to evaluate the time needed by the operators to react following an unplanned shutdown.

6.1.1 Shutdown of injection wells & no shutdown onshore

Simulations have been performed to assess the pressure build-up in the trunkline in case of spurious shutdown of injection wells while the feed source from onshore facilities are still in operation. The packing of the transport pipeline has been assessed considering peak rate (22 MTPA) as it is considered as the most stringent. Should the injection rate be at plateau, then no major difference savings are anticipated compared to what is summarized here after.

Initial transport pipeline pressure for these considered scenarios are based on steady state operations at 22 MTPA. Both cases are listed here after:

- **Base case**: Steady state of 22 MTPA including a take-off of 8 MTPA at K14 PLET and remaining 14 MTPA flowrate to DHUB, followed by a well shutdown occurrence. The injection rate at shore is maintained constant, what is conservative considering anticipated export pump technology.
- **Sensitivity case – RIV closure**: Steady state of 22 MTPA all the way to the DHUB, followed by the RIV closure sequence. The injection rate at shore is maintained constant as well.

6.1.1.1 Base case

Pressure build-up anticipated in transport pipeline for this shutdown scenario is presented here after. It is worth mentioning that a Pressure Protection System for the trunkline is supposed to be triggered at 200 barg.

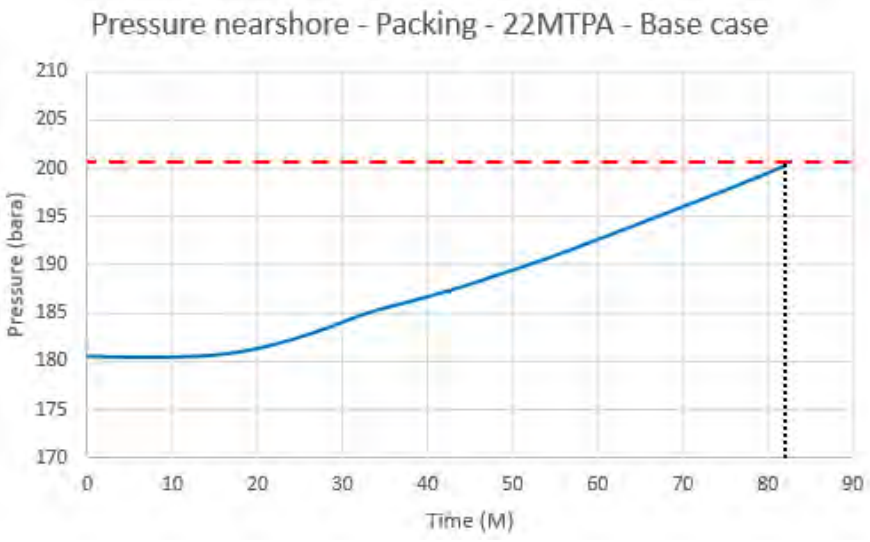


Figure 6-1: Pressure build-up in pipeline with shutdown of injection wells and no shutdown onshore – Base Case

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As presented on figure above, the pressure build-up in the transport pipeline is relatively rapid because of the high initial steady state operating pressure. The higher is the pressure build-up in the reservoir due to CO_2 injection, then the faster is the packing of the transport pipeline.

During the first 12 min of the unplanned shutdown, due to the "small" compressibility of the CO_2, the pressure in the subsea system is almost constant and then increases by approximately 0.3 bar / min. The Pressure Protection System alarm is triggered after 82 min of the unplanned shutdown.

Even though the pressure build-up in the system could be relatively fast, consequence of the high initial steady state pressure in the system, the large volume of the trunkline and the low compressibility of the CO_2 (behaving as a liquid filled system), the operators, the pipeline control or pipeline safety system should have time to respond and to avoid a high pipeline shut-in pressure.

6.1.1.2 Sensitivity Case - RIV closure

Pressure build-up anticipated in transport pipeline for this shutdown scenario is presented here after. It is worth mentioning that a Pressure Protection System of the trunkline is supposed to be triggered at 200 barg.

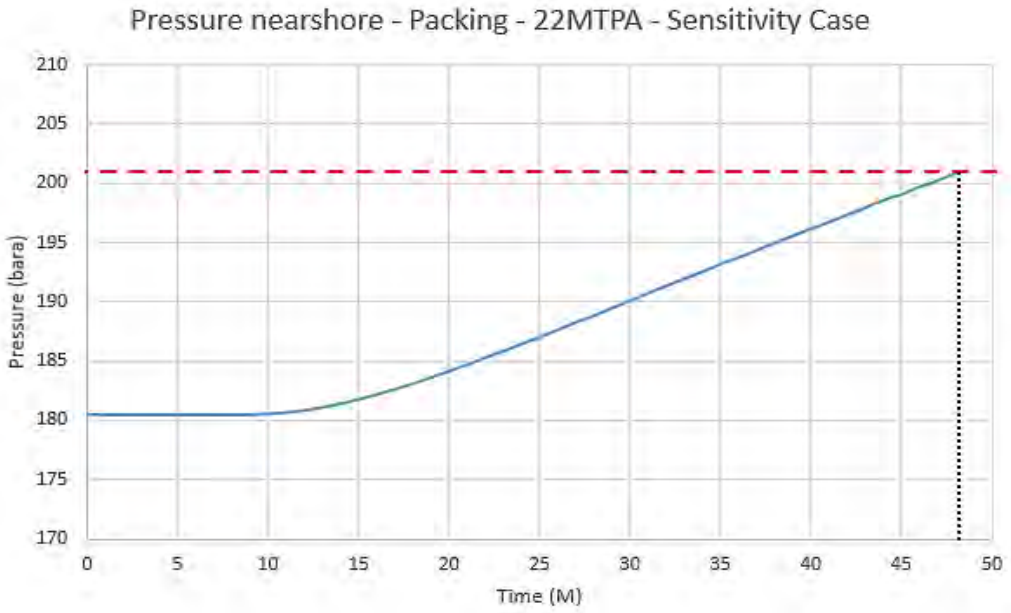


Figure 6-2: Pressure build-up in pipeline with RIV shutdown and no shutdown onshore – Sensitivity Case

During the first 10 min of the unplanned shutdown, the pressure in the subsea system is almost constant and then increases by approximately 0.6 bar / min. The Pressure Protection System alarm is triggered after 48 min of the unplanned shutdown.

Even though this case is most likely not to occur, the operators, the pipeline control or pipeline safety system should still have enough time to respond and to avoid a high pipeline shut-in pressure.

6.1.2 Shutdown onshore & no shutdown of the injection wells

A sudden shutdown onshore without shutdown of the injection wells may potentially result in low pipeline pressure and two-phases conditions in the transport pipeline. Transient shutdown simulations have been therefore performed in order to evaluate the time required before observing the minimum acceptable settle-out pressure in the transport pipeline before triggering the two-

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phases flow region envelope or any crossflow between the injection wells and therefore to evaluate the time for the operators to respond in case of such unplanned shutdown.

Initial transport pipeline pressure for this considered scenario is based on steady state operations at 22 MTPA. After onshore plant shutdown event, then the opening of the Injection Choke Valves is kept constant, what is relevant considering control philosophy of wells. No closure of Downhole safety valve is also considered in present study to evaluate the time between the shutdown event and the occurrence of back-flow from reservoir and crossflow between wells, if any.

Transport pipeline blowdown into wells for such shutdown scenario is presented here after.

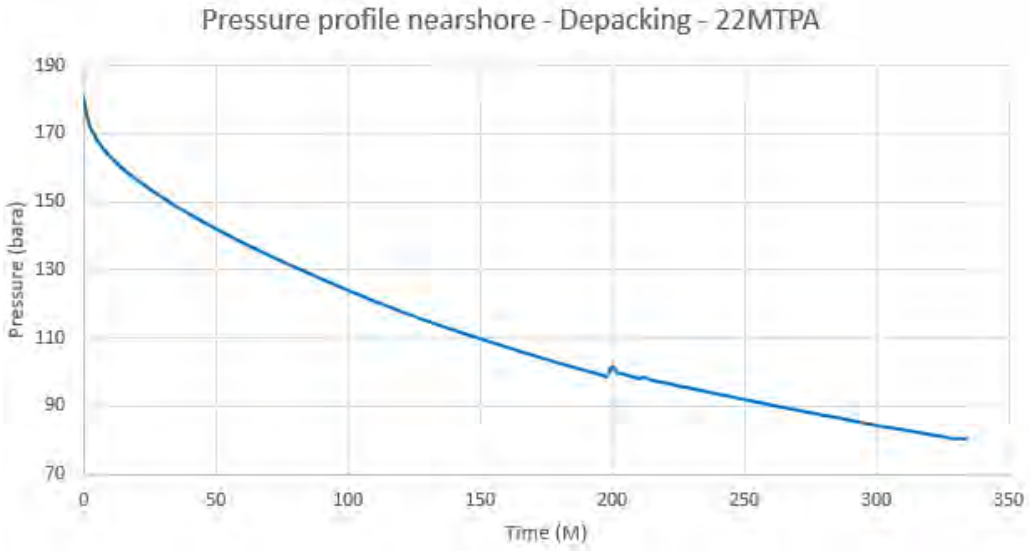


Figure 6-3: Transport pipeline blowdown into wells with shutdown onshore and no shutdown of injection wells

As presented on figure above, the pressure in the transport pipeline decreases by approximately 0.3 bar / min. The present study also highlights that gas flashing is experienced after about 5 hours following unplanned shutdown in the beginning of the transport pipeline between the Onshore and the Micro-Tunnel sections. The figure below illustrates the gas flashing through the liquid hold-up measurements near the Maasvlakte terminal just before entering the Micro-Tunnel.

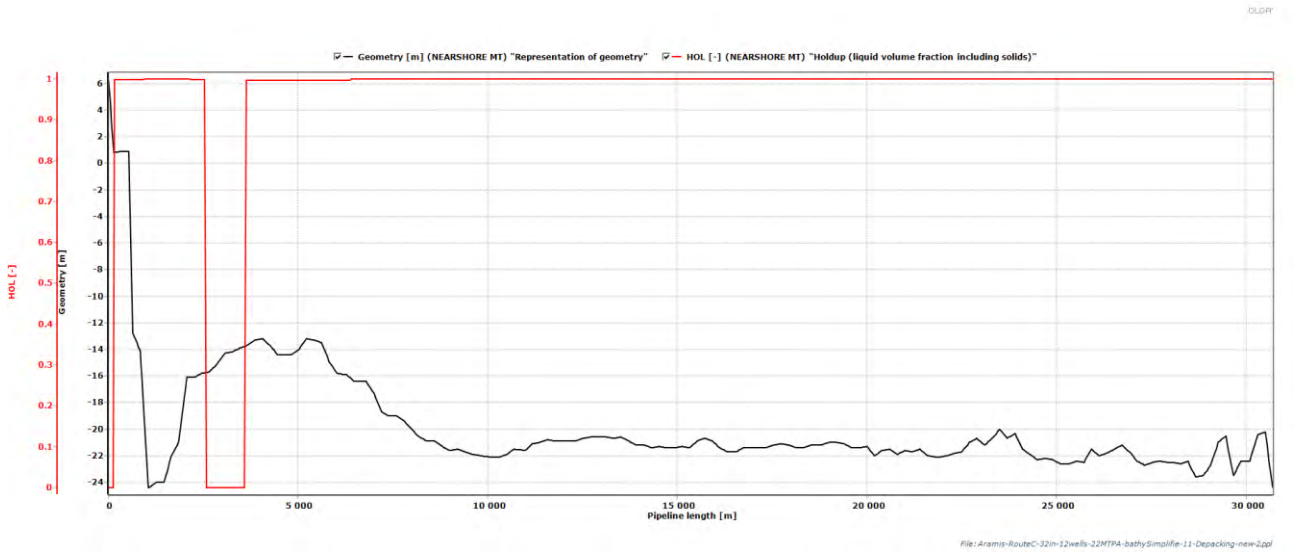


Figure 6-4: Liquid hold-up – Two-phase flow conditions in the Micro-Tunnel following unplanned shutdown of onshore facilities

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Those two-phase conditions in the transport pipeline are observed as soon as the Pressure @ Maasvlakte goes below 82 barg considering the most stringent sea water ambient conditions and the CO_2 specification with impurities. It is worth mentioning that, with reservoir pressure build-up, the gas flashing should be delayed.

Even with such conditions, operators and control system should have enough time to respond and avoid the appearance of gas pockets within transport pipeline. A pressure set point of 90 barg including a 10 bar margin over the critical point should be respected at Maasvlakte terminal, after which the risks of two-phase flow become unavoidable. Should this situation occur, the Injection Choke Valves (or any other valves – Master Etc.) should be closed, and refilling operations of the transport pipeline should be carefully carried out from shore to go back in liquid filled conditions. The operating philosophy associated to those refilling operations should be developed in the upcoming phases of the project.

Another outcome of the present study is that no crossflow phenomena between the different injection wells will be observed, at least, in the first 5 hours following unplanned shutdown event as the appearance of two-phase flow conditions seems to be the driving parameter.

From the previous figure and blowdown analysis, it can be also extrapolated and estimated that at early life conditions, when injecting 5 MTPA, the time for the trunkline to blowdown into the injection wells if this scenario will be encountered will be also large enough for the operators to react before triggering the two-phase flow conditions. Indeed, a minimum 3.5 hours should be required before observing gas flashing into subsea network.

6.2 Trunkline depressurization

There is no specific operational requirement for depressurization of the subsea network in normal situation / shutdown. The potential scenarios that may impose a depressurization of the subsea system could be:

- Damage of the transport pipeline requiring repair and then blow-down of subsea system prior any intervention,
- Formation of a plug requiring blow-down to attempt remediating,
- Pipeline decommissioning,
- Operational issues at onshore plant requiring blow-down of the subsea system to control CO_2 release if any.

Depressurization of the transport pipeline should be avoided as much as possible because this operation will take time (more than 3 days) and refilling operations might be complex and will present non-negligible risks (gas pocket collapse, slack flow, low temperature, heater requirements, Etc.).

Nevertheless, even if infrequent operations, relevant facilities (Restriction Orifices, boot, Etc.) have to be integrated in the network.

When depressurizing the CO_2 to atmospheric conditions, extremely low temperatures are anticipated whatever the considered scenario. As the design temperature of the transport pipeline is supposed to be -25°C as per previous phase of the project (concept select), it is important to control the pressure in the transport pipeline during depressurization operations in order to comply with design temperatures of the transport pipeline. The control of the pressure during blow-down has been achieved by considering staggered depressurization sequence and by adjusting the diameter of the Restriction Orifices over depressurization sequence.

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Since there is a high risk of ice formation around the pipe and in its layers at very low temperatures and in order to take into account enough margin to cover the uncertainties related to *OLGA* software, the minimum considered temperature is 0°C. It is also worth mentioning that the depressurization simulations are very slow, and the temperature does not fall rapidly with proposed sequence which means that the margin over the temperature could be relaxed as these calculations are not considered as fast transient.

Special attention should be also paid to the partially and totally buried sections of the transport pipeline that will not take benefits of the potential heating brought by the surrounding sea water.

The back pressure downstream Restriction Orifice should be also defined to avoid ice formation in the depressurization system. In the present study, and considering the phase diagram of CO_2, the pressure has been fixed at 7 bara (above triple point) to avoid ice formation and risk of plugging of depressurization lines. The transition from 7 bara to atmospheric conditions at vent and associated equipment should be developed by Process team in accordance with Flow Assurance outcomes / recommendations presented in this report and to mitigate the risks of plugging of the depressurization network.

In the frame of this study, 3 main scenarios have been considered. They are summarized here below. All cases have been covered and deeply assessed. Nevertheless, in order to ease the reading of this report, it has been decided not to present all the cases as all the results are almost similar and proposed design complies with all requirements.

➢ Normal / Planned shutdown:

- Shutdown of the export pumps while the wells are still open in order to empty the pipeline as much as possible,
- When the pressure reaches 90 barg at Maasvlakte terminal and before triggering the two-phase flow, the blowdown through the wells is stopped,
- 1 hour waiting time for the preparation of venting operations,
- Vent through restricted orifice(s),

➢ Abnormal / Unplanned shutdown:

- Spurious closure of wells while the export pumps are still in operation,
- Packing of the transport pipeline at the highest pressure,
- Blowdown operation into the furthest well having the lowest WHSIP (for better control of the depressurization activity, nevertheless number and location of wells still to be defined by Field Operations team– Single well or multi wells operation, acceptance of two-phase flow in well during blowdown, Etc.) until reaching the pressure set point of 90 barg at Maasvlakte terminal, or 10 bar above the lowest WHSIP
- After settle-out pressure in network is about 90 barg or 10 bar above the lowest WHSIP, well is shutdown, and vent through restricted orifice(s),

Because this case is similar to the planned shutdown with minor differences, only relative results will be presented.

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- ➢ Abnormal / Unplanned shutdown with line packed and wells are not available,

- Representative scenario in case of hydrates plug before reaching the platforms,
- The export pumps are still in operation and the line is packed,
- 1 hour waiting time for the preparation of venting operations,
- Vent through restricted orifice(s).

This case has a very low probability of occurrence as wells should always be available, at least one, which means that blowdown and pressure reduction into transport pipeline should always be possible through the wells at first. Because this case is similar to the planned shutdown with minor differences, only relative results will be presented.

After completion of the different analyses, proposed design of depressurization system consists in implementing 4 Restriction Orifices. This arrangement has been identified as the best compromise in order to avoid too low temperatures in transport pipeline with regard to design temperature and water icing risks, but also to shorten the duration of the depressurization sequence.

Proposed diameters of the Restriction Orifice are 5, 7, 10 and 14 inches for the depressurization of the BB03 trunkline. Those Restriction Orifices are used in sequence (the one after the other). The switch between the first and second Restriction Orifices occurs 10 hours after depressurization of first RO. 24 hours later, occurs the second switch. The third switch occurs 7 hours after depressurization of third RO. The minimum achieved bulk temperature is 1°C (for a few minutes).

It is worth mentioning that the Restriction Orifice is modeled as a Leak in *OLGA*, which means it has a fixed diameter.

The following operating philosophy, which has been developed based on the different analyses carried out during the depressurization study, is proposed.

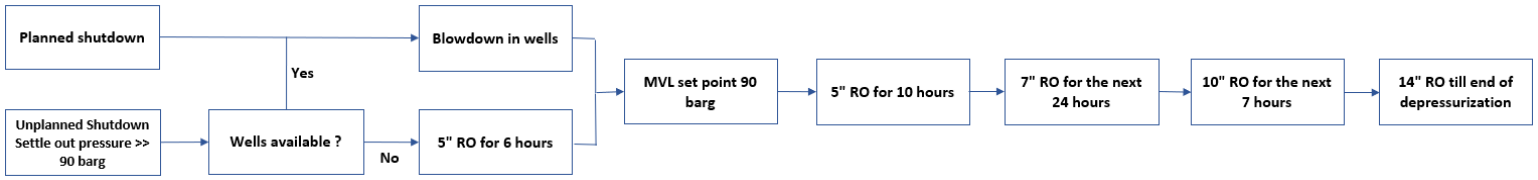


Figure 6-5: Operating philosophy of the depressurization post planned and unplanned shutdowns

The figures here below present the evolution of the pressure during depressurization at key positions of the trunkline in the case of a planned shutdown and unplanned shutdown with previous operating guidelines.

As illustrated on the sequence above, the duration of the depressurization starting from a pressure set point of 90 barg at MVL lasts approximately 2 days and a half (58 hours).

As illustrated on next figure, there is some delay / extended pressure gradient over the trunkline length. Indeed, the pressure decrease close to the DHUB appears to be faster than at onshore terminal as illustrated above. This gradient of pressure over the distance can be explained by the large volume of the trunkline and the pressure drop induced into the system due to fluid displacement.

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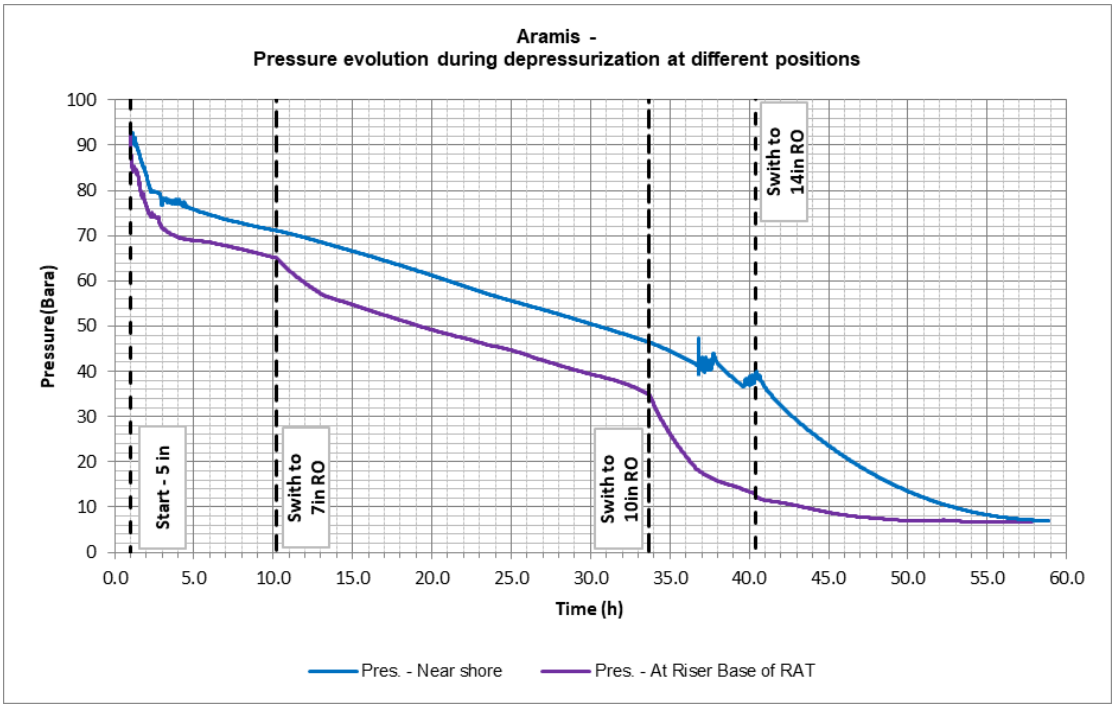


Figure 6-6: Pressure evolution in pipeline during depressurization after 90 barg set point is reached at MVL

It is worth reminding that for planned depressurization, the blowdown in wells before reaching the pressure set point at MVL terminal lasts about 5 hours after the shutdown.

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Concerning the unplanned shutdown with wells available post packing of the line, the blowdown through the well with the lowest WHSIP lasts a little more than 10 days as illustrated in the figure below presenting the pressure at MVL terminal from shutdown until reaching the pressure set point of 90 barg. In the present study, the WHSIP of the considered well for blowdown operations being lower than 90 barg, the two-phase flow condition is driving the switch to Restriction Orifice to complete the depressurization of the injection network. Once the pressure set point is reached at MVL terminal, the proposed operating philosophy detailed above can be applied.

Applying the previous sequence of staggered Restriction Orifices as presented just before following the blowdown into the wells, then the results / behavior obtained will be almost similar to the case presenting here after in the report and referring to planned shutdown. This conclusion can be extrapolated from the different figures and behavior observed during the planned shutdown and by advanced analysis of the results.

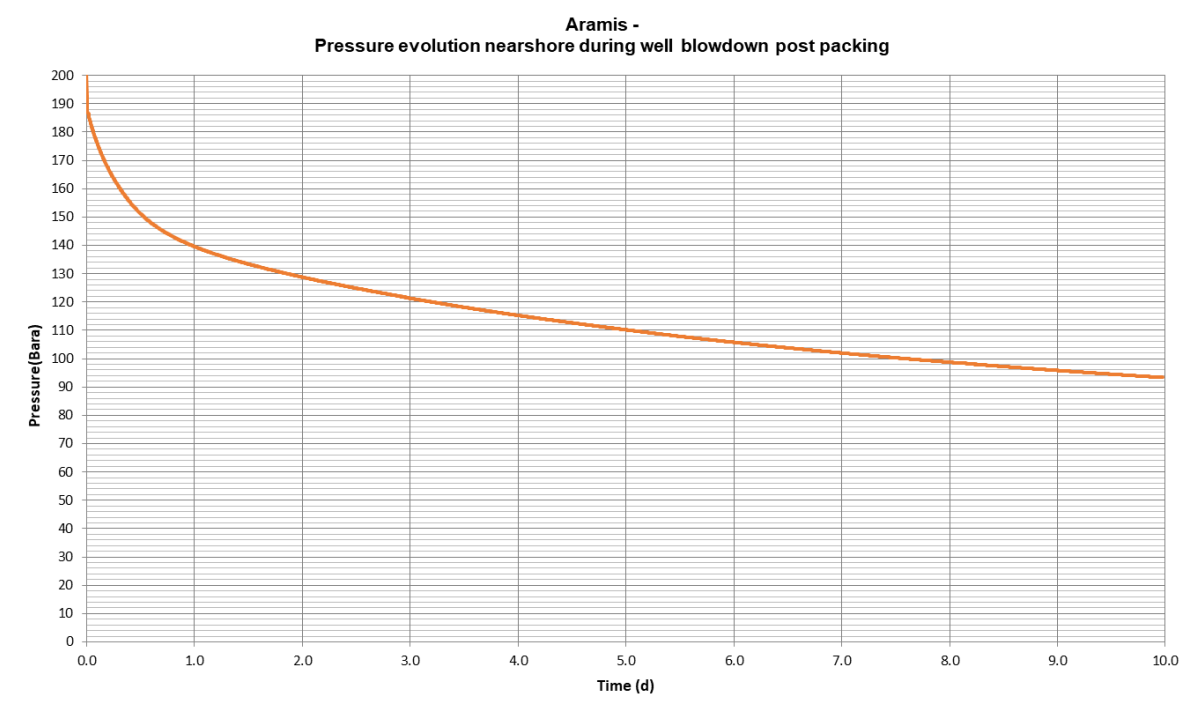


Figure 6-7: Pressure evolution in pipeline during well blowdown post unplanned shutdown - packing and prior reaching 90 barg set point at MVL

Once the pressure set point is reached at MVL terminal, the proposed operating philosophy detailed above can be applied.

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On the other hand, for the unplanned shutdown with line packing and wells not available, the procedure of the depressurization can start directly with a 5" RO and the steps detailed above can still be valid and applicable as the temperature can still be controlled and does not drop to very low values, respecting the 0°C threshold. The temperature at Riser Base (coldest spot) is presented in the following figure.

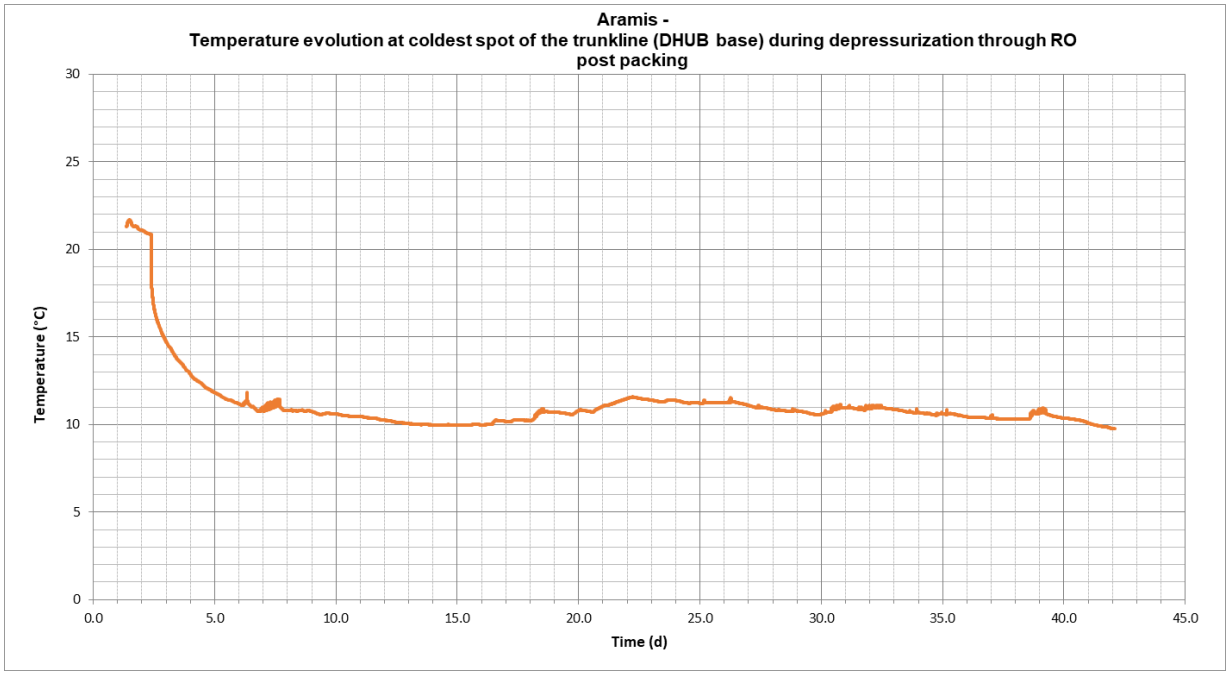


Figure 6-8: Temperature evolution at coldest spot of the trunkline (DHUB base) during depressurization through RO following unplanned shutdown - post packing

It is worth mentioning that the set point of 90 barg at MVL is reached after about 6 hours (357.9 min) of depressurization through the 5" RO in addition to the previously mentioned 10 hours. The rest of the proposed sequence for the depressurization remains unchanged with no risk of dropping to very low temperatures and ice formation around the pipe can be avoided.

As for the other unplanned shutdown, applying the previous sequence of staggered Restriction Orifices to this scenario after the blowdown through the 5" RO has been completed, then the results / behavior obtained will be almost similar to the case presenting here after in the report and referring to planned shutdown. This conclusion can be extrapolated from the different figures and behavior observed during the planned shutdown and by advanced analysis of the results.

Because of the isenthalpic phenomena during the liquid blow-down, the minimum expected temperature downstream the different Restriction Orifices is about -56°C whatever the shutdown scenario considered. Those low temperatures should be experienced as long as liquid CO_2 will be observed downstream Restriction Orifice. To cover the uncertainties related to modeling with *OLGA*, and because of the fast transient phenomena observed across Restriction Orifice, then a 20°C margin is added to the minimum temperature leading to a design temperature of the topside piping of - 76°C.

The figure below presents the evolution of the temperature downstream Restriction Orifice during the depressurization sequence. The liquid and gas mass rates are also presented downstream Restriction Orifice.

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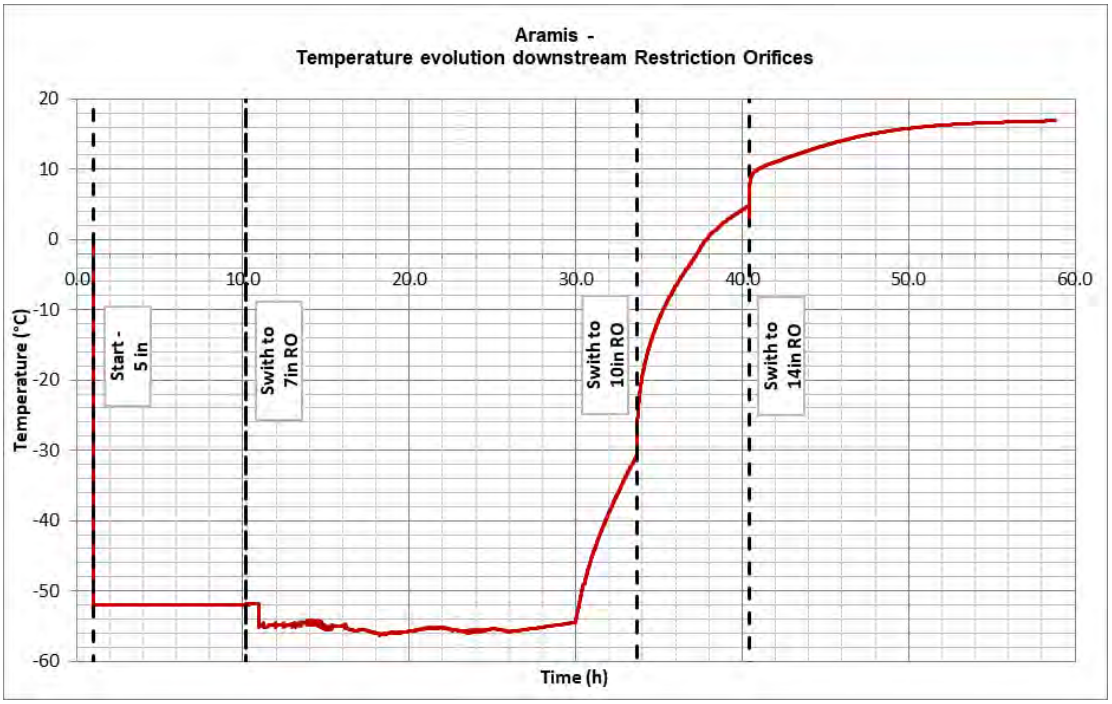


Figure 6-9: Temperature evolution downstream Restriction Orifices during depressurization

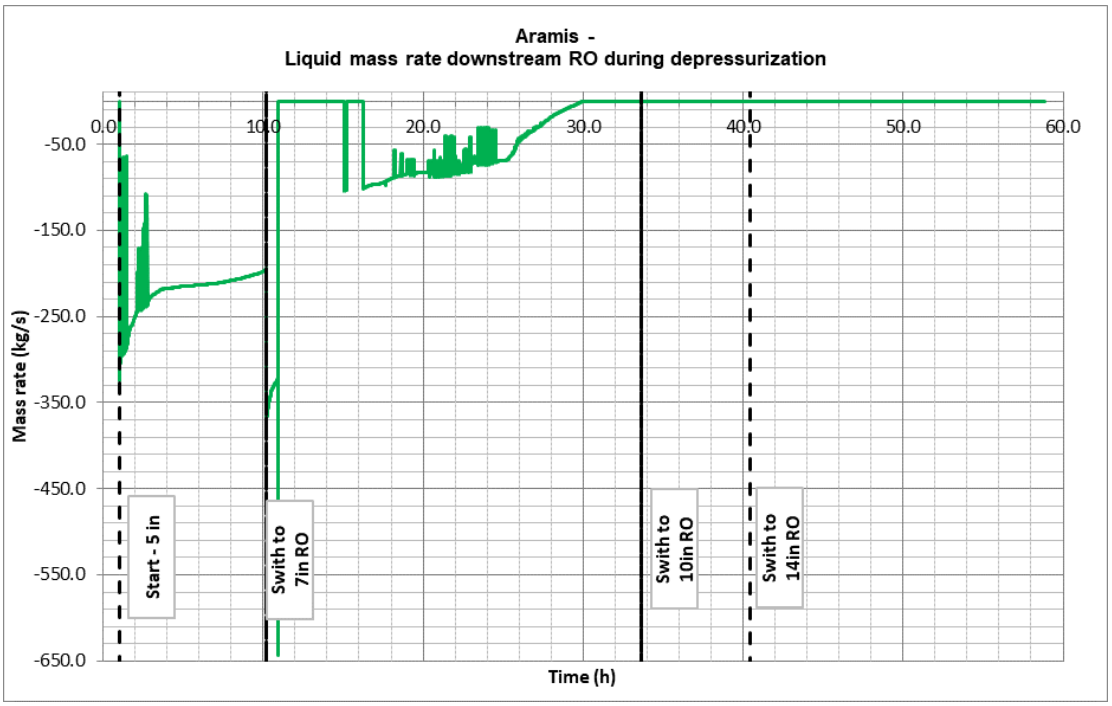


Figure 6-10: Liquid mass rates downstream Restriction Orifices during depressurization

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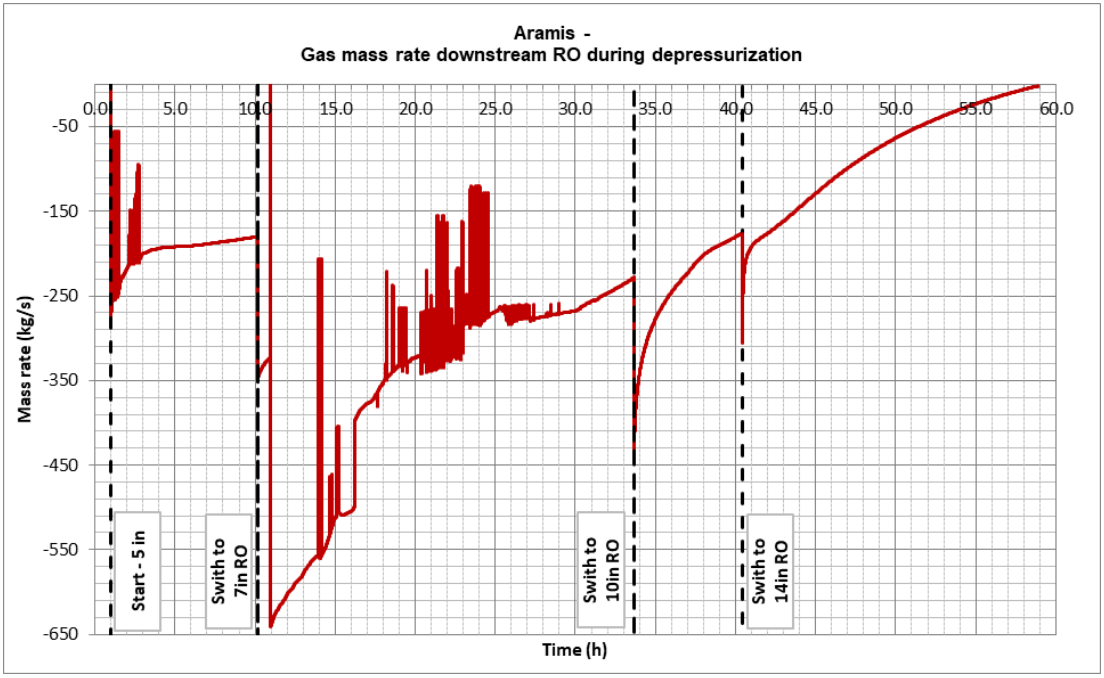


Figure 6-11: Gas mass rates downstream Restriction Orifices during depressurization

From the figures above, it is worth to mention that as soon as no more liquid CO_2 is expected downstream Restriction Orifice, then an increase of the temperature is also observed. Based on the different simulations performed, it appears that the increase of the temperature associated to the stop of liquid CO_2 flowing downstream could be used as the decision to switch to the third Restriction Orifice (10" RO) during the depressurization sequence.

Implementing TT sensors downstream Restriction Orifice is therefore recommended in order to support depressurization operations and the decision to activate the third Restriction Orifice. The last Restriction Orifice is used in order to vent faster the CO_2, once the risk of very low temperatures is over.

The following figure presents the minimum temperatures expected in the transport pipeline during the depressurization sequence for planned and unplanned shutdowns.

For all the scenarios considered in the present study, the critical location always corresponds to the section of the transport pipeline in front of the Restriction Orifice at least during the first 32 hours of the depressurization. After which, the coldest temperature can be seen close to the K14 PLET for a few hours until switching to a 10" RO, where the coldest temperatures are experienced in front of the RO again. After switching to a 14" RO all temperatures start converging to the same value.

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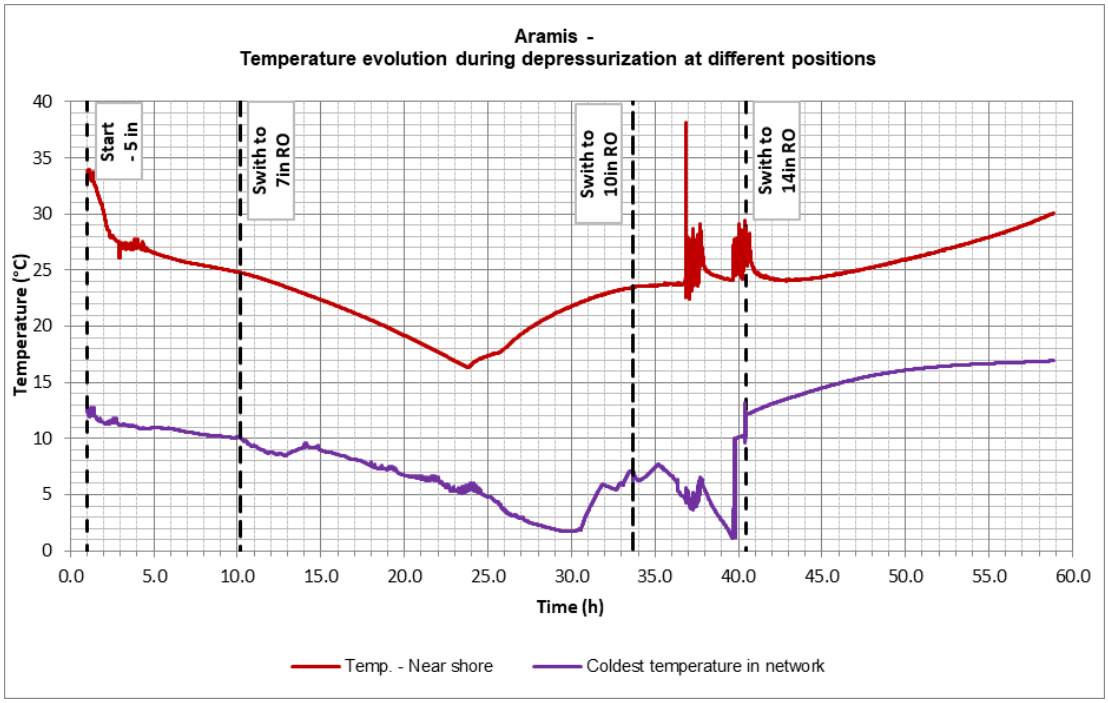


Figure 6-12: Temperature evolution at different positions upstream Restriction Orifices during depressurization

As presented on previous figures, proposed design keeps the temperatures high enough in order to avoid free water appearance and ice formation risks at 0°C and to avoid exceeding the design temperature of the trunkline. The minimum achieved temperature is 1°C for a few minutes to which a 5°C margin should be applied. A minimum temperature of -4°C should be considered at design.

The following table summarizes the peak rates of liquid and gas CO_2 expected downstream Restriction Orifice during the depressurization sequence. Both peak rates coincide at the same time, and they should be considered for the boot design and the dispersion study.

Peak liquid CO_2 (kg/s) ***10 % margin included***	**Peak gas CO_2 (kg/s)** ***10 % margin included***
708	705

Table 6-1: Peak quantity of CO_2 expected downstream Restriction Orifices during depressurization

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It is worth reminding that the presented results of the depressurization are based on steady state warm conditions (warm inlet and summer ambient temperatures). In fact, it is more favorable to start the planned depressurization in warmer conditions as demonstrated in the Mollier diagram below where two starting points are presented one being colder than the other.

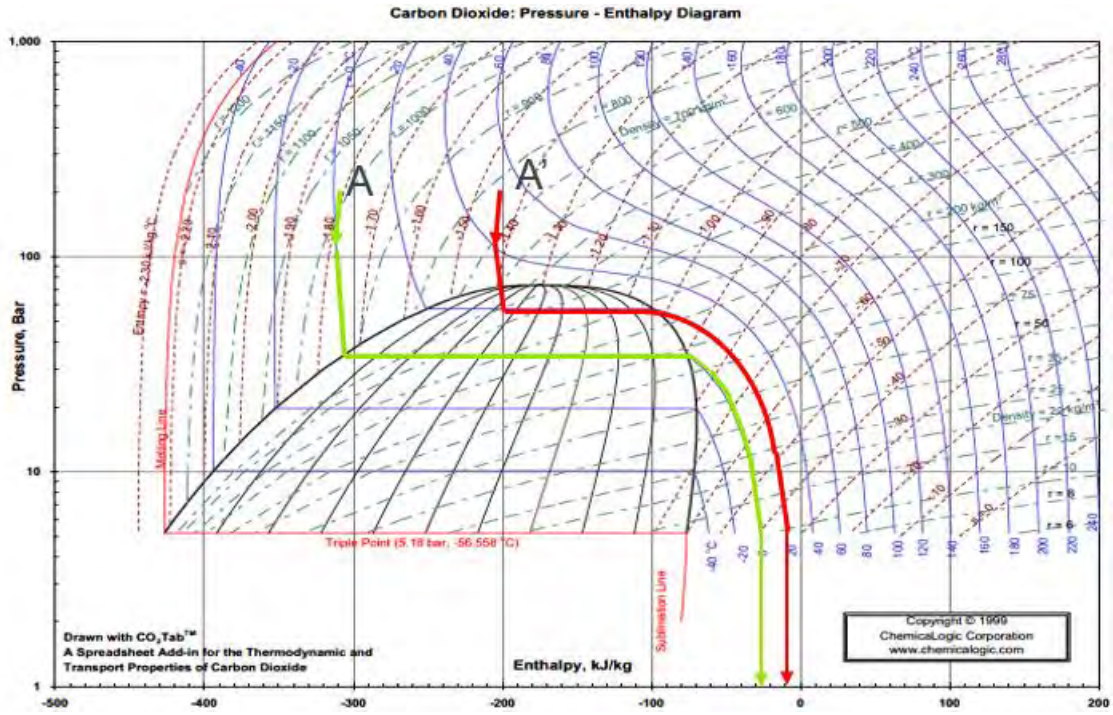


Figure 6-13: Comparison of cold and warm start of depressurization on the Mollier diagram

As observed on the figure above, the depressurization of relatively cold liquid phase CO_2 may lead to unacceptable low temperatures which could exceed the minimum design temperatures unless the conditions are controlled. When the start is at warmer conditions, the pipe is still warm thanks to the inertia and could help heat the vapor CO_2 which is also a way of controlling the minimum temperature in the system. When the system is in cold thermal equilibrium the depressurization could take longer time because it should be further sequenced with more intermediate RO sizes in order to control the temperature.

It is also worth mentioning that the probability of occurrence of such scenario where the system is in full thermal equilibrium with the ambient is very unlikely. The system is highly pressurized with liquid CO_2 and taking into account the thermal inertia even with a bare pipe and the thermal capacity of CO_2, which is very favourable, it would take days in order to be in the full thermal equilibrium which gives more flexibility in terms of operations.

Depressurization at cold temperatures with the system being in full equilibrium with the surroundings cold conditions is very unlikely to occur, and the results should not be significantly different compared to the ones presented in the present report, as illustrated on the diagram of Mollier for the CO_2, that is why it was not considered as the basis of the depressurisation design at least not at this phase of the study. As part of the Flow Assurance dossier to be developed at the next phase, the depressurization during winter conditions should be covered, what will allow verifying that the current design is still applicable even for colder temperatures.

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7 UNCERTAINTIES & RISKS OF FLOW ASSURANCE STUDY

Main uncertainties & risks associated to present Flow Assurance study are listed and detailed here below:

- Reservoir Pressure:
  - The present study is considering an average reservoir pressure per year and not minimum reservoir pressure for start-up flowrates. This uncertainty also applies for late life conditions,
  - Flow Assurance study should be updated as soon as relevant information about expected reservoir pressures for the different panels will be better known,
- Well injectivity:
  - Should the injectivity not be equal to the target injection rate, then there is no guarantee to achieve the 22 MTPA injection rate through transport pipeline,
  - Flow Assurance study should be updated as soon as relevant information on well models and injectivities will be available for the different injection panels,
  - Range of injectivity (low injectivity, high injectivity, mid injectivity) should be considered as for other CCS projects to cover uncertainties at reservoir level,
- Inlet conditions & injection profile:
  - The inlet conditions to the transport pipeline (Pressure and Temperature) were provided at early stages of the project. Should any of these conditions be updated and/or modified, then a sensitivity study should be conducted in order to make sure of the feasibility of the selected concept,
  - Design temperature is based on combinations of different flowing conditions at terminal (22 MTPA – 56°C / 11 MTPA – 65°C). This design temperature assumes that Porthos premise will never deliver more than 11 MTPA. Should any upgrade of the Porthos facilities be considered in the future to get more emitters, then the design temperature of the pipeline might be a major bottleneck,
- CO_2 specifications and modelling:
  - CO_2 with impurities has been used as base case for all steady state and transient operations as there is at least 95% of CO_2 in the injected fluid. The considered fluid composition was based the Aramis Premises (Ref. [1]) and includes several assumptions (components ignored, others replaced with alike components...),
  - There are also some limitations in current commercial thermodynamic software, some impurities being not supported as Nox & Sox, while it is known today those impurities have strong impact on phase envelope of CO_2. Nox & Sox should not have a great impact on pressure drop (low impact on density and viscosity) but do have an impact on phase envelope and thus the risk of appearance of Two-phase flow and free water,
  - Since, the choice of the fluid could induce uncertainties on pressure drop calculations and depressurization key figures and although the different applied margins should cover these uncertainties, further sensitivity studies regarding CO_2 specifications should be conducted. Should the fluid composition be updated and/or modified, a feasibility study should be done in order to validate the selected concept,
- Depressurization operating philosophy,

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  - Scenario of depressurization to be considered are unclear because of the lack of consolidated Basis of Design. Some scenario was discarded unanimity by project at the beginning and scenario came back at the end of the Flow Assurance study,

- Pipeline characteristics,
  - In the present study, most of the pipeline characteristics were provided by the pipeline specialists. Some of the cross-section details were based on assumptions, although validated by pipeline specialists could still induce uncertainties on the temperature profile of the transport system. Even though, the applied margins should cover these uncertainties, should there be any modifications in the pipeline characteristics, a feasibility study of the selected concept should be conducted.
- *Multiflash* and *OLGA* used versions,
  - Flow Assurance study has been carried out using *Multiflash 7.1* and *OLGA 2021.2*, the latest versions adequate with CO_2 fluids,
  - The version of *OLGA* used in present study may not capture all improvements related to CO_2 modeling and it is difficult to state if results are conservative or not.

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8 CONCLUSIONS & WAY FORWARD

Based on the Flow Assurance study carried out in the frame of the pre-project study of the phase 1 of the Aramis project, no major showstoppers have been identified with the proposed pipe diameter. However, it appears that the injection of 22 MTPA might be highly challenging at the end of life, therefore highlighting the strong effect of the pressure build-up observed in the reservoir during field life. It is nevertheless important to keep in mind that depending on the pressure build-up in the reservoir, this plateau might be severely affected.

It is also worth mentioning that no concern is anticipated with regards to the transport pipeline operability.

The following way forward are nevertheless proposed to complete the Flow Assurance scope of work and further refine the design and the operating philosophy / strategy:

- The selected concept needs to be further studied and validated with updated Basis of Design (CO_2 specifications, Pipeline characteristics, Injection profile, Inlet conditions, Reservoir pressure evolution, Well models…),
- Further investigate the spurlines and BB04 pipelines diameters against updated injection profiles,
- Further develop the start-up sequence and associated operating philosophy (risks of hydrates, drying philosophy, Etc.),
- Further develop the hydrates mitigation strategy to cover well restart operations and initial start-up,
- Cover wells restart operating philosophy and procedures after both planned shutdown and abnormal shutdown followed by blowdown sequence in wells, especially the way Well Performance team intend to operate the different injection wells (respect of a certain drawdown for wellbore integrity management, full Injection Choke Valve opening instantaneously, well by well or all wells together, Etc.). Once this sequence of operations will be defined, then overall impact of the well restart sequence on the dynamic of the subsea network could be addressed,
- Develop hydrates remediation strategy considering the risks of hydrates formation in the transport and injection system during operating life,
- Further clarify the scenario of design of the pipeline with regards to the probability of occurrence. At this stage, a subsea trunkline at thermal equilibrium with surrounding sea water has been discarded by project unanimity and has not been considered by Flow Assurance team,
- Redevelop same scope considering pure CO_2, even if, from literatures, present assumptions are the most stringent,
- Develop the Flow Assurance dossier for the trunkline capturing the impact of the BB04 scope,
- Further develop the integrated model mimicking the different injection sites of all partners to fully capture the dynamic of the system and the impact of the different injection sites on each other.

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9 APPENDIX

9.1 Steady state results

9.1.1 22 MTPA scenario

9.1.1.1 Pressure Profile

	Pipeline length (m)	Pressure (bara)	Pressure including margin (bara)
Onshore to MVL	0	180.97	180.97
	1894.00	180.52	180.47
Nearshore (including Micro-Tunnel part)	1917.20	180.54	180.49
	32569.63	174.51	173.86
A-ALT	32618.41	174.51	173.86
	126474.15	152.94	150.13
Section F ends with K14 PLET	126499.15	152.89	150.08
	162706.17	145.56	142.02
Section D ends with DHUB	162731.17	145.54	142.00
	196259.45	139.42	135.26
Section C ends with the PLEM	196272.28	139.40	135.25
	222489.78	140.48	136.43
PLEM to L4A ends with L4A platform	222515.83	140.39	136.33
	224417.70	136.31	131.84

9.1.1.2 Temperature Profile

	Pipeline length (m)	Temperature (C)
Onshore to MVL	0	49.99
	1894.00	49.77
Nearshore (including Micro-Tunnel part)	1917.20	49.77
	32569.63	43.12
A-ALT	32618.41	43.08
	126474.15	25.29
Section F ends with K14 PLET	126499.15	25.27
	162706.17	20.02
Section D ends with DHUB	162731.17	20.02
	196259.45	16.99
Section C ends with the PLEM	196272.28	17.00
	222489.78	16.33

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PLEM to L4A ends with L4A platform	222515.83	16.38
	224417.70	15.78

9.1.2 5 MTPA scenario

9.1.2.1 Pressure Profile

	Pipeline length (m)	Pressure (bara)	Pressure including margin (bara)
Onshore to MVL	0	150.00	149.90
	1894.00	150.00	149.90
Nearshore (including Micro-Tunnel part)	1917.20	150.05	149.96
	32569.63	151.30	151.32
A-ALT	32618.41	151.35	151.38
	126474.15	150.37	150.31
Section F ends with K14 PLET	126499.15	150.37	150.31
	162706.17	150.28	150.21
Section D ends with DHUB	162731.17	150.28	150.21
	196259.45	146.78	146.36
Section C ends with the PLEM	196272.28	146.78	146.36
	222489.78	150.64	150.61
PLEM to L4A ends with L4A platform	222515.83	150.64	150.61
	224417.70	146.55	146.10

9.1.2.2 Temperature Profile

	Pipeline length (m)	Temperature (C)
Onshore to MVL	0	49.98
	1894.00	49.39
Nearshore (including Micro-Tunnel part)	1917.20	49.40
	32569.63	31.32
A-ALT	32618.41	31.20
	126474.15	17.59
Section F ends with K14 PLET	126499.15	17.59
	162706.17	17.41
Section D ends with DHUB	162731.17	17.41
	196259.45	16.62
Section C ends with the PLEM	196272.28	16.66
	222489.78	16.02
PLEM to L4A ends with L4A platform	222515.83	16.02
	224417.70	15.50

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9.1.3 Sensitivity study 1

9.1.3.1 Pressure Profile

	Pipeline length (m)	Pressure (bara)	Pressure including margin (bara)
Onshore to MVL	0	180.97	180.97
	1894.00	180.53	180.48
Nearshore (including Micro-Tunnel part)	1917.20	180.54	180.49
	32569.63	174.59	173.94
A-ALT	32618.41	174.58	173.94
	126474.15	153.20	150.42
Section F ends with K14 PLET	126499.15	153.16	150.38
	162706.17	145.87	142.36
Section D ends with DHUB	162731.17	145.83	142.31
	196259.45	135.61	131.07

9.1.3.2 Temperature Profile

	Pipeline length (m)	Temperature (C)
Onshore to MVL	0	49.99
	1894.00	49.77
Nearshore (including Micro-Tunnel part)	1917.20	49.77
	32569.63	43.10
A-ALT	32618.41	43.06
	126474.15	24.90
Section F ends with K14 PLET	126499.15	24.88
	162706.17	19.86
Section D ends with DHUB	162731.17	19.85
	196259.45	17.32

9.1.4 Sensitivity study 2

9.1.4.1 Pressure Profile

	Pipeline length (m)	Pressure (bara)	Pressure including margin (bara)
Onshore to MVL	0	181.00	181.00
	1919.00	180.43	180.38

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Nearshore (including Micro-Tunnel part)	1919.91	180.43	180.37
	32620.51	172.63	171.79
A-ALT	32621.81	172.55	171.70
	126576.34	145.30	141.73
Section F ends with DHUB	126576.36	145.30	141.74
	196399.47	127.92	122.62

9.1.4.2 Temperature Profile

	Pipeline length (m)	**Temperature (C)**
Onshore to MVL	0	65.00
	1919.00	64.80
Nearshore (including Micro-Tunnel part)	1919.91	64.80
	32620.51	55.06
A-ALT	32621.81	55.06
	126576.34	31.08
Section F ends with DHUB	126576.36	31.08
	196399.47	17.89

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Aramis Pipeline Routing Desktop Study - Expected Site Conditions

Consultancy Report | Dutch Sector of the North Sea

R201644 03 | 10 February 2022

TotalEnergies

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03	10 February 2022	Final	Update of cables	[redacted]	[redacted]	[redacted]

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Nanterre, 10 February 2022

Dear [redacted],

Please find attached the final version of the Desktop Study performed as part of the ARAMIS Pipeline Routing project.

This report, referenced R201644 (03), was prepared by the joint efforts of [redacted], Engineering Geologist, [redacted] Geologist, [redacted], Principal Geologist. It was reviewed by [redacted], Principal Geologist, under the supervision of [redacted].

Thank you for giving us the opportunity to work for you.

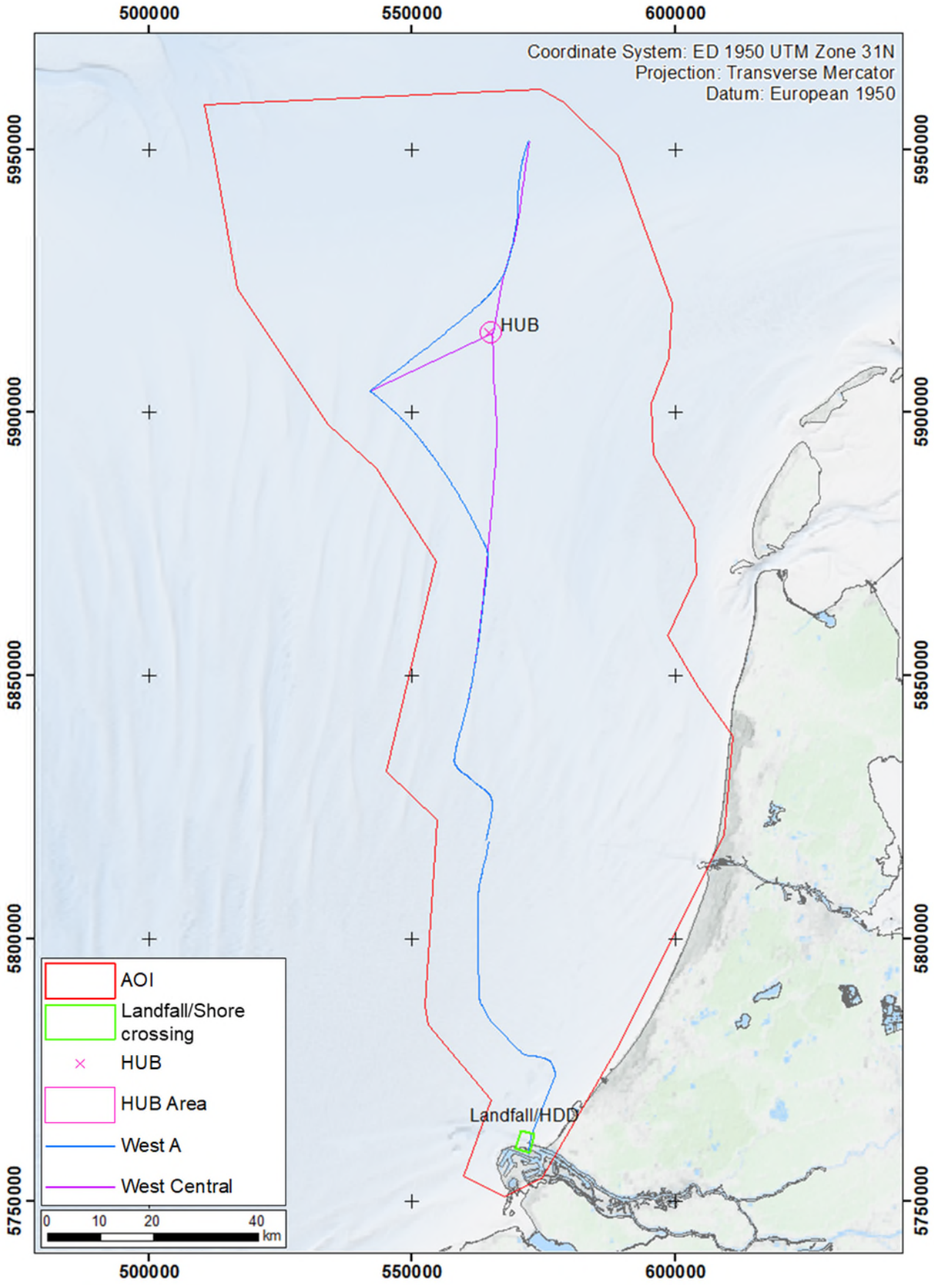
Please do not hesitate to contact us should you have any queries.

Yours faithfully,

[redacted]

[redacted]
Engineering Geologist

Frontispiece



Executive Summary

TotalEnergies requested Fugro to perform a desktop study (DTS) aimed at characterising soil conditions and site use based on publicly available data and Fugro experience over an area of 11,355 km^2 within the Dutch sector of the North Sea. Two areas of particular attention were differentiated within the general area of interest (AOI). These are the Landfall/Shore crossing Area and the Offshore Distribution HUB Area.

The main results of the DTS are summarised as follows:

- Information relating to site use, restricted areas, past or present activities, and any seafloor objects that may affect and constrain development of the proposed pipeline infrastructure was gathered and presented in the report in the form of text and maps;
- Water depths range from 0 m to a maximum of approximately 46 m relative to lowest astronomical tide (LAT). Seafloor gradients are generally less than 1°, but may be locally up to 30° and are related to anthropogenic features and crests of bedforms;
- Three zones with a distinct seafloor morphology were identified within the AOI: a coastal zone, a shallow continental shelf with low-angle topography covered by a complex compound of rhythmic bedforms, and a relatively deep low-energy zone with low-angle seafloor gradient;
- Three types of bedforms were observed within the AOI: sand banks, sand waves and megaripples;
- Sand waves are mobile over the lifetime of a pipeline and are considered to have a significant impact on pipeline foundation design and asset integrity;
- Six groups of surficial sediments were identified across the AOI: Sandy GRAVEL, (slightly) gravelly SAND, (slightly) gravelly muddy SAND, SAND, muddy SAND and sandy MUD. The main constituent is SAND;
- The AOI is characterised by variable soil conditions down to the depth of interest, which were grouped into geotechnical soil units based on the available data (geological, geophysical and geotechnical);
- Separate ground models are presented for the AOI, the Landfall/Shore crossing Area and the Offshore Distribution HUB Area. These ground models take into account the different depths of interest and site-specific site conditions;
- Eighteen soil profiles were generated to display the lateral and vertical variability across the AOI;
- In the Landfall/Shore crossing Area, the surficial sediments comprise predominantly sand to locally sandy gravel, and very soft clay in the Maasmond Kanaal. In the subsurface, the main units are the Naaldwijk Formation, comprising of interbedded sand and clay, with locally peat (laminae to thin beds), and the Kreftenheye, IJmuiden Ground and Winterton Shoal Formations, which comprise dense to very dense sand, with locally layers of silty sand and/or (laminated) clay in the lower part of the depth of interest.
- Three soil province maps were created to depict the spatial extent of each predicted soil profile within the AOI, Landfall/Shore crossing Area and Offshore Distribution HUB Area;
- A geohazards inventory list is provided, detailing (geo)hazards, soil and anthropogenic constraints and man-made obstructions identified across the AOI;

- Recommendations for site-specific geophysical and geotechnical surveys are detailed at the end of the report. These recommendations may aid in reducing uncertainties and aid decision making regarding the ARAMIS Pipeline routing.

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Abbreviations

AOI	Area of interest
BH	Borehole
bLAT	below Lowest Astronomical Tide
BP	Before Present
BSF	Below seafloor
CD	Chart datum
CM	Central meridian
CPT	Cone penetration test
DTM	Digital terrain model
DTS	Desktop study
ED	European Datum
Fm.	Geological formation
GIS	Geographic information system
ETRS	European terrestrial reference system
LAT	Lowest Astronomical Tide
ka	Period of thousand years
LGM	Last Glacial Maximum
Ma	Million years ago
Mb.	Geological formation member
MBES	Multibeam echosounder
MSL	Mean Sea Level
OWF	Offshore wind farm
SBP	Sub-bottom profiler
SHOM	Service Hydrographique et Océanographique de la Marine
SSS	Side Scan Sonar
UHR	Ultra High resolution
UTM	Universal Transverse Mercator
UXO	Unexploded ordnance
WFZ	Wind farm zone
WGS	World Geodetic System
WMS	Web Map Service

1. Introduction

1.1 Purpose

Fugro France SAS (Fugro) was contracted by TotalEnergies (client) to provide a desktop study to characterise the site conditions for the ARAMIS Pipeline Routing project.

This geological desktop study (DTS) aims to better understand the ground conditions along the future ARAMIS Pipeline located in the Dutch sector of the North Sea.

The final purpose is to provide the client with a geological and geotechnical model across area of interest (AOI), providing the necessary information to help decision making for the pipeline routing.

1.2 Study Areas

The AOI comprises an area of 11355 km^2 and is located in the southern North Sea, north-west off the coast of the Netherlands, within the Dutch administrative zone (Figure 1.1). Along the coastline, the AOI extends from Maasvlakte within the Port of Rotterdam in the south, to Egmond aan Zee in the north. The AOI extends over approximately 210 km in a north–south direction and 90 km in a west–east direction.

Within the AOI, two areas of particular attention were differentiated. These are:

- Landfall/Shore crossing Area: the first 3 km of the planned pipeline routing for horizontal directional drilling (HDD) and trenching at Maasvlakte;
- Offshore Distribution HUB Area: a 2 km radius area around the planned Offshore Distribution HUB location. This area is mentioned as HUB Area in maps throughout the report.

The depth of interest is 20 m below seafloor (BSF) for the entire AOI, except for the Landfall/Shore crossing Area, where it is 40 m to 50 m BSF and the Offshore Distribution HUB Area, where it is 100 m BSF.

Client provided preliminary offshore rigid pipeline routing (two options: West A and West Central). At this point the final pipeline routing is not defined.

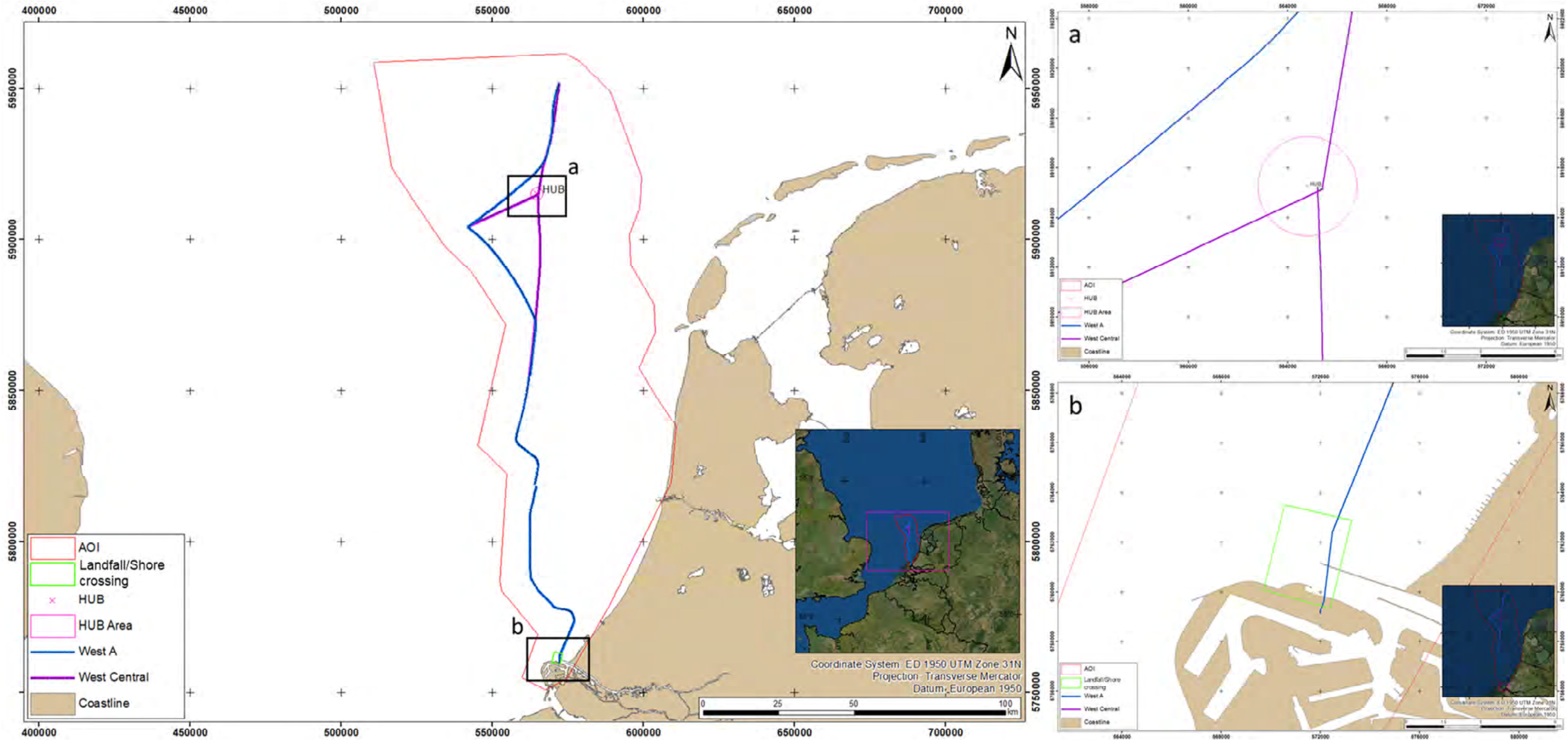


Figure 1.1: Extent of the AOI and definition of the Landfall/Shore crossing and Offshore Distribution HUB Areas

1.3 Scope of Work

The report presents the site-specific seafloor and sub-seafloor conditions derived from available data and the present understanding of the regional geology. These elements will be described across the AOI, Landfall/Shore crossing and Offshore Distribution HUB Areas.

This study includes comments on the site suitability considering a list of potential site-specific (geo)hazards, as well as soil and anthropogenic constraints across the AOI.

The UXO historical desktop study and archaeological desktop study were sub-contracted. Reports from sub-contractors are provided as Appendix B and Appendix C.

1.4 Study Limitations

This report does not cover the following topics:

- Metocean conditions;
- Environmental impact of foundations, if any;
- UXO risk assessment at the AOI.

The results of this study are dependent on the origin, quality, and quantity of available data. The presented ground model is preliminary and should only be used to help decision making during the bidding process.

Geotechnical parameters presented in this report are estimates, derived from Fugro experience over analogous representative areas within the AOI (e.g. planned wind farm sites). Future site-specific in situ measurements are required to confirm or adjust the presented geotechnical parameter ranges before any installation

1.5 Geodetic Parameters

Table 1.1 presents the coordinate reference system for this project. All illustrations in the report as well as the A3 maps are prepared using the ED50 datum and UTM Zone 31N projection.

Table 1.1: Geodetics parameters

Geodetic Datum	
Datum	International_1924
Spheroid	D_European_1950
Semi major axis	a = 6 378 137.0 m
Semi minor axis	b = 6 356 911.946127946 m
Inverse flattening	$^1/_f$ = 297.0
Map Projection	
Projection system	Transverse Mercator (UTM Zone 31N)
Central meridian	3°
Latitude of origin	0°

False easting	500 000 m
False northing	0 m
Linear unit	Metre

1.6 Data Use

Fugro understands that this report will be used for the purposes described in the 'Introduction' section. These purposes are a key factor in defining the scope and level of services offered.

It should also be noted that the geological and geotechnical data presented in this report are based on interpretations, correlations, and extrapolations, which implies a certain degree of uncertainty to be considered. This study will emphasise the level of confidence in the geological model and will detail the uncertainties related to stratigraphic conditions, the nature and thickness of the geological formations and geotechnical parameters.

However, the results of this report should not be used for purposes other than those for which this report was prepared, or if the original development or activity is modified by the client without prior control of their suitability.

1.7 Guidelines on Use of Report

Appendix A outlines the limitations of this report, in terms of a range of considerations including, but not limited to, its purpose, its scope, the data on which it is based, its use by third parties, possible future changes in design procedures and possible changes in the conditions at the site with time. It represents a clear description and explanation of the constraints which apply to all reports issued by Fugro. It should be noted that the Guidelines do not in any way supersede the terms and conditions of the contract between Fugro and TotalEnergies.

2. Approach and Data Review

2.1 Desktop Study Approach

The first step for the desktop study was to gather any relevant data, both public and internal, related to geological, geophysical and geotechnical features within the AOI but also covering a wider area. Based on these, the regional geological background was determined. This allowed for a better understanding and identification of potential or identified geological features or processes that may be expected across the AOI.

In addition, information relating to site use, restricted areas, past or present activities, and any seafloor objects that may affect and constrain development of the proposed pipeline infrastructure was gathered and presented in a number of maps.

These data were then reviewed and studied to characterise the different geological features, stratigraphic units, geotechnical parameters and constraints (geological and site-use) across the AOI, with a particular focus on the Landfall/Shore crossing Area and the Offshore Distribution HUB Area. Geotechnical parameters were derived mainly based on public information and Fugro experience. Note that no project names or locations are shared for confidentiality reasons. The data that were used are introduced in Section 2.2.

Attention is given to the identification of possible missing data or areas of uncertainties to establish recommendations for future geophysical and geotechnical site-specific surveys.

The ultimate result of the DTS is to provide a geotechnical ground model allowing to describe the soil variability, both vertically (soil profiles) and laterally (soil provinces), in the AOI (including Landfall/Shore crossing and Offshore Distribution HUB Areas).

The available data used for this study were compiled in a GIS (Geographic Information System) geodatabase. The maps were created using ArcGIS® software by Esri (version 10.8).

The final GIS project is delivered along with the final revision of the report.

2.2 Available Data

The main sources of information used in this study include:

- Client-supplied information (Table 2.1);
- Fugro internal databases;
- Digital public domain data (Table 2.2);
  - WMS
  - Freely downloadable GIS-compatible data
- Published literature.

For those sources that are not included in the GIS database deliverable, URL links are given to allow TotalEnergies to retrieve the relevant information.

2.2.1 Client-Supplied Information

Table 2.1: Project information

Data	Data Format	Date Provided
Boundaries of Area of Interest (AOI)	Shapefile	06 December 2021
WEST A and WEST CENTRAL Routings	Shapefile	07 December 2021
Offshore Distribution Area	Shapefile	04 November 2021
Outline of Landfall/Shore crossing Area	Coordinates	15 December 2021

2.2.2 Fugro Database

This report uses and summarises Fugro-held information:

- Information about regional geology;
- General geotechnical data;
- Previous geotechnical and geophysical investigation data applicable to development sites within the AOI.

2.2.3 Public Domain

Data from public sources have been gathered and reviewed. These data are accessible for consultation online, to download or using WMS servers. Table 2.2 presents the data sources used.

Table 2.2: Public domain data sources

Type	Source	Link
SITE USE		
Landing stations	EMODnet	https://www.emodnet-humanactivities.eu/view-data.php
Telecommunication cables	EMODnet, SHOM, Rijkswaterstaat	https://www.emodnet-humanactivities.eu/view-data.php https://www.rijkswaterstaat.nl/en
Power cables	Rijkswaterstaat	https://www.rijkswaterstaat.nl/en
Buoys	Rijkswaterstaat	https://www.rijkswaterstaat.nl/en
Offshore facilities	NLOG	https://www.nlog.nl/index.php/en/files-interactive-map
Wells	NLOG	https://www.nlog.nl/index.php/en/files-interactive-map
Pipelines	EMODnet	https://www.emodnet-humanactivities.eu/view-data.php
Active HC licenses	EMODnet	https://www.emodnet-humanactivities.eu/view-data.php
Navigation channels	Noordzeeloket	https://www.noordzeeloket.nl/en/up-date-atlas/

Type	Source	Link
Anchoring areas	Noordzeeloket	https://www.noordzeeloket.nl/en/up-date-atlas/
Harbour approach areas	Noordzeeloket	https://www.noordzeeloket.nl/en/up-date-atlas/
Wind farm active areas	Noordzeeloket	https://www.noordzeeloket.nl/en/up-date-atlas/
Wind farm development areas	Noordzeeloket	https://www.noordzeeloket.nl/en/up-date-atlas/
Dredging areas	EMODnet	https://www.emodnet-humanactivities.eu/view-data.php
Military areas	EMODnet	https://www.emodnet-humanactivities.eu/view-data.php
Environment Natura 2000 areas	EMODnet	https://www.emodnet-humanactivities.eu/view-data.php
Dredging areas	Rijkswaterstaat	https://geo.rijkswaterstaat.nl/services/ogc/gdr/stort_loswal/ows?
Fishing and shipping activities	EMODnet	https://www.emodnet-humanactivities.eu/view-data.php
BATHYMETRY		
AOI	EMODnet (2020)	https://portal.emodnet-bathymetry.eu/
Rotterdam approach area	EMODnet (2020)	https://portal.emodnet-bathymetry.eu/
Landfall/Shore crossing Area	EMODnet (2018)	https://portal.emodnet-bathymetry.eu/
Hollandse Kust WFZs	RVO	https://offshorewind.rvo.nl/
SOIL		
Substrate type	EMODnet	https://www.emodnet-geology.eu/map-viewer/?p=seabed_substrate
Grab samples, vibrocores and boreholes	DINOloket	https://www.dinoloket.nl/en/subsurface-data
Hollandse Kust WFZs	RVO	https://offshorewind.rvo.nl/
GEOLOGICAL INFORMATION		
Southern Bight Fm.	Balson et al. (1991), NITG–TNO (2004b)	-
Urania Fm.	NITG–TNO (2004b)	-
Naaldwijk Fm.	Cameron et al. (1984), Harrison et al. (1987), Balson et al. (1991)	-
Boxtel (Twente) Fm.	NITG–TNO (2004d)	-
Eem Fm / Brown Bank Mb.	NITG–TNO (2004d)	-
Kreftenheye Fm.	NITG–TNO (2004d)	-
Eem Fm.	Cameron et al. (1984, 1986)	-
Drente (Borkum Riff) Fm.	Laban (1995)	-
Drente (Cleaver Bank) Fm.	Laban (1995), NITG–TNO (2004d)	-
Tea Kettle Hole Fm.	Laban (1995)	-

Type	Source	Link
Egmond Ground Fm.	Cameron et al. (1984, 1986), Laban (1995)	-
Peelo (Swarte Bank) Fm.	Cameron et al. (1986), Laban (1995), Laban & van der Meer (2011)	-
Yarmouth Roads Fm.	Cameron et al. (1984, 1986)	-
Ice sheet extents	Laban (1995)	-
Notes: Data was accessed between December 2021 and January 2022		

3. Regional Geology

3.1 Regional Geodynamics and Geological History

The large-scale tectonic setting of the Netherlands and adjacent areas is driven by the north–south collision of Gondwana and Laurussia during the Late Carboniferous to form Pangaea, and the subsequent rifting during the Triassic in the Arctic–North Atlantic and western Tethys domains. This formed, in conjunction with the anisotropic and thickened crust of the Variscan fold belt, a complex system of basins and rifts in Northwest Europe (Geluk, 2005). Alpine inversion of these basins took place during the Late Cretaceous and early Paleogene as a result of the collision of Iberia and Europe. This was followed by multiple phases of subsidence from the Eocene up to recent times (Wong et al., 2007).

3.2 Pre-Quaternary Geology

From the late Miocene onwards, a complex fan delta system developed, which gradually evolved into an alluvial plain prograding from the east. Until the end of the Neogene, deposition in the North Sea was dominated by sediment input from the Eridanos (Baltic) river system (Overeem, 2002; Knox et al., 2010; Rasmussen & Dybkjaer, 2014; Thöle et al., 2014).

3.3 Quaternary Geology

During the Pleistocene, the depositional evolution of the North Sea basin was strongly influenced by climatic variations, glaciations and associated sea level fluctuations (Funnell, 1996; Overeem et al., 2001; Kuhlmann & Wong, 2008; Thöle et al., 2014). This resulted in a complex interplay of glacial, glaciolacustrine, glaciofluvial, fluvial, aeolian, deltaic and (shallow) marine environments and deposits (Laban, 1995; Laban & Rijswijk, 2002; Joon et al., 1990; Peeters et al., 2015).

By the mid-Pleistocene (~1 Ma), the Rhine, Meuse and Scheldt rivers had become important contributors of sediment influx to the North Sea basin, as a result of uplift of highland areas in Germany (Laban and Rijsdijk, 2002). Subsidence decreased during this time and the basin had become largely filled with deltaic deposits.

The AOI has been affected by an alternating series of glacial and interglacial periods that has occurred since the Pleistocene and continues to the present day. Below follows a more detailed description of the three glacial and three interglacial periods that took place.

3.3.1 Elsterian Glaciation (Middle Pleistocene)

During the Elsterian glaciation (475 ka to 410 ka BP), the Scandinavian and British ice masses coalesced and spread in southern direction to cover the northern part of the Netherlands and the southern North Sea (Ehlers, 1990; De Gans, 2007). The northern half of the AOI has been affected by the Elsterian ice sheet, while the southern half was influenced by the Rhine and Meuse river systems (Figure 3.1a). The Aramis area was also influenced by the Eridanos river

system, which was deflected south of the ice limit. Deposition of predominantly low energy open marine deltaic sediments consisting of siliceous sands and clays ensued, which are thought to belong to the Yarmouth Roads Formation (Laban, 1995; Laban & Rijsdijk, 2002; Rijsdijk et al., 2005). Elsterian tunnel valleys occur within the Yarmouth Roads Formation. The infill of these tunnel valleys comprises glaciofluvial, glaciolacustrine and proglacial clays and sands of the former Swarte Bank Formation (now part of the Peelo Formation; Praeg, 1996; Rijsdijk et al., 2005; Graham et al., 2011; Moreau et al., 2012).

3.3.2 Holsteinian Interglacial (Middle Pleistocene)

During the subsequent Holsteinian interglacial (410 ka to 370 ka BP), sea level rose because of climate amelioration and melting ice masses. This resulted in a transgression phase in the AOI.

Fluvial and marine deposits were prevalent in this period. The fluvial deposits have been defined as the onshore Urk Formation (Bosch et al., 2003), while the offshore equivalent comprises marine deposits belonging to the Egmond Ground Formation (Bosch et al., 2003; Rijsdijk et al., 2005). Laterally, the Urk Formation grades into the Egmond Ground Formation (Bosch et al., 2003). The Urk Formation can contain clay interbeds, while the Egmond Ground Formation can contain marine shells. The Urk Formation and Egmond Ground Formation may locally incise into the underlying Yarmouth Roads Formation.

3.3.3 Saalian Glaciation (Middle to Late Pleistocene)

During the Saalian glaciation (370 ka to 130 ka BP), the eastern half of the AOI was probably covered by the Saalian ice sheet while the western half was located in close proximity to the Saalian Ice Margin (Figure 3.1b). However, the exact limit of the ice sheet advance offshore remains uncertain.

Ice masses formed glacially scoured basins and several ice-pushed ridges (moraines). The ice-pushed ridges were recognised directly south of the Hollandse Kust (noord) wind farm zone (WFZ) (Laban & van der Meer, 2011; Peeters et al., 2015; Cartelle et al., 2021).

Numerous tunnel valleys were created during the Saalian in subglacial and proglacial settings. A major tunnel valley is present in the centre of the site, and more tunnel valleys may be present near the north-eastern boundary of the Aramis area (Cameron et al., 1984a; Joon et al., 1990; Laban, 1995; Stouthamer et al., 2015).

Fluvial erosion of underlying formations occurred. During the Saalian glaciation, the Rhine–Meuse river system merged with a proglacial river system south of the ice margin (Peeters et al, 2015). This setting implies variable soil conditions dominated by extensive areas of glaciofluvial sands and gravels (outwash plains/sandurs) deposited in front of the ice sheet, with clays deposited in glaciolacustrine environments. Local aeolian deposition took place near the Saalian Ice Margin. The glaciofluvial and aeolian sediments belong to the Drachten Formation (formerly Tea Kettle Hole Formation), while the glaciolacustrine sediments belong

to the Uitdam Member of the Drenthe Formation (formerly Cleaver Bank Formation). The latter is mainly confined to the Saalian tunnel valleys (Laban, 1995).

Between the coast of the island of Texel to a position about 14 km to the west, a till plateau is present.

TILL is unsorted glacial sediment. Within the AOI the TILL is expected to comprise silty, sandy CLAY, with matrix-supported gravel to boulder-sized grains. It is present in the north-east of the AOI and belongs to the Drenthe Formation (Gieten Member). Glacial TILL may pose a risk to the installation of offshore structures due to its heterogenic grain size composition and overconsolidated nature.

The Saalian glaciation is associated with widespread glacial deformation both onshore and offshore. Large deformation structures have been reported within the AOI (Joon et al., 1990; Laban, 1995). Some indications of glacial deformation have been identified in the Hollandse Kust WFZs.

Saalian sediments in the southern North Sea have been largely eroded by the subsequent Eemian transgression but are still present in Saalian channels and valleys.

3.3.4 Eemian Interglacial (Late Pleistocene)

A major marine transgression affected AOI during the Eemian interglacial (130 ka to 115 ka BP). The AOI became part of the delta plain of the river Rhine. Shallow marine sands (Eem Formation), lagoonal and estuarine clays and sands, and fluvial sands (Kreftenheye Formation) were laid down in a complex depositional setting (Peeters et al., 2015). Existing glacial valleys and channels were inundated by the marine transgression (Figure 3.1c).

With the onset of the marine regression at the end of the Eemian and beginning of the Weichselian glaciation, brackish marine clays and lagoonal or lacustrine silty laminated clays, identified as the Brown Bank Member (part of Eem Formation), were deposited in a low-energy environment in the (north-)western part of the AOI (Figure 3.1d; Cameron et al., 1984a; Peeters et al., 2015; GDN, 2018).

3.3.5 Weichselian Glaciation (Late Pleistocene)

During the youngest glacial period, the Weichselian (115 ka to 18 ka BP), the limit of the ice sheet extent was just north-west of the AOI. At the time, deposition in the southern North Sea was dominated by periglacial conditions with temporary fluvial influences of the Rhine–Meuse river system (Figure 3.1e).

The periglacial deposits comprise sand, sandy loam, peat, thaw-lake deposits and aeolian sediments belonging to the Boxtel Formation. The aeolian deposits are considered to have little preservation potential in a dominantly (glacio)fluvial environment (NITG–TNO, 2004). The glaciofluvial deposits comprise sand, gravelly sand and clay of the Kreftenheye Formation. Erosion of underlying formations probably occurred.

3.3.6 Holocene (Recent)

With the transition from late glacial to early Holocene (11.6 ka BP to present), climatic amelioration resulted in sea level rise, and the North Sea basin became flooded. Deposition took place in a terrestrial periglacial environment, transitioning into tidal and lagoonal as the sea level rose. Sediments from this period belong to the Naaldwijk Formation and are preserved as (scattered) sands and clays that often infill channels. Locally, peat beds were deposited in shallow marsh settings (Nieuwkoop Formation). As transgression progressed, the AOI was overlain by sands of the Southern Bight Formation and muddy sands of the Urania Formation.

The North Sea Basin has remained essentially sediment starved since the start of the Holocene (Jacobs & De Batist, 1996), and deposits occur mainly in the form of sand banks and sand waves (Liu et al., 1993). Surficial sediments in the AOI mainly consist of sand with shell and shell fragments typical of a high energy, open marine environment. These sands are partially derived from reworking of the sediments from the underlying fluvial deposits. Sands with a higher mud fraction are present in a bathymetric depression in the northern part of the AOI. These sediments belong to the Urania Formation and are indicative of a low energy open marine environment.

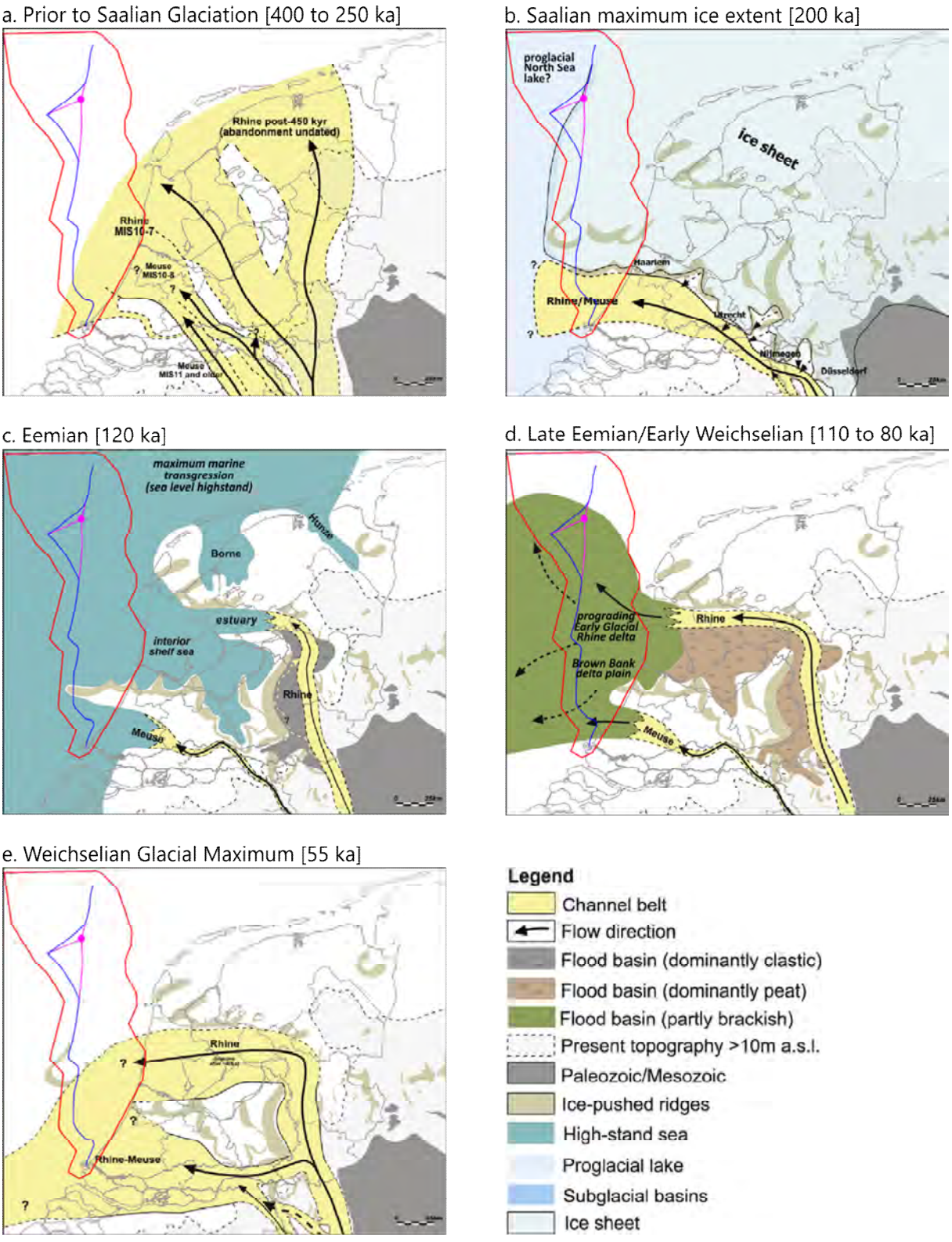


Figure 3.1: Paleo-geographical reconstructions of the Netherlands during the Middle to Late Pleistocene illustrated by five successive time frames. a) Rhine–Meuse drainage configuration prior to Saalian Glaciation. b) Maximum Saalian ice extent. c) Eemian interglacial maximum transgression during sea level highstand. d) Rhine delta prograding into lower-deltaic flood basin environment. e) Configuration of the Rhine and Meuse during the Weichselian glacial maximum (modified after Peeters et al., 2015).

3.4 Maximum Ice Sheet Extent and Subglacial Valleys

Three Pleistocene glaciations resulted in ice sheets covering large parts of the Dutch sector of the North Sea. From the oldest to the youngest, these glaciations are named Elsterian, Saalian and Weichselian. Figure 3.2 presents the maximum extent of the Pleistocene ice sheets and the location of the associated subglacial valleys.

The Elsterian valleys form a complex system of anastomosing, but mainly NNE–SSW trending, broad (approximately 1 km to 10 km wide) and deep (up to 400 m BSF) erosional features. They are present in the northern half of the AOI. These subglacial valleys were mainly filled with glaciofluvial SAND near the base and glaciolacustrine CLAY near the top, belonging to the Peelo Formation (Cameron et al., 1986; Laban, 1995).

A major Saalian subglacial valley runs in a N–S direction, along the margin of the maximum extent of the Saalian ice sheet, located in the centre of the AOI. It is approximately 10 km wide and up to 80 m deep. The infill consists locally of glaciolacustrine CLAY (Uitdam Member) near the base, covered with marine SAND of the Eem Formation (Laban, 1995, Fugro, 2020).

Weichselian subglacial valleys occur as close as 6 km north of the AOI (Laban, 1995).

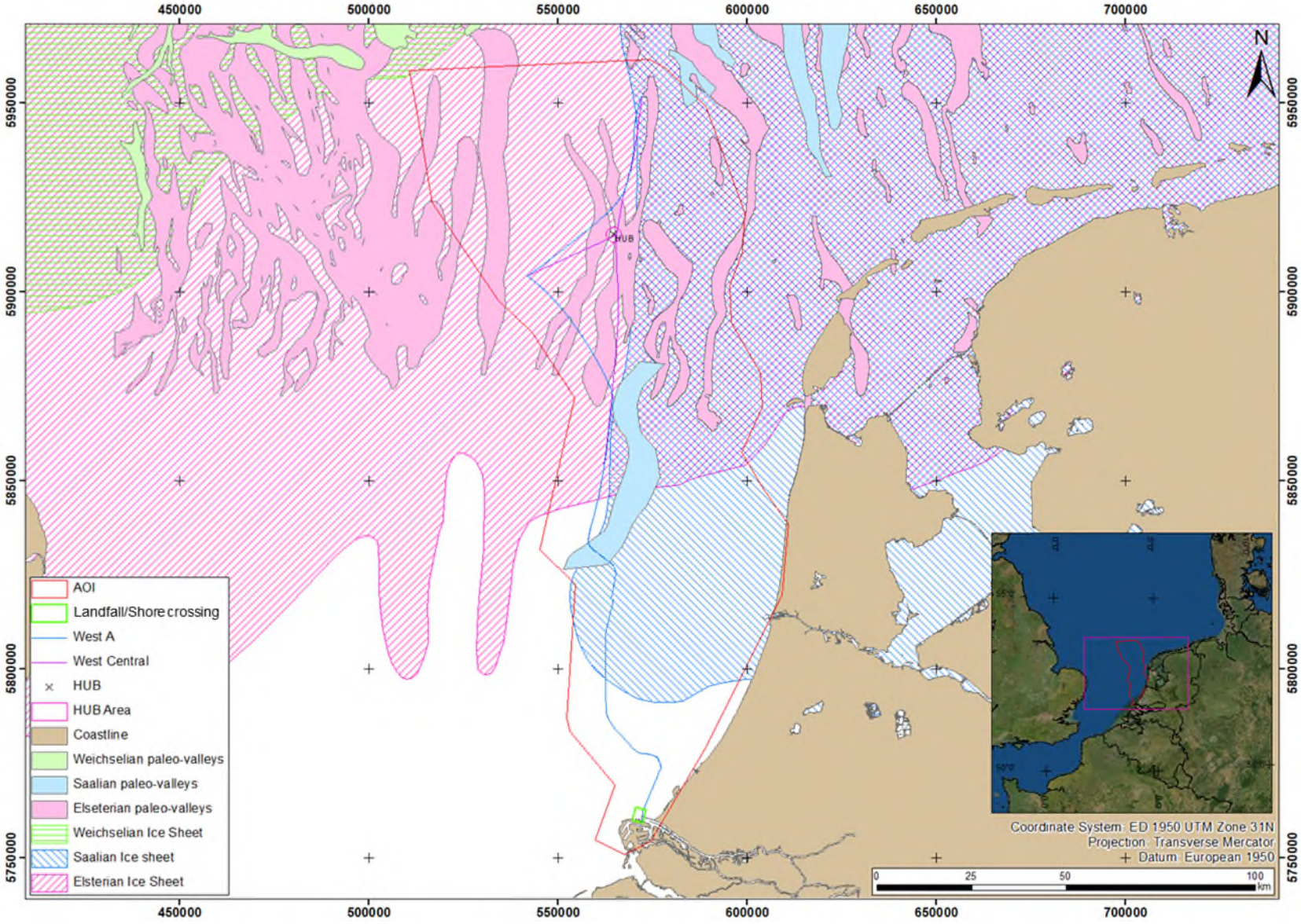


Figure 3.2: Maximum ice extent of the Pleistocene glaciations and associated paleo-valleys (Laban, 1995)

4. Site-Specific Conditions

4.1 Site Use

4.1.1 AOI

Past and/or present activities in the AOI can affect and constrain development of the pipeline infrastructure. Evidence of human activity and seafloor objects are documented in the Archaeological Desktop Study (Appendix B) and in the UXO Desktop Study (Appendix C).

Figure 4.1 presents navigation areas or infrastructure identified within the AOI:

- 197 navigation buoys;
- 7 navigation channels;
- 6 anchoring areas;
- 4 harbour approach areas.

Figure 4.2 presents restricted areas identified within the AOI:

- 7 navigation channels;
- 6 anchoring areas;
- 4 harbour approach areas;
- 3 wind farms in operation;
- 4 wind farms under development;
- 121 dredging areas;
- 11 dredge spoil areas;
- 4 military exercise areas;
- 7 natural protected areas.

Figure 4.3 presents seafloor oil and gas infrastructure identified within the AOI:

- 149 offshore facilities;
- 1153 wells;
- 227 pipelines.

Figure 4.4 presents seafloor cable and wind energy related infrastructure identified within the AOI:

- 1 cable landing station;
- 8 telecommunication cables;
- 139 wind turbine generators;
- 23 power cables.

Based on the currently available information, 36 cables and 35 pipeline crossings are to be expected in the AOI considering the current proposed pipeline routes.

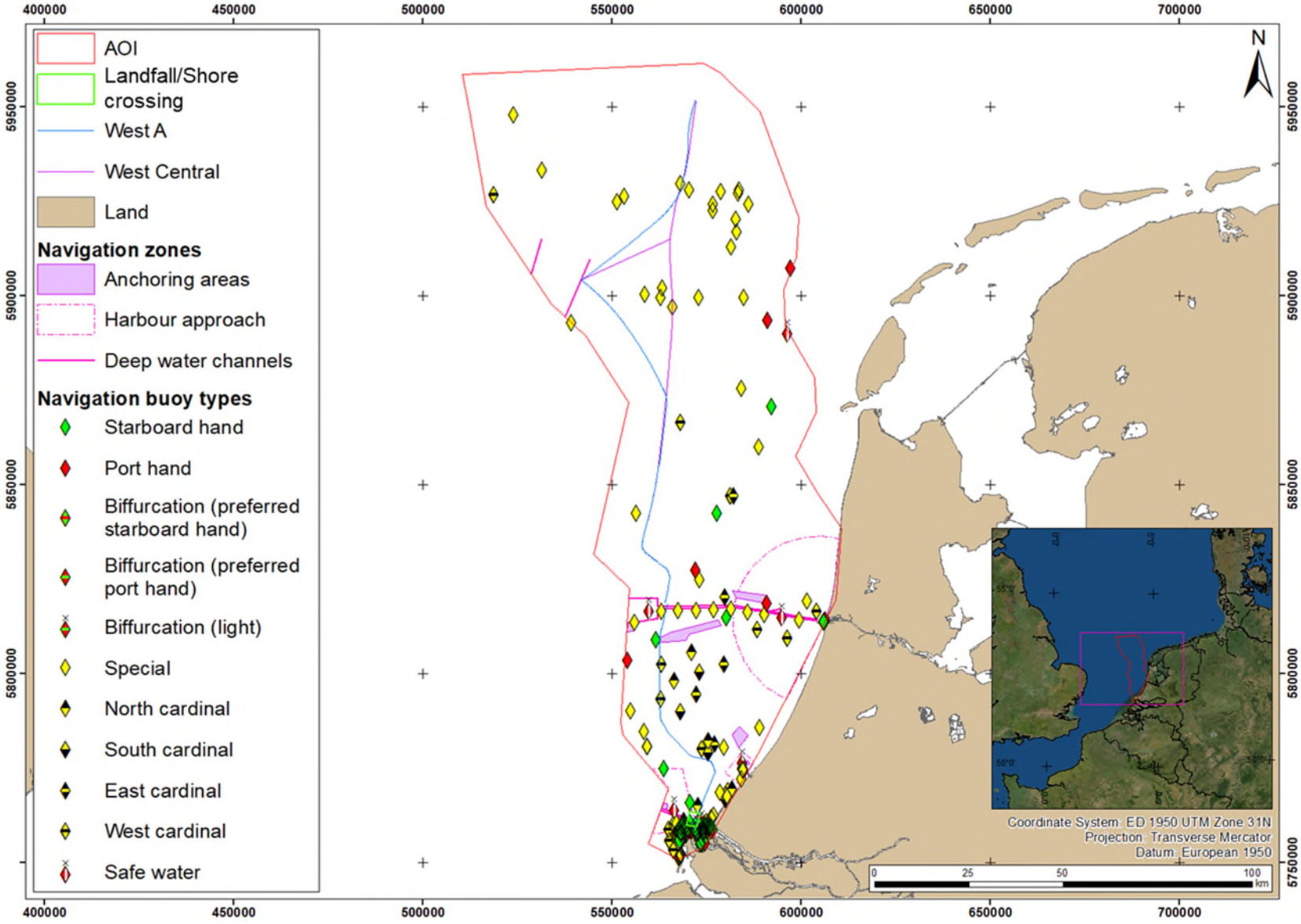


Figure 4.1: Navigation areas or infrastructures identified within the AOI

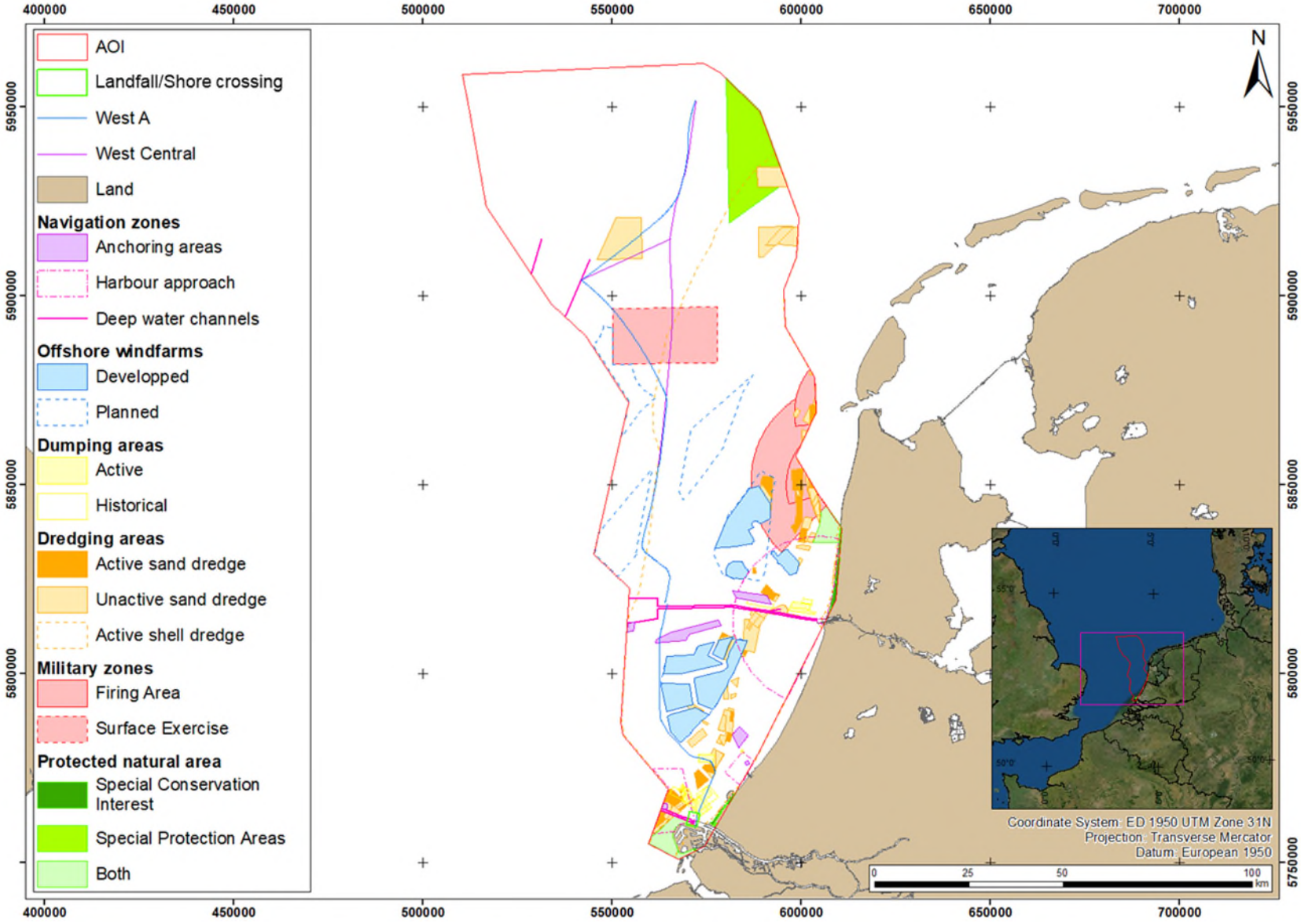


Figure 4.2: Restricted areas identified within the AOI

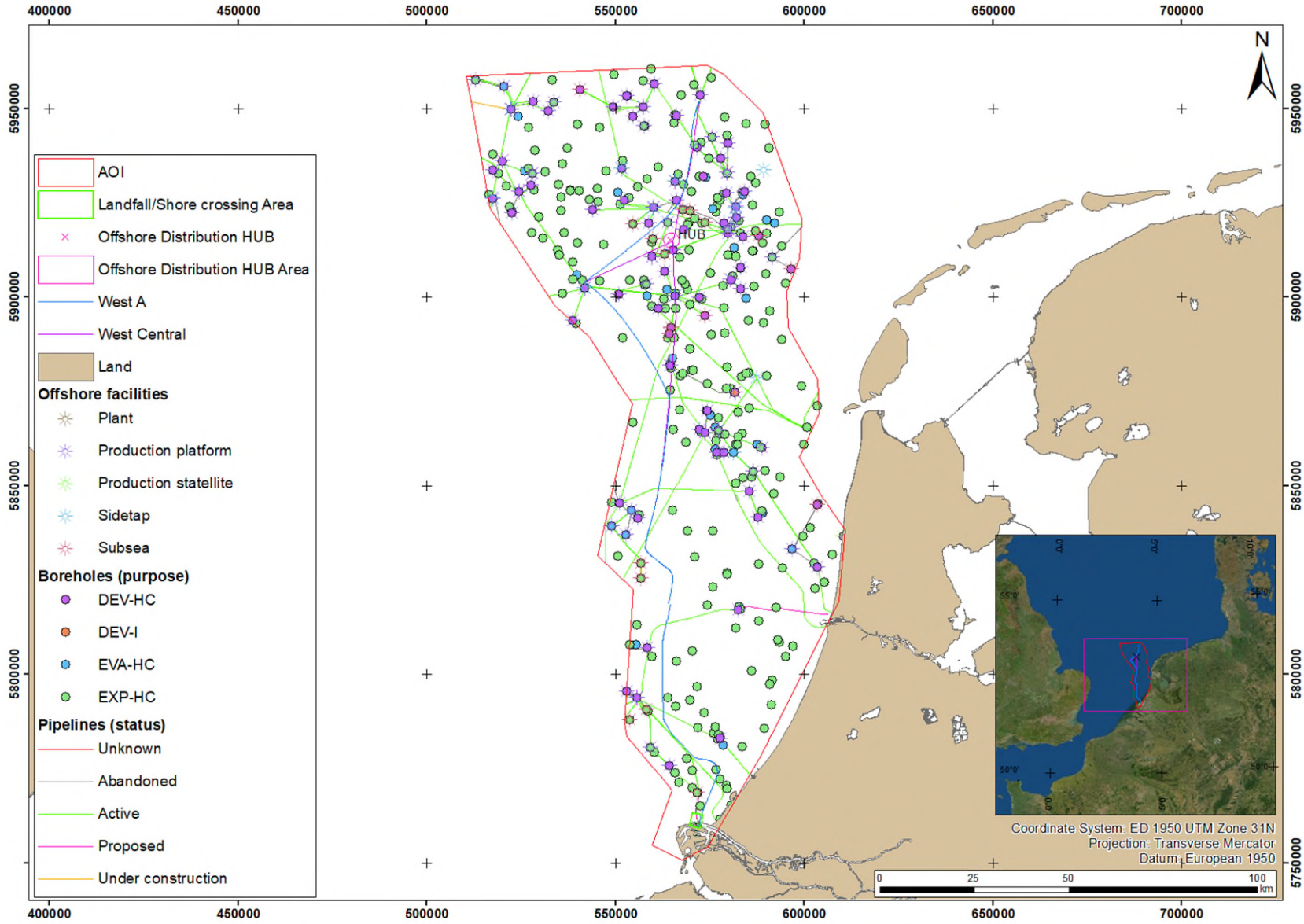


Figure 4.3: Oil and gas seafloor infrastructures identified within the AOI

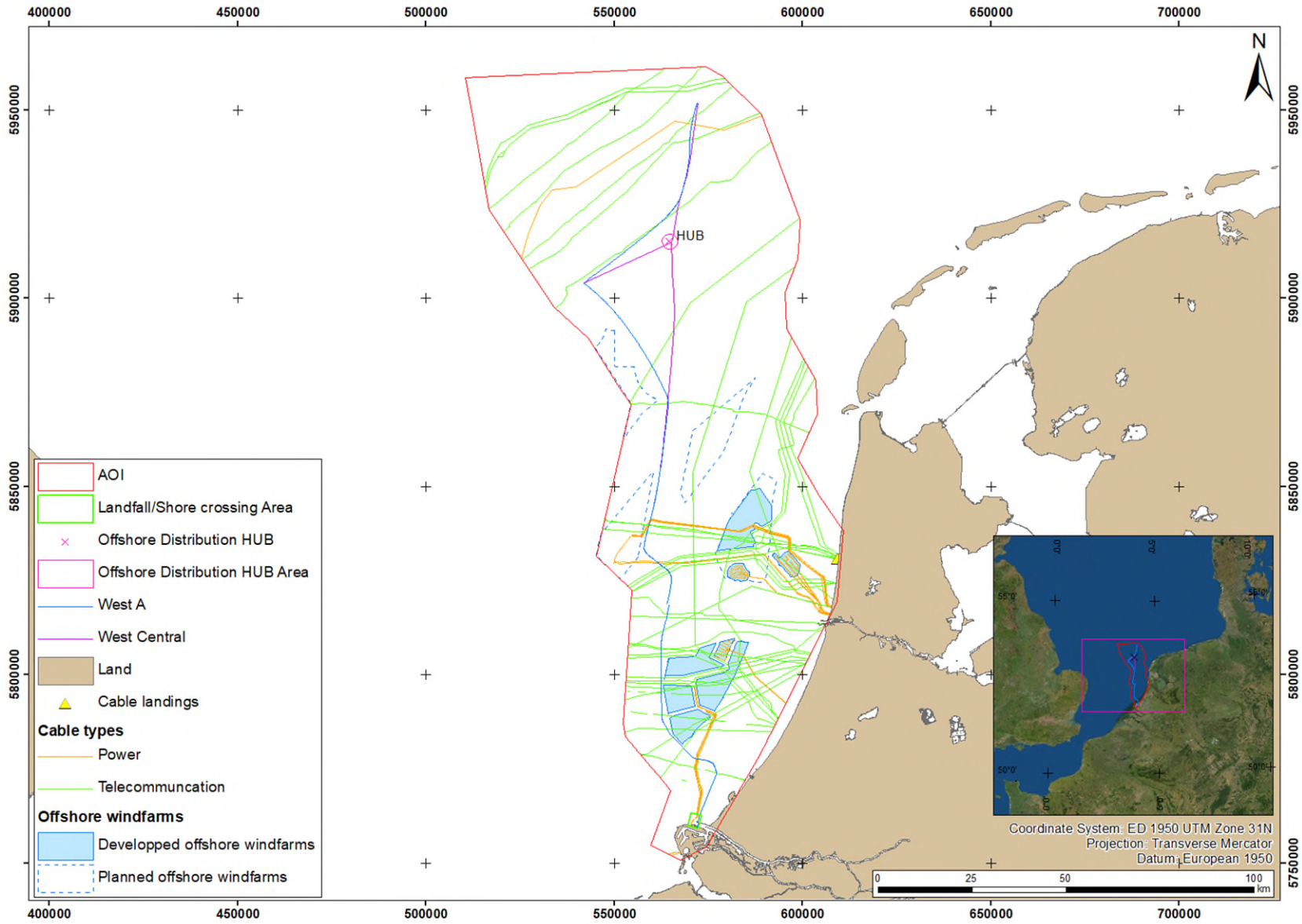


Figure 4.4: Cable and wind-energy related infrastructures identified within the AOI

Vessel route densities per type of vessels as well as vessel density per activity for 2020 were extracted from EMODnet.

Figure 4.5 present the total vessel route density for 2020 within and around the AOI, regardless of the types of boats. The main commercial routes are clearly visible as red lines, connecting the North Sea, Baltic Sea and English Channel as well as joining the main harbours (such as Rotterdam and IJmuiden). The present pipeline layout crosses three of the highest density routes. The Offshore Distribution HUB Area is within an area with medium density routes, probably corresponding mainly to small cargos, fishing, or leisure vessels.

Figure 4.6 presents the average fishing activity for 2020 within and around the AOI. Fishing activity is medium in the southern half of the AOI, and low within the northern half (and close to the Offshore Distribution HUB Area). Fishing activity is high within 20 km from the shore. However, within the Maasmond Kanaal, it is expected that fishing activity is low due to the presence of dense shipping traffic.

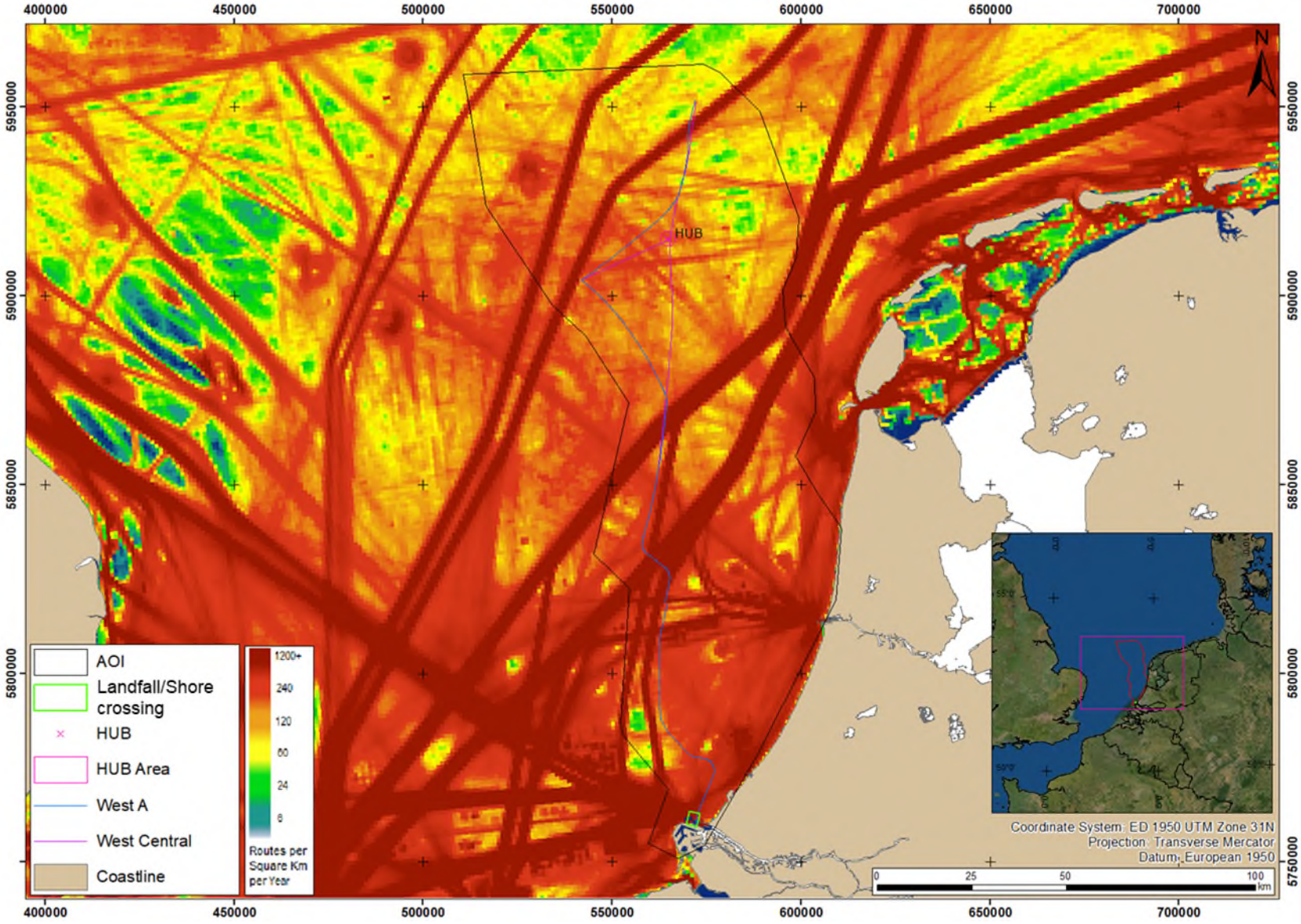


Figure 4.5: Total vessel routes density given as routes per km² per year for 2020 (EMODnet, 2022)

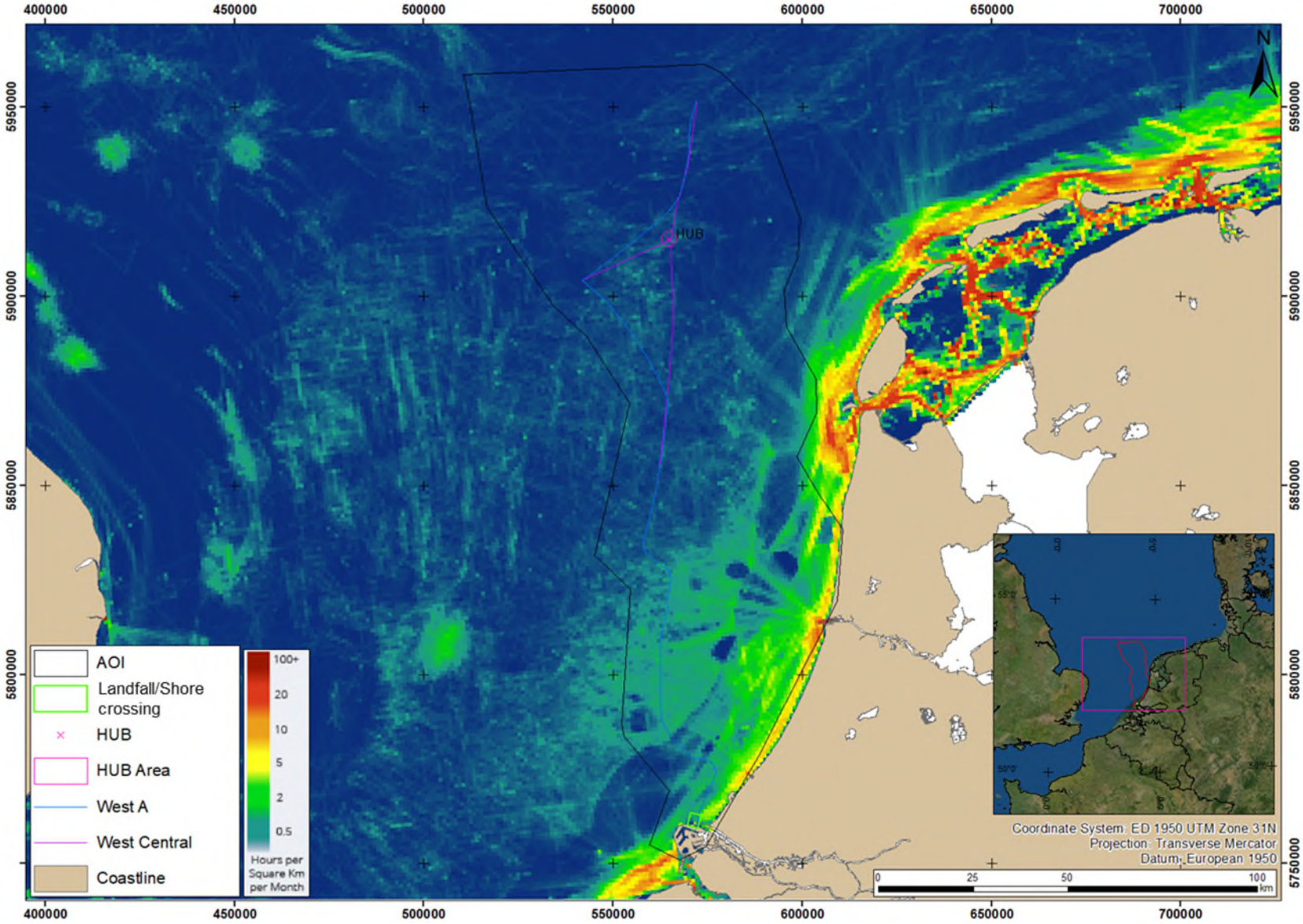


Figure 4.6: Average fishing activity density given in hours per km² per month for 2020 (EMODnet, 2022)

4.1.2 Landfall/Shore Crossing Area

Within the Landfall/Shore Crossing Area a number of restricted areas and infrastructure was identified.

Figure 4.7 presents the following:

- restricted areas and navigation infrastructures identified within the AOI:
  - 2 navigation buoys;
  - 1 (deep water) navigation channel;
  - 1 harbour approach area;
  - 1 dredge spoil area;
  - 1 natural protected area.
- seafloor oil and gas infrastructure identified within the AOI:
  - 1 production facility;
  - 4 wells;
  - 3 pipelines.
- power cables, related to wind energy infrastructure, identified within the AOI:
  - 4 power cables.

4.1.3 Offshore Distribution HUB Area

No specific site use or seafloor obstructions of any type are expected within the Offshore Distribution HUB Area, except for fishing activities and vessels crossing the area.

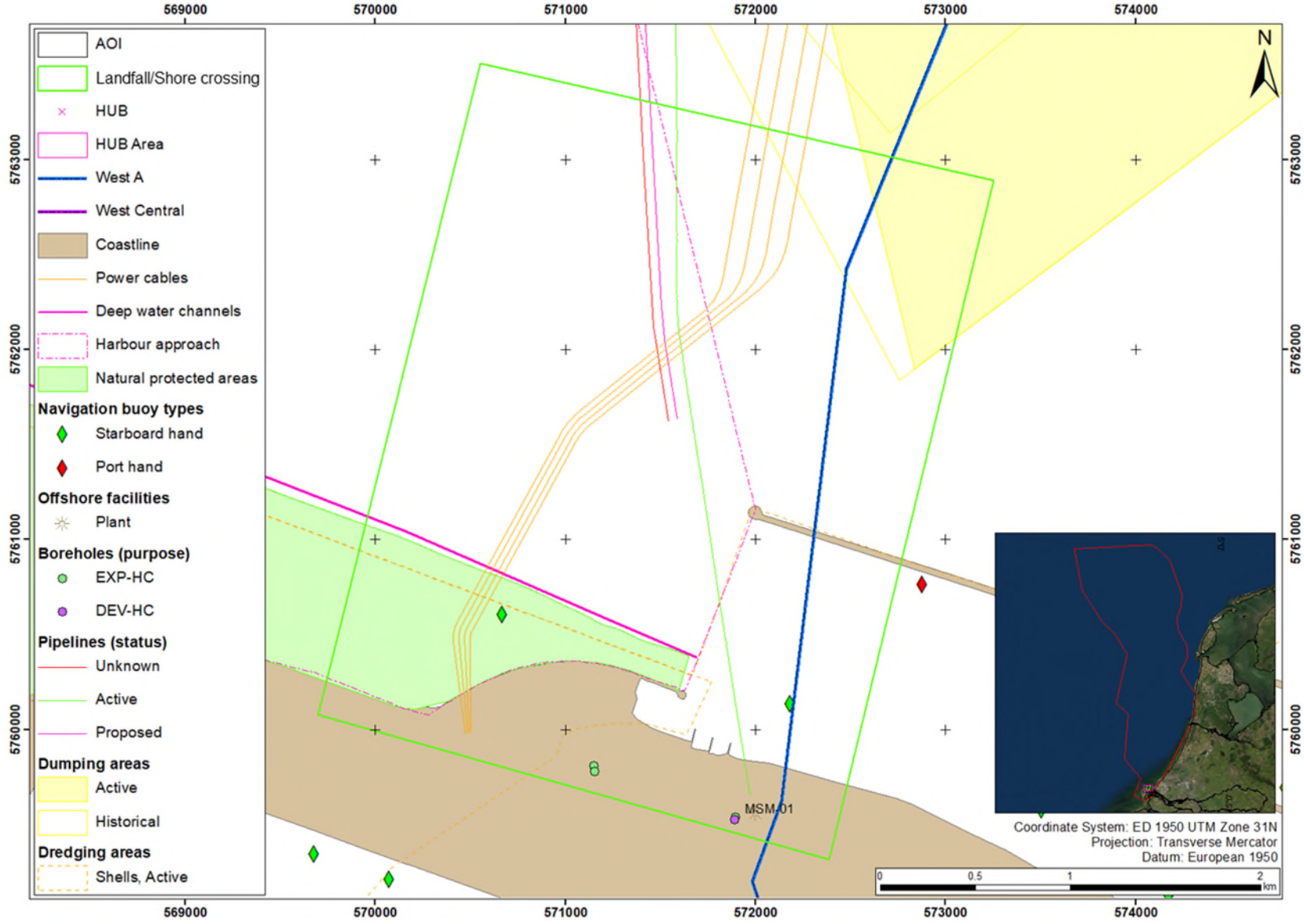


Figure 4.7: Site use across the Landfall/Shore crossing Area

4.2 Seafloor Conditions

4.2.1 Bathymetry and Seafloor Gradient

4.2.1.1 AOI

The Dutch offshore sector has been extensively surveyed by the Dutch Hydrographic Office, and historical data have been acquired and interpolated since 1979 (Deltares, 2016, 2020). This includes bathymetric data, which is publicly available on EMODnet.

Table 4.1 summarises the water depth and slope gradient values as observed in the individual bathymetry datasets available for the AOI. Included in the table is the resolution of the respective bathymetry datasets. Bathymetry and seafloor gradients of the AOI are presented in Figure 4.8. Close-ups for the Rotterdam approach, northern coastal, southern coastal, Hollandse Kust (noord), Hollandse Kust (west) and Hollandse Kust (zuid) WFZs are given in Figure 4.9 to Figure 4.14, respectively.

In general, the seafloor is gently dipping towards the west to west-north-west, perpendicular to the coast. The water depth in the AOI averages approximately 25 m below lowest astronomical tide (bLAT). Approximately 15 km north of the Offshore Distribution HUB Area, the seafloor deepens in a northern direction from approximately 20 m to 39 m bLAT over a distance of 20 km.

Most of the AOI is characterised by low seafloor gradients of less than 5°. Locally, higher seafloor gradients were observed and can have either a hydrodynamic (natural) or man-made origin.

The highest seafloor gradients associated with bedforms were observed on the lee side of sand waves (up to 30°). In the coastal area seafloor gradients up to approximately 19° were observed.

Man-made seafloor features resulting in higher seafloor gradients in the AOI include navigation channels, dredging areas, dumping areas, wrecks and other seafloor obstructions.

However, it should be noted that slope gradients are computed from bathymetry maps and therefore dependant on the data resolution. Where multibeam echosounder (MBES) data were acquired (WFZs), the calculated slope gradients are considered reliable and allow to visualise slope breaks linked to features as small as 2 m to 5 m. Outside of the wind farm sites, the grid resolution is either 30 m or 100 m and therefore smaller features cannot be imaged, and slope gradients are likely to be underestimated or overestimated locally.

Since the AOI covers a large area, Fugro does not recommend acquiring higher-resolution data at this stage. However, acquisition of MBES data along the final pipeline route will be paramount in order to assess and mitigate any seafloor hazards.

Table 4.1: Summary of water depths and seafloor gradients as observed in the different bathymetry datasets

Area	Maximum Water Depth [m LAT]	Minimum Water Depth [m LAT]	Average Slope Angle [°]	Maximum Slope Angle [°]	Minimum Slope Angle [°]	Bathymetry Grid Resolution [m]
AOI	-46.3	0	0.1	8	0	100
Hollandse Kust (noord) WFZ	-28.1	-14.9	1.7	29.9	0	2
Hollandse Kust (west) WFZ	-33.1	-22.5	2.2	20.6	0	2
Hollandse Kust (zuid) WFZ	-27.8	-16.1	0.6	14.9	0	5
Rotterdam approach area	-41.5	-13.5	0.3	9.5	0	30
Coastal area	-15.2	36.4	1.0	18.8	0	30

Notes:
m LAT = metres relative to Lowest Astronomical Tide

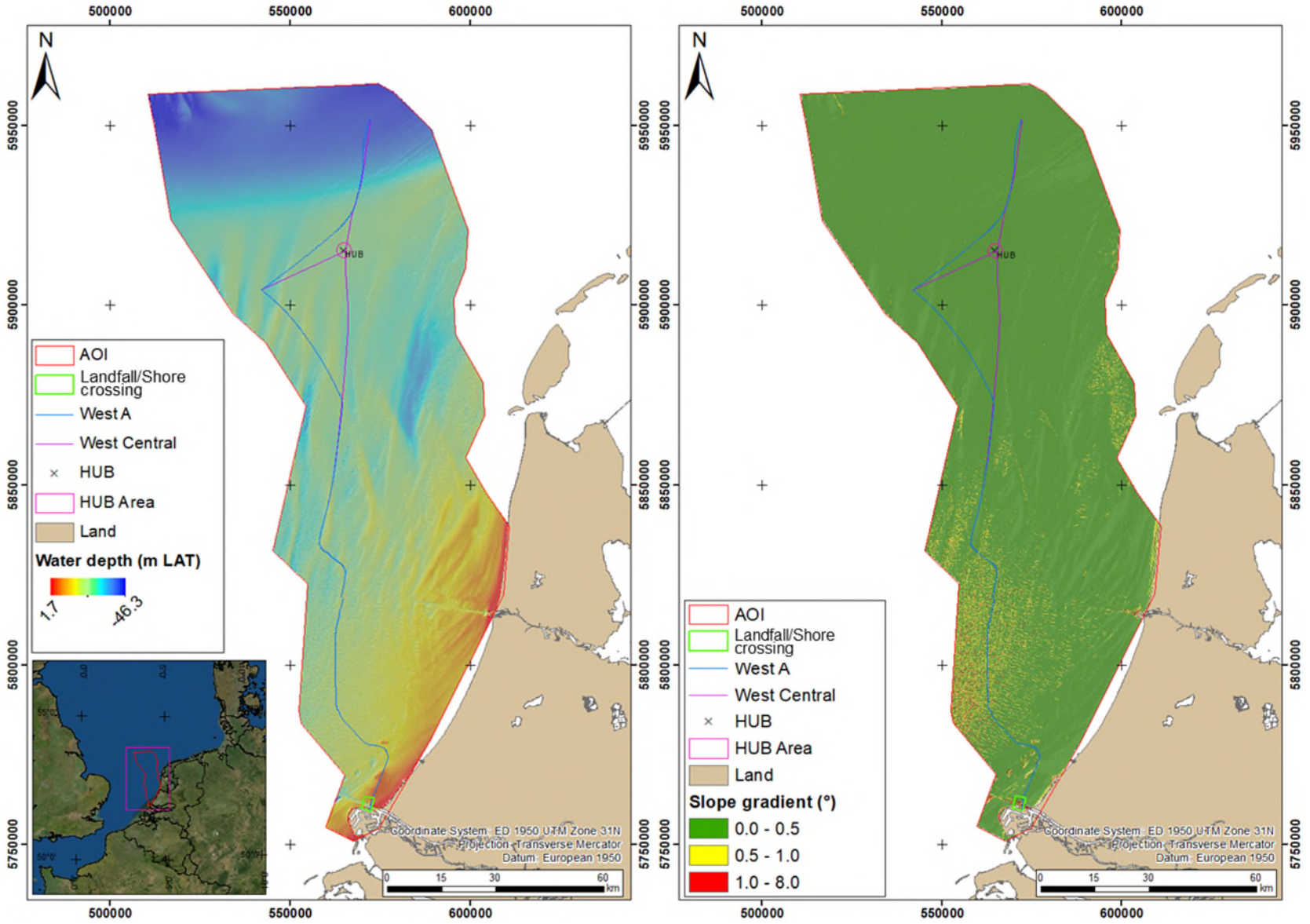


Figure 4.8: Left: bathymetric map and Right: slope gradient map of the entire AOI based on EMODnet 2020 data

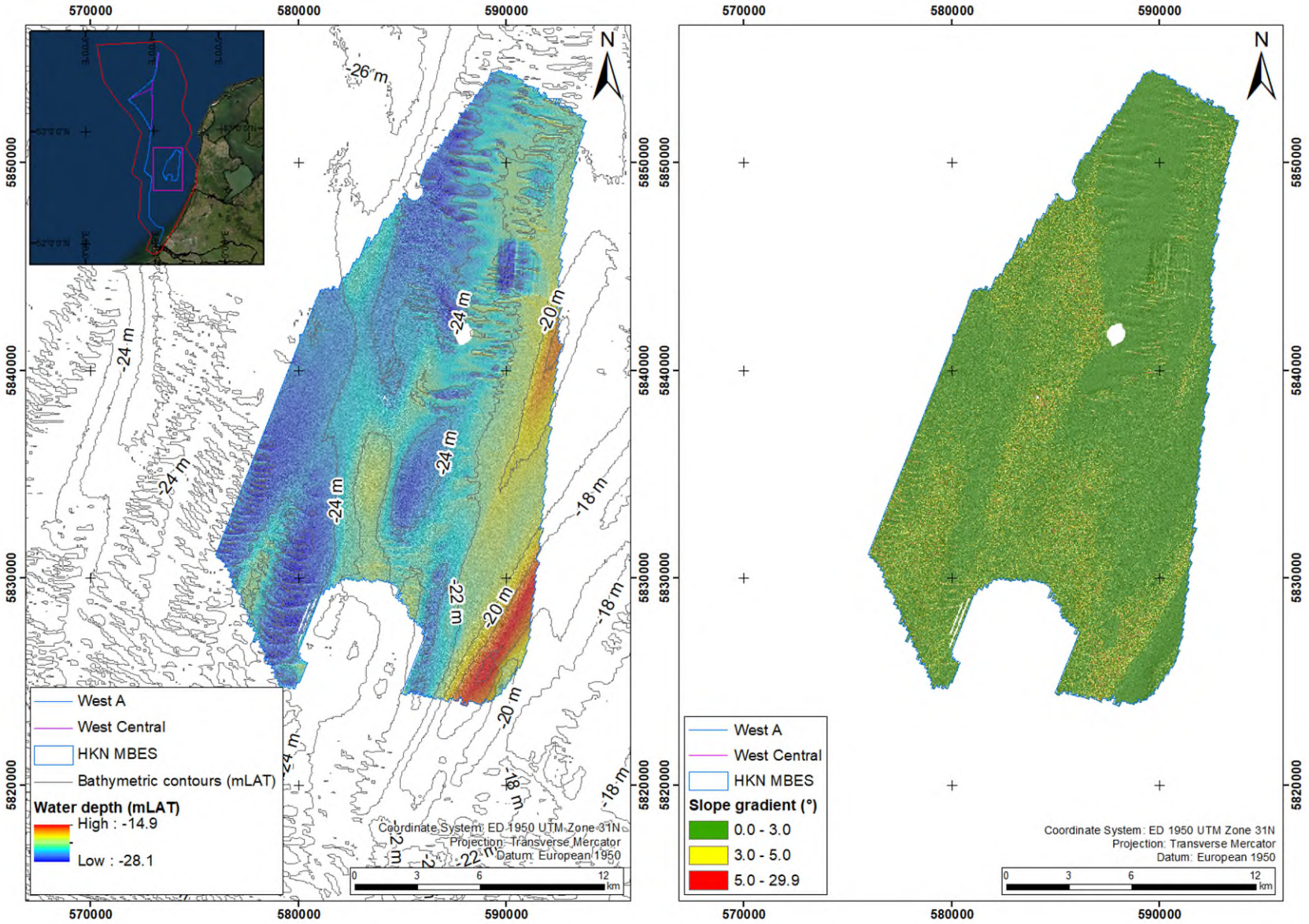


Figure 4.9: Left: bathymetric map and Right: slope gradient map of the Hollandse Kust (noord) WFZ area based on Fugro 2018 MBES data

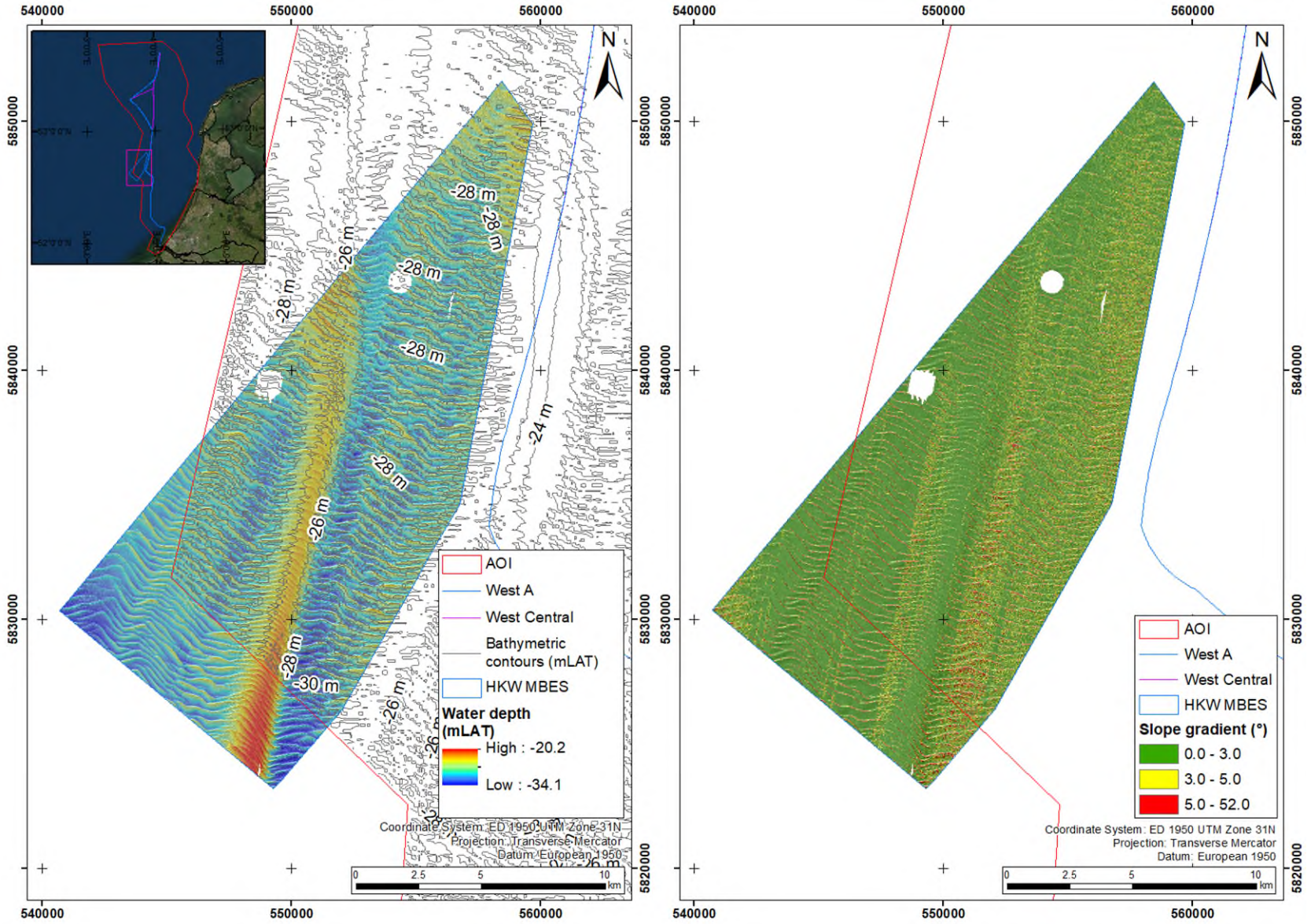


Figure 4.10: Left: bathymetric map and Right: slope gradient map of the Hollandse Kust (west) WFZ area based on Fugro 2019 MBES data

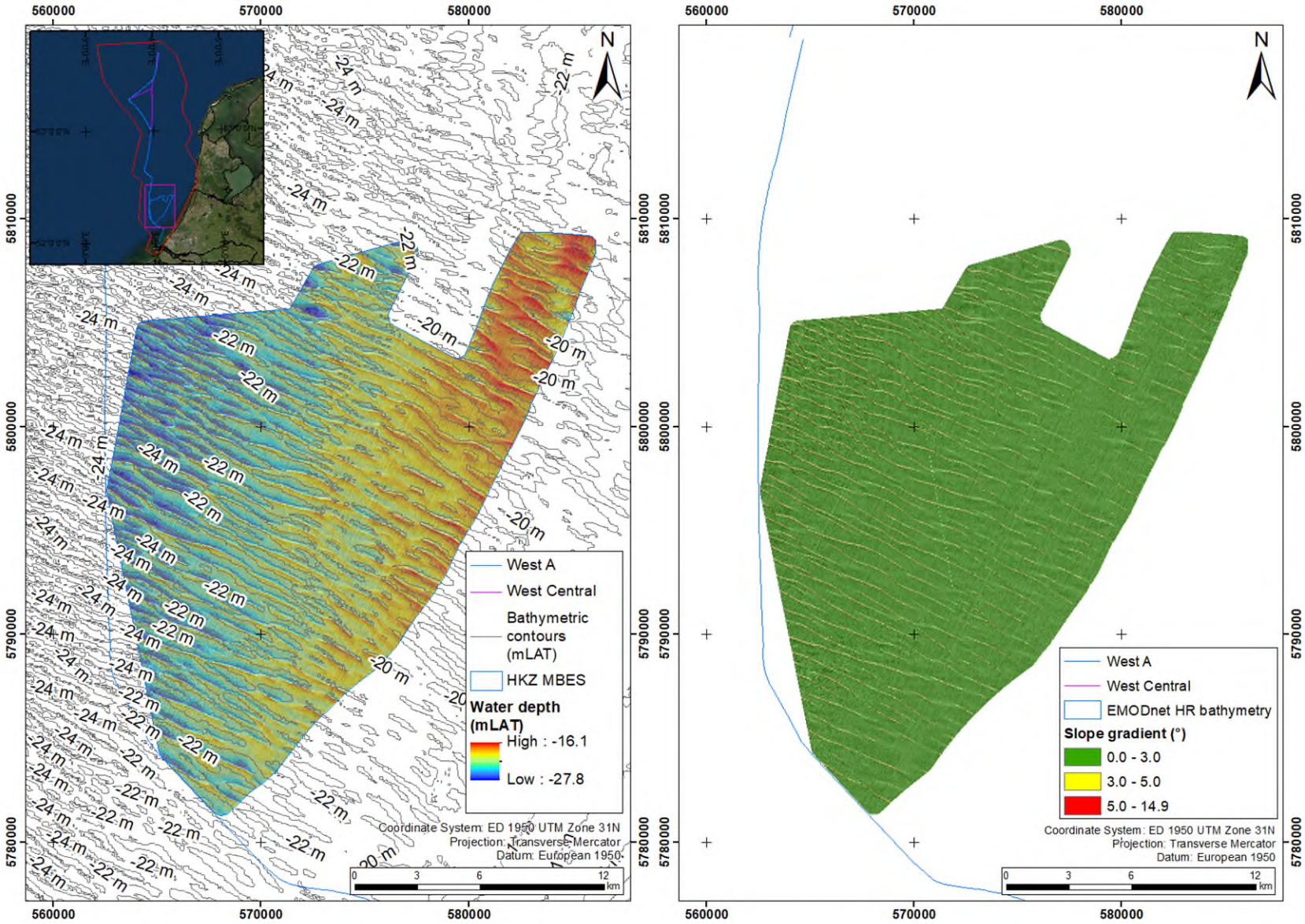


Figure 4.11: Left: bathymetric map and Right: slope gradient map of the Hollandse Kust (zuid) WFZ area based on Fugro 2016 MBES data

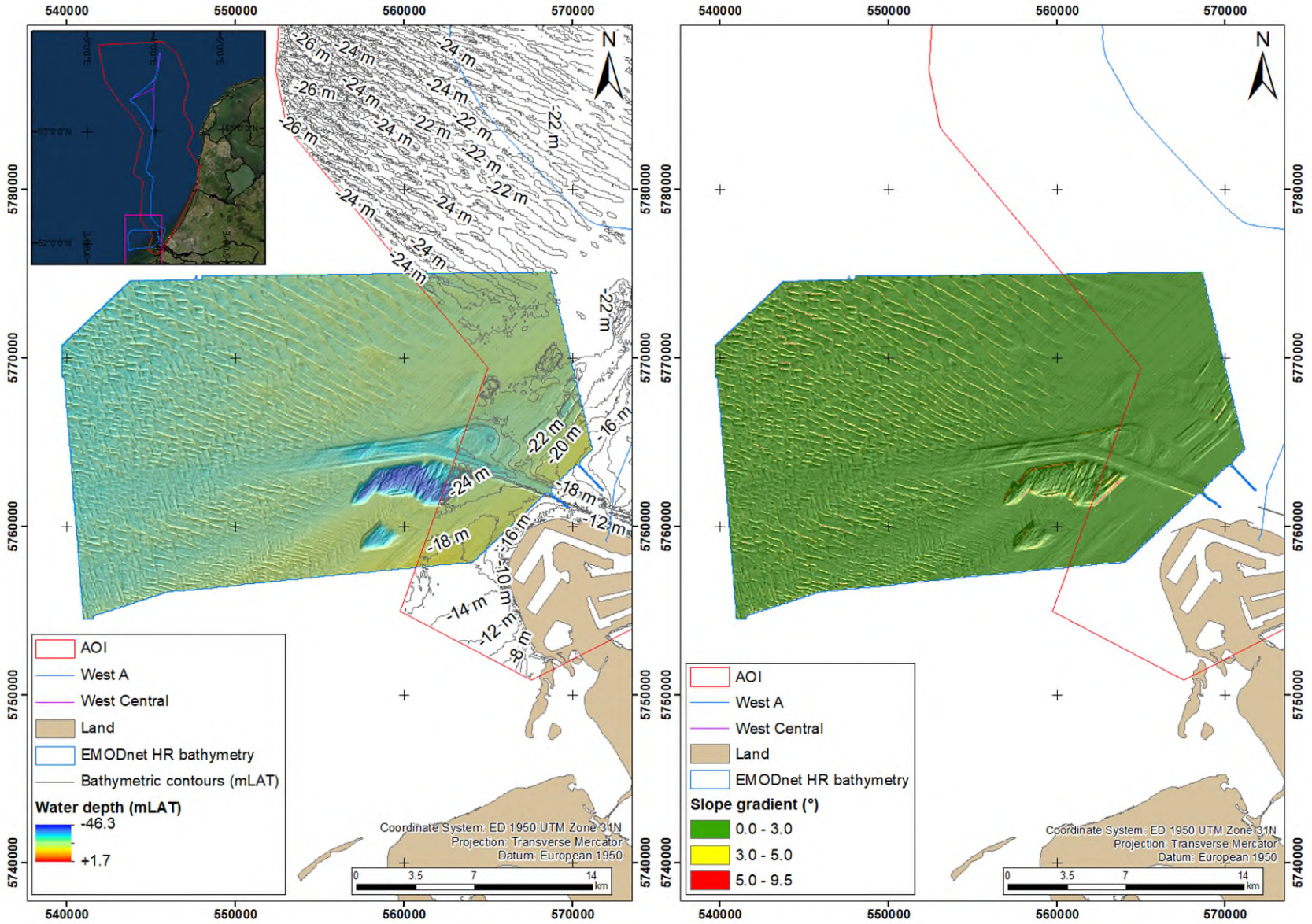


Figure 4.12: Left: bathymetric map and Right: slope gradient map of the Rotterdam approach area based on EMODnet 2020 high-resolution data

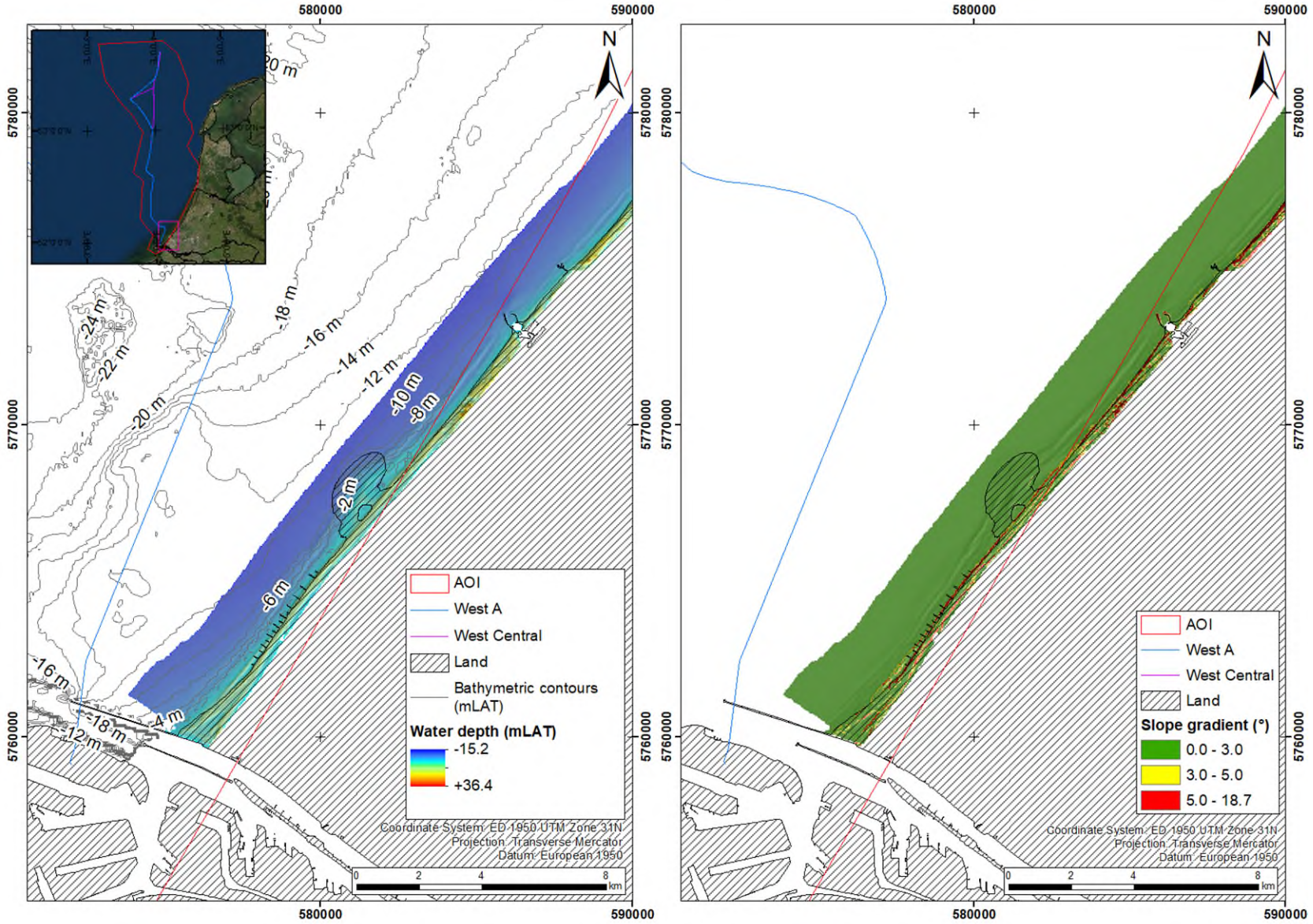


Figure 4.13: Left: bathymetric map and Right: slope gradient map of the southern coastal area based on EMODnet 2018 high-resolution data

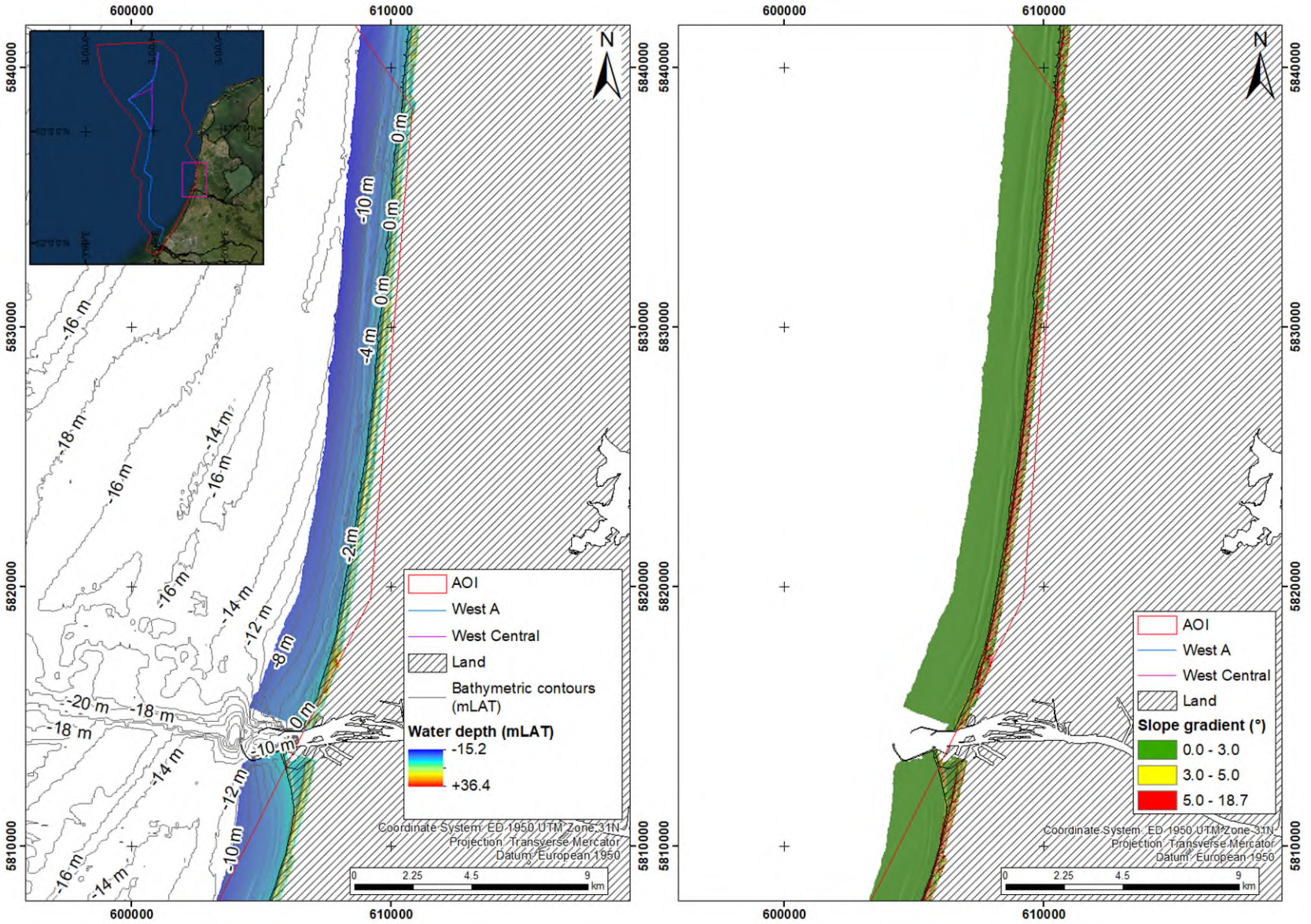


Figure 4.14: Left: bathymetric map and Right: slope gradient map of the northern coastal area based on EMODnet 2018 high-resolution data

4.2.1.2 Landfall/Shore Crossing Area

The Landfall/Shore crossing Area is covered by the EMODnet 2020 tile having a 100 m grid resolution.

Table 4.2 provides the water depth and slope gradient values for the Landfall/Shore crossing Area based on the available EMODnet data.

Table 4.2: Summary of water depths and seafloor gradients at the Landfall/Shore crossing Area

Area	Maximum Water Depth [m LAT]	Minimum Water Depth [m LAT]	Average Slope Angle [°]	Maximum Slope Angle [°]	Minimum Slope Angle [°]
Landfall/Shore crossing	-31.1	0	0.7	6.8	0

Notes:
m LAT = metres Lowest Astronomical Tide
Values derived from publicly available EMODnet (2020) bathymetry data, DTM with 100 m of grid resolution

The bathymetric map for the Landfall/Shore crossing Area is given in Figure 4.15.

Water depth within the Landfall/Shore crossing Area varies between 0 m and 31.1 m bLAT. The major bathymetric feature in this area is the relatively deep navigation channel (Maasmond Kanaal). The navigation channel is well imaged by the EMODnet bathymetry data, forming a WNW–ESE oriented depression. The water depth at the edges of the Maasmond Kanaal is approximately 15 m bLAT, whereas in the navigation channel it is ranging between approximately 20 m 25 m bLAT. In local depressions within the Maasmond Kanaal water depths may exceed 30 m bLAT.

North of the navigation channel, no seafloor features are visible, and the seafloor gently dips from SE to NW ranging between 11 m to 18 m bLAT.

The slope gradients range from 0° to 7° with an average value of 0.7°. Slope gradients up to 20° are expected at the flanks of the navigation channel.

The southern flank of the Maasmond Kanaal appears regular, steep and narrow in the south-east and widens towards the south-west. The northern flank of the Maasmond Kanaal has locally an irregular shape, possibly as a result of slumping observed in this area. Seafloor gradients of up to 34° are related to these slumped areas (Fugro database).

A site-specific MBES survey across the entire Landfall/Shore crossing Area would allow to increase the resolution of these maps and highlight any features smaller than 100 m (which cannot be imaged based on the present data resolution).

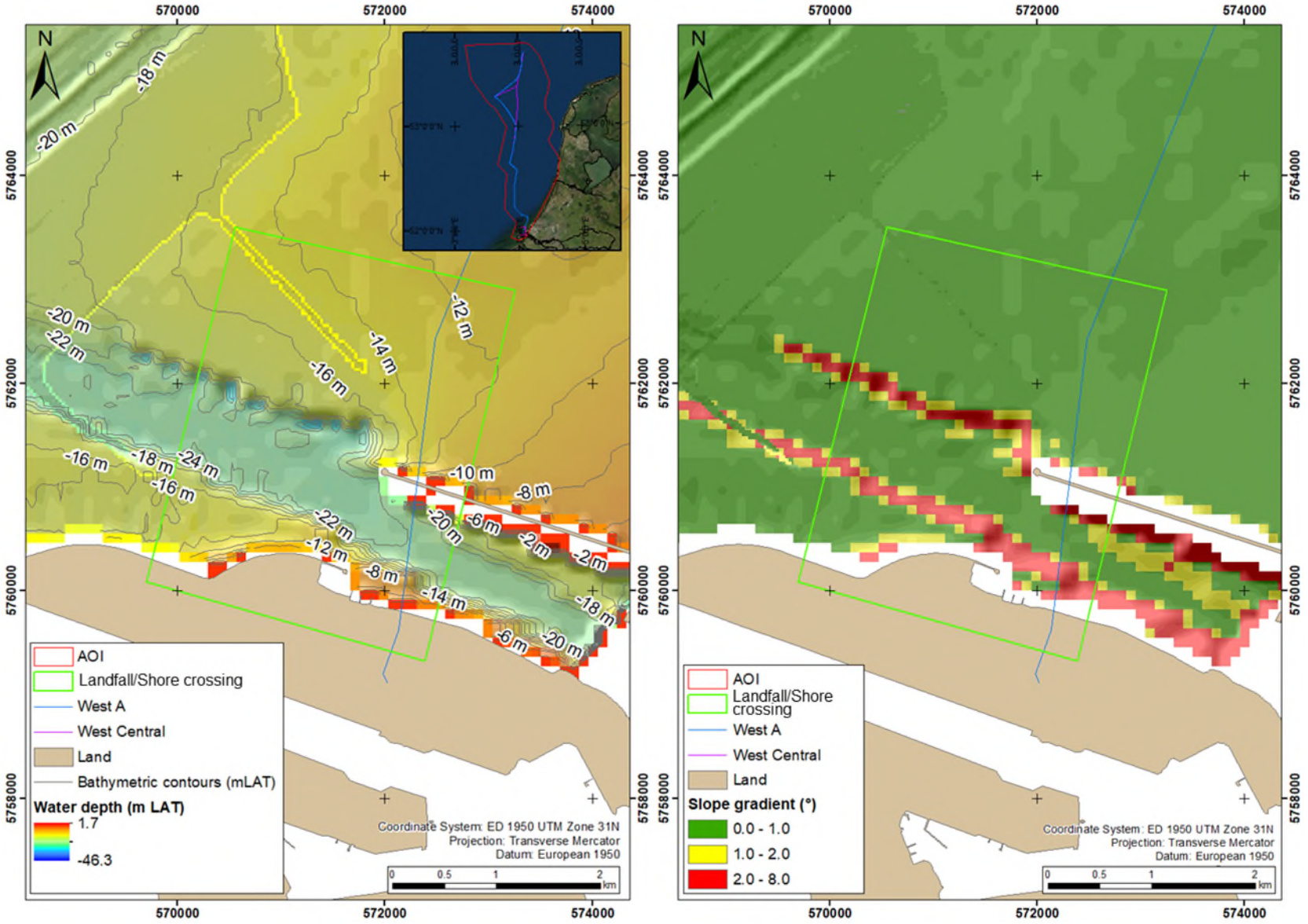


Figure 4.15: Left: bathymetric map and Right: Slope gradient map of the Landfall/Shore crossing Area based on the EMODnet 2020 data

4.2.1.3 Offshore Distribution HUB Area

The Offshore Distribution HUB Area is covered by the EMODnet 2020 tile having a 100 m grid resolution.

Table 4.3 provides the water depth and slope gradients values for the Offshore Distribution HUB Area based on the available EMODnet data.

Table 4.3: Summary of water depths and seafloor gradients at the Offshore Distribution HUB Area

Area	Maximum Water Depth [m LAT]	Minimum Water Depth [m LAT]	Average Slope Angle [°]	Maximum Slope Angle [°]	Minimum Slope Angle [°]
Offshore Distribution HUB Area	-26.2	-25.2	0.05	0.1	0

Notes:
m LAT = metres Lowest Astronomical Tide
Values derived from publicly available EMODnet (2020) bathymetry data, DTM with 100 m of grid resolution

Water depth within the Offshore Distribution HUB Area varies between 25.2 m and 26.2 m bLAT.

The bathymetric map for the Offshore Distribution HUB Area is given in Figure 4.16. The seafloor appears smooth, with a maximum water depth to the west of the Offshore Distribution HUB Area and minimum values to the north-east. No clear dipping trends can be noticed, except with bathymetric contours that tend to show that the Offshore Distribution HUB Area is crossed by a NE–SW oriented trough of less than 1 m deep (probably linked to a small seafloor bedform).

The slope gradients range from 0° to 0.1° confirming the presence of a flat and smooth seafloor. However, it has to be noted that slope gradients were computed based on the 100 m grid resolution bathymetry and that local features presenting higher seafloor gradients may occur.

A site-specific MBES survey across the entire Offshore Distribution HUB area would allow to increase the resolution of these maps and highlight any feature smaller than 100 m such as sand waves, megaripples and any other types of bedforms and seafloor obstructions that may occur.

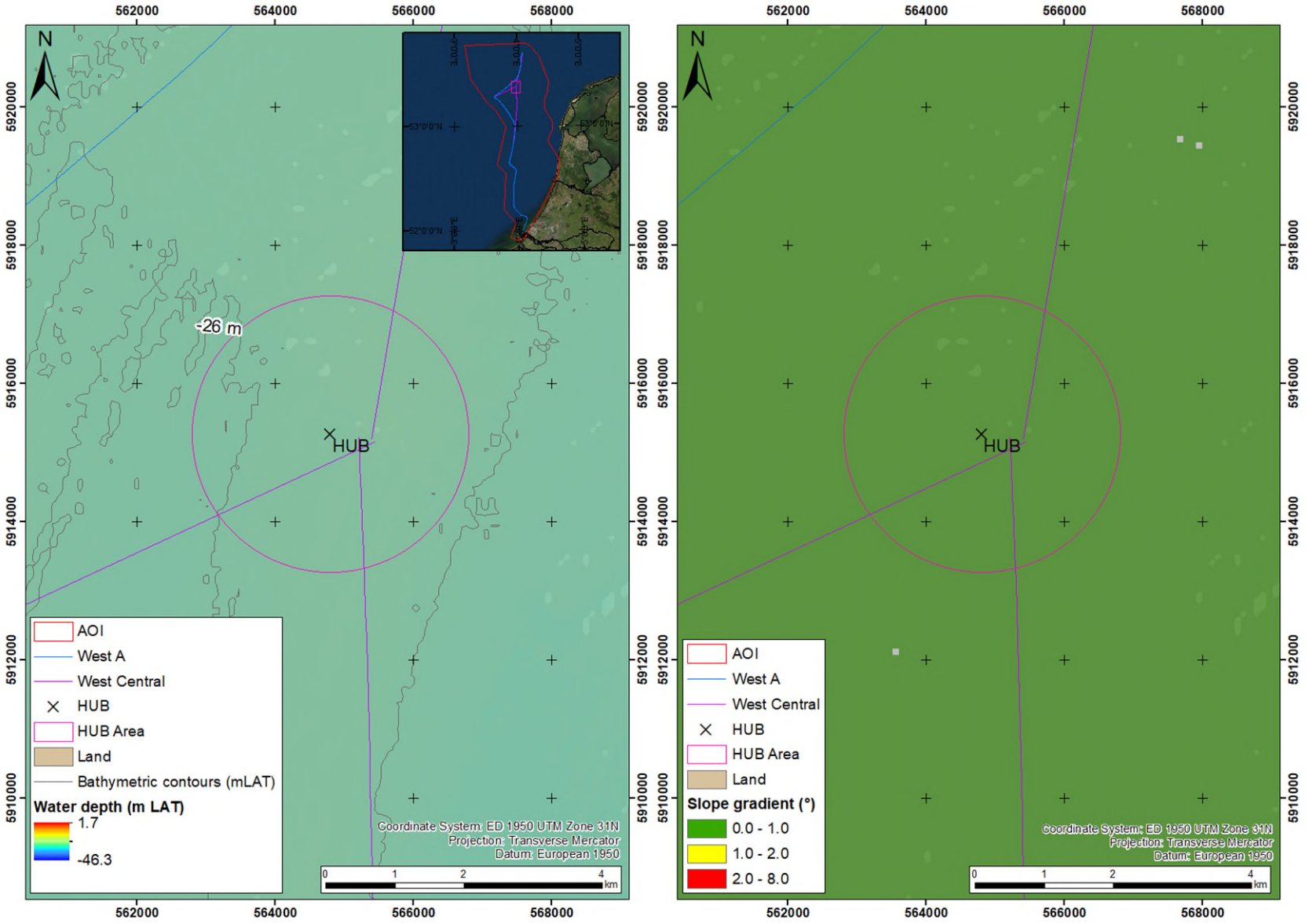


Figure 4.16: Left: bathymetric map and Right: slope gradient map of the Offshore Distribution HUB Area based on the EMODnet 2020 data

4.2.2 Seafloor Morphology

4.2.2.1 AOI

The seafloor morphology within the AOI can be divided into three distinct zones as illustrated in Figure 4.17: 1) a coastal zone covered by a complex compound of rhythmic bedforms, 2) a shallow continental shelf with low-angle topography covered by a complex compound of rhythmic bedforms, and 3) a relatively deep low-energy zone with low-angle topography (Figure 4.8).

The bedforms observed in Zones 1 and 2 include sand banks, sand waves, megaripples and ripples. These bedforms have been classified by Deltares (2016, 2019 and 2020), as part of morphodynamic desktop studies to aid development of the wind farms. The classification considers different parameters such as wavelength, wave height and mobility, which are the result of the complex interaction between hydrodynamics, sediment grain-size and character, sediment transport and morphology.

Below follows a more detailed description of the bedforms observed in the AOI. Table 4.4 summarises the characteristics of the different bedform types observed in the AOI.

Table 4.4: Bedform characteristics in the AOI

Type	Wavelength [m]	Wave Height [m]	Orientation
Sand bank	3000 to 10000	2.5 to 8	N–S to NNE–SSW
Sand wave	120 to 1750	0.5 to 6	NW–SE to WNW–ESE
Megaripple	4 to 20	0.1 to 0.4	NW–SE to WNW–ESE
Notes: N: North E: East		S: South W: West	

Bedforms across the AOI were mapped based on what is imaged on the EMODnet 100 m grid resolution data. Elements that were identified include sand banks, areas with sand waves as well as troughs and other depression features. Megaripples are below resolution of the EMODnet data. The resulting map is presented in Figure 4.8. The identified and expected bedforms across the AOI are further detailed hereafter.

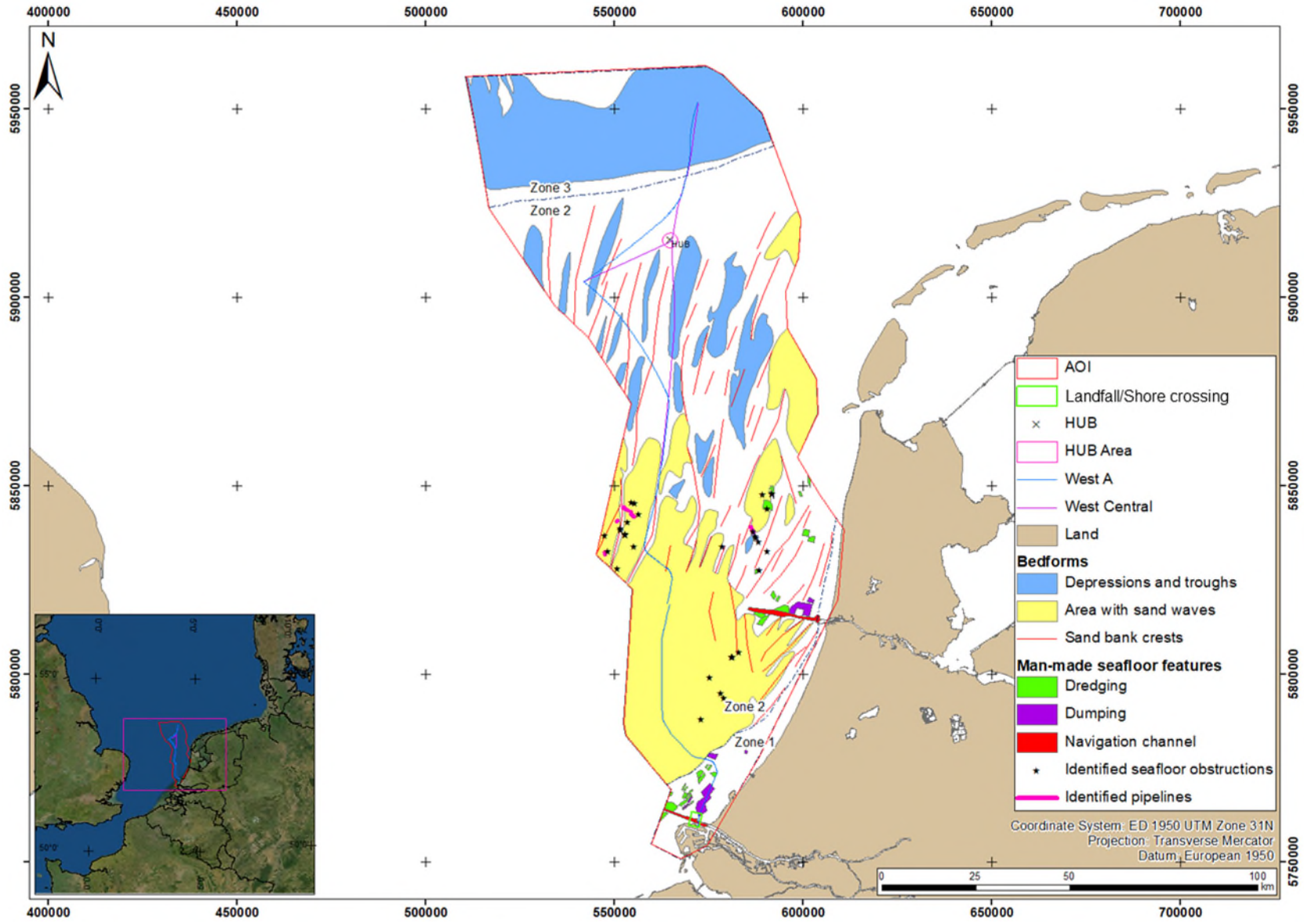


Figure 4.17: Map of the identified bedform and man-made seafloor features across the AOI

Sand Banks

The largest bedforms within the AOI are sand banks. They are present only in Zones 1 and 2 of the AOI (Figure 4.17). They form elongated ridges (sub-)parallel to the coast with a N–S to NNE–SSW orientation. The ridges are tens of kilometres long with a symmetric cross profile and lie several kilometres apart. They are on average 10 m high. An example of sand banks as imaged in Hollandse Kust (west) MBES data is given in Figure 4.18, with a bathymetric section perpendicular to the sand bank crest allowing to illustrate the morphology, height, and wavelength of sand banks in the AOI.

The sand banks are orientated roughly parallel to the main current direction (Hulscher et al., 1993). Near the coast they may be orientated more obliquely to the tidal current (Calvete et al., 2001). The sand banks closer to the shore are classified as tidal ridges (van Dijk et al., 2012). The formation of sand banks can broadly be divided into two categories (Dyer and Huntley, 1999):

- relict features, remaining after postglacial sea level rise;
- newly formed, in the present hydrodynamic regime.

The offshore sand banks may have formed during the early Holocene and the tidal ridges have been possibly formed more recently. Formation of tidal ridges is related to tidal currents in a tide-dominated coastal embayment (Ashley, 1990).

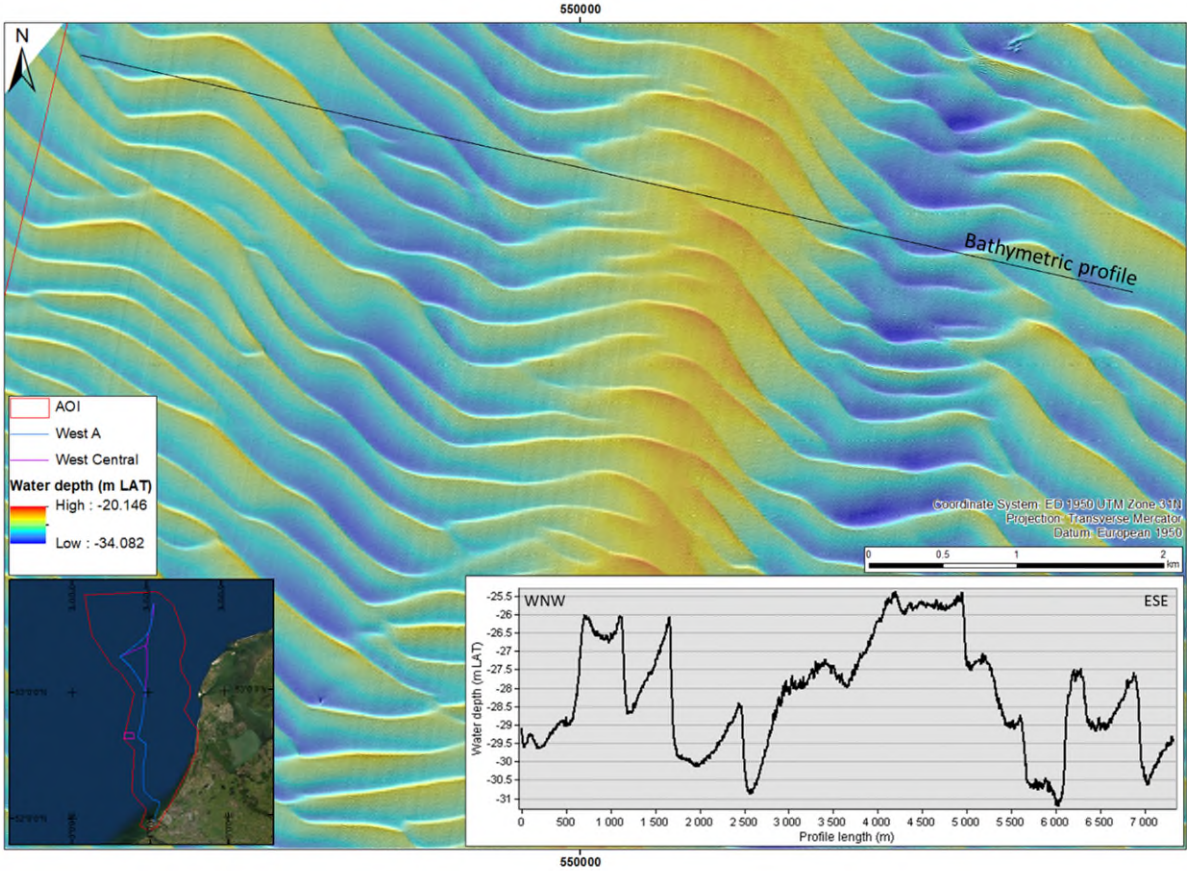


Figure 4.18: Example of sand banks with superimposed sand waves in the Hollandse Kust (west) WFZ as imaged on MBES bathymetry data. A bathymetric profile is given in a perpendicular direction to the sand banks.

Sand Waves

Sand waves are superimposed on the sand banks. They are observed in water depths of approximately 20 m to 28 m bLAT within Zones 1 and 2 of the AOI (Figure 4.17). The crests of the sand waves are orientated NW–SE to WNW–ESE, roughly perpendicular to the sand banks (see Figure 4.18). Their wavelength ranges between approximately 120 m and 1750 m, while wave height varies between 0.5 m and 4 m. The sand waves typically have an asymmetric profile with a lower angle stoss side and a steep lee side facing the direction of propagation. This morphology implies that the dominant migration direction is north to north-north-east (for sediment mobility refer to Section 4.3).

Sand waves are created due to tidal flow and may be as high as 25% of the water depth (McCave, 1971), and have wavelengths in the order of hundreds of metres (Ashley, 1990; van Dijk & Kleinhans, 2005; Deltares, 2016).

An example of sand waves as imaged in Hollandse Kust (west) MBES data is given in Figure 4.19, with a bathymetric section perpendicular to their direction, allowing to illustrate the morphology, height, and wavelength of sand waves in the AOI. Sand waves are also visible in Figure 4.18, perpendicular to the sand banks.

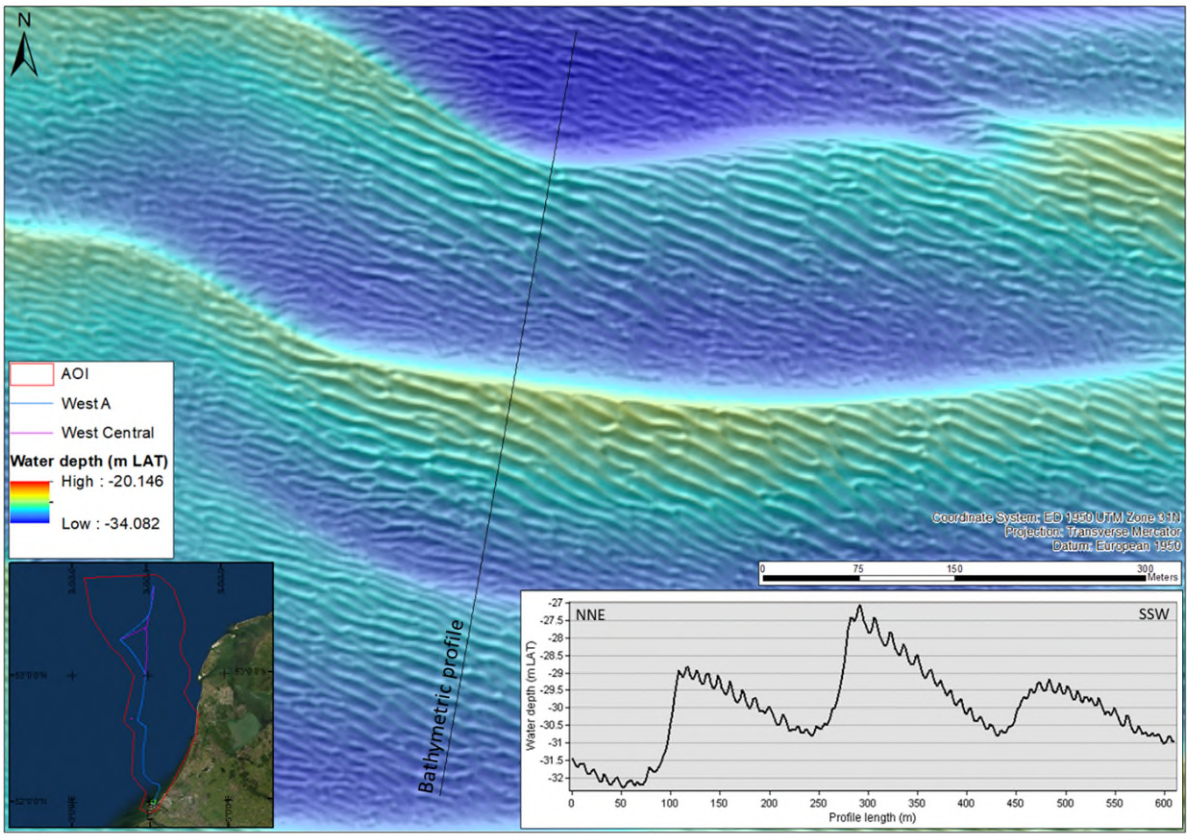


Figure 4.19: Example of sand waves with superimposed megaripples in the Hollandse Kust (west) WFZ as imaged on MBES bathymetry data. A bathymetric profile is given in a perpendicular direction to the sand waves.

Megaripples

High resolution bathymetry datasets for the wind farm sites located within the AOI allowed to capture the presence of megaripples. Megaripples are ubiquitous, superimposed on the stoss side of sand waves and are similarly orientated (Figure 4.19). They have wavelengths of approximately 4 m to 20 m, with heights between 0.1 m and 0.4 m.

An example of megaripples as imaged in Hollandse Kust (west) MBES data is given in Figure 4.19, with a bathymetric section perpendicular to their direction allowing to illustrate their morphology, height, and wavelength in the AOI.

Ripples

Ripples are the smallest bedforms, with dimensions in the order of centimetres. Because of their limited size, they cannot be observed in bathymetry data. They are superimposed on the megaripples and are similarly orientated. Because of their small size, ripples are not a concern for offshore pipeline design. They are, however, relevant for the seafloor roughness and sediment transport in the area (Deltares, 2020).

Troughs and Depressions

Troughs are linked to the presence of the sand banks in areas that are not affected by sand waves (deeper than 28 m bLAT). These troughs can be 4 m to 6 m deep and are elongated in a N–S direction (parallel to the sand banks). Where sand waves are present, these troughs were probably subsequently filled by sediments through the formation and evolution of the sand waves. Seafloor within the troughs appears to be smooth and regular on the EMODnet bathymetry. Troughs are only found in Zone 2 of the AOI as mapped in Figure 4.17.

Moreover, the northern depression (Zone 3) is characterised by a smooth seafloor and no bedform is imaged at the resolution of the EMODnet bathymetry. This is probably linked to the sudden increase of water depth (from 30 m bLAT to 42 m bLAT).

4.2.2.2 Landfall/Shore crossing Area

No bedforms were imaged at the EMODnet 2020 grid resolution of 100 m in the Landfall/Shore crossing Area. A site-specific MBES survey will provide a higher resolution, potentially imaging small-scale bedforms such as megaripples or ripples.

4.2.2.3 Offshore Distribution HUB Area

No bedforms were imaged at the EMODnet 2020 grid resolution of 100 m in the Offshore Distribution HUB Area. However, the Offshore Distribution HUB Area is located within an area containing sand banks (Zone 2), to the north of a trough (Figure 4.17). As the sand banks are the largest expected bedforms in the AOI (Table 4.4), it is likely that the Offshore Distribution HUB Area is too small to capture the typical sand bank morphology entirely. A site-specific MBES survey will provide a higher resolution, potentially imaging small-scale bedforms such as sand waves and/or megaripples.

4.2.3 Seafloor Sediments

4.2.3.1 AOI

An overview of the substrate type classification (Folk, 1954) is presented in Figure 4.20 (EMODnet). The seafloor sediments map is corroborated by information contained in the DINOloket (2021) database, which includes grab sample data, vibrocore data and sampling borehole data. In addition, seafloor sediments were mapped in high detail at the Hollandse Kust (noord), Hollandse kust (west) and Hollandse Kust (zuid) WFZs.

The following seafloor sediments are present in the AOI:

- Sandy GRAVEL
- (Slightly) gravelly SAND
- (Slightly) gravelly muddy SAND
- SAND
- Muddy SAND
- Sandy MUD

MUD is defined in the geological maps as the fraction composed of clay-sized to silt-sized sediments.

The AOI is covered by predominantly SAND with numerous patches of (slightly) gravelly SAND. North of the Offshore Distribution HUB Area, the seafloor comprises mainly muddy SAND with some patches of (slightly) gravelly muddy SAND and sandy MUD. This area with a higher MUD fraction coincides with the deeper low-energy marine environment as described in Section 4.2.2.1. Areas of (slightly) gravelly SAND correspond to areas where sand banks and sand waves are expected based on Figure 4.17 and Figure 4.20.

In terms of expected stratigraphy at the seafloor, three main Holocene units were mapped (Figure 4.21):

- Southern Bight Formation, deposited in a high-energy open-marine environment, mainly composed of SAND to (slightly) gravelly SAND, distributed in Zone 2 of the AOI;
- Urania Formation, deposited in a low-energy open-marine environment mainly composed of sandy MUD to muddy SAND, covering Zone 3 entirely;
- Naaldwijk Formation, deposited in a coastal to tidal-dominated environment and is mainly composed of (slightly) gravelly SAND, covering Zone 1 (not completely mapped).

Fugro recommends acquiring site-specific geotechnical data along the final pipeline layout prior to pipe installation in order to verify and refine the seafloor sediment types.

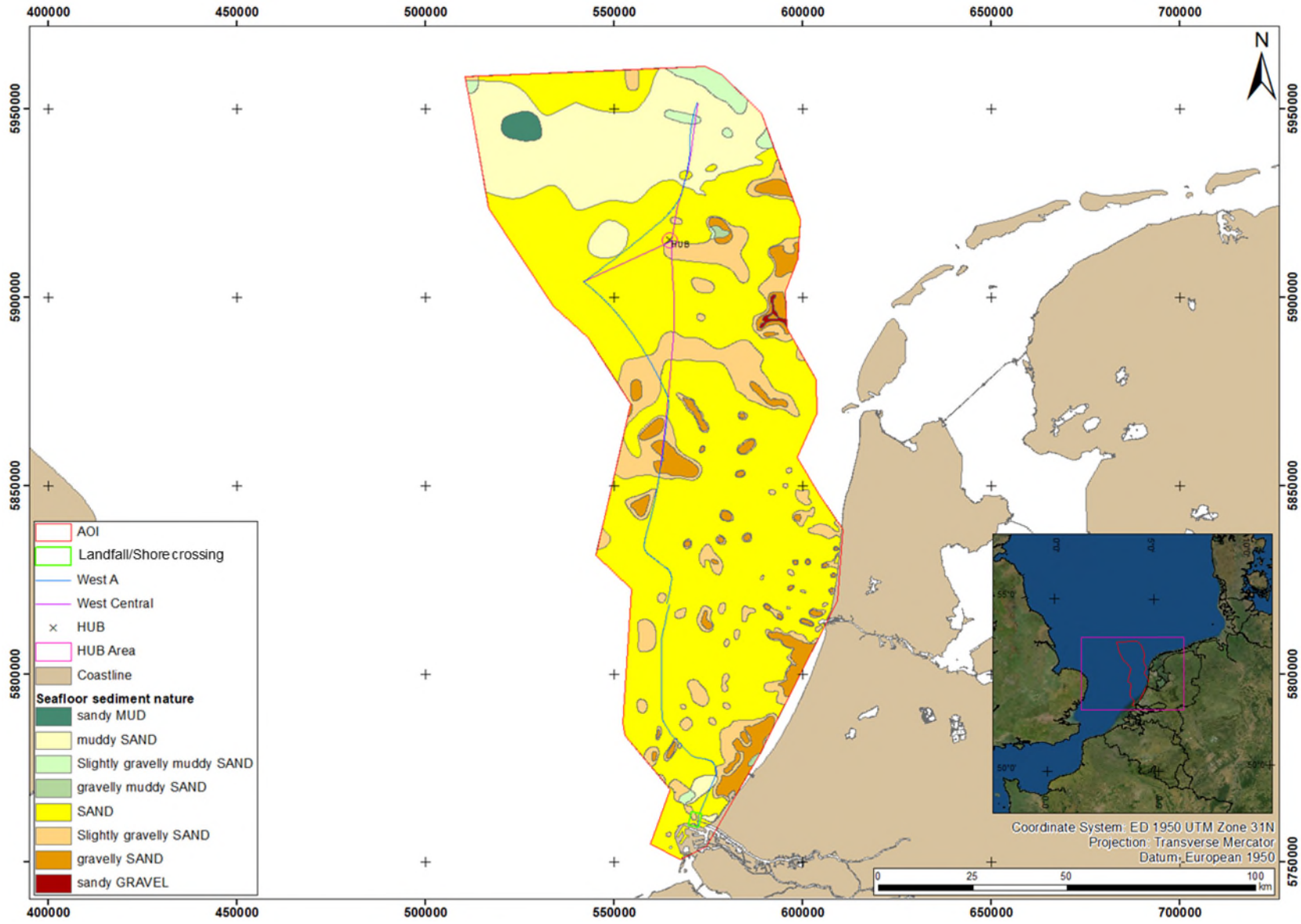


Figure 4.20: Surficial sediments across the AOI

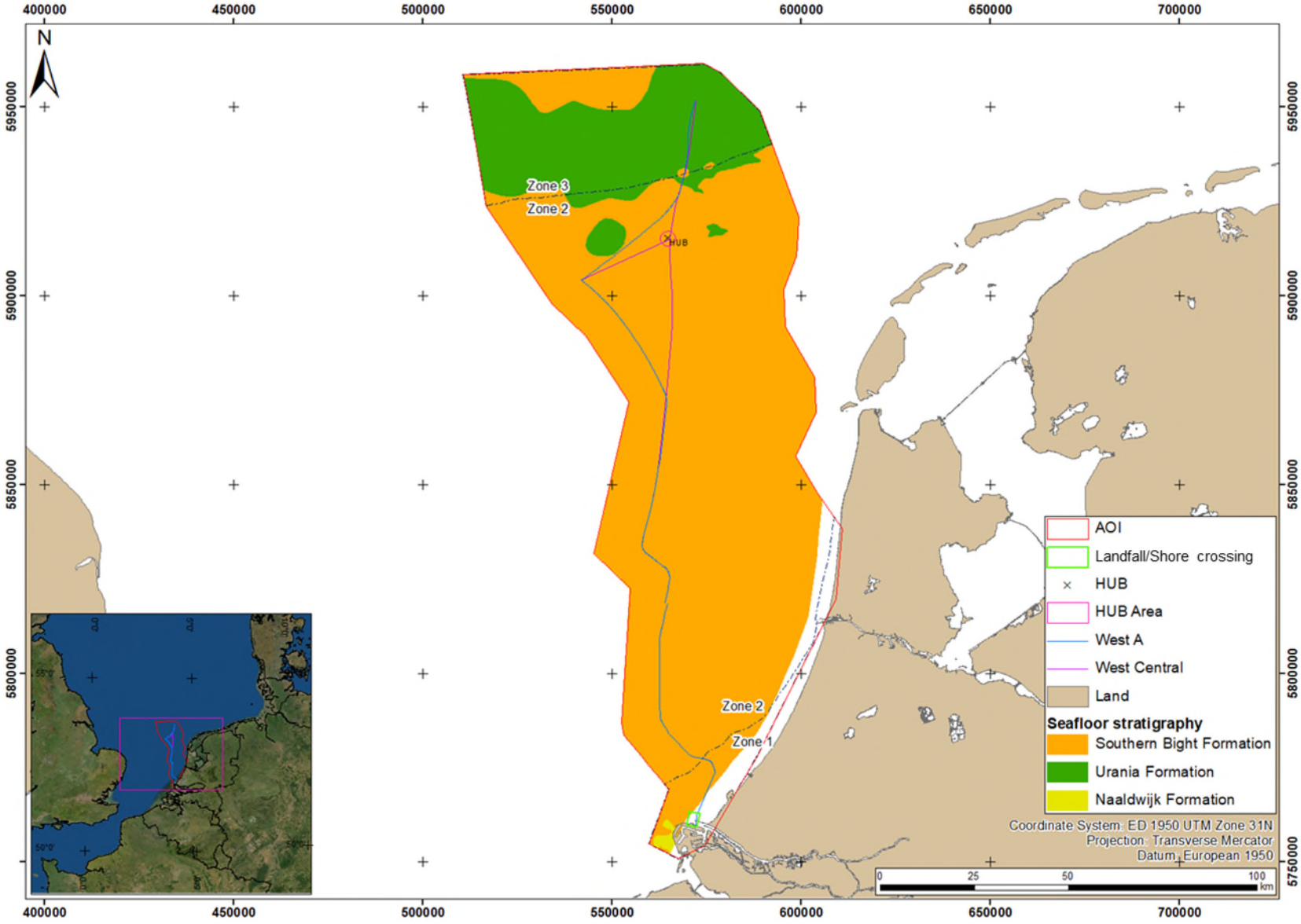


Figure 4.21: Surficial sediment stratigraphy across the AOI. Coverage is missing along the coastal area. In this area the Naaldwijk Formation is expected

4.2.3.2 Landfall/Shore Crossing Area

Two main seafloor sediment types are to be expected in the Landfall/Shore crossing Area (Figure 4.22):

- SAND;
- Slightly gravelly SAND, in the north-west corner.

Based on Fugro experience, clayey or silty SAND, locally slightly gravelly dominates at seafloor in areas outside the Maasmond Kanaal. In the Maasmond Kanaal very soft to soft CLAY dominates, with localised patches of clayey SAND.

Site-specific geotechnical surveys would allow to refine the sediment nature within the Landfall/Shore crossing Area.

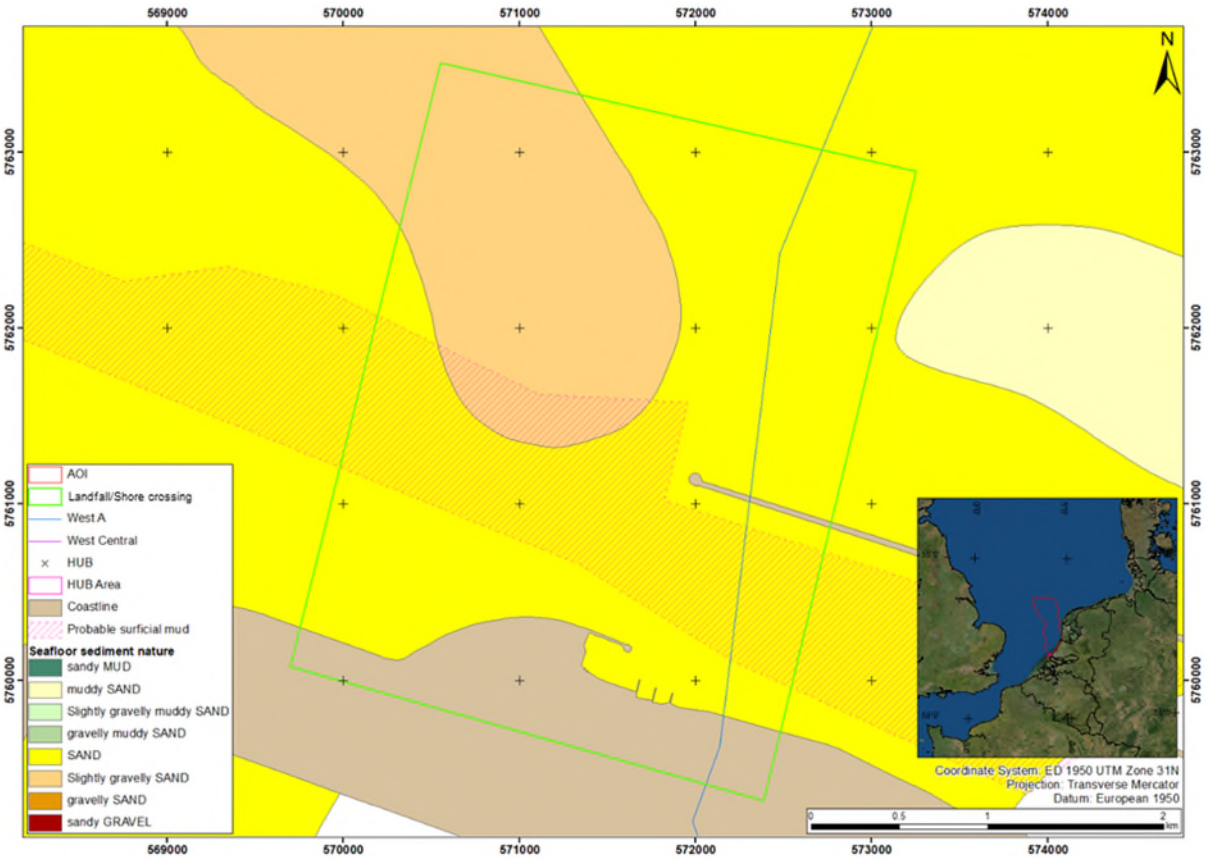


Figure 4.22: Surficial sediment nature across the Landfall/Shore crossing Area

4.2.3.3 Offshore Distribution HUB Area

The Offshore Distribution HUB Area comprises two main seafloor sediment types that are presented in Figure 4.23:

- SAND;
- Slightly gravelly SAND, in the south.

Site-specific geotechnical surveys would allow to refine the sediment nature within the Offshore Distribution HUB Area.

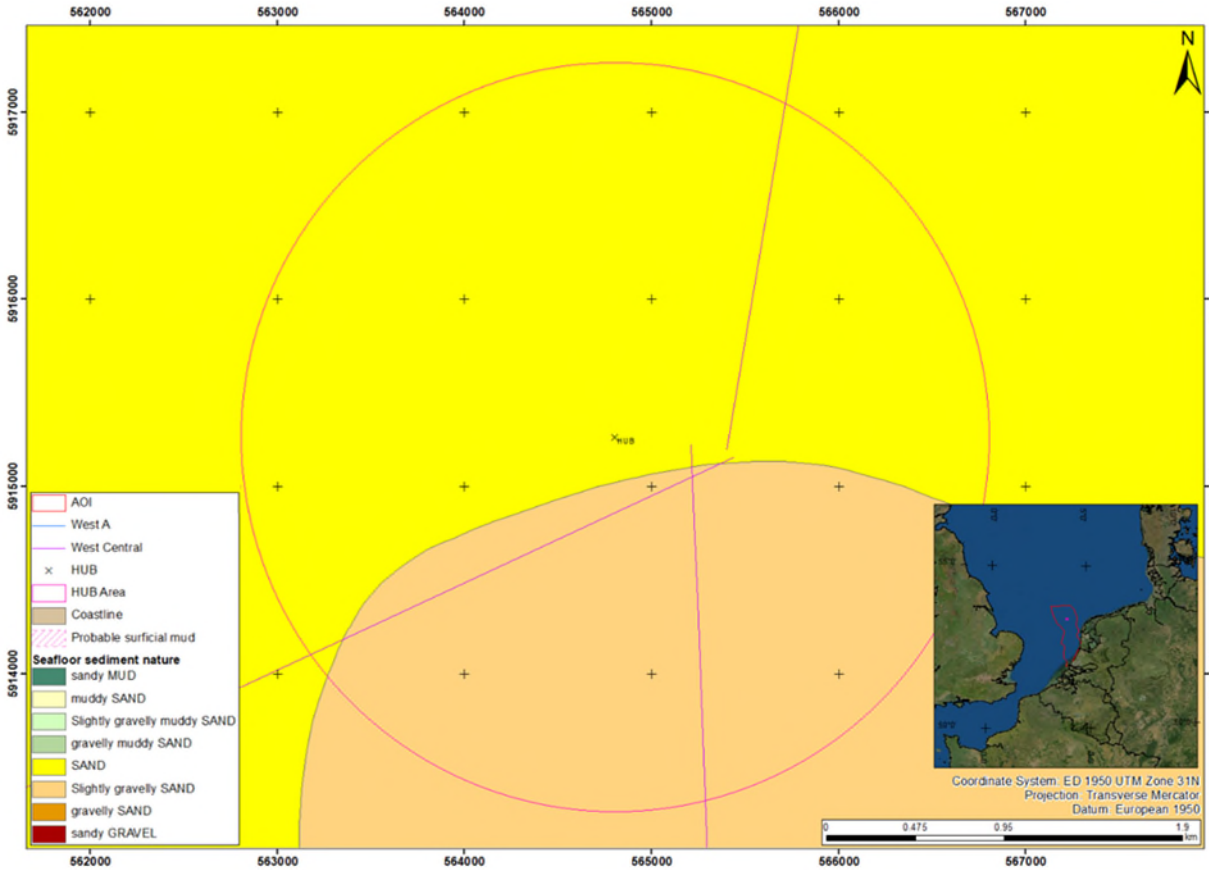


Figure 4.23: Surficial sediment nature across the Offshore Distribution HUB Area

4.2.4 Man-Made Seafloor Features

4.2.4.1 AOI

Man-made seafloor features were identified in the different bathymetric data. These features include:

- Unidentified seafloor obstructions (including probably several wrecks and wellheads);
- Pipelines;
- Dredged areas;
- Dumped material;
- Navigation channels.

These elements were mapped and are displayed in Figure 4.17. The man-made obstructions could only be mapped on the high-resolution MBES data. More details on the man-made obstructions are provided in the UXO and Archaeological DTS reports (Appendix C and Appendix B).

4.2.4.2 Landfall/Shore Crossing Area

The Maasmond Kanaal navigation channel and a dumping area were recognised within the Landfall/Shore crossing Area as mapped in Figure 4.24. In addition, ROCK dumps related to coastal defence structures are present on the shores of the Maasmond Kanaal as well as numerous seafloor scars related to dredging operations (Fugro database).

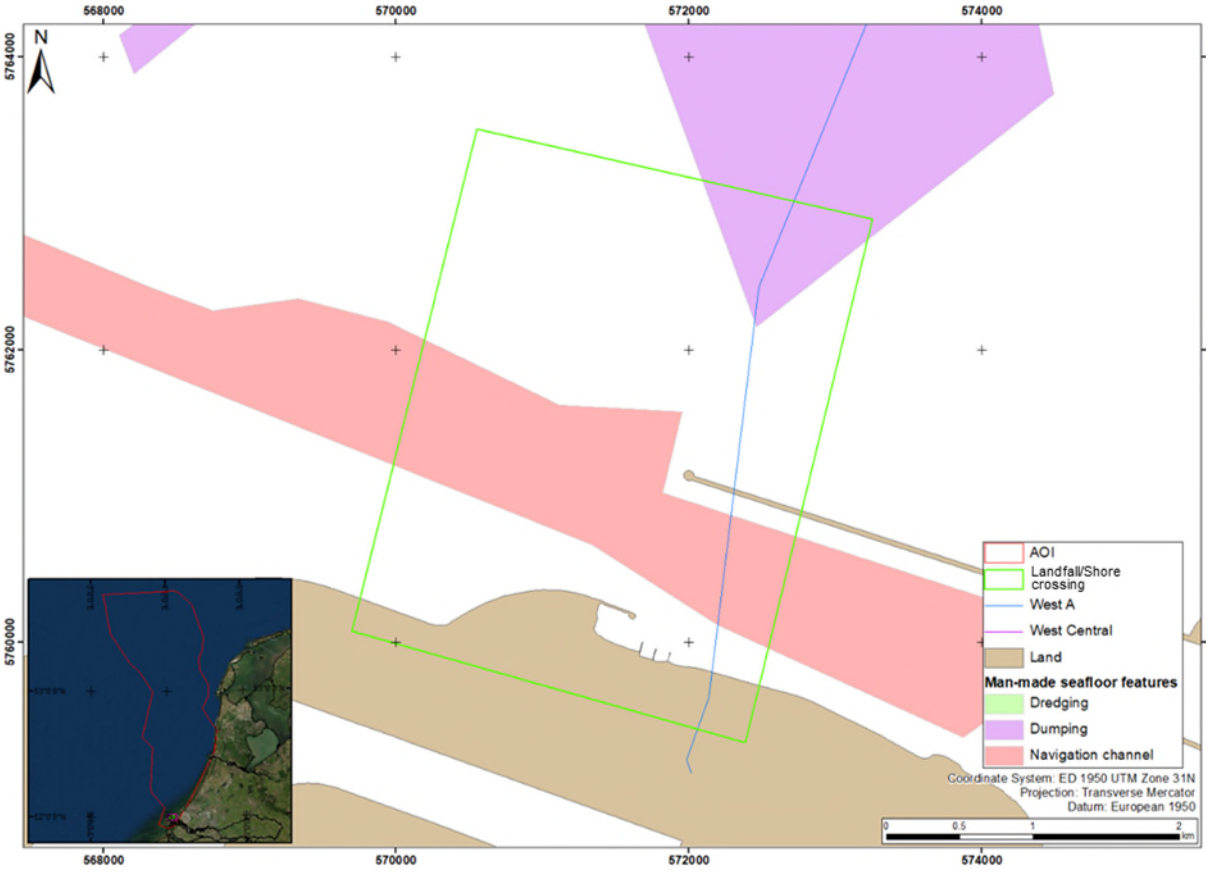


Figure 4.24: Surficial sediment nature across the Landfall/Shore crossing Area

4.2.4.3 Offshore Distribution HUB Area

No man-made seafloor features were recognised within the Offshore Distribution HUB Area.

4.3 Seafloor Mobility

The high availability of sand at seafloor facilitates the formation of dynamic bedforms (refer to Section 4.2.2 for description of bedforms), which are mobile in response to (tidal) currents.

Sand waves and sand banks have dimensions that are significant for pipeline foundation design, while megaripples and ripples are perceived as not having a significant impact. The sand banks are considered stationary over the lifetime of a pipeline, whereas the sand waves may migrate at a speed up to tens of metres per year (van Dijk & Kleinhans, 2005; Dorst et al., 2009; van Santen et al., 2011) and cause metres-scale vertical seafloor variations over the lifetime of a pipeline.

If sand waves are removed by dredging, they may regenerate within a period of years (Knaapen and Hulscher, 2002). This is illustrated in Figure 4.25, where sand waves appear to be building back within a former dredging area.

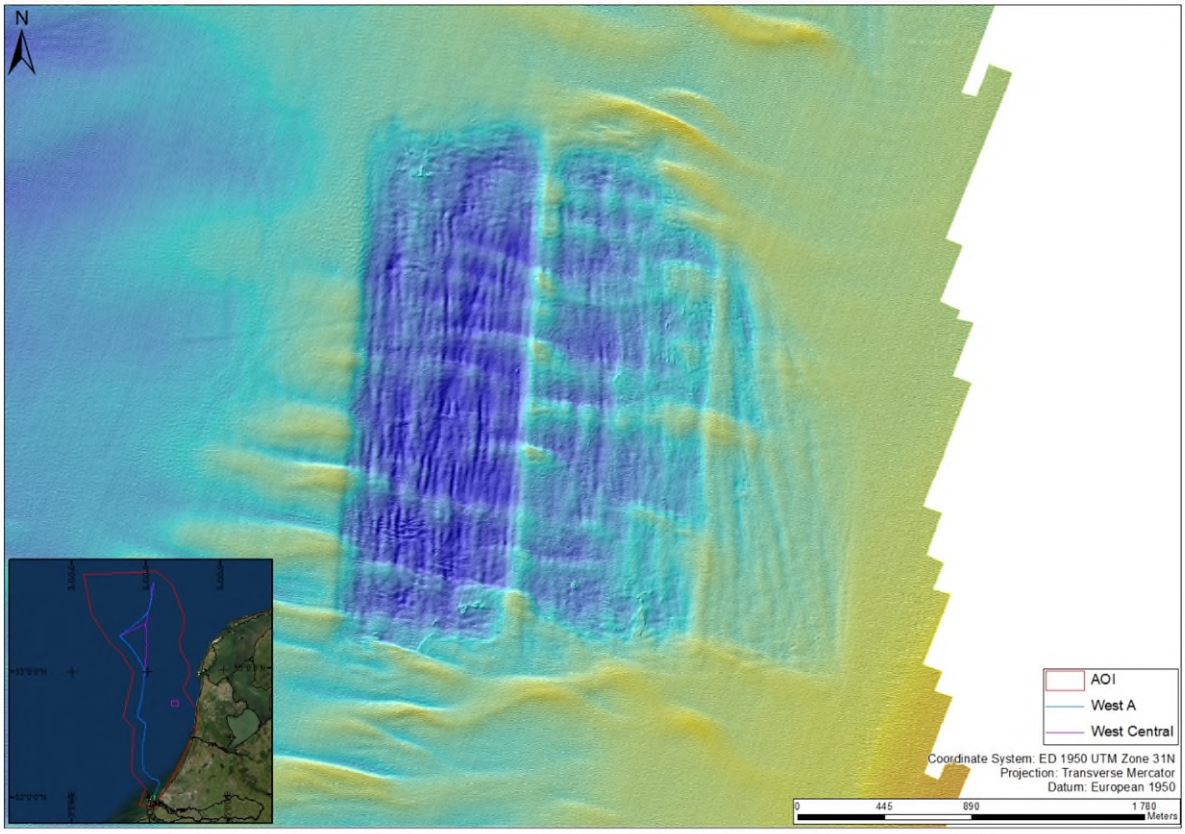


Figure 4.25: Former dredging area where sand waves are building back , as imaged in Hollandse Kust (noord) MBES bathymetry

Table 4.5 provides a summary of sand wave migration rates based on a selection of studies performed in the southern North Sea.

Table 4.5: Sand wave migration rates in the southern North Sea

Location	Average Migration Rate [m/year]	Source
Hollandse Kust (noord) WFZ	1.9 to 5.4	Deltares (2019)
Hollandse Kust (west) WFZ	1 to 3.9	Deltares (2020)
Hollandse Kust (zuid) WFZ	1 to 2.6	Deltares (2016)
Prinses Amalia OWF	4	Deltares (2017)
Luchterduinen OWF	2 to 3	Deltares (2017)
Texel	> 20	Van der Meulen et al. (2004)
Rotterdam Harbour	0	Van der Meulen et al. (2004)
Belgian Sector	1 to 4	Fugro database
UK Sector – east of Norfolk Banks	0 to 4	Fugro database

Typical sand wave migration rates in the southern North Sea are between 1 m/year to 10 m/year and in exceptional cases, as for example coastal zones, up to 20 m/year (Deltares, 2020). The sand wave morphology indicates that the dominant migration direction in the North Sea is to the north-north-east.

The migration rates of sand waves vary spatially and over time. In general sand waves in shallower water depths, e.g., on top of the sand banks migrate faster than in the deeper parts and locally migration speeds as high as 9.0 m/year are observed (Deltares, 2019).

The migration distance may increase in the event of storms or exceptional weather surge. Winter storm events can change the morphology of sand waves. For example, sediment can be transported from crest to trough, decreasing the height of bedforms. Additionally, megaripples and ripples may be smoothened. These small-scale bedforms will reappear once the rhythmic currents' regime is re-established (Deltares, 2016).

Van der Meulen et al. (2004) reported a migration rate of over 20 m/year near the island of Texel, with typical migration rates decreasing southwards to a stationary (0 m/year) field near the Rotterdam harbour. Migration rates in the Prinses Amalia offshore wind farm (OWF) and Luchterduinen OWF, located in the centre of the AOI, were assessed to be in the order of 4 m/year and 2 m to 3 m per year, respectively.

Fugro performed several seafloor mobility studies in the North Sea, which included comparison of MBES data between different years. For example, in the Belgian sector, MBES data acquired 3 years apart revealed sand wave migration rates in the order of 1 m to 4 m per year. In the UK sector, east of Norfolk Banks, the MBES data between consecutive years revealed sand waves migration rates from 0 m to 4 m per year.

4.4 Sub-seafloor Conditions

Section 3 provides background information on the regional geological setting. The following sections provide project-specific results on sub-seafloor conditions. The Stratigraphic

Nomenclature by TNO – the Geological Survey of the Netherlands is used and is available on the DINOloket website (TNO-GDN, 2022).

4.4.1 AOI

The expected geological formations that occur in the AOI and description of the lithologies associated with these formations are summarised in Table 4.6. Included are the expected thickness ranges and distribution of the formations across the AOI. The expected thickness values are based on Cameron et al. (1984; 1986), Laban et al. (1992), Laban (1995), Fugro (2019a, 2020) and DINOloket (2022). The distribution of the geological formations was compiled from maps by Cameron et al. (1984, 1986), Harrison et al. (1987), Balson et al. (1991), Laban (1995), NITG–TNO (2004b, 2004d) and Laban & van der Meer (2011), which are stored in the GIS database for easy access.

To illustrate the subsurface stratigraphy a schematic profile from northern part of the AOI is provided on Figure 4.27. Figure 4.26 shows a detailed interpreted seismic profile taken from the Hollandse Kust (west) WFZ (Fugro, 2020) situated in the central-west part of the AOI.

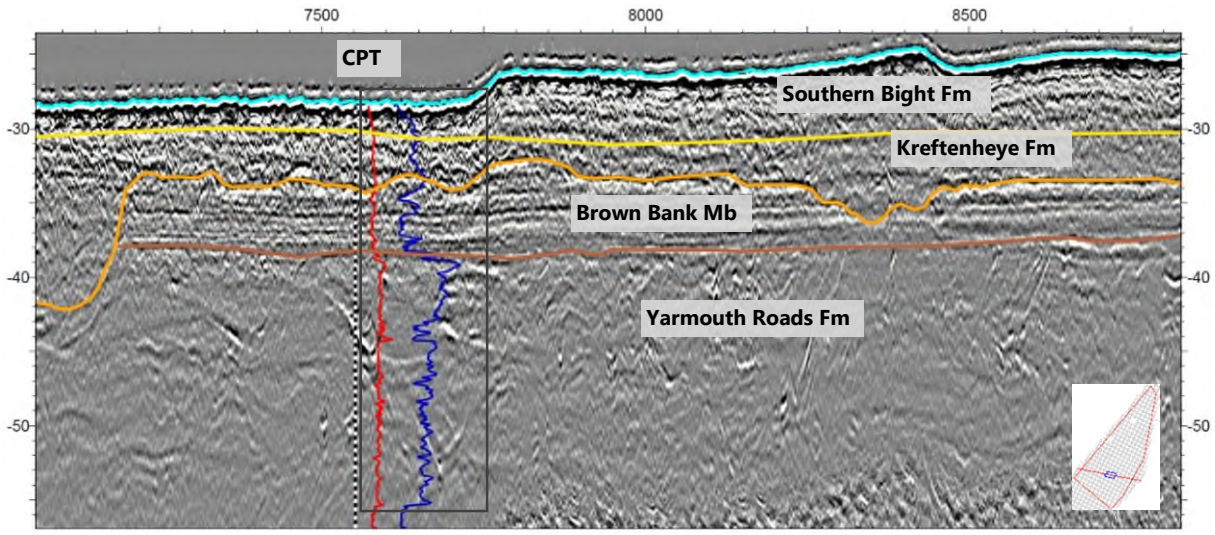


Figure 4.26: Example seismic reflection (2DUHR) cross section within the Hollandse Kust (west) WFZ (modified from Fugro, 2020). *Vertical scale is in metres reduced to LAT. The horizontal scale shows relative distance in metres along the seismic line. Width of the Cone Penetration Test (CPT) box shows cone resistance values (blue curve) within range of 0 to 60 MPa and sleeve friction values (red curve) from 0 to 1 MPa*

Maps showing distribution of the geological formations are provided in the following figures:

- Figure 4.21 shows the geological formations occurring at the seafloor;
- Figure 4.28 shows the thickness of the Holocene;
- Figure 4.29 shows distribution of the Late Pleistocene formations (directly below Holocene sediments);
- Figure 4.30 shows distribution of the Early to Middle Pleistocene formations, from the Drente Formation (Gieten Member) down to the Yarmouth Roads Formation;
- Figure 4.31 shows the distribution of the Early Pleistocene formations, comprising the Peelo Formation and the Yarmouth Roads Formation.

Note that the formations may have a larger extent than indicated on these figures (display effect—younger formation may partially cover the older formation). Refer to the GIS database for their full extents.

Table 4.6: Overview of the stratigraphy in the AOI specifying the geological units present

Age	Geological Formation / *Member**	Expected Thickness Range [m]	Soil Type†	Depositional Environment	Distribution and Comments
Holocene	Southern Bight	0 to 25	Very loose to very dense, fine to coarse SAND with shells and shell fragments, locally silty	High energy open marine	Present across the entire AOI, except the depression in the north and locally in the south The unit is thicker at the crests of the sand waves and thinner in the troughs between them. The maximum thickness is approximately 10 m. The extreme values are reached locally in the coastal area
Holocene	Urania	0 to 7	Very soft to soft (sandy) CLAY or very loose to medium dense (clayey) SAND	Low energy open marine	Present in the depression in the north
Early Holocene	Naaldwijk	0 to 15	Medium dense to very dense fine to medium (clayey) SAND and/or loose to medium dense (sandy) SILT or soft (low strength) CLAY, locally with beds of PEAT, locally thin beds of gravelly sand	Coastal to tidal	Present locally across the entire AOI, mostly as infill in shallow paleo-channels, which are highly variable in lateral and vertical extent. In general, the unit is more extensive and increase in thickness towards the coastline.
Weichselian	Boxtel (Twente)	0 to 5	Medium dense to very dense fine SAND, with minor intercalations of clay, silt, gravel and/or peat	Periglacial, aeolian	Patchy distribution across the AOI
Weichselian	Kreftenheye	0 to 25	Dense to very dense fine to medium SAND, with locally beds of gravelly sand, silty clay, clayey peat	Glaciofluvial to fluvial	Mainly present in the southern half of the AOI. Reaches maximum thickness in the southern part (Landfall/Shore crossing Area) and is absent in the northern part of the AOI
Late Eemian to Early Weichselian	Eem / *Brown Bank* (Brown Bank)	0 to 20	Firm to very stiff calcareous CLAY or SILT, with extremely closely to very closely spaced laminae to thick beds of sand	Brackish marine lagoonal to lacustrine	Present in the north-western part of the AOI. The unit reaches largest thickness (>10 m) very locally, where it forms infill of channelling features
Eemian	Eem	0 to 15	Medium dense to very dense fine SAND with shells and shell fragments; locally clay and silt beds	Shallow to open marine, locally glaciofluvial	Present in the most of the AOI, can be locally absent. Absent in the southernmost part of the AOI
Saalian	Drente / *Gieten* (Borkum Riff)[2)]	0 to 5	Very stiff to hard silty sandy gravelly CLAY (glacial TILL)	Glacial	Locally present only in the north-eastern part of the AOI
Saalian	Drente / *Uitdam* (Cleaver Bank)[2)]	0 to 25	Stiff to hard CLAY, locally with silt, sand, and gravel beds	Periglacial, glaciolacustrine	Mainly confined to Saalian tunnel valleys in the northern half of the AOI. The unit thickness is typically <10 m, larger thickness observed only very locally
Saalian	Drachten (Tea Kettle Hole)	0 to 10	Medium dense to dense, fine to medium SAND, with locally laminae of silt or/and clay	Periglacial, glaciofluvial, aeolian	Present locally in the northern half of the AOI
Holsteinian	Egmond Ground	0 to 40	Medium dense to very dense fine SAND with shells and shell fragments, with thin clay and silt interbeds	Open marine	Present across the northern half of the AOI
Elsterian	Peelo (Swarte Bank)	0 to > 100	Interbedded medium dense to very dense (silty) SAND and very stiff to hard (sandy) CLAY	Glacial, glaciofluvial (infill of valleys) to glaciolacustrine	Present across northern half of AOI, thickness significantly increases in (deep) tunnel valleys
Early to Middle Pleistocene	Yarmouth Roads	0 to > 100	Interbedded medium dense to very dense, slightly silty to very silty, fine to medium SAND, and stiff to very stiff CLAY or SILT with laminae of sand; locally laminae to thin beds of PEAT	Fluvio-deltaic to marine	Present across the AOI, except in the most south-eastern part
Early Pleistocene	Winterton Shoal / IJmuiden Ground	0 to > 100	Interbedded medium dense to very dense, silty, fine to medium SAND, with laminae to thick beds of (organic) clay and stiff to hard CLAY or SILT with laminae of sand; locally laminae of PEAT	Fluvio-deltaic to marine	Present in the south-eastern part of the AOI (Landfall/Shore crossing Area)

Notes:

Information is presented for depth range of interest (to 100 m BSF)

'Greater than' sign ('>') indicates minimum observed thickness

* = BGS naming convention between brackets

† = May contain boulders

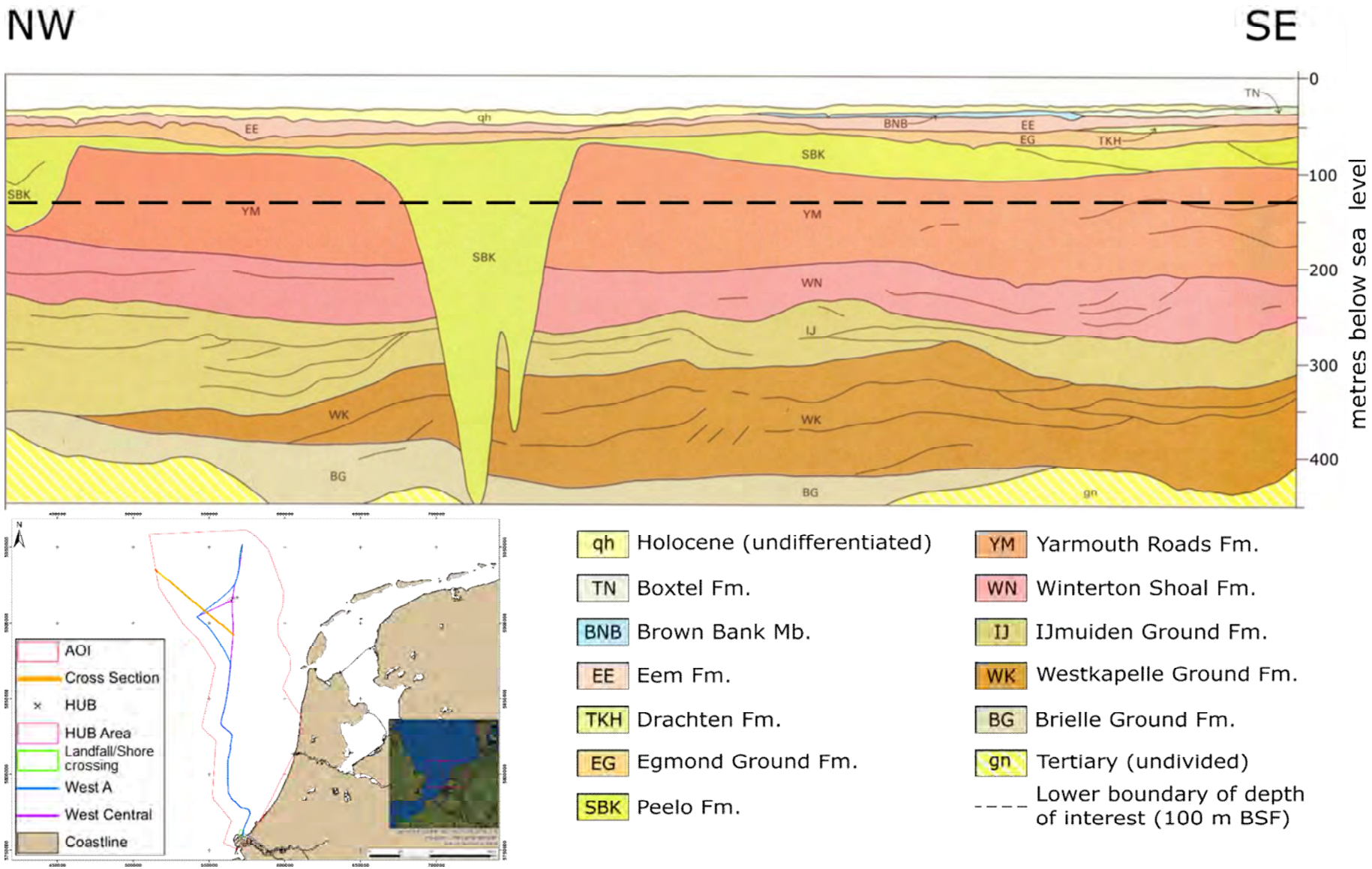


Figure 4.27: Schematic profile (with 50x vertical exaggeration) of the north-west part of the AOI. See the inset in the bottom left-hand corner for the location of the cross section (in orange). Modified after Cameron et al. (1986)

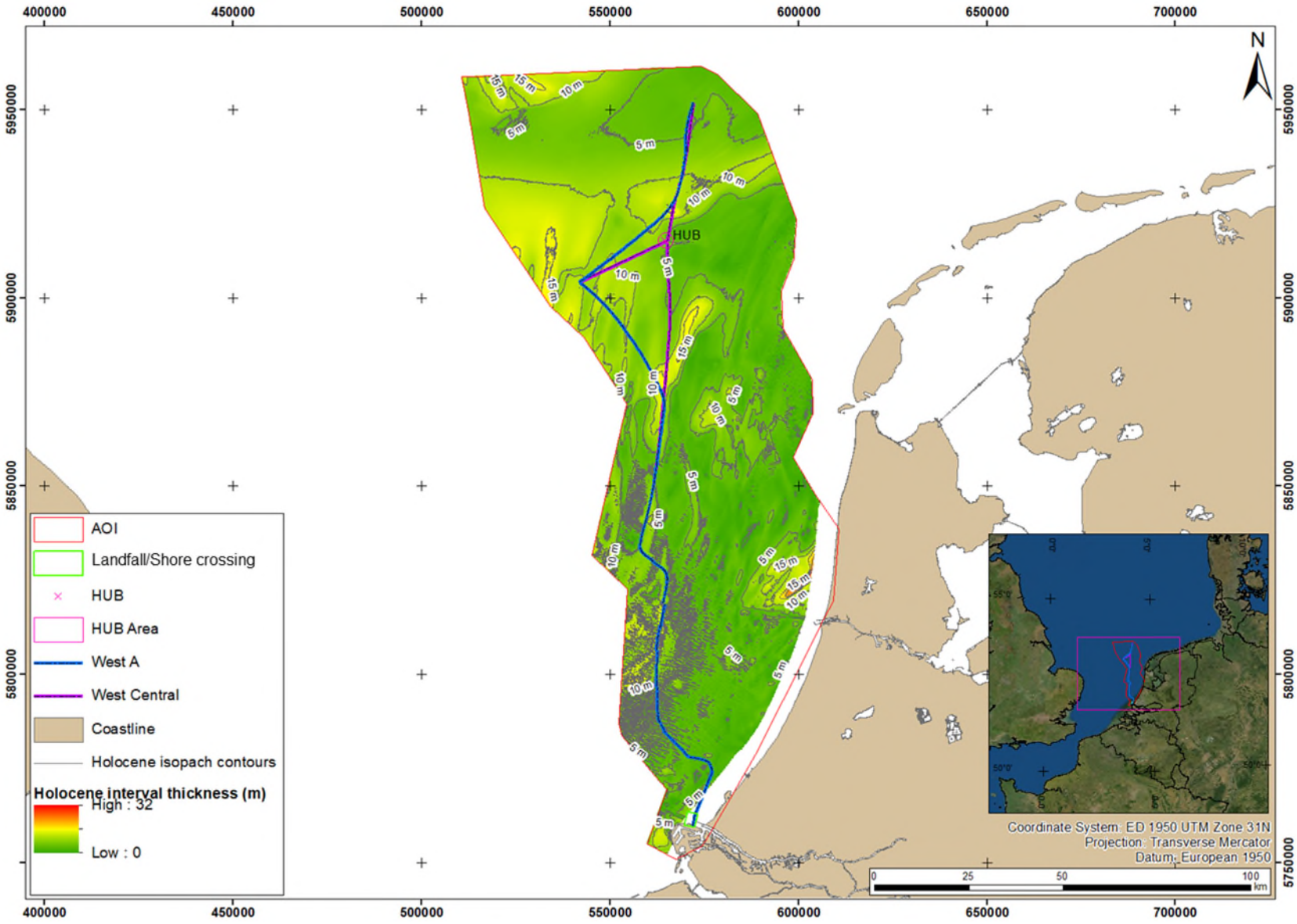


Figure 4.28: Expected thickness of the Holocene in the AOI

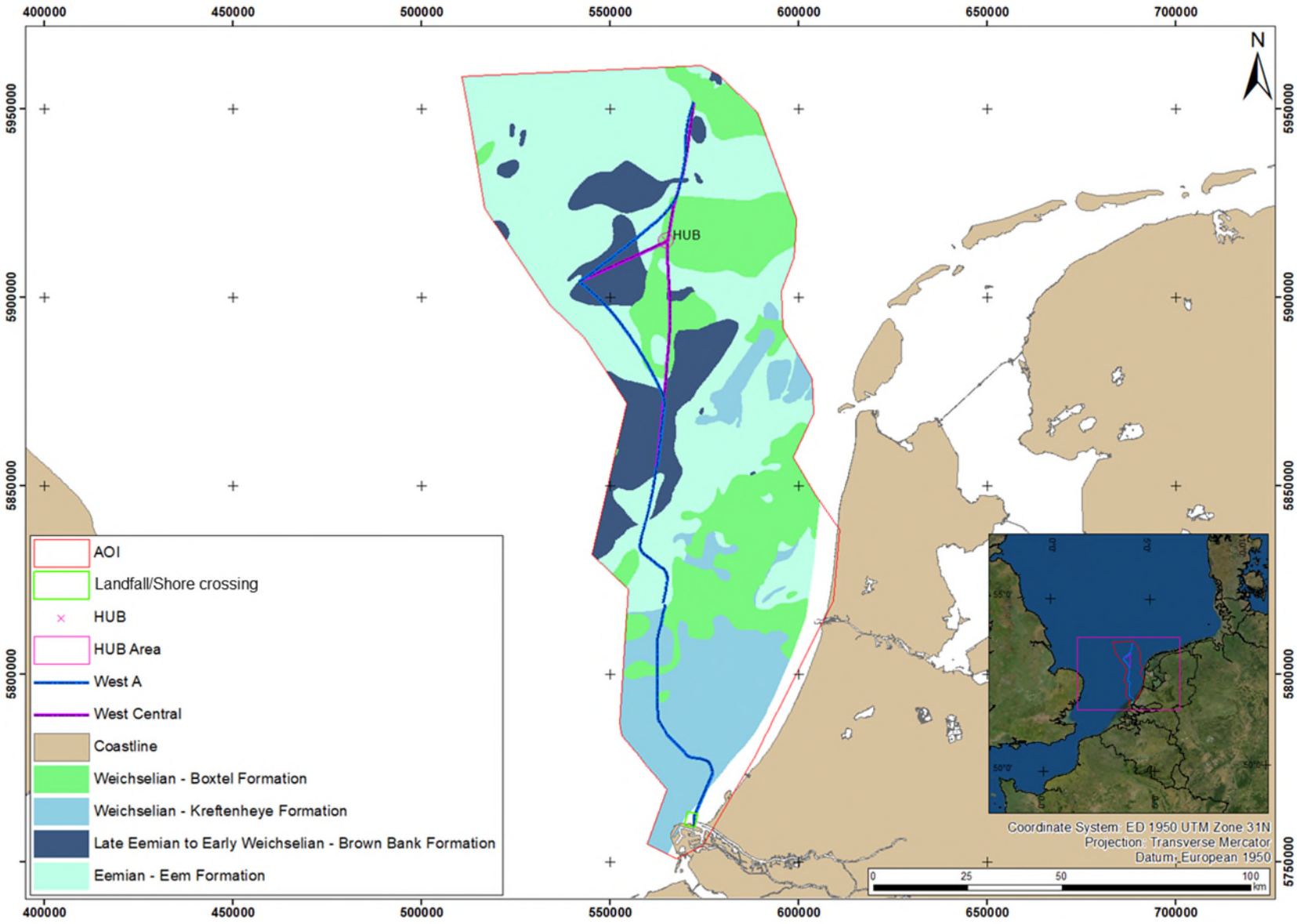


Figure 4.29: Distribution of the Late Pleistocene formations and members

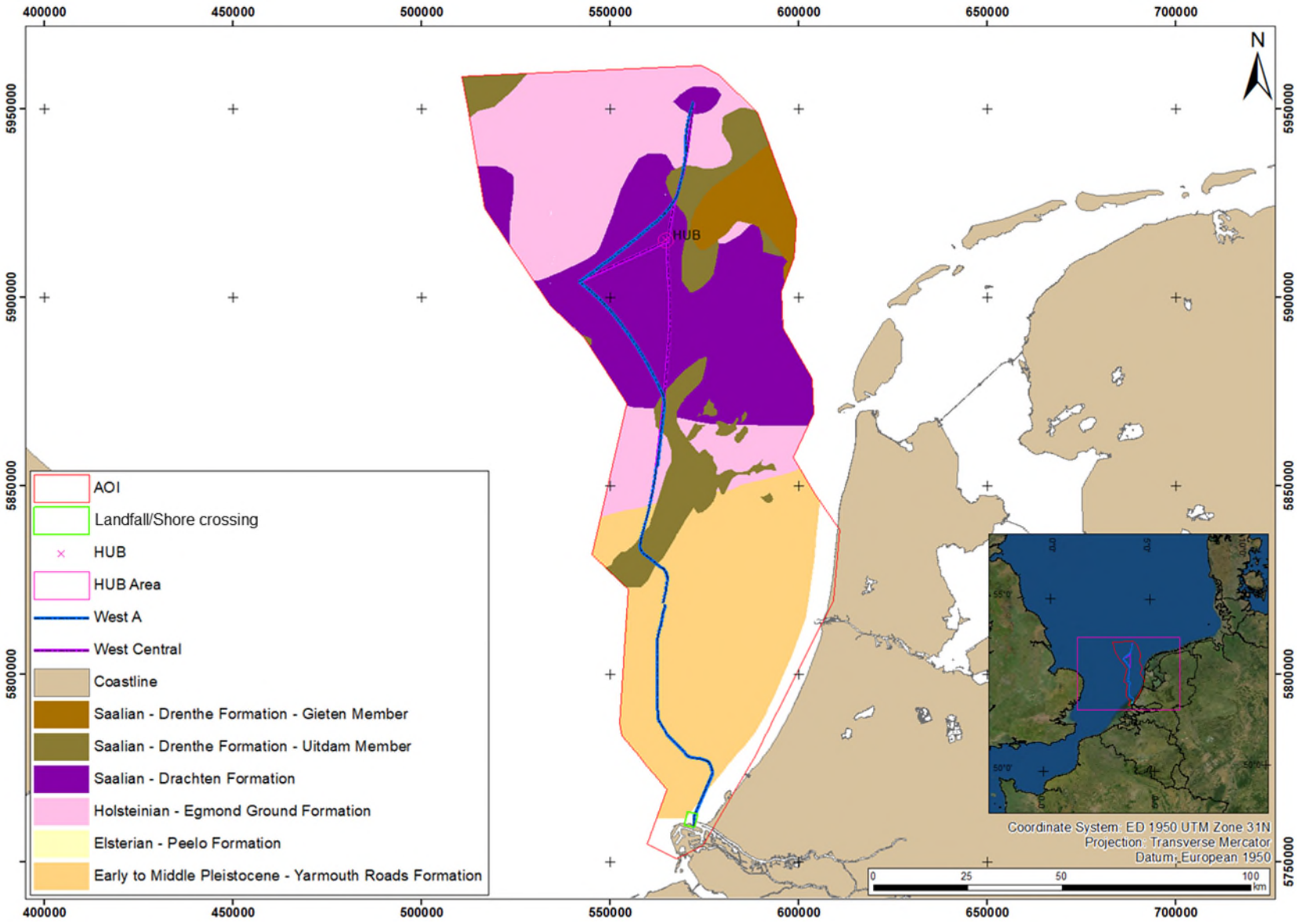


Figure 4.30: Distribution of the Early to Middle Pleistocene formations and members

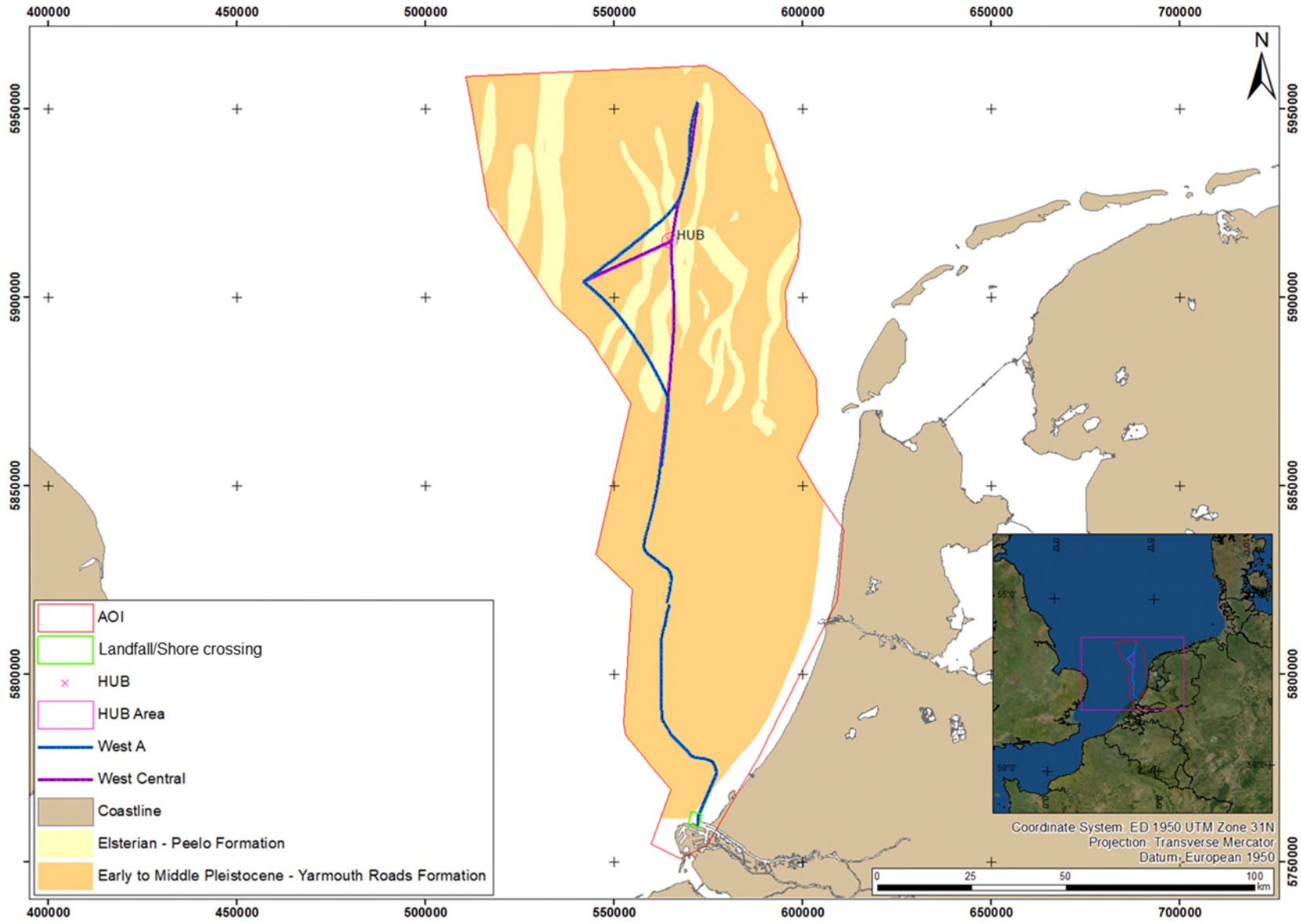


Figure 4.31: Distribution of the Early Pleistocene formations

4.4.2 Landfall/Shore Crossing Area

The expected stratigraphy and lithologies in the Landfall/Shore crossing Area, based on the information from DINOloket is presented in Figure 4.32.

There are three main units/geological formations to be expected, from top: Naaldwijk, Kreftenheye and Early Pleistocene formations, which comprise the Winterton Shoal and/or IJmuiden Ground Formations. The Naaldwijk Formation is internally very variable with dominant clay and locally some inclusions of peat. Kreftenhaye Formation is dominated by SAND and the Early Pleistocene deposits by SAND mixed with CLAY.

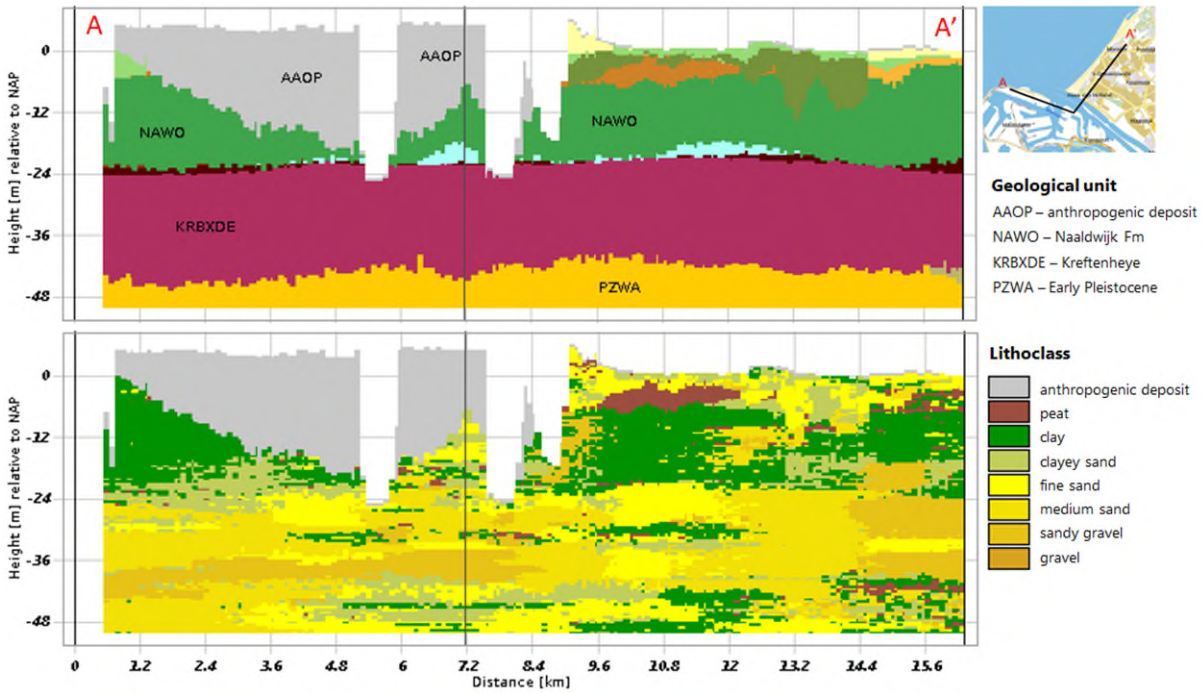


Figure 4.32: Synthetic ground models showing geological units (top image) and most probable lithologies (bottom image) in the vicinity of the Landfall/Shore crossing Area (source: DINOloket)

Table 4.7 presents the expected stratigraphy and spatial soil variability at the Landfall/Shore crossing Area. The information presented is based on (1) three geotechnical boreholes with penetration depth from approximately 17 m to 35 m BSF (Fugro, 2019c); (2) numerous geotechnical sampling and CPT testing locations from Fugro database, with various penetration depths from a few metres to approximately 40 m BSF. The geotechnical borehole data are within the boundaries of the Landfall/Shore crossing Area, located mainly in the western part.

Particularly, the presented depth and thickness values for the identified stratigraphic units/geological formations, as well as the spatial soil variability are based on previous geotechnical and geophysical investigation data performed by Fugro in the area. Figure 4.33 presents a schematic cross section along the first 3 km of the proposed pipeline route based on the interpretation of these data.

Table 4.7: Expected stratigraphy for the Landfall/Shore crossing Area

Geological Formation	Depositional Environment	Expected Thickness [m]	Soil Type	Distribution and Spatial Variability*
Disturbed Soil (DS)	Recent accumulation	0 to 5	Very soft to soft CLAY, locally sandy, locally gravelly	Present in the Maasmond Kanaal
Southern Bight	Marine	0 to 1	Very loose to dense, medium SAND with frequent shells and shell fragments	Locally present as a thin cover or in form of possible localised small-scale bedforms; can be present especially in the northern part of the area
Naaldwijk	Coastal, tidal channel and tidal flat	0 to 13	Medium dense to very dense, fine and medium SAND and soft to firm (sandy) CLAY, locally PEAT interlayers	Present across the entire area. Locally this unit might be removed due to dredging activities (i.e., in the Maasmond Kanaal) The unit is characterised by very high spatial soil variability. The unit locally forms infill of paleo-channels, where it reaches maximum thickness. More extensive paleo-channels are expected in the northern part of the area (Figure 4.34)
Kreftenheye	Fluvial	10 to 25	Very dense fine to medium SAND, locally slightly gravelly to gravelly, locally with traces to few gravels; locally with laminae to thin beds of clay	Present across the entire area. Relatively homogenous unit, with minor localised laminae to thin beds of clay
IJmuiden Ground/ Winterton Shoal	Deltaic to fluvial	> 20	Medium dense to very dense (slightly) silty SAND, locally beds of laminated CLAY, locally with thin to thick beds of very stiff to hard CLAY	The entire area; high variability in relative density of sand or an alternation of sand and clay; beds of laminated sandy clay can be (locally) present

Notes:
Information is presented for depth range of interest (to 40 m BSF)
'Greater than' sign ('>') indicates minimum observed thickness
* = refer to Figure 4.33 for schematic cross section

Comments are as follows:

- The base of the Maasmond Kanaal has been dredged up to 10 m depth. As a result, the upper strata (i.e., the Naaldwijk Formation) were likely removed or reduced to thickness of occasionally less than 1 m.
- In the Maasmond Kanaal the top comprises very soft to soft clay or medium dense (clayey or silty) sand laminated with clay. This top relatively weak layer can be a recent deposit in the channel and/or partly a remnant or of the Naaldwijk Formation. Thickness of this layer is on average between 1 m and 3 m, but locally can be up to 6 m.

- Peat/organic clay layers (laminae to thin beds) can be present locally within the Naaldwijk Formation outside of the Maasmond Kanaal, and within the top layer in the Maasmond Kanaal. On seismic reflection data, localised areas of acoustic blanking were observed in and outside of the Maasmond Kanaal, which can be related to the peat and/or possible accumulations of gas as a result of decomposition of the organic material.
- Localised gravel beds may be present in the subsurface. A thick bed of very sandy gravel was encountered at a depth of approximately 5 m BSF at a single location south of the Maasmond Kanaal.
- Rock dumps made of gravel, cobbles and boulders (as part of the flood-defence structure) are present in the coastal zones. Side scan sonar (SSS) data indicated that submerged rock dump extent from several metres to tens of metres from the shoreline. No information on the thickness of this layer is available. In boreholes located onshore 2 m to 6 m-thick layers of gravel/cobbles were encountered.
- Seafloor depressions associated with objects interpreted as possible boulders were observed sporadically on the MBES data in the Landfall/Shore crossing Area. Boulders were not encountered or reported in the subsurface, based on the available information.

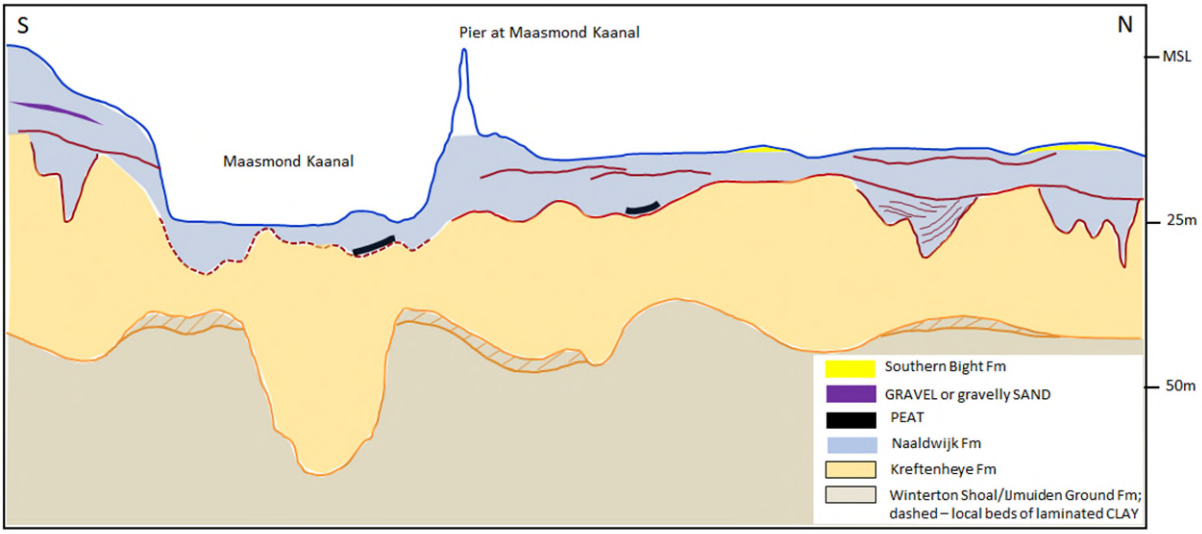


Figure 4.33: Schematic simplified cross section across the Maasmond Kanaal (based on geotechnical Fugro experience). Refer to Table 4.7 for detailed description of the units/geological formations

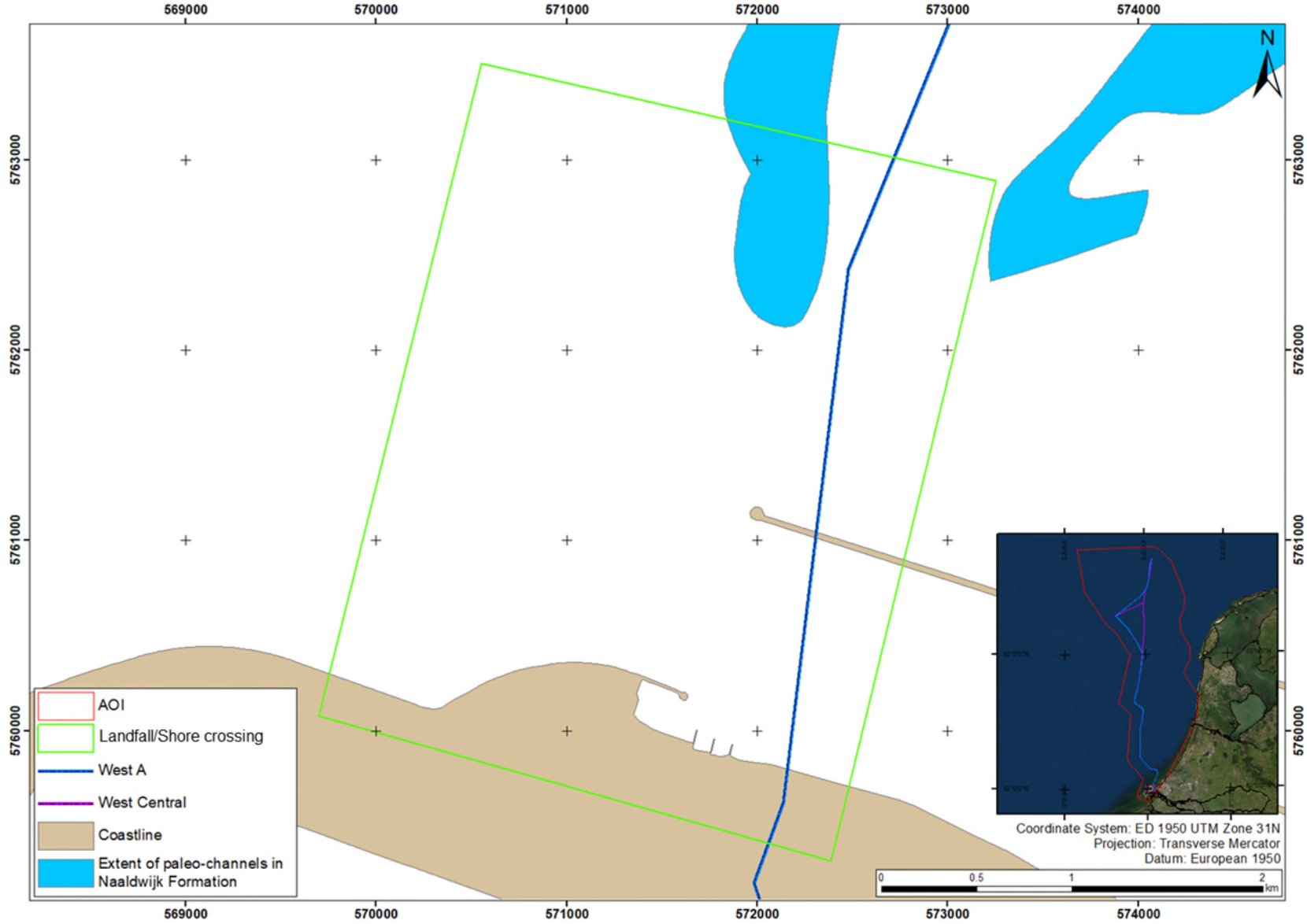


Figure 4.34: Distribution of the early Holocene (Naaldwijk Formation) paleo-channels in the Landfall/Shore crossing Area

4.4.3 Offshore Distribution HUB Area

Table 4.8 presents the general stratigraphy and spatial soil variability at the Offshore Distribution HUB Area. The information presented is based on geological maps and three geotechnical boreholes located approximately 3 km from the Offshore Distribution HUB Area boundary (Fugro confidential experience). No borehole information is available within the Offshore Distribution HUB Area.

Table 4.8: Expected stratigraphy for the Offshore Distribution HUB Area

Geological Formation / *Member*	Depositional Environment	Expected Thickness [m]	Soil Type	Distribution and Spatial Variability
Southern Bight	Marine	2 to 10	Very loose to very dense SAND with shells and shell fragments, locally silty	Present across the entire area
Naaldwijk	Coastal to tidal	0 to 5	Highly variable; generally soft CLAY, with silt, sand and peat beds	May be present (locally)
Boxtel	Periglacial, aeolian	0 to 5	Medium dense to very dense fine SAND	May be present (locally)
Eem / *Brown Bank*	Brackish marine lagoonal to lacustrine	0 to 10	Firm to very stiff calcareous CLAY or SILT, with extremely closely to very closely spaced laminae to thick beds of sand	May be present (locally)
Eem	Marine	5 to 15	Medium dense to very dense SAND with shells and shell fragments, locally silty and with peat beds	Expected to be present
Drente / *Uitdam*	Periglacial, glaciolacustrine	0 to 5	Stiff to hard CLAY, locally with silt, sand, and gravel beds	May be present (locally)
Drachten	Periglacial, aeolian	0 to 5	Medium dense to dense, fine to medium silty SAND	Expected to be present
Egmond Ground	Marine	10 to 40	Medium dense to very dense SAND with shells and shell fragments and beds of clay and silt	Expected to be present
Peelo	Glacial, glaciofluvial to glaciolacustrine	> 20	Interbedded medium dense to very dense SAND and very stiff to hard sandy CLAY	Expected to be present, although thickness may vary within the area
Yarmouth Roads	Fluvio-deltaic to marine	> 40	Dense to very dense SAND with shells and shell fragments, locally slightly silty	Expected to be present, although thickness may vary within the area

Notes:
Information is presented for depth range of interest (to 100 m BSF)
'Greater than' sign ('>') indicates minimum observed thickness

Comments are as follows:

- Based on the available geological maps, the Naaldwijk Formation and the Brown Bank Member may be (partly) present in the Offshore Distribution HUB Area. Based on

information from the nearby boreholes it is not possible to distinguish between these formations and member. However, CLAY with a thickness of 0.5 m to 5 m between the Southern Bight Formation and the Eem Formation was observed. Therefore, either Naaldwijk or Brown Bank is expected to be (locally) present.

- Beds of PEAT may be present locally and belong to either the Naaldwijk, or the Brown Bank Member.
- Stratigraphy descriptions for the nearby geotechnical boreholes incorporated the Drachten Formation and Uitdam Member into the Eem Formation and/or Egmond Ground Formation. Therefore, it is not possible to confirm the presence of these strata. The geological maps suggest that the Drachten Formation should be present, while the Uitdam Member might be (locally) present. The expected thickness of each of these formations is up to 5 m.
- The thickness of the Peelo Formation as observed in the nearby boreholes is approximately 22 m and 29 m. Regional geophysical and geotechnical information suggests that the formation is present throughout the area (Figure 4.27; Cameron et al., 1986; Laban, 1995).
- The base of the Yarmouth Roads Formation was not encountered in the nearby geotechnical boreholes. However, regional geophysical and geotechnical information suggests the formation is present throughout the wider area and has a thickness of at least 40 m (Figure 4.27; Cameron et al., 1986; Laban, 1995).

4.5 Ground Models

One ground model per study area is presented in this report, allowing to capture site-specific details and the different depth of interest for each site.

4.5.1 AOI

4.5.1.1 Predicted Soil Units and Geotechnical Parameters

To predict soil units across the AOI, the seafloor and sub-seafloor features identified in the available geological, geophysical and geotechnical data and literature were reviewed and summarised (Sections 4.2 and 4.4). Predicting soil units enables soil profiles and associated soil province map(s) to be generated.

Soil units were defined by grouping together stratigraphic formations expected to have similar lithologies (e.g., principal soil type). A geotechnical description is given allowing to encompass the possible variability and change in lithology within each of the soil units.

Eight soil units were predicted to be present across the AOI and within the depth of interest. Table 4.9 presents the predicted soil units and the associated preliminary geotechnical parameters defined for each unit.

The geotechnical description of soil units, detailed below, are applicable for the complete AOI as well as on the specific Landfall/Shore crossing and Offshore Distribution HUB Areas:

- Soil unit i, comprising the Holocene surficial sediments:
  - ia: sandy very soft MUD to muddy loose SAND;
  - ib: very loose to very dense SAND;
  - ic: slightly gravelly loose SAND to sandy GRAVEL;
- Soil unit ii, comprising tidal and coastal deposits of Early Holocene: interbedded very thin to thick beds of CLAY and SAND;
- Soil unit iii, grouping the Pleistocene formations dominated by SAND: SAND, locally (slightly) silty, with locally (and minor) beds of CLAY, SILT, GRAVEL and PEAT;
- Soil unit iv, grouping the Pleistocene formations dominated by CLAY, subdivided based on age (strength):
  - iva: overconsolidated (firm to stiff) CLAY with SAND laminae/thin beds;
  - ivb: overconsolidated (stiff to hard) CLAY, with beds of SILT to SAND;
- Soil unit v, corresponding to glacial TILL: very stiff to hard silty sandy gravelly CLAY.

Geotechnical parameters are derived from Fugro experience comprising numerous geotechnical sampling and CPT boreholes across the AOI. Thicknesses given are based on the same experience as well as on geological maps used in this report. The AOI being very large, the geotechnical parameters values cannot be detailed precisely, and ranges given in Table 4.9 allow to encompass potential range of values across the AOI.

Fugro recommends geotechnical sample data and CPTs along the final pipeline route to refine parameter ranges, and precise the expected thicknesses of the different units along the pipeline route. It is also recommended that the siting of the sampling and CPT locations is performed once geophysical data has been acquired to ensure areas of variability are sufficiently characterised and consistent areas only collect the required information. Based on these future geophysical and geotechnical surveys, the soil units may be discriminated further along the pipeline route.

Table 4.9: Predicted preliminary geotechnical parameters for the AOI

Stratigraphic Unit (Geological Formation)	Soil Unit	Description	Soil Type	Thickness [m]	γ′ [kN/m³]	D_r [%]	s_u [kPa]	S_t [-]	Φ′ [°]	q_c [MPa]
Surficial Sediments (Southern Bight and Urania)	ia	sandy very soft MUD to muddy loose SAND	CLAY	0 to 5	18 to 19	N/A	5 to 50	-	N/A	<2
	ib	very loose to very dense SAND	SAND	0 to 10	18 to 19.5	<35 to >100		N/A	25 to 45	2 to 20
	ic	slightly gravelly loose SAND to sandy GRAVEL	SAND	0 to 5	19 to 20	<35		N/A	25 to 30	4 to 20
Naaldwijk	ii	interbedded very thin to thick beds of CLAY and SAND	CLAY	0 to 15	18 to 19.5	N/A	20 to 100	1 to 3	N/A	1 to 3
			SAND			25 to 85		N/A	25 to 35	2 to 10
Boxtel (Twente) Kreftenheye, Eem Drachten (Tea Kettle Hole) Egmond Ground Yarmouth Roads	iii	SAND, locally slightly silty, with locally beds of CLAY, SILT, GRAVEL and PEAT	CLAY	0 to >20	18.5 to 20.5	N/A	100 to 200	~1 to 3	N/A	2 to 4
			SAND			65 to >100		N/A	30 to 45	15 to 90
Brown Bank	iva	overconsolidated firm to stiff CLAY with SAND laminae/thin beds	CLAY	0 to 10	18.5 to 19.5	N/A	50 to 200	1 to 3	N/A	1 to 4
			SAND			25 to 75		N/A	30 to 40	2 to 10
Drenthe (Cleaver Bank) Peelo (Swarte Bank)	ivb	overconsolidated stiff to hard CLAY, with beds of SILT to SAND	CLAY	0 to >20	19.5 to 21	N/A	200 to 400	~1 to 2	N/A	4 to 8
			SAND			65 to >100		N/A	35 to 45	15 to 90
Drenthe (Borkum Riff)	v	sandy, gravelly CLAY (glacial TILL)	CLAY	0 to 5	20 to 22	N/A	200 to 600	~1 to 2	N/A	4 to 12

Notes:
N/A = not applicable
- = no information available
γ′ = total unit weight
s_u = undrained shear strength
S_t = sensitivity
Dr = relative density
Φ′ = drained peak effective friction angle
q_c = CPT cone resistance

4.5.1.2 Geotechnical Profiles

Nine soil profiles were generated for the AOI based on available data. These soil profiles describe the possible lateral and vertical variability of soil units predicted to be present to 20 m BSF across the AOI. Soil profiles are presented in Figure 4.35. They were designed to discriminate areas with presence of:

- glacial TILL (profiles numbered 2);
- firm to stiff CLAY from the Brown Bank Formation (profiles numbered 3);
- neither glacial TILL or Brown Bank CLAY (soil profiles numbered 1).

The other criteria differentiating between the soil profiles are the types of surficial sediments: (a) mud-rich, (b) sand and (c) gravel-rich.

Bedforms were considered as positive features relatively to the mean seafloor level and are shown as positive triangles at the top of the profiles.

4.5.1.3 Soil Provinces

A soil province map, presented in Figure 4.36, was generated for entire AOI to depict the spatial extent of each predicted soil profile (Figure 4.35). The soil province map allows the lateral variability in soil units to be better understood and pictured.

Areas covered by each soil province are given in Table 4.10 along with the percentage of the total AOI surface area they represent. From this table, it appears that over 84 % of the AOI is characterised by the normal soil profiles (profiles numbered 1 in Figure 4.35). Less than 4% of the AOI is likely to present glacial TILL (unit v) within the depth of interest (profiles numbered 2), while 12% of the AOI present firm to stiff CLAY of the Brown Bank Formation (unit iva) within the depth of interest (profiles numbered 3). 65% of the area is covered by SAND rich surficial sediments (profiles numbered ‘b’), less than 19% is covered by MUD-rich sediments (profiles numbered ‘a’) and 16% is covered by GRAVEL-rich surficial sediments (profiles numbered ‘c’).

Table 4.10: Area covered by each soil province

Soil Province	Area (km^2)	% of AOI
AOI - 1a	1920.2	16
AOI - 1b	6455.9	56
AOI - 1c	1395.2	12
AOI - 2a	18.6	<1
AOI - 2b	321.7	2
AOI - 2c	123.8	1
AOI - 3a	235.3	2
AOI - 3b	807.3	7
AOI - 3c	347.1	3

Figure 4.36 presents the maximum extent of units consisting of stiff to hard CLAY (unit ivb) as hatched areas. However, the stiff to hard CLAY is in general likely to occur below the depth of interest of the AOI.

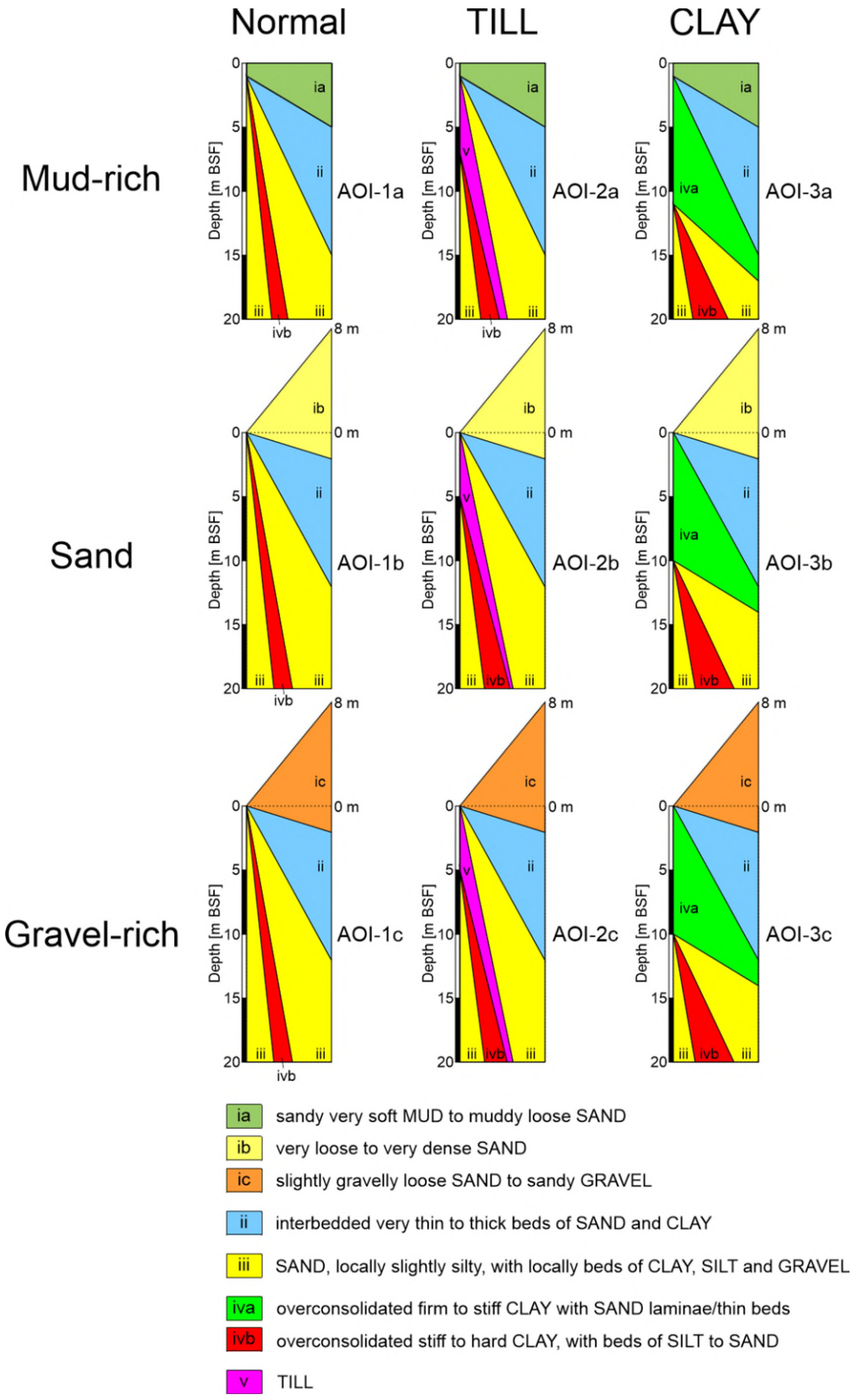


Figure 4.35: Predicted soil profiles across the AOI

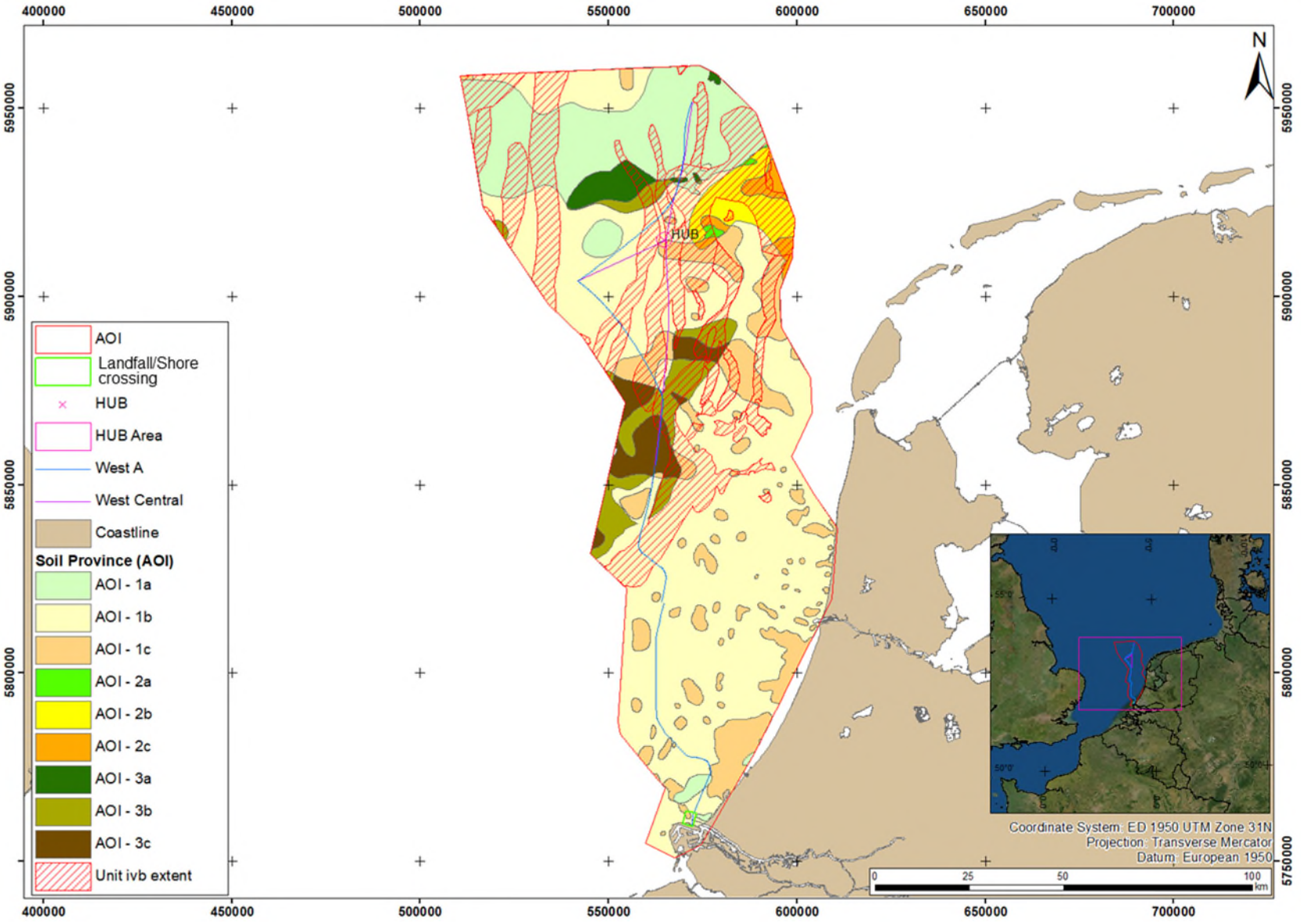


Figure 4.36: Soil province map across the AOI

4.5.2 Landfall/Shore Crossing Area

4.5.2.1 Predicted Soil Units and Geotechnical Parameters

Five soil units were predicted to be present in the Landfall/Shore crossing Area and within the depth of interest (40 m to 50 m BSF). Table 4.11 presents the predicted soil units and the associated preliminary geotechnical parameters defined for each unit.

Geotechnical descriptions and soil units are the same as those defined for the AOI (Section 4.5.1.1), with the addition of unit 'ds' corresponding to disturbed soil/recent accumulation consisting of very soft CLAY or very loose to medium dense SAND. This unit is limited to the Maasmond Kanaal and probably comprises residues of dredging operations.

Unit iii also includes the Early Pleistocene Winterton Shoal/IJmuiden Ground Formations, which are lateral equivalents of the Yarmouth Road Formation.

GRAVEL beds may be present locally in the subsurface. In the coastal zones there are gravel/cobbles/boulders accumulations (as part of rock dumps of the flood-defence structure). These deposits extent laterally from metres to several tens of metres from the shoreline. The thickness is unknown but may be up to several metres. No boulders were encountered in the subsurface, however presence of boulders cannot be entirely excluded (see also Section 4.4.2).

Geotechnical parameter values and thickness ranges are specific to the Landfall/Shore crossing Area and were derived from geotechnical Fugro experience in the Landfall/Shore crossing Area.

Fugro recommends acquisition and interpretation of site-specific geophysical data (sub-bottom profiler (SBP), MBES and SSS) across the Landfall/Shore crossing Area in order to confirm or refine the pipeline routing. Once the final routing is agreed, a site-specific survey should be planned depending on the expected soil variability. This would then allow to confirm and further refine geotechnical parameters and soil unit vertical and lateral variability. An update of the ground model may be subsequently considered based on any new findings.

Table 4.11: Predicted preliminary geotechnical parameters for the Landfall/Shore crossing Area

Stratigraphic Unit (Geological Formation)	Soil Unit	Description	Soil Type	Thickness [m]	γ′ [kN/m³]	D_r [%]	s_u [kPa]	S_t [-]	Φ′ [°]	q_c [MPa]
Disturbed Soil	ds	very soft CLAY	CLAY	0 to 5	15 to 19	N/A	< 2	-	N/A	< 2
		very loose to medium dense SAND	SAND			<35 to 65		N/A	25 to 35	2 to 10
Surficial Sediments (Southern Bight and Urania)	ib	very loose to very dense SAND	SAND	0 to 5	18 to 19.5	<35 to 100		N/A	25 to 35	2 to 20
	ic	slightly gravelly loose SAND to sandy GRAVEL	SAND	0 to 5	18 to 19	<35		N/A	25 to 35	4 to 10
Naaldwijk	ii	interbedded very thin to thick beds of CLAY, SAND and locally PEAT	CLAY	0 to 13	18 to 19.5	N/A	2 to 100	1 to 3	N/A	1 to 4
			SAND			25 to 100		N/A	25 to 45	2 to 20
Kreftenheye,	iii	Dense to very dense SAND	SAND	10-25	18.5 to 20.5	80 to >100		N/A	25 to 45	20 to 60
Winterton Shoal / IJmuiden Ver		SAND, silty, with locally beds of CLAY and/or SILT	CLAY	>40		N/A	100 to 300	~1 to 3	N/A	2 to 6
			SAND			35 to >100		N/A	25 to 45	15 to 90

Notes:
N/A = not applicable
- = no information available
γ′ = total unit weight
s_u = undrained shear strength
S_t = sensitivity
Dr = relative density
Φ′ = drained peak effective friction angle
q_c = CPT cone resistance

4.5.2.2 Geotechnical Profiles

Four soil profiles were drawn for the Landfall/Shore crossing Area based on available data. These soil profiles describe the possible lateral and vertical variability of soil units predicted to be present to 40 m BSF across the Landfall/Shore crossing Area.

Soil profiles are presented in Figure 4.37. They were designed to discriminate areas with different surficial sediment types (GRAVEL and MUD above SAND), as well as areas with anthropogenic reworked material. Profile 1 was subdivided to discriminate areas where unit ii may be thicker (up to 14 m) due to the presence of paleo-channels from the Early Holocene.

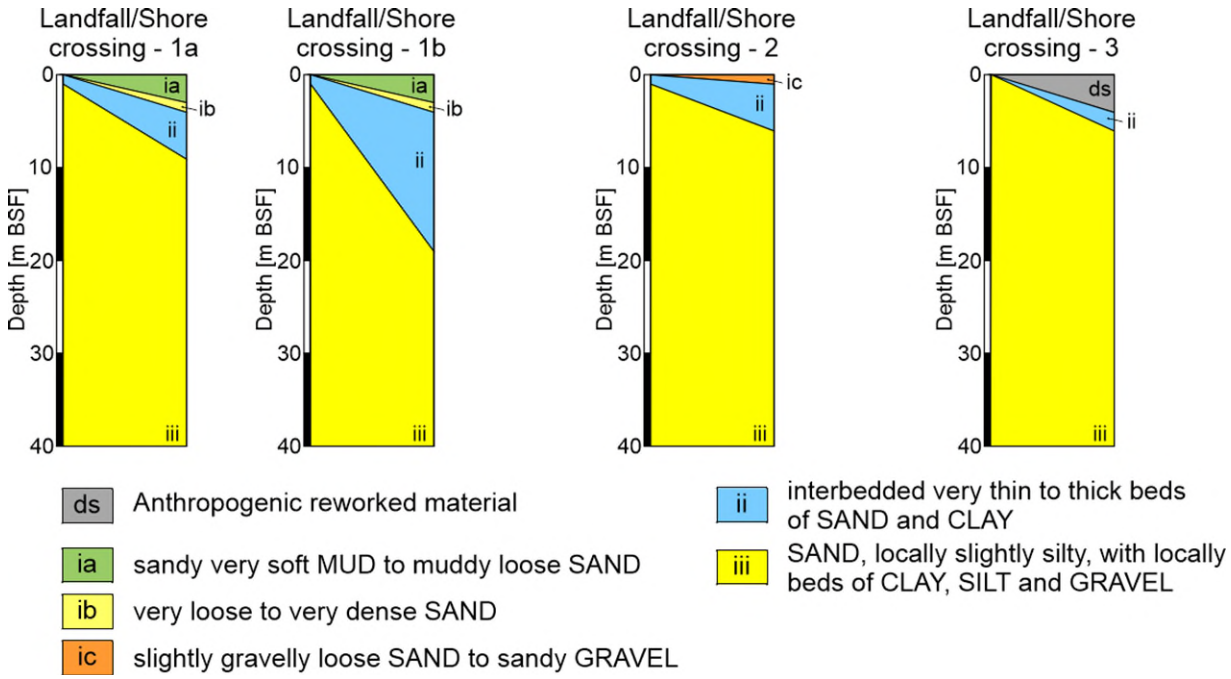


Figure 4.37: Predicted soil profiles across the Landfall/Shore crossing Area

4.5.2.3 Soil Provinces

A soil province map presented in Figure 4.38 was generated for the entire Landfall/Shore crossing Area to depict the spatial extent of each predicted soil profile (Figure 4.37). The soil province map allows the lateral variability in soil units to be better understood and pictured.

Areas covered by each soil province are given in Table 4.12 along with the percentage of the total Landfall/Shore crossing Area they represent. From this table, it appears that 38% of the area is characterised by mud-rich and muddy SAND surficial sediments (units ia and ib) with thin unit ii. 25% of the area, to the north-eastern corner, is expected to be covered by GRAVEL-rich sediments (unit ic). 21% of the area corresponds to the Maasmond Kanaal, potentially covered by disturbed/reworked deposits. Finally, only 4% of the area corresponds to the potential extent of paleo-channels (Naaldwijk Formation) based on geological maps (Figure 4.34).

About 12% of the Landfall/Shore crossing Area is covered by land and is not covered by any soil province.

Table 4.12: Area covered by each soil province across the Landfall/Shore crossing Area

Soil Province	Area (km^2)	% of AOI
Landfall/Shore crossing - 1a	3.8	38.3
Landfall/Shore crossing - 1b	0.4	4.4
Landfall/Shore crossing - 2	2.5	24.9
Landfall/Shore crossing - 3	2.1	20.8
Notes: 11.6% of the Landfall/Shore crossing Area is covered by land		

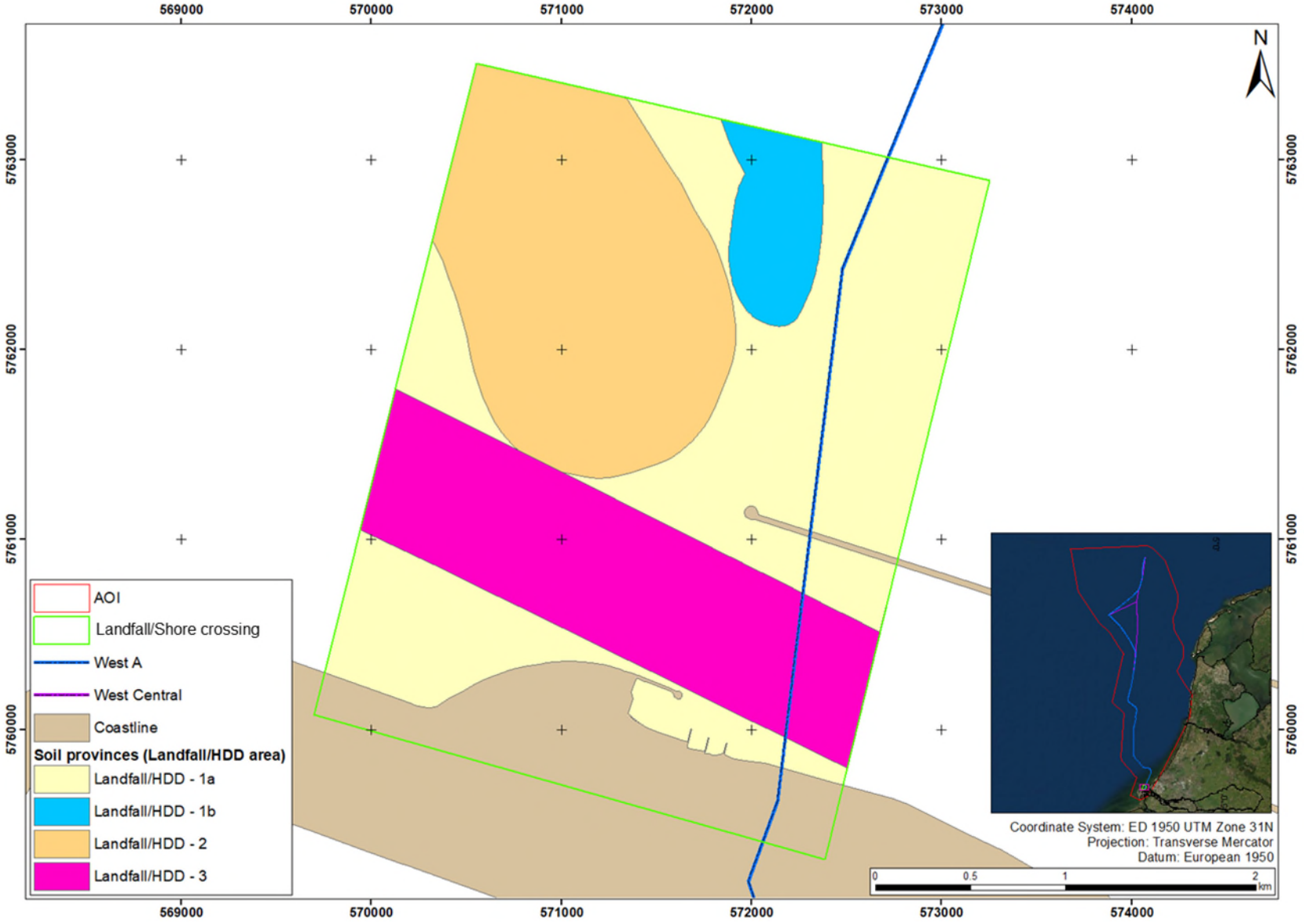


Figure 4.38: Soil province map across the Landfall/Shore crossing Area

4.5.3 Offshore Distribution HUB Area

4.5.3.1 Predicted Soil Units and Geotechnical Parameters

Five soil units were predicted to be present across the Offshore Distribution HUB Area and within the depth of interest (e.g., 100 m BSF). Table 4.13 presents the predicted soil units and the associated preliminary geotechnical parameters defined for each unit.

Geotechnical descriptions and soil units are the same as those defined for the AOI (Section 4.5.1.1).

Geotechnical parameters are the same as those presented for the entire AOI (Section 4.5.1.1). Fugro experience does not cover the Offshore Distribution HUB Area specifically, but the geotechnical parameter ranges for the AOI are likely to apply for the Offshore Distribution HUB Area to a depth of 100 m BSF. Expected thicknesses were adapted based on information from publicly available data and three geotechnical boreholes (Fugro experience) within 3 km of the Offshore Distribution HUB Area boundary.

Fugro recommends acquisition and interpretation of site-specific geophysical data (SBP, MBES and SSS) across the Offshore Distribution HUB Area to confirm or refine the pipeline routing. Once the final routing is agreed, a site-specific survey should be planned depending on the expected soil variability. This would then allow to confirm and further refine geotechnical parameters and soil unit vertical and lateral variability. An update of the ground model may be subsequently considered based on any new findings.

Table 4.13: Predicted preliminary geotechnical parameters for the Offshore Distribution HUB Area

Stratigraphic Unit (Geological Formation)	Soil Unit	Description	Soil Type	Thickness [m]	γ′ [kN/m³]	D_r [%]	s_u [kPa]	S_t [-]	Φ′ [°]	q_c [MPa]
Surficial Sediments (Southern Bight and Urania)	ib	very loose to very dense SAND	SAND	4 to 9	18 to 19.5	<35 to >100		N/A	25 to 45	2 to 20
	ic	slightly gravelly loose SAND to sandy GRAVEL	SAND	4 to 9	19 to 20	<35		N/A	25 to 30	4 to 20
Naaldwijk	ii	interbedded very thin to thick beds of CLAY and SAND	CLAY	0 to 1	18 to 19.5	N/A	20 to 100	1 to 3	N/A	1 to 3
			SAND			25 to 85		N/A	25 to 35	2 to 10
Boxtel (Twente) Kreftenheye, Eem Drachten (Tea Kettle Hole) Egmond Ground Yarmouth Roads	iii	SAND, locally slightly silty, with locally beds of CLAY, SILT, GRAVEL and PEAT	CLAY	40 to >100	18.5 to 20.5	N/A	100 to 200	~1 to 3	N/A	2 to 4
			SAND			65 to >100		N/A	30 to 45	15 to 90
Drenthe (Cleaver Bank) Peelo (Swarte Bank)	ivb	overconsolidated stiff to hard CLAY, with beds of SILT to SAND	CLAY	0 to 30	19.5 to 21	N/A	200 to 400	~1 to 2	N/A	4 to 8
			SAND			65 to >100		N/A	35 to 45	15 to 90

Notes:
N/A = not applicable
- = no information available
γ′ = total unit weight
s_u = undrained shear strength
S_t = sensitivity
Dr = relative density
Φ′ = drained peak effective friction angle
q_c = CPT cone resistance

4.5.3.2 Geotechnical Profiles

Four soil profiles were drawn for the Offshore Distribution HUB Area based on available data. These soil profiles describe the possible lateral and vertical variability of soil units predicted to be present to 100 m BSF across the Offshore Distribution HUB Area.

Soil profiles are presented in Figure 4.39. They were designed to discriminate areas with overconsolidated stiff to hard CLAY (unit ivb) at depth from the Peelo Formation. A subdivision was made to differentiate areas where SAND (ib) is expected at the seafloor from areas where GRAVEL-rich sediments (unit ic) are mapped.

The Offshore Distribution HUB Area is localised in-between two sand banks and therefore positive features of 1 m have been drawn to encompass the presence of the flanks of these bedforms.

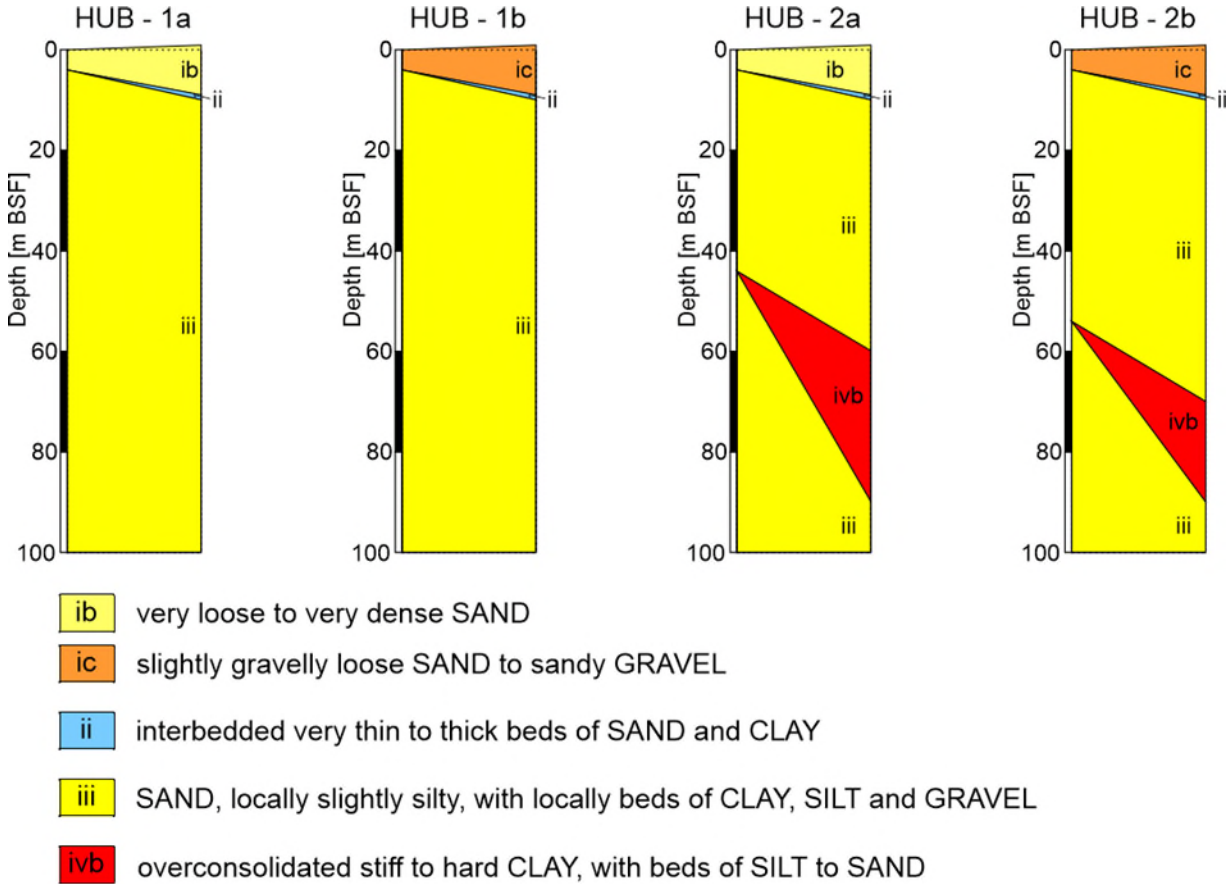


Figure 4.39: Predicted soil profiles across the Offshore Distribution HUB Area

4.5.3.3 Soil Provinces

A soil province map presented in Figure 4.40 was generated for the entire Offshore Distribution HUB Area to depict the spatial extent of each predicted soil profiles (Figure 4.37). The soil province map allows the lateral variability in soil units to be better understood and pictured.

Areas covered by each soil province are given in Table 4.14 along with the percentage of the total Offshore Distribution HUB Area they represent. From this table, it appears that 54% of the area is characterised by the potential presence of stiff to hard CLAY (unit ivb) within the depth of interest. This surface is divided within two distinct areas covering the western and eastern sides of the Offshore Distribution HUB Area. The areas correspond to two distinct paleo-channels from the Peelo Formation orientated north–south. More than 60% of the area is expected to be covered by SAND, while the southern part (40%) is expected to be composed of GRAVEL-rich material.

Table 4.14: Area covered by each soil province across the Offshore Distribution HUB Area

Soil Province	Area (km^2)	% of AOI
HUB - 1a	3.6	28
HUB - 1b	2.3	18
HUB – 2a	4.4	35
HUB – 2b	2.3	19

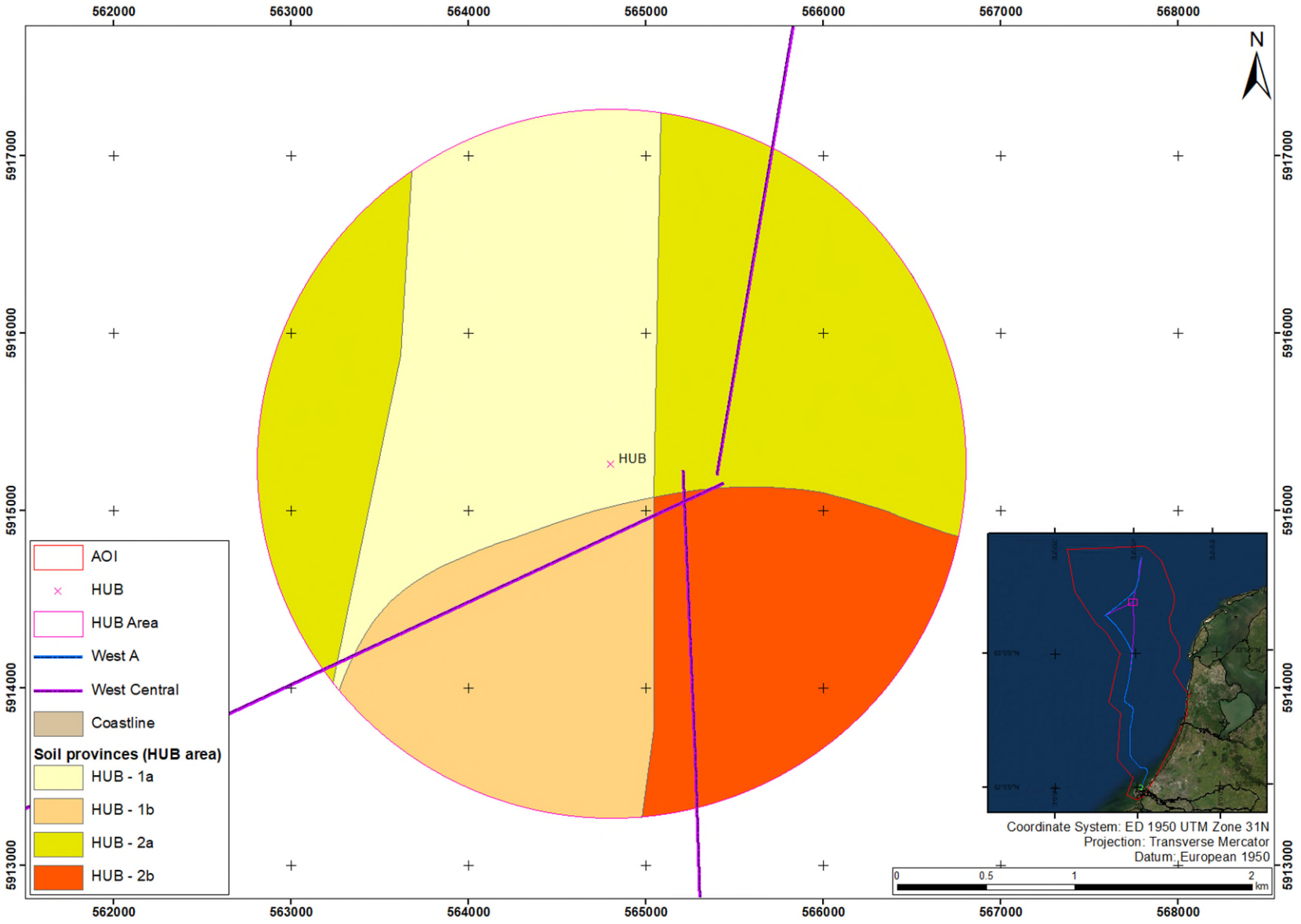


Figure 4.40: Soil province map across the Offshore Distribution HUB Area

5. Geohazards, Hazards and Site Constraints

5.1 General

Table 5.1 presents potential and identified geohazards and soil constraints for pipeline and other offshore infrastructures as well as for their installation. The information provides screening-level hazard characterisation (i.e. indicative) and may not be complete or comprehensive. Mitigation measures are proposed to reduce associated risks.

Table 5.2 presents potential and identified man-made related hazards, obstructions and site constraints for a pipeline and other offshore infrastructures. The information provides screening-level hazard characterisation (i.e. indicative) and may not be complete or comprehensive. Mitigation measures are proposed to reduce associated risks.

Table 5.1: Summary of potential and identified geohazards and soil constraints across the AOI

Constraint / Geohazard	Location / Distribution	Impact on Structure	Possible Mitigation
(Migrating) bedforms	Entire AOI, except northern part (Zone 3)	• Exposure or burial of structure; leading to snagging from trawling or anchoring, scour affecting structure stability • Spanning leading to uneven support of structure, critical stresses on structure • Temperature variations may lead to expansion / contraction of pipeline (increased susceptibility to walking in areas of exposure)	• Detailed mapping of bedforms through MBES data acquisition along pipeline route and within specific areas (Landfall/Shore crossing, Offshore Distribution HUB Areas) • Sediment mobility assessment, morphodynamic assessment and specific site survey works in areas of high risk • Meteocean site-specific desktop study to precisely assess migration/stability of bedforms • Avoid where possible areas with sand waves • Trenching to a certain depth (depending on bedform amplitude)
Storm events / wave action	Entire AOI. Probably lower impact within the areas deeper than 30 m LAT (northern AOI)	• Dynamic and cyclic loading • Burial or exposure, leading to loss of support, instability and damage	• Meteocean site-specific desktop study • Scouring site-specific study • Trenching to a certain depth (depending on estimated wave action depth)
Steep slopes / irregular topography	Flanks of Maasmond Kanaal Steep slopes also associated with bedforms, seafloor objects and dredging areas	• Uneven support of structure • Critical stresses on structure • Non-uniform penetration	• Avoidance • Trenching within bedforms

Constraint / Geohazard	Location / Distribution	Impact on Structure	Possible Mitigation
		• Slope failure • Lateral displacement of structure • Trenching difficulties	
Slumping	Northern flank of Maasmond Kanaal	• Slope instability and failure • Critical stresses • Scour and spanning or burial and loading • Rupture or failure of pipeline	HDD solution
Very soft clays	In Maasmond Kanaal and locally across the entire AOI, especially in paleo-channels	• Potential plough sinkage • Non-uniform penetration	• Jetting to install pipeline in soft sediments • Geophysical survey data to perform precise mapping of paleo-channels using UHR seismic or SBP data
Interbedded sand and clay sediments	Offshore Distribution HUB Area	Punch-through risk for foundation	Geotechnical survey at Offshore Distribution HUB location to refine geotechnical unitisation and parameters
Very dense sand	Entire AOI	• Trenching difficulties • Early refusal/limited penetration with plough	Selection of tools for pipeline emplacement suitable to deal with geotechnical properties
Gravel, cobbles and / or boulders	Localised areas across the AOI, particularly close to shore in the Landfall/Shore Crossing Area (in rock dumps of the flood-defence structure) and in deposits of Drente Formation	• Obstruction, trenching difficulties, possible early refusal or damage to structure • Gravel layers may impact HDD operations	• Detailed mapping of seafloor sediments along pipeline routing and across Offshore Distribution HUB area (MBES, SSS) • Detailed mapping of boulders expected at depth in UHR seismic and SBP data • Avoid areas with boulders
Peat / organic material	Locally present across AOI	• High compressibility, non-uniform support • chemical reaction between soil and steel • shallow gas	Geophysical and geotechnical survey in order to map and avoid areas where peat is expected
Pockmarks / shallow gas (peat)	Locally present in the Landfall/Shore crossing Area. Can be locally present in the AOI	• Laterally variable soil strength, steel corrosion, spanning of pipeline • Masking of acoustic signal • Risk of blowout and gas release during drilling and piling operations	• Geophysical survey data to detect shallow gas accumulations within seismic data • Map related seafloor features (pockmarks) • Avoid areas with shallow gas or identified markers (pockmarks)

Constraint / Geohazard	Location / Distribution	Impact on Structure	Possible Mitigation
Glacial TILL / boulder clay	Present locally in NE of AOI (Gieten Member)	• Spatially variable soil conditions • Heterogenous soil • Cobbles and boulders leading to challenging installation conditions	• Geophysical survey data to perform precise mapping and identification of these type of deposits using UHR seismic or SBP data • Geotechnical data collection to characterise conditions • Selection of pipeline emplacement method that can cope with variable soil conditions
Glaciotectonic deformation features	Present locally in NE and centre of AOI, related to the Gieten Member and Drachten Formation	• Variable soil conditions • Lower lateral resistance	• Geophysical survey data to perform precise mapping and identification of these type of deposits using UHR seismic or SBP data • Geotechnical data collection to characterise conditions
Regional subsidence / (historic) oil and gas extraction	Entire AOI	• Time-dependent reduction of freeboard of pipeline • Damage to structure	Monitoring during ongoing pipeline inspection surveys

Table 5.2: Summary of identified man-made obstructions and constraints across the AOI

Constraint / hazard	Location / Distribution	Impact on Structure	Possible Mitigation
Existing and planned future structures	Across AOI	• Obstruction • Potentially disturbed ground • Potential interruption in hydraulic flow regime affecting scour and soil deposition processes	• Relocation • Design pipeline/cable crossing • Collection of specific geophysical survey data at crossing locations
Rock dump / fill	Shorelines in the Landfall/Shore crossing Area related to coastal defence structures	• Disturbed soil / variable soil conditions • Potential interruption in hydraulic flow regime affecting scour and soil deposition processes • Pipeline abrasion • Installation problems	• Identify and map • Avoidance and relocation
Artificial soil / contaminated soil	Landfall/Shore crossing Area and dumping areas	• Variable soil conditions • Contamination	Avoidance and relocation
Wellheads	Across AOI	• Obstruction • Potentially pressurised shallow gas in soil	Avoidance and relocation

Unexploded ordnance (UXO)	See Appendix C	• Obstruction • Damage to structures • Uneven seafloor, disturbed soil	• UXO precise identification along pipeline route via magnetometer survey • UXO hazard risk assessment • Relocation • UXO clearance processes
Shipwrecks / dropped objects	See Appendix B and Appendix C	Obstruction	• Archaeological study and identification along pipeline route • Relocation • Investigate and remove if required
Potential archaeological targets	See Appendix B	• No / limited access • Project delay	• Archaeological study and identification along pipeline route • Relocation • Investigate and remove if required
Restricted areas (nature reserve, military exercise)	Across AOI	No / limited access	• Relocation • Permission requirements
Dredging and dumping areas	Across AOI	• Uneven seafloor • Disturbed soil • Variable soil conditions • Lateral displacement • No / limited access	• Damage to structures • Relocation • Permission requirements
Fishing activity (anchor and / or trawl scars)	Throughout most of AOI	• Disturbed soil / variable soil conditions • Entanglement of fishing gear • Damage to structure and offshore equipment • Lateral displacement	• Clearance operations before any site surveys, fishing liaison officer during survey works • Trenching to avoid damage from anchors or trawls
High level of shipping activity and anchorage areas	• Near Rotterdam and IJmuiden harbours • Navigation Channels	• Entanglement of anchor(line) • Damage to structure • Lateral displacement	• Clearance operations before any site surveys • Trenching to avoid damage from anchors or trawls

Figure 5.1 displays the extent of some mapped and identified soil constraints and geohazards. These includes:

- Glacial TILL;
- Areas with expected boulders;
- Areas with very soft surficial sediments;
- Expected paleo-channels;
- Extent of unit ivb, composed of stiff to hard CLAY.

Bedforms are mapped and highlighted as part of Figure 4.17, while steep slopes are highlighted in Figure 4.8 to Figure 4.16.

Most of the identified man-made seafloor obstructions and constraints are listed and mapped within Sections 4.1 and 4.2.4 of the report. More details on UXO and archaeological related features are provided within specific reports (see Appendix B and Appendix C).

Soils containing the mineral glauconite and/or carbonate soils are not expected to be present in the AOI (including the Landfall/Shore crossing Area) within the depth of interest based on available data.

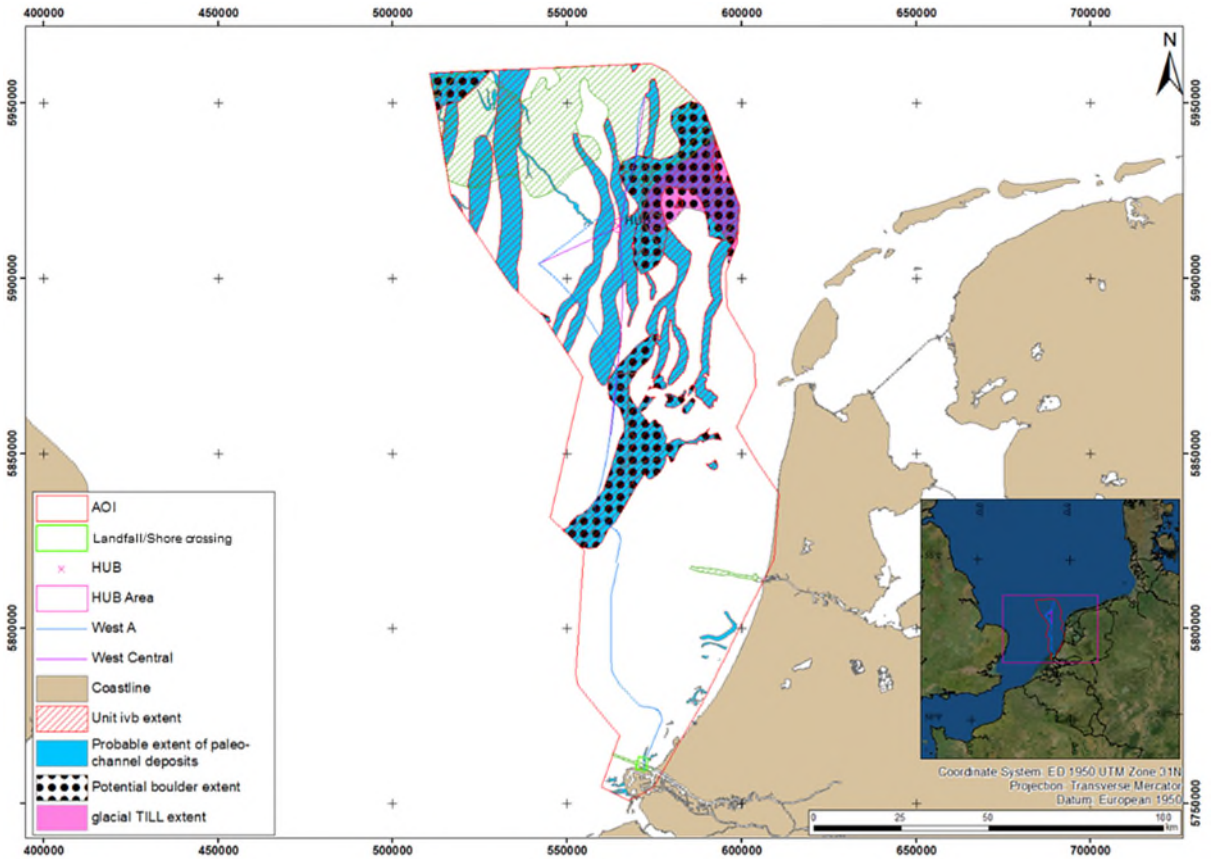


Figure 5.1: Map of identified soil constraints and potential geohazards across the AOI

5.2 Seismicity

Natural seismicity is mainly restricted to the southern (onshore) part of the Netherlands, where earthquakes with magnitudes of 2.5 to 6.0 are possible. The AOI lies within a tectonic region known as the West Netherlands Basin, which has been seismically quiet since the Neogene (Deltares, 2017).

The extraction of natural gas is known to produce induced seismicity. A total of 186 oil and gas fields are located in the AOI. Several induced seismic events related to these fields were recorded. These earthquakes had a magnitude between 2 and 4 (Deltares, 2017; Arcadis, 2018).

It is recommended that a probabilistic seismic hazard assessment is performed for the gas fields that are within a 5 km radius of the Landfall/Shore crossing Area and Offshore Distribution HUB Area to confirm the actual seismic hazard.

6. Conclusions and Recommendations

6.1 Conclusions

This desktop study aimed at characterising the soil conditions based on available public data and Fugro experience over an area of 11355 km^2 within the southern North Sea, Dutch sector. The ultimate purpose of the report is to provide information to help TotalEnergies in decision making regarding the ARAMIS Pipeline routing and provide recommendations regarding future site-specific surveys.

Based on available data, three preliminary geotechnical ground models focusing on three different areas are provided. These allow to picture the soil conditions and vertical and lateral variability to depth of interest. Geotechnical parameters were derived based on Fugro experience across the southern North Sea. The data review and analysis also allowed to list potential (geo)hazards, soil and anthropogenic constraints and man-made obstructions within the AOI.

The results provided within this desktop study are dependent on the available data and on data quality. Due to the large surface covered by the AOI, approximations and simplifications were made to create a comprehensive ground model allowing to capture the expected range of soil conditions. Variability within the defined soil units is expected, arising from varying depositional environments captured within independent units.

Site-specific data acquisition should be considered to refine and confirm the findings of the present study, once a more precise pipeline routing has been decided. Some recommendations are provided hereafter to help reducing uncertainties and mitigate identified (geo)hazards in the AOI.

6.2 Recommendations

Possible mitigation of identified or potential (geo)hazards and anthropogenic or soil constraints, including relocation of pipeline, engineering solutions or avoidance of certain features are already detailed in Table 5.1 and Table 5.2. These elements should help TotalEnergies in the decision making for the final pipeline route.

To better capture site conditions and soil variability along the future pipeline route and at specific areas (Offshore Distribution HUB and Landfall/Shore crossing Areas), several recommendations on further specific studies, geophysical and geotechnical site surveys are listed in this section. Most of these recommendations, in particular geophysical and geotechnical surveys will have to be considered once the pipeline route is decided.

6.2.1 Further Specific Studies

To better characterise some elements that are highlighted or identified within the present DTS, Fugro recommends performing specific studies including, but not limited to:

- Metocean site-specific desktop study to better understand mobility of bedforms and sediments due to currents, waves and tides;
- A sediment mobility assessment and study based on bathymetric data acquired at different dates across the area. This could be accompanied by specific site surveys in areas of identified high risks;
- UXO risk assessment study as defined in the conclusions of the UXO historical DTS (Appendix C) allowing to set fitting mitigation strategies.

6.2.2 Geophysical Site Surveys

Once the pipeline route corridor is agreed on, a number of geophysical methods should be considered to refine the mapping and identification of seafloor features and better define the variability of sub-seafloor soil units. They will in turn allow to better mitigate soil constraints and (geo)hazard-relatedrisks. Data acquired during these geophysical site surveys may include:

- MBES data to be acquired along the pipeline route with a typical corridor of 2 km allowing any re-routing if avoidance of any identified feature is required. MBES data will provide a high-resolution bathymetry along the route allowing to compute precise slope maps. Reflectivity may also be acquired during MBES operations giving a detailed representation of the seafloor rugosity. MBES should also be acquired around the planned Offshore Distribution HUB Area;
- SSS data to be acquired along the pipeline corridor with a typical corridor of 2 km and around the Offshore Distribution HUB location. SSS data helps identifying seafloor features and sediment types;
- SBP data to be acquired along the pipeline corridor. This will better characterise the sub-seafloor variability at the pipeline location, helping in the planning of the geotechnical site survey. At the Offshore Distribution HUB location and along the planned Landfall/Shore crossing Area, SBP grids should be acquired before any operations to identify potential sub-seafloor soil constraints and estimate soil variability. SBP can also provide valuable information when identifying preserved paleo-landscapes and potential prehistorical archaeological sites (Appendix B);
- UHR seismic data can be planned locally where specific designs are needed (such as HDD, piling at the Offshore Distribution HUB Area, trenching, tunnelling). UHR seismic data will provide a better penetration within deeper dense/hard units;
- A magnetometer survey must be performed along the entire pipeline corridor to identify any wrecks and UXOs at or close to the seafloor.

6.2.3 Geotechnical Site Surveys

Soil sampling and in situ testing (CPTs) are paramount to refine the geotechnical soil conditions and variability with depth. A geotechnical survey should be designed after geophysical data are acquired and interpreted to optimise the sampling and locations (both distribution and quantities). Where variable conditions or specific risks are identified, more

locations may be required to better constrain them. Where more homogeneous conditions are expected, less locations could be planned. Geotechnical surveys should include:

- Sediment sampling to identify, log and test soil types. Sampling methods include gravity corers, box corers, grab samples and vibrocorers. A variety of laboratory testing can be considered, including geological testing (Multi-Sensor Core Logging, mineralogy, or dating) or geotechnical testing (water content, P-wave velocity, electrical resistivity, thermal conductivity, shear vane and oedometer tests). Specific geotechnical testing could be considered in order to measure the clay sensitivity;
- CPT allows to capture the site-specific soil conditions through a variety of measurements such as cone resistance and sleeve friction. It allows to identify soil units at depth and measure in situ mechanical properties such as sediment undrained shear strength (s_u) for clay or relative density for sand.

Along the pipeline route the depth of geotechnical locations can be limited to the first 5 m to 6 m BSF, while geotechnical locations within the Landfall/Shore crossing Area and at the Offshore Distribution HUB location should have greater penetration depths. For these deeper locations Fugro recommends downhole sampling and testing from a dedicated drilling platform (e.g. geotechnical drilling vessel or jack-up platform).

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Appendix A

Guidelines on Use of Report

A.1 Guidelines on Use of Report

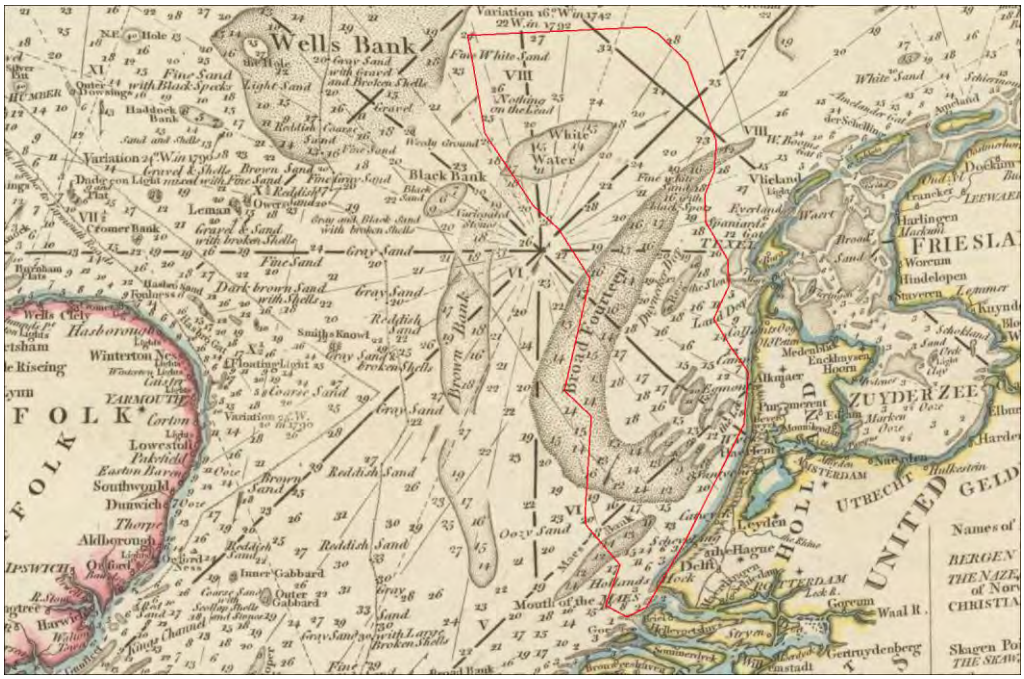
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Appendix B

Archaeological Desktop Study

Periplus Archeomare

Archaeological Desk Study
Area of interests
Aramis pipelines



Authors

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At the request of

FUGRO

Document Control	
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Colophon

Periplus Archeomare Report 21A036-01

Archaeological desk study area of interest Aramis pipelines
Authors: [redacted] and [redacted]
At the request of: Fugro
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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

Location:	North Sea		
Toponym:	Aramis pipelines		
Chart:	1801-01		
Coordinates Geodetic datum: ED50 Projection: UTM31N	Centre:	E 560722	N 5856233
	NW	E 510577	N 5961562
	NE	E 610866	N 5961562
	SW	E 510577	N 5750904
	SE	E 610866	N 5750904
Depth (LAT):	0 to 46.1 meter, average 26.7 meter		
Surface investigation area	11,355 km^2		
Environment:	Tidal currents, salt water		
Area use:	Shipping , fishing, wind farm zones		
Area administrator:	Rijkswaterstaat Zee en Delta Municipality of Rotterdam		
ARCHIS number:	5144645100		
Periplus-project reference:	21A036-01		
Period of execution	January 2022		

Samenvatting (in Dutch)

Periplus Archeomare heeft in opdracht van Fugro een archeologisch bureauonderzoek uitgevoerd naar het plangebied voor de Aramis-leidingroutes. Het gebied van 11.355 km2 ligt in de Noordzee, voor de kust van Nederland.

Door de aanleg van de leidingen kunnen eventueel aanwezige archeologische resten in het gebied worden bedreigd. Volgens de Erfgoedwet (2016) is een wettelijke verplichting om archeologisch onderzoek te doen om archeologische resten te beschermen. Dit archeologische bureauonderzoek is de eerste stap in het archeologisch proces om vast te stellen of archeologische resten aanwezig zijn en of deze resten kunnen worden aangetast door de aanleg van de geplande pijpleidingen. De resultaten zijn hieronder samengevat.

Het gebied heeft hoge verwachtingen voor de aanwezigheid van (overblijfselen van) scheepswrakken en vliegtuigwrakken uit de Tweede Wereldoorlog. Intacte prehistorische landschappen en verwante in situ overblijfselen van paleolithische en vroeg-mesolithische campings en opgravingen kunnen op bepaalde plaatsen bewaard zijn gebleven. De voorlopige pijpleidingroutes zijn nog niet onderzocht door gedetailleerde geofysische onderzoeken. Deze gebieden bevatten mogelijk meer onontdekte scheepswrakken of overblijfselen van scheepswrakken dan nu bekend is.

Op dit moment is er nog weinig bekend over de integriteit van het Pleistoceen landschap. Door middel van seismiek kunnen hierin de voorkomende geologische eenheden (zowel horizontaal als verticaal) en archeologische niveaus in kaart worden gebracht. Het karakter van laaggrenzen (erosief of niet-erosief) kan worden geïnterpreteerd. Het is echter onwaarschijnlijk dat archeologische overblijfselen van paleolithische en mesolithische nederzettingsresten op basis van geofysisch en geotechnisch onderzoek met voldoende zekerheid kunnen worden geïdentificeerd om beperkingen op te leggen aan de aanleg van pijpleidingen. In dit stadium moet daarom niet worden geconcentreerd op het opsporen van prehistorische nederzettingsresten, maar op een pragmatische inzet geofysische technieken inzetten om een beter inzicht te krijgen in (de integriteit van) het Pleistoceen landschap. De verkregen inzichten zullen worden gebruikt om a) het archeologische verwachtingsmodel te verfijnen en b) gebieden met een hoge verwachting voor in situ prehistorische overblijfselen toe te wijzen.

Conform de AMZ-cyclus wordt geadviseerd om een inventariserend veldonderzoek uit te voeren om de archeologische verwachting. In het algemeen bestaan vergelijkbare onderzoeken uit een geofysisch onderzoek met side scan sonar, magnetometer en subbottom profiler en een geotechnisch onderzoek. De resulterende gegevens moeten worden geanalyseerd nadat de algemene verwerking, interpretatie en rapportage door de onderzoeksaannemer is uitgevoerd.

De archeologische beoordeling van de gegevens dient te worden uitgevoerd door een geofysisch specialist (KNA prospector Waterbodems). De datakwaliteit van de onderzoeken moet aansluiten bij de eisen voor deze archeologische beoordeling. Om de afstemming tussen het geofysisch onderzoek en de vereiste kwaliteit voor deze beoordeling te waarborgen, dient een Programma van Eisen opgesteld te worden conform de KNA (Kwaliteitsnorm Nederlandse Archeologie 4.1) dat door de bevoegde autoriteit wordt beoordeeld en goedgekeurd.

Summary

Periplus Archeomare was assigned by Fugro to conduct an archaeological desk study of the area of interest for the Aramis pipeline routes. The area of interest of 11.355 km^2 is located in the North Sea, off the coast of the Netherlands.

The installation of the pipelines may affect archaeological remains in the area, if present. According to the Law on Archaeological Heritage (Dutch: Erfgoedwet 2016) there is a statutory obligation to conduct archaeological research in order to protect the remains. This archaeological desk study is the first step in the archaeological process aiming to establish whether archaeological remains are, or are likely to be, present, and whether these remains could be effected by the development of the planned pipelines. The results are summarized below.

The area of interest has a high expectation for the presence of (remains of) ship wrecks and WWII plane wrecks. Intact prehistoric landscapes and related *in situ* remains of Palaeolithic and Early Mesolithic camp sites and inhumations are expected to have been preserved in places.

The proposed pipeline routes have not been investigated by detailed geophysical surveys yet. These areas may contain more undiscovered shipwrecks or remains of shipwrecks than currently known.

At this stage little is known about the integrity of the *Pleistocene* landscape. By means of subbottom profiling the occurrence geological units (both horizontal as vertical) and archaeological levels herein can be mapped. The character of layer boundaries (erosive or non-erosive) can be interpreted. It is unlikely however that archaeological remains of Palaeolithic and Mesolithic camp sites can be identified with sufficient certainty (based on the geophysical and geotechnical surveys) to impose restrictions on pipeline development. At this stage focus should therefore not be put on tracing prehistoric camp sites but on a pragmatic employment of geophysical techniques in order to obtain a better insight in (the integrity of) the *Pleistocene* landscape. The insights gained shall be used to a) refine the archaeological expectancy model and b) allocate areas with a high expectancy for *in situ* prehistoric remains.

In accordance with the AMZ cycle it is advised to conduct a field investigation (in Dutch '*Inventariserend veldonderzoek opwaterfase*') in order to test the archaeological predictive model and further specify the type, vertical and lateral extent, age, integrity and preservation of ship wrecks, prehistoric landscapes and potential archaeological levels.

Archaeological Expectancy	**Method**		**Goal**	**Remarks**
Ship and aircraft wrecks	Geophysical	Side Scan Sonar	detect and map wreck sites	wrecks exposed at, or protruding from the seabed
		Multibeam	characterize wreck sites morphologically; detect (partially) buried wrecks by the occurrence of scours	in addition to side scan sonar
		Sub-bottom Profiler	detect buried objects including possible ship wrecks and remains of aircraft	nature of the buried object cannot be determined directly
		Magnetometer		
Prehistoric settlements		Sub-bottom Profiler	map the Pleistocene landscape; specify expectancy	supported by, and validated with drill data

Archaeological Expectancy	Method		Goal	Remarks
(camp sites)	Geotechnical	Geological Sampling	determine lithostratigraphy, soil layer boundaries (erosive or gradual) and characteristics of soil formation and maturation; specify expectancy	designation of borehole and/or vibrocore locations for geo-archaeological research based on SBP data
		Cone Penetration Test	determine lithostratigraphy	correlate with drilling data

In general, similar investigations carried out in the past consist of a geophysical survey with *side scan sonar*, *magnetometer* and *subbottom profiler* and a geotechnical survey. The resulting data should be assessed after the general processing, interpretation and reporting has been performed by the survey contractor.

The archaeological assessment of the data shall to be conducted by a geophysical specialist (KNA prospector Waterbodems). The data quality from the surveys needs to match the demands for this archaeological assessment. To ensure compatibility between the site investigation and the required quality for this assessment it is recommended to define a Program of Requirements (In Dutch: 'Programma van Eisen') in accordance with the 'KNA' (the Dutch quality standards for archaeological research), to be authorized by the competent authority.

1 Introduction

Periplus Archeomare was assigned by Fugro to conduct an archaeological desk study of the area of interest for the proposed Aramis pipeline routes. The area of interest of 11.355 km^2 is located in the North Sea off the coast of the Netherlands.

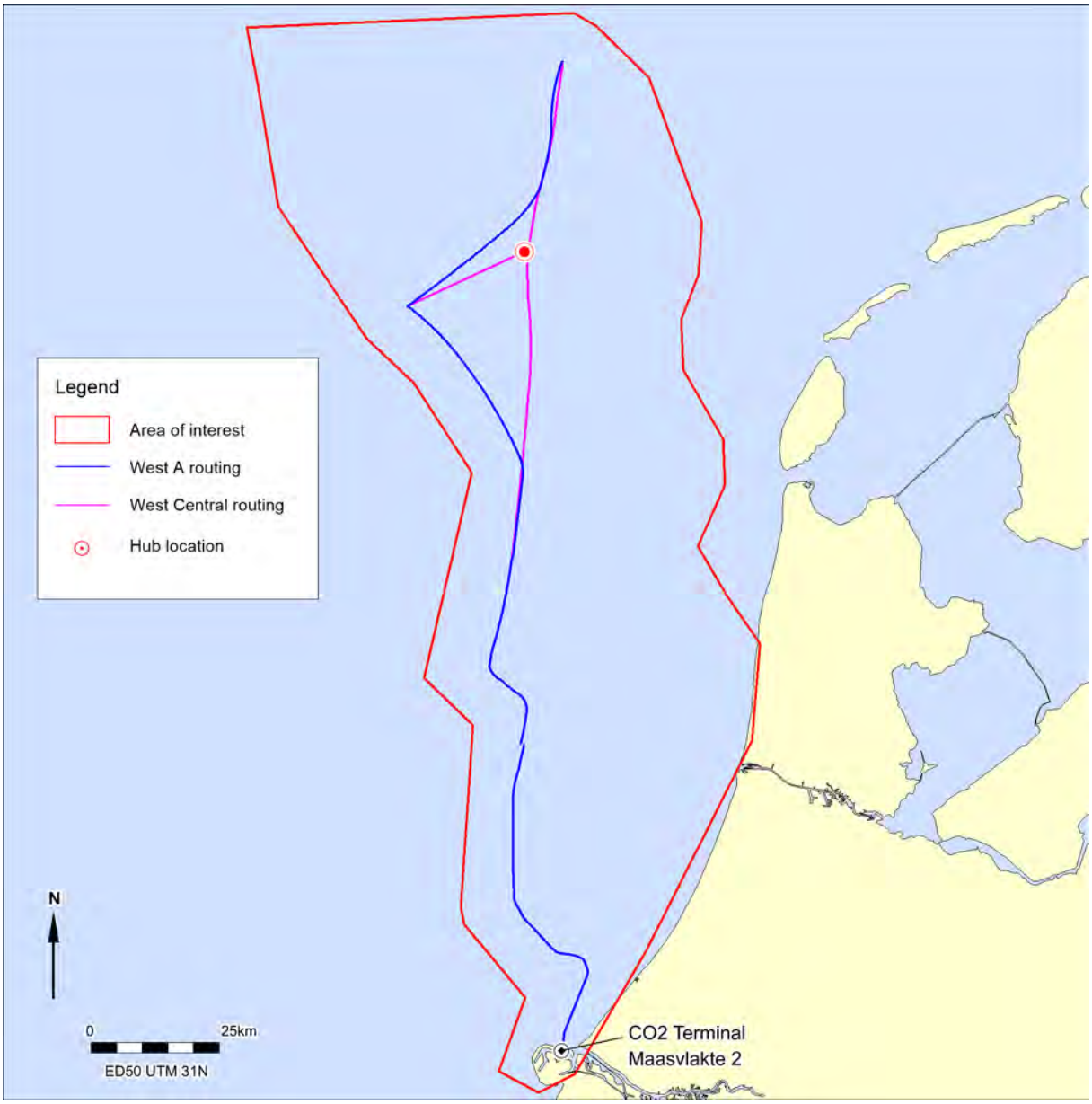


Figure 1. Location map of the area of interest

The desk study and reporting were carried out in accordance with the Dutch Quality Standard for archaeological research[1].

[1] Kwaliteitsnorm Nederlandse Archeologie (KNA waterbodems 4.1).

1.1 Background

TotalEnergies plans to build a new pipeline from Maasvlakte 2 to offshore blocks L4/K6 as part of the CCS Aramis project. The area to be investigated encompasses:

(1) the shore approach/Landfall pipeline routing for HDD and dredging part at Maasvlakte
(2) the offshore rigid pipeline routing from Maasvlakte to blocks L4/K6
(3) the offshore distribution hub.

As a preparation phase of the future surveys to be performed, TotalEnergies intends to conduct desktop studies of the area of interest. The final routing and the location of the distribution hub are not defined yet.

In the Law on Archaeological Heritage (Erfgoedwet 2016), emerged from the Malta Convention (1992), incorporated in the Monuments Act through the Archaeological Heritage Act, the protection of the archaeological heritage is regulated. Planned activities, such as the installation of pipelines in the North Sea, may affect the archaeological values if present. If effects on possible remains are expected, there is a statutory obligation to conduct archaeological research. This process is also outlined in the Water Decree (Dutch: Waterbesluit).

This archaeological desk study for the proposed Aramis pipeline is the first step in the archaeological process as part of the so-called *AMZ* cycle.

1.2 Objective

The purpose of an archaeological desk study in general is to specify the archaeological expectancy for a certain area. More in detail, the purpose of this desk study is to establish whether archaeological remains are, or are likely to be, present along the pipeline route, and whether these (possible) remains could be affected by the installation of the pipeline. Where possible, the desk study aims to give insight into the (possible) archaeological value of these remains in terms of their physical or scientific value, such as the overall quality of preservation and the rarity of the remains. Furthermore, this report aims to make recommendations regarding subsequent steps in dealing with known and expected archaeological remains along the pipeline route.

The archaeological management procedure (‘AMZ-cycle’) is a defined sequence of steps and decisions within archaeological heritage management in the Netherlands. The procedure is embedded in the Dutch Quality Standard for Archaeology (KNA Waterbodems 4.1) as the mandatory workflow for archaeologists. A detailed description of the different phases of archaeological research is included in appendix 1.

1.3 Research questions

For an archaeological desk study, the following research questions are applicable:

- Are there any known archaeological values present within the area of interest? If so, what is the nature, extent (depth) location and dating of these sites?
- Are there, in addition to any known values, archaeological remains to be expected? If so, what are the nature, extent (depth) location and date of the expected archaeological remains?
- Can the proposed activities affect known or expected archaeological values? If so, can an impact on archaeological assets be prevented or restricted by planning adaptation?
- If the archaeological values cannot be saved: What kind of further research is needed to determine the presence of archaeological values and their size, location, type and date to be determined enough to come to a selection decision?
- What are the possible effects of the installation of the pipeline on the areas with specific archaeological interest?
- What are the possibilities to mitigate the disturbance of areas with specific archaeological interests?
- Should further investigations be carried out from archaeological point of view and what are the recommendations on the scope and specifications of these investigations?

If, on the basis of this desk study, a connection can be made with other questions from the *NoaA* 2.0, then these must be answered. Given the nature of the research and the often limited possibilities for the identification of archaeological object, it is not possible to select all the questions in advance. As far as the possible find categories are concerned, there are also various ongoing research programs at universities, with which a relationship can be established.

1.4 Research and management framework

Our knowledge of the development of *Pleistocene* and Early *Holocene* landscapes and the plants, animals and humans who lived in the North Sea area is limited. This gap in geo-archaeological knowledge was recognized by the Dutch Cultural Heritage Agency (Rijksdienst voor het Cultureel Erfgoed). To provide tools to fill this gap the 'North Sea Prehistory Research and management Framework (NSPRMF)' was published, in which the foundation was laid for future research and management of the prehistoric heritage. The themes and topics of the NSPRMF are listed in table 3.

Theme	Topics
A. Stratigraphic and chronological frameworks	A.1: Lithostratigraphic classification and chronological anchoring A.2: Sea level change and glacio-isostacy A.3: Survival of deposits of archaeological significance A.4: Biostratigraphies and absolute dating
B. Palaeogeography and environment	B.1: Middle/Late Pleistocene reshaping of topography and river drainage B.2: Development of the Weichselian/Devensian landscape B.3: Palaeogeographic evolution after the Last Glacial Maximum (LGM) B.4: Quaternary palaeoecology
C. Global perspectives on intercontinental hominin dispersals	C.1: North Sea coastal dynamics and human uses of the coastal zone C.2: Pleistocene North Sea level oscillations and population of islands
D. Pleistocene hominin colonisations of northern Europe	D.1: Early human exploitation strategies in changing environments D.2: Natural barriers for hominin expansion
E. Reoccupation of northern Europe after the Last Glacial Maximum (LGM)	E.1: Post-LGM occupation flux E.2: Occupation strategies
F. Post-glacial land use dynamics in the context of a changing landscape	F.1: Changing landscape structure F.2: Behavioural diversity among hunter-gatherers F.3: Maritime archaeologies of the North Sea
G. Representation of prehistoric hunter-gatherer communities and lifeways	G.1: Spatial perspectives on North Sea palaeolandscapes G.2: The distributional nature of early hominin communities G.3: Enculturated hunter-gatherer landscapes

* Despite the fact that theme G primarily focusses on post-LGM hunter-gatherers, topic G.2 was broadly defined, and of equal relevance to theme D.

Table 3. NSPRMF - research themes and topics (Peeters 2009)

In 2019 the NSPRMF agenda was retuned based on the developments in the previous decade. This report contains the basis for policy in the years to come. The archaeological studies currently conducted in the context of wind farm development, pipeline and cable installation, sand extraction and exploration for oil and gas in the North Sea area, are conducted in accordance to the AMZ-cycle. These studies shall contribute to the goals set in the NSPRMF.

As described above little is known about the early *Holocene* inhabitants of the North Sea region, their settlements and the way in which they maintained themselves in the rapidly changing landscape. The information value of the expected settlements is therefore large. This is also stated in the National Research Agenda for Early Prehistory: *Locations and any surrounding phenomena that are located in paleo-landscape contexts that have not or have hardly been investigated have by definition a large information value.* For future investigations, reference shall therefor be made to the framework and the research questions in the *NOaA* in addition to the NSPRMF.

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 LS01, LS02, LS03, LS04 and LS05. The study is reported in accordance with specification LS06.

In order to comply with the main objectives and answer the research questions, the archaeological desk study is carried out according to the scope of Work as described in the following steps:

- Description of the Area of Interest and determination of the consequences for future use (LS01);
- Description of the current usage of the area of Interest (LS02);
- Description of the historical situation and possible disturbances (LS03);
- Description of the geological setting within which the archaeological objects are to be found (LS04);
- Description of the known archaeological features and objects (LS04);
- Definition of a specified archaeological expectation (LS05).

Based on these components a specified archaeological expectation is defined. It is expressed whether, and if so, which archaeological values can 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 3. Based on the results the research questions are answered in chapter 4. The study concludes with a summary and recommendation in chapter 5.

The research and reporting were conducted by S. van den Brenk (senior marine archaeologist) and R. van Lil (senior marine prospector). The results were approved and authorized by B. van Mierlo (Senior marine prospector).

2.1 Sources

The following sources were consulted for the study:

- Archis III, archaeological database of the Dutch Cultural Heritage Agency
- Databases of Periplus Archeomare
- Dutch Federation for Aviation Archaeology (NFLA)
- Geological maps
- Geological publications
- Scope of Work NL DTS Aramis (Memo TotalEnergies)
- National Contact Number (NCN) database Rijkswaterstaat
- Rijkswaterstaat Zee en Delta
- The Hydrographic Service of the Royal Netherlands Navy
- *TNO-NITG*; geological borehole data and maps
- Various results from previous investigations in the area of interest
- Various sources from the Internet

For a complete overview of the sources and literature see references on page 51. Words in *italics* and abbreviations are explained in the glossary on page 50.

3 Results

3.1 Definition of the area of interest and consequences of future use (LS01)

The area of interest is located off the west coast of the Netherlands and stretches from Maasvlakte 2 to mining block L4, 75 km northwest of the island of Texel.

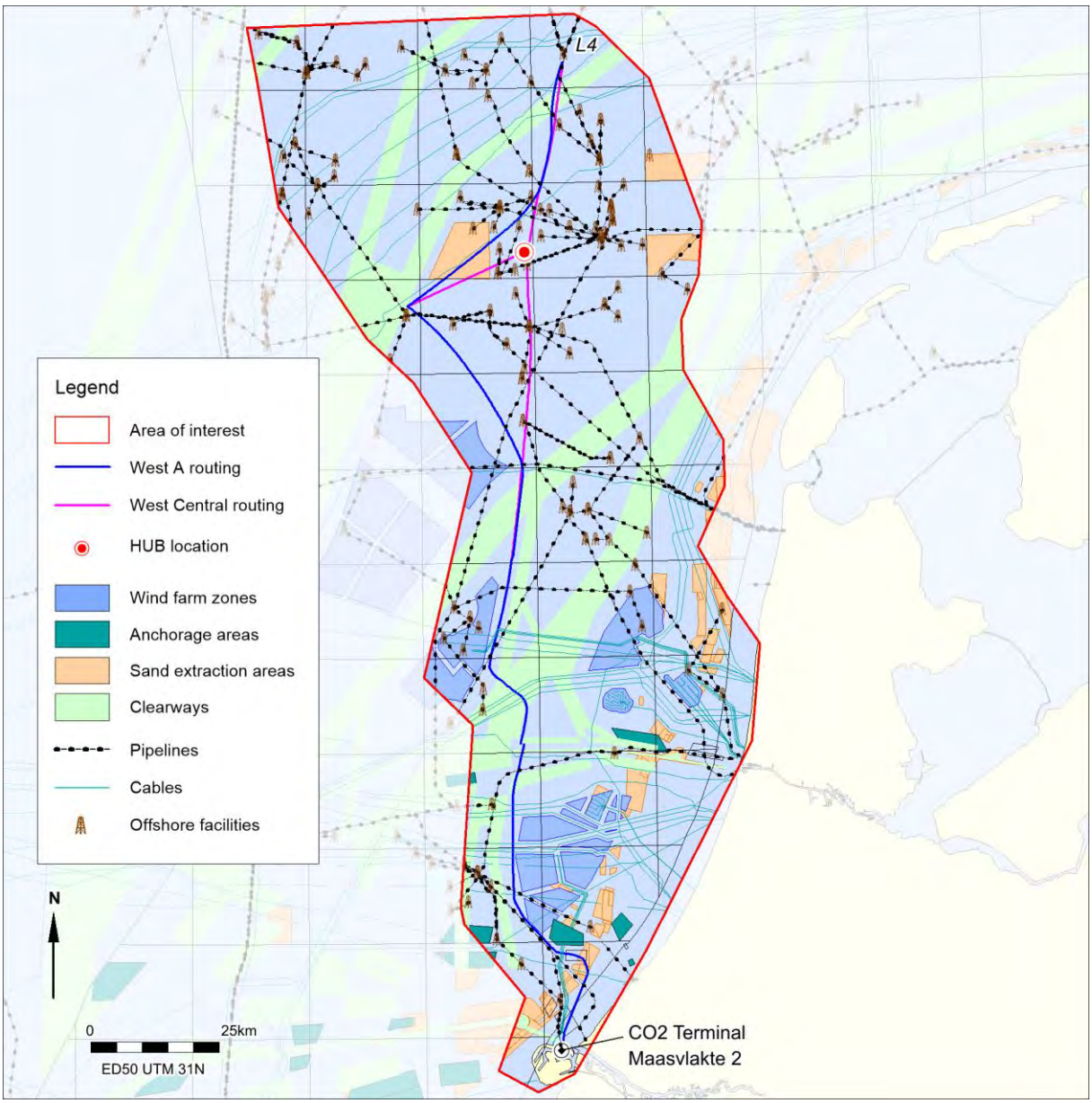


Figure 2. Overview of the area of interest in relation to other areas of use

The trenching of the pipelines has a direct impact on the seafloor, which might have an effect on the possible presence of cultural heritage. In the longer term, exposed pipelines can cause a change in seafloor morphology due to change of tidal currents. This may cause, in turn buried ship wrecks to emerge at the surface, exposing them to erosion.

Previous research

Parts of the area of interest have been investigated in the past for archaeological purposes:

- Several offshore drill locations
- Wind farm zones Hollandse Kust North, South and West
- Cable and pipeline corridors

The outlines of the investigated areas are shown in the figure below.

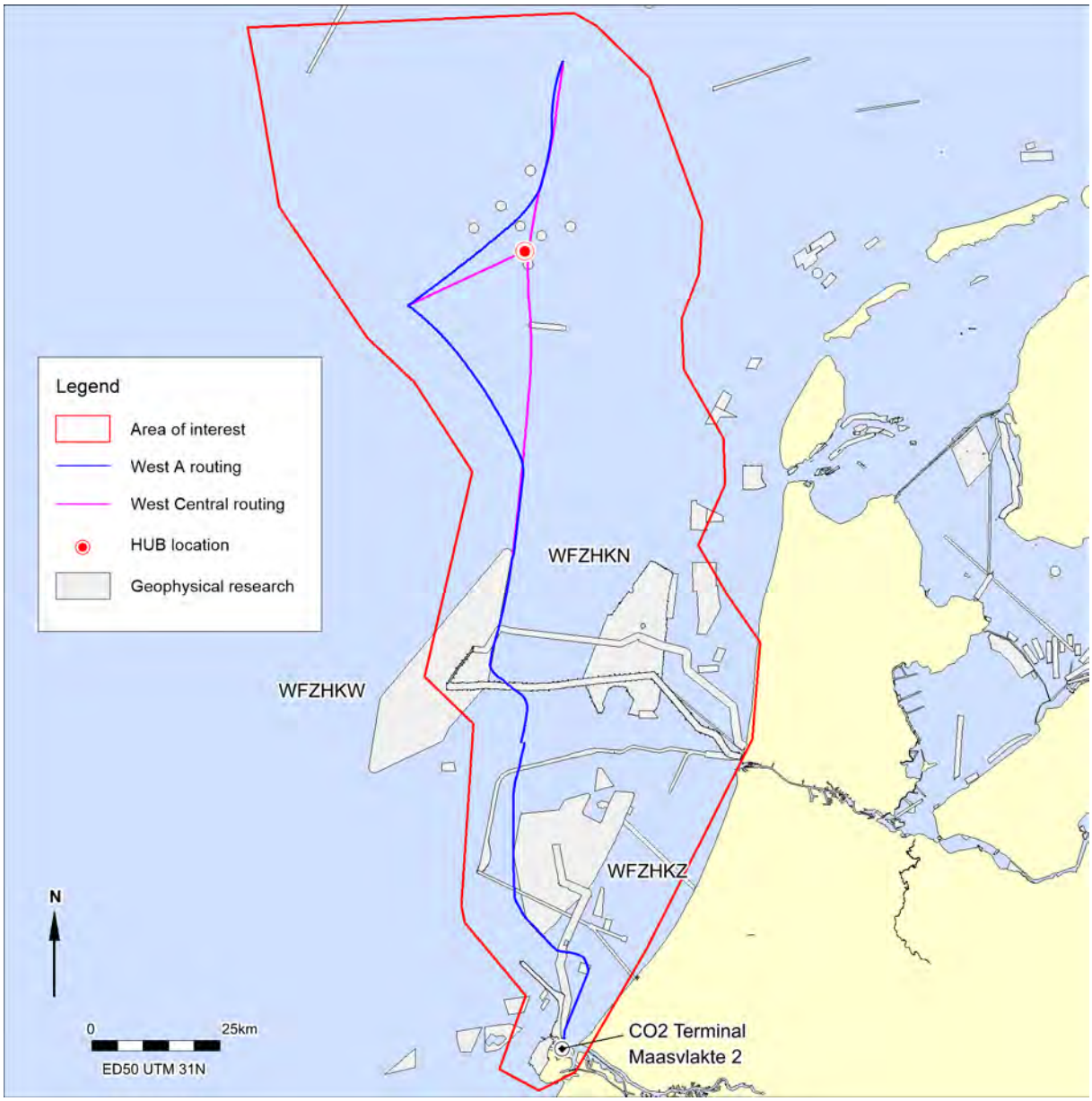


Figure 3 Previous conducted archaeological investigations in the area

The results of these investigations have been incorporated in paragraph 3.5, description of known archaeological values.

3.2 Description of the current situation (LS02)

The figure below shows a colour depth map based on composite data from the Hydrographic Service (25m grid, 2009) and data from various wind farm zones (5m, 2026-2020).

The water depth within the area of interest varies from 0 to 46.1 meter (LAT), with an average of 26.7 meter (LAT).

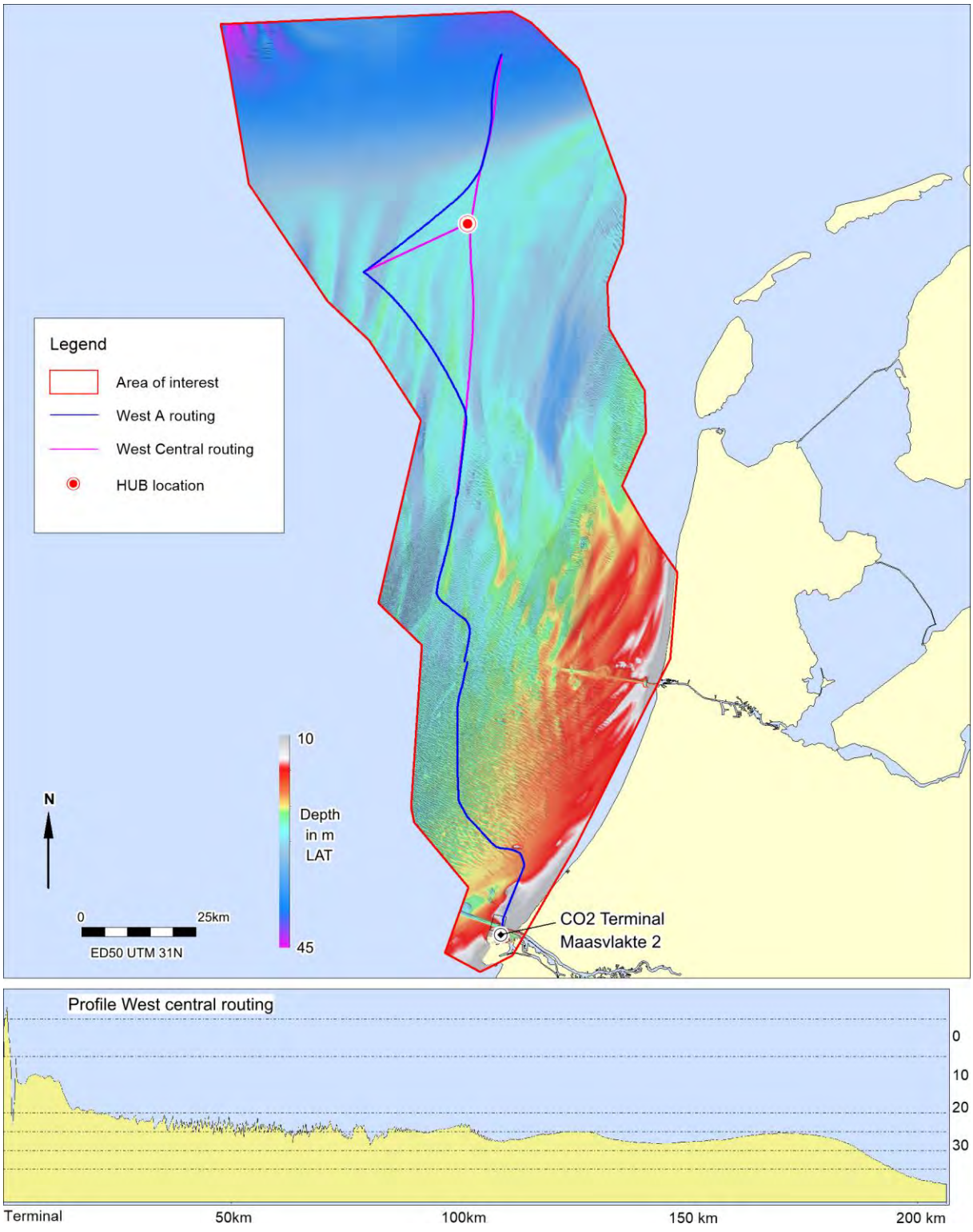


Figure 4. General bathymetry of the seabed and profile along the West central routing

The seabed is characterized by three types of morphological structures. The largest structures are north-south orientated ridges. The ridges vary in width from 1km to 4km and are generally up to 10m in height. Superposed on the ridges sand waves have developed. The occurrence of sand waves is confined to the southwestern and central part of the area. The sand waves are up to 4m in height; the average distance between the crests is 300m. The crest heights tend to diminish towards the north. The sand wave crest orientation changes from west-east to northwest-southeast at the intersections with the large north-south orientated ridges.

Mega-current ripples which developed on top of the sand waves cannot be distinguished due to the grid-scale available (25m), but are nonetheless expected to be present. The ripple height is often less than a few dm; the distance between the current ripple crests is up to 10m.

The large ridges, sand dunes and current ripples have formed in the top layer of mobile sand. The ripples migrate along with tidal currents; the sand dunes typically migrate with a speed of 1 to 10 m/year. The migration rate of sand dunes in the Princes Amalia Wind Farm Zone was assessed to be in the order of 4 m/year[2].

[2] Laban 2004.

Landfall area

An overview of the recent bathymetry in the landfall area is constructed based on composite data from various surveys (Hydrographic service, Rijkswaterstaat and Tennet, with permission).

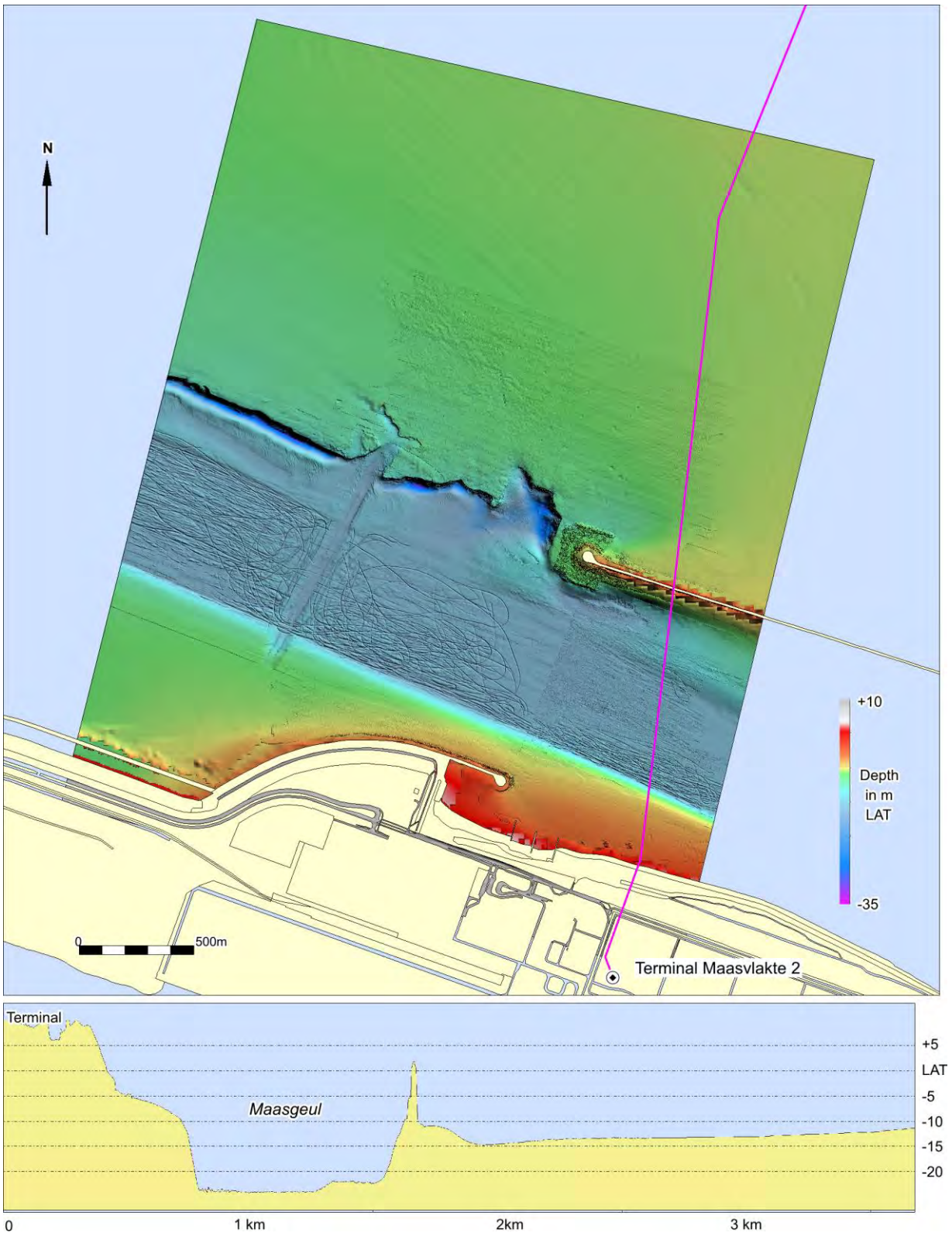


Figure 5. Bathymetry of the seabed in the landfall area

Seabed morphology

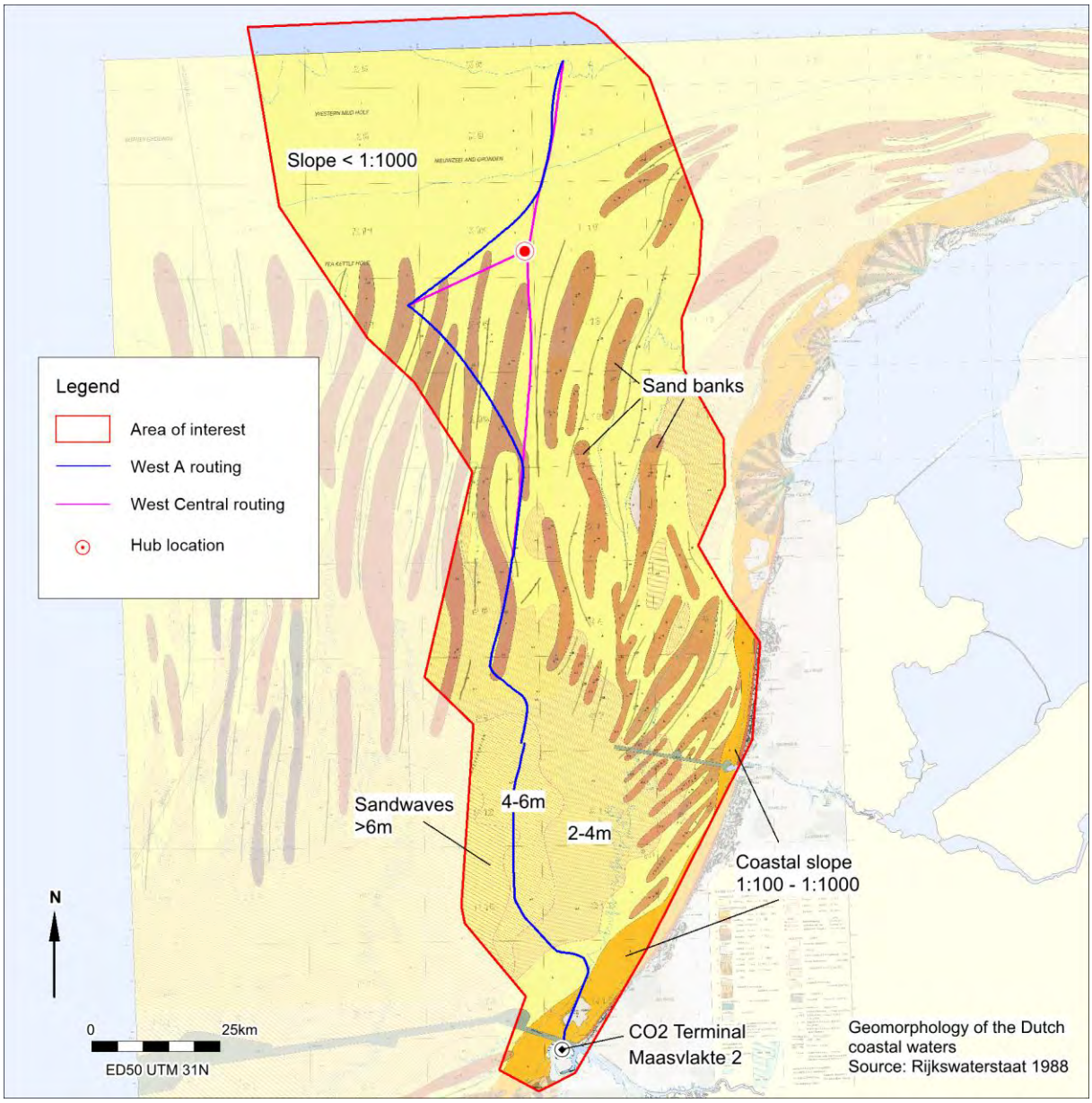


Figure 6. Geomorphology of the seabed

The southern part of the area of interest is dominated by sand waves with a northwest-southeast orientation and a height of 4 to 6 meters. The central area is dominated by large north-south oriented sand banks, superimposed by sand waves. The northern part is predominantly flat and featureless.

3.3 Historical situation and possible disturbances (LS03)

The North Sea basin formed about 12000 years ago as an extensive aeolian sand landscape with a tundra climate. At the end of the last Ice Age (ca 11500 years ago), the temperature rose as a result, the northern glaciers melted. The sea level rose and the North Sea basin was gradually filled. The filling of the North sea plains did occur over a period of 3500-5000 years. During this time the landscape changed, from freezing tundra to woodland where birch dominated the region, with some alder, hazel, juniper, and pine[3]. During this time, the North sea rose more rapidly than it does today, therefore, the residents of the area had to leave eventually for higher ground.[4]



Figure 7. Reconstruction of the historical coast lines in the North Sea basin (map by: McNulty, W.E. and J.N. Cookson in National Geographic Magazine)

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. However, all over the North Sea, remnants are found of hominin occupation of the region. For example, the only known Neanderthal from the Netherlands was found in the North sea. Moreover, multiple Palaeolithic and Mesolithic artefacts and even human remains have been found within the remains of the North Sea[12]. A number of artefacts have been found within the area of interest [5.] By 6000 years ago, the North sea plains were fully submerged, and the North sea looked very much as it does today.

[3] Van de Noort, 2011

[4] Gaffney e.a. 2005.

[5] Louwe Kooijmans 1970.

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]. Authors concluded that a large part of the Southern North Sea contains an in-situ prehistoric landscape.

Figure 8 shows the remains of mammal bones, among which many remains of mammoths which have been found in the nets of fishermen in the North Sea area. Among the finds is a well-preserved prehistoric human skull. Possibly the skull has been found near the Brown Bank area, but unfortunately the location of these finds is not known [7].

The finds are done by different fishermen, but given to fisherman Kommer Tanis who preserves and collects the finds. Tanis reports important finds, such as the human skull shown in figure 8 to scientists. In close cooperation with the scientists he makes the finds available for further analysis, such as DNA research.



Figure 8. Human skull found in the nets of fishermen in 'North sea/Doggerland' in November 2019

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

[7] Pers. Comm. Fisherman and collector Kommer Tanis.



Figure 9. Prehistoric artefacts collected by fishermen and found at the beach (after Kooijmans 1970 en Armkreutz 2018).

Shipping

The earliest evidence of shipping in the North Sea dates from the Neolithic. For example, evidence of this can be found in prehistoric Rhineland burials. In this region the access of tin was limited and was therefore considered a luxury good. It had to be imported from other regions. One of such regions is South-West Britain[8]. It can be seen the other way around as well, Alpine jade axe heads have been sporadically found across the British Isles. Since this age, 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. Ship wrecks are

[8] Van de Noort 2011.

the traces of the maritime past and this can be preserved under favourable storage conditions in sediment. Obviously, the possible existing wreck sites only occupy a very small area of the total area of interest.

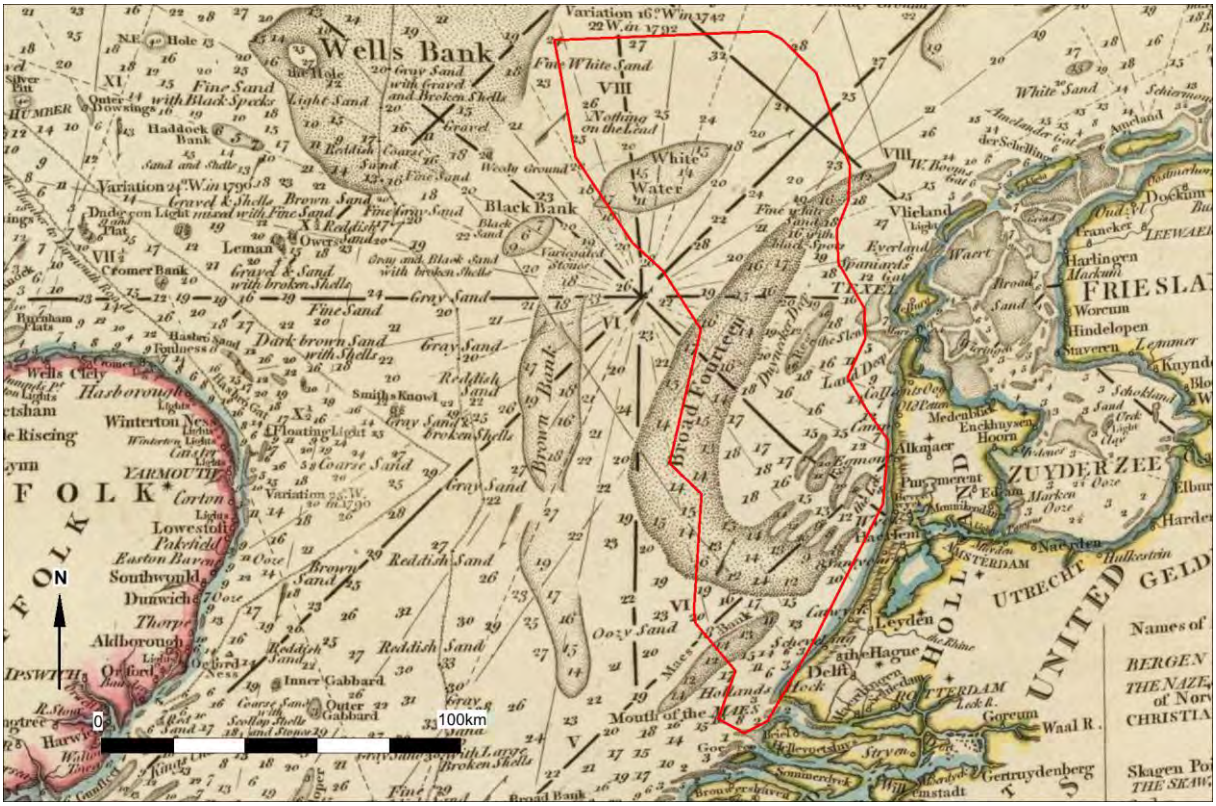


Figure 10. The area of interest on the historical map of 1777 (Faden)

Known disturbances of the seabed

In the past, parts of the seabed within the area of interest have been disturbed by trenches for cables and pipelines. The initial depth of burial of the cables is unknown, but should be a minimum of 1 meter according to the environmental permits. It is however expected that the cables are laid at a depth of 2 meters up to a maximum of 5 meters below the seabed. This also applies to the pipelines in the area.
Within the area of interest, more than 100 areas are known where sand is extracted, generally to a depth of 2 meters in relation to the seabed.

In general, large parts of the seabed have been disturbed by trawl nets of fishermen.

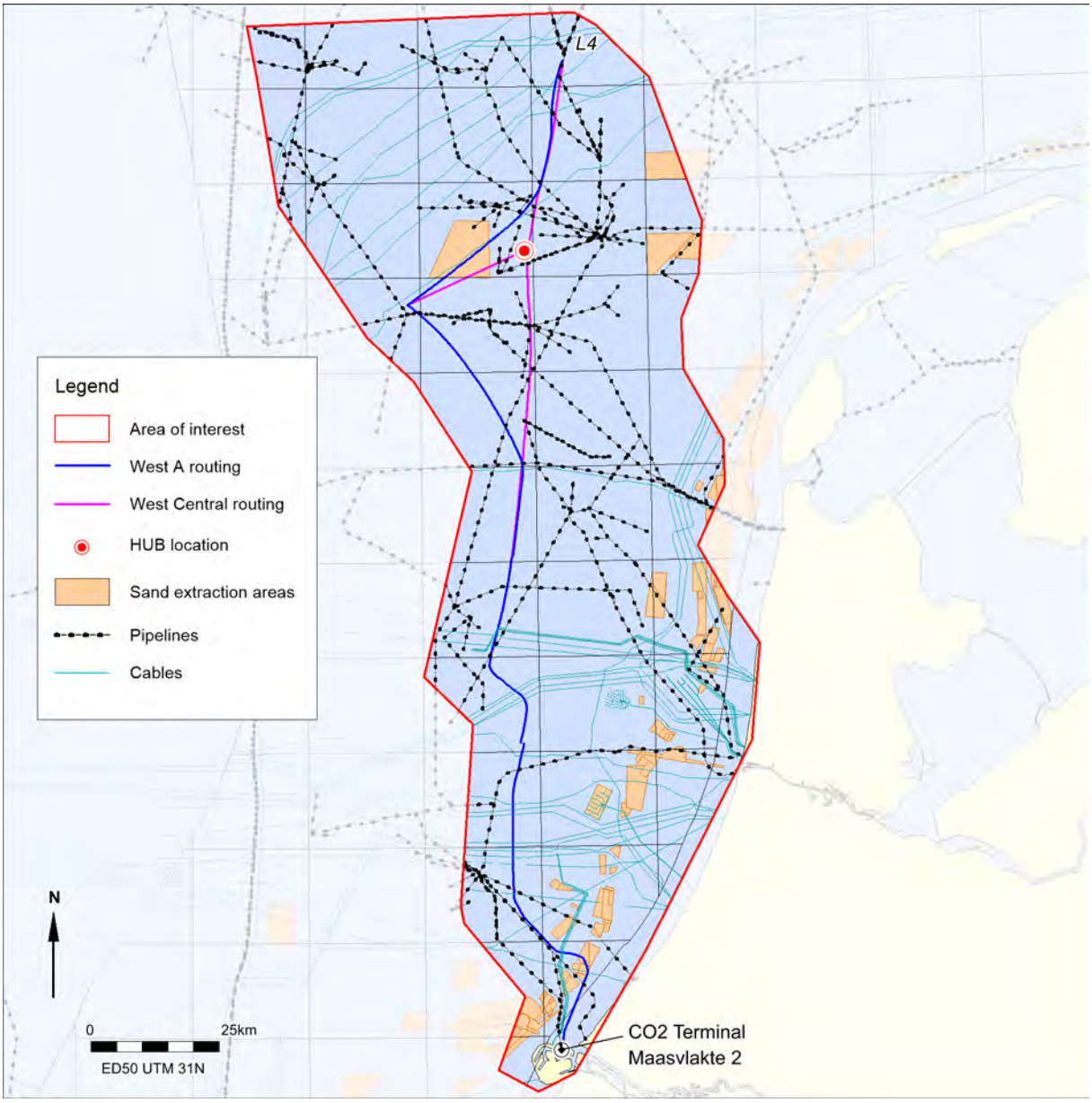


Figure 11. Pipelines, cables and sand extraction areas in the area

Locations and status of cables, pipeline and sand extraction areas are based on the database of Rijkswaterstaat (November 2021). This may differ from the as-built data from the operators.

3.4 Geological setting within which the archaeological objects are to be found (LS04)

The archaeological prospect for (pre)historic settlements is strongly related to the geogenesis of the plan area. The geogenesis is reflected by the lithostratigraphic units present, the character of layer boundaries (erosive vs non-erosive) and indications for the development of soils within the sediments in prehistoric times. Therefore geophysical and geological data are an important source to answer questions with respect to the nature, age, depth and location of occurrence, integrity and preservation of the archaeological remains which are to be expected within the area of interest.

Seabed sediments

The seabed sediments in the area of interest consist mainly of sand, with patches of gravelly sand in the southern and central area. In the northern part the sediments become finer (muddy sand).

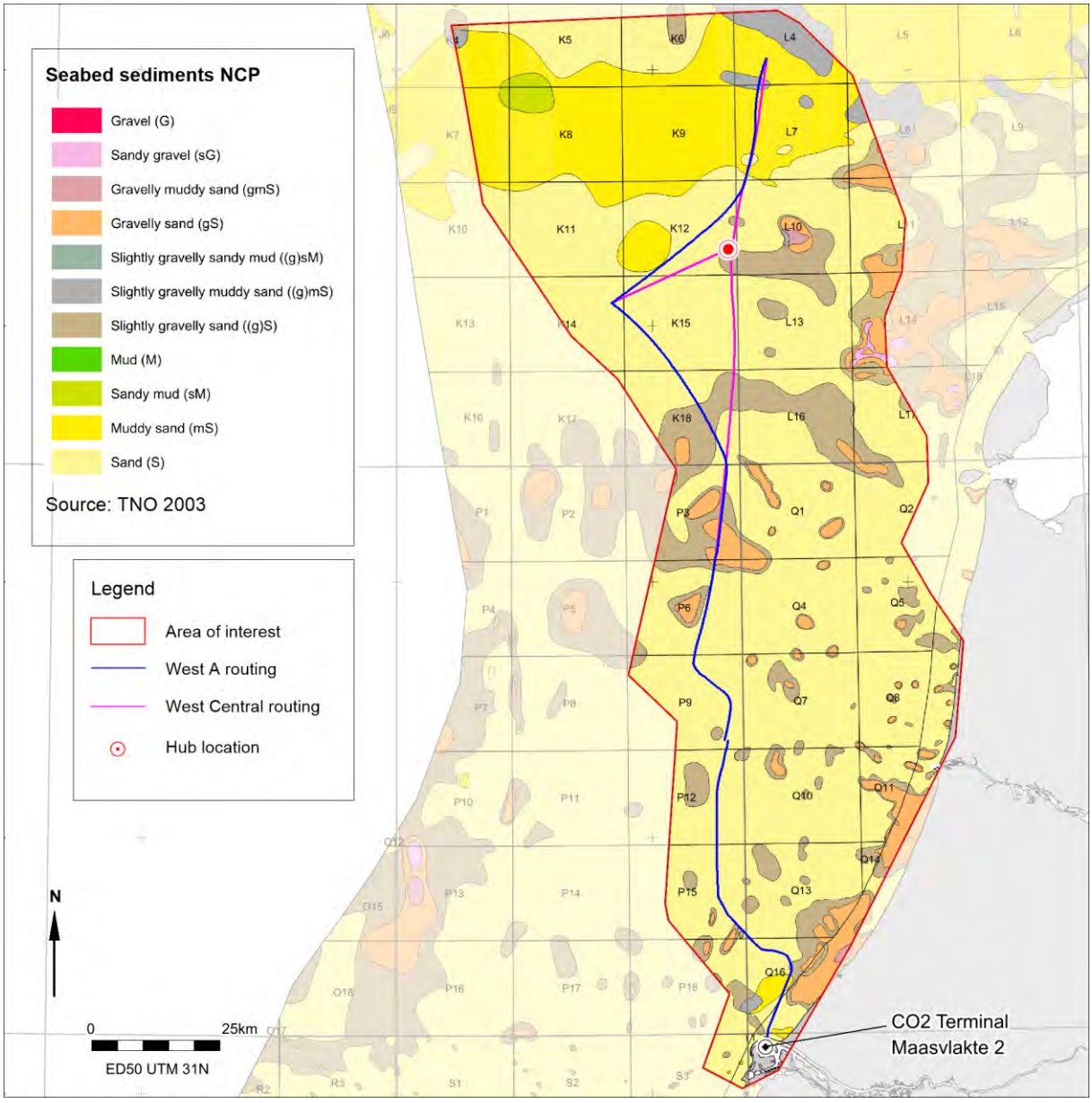


Figure 12. Seabed Sediments (Laban 2003)

Pleistocene Units

Figure 13 shows the different subcropping *Pleistocene* units in the area of interest[9].

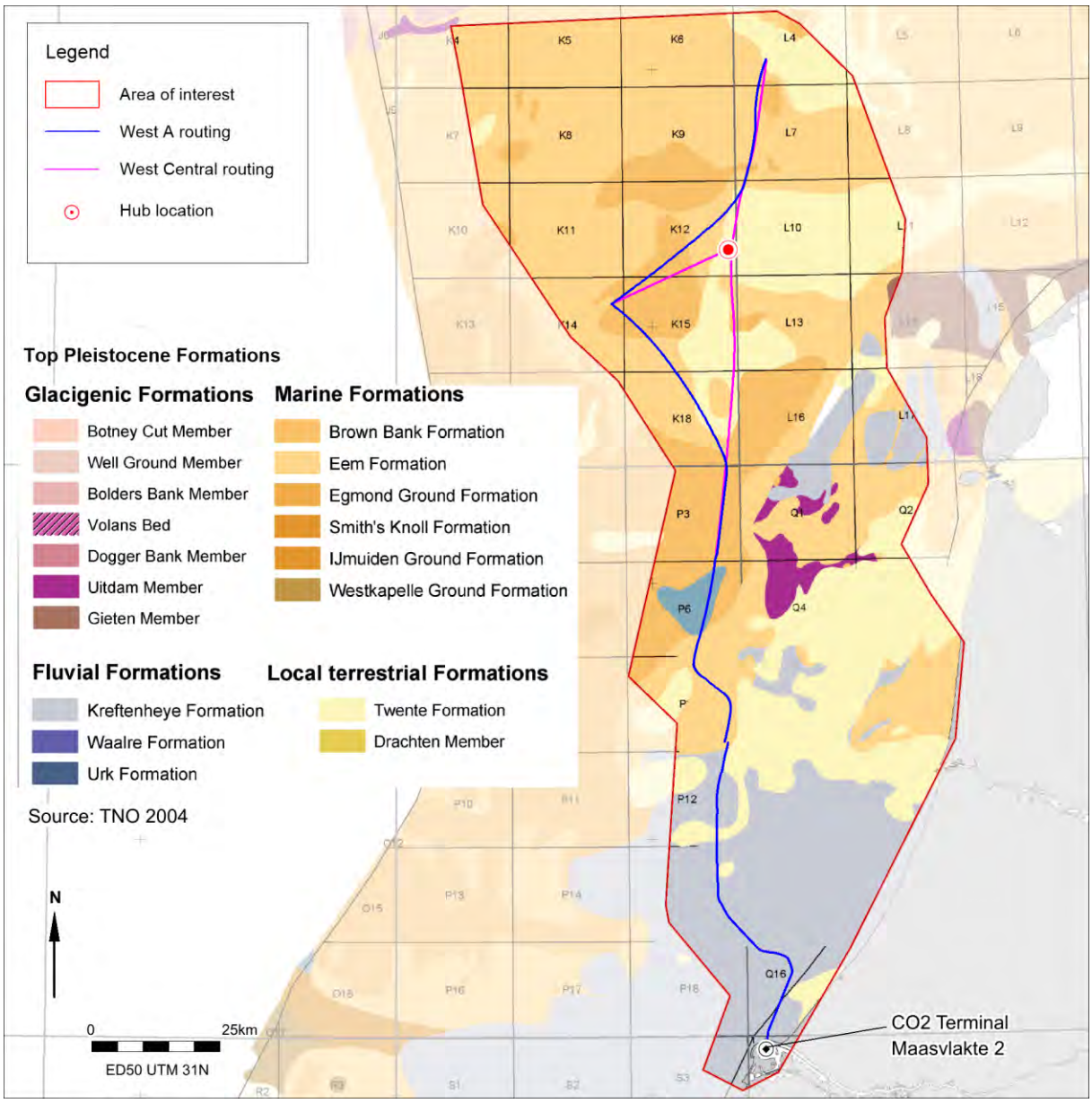


Figure 13. Subcropping Pleistocene formations

Within the boundaries of the area of interest several subcropping *Pleistocene* units have been mapped. The most relevant are described below.

Yarmouth Roads Formation

The Yarmouth Roads Formation consists of fine or medium-grained grey-green sands, typically non-calcareous, with variable clay lamination and local intercalations of reworked peat. According to the Lexicon of Named Rock Units of the British Geological Survey the depositional environment of the Yarmouth Roads Formation is interpreted to be 'mainly fluviatile, with possible shallow marine incursions'.[10]

[9] Laban 2004.

[10] https://webapps.bgs.ac.uk/lexicon/lexicon.cfm?pub=YM.

In the DINO nomenclature the depositional setting is described as 'predominantly low energy open-marine deltaic, delta top and fluvial'.[11] The Yarmouth Roads Formation is older than 500 kyr. The unit has been glacially deformed into ice-pushed ridges in the section that is crossed by the current Aramis route trajectory.

Egmond Ground Formation

The Egmond Ground Formation consists of fine-grained, sparsely shelly marine sands with clay interbeds. The amount of shells and shell fragments is markedly less than the overlying younger sands of the Eem Formation.[12] The marine deposits date from the Holsteinian interglacial period. The exact age of the deposit is uncertain, including both Marine Isotope Stage 11 (424 kyr – 374 kyr ago) and Marine Isotope Stage 11 (424 kyr – 374 kyr ago) and Marine Isotope Stage 9 (300 kyr – 337 kyr years ago). The deposits of the Egmond Ground Formation predate the Saalian glacial period and can therefore be part of the ice-pushed ridges.

Eem Formation

The Eem Formation predominantly consists of shell bearing fine sands deposited in an open marine environment during the Remain interglacial (warm) period.[13]

Brown Bank Member (Eem Formation)

At the end of the Eemian period brackish and fresh water clays were deposited in lagoons and lakes which remained in the glacial basins during regression of the Eemian Sea. These lake and lagoonal deposits have separately been classified as the Brown Bank Member within the Eem Formation. The Brown Bank Member was previously referred to as Brown Bank Bed or Brown Bank Formation.

Woudenberg Formation

In the Early Weichselian cooling climate peat was locally deposited on top of the clayey Brown Bank Member. At its base the peat is often rich in wood remains; at the top moss is a major constituent. The unit consists of firm, amorphous, clayey, non-calcareous, brown to black peat or gyttja. The peat has been deposited in a nutrient-poor (moss peat) to nutrient-rich (reed, sedge and woody peat) marsh or swamp. Occurrences of the Woudenberg Formation have been described in the Amersfoort Basin, not in the North Sea area. Formerly, this unit was part of the Eem Formation. As the Saalian glacial basins are present in the North Sea area which is crossed by the proposed Aramis pipeline routes, local occurrences of this unit could be crossed.

Kreftenheye Formation (Weichselian)

The Kreftenheye Formation consists of sands of the Rhine | Meuse fluvial system. The depositional environment includes braided and meandering stream, and braidplain and floodplain. The deposits consist of yellowish grey to greyish brown medium to very coarse sand. The sands are moderately to very gravelly. Locally, fine to coarse gravel lags occur. Occasional thin clay laminae and clay pebbles can be present intercalations in the predominantly sandy sequence. Characteristic of the Kreftenhye river deposits is a parallel layering on mm- to cm-scale which is related to small variations in grain size and composition. Offshore the coast of South Holland, small shallow channel incisions are observed in subbottom profiler data. These incisions occur in the top of the Kreftenheye Formation which is truncated by the Bligh Bank

[11] In accordance with Rijsdijk 2005.

[12] British Geological Survey: Lexicon of Named Rock Units.

[13] Eemien: interglacial period between 128.000 and 115.000 years ago.

Member. The channels are filled with fine sand. An impression of the stratigraphy that is to be expected in the southern part of the current Aramis route trajectory in the vicinity of sand extraction areas Q16H and Q16H is illustrated in figure 14 below.

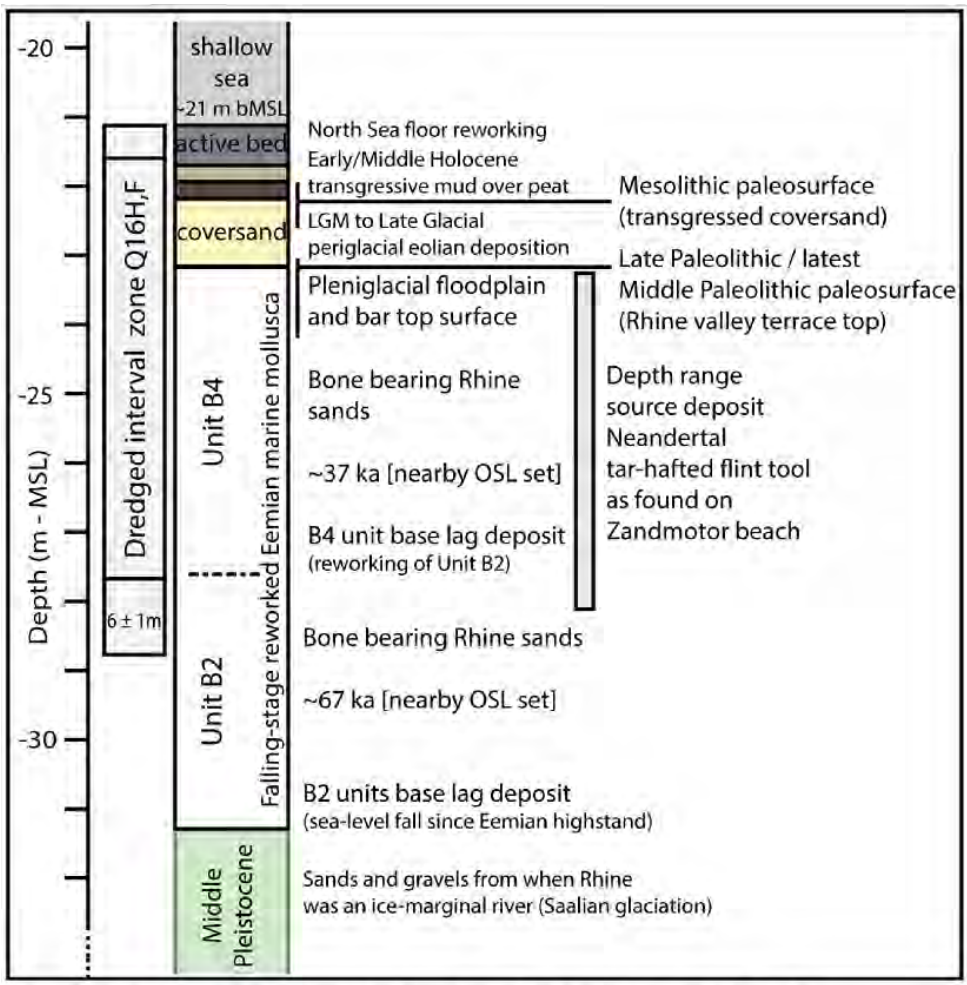


Fig. S2. Stratigraphy of the dredging area Q16. The upper 6-8 meters of the sedimentary column consist of: 1) a dynamic sheet of shelly sand of the active sea bed, 2) beds of Early-Middle Holocene transgressive tidal muds on basal peat, 3) Late Glacial eolian coversands containing Mesolithic materials (27, 28), and 4) medium to coarse grained fluvial sands of the Rhine-Meuse valley, Units B2 and B4, dating to 70-30 ka.

Figure 14. Stratigrafie van het zandwingebied Q16 (Niekus 2019).

During the installation of the Hollandse Kust (zuid) export cables mammoth bones were found on the trencher when the trencher emerged above water (see for site location figure 1). The very well preserved mammoth bones probably originate from an infilled channel.

The course of the river Rhine changed during the Weichselian. The extent and distribution of the Rhine - Meuse channel belts is shown in figure 15, below.

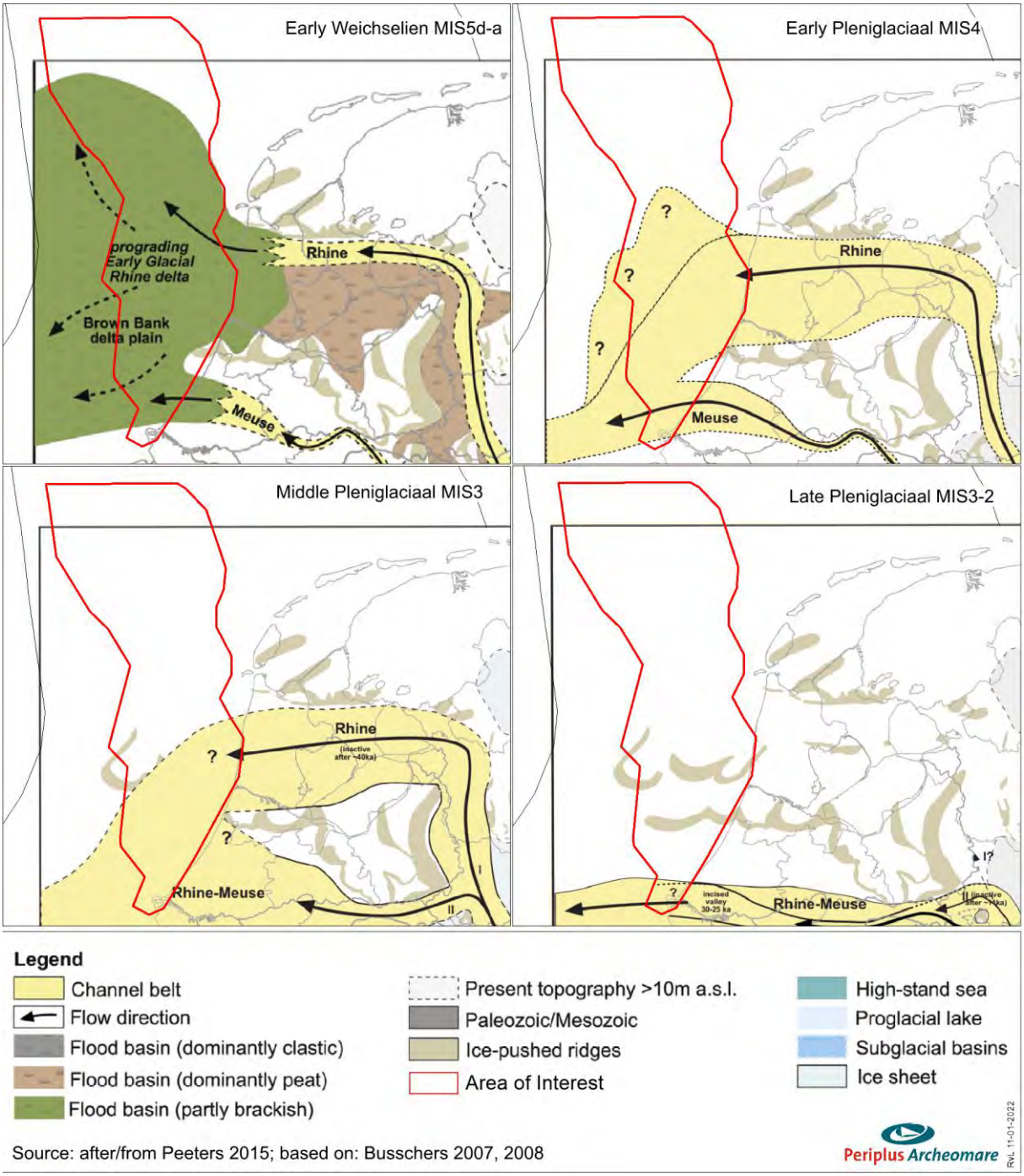


Figure 15. Paleogeographic maps of the Weichselian.

North and south of Maasgeul firm beds of clay and loam occur at the top of the Kreftenheye Formation. The firm clay dates from the Late Weichselian (Allerød interstadial) and Early *Holocene* and is separately classified as the Wijchen Bed. The Wijchen Bed has been deposited in meandering floodplain of the Rhine which is subject to frequent overbank flow.[14] The deposition of the Wijchen Bed is related to the evolution of the Rhine – Meuse river pattern from braided to meandering. The change to a meandering river pattern is triggered by a warming of the climate, which resulted in the development of a vegetation cover. The landscape morphology is more or less fixed by the vegetation, thus promoting incision of the river. This

[14] Törnqvist 1994; Makaske 1995; Busschers 2008.

also explains why the overbank clay of the Wijchen Bed is characterized as 'humic and non-calcareous, especially at the organic-rich top, which may be marked by a palaeosol'.[15]

The Late Glacial fluvial evolution of the Niers–Rhine and Maas in relation to climate and vegetation changes is nicely illustrated by Kasse (see, below).[16]

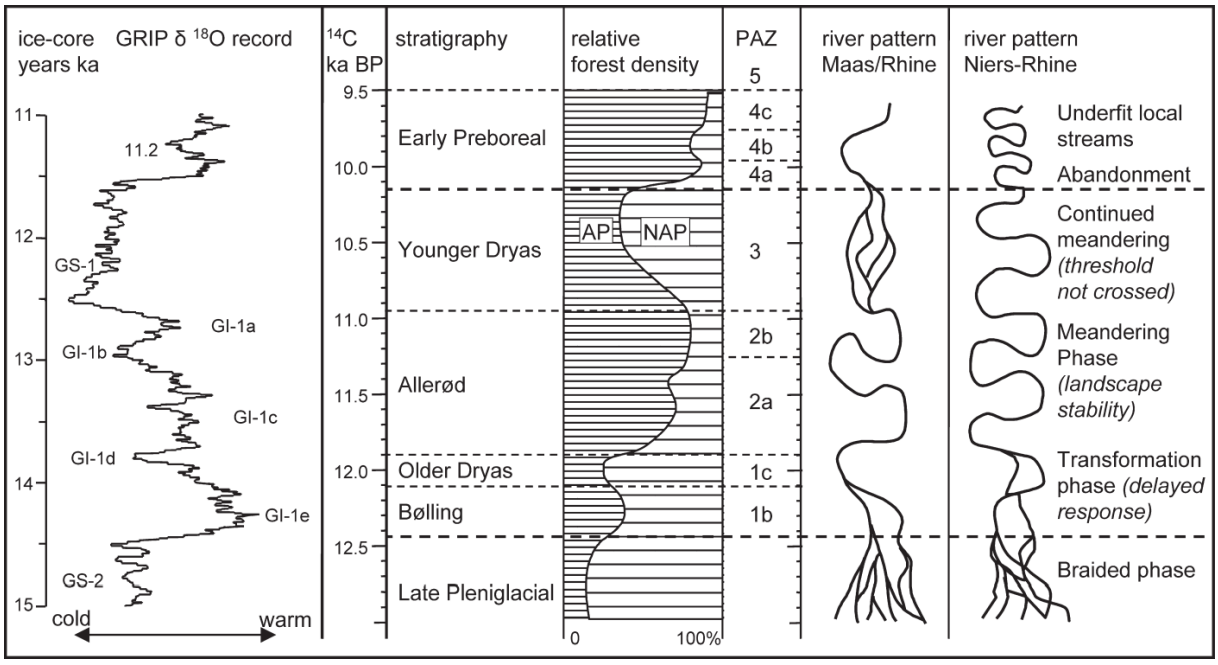


Figure 16. Late Glacial fluvial evolution of the Niers–Rhine and Maas in relation to climate and vegetation changes (from: Kasse 2005).

In the Yangtze area two separate beds are distinguished in the Wijchen Bed:[17] a lower bed that is described as 'grey loam, sandy clay and clayey sand, and is internally stratified', and an upper bed that is described as 'moderately silty to strongly silty and humic (often humically stratified), and at the base sandy and mostly sandy-stratified.' The lower bed was found between 23m and 22m – asl; the upper bed between 22m and 19m – asl. In the upper bed charcoal is found which is related to the archaeological sites that were found on the nearby river dunes.

Boxtel Formation (Weichselian and Early *Holocene*)

The Boxtel Formation consists of terrestrial deposits. The upper part of the unit subcrops below a cover of *Holocene* deposits in parts of the area of interest (figure 13). The subcrops of the Boxtel Formation shown in figure 13 date from the latest ice age, the Weichselian, and Early *Holocene*. This upper part of the unit most probably consists of aeolian deposits of the Wierden Member (cover sands) and loamy stream deposits of the Singraven Member. Apart from loam (=silt) the Singraven Member can contain sand, clay and peat. The Boxtel Formation overlies brackish to fresh water lagoonal and deposits or laminated fresh water lacustrine clays of the Brown Bank Member and peat of the Woudenberg Formation. The thickness of the Boxtel Formation is unknown.

[15] TNO-GDN (2022). Wijchen Bed. In: Stratigraphic Nomenclature of the Netherlands, TNO – Geological Survey of the Netherlands. Accessed on 13-01-2022 from http://www.dinoloket.nl/en/stratigraphic-nomenclature/wijchen-bed-0.

[16] Kasse 2005.

[17] Moree and Sier 2015; The Wijchen Bed is refered to as Wijchen Member.

During the Early *Holocene* aeolian sands were deposited within the floodplain bordering the dry bed of the river Rhine (these river deposits themselves are part of the Kreftenheye Formation; see above). The so-called river dunes are found in the subsurface of the route trajectory north and south of the Maasgeul. The river dune deposits are described as grey to brown, fine to medium, moderately sorted sand, mostly non-calcareous but calcareous near base, with sporadic silt layers or granule laminae. The river dune deposits are separately classified as the Delwijnen Member within the Boxtel Formation.

Drachten Formation

Terrestrial deposits can also occur at a deeper stratigraphic level. The Drachten Formation is located in between the Egmond Ground Formation and the Eem Formation. Formerly the Drachten Formation was onshore classified as the Eindhoven Formation and later as a member of the Boxtel Formation. Offshore the Drachten Formation was referred to as the Tea Kettle Hole Formation. The local terrestrial deposits date from the Saalian ice age and consist of fine grained periglacial aeolian, fluvial and lacustrine sands. The Drachten Formation predates the Saalian glaciation and is often deformed due to the overriding ice-sheet. Deposition took place during the Hoogeveen and Bantega interstadials (227 – 180 ka. ago), when the landscape was covered by temperate zone forests. In the 1980s, Neanderthal camps related to the Hoogeveen or Bantega interstadials were excavated in the Maastricht-Belvédère quarry in Limburg. Therefore, remains of Neanderthal camps may exist *in situ* if intact palaeosol are present.

Holocene Units

The *Pleistocene* units are - except from some local outcrops - covered in by a sequence of *Holocene* deposits. The overall thickness of the *Holocene* sediments ranges from 0m to 37m. The differences in thickness are for a major part related to the present-day seabed morphology, which is characterized by sand dunes, ridges and valleys. The occurrence of *Holocene* units which are exposed at the seabed is shown in figure 17. Because this map displays the exposed lithostratigraphic units, under these units older *Holocene* deposits can occur.

Nieuwkoop Formation (*Holocene*)

Fluvial deposits of the Kreftenheye Formation and terrestrial deposits of the Boxtel Formation are in places covered by peat. This Early *Holocene* peat layer is classified as the Basal Peat Bed within the Nieuwkoop Formation. Occurrences of the Basal Peat Bed could indicate that the underlying *Pleistocene* landscape has been preserved intact, provided that no erosion as taken place prior to the deposition of the peat. If the Basal Peat Bed is found in borehole or vibrocore samples, signs that the top of the underlying unit is intact can be found in the occurrence of palaeosol horizons. Known are the podzol soils which developed at the higher parts of the cover sand landscape during the Early *Holocene*. These cover sands are classified as the Wierden Member within Boxtel Formation (see text above).

Echteld Formation (*Holocene*)

Both north and south of the Maasgeul a bed of silty humic clay with silty laminae occurs. The presence of washed-in wood remains is characteristic.[18] The clay is deposited in a freshwater environment, with slight tidal influence. Presumably, sedimentation took place under water (subaquatic, subtidal). The bed of humic clay is classified by Hijma as Terbregge Member | Echteld Formation. The classification as a separate member has not been formalized in the DINO nomenclature, yet. The Terbregge Member covers the Early *Holocene* Basal Peat Bed and is itself covered by the Wormer Member | Naaldwijk Formation.

Naaldwijk Formation (*Holocene*)

Pleistocene units and the Early *Holocene* Basal Peat Bed are in places covered by *Holocene* tidal deposits (clay and fine sand). These layered and laminated tidal deposits are part of the Wormer Member within the Naaldwijk Formation. The earliest clastic deposits are those of the Velsen Bed. The Velsen Bed consists of firm to stiff humic clay, sometimes containing considerable amounts of Hydrobia shells. The lower boundary can be present as a gradual transition from peat deposits of the Basal Peat Bed to clastic lagoonal deposits of the Velsen Bed.

Southern Bight Formation (*Holocene*)

The Southern Bight Formation consists of reworked sediments. The Southern Bight Formation is exposed at the seabed surface in major part of the Aramis route trajectory (see figure 17). Along the route, three members of this formation have been mapped. The Bligh Bank Member is a mobile sand layer in which sand ridges, dunes and mega-ripples have developed. This unit predominantly consists of marine sands with variable admixtures of gravel. The formation often has a more gravelly structure towards the base. It should be noted that shell fragments over 4 mm are considered to be 'gravel'.

In the northern part of route, the Bligh Bank Member changes into the Terschellingerbank Member, which consists of reworked (peri-)glacial sand with a small amount (< 10%) of mud.[19]

[18] Moree and Sier 2015.

[19] Mud = clay (< 2µm) + silt (>2µm and <63µm)

Urania Formation (*Holocene*)

The Urania Formation is found in the northernmost of the route, where the Western Mudhole Member is mapped. Alike the Terschellingerbank Member, the Western Mudhole Member consists of reworked (peri-)glacial material, but the grain size of the sediments is smaller. The unit is described as very fine sand with a considerable admixture (> 10%) of mud.



Figure 17. Geological overview map (De Mulder 2003).

Only the total thickness of the *Holocene* sequence including the Basal Peat Bed, the Naaldwijk Formation, the Southern Bight Formation and Urania Formation is known. The total thickness of the *Holocene* layer ranges from less than 1 to over 10 meters in the area of interest (see figure below).

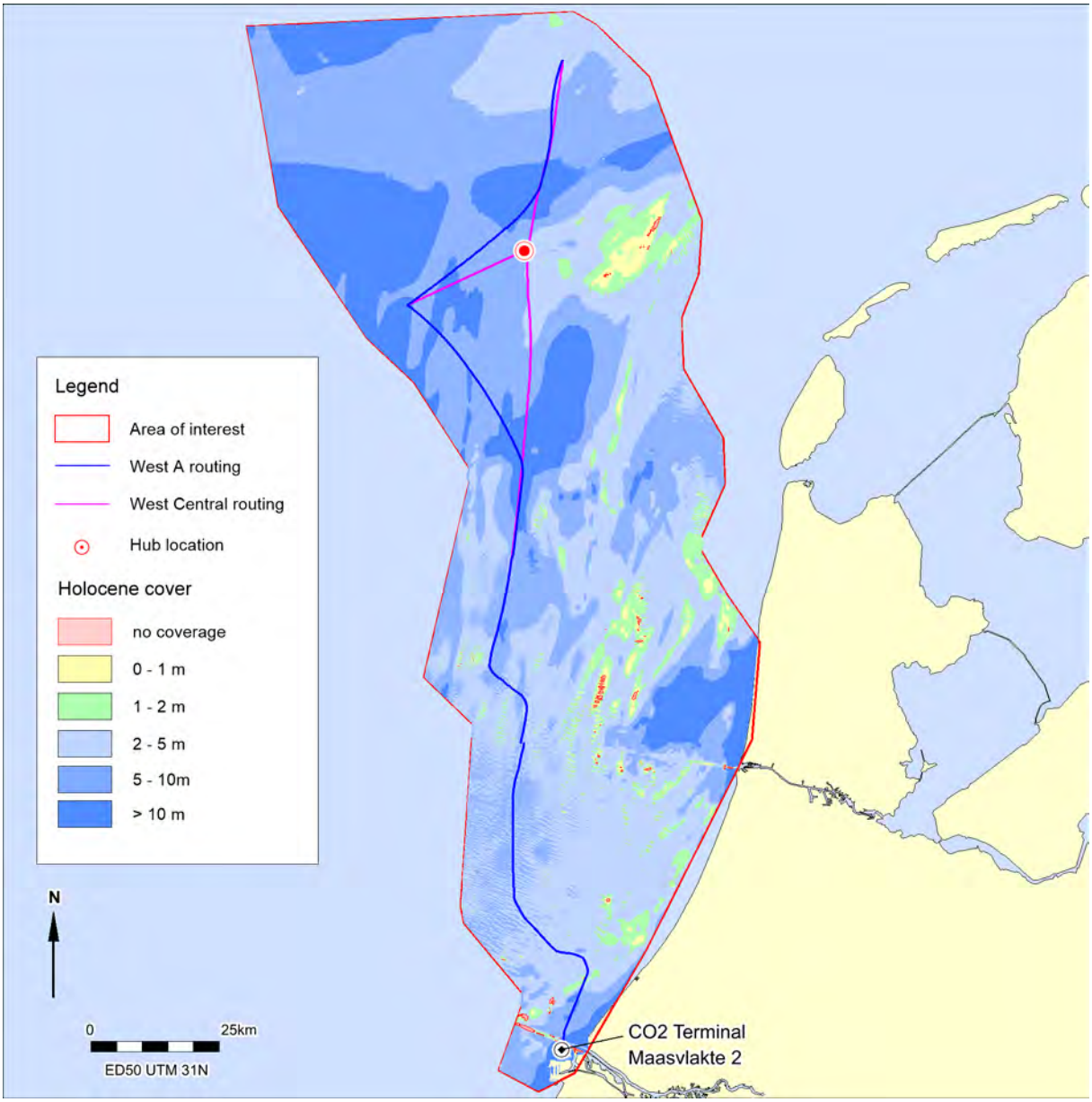


Figure 18. Thickness of Holocene cover

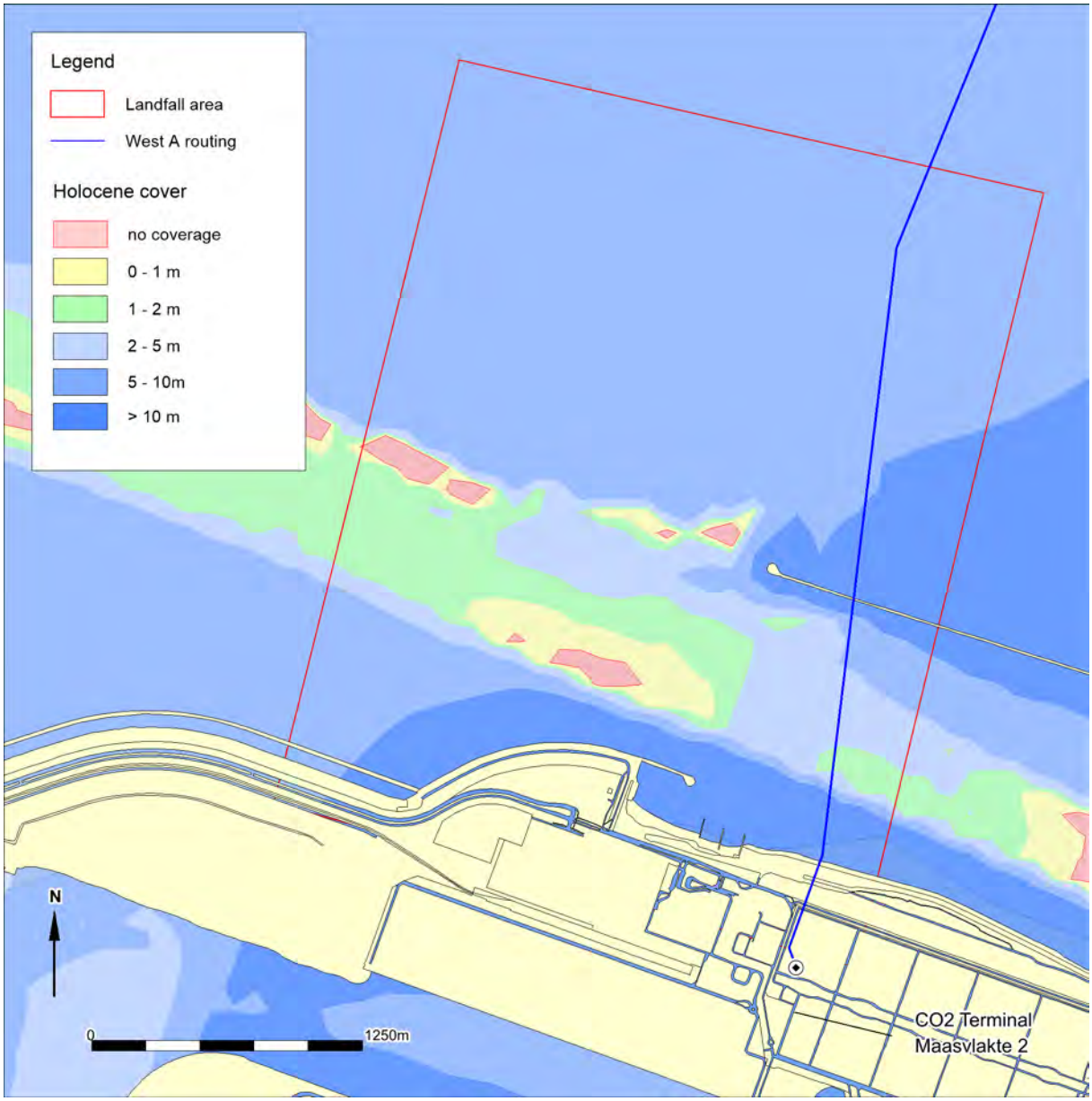


Figure 19. Holocene cover within the landfall area

3.5 Known archaeological values and other objects (LS04)

The former National Service for Archaeological Heritage (ROB, now Dutch Cultural Heritage Agency or RCE) in collaboration with Rijkswaterstaat and TNO NITG has developed a comprehensive archaeological map of the continental shelf based on geological and archaeological observations (see figure below)[20].

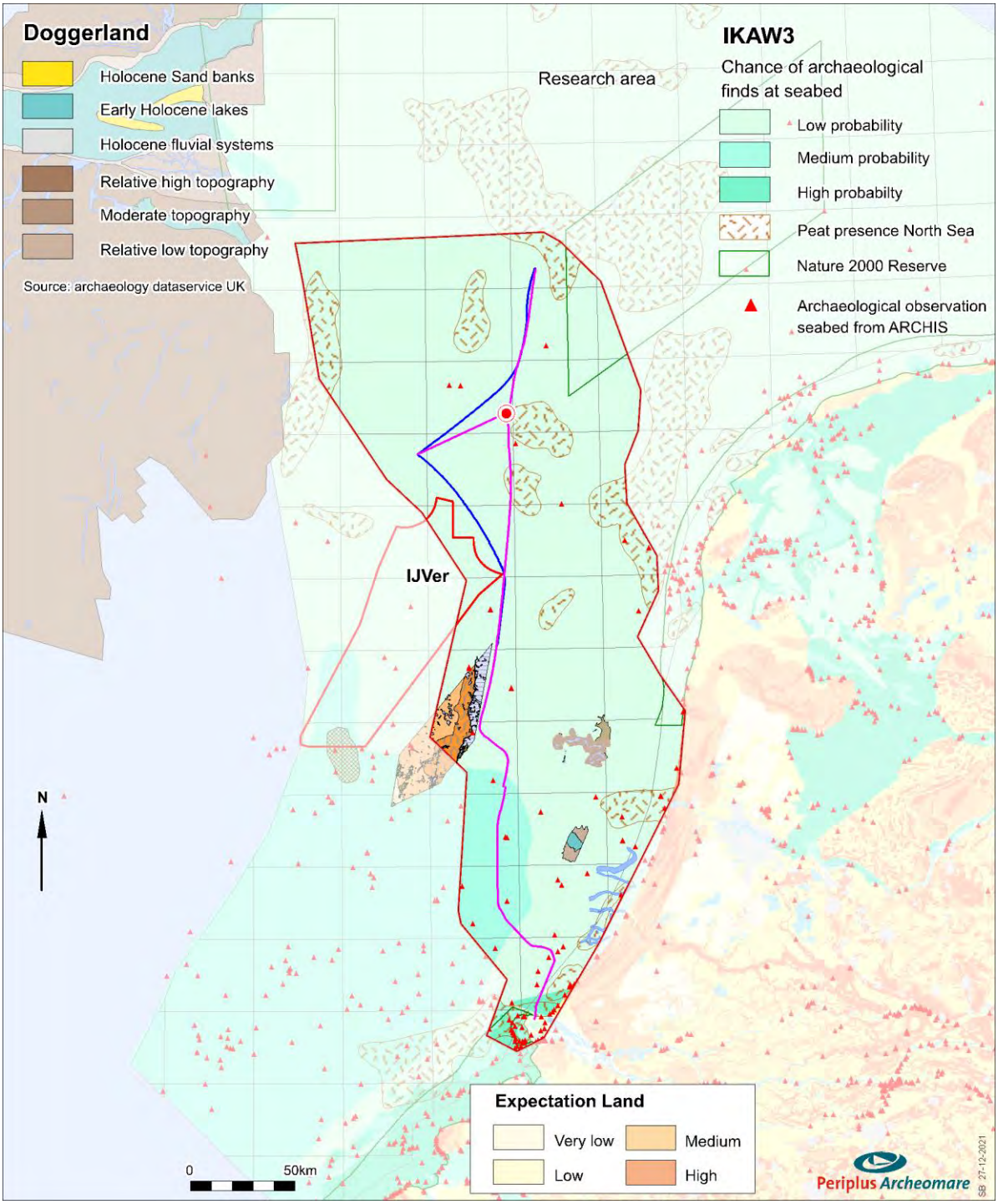


Figure 20. Overview indicative map of archaeological values (IKAW)

[20] IKAW 3e generatie, RCE 2008.

This global map presents the probability of well-preserved shipwrecks to be encountered (and often a ship's discovery of high archaeological value) in the Dutch part of the Continental Shelf, expanded with available palaeogeographic reconstructions.

However, this map is of very limited use. This is partly due to the large scale (1: 500,000). Further the map has become outdated, because it shows the state of knowledge 25 years ago. The degree of conservation of wreck remains is closely related to geology and morphology which has not been taking into account in the IKAW3 map. 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.

Figure 20 also indicates areas where peat and clay have been 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. West of the area of interest lies the nature reserve Brown Bank, a shoal known for its paleontological and prehistorical finds. At this archaeological hotspot rigid *Pleistocene* clays and silts of the Brown Bank Member are exposed at the seabed. These sediments contain the prehistoric remains which are found in the nets of fishermen.

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 is therefore being revised. In 2016, an indicative model of the archaeological potential of the North Sea was published by Deltares[21]. A detail of this map is shown in figure 21. The potential for prehistoric remains is closely related to the lithostratigraphic units which have been discussed and outlined in previous paragraphs. For instance the potential for Middle Palaeolithic remains indicated in red coincides with the occurrence of the Kreftenhye Formation and Brown Bank Member, the potential for residual Mesolithic and Late Palaeolithic remains indicated in beige coincides with the occurrence of the Boxtel Formation and the limited potential for prehistoric remains in areas indicated in grey relates to the occurrence of the marine deposits of the Egmond Ground Formation and the Eem Formation[22].

It should however be stressed that figure 21 offers a two dimensional view. The occurrences of the Eem Formation (grey), the Kreftenheye Formation and the Brown Bank Member (red) are not limited to the mapped areas but extend underneath the Boxtel Formation (beige). This means that Middle Palaeolithic remains are also to be expected in those areas.

It is important to bear in mind that the occurrences and boundaries of the lithostratigraphic units mapped are based on a limited amount of geological data. The occurrences and boundaries should therefore not be considered definite, but an indication of what is to be expected in the area and a framework for further research. Also morphological phenomena like the ice-pushed ridges have not been taken into account in this map.

[21] Vonhögen et al, 2016.

[22] Occurrence Naaldwijk Fm according to Deltares grids (2004).

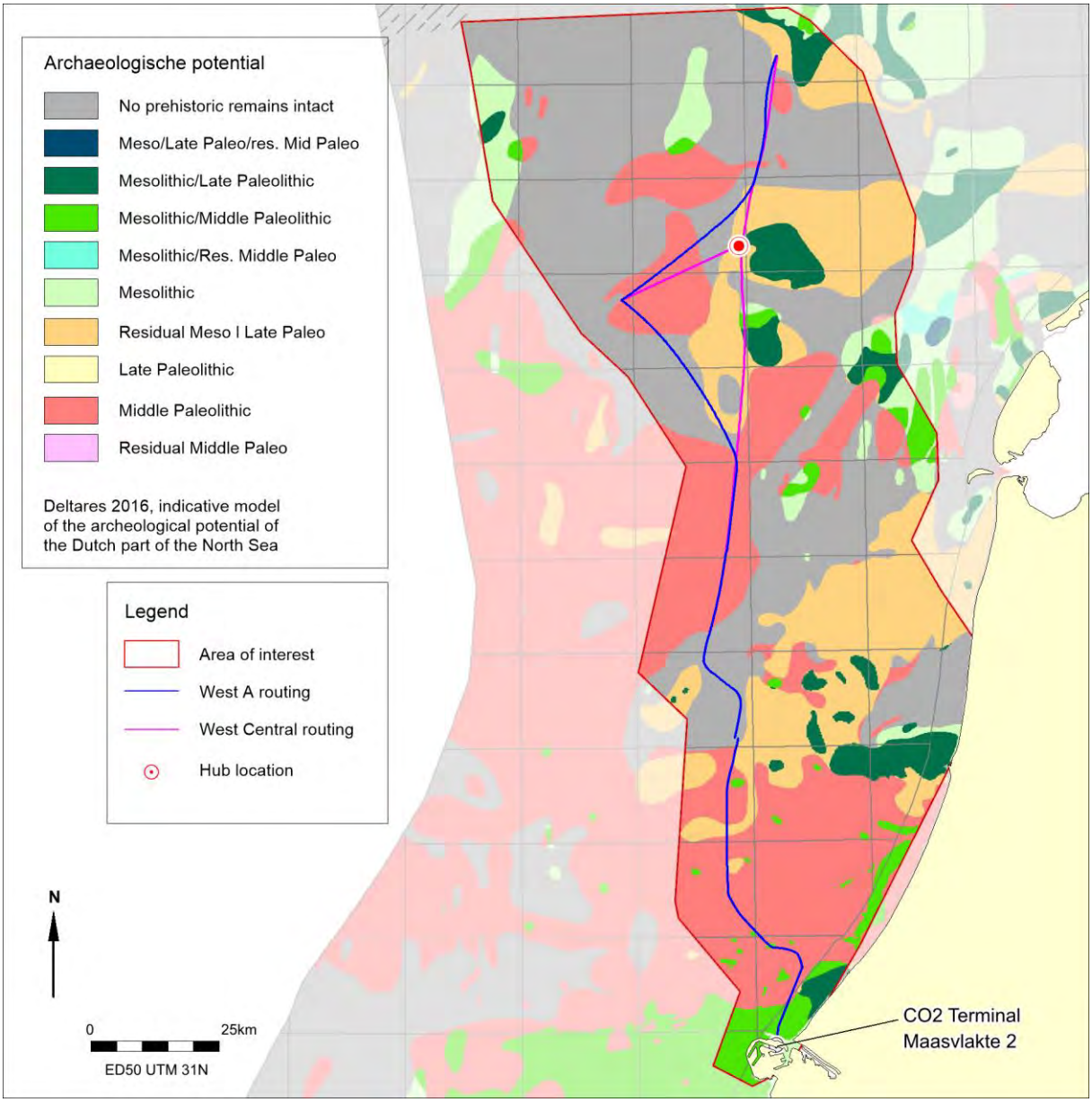


Figure 21. Archeological potential for prehistoric remains

Ice-pushed ridges

The ice-pushed ridges have been formed by Saadian glaciers which stretched into the North Sea area. pre-dates the Eemian, Weichselian and Early *Holocene* deposits. The ice-pushed river sands of the Yarmouth Roads Formation can contain reworked flint artefacts from Lower and Middle Palaeolithic times. At the top of the ice-pushed ridge in situ remains of camp sites and inhumations of Neanderthal and Late Palaeolithic and Mesolithic hunters and gatherers can be expected.

Open sea (Eemian)

The Eem Formation consists predominantly of marine sand deposited in the Eem Sea during the Eemian interglacial (warm) period.[23] Within the sandy marine deposits no *in situ* archaeological remains are expected.

[23] Eemien: interglacial which lasted from 130.000 till 115.000 years ago.

Lagoons, lakes and fens (Eemian to Early Weichselian)

The Brown Bank Member at the top of the Eem Formation consists of lacustrine fresh water and coastal marine brackish water deposits of silty clay. At the end of the Eemian the sea regressed and the Brown Bank clays were deposited. This layer can contain Middle Palaeolithic artefacts from, or remains of Neanderthals who in this period populated the Netherlands and the North Sea area. Little archaeological research has been done into this often deep-seated stratigraphical unit. Camp sites are expected to be intact and well preserved, especially when the remains are contained in a clayey context and covered by peat of the Woudenberg Formation and/or cover sands of the Wierden Member | Boxtel Formation. The Woudenberg Formation can contain dumps from close-by camps, lost hunting gear and intended depositions. The available geological information does not suffice to assess whether the Late Eemian to Early Weichselian facies of sandy lagoonal beaches and/or clayey shores of lakes and fens is present.

The top of the Brown Bank Member is expected at depths varying from 0m to 30m below the seabed.

River valley (Weichselian)

The Kreftenheye Formation consists of fluvial deposits of the Rhine and Rhine - Meuse system. The extent and distribution of the channel belts during the Pleniglacial (74 ka – 15 ka ago) is illustrated in Figure 15. Well-preserved finds prove that Neanderthal occupied the Rhine valley. Melt water discharged through the braided channels of the Rhine. Peak discharge occurred during the summer months, when temperatures rose above freezing point in the hinterland. Large mammals including woolly mammoths, woolly rhinoceros, musk ox and steppe wisent migrated over the steppe-tundra landscape. This landscape was vegetated with grasses, herbs and occasional dwarf birches. The water-intake of mammoths was immense, so the fresh-water-filled channels must have had a large attraction to these animals, thus offering Neanderthal the opportunity to hunt them. The change of encountering *in situ* remains in the residual infilled channels of the Kreftenheye Formation is considered to be relatively large. It is believed that the Neanderthal became extinct some 40 kyr to 35 kyr ago, prior to the Late Glacial Maximum, some 27 kyr to 19 kyr ago.

The Wijchen Bed at the top of the Kreftenheye Formation consists of firm, matured humic clays in which locally palaeosol developed. In the clayey context of this bed well-preserved Late Palaeolithic and Mesolithic remains could be encountered. These remains include lost hunting gear and waste of camp sites which are found on nearby river dunes. Also the presence of camp site relics on the overbanks deposits cannot fully be excluded.

Cover sand landscape (Late Weichselian and Early *Holocene*)

The camp sites of Late Palaeolithic and Mesolithic hunters and gatherers are found in a cover sand landscape with ridges and dunes and valleys formed by small streams. Stream valleys offered fresh water, a large variety of plant species and ample opportunities for hunting. Camps were installed along the borders of those valleys. The remains of sites can be encountered in the context of sandy, loamy, clayey or peaty beak deposits of the Singraven Member. The lithological context of settlements found at the dunes and ridges comprises well sorted non-calcareous fine cover sand of the Wierden Member. Both Singraven and Wierden Member are part of the Boxtel Formation.

Late Palaeolithic and Mesolithic remains are expected at two distinct levels within the cover sand sequence. The first is a palaeosol found in between two cover sand layers Late Palaeolithic remains of camp sites of reindeer hunters are to be expected. The palaeosol is a charcoal rich layer called the Usselo Bed, which has been formed during the Bølling and Allerød interstadials. The second level is the top of the

cover sand sequence. The sandy dunes and ridges often display a well-developed podzol, if not eroded. Due to the low carbonate content presence of oxygen in the pores of the sand the preservation conditions for organic remains (wood, bone, et cetera) is a priori not so good in cover sands. The preservation of organic remains is therefore highly dependent on the timing of the water table rising above the archaeological level.

If the Boxtel Formation is covered by the Basal Peat Bed or the Velsen Bed the integrity and conservation of archaeological remains is expected to be high. Considering our limited knowledge of prehistoric sites in the North Sea area such well-preserved finds would *a priori* be worth preserving. Archaeological markers consist of flint and bone artefacts, burnt nuts and seeds and charcoal. Zones of interest are locations where the top of the cover sands and river dunes (if present) are not eroded. The presence of the Basal Peat Bed and Velsen Bed indicate that underlying Boxtel Formation and possible archaeological remains herein could be intact.

Peat and humic clays

The Basal Peat Bed and Velsen Bed themselves can also contain archaeological remains. These remains include dumped waste from nearby camp sites, lost hunting gear or intentional (e.g. ritual) depositions. Due to the low levels of oxygen and wet conditions both organic and inorganic remains might be very well preserved.

Site characteristics

The expected camp sites of hunters and gatherers are generally small (a few sqm), although larger settlements (up to approximately 2000 sqm) can occur in case the site repeatedly or for prolonged period of time was occupied. Sites are characterized by the presence of concentrations of charcoal, flint artefacts, bone remains, burnt seeds and nuts, natural stones and artefacts of bone or horn. Inhumations can occur. The density of finds (debris of flint processing) can vary from low to high.

Physical Quality

It is not known to what extent erosion has affected the integrity of the *Pleistocene* landscape and embedded remains of prehistoric settlements. The presence of the Basal Peat Bed, the Terbregge Member (Maasgeul area) and/or Velsen Bed provides an indication for an intact *Pleistocene* landscape, although it should be noted that erosion could have taken place prior to the deposition of peat and clay, leading to degradation or even annihilation of prehistoric remains. If the *in situ* prehistoric remains did not suffer from erosion, the very rapid Early *Holocene* 'drowning' of the *Pleistocene* landscape and local deposition of a peat and/or clay cover offered perfect conditions for the conservation of both organic and inorganic remains. In this situation well-preserved sites of high physical quality can occur.

Occurrence and spacial distribution

The occurrence and spacial distribution of Late Saalian ice pushed-ridges, Early Weichselian lagoons, lakes and fens, Pleniglacial river deposits and the Late Weichselian wind-blown dunes and stream valleys in the area of interest is not known in detail. Surely the available geological maps of the Flemish Bight Map (1984), the Indefatigable Map (1986), the Top *Pleistocene* Formation map and Deltares' grid data (2004) and palaeogeographic maps (2015) provide an indication, but the actual situation can only be established through subbottom profiling in combination with borehole sample analysis. The depth below the seabed of the *Pleistocene* landscape ranges from 0m (*Pleistocene* exposed) to nearly 30m.

Known objects and shipwrecks

For a listing of known objects and shipwrecks within the area of interest, the united NCN database is consulted[24].

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 SonarReg92 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 was granted by the owner (Rijkswaterstaat Sea and Delta)

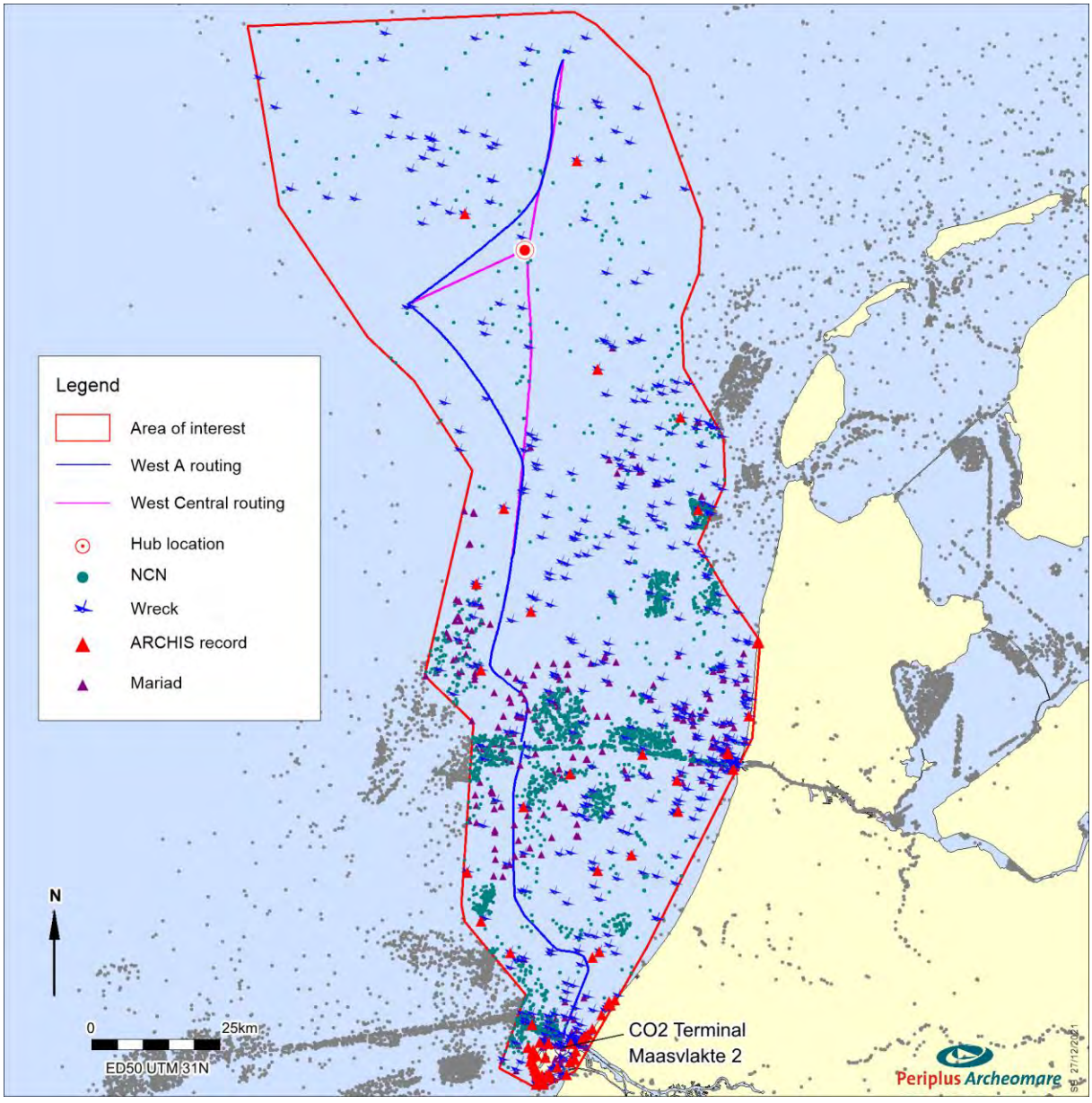


Figure 22. Overview of known objects and contacts in the area of interest

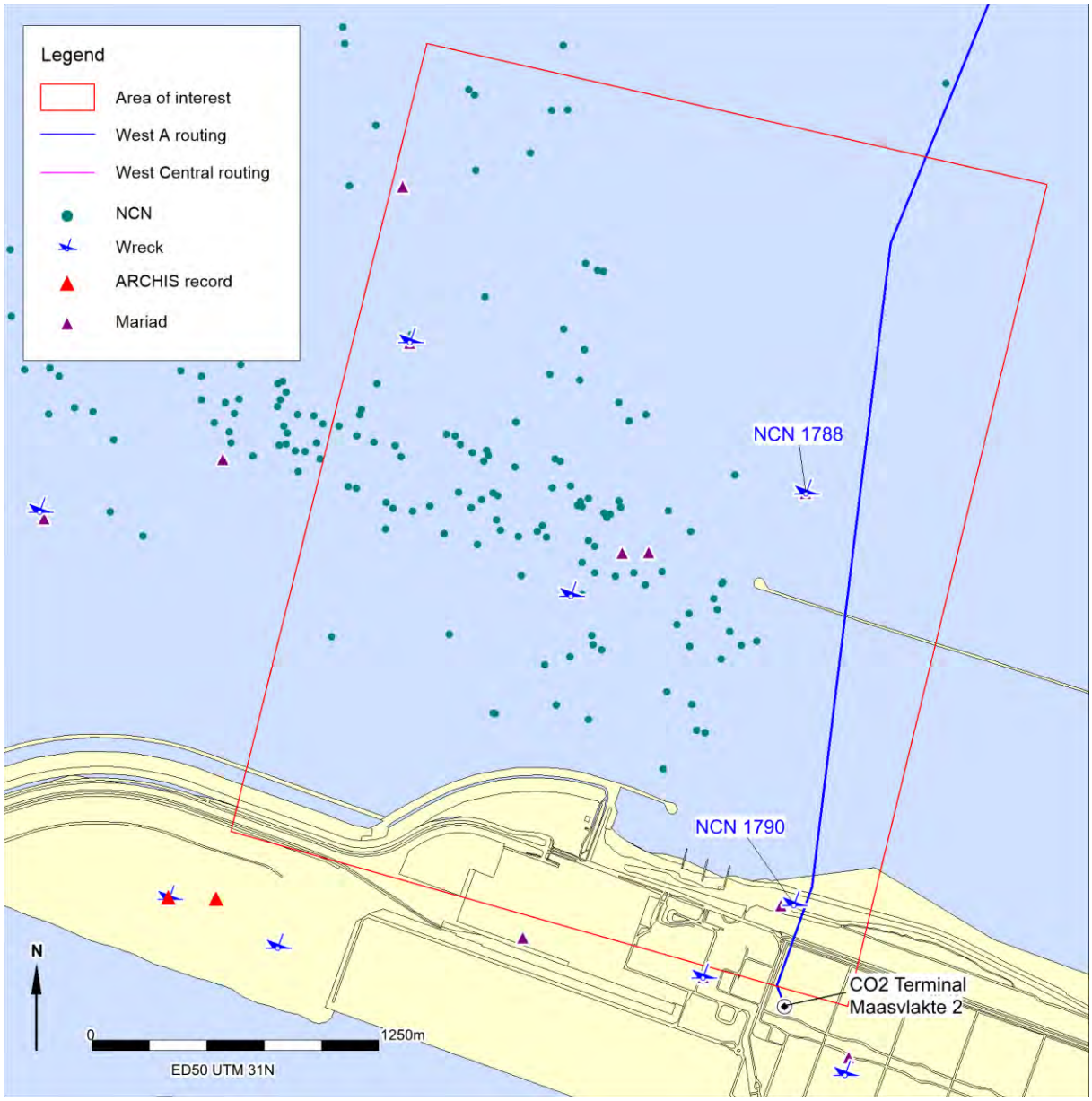


Figure 23. Overview of known objects and contacts in the landfall area

Archaeological records.

Within the area of interest, 316 records of archaeological finds are known with the ARCHIS 3 database. These vary from prehistoric artefacts (mainly concentrated around Maasvlakte 2) to remains of shipwrecks, (see next paragraph).

Shipwrecks

There are 458 known shipwrecks within the area of interest of which 38 are officially recorded in the ARCHIS database. 307 wrecks are identified and date from the 16th to the 21st century. The remaining 151 wrecks have not been identified and dated yet. Additional research is needed to determine the cultural-historical value.

Within the landfall area, two records of ship wrecks are known in the vicinity of the proposed route. NCN 1788 was the wreck of the *SS Ceres*, sunk in 1934, and was cleared away to a depth 0f 75 dm. Remains may still be present. NCN 1790 was the wreck of the *Hertha Engelina Frit, sunk in 1941.* It is now covered by sand in reclaimed area.

In general, when a sinking ship ends up on the seabed, the tidal currents will create scouring around the wreck, and bury it down to a level of a harder surface within the sedimentary sequence. The thicker the layer of loose material, the more the ship will be packaged therein and will be retained. Especially in areas where the sediments have high clay content the wreck remains will be sealed and well preserved. In more sandy areas this effect is much smaller. Uncovered wooden parts may be affected by a naval shipworm (Teredo Navalis).

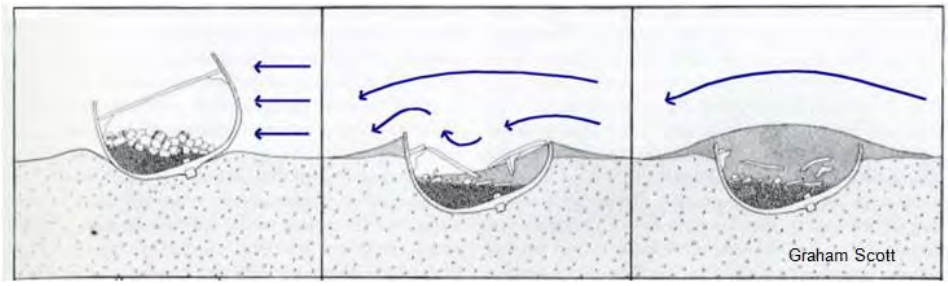


Figure 24. Example of wreck site formation (Graham Scott)

Other know objects

Besides wrecks, the SonarReg database contains records of 3494 other known objects within the area of interest. A summary is listed below.

Classification	Amount
Anchors	121
Boulders	77
Cables/Chains	304
Man-made objects	193
Natural phenomena	10
Seabed disturbances	226
Unidentified objects	2563
Total	**3494**

Table 4. Observations of known objects

Among the man-made objects and unidentified objects archaeological artefacts may be present.

Airplane wrecks

During World War II, many airplanes crashed into the North Sea. Several sources are ambiguous about the number of aircraft still missing. It is at least hundreds[25]. Remains are found on a regular basis by fishermen or during sand extraction or and beach protection projects. Within the area of interest, five locations with remains of aircrafts are known.

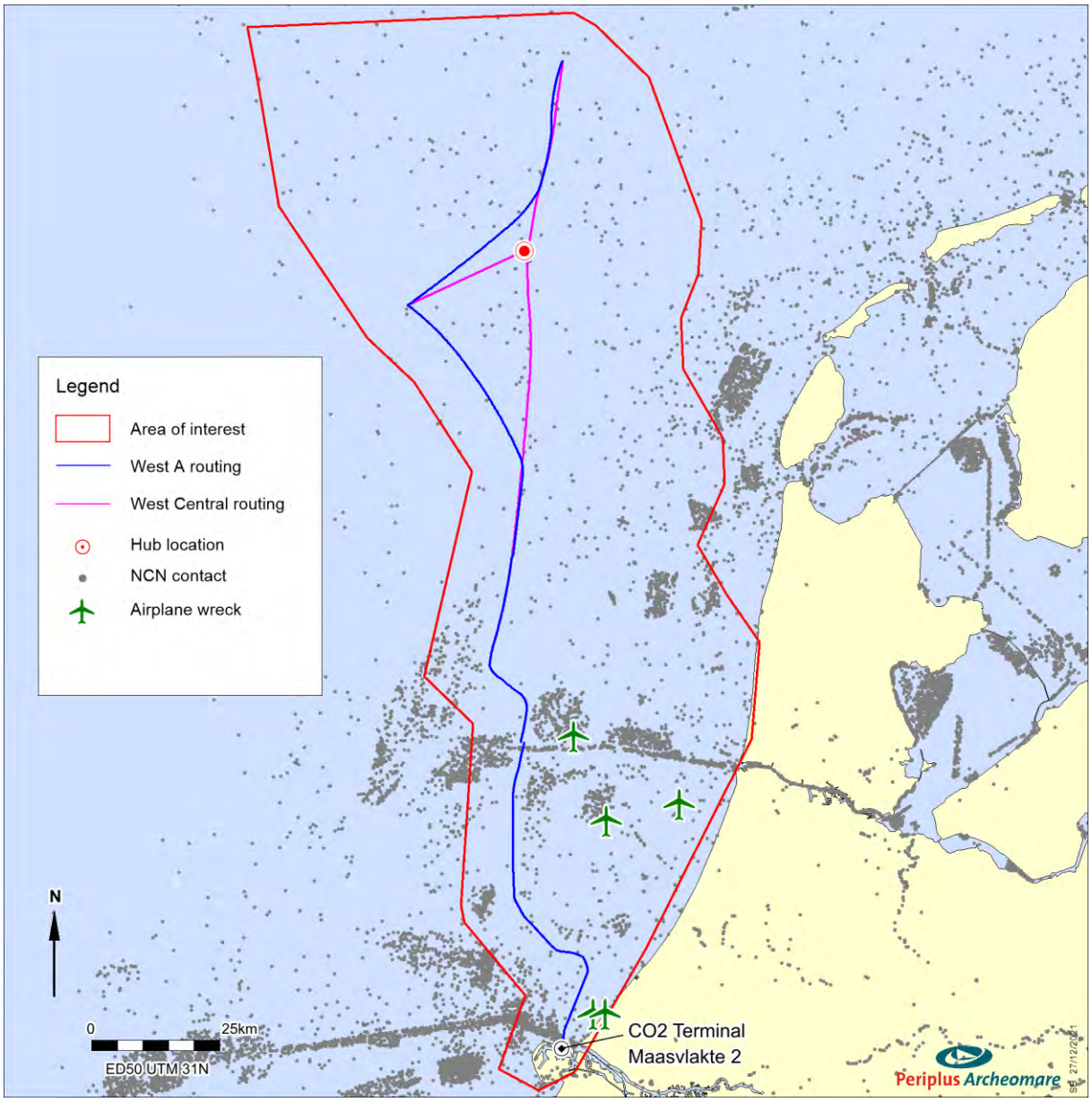


Figure 25. Known airplane wrecks within the area of interest

A complete listing of all known wrecks and objects within the area of interest can be made digitally available in consult with the administrator, Rijkswaterstaat Zee en Delta.

[25] Dutch Federation of Aviation Archaeology

3.6 Specified archaeological expectancy (LS05)

Shipwrecks

The area has a high expectation for shipwrecks from all periods. A total of 458 shipwrecks are known in the area, and more undiscovered wrecks can be expected. For some of the wrecks details like names, types and date of sinking are not known. Further research is needed to determine the cultural-historical value of these wrecks.

Plane wrecks

The area has a high expectation for plane wrecks from the Second World War. Several sources are ambiguous about the number of aircraft still missing. It is at least hundreds [26]. Within the area of interest, five locations with remains of aircrafts are known.

> **Current theme : wrecks from the First and Second World Wars**
> In addition to archaeological and cultural-historical value, ship and aircraft wrecks can also have a, memorial or emotional value. The commotion that arose as a result of the clearing of WWII wrecks in the Java Sea can be mentioned as an example. With regard to wrecks from the World Wars in Dutch waters, more and more voices are coming from society to deal with this respectfully.

Prehistory

During the last ice ages the area of interest was exposed due to very low sea levels. In those times the landscape was occupied by hunters and gatherers. Therefore camps sites are to be expected in the top of *Pleistocene* formations. The archaeological expectancy is discussed below by means of the geogenesis of the area and lithostratigraphic units present. As discussed in the section on ship wrecks, also for the *Pleistocene* landscape applies that our specific knowledge is limited, because a major part of the area has not been investigated by detailed geophysical surveys or the analysis of high quality borehole samples. As part of the Aramis pipeline development shall therefore be strived to gather additional information to broaden and deepen our geo-archaeological knowledge of the area, as outlined in the NSPRMF report.

[26] Dutch Federation of Aviation Archaeology.

Formation	Member / Bed	Lithology	Environment	Age	Arch. Potential*	Period
Southern Bight	Bligh bank	sand	open marine	Holocene	I, IV	Historical periods
Naaldwijk	Wormer	clay and sand	tidal		I	
	Velsen	humic clay	lagoon	Early Holocene	II	Meso
Echteld	Terbregge	humic clay with plant remains	freshwater tidal		II	
Nieuwkoop	Basal Peat	Peat	coast marsh		II	
Boxtel	Singraven	sand, loam, clay and peat	small-scale fluvial	Weichselian and Early Holocene	II and III	LPaleo + Meso
	Delwijnen	sand	river dune		III	
	Wierden	fine sand	cover sand		III	
Kreftenheye	Wijchen	clay and loam	overbank	Weichselian and Early Holocene	II and III	
		sand	bedding sand		II and III	MPaleo
Woudenberg		Peat	lakes	Eemian and Early Weichselian	II	
Eem	Brown Bank	humic clay and silt	lagoons and lakes	Eemian and Early Weichselian	II and III	
		sand and clay	open marine	Eemian	IV	
Boxtel | Drachten		gravel, sand, loam, peat	terrestrial	Late Saalian to Early Eemian	II and III	
Egmond Ground (ice-pushed)		sand with clay beds	open marine	Pre-Saalian deposition; Saalian (ice-push event)	II, III and IV	MPaleo - Meso
Yarmouth Roads (ice-pushed)		sand and clay	open-marine deltaic, delta top and fluvial	Pre-Saalian deposition; Elsterian/Saalian (ice-push event)	II, III and IV	Paleo - Meso

Table 5. Relation between lithostratigraphy and archaeological potential

*

Archaeological Expectancy	
I	Ship wrecks and shipping related objects; air planes from World War I and II
II	Lost or dumped objects including flint and bone hunting gear, fish weir, fish traps and dugout boats
III	Camp sites and inhumations
IV	Artefacts in reworked context

Archaeological levels are contained in the stacked sequence of *Pleistocene* and *Holocene* units. The relationship between the lithostratigraphic units and archaeological levels contained herein is summarized in table 5.

4 Synthesis

Based on the results of de data analysis the research questions are answered.

Are there any known archaeological values present within the area of interest? If so, what is the nature, extent (depth) location and dating of these sites?
Yes, within the area of interest, 316 records of archaeological finds are known with the ARCHIS 3 database. These vary from prehistoric artefacts (mainly concentrated around Maasvlakte 2) to remains of shipwrecks.

Are there, in addition to any known values, archaeological remains to be expected? If so, what are the nature, extent (depth) location and date of the expected archaeological remains?
Yes. There are 458 known shipwrecks within the area of interest of which only 38 are officially recorded in the ARCHIS database. 307 wrecks are identified and date from the 16th to the 21st century. The remaining 151 wrecks have not been identified and dated yet. Additional research is needed to determine the cultural-historical value.

The area may contain shipwrecks, remains of shipwrecks or remains of airplanes from the Second World War which have not been discovered to date. Apart from undiscovered ship and plane wrecks it is expected that locally prehistoric landscapes have been preserved intact. Related to these intact landscapes *in situ* prehistoric remains left behind by Palaeolithic and Mesolithic hunters and gatherers can be encountered.

Those *in situ* prehistoric remains include camp sites, burials, lost hunting gear, et cetera. Remains of camp sites are characterized by the presence of flint and bone artefacts, burnt nuts and seeds, charcoal and hunting gear.

Can the proposed activities affect known or expected archaeological values? If so, can an impact on archaeological assets be prevented or restricted by planning adaptation?
This question can only be answered once the area has been geophysically investigated and when the cultural historic value of the objects in the area has been determined.

If the archaeological values cannot be saved: What kind of further research is needed to determine the presence of archaeological values and their size, location, type and date to be determined enough to come to a selection decision?

Further research is to be performed within the framework of the standardized sequence of phases of maritime archaeological research as defined in the Dutch archaeological management procedure (Dutch: 'AMZ Cycle'). The research strategy is further determined by the type of archaeological remains which, based on the archaeological expectancy outlined in section 3.6 of this report, are to be expected. In summary the expectancy is two-fold comprising plane and ship wrecks on one hand and prehistoric remains on the other. The first phase after the archaeological desk study is an inventory field research. This field research comprises a geophysical survey. The methods employed include multibeam echo sounder, side scan sonar and magnetometer to trace and map wrecks and shipping related objects. A subbottom profiler is used to assess the potential for prehistoric remains by mapping the top of the buried *Pleistocene* landscape, identify seismostratigraphic units and correlate those units with the expected lithostratigraphic units (and potential archaeological remains herein), and determine the locations at which archaeological levels have been affected by erosion.

What are the possible effects of the installation of the pipeline on the areas with specific archaeological interest?

Archaeological values can be affected by human activities which result in a disturbance of the seabed. Direct disturbances are caused by trenching operations. Scouring adjacent to the pipeline is considered to be an indirect disturbance which might lead to the exposure of wrecks and erosion of the prehistoric landscape.

What are the possibilities to mitigate the disturbance of areas with specific archaeological interests?

In general, a buffer or safety zone of 100 meters around an archaeological object or an object with an archaeological expectation is to be defined in which seabed disturbing activities are not allowed[27]. If additional research shows that the object has no archaeological value, the location and the buffer zone can be omitted. The identification and mapping of camp sites from the Palaeolithic and Mesolithic is, due to their limited size and depth of burial, in practice troublesome. Mitigating measures to preserve those sites can therefore only be effected by excluding areas in which prehistoric landscapes have been preserved intact and which are considered to have a high probability for containing those sites.

Should further investigations be carried out from archaeological point of view and what are the recommendations on the scope and specifications of these investigations?

Additional research in the form of a geophysical survey is standard in the process of archaeological investigations. (in Dutch: *Inventariserend veldonderzoek opwaterfase*). The scope and specifications for this geophysical survey are to be recorded in a mandatory Program of Requirements (PvE). Typical requirements include restrictions about the maximum range and minimum frequency of the side scan sonar, survey speed and line spacing.

[27] Beleidsregels ontgrondingen in Rijkswateren, see http://wetten.overheid.nl/BWBR0028498/

5 Summary and recommendations

The installation of the pipelines may affect archaeological remains in the area, if present. According to the Law on Archaeological Heritage (Dutch: Erfgoedwet 2016) there is a statutory obligation to conduct archaeological research in order to protect the remains. This archaeological desk study is the first step in the archaeological process aiming to establish whether archaeological remains are, or are likely to be, present, and whether these remains could be effected by the development of the planned pipelines. The results are summarized below.

The area of interest has a high expectation for the presence of (remains of) ship wrecks and WWII plane wrecks. Intact prehistoric landscapes and related *in situ* remains of Palaeolithic and Early Mesolithic camp sites and inhumations are expected to have been preserved in places.

The proposed pipeline routes have not been investigated by detailed geophysical surveys yet. These areas may contain more undiscovered shipwrecks or remains of shipwrecks than currently known.

At this stage little is known about the integrity of the *Pleistocene* and Early *Holocene* landscapes. By means of subbottom profiling the occurrence geological units (both horizontal as vertical) and archaeological levels herein can be mapped. The character of layer boundaries (erosive or non-erosive) can be interpreted. It is unlikely however that archaeological remains of Palaeolithic and Mesolithic camp sites can be identified with sufficient certainty (based on the geophysical and geotechnical surveys) to impose restrictions on pipeline development. At this stage focus should therefore not be put on tracing prehistoric camp sites but on a pragmatic employment of geophysical techniques in order to obtain a better insight in (the integrity of) the *Pleistocene* landscape. The insights gained shall be used to a) refine the archaeological expectancy model and b) allocate areas with a high expectancy for *in situ* prehistoric remains.

In accordance with the AMZ cycle it is advised to conduct a field investigation (in Dutch '*Inventariserend veldonderzoek opwaterfase*') in order to test the archaeological predictive model and further specify the type, vertical and lateral extent, age, integrity and preservation of ship wrecks, prehistoric landscapes and potential archaeological levels.

Archaeological Expectancy	Method		Goal	Remarks
Ship and aircraft wrecks	Geophysical	Side Scan Sonar	detect and map wreck sites	wrecks exposed at, or protruding from the seabed
		Multibeam	characterize wreck sites morphologically; detect (partially) buried wrecks by the occurrence of scours	in addition to side scan sonar
		Sub-bottom Profiler	detect buried objects including possible ship wrecks and remains of aircraft	nature of the buried object cannot be determined directly
		Magnetometer		
Prehistoric settlements (camp sites)		Sub-bottom Profiler	map the Pleistocene landscape; specify expectancy	supported by, and validated with drill data
	Geotechnical	Geological Drilling	determine lithostratigraphy, soil layer boundaries (erosive or gradual) and characteristics of soil formation and maturation; specify expectancy	designation of borehole and/or vibrocore locations for geo-archaeological research based on SBP data
		Cone Penetration Test	determine lithostratigraphy	correlate with drilling data

Table 6. Testing of archaeological expectation with geophysical and geotechnical methods

In general, similar investigations carried out in the past consist of a geophysical survey with *side scan sonar*, *magnetometer* and *subbottom profiler* and a geotechnical survey. The resulting data should be assessed after the general processing, interpretation and reporting has been performed by the survey contractor.

The archaeological assessment of the data shall to be conducted by a geophysical specialist (KNA prospector Waterbodems). The data quality from the surveys needs to match the demands for this archaeological assessment. To ensure compatibility between the site investigation and the required quality for this assessment it is recommended to define a Program of Requirements (In Dutch: 'Programma van Eisen') in accordance with the 'KNA' (the Dutch quality standards for archaeological research), to be authorized by the competent authority.

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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
NoaA	Nationale Onderzoeksagenda Archeologie
NSPRMF	North Sea Prehistory Research and management Framework
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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- Dienst der Hydrografie (www.hydro.nl)
- Geologische Dienst Nederland - Data Informatie Nederlandse Ondergrond (www.dinoloket.nl)
- Noordzeeloket (www.noordzeeloket.nl)
- North sea paleolandscapes, University of Birmingham (http://www.iaa.bham.ac.uk)
- Olie en Gasportaal (www.nlog.nl)
- Stichting Aircraft recovery Group 40-45 (http://www.arg1940-1945.nl)
- Stichting Infrastructuur Kwaliteitsborging Bodembeheer (SIKB.nl)
- Stichting Maritiem Historische Databank (http://www.marhisdata.nl/)

Various sources

- Archis III, archeologische database Rijksdienst voor het Cultureel Erfgoed
- Databases Periplus Archeomare
- KNA Waterbodems 4.1
- Nationaal Contactnummer Nederland (NCN)
- SonarReg92, objectendatabase Rijkswaterstaat Zee en Delta

Appendix 1. 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:

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:

Exploratory geophysical 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 echo sounder 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:

Exploratory field research under water (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.

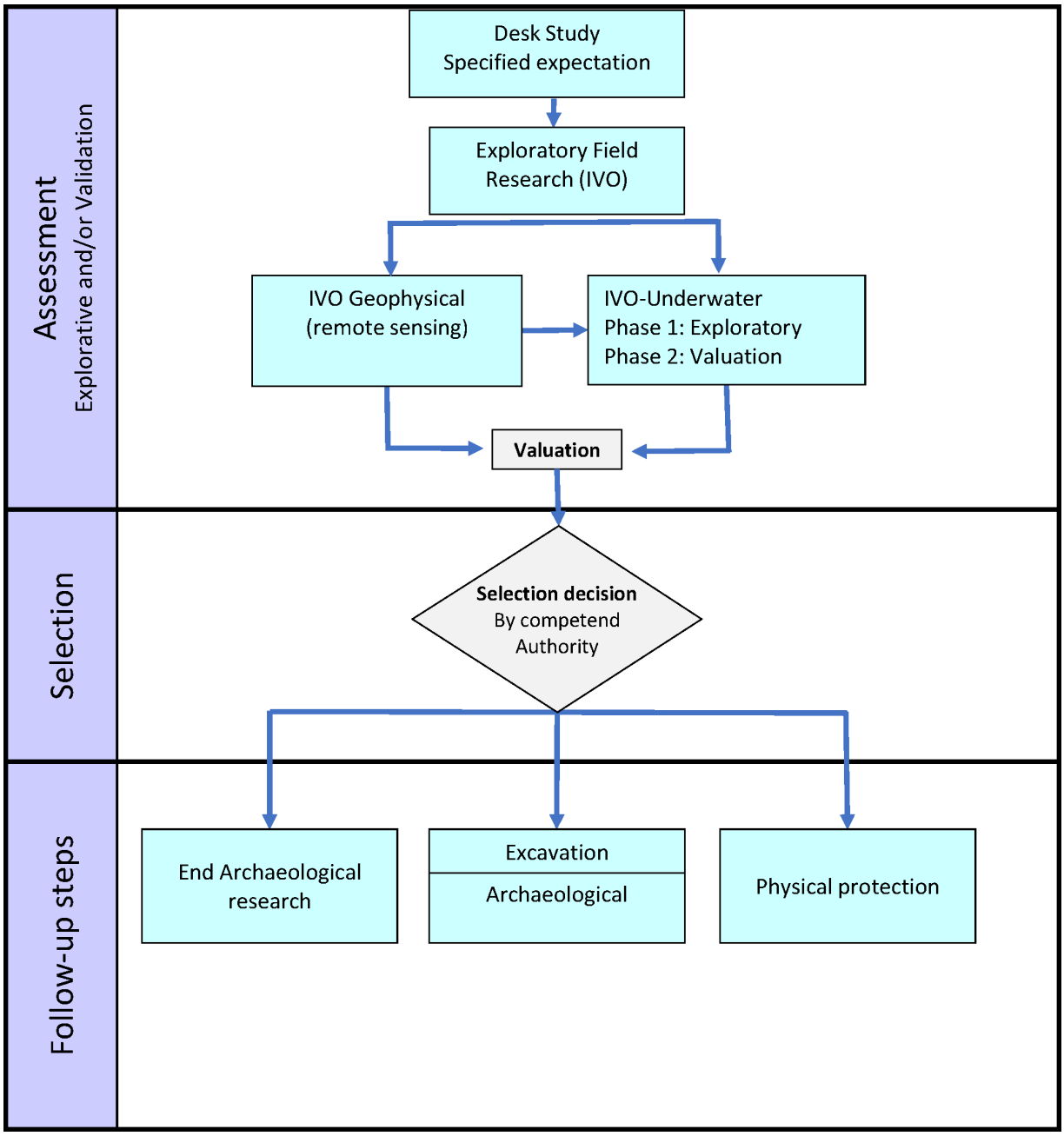
IF as site is identified as an archaeological object or structure then the next phase must be carried out:

Validating 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:

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 and structures. The figure on the next page shows these moments schematically.

Schematic overview KNA Waterbodems version 4.1



Appendix 2. Archaeological and geological periods and 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			Paleolithicum	Laat	B	12.500
			11.000						
			Allerød						
			12.000						
			Oude Dryas						
			12.100						
			Bølling						
			13.000						
		Pleniglaciaal L					Jong		16.000
			17.000						
			Late Glacial Max						
			20.000						
			31.500						
			Denekamp					A	35.000
			34.000						
		Pleniglaciaal M					Midden		250.000
			40.000						
			Hengelo						
			41.500						
			45.000						
		Pleniglaciaal V	Moershoofd						
			50.000						
			71.000						
		Vroeg Glaciaal	Odderade				Oud		
			74.000						
			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 C

UXO desktop Study

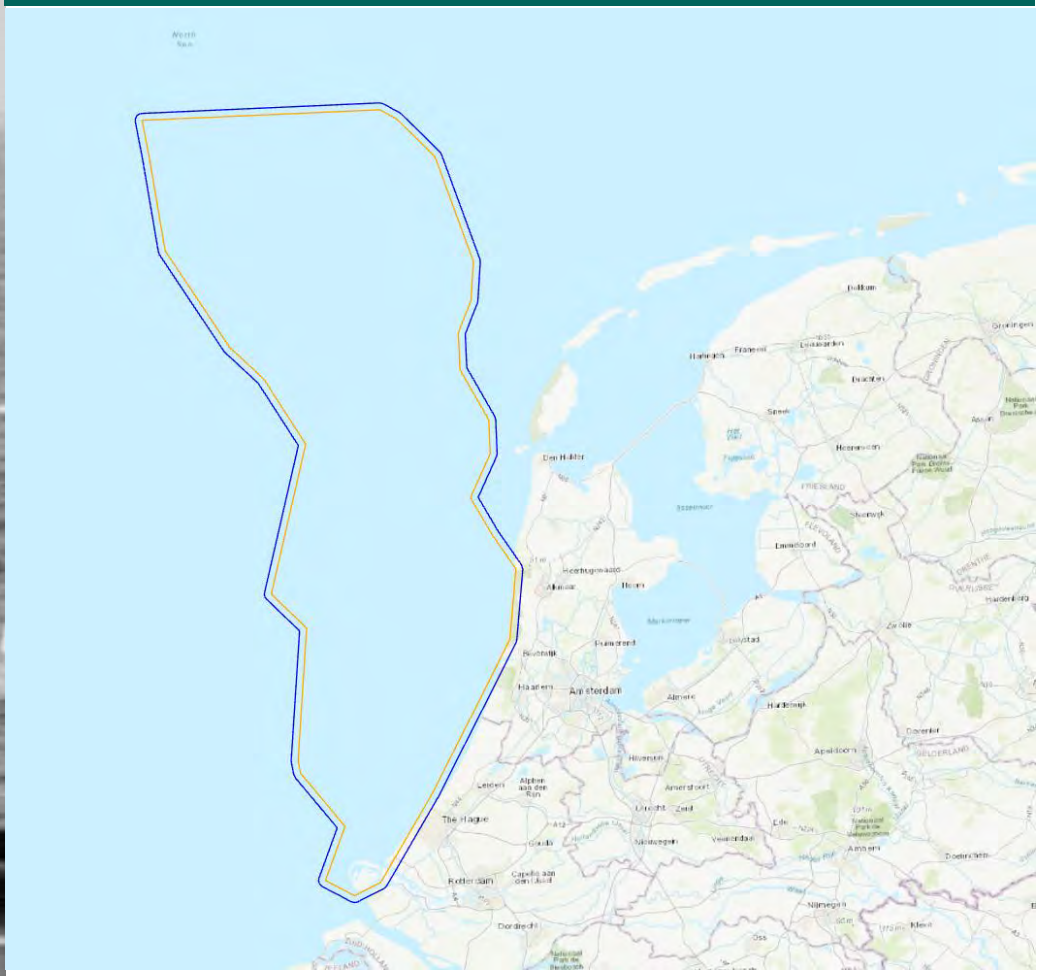


Historical Desktop Study

Unexploded Ordnance (UXO)

Maasvlakte Aramis CCS Project

RO-220005 Report version 1.0 (final)
9th February 2022



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Historical Desktop Study

Unexploded Ordnance (UXO)

Maasvlakte Aramis CCS Project

Client	:	Fugro GB Marine Limited
Label	:	74497 / RO-220005 version 1.0 (final)
Place, Date	:	Riel, 9th February 2022

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Accepted	[redacted] Manager Marine Geotechnics		

Front page image: Fragment of oblique aerial photograph showing Bristol Beaufighter's of the North Coates Strike Wing attacking a small enemy convoy off Terschelling, Holland. The nearest trawler is being attacked with cannon gunfire, and also with rocket projectiles fired by the aircraft from which the photograph was taken. Source: Imperial War Museum.

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SUMMARY

Historical research

The Central North Sea was the scene of several war related events during World War I and II. Among these are the sinking of a large amount of vessels and aircraft, bombing by planes, naval battles and the presence of minefields, military exercise zones and munition dumping grounds. Due to these events UXO may be located within the area of interest. The UXO items considered most likely to be present within the investigation area are shown in the overview below. Note that the overview shows the likelihood of presence of generic UXO types within the site based on the evidence available in the REASeuro GIS-Database at the time of writing this report.

UXO type	Likelihood of presence	Subtype / calibre	Remarks
Naval mines (WWII)	Feasible	German E-Mine moored contact mines British Vickers / British Elia and H Mark II moored contact mines	The area of interest was situated between the British coast and Germany. During the First World War this area was a theatre of mine warfare. Multiple German and British minefields were laid within the area of investigation. This evidence supports a strong likelihood that naval mines are present within the boundaries of the known minefields. Outside these boundaries likelihood of presence is determined to be feasible.
	Probable		
Naval mines (WWII)	Probable	British Mk I-IV ground mines and British Mk VII- VIII and Mk XIV German EMB, EMC, EMD, UMA, RMA, KMA contact mines German LMB Ground mines German Exploding Floats (and also non explosive sweep obstructors) Dutch Model 1921 '2e soort'	During the Second World War the area of interest was situated between the British oast and the German occupied coasts of Europe. During the Second World War this area was once again a theatre of mine warfare. Multiple German and British minefields (filled with mines and sweeping obstructers) were laid within the area of investigation. Primary sources lead to the conclusion that within the boundaries of the known minefields, the likeliness of presence of naval mines is certain. Outside these boundaries likelihood of presence is determined to be probable.
	Certain		
Aerial bombs	Certain	4 lbs, 25 lbs, 30 lbs, 100 lbs, 250 lbs, 260 lbs, 300 lbs, 500 lbs, 1.000 lbs, 4.000 lbs	During the Second World War, aerial warfare played a huge factor. Research shows that a large amount of allied airstrikes took place in the area of investigation. Depending on the target bombs, rockets, torpedoes and depth charges could be deployed. Besides airstrikes, allied aircraft often jettisoned bombs over the North Sea. At least one direct indication of jettisoning in the area of investigation has been derived from the historical sources. Indirect indications are plentiful. Due to the large amount of sources stating attacks near the convoy routes it is deemed certain that UXO as a result of aerial warfare might still be present near these convoy routes. In the rest of the area of investigation the likelihood of presence of UXO is deemed probable due to the large amount of jettisons in the North Sea.
	Probable		
Rockets	Certain	3 inch rocket with 25 lbs or 60 lbs (SAP) warhead	
	Probable		
Under water ammunition	Certain	18 inch torpedo Mk XV Depth charge	
	Probable		

UXO type	Likelihood of presence	Subtype / calibre	Remarks
Artillery Shells Small calibre ammunition (Naval weaponry)	Probable Remote	Small Calibre Ammunition .303 .50 13,2 mm 15 mm Artillery Shells 2 cm/20 mm 2 pr. pompom 3.7 cm 6 pr. 8.8 cm	As mentioned, German shipping was attacked regularly by Allied aircraft. As a countermeasure German ships were equipped with anti-air (machine)guns. Due to the deployment of these guns, UXO might be present near the commonly used German convoy routes. Outside of these convoy routes the likelihood of presence of UXO is deemed remote. This statement is further enhanced by the fact that British surface craft tried to infiltrate the German convoy routes and, in some instances, fought small scale naval battles with German ships.
Artillery Shells	Probable Negligible	Coastal guns: 5 cm 7,5 cm 9,4 cm 10,5 cm 12 cm 14,91 cm 15 cm 15,2 cm 24 cm 28 cm	After the German occupation coastal guns were installed along the Dutch coast as part of the *Atlanikwall.* The coastal guns covered the whole coast in order to repel a possible Allied attack. Due to exercises and combat UXO of artillery shells could be present within the area of investigation. However, UXO could only have reached as far as the range of the coastal guns. Within range of the coastal guns the likelihood of presence is deemed to be probable, outside of this range the likelihood of presence is deemed negligible.
Unknown (exercise) munition	Certain Negligible	Each military exercise zones had it's own purpose, it is outside the scope if this research to determine the munition used in each zone.	Within the area of investigation there were several military exercise zones. Some were already in use by German troops during the Second World War, others taken into use by the Dutch military after the war. It is deemed certain that UXO of (exercise) munition is still present within the boundaries of the military exercise zones, outside these zones the presence of UXO of (exercise) munition is deemed negligible.
Unknown dumped munition	Certain Probable Negligible	-	A total of three known munition dumping grounds overlap with the area of investigation. Sources state that fishermen found munition outside of the dumping grounds, therefore a buffer of three nautical miles was projected around dumping grounds. 'Fishing, intrusive, and seismographic activities' were deemed dangerous within this buffer. The presence of munition dumping grounds lead to the determination of a UXO Risk Area at the location of the dumping ground. The likelihood presence of UXO at this location is deemed certain. Within the buffer of three nautical miles this likelihood presence is deemed probable, in the rest of the area of investigation the likelihood presence is set to negligible.

Table 1: UXO items likely to be encountered in the area of interest.

1 GENERAL INFORMATION

This chapter describes the context and goal for the Historical Desktop Study–Unexploded Ordnance (HDTS-UXO). Furthermore the area of investigation, the area of interest, the purpose and methodology are described. The chapter concludes with a general structure of the report.

2.1 INTRODUCTION

Fugro has invited REASeuro to conduct an HDTS-UXO for the CCS Aramis project. The plans are to build a new pipeline from Maasvlakte (man-made westward extension of the Europoort port and industrial facility within the Port of Rotterdam) to offshore blocks L4/K6. To obtain insight in the possible chance of encountering UXO during this project, Fugro Survey B.V. has requested REASeuro to provide a HDST-UXO.

2.2 AREA OF INTEREST AND AREA OF INVESTIGATION

The area of interest is located off the Maasvlakte, Netherlands to offshore blocks L4/K6, located within the northwestern part of the North Sea. The area of investigation is the given radius, based on the inaccuracies inherent to conducting offshore desk research. The positions of naval minefields, air strikes, crashes and convoy routes in historical sources are given approximately only, since navigation equipment was not nearly as accurate as it is in modern systems. The most common method of marking locations during the World Wars was based on decimal degrees, which were accurate down to 1 naval mile (1,852 meters). Another way of positioning is found in German sources, which are based on the German Naval Grid (*Kriegsmarine Quadranten*), with a grid size of 6x6 nautical miles. Historical sources based on this grid thus position war related events in an area of 123 square kilometres.

Besides these inherent inaccuracies from historical sources, one must take into account the displacement of UXO on the seabed. Bottom trawling, tides and currents, and recent developmental activities may have caused this displacement. The area of interest and research area are shown in Figure 1.



Figure 1: Area of interest and area of investigation (Source of base map: ESRI).

2.3 PURPOSE AND MAIN OBJECTIVES

The HDTS-UXO will be performed with sources which are currently in the REASeuro-database and open sources in a short amount of time. Therefore, it provides an indication if UXO might be present in the Area of interest. By conducting the sources which are mentioned above, historical research will be conducted on the war-related events that took place within the Area of Interest. More specifically, the HDTS-UXO will provide historical research on:

- Aerial attacks on ships
- Airplane crashes
- Shipwrecks
- Laying of minefields (WWI, WWII)
- Dumping of UXO
- Military zones

The starting point of REASeuro is, that the presence of UXO cannot be excluded. In the HDTS-UXO REASeuro will examine whether this premise is true and if there are areas with an increased risk of UXO. Based on the historical sources, the possible calibres and type of UXO are determined which could be present within the Area of Interest.

The HDTS-UXO will provide historical research on:

1. The military events, battle activities, aerial attacks on ships, airplane crashes, shipwrecks, laying of minefields (WWI, WWII), dumping and submarine activities.
2. The possible calibres and type of expected UXO.

3 APPRAISAL OF HISTORICAL SOURCES

This chapter describes the consulted sources. Detailed information extracted from each source is included within the annexes. Information extracted from the sources, results in an overview of relevant war events. These events are the starting point for the review and analysis of sources in chapter 4 of this historical research.

3.1 METHODOLOGY OF HISTORICAL RESEARCH

This research report is conducted in accordance with the Dutch CS-OOO regulations for UXO research and REASeuro's internal standards for offshore desk top studies. War related events that took place in the area of investigation are derived from historical sources, and subsequently analysed. Based on this analysis a UXO risk area may be demarcated.

Due to several years of experience with offshore research, REASeuro has built up a substantial database regarding war related events in the North Sea. A multitude of sources are consulted for this report. All consulted sources are listed and explained in paragraph 2.2.

The research has been conducted by an historian. Page 1 of this report mentions the involved experts. ArcGIS Pro version 2.9.0[1] has been used as a tool to conduct this research. Historical maps and other information have been gathered and projected in this geographical information system for analysis[2]. GIS is also used to position and clarify the relevant war related events mentioned in the list of war related events in chapter 3.

3.2 SOURCES

For more than twenty years, REASeuro has collected historical sources regarding war-related events within the North Sea. Many of these sources have been made available for historical research through an internal database in our own Geographical Information System (GIS). This database contains a wide variety of sources. The following sources will be consulted for the HDTS-UXO:

Sources
Literature • Maps and charts regarding minefields
Nationaal Archief, The Hague, The Netherlands • Coastal guns
Noorzeeloket, The Netherlands • Military zones
Dienst der Hydrografie, Koninklijke Marine, The Netherlands • Wrecks • Military zones
Nederlands Instituut voor Militaire Historie, The Hague, The Netherlands • Minefields
Marinemuseum, Den Helder, The Netherlands • Coastal guns
Bundesarchiv-Militärarchiv, Freiburg, Germany • ZA 5 Deutscher Minenräumdienst (German Minesweeping Administration) – mine-clearance operations
The National Archives, Richmond, United Kingdom • Bomber Command: aerial attacks and minelaying within the North Sea

[1] Mentioned as 'GIS' throughout this report.

[2] Historical charts are "georeferenced" in GIS and used for this report. Georeferencing is the name given to the process of transforming a scanned map or aerial photograph so it appears "in place" in GIS. By associating features on the scanned image with real world x and y coordinates, the software can progressively warp the image so it fits to other spatial datasets. For this research, historical charts have been georeferenced by distinguishing points of recognition on both the historical and present maps and placing 'those points together' so that both maps align. Since several of these charts are hand-drawn or lack exact coastlines, inaccuracies may occur and exact inaccuracies in meters could not be given.

• Coastal Command: aerial attacks and minelaying within the North Sea • Squadrons: Loss charts
National Archives and Records Administration, College Park (MD), United States • Documents from the US Army Air Forces (USAAF)
Beneficial Cooperation - The Royal Netherlands Navy and the Belgian Navy • UXO-clearance operations • Military zones
OSPAR-convention • UXO-clearance operations
Wrecksite • Locations of wrecks (airplanes/ships etc.) within the North Sea
UK Hydrographic Office • Charts regarding minefields • Charts regarding naval routes
Library of Congress • Charts regarding minefields

Literature

An overview of used literature can be found in Annex 2. Literature is consulted in order to get a general depiction of the war related events (especially the laying of minefields) within the area of investigation. The resulting events are shown in chronological order in tables. The references (book and page) for each event are included in the tables.

Nationaal Archief, The Hague, The Netherlands

The Dutch National Archives have been consulted for more information on the coastal guns on the Dutch Coast.

Noordzeeloket, The Netherlands

The Noordzeeloket is a comprehensive website, covering relevant Dutch maritime policy related North Sea information. On the website relevant information about the locations of Voormalige munitiestortplaatsen (Former munitions dump locations), Oefengebieden Mijnenruimen (Mine clearance training areas), (Laag)vlieggebieden ((Low) flying areas) and Schietterrein / onveilige zone (Shooting site / unsafe area) is available.

Dienst der Hydrografie, Koninklijke Marine, The Netherlands

Naval charts of the area of analysis have been acquired through the Hydrographic Service. Besides naval charts regarding military usage the HP39 (wreck registry) publication has been consulted to gain information on possible wrecks in the area of investigation.

Nederlands Instituut voor Militaire Historie, The Hague, The Netherlands

The 'Nederlands Instituut voor Militaire Historie' has been consulted on information about Dutch naval minefields.

Marinemuseum, Den Helder, The Netherlands

The map collection of the Marinemuseum (Navy Museum) in Den Helder has been consulted. NEMEDRI-maps were found in this collection. These maps offer information on minesweeping after the Second World War. The NEMEDRI maps show some information about mine clearance shortly after the war.

Bundesarchiv-Abteilung Militärarchiv (BAMA) in Freiburg

The German military archives were severely damaged during World War II. The remains of the archives are kept and maintained in the Bundesarchiv in Freiburg. The archives of the German navy (*Kriegsmarine*) survived the war relatively well compared to the other service branches. These have been consulted for this

desktop study, as well as the German Air Force (*Luftwaffe*) archives, of which only 2% of the documents survived the war. Annex 4 contains the relevant information from the BAMA.

The National Archives (TNA) in Londen

The National Archives have been consulted for information on naval minefields, air strikes, naval combat, bomb jettisoning and other relevant war related events. The Admiralty, War Cabinet and Air Ministry archives have been consulted for this information. Annex 4 contains relevant results from TNA.

National Archives and Records Administration (NARA) in College Park (MD)

Research has been conducted in the US National Archives and Records Administration. The NARA has been consulted for documents from the US Army Air Forces (USAAF) and for the collection of captured German records. Annex 4 contains the relevant information from the NARA.

Beneficial Cooperation - The Royal Netherlands Navy and the Belgian Navy

The Dutch navy is working with the Belgian navy to keep the sea, coastal waters and harbour mouths free of mines. Therefore, the UXO-related interventions in the database of the Beneficial Cooperation is consulted.

Post-war UXO clearance: OSPAR

The area of interest is situated in the North Sea. Therefore, the UXO-related interventions in the database of the OSPAR Commission[3] were consulted. The results are shown in Annex 4.

Wrecksite

The wreck site is the world's largest online wreck database. The website has information about 205.740 wrecks around the world. When information about the reason for the sinking of a ship is known, it is mentioned on the website.

UK Hydrographic Office

The UK hydrographical office maintains a collection of historical naval charts, including charts that contain minefields and convoy routes. Naval charts showing the area of investigation have been consulted, but no map has been found with information regarding the area of interest.

Library of Congress

On the website of the Library of Congress, which is known as the national library of the United States, a chart has been consulted regarding minefields in the First World War. This chart is shown in Annex 5.

[3] The Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR-convention) provides a framework for reporting encounters with conventional and chemical munitions in the OSPAR maritime area.

4 ANALYSIS OF WAR RELATED EVENTS

The consulted historical sources (see annexes) indicate several war related events within the area of interest. The war related events derived from the historical sources that are relevant for the area of interest are listed categorically in the tables underneath. The events are grouped into four categories: war at sea, the air war, naval mines, and other UXO-related events. Following these tables per category, the UXO type and likeliness of presence within the area of interest is determined. Before each category is analysed below, the method of defining UXO risk areas is explained.

Defining the UXO risk area

The UXO items considered most likely to be present within the area of interest are shown in each specified category. Note that the table at the end of each paragraph shows the probable presence of generic UXO types within the site based on the evidence gathered about potential UXO sources. It's important to recognise that the presence of a UXO type does not necessarily mean that it will be encountered. The likelihood of encounter (i.e. a positive interaction with the UXO during a specific project activity), will generally be less than the probability of items of that particular UXO type being present across the whole area of interest; given that the actual footprint of the anchor locations will be less than the total investigation area volume. In the following table the terminology used for the likely presence of UXO is shown.

"Presence" Term	Meaning
Negligible	No evidence pointing to the presence of this type of UXO within an area but it cannot be discounted completely.
Remote	Some evidence of this type of UXO in the wider region but it would be unusual for it to be present within the area of study.
Feasible	Evidence suggests that this type of UXO could be present within the area.
Probable	Strong evidence that this type of UXO is likely to be present within the area.
Certain	Indisputable evidence that this type of UXO is present within the area.

Table 2: Definitions of terminology used for the likely presence of UXO.

Condition of expected UXO

The majority of the expected UXO are likely to be in an armed condition. This means that the safety devices preventing the UXO from premature detonation, e.g. during handling, have been removed. Therefore, the explosive train, is in line.

The explosive train is a sequence of events that culminates in the detonation of explosives and can be different for each type of UXO:

- In the case of aerial bombs which were dropped by aircraft in distress situations, the bombs could have been dropped with safety features still in place, however they still present an explosive risk, e.g. as a result of corrosion of vital safety features.
- Some of the expected UXO, e.g. naval munitions, contain a large quantity of explosives and may be encountered in very poor condition as the thin metal casings may have severely eroded. In many cases, the explosive capability could remain more or less undiminished. Some explosive charges neither absorb nor dissolve in water, and some charges do. However, stability of the explosive charge may have deteriorated with age.
- Naval contact mines from the period of interest typically contained a dry cell battery with an electrical detonating circuit which was connected to external conventional switch horns. These batteries will have now deteriorated and no longer have the ability to supply sufficient power to function. However, the condition of the explosives can be unstable.
- Contact mines with Hertz Horns were also common from World War I and onwards. Each horn contains a container of acid. Heavy contact with the horn can brake the acid container within, which

subsequently energizes a battery and detonates the main charge. Therefore, this type of mine (like all other UXO) must be handled with extreme caution.

Although corrosion can make a UXO more sensitive, it can also make it less likely to detonate, as i.e. electrical wiring may have corroded resulting in a break in the explosive train. As a wide range of UXO can be expected, all UXO must be handled with extreme caution until the exact state is determined after positive identification by an EOD-expert.

4.1 NAVAL MINES

Naval mines were laid in the North Sea during the First and Second World War. The purpose was twofold. Mines were used in a defensive way to protect own waters and ports and to hold off enemy ships. At the same time, mines could be used to harass enemy shipping and obstruct military movements. Mines could be laid by surface ships, submarines and aircraft. During the First World War moored contact mines were used almost uniquely. Moored mines float beneath the water surface and are kept in position with an anchor and anchor cable. This technique was also used during the Second World War. Next to contact mines, the belligerent parties developed influence mines. These mines were laid on the sea bottom and would detonate if sensors in the mine detect a difference in pressure, sound, or magnetism caused by a passing ship.

The area of investigation has overlap with a suspected British minefield from the First World War and several German minefields from the Second World War. These minefields, the post-war clearance and UXO encounters are discussed in the next paragraphs. A conclusion is added in paragraph 4.1.4.

4.1.1 First World War

A map from the Library of Congress (see Annex 3) shows two minefields on relatively large distance from the area of investigation. It was a large German minefield (red, marked with a '3') lying along the Dutch coast. The map title (see subscript of Figure 2) explains that only the approximate position of the minefield is showed. The presence of the minefield is confirmed in the book *The Hidden Threat* (see Annex 2). According to this book 664 mines were laid in the field. No information about the exact type of mines was found, but the belligerent parties during the First World War used almost uniquely moored contact mines.

The second Minefield was British (bordered in red, northeast of the area of investigation). The border indicates an area in which multiple smaller minefields were laid. The mined area, the German Bight, was a major theatre of naval warfare during World War I. British forces laid 42.899 naval mines in the Bight. Only few German minefields can be found in the German Bight.

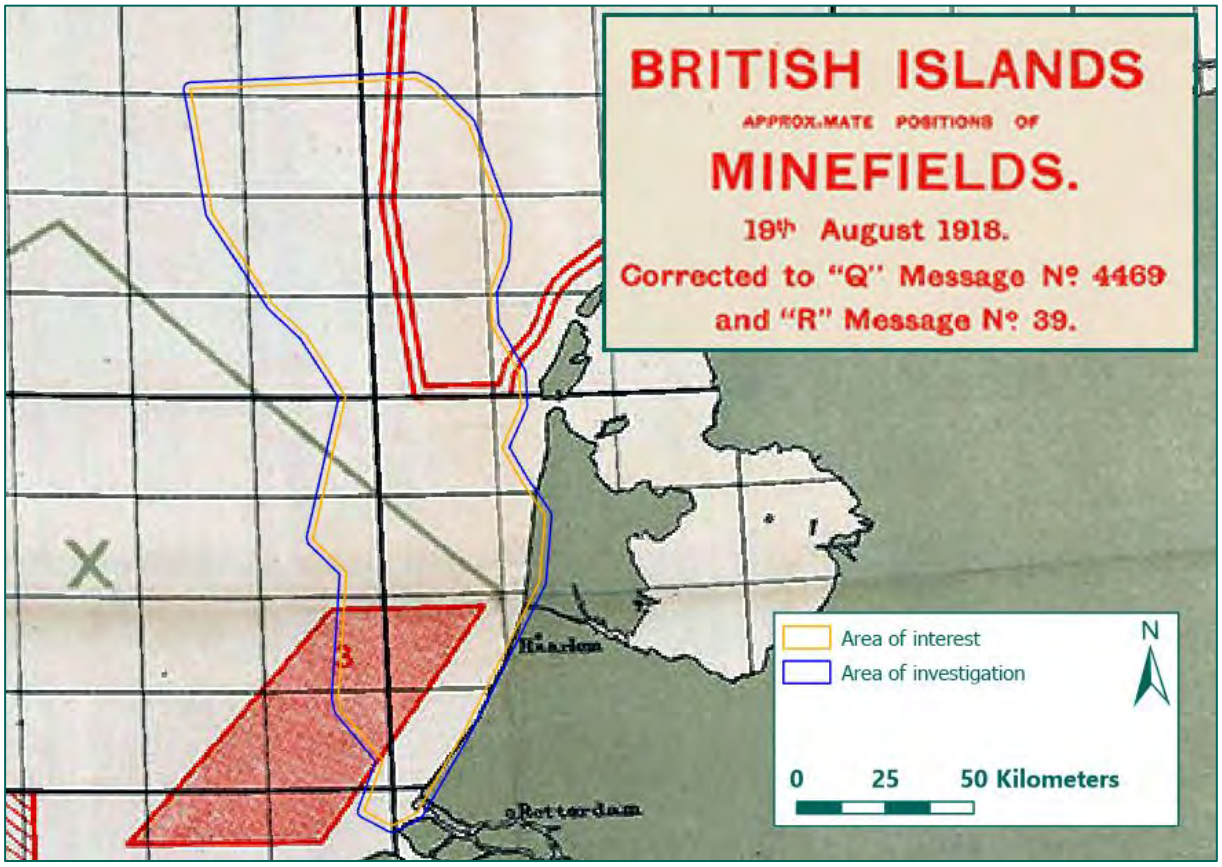


Figure 2: Cutout of the map *British Islands. Approximate position of minefields, 19th August 1918,* showing minefields around the British Islands (Source: Library of Congress).

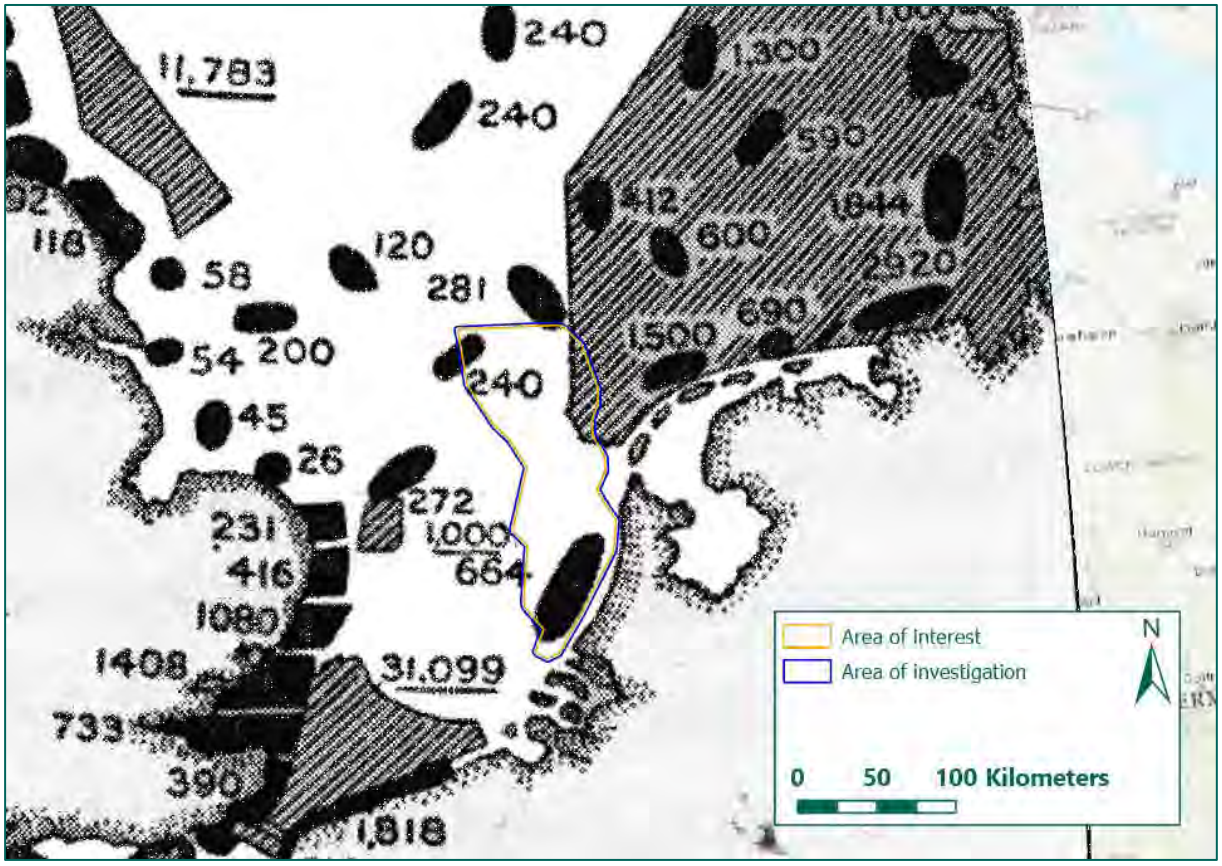


Figure 3: British, German and American mines laid during the First World War (Source: Literature CRO 62).

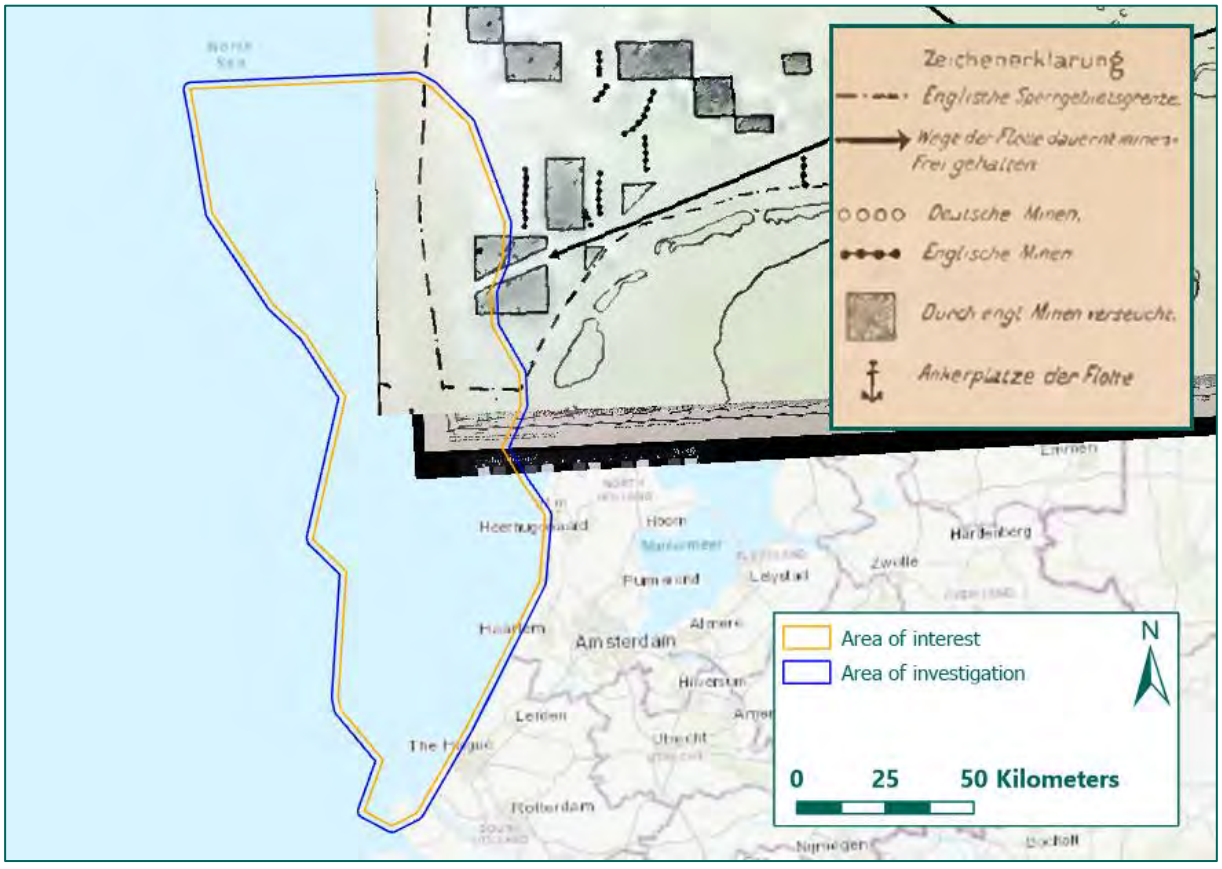


Figure 4: Details about minefields near the Dutch coast (Source: Literature SCH 288)

According to German sources derived from the Bundesarchiv, the area of investigation has overlap with an area which is suspected to have been mined. Reports from the *Kommando der Hochseestreitkräfte* (Command of the Naval Forces) contain a map showing the minefield. *Treibende Minen* (Contact mines) were laid on the Dutch Coast. Additional information about these minefields is not given.

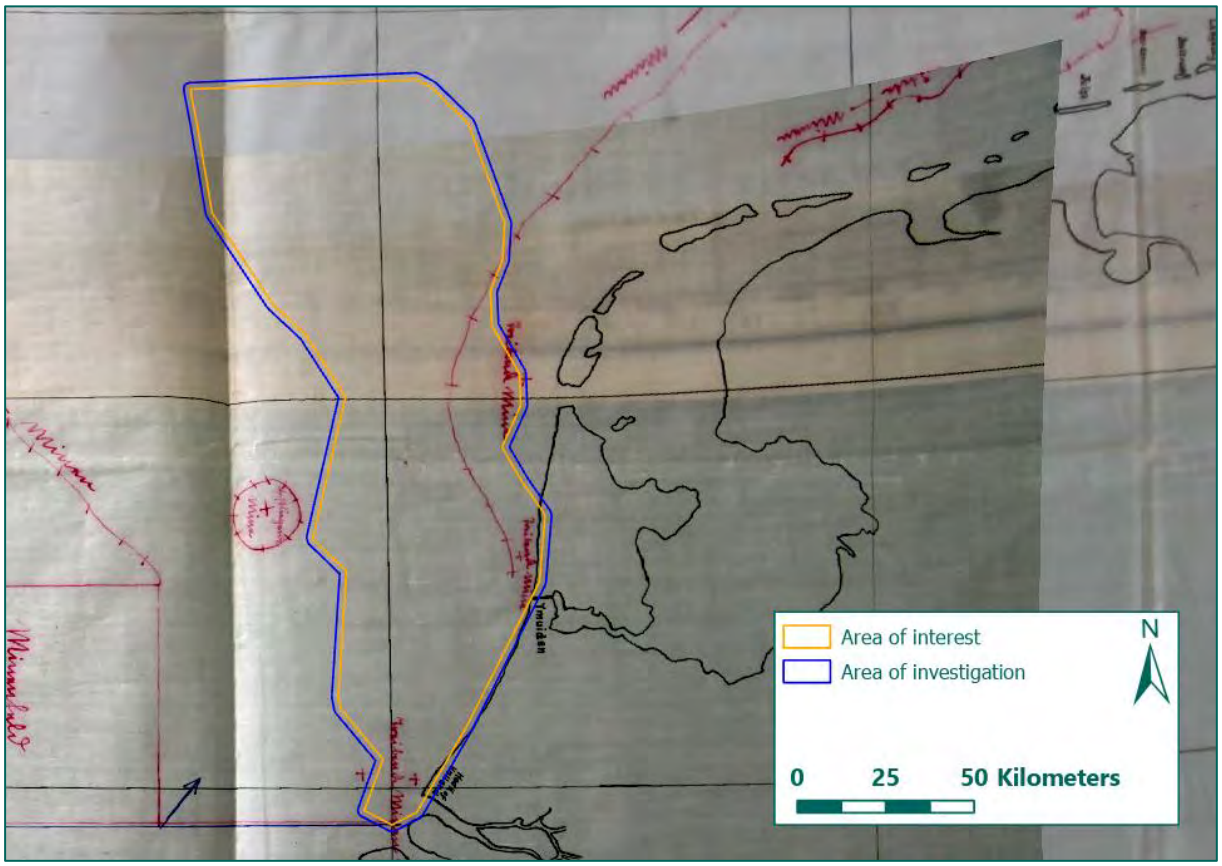


Figure 5: German map showing the suspected Allied minefield, according to the situation of March 1915 (Source: BaMa, RM 5/4721K).

During the First World War, a lot of mines broke loose from their anchor and drifted away. A total of 6.000 mines washed ashore on the Dutch beaches. Amongst those mines 4.981 were from British origin, 431 were German, 81 were French, and 500 mines were from other or unknown origins. It is estimated that no less than 240.000 mines have been spread out in the North Sea.

The information about minefields have been entered into our GIS-system. Relevant minefields within the area of investigation are shown below.

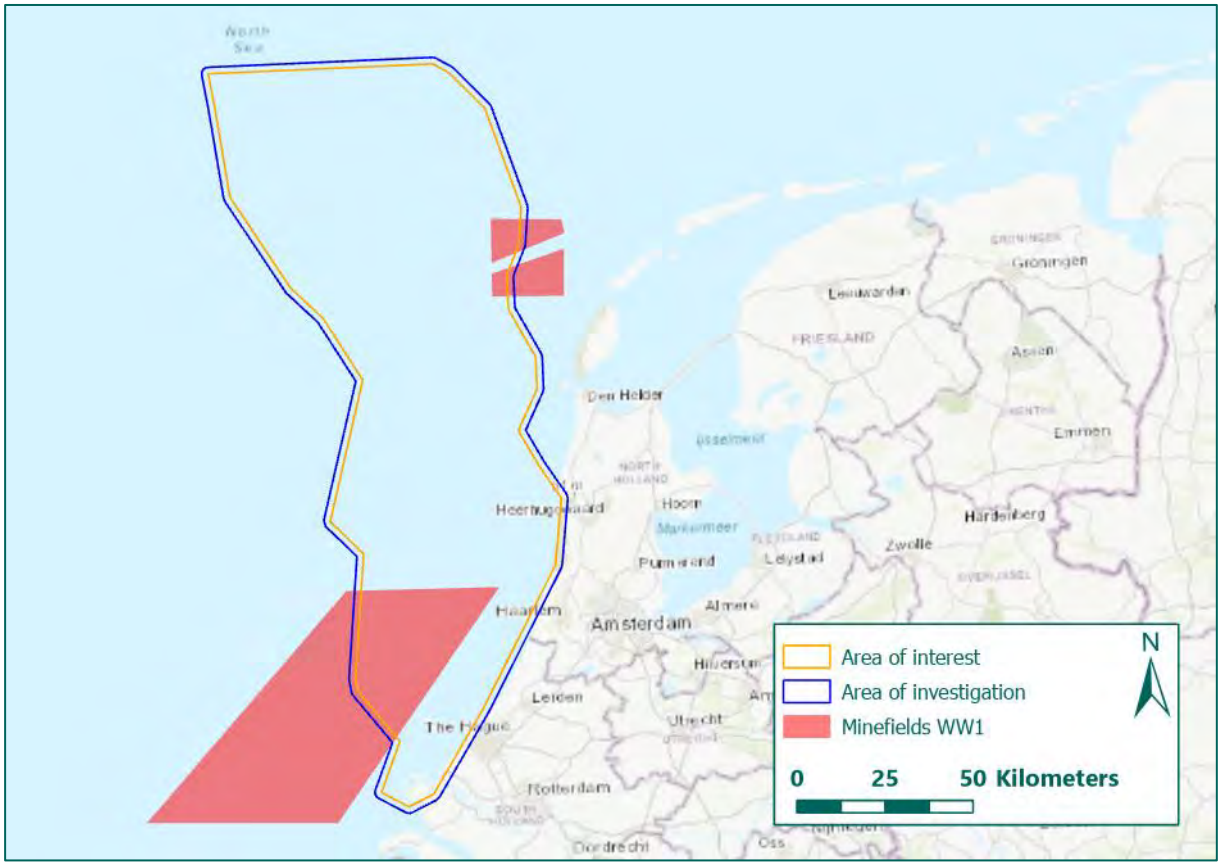


Figure 6: British and German minefields during WW1 (Source basemap: ESRI).

Records from The Dutch National Archives (see Annex 3) contain evidence that mines were present in the area of investigation during the First World War. On a map obtained in the "Nationaal Archief" (Dutch National Archives) it is shown that during 1914-1916 multiple Dutch ships ran onto mines. Most of these accidents happened outside of known minefields. One of these incidents occurred within the area of investigation. As can be seen in the figure below, the black dots indicate the locations where Dutch ships ran onto contact mines. Several black dots are visible within the area of investigation. However, no details have been provided about the ship that sunk at this location. Because there are no known minefields near the locations of the incidents, it is possible that the ships ran upon a contact mine that broke loose from the minefields seen in Figure 2, Figure 3, Figure 5.

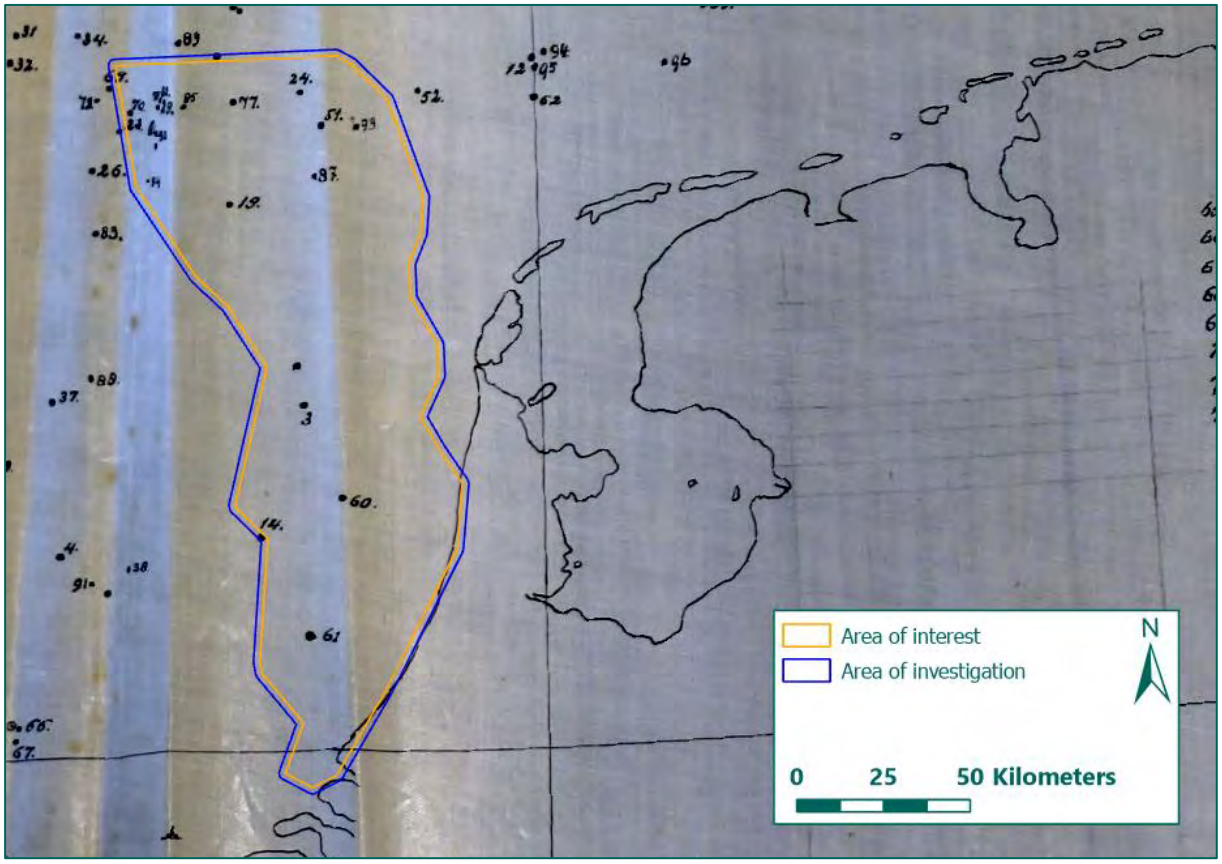


Figure 7: Map showing locations where Dutch ships ran onto mines during 1914-1916 (Source: NA, 2.05.32.09, file 44).

Wrecksite.eu also shows a lot of wrecks within the North Sea. A total of 39 ships were sunk due to mines laid in WW1 and WW2. Besides that a lot of ships were sunk due to unknown causes. The book 'HP39 Wrakkenregister, Nederlands Continentaal Plat en Westerschelde' (abbreviated to HP39), drawn up by the Dutch navy, show an abundance of wrecks (ships and aircraft) within the area of interest. In HP39 no details are given about the reason/cause of the sinking of the ships or aircraft. However. An overview of all wrecks according to this book is shown below.

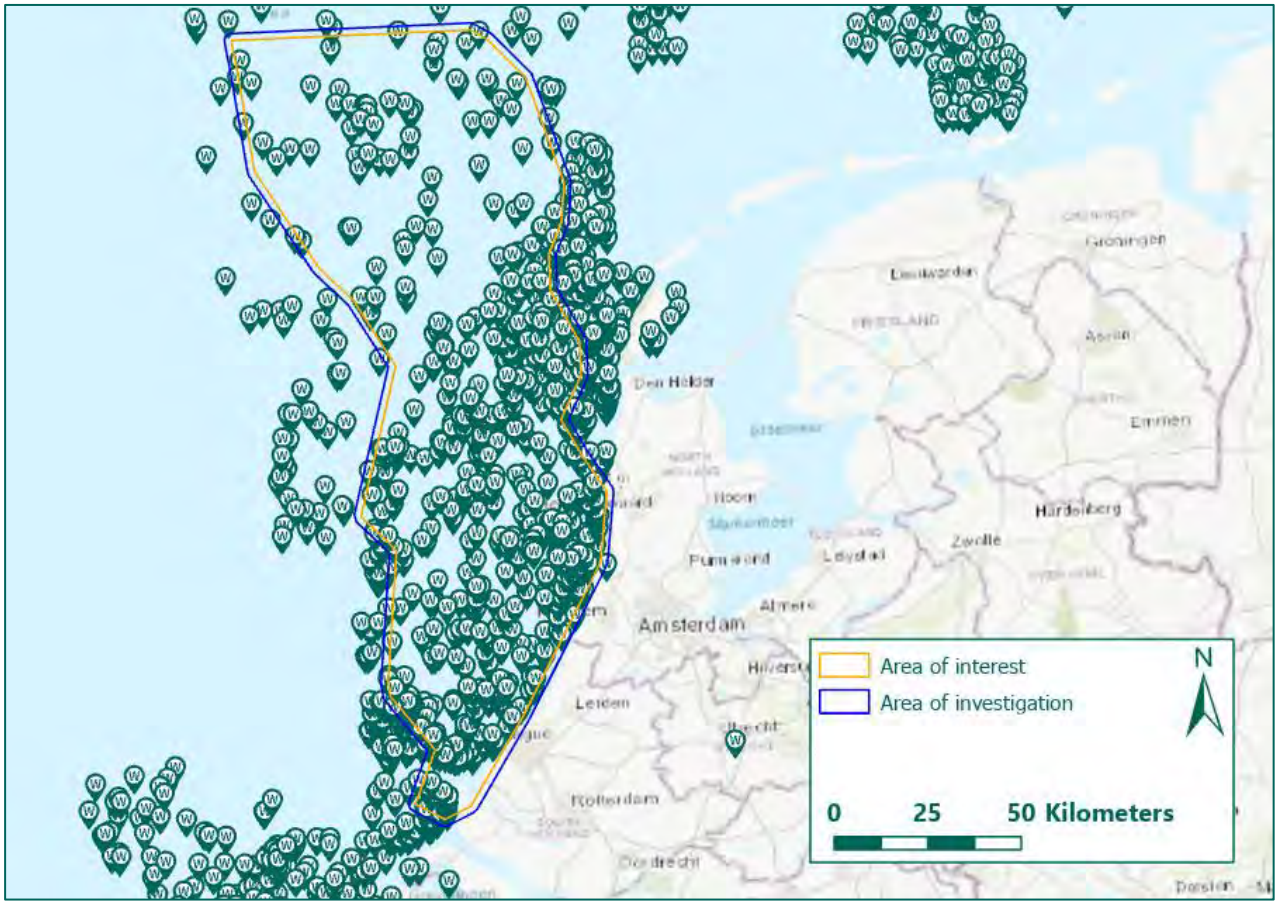


Figure 8: Overview of wrecks within the area of interest according to HP39 (Source: HP39).

According to sources that were consulted by REASeuro British and German minefields overlapped the area of investigation during the First World War. Several ships were sunk due to mines laid within the Area of investigation.

Based upon the sources available, it is concluded that First World War German and British contact mines could be present in the area of investigation. Since no information is found about the precise types of the mines, it is presumed that the most common types of German and British mines could be present in the area of investigation, the German E-Mine and British Vickers / British Elia and H Mark II moored contact mines. Conclusions about the UXO Risk Area as a result of naval mines is given in paragraph 4.1.4.

4.1.2 Second World War

During the Second World War several German minefields were laid in the area of investigation. The German minefields were laid defensively, with the intention to hinder allied ships from approaching the Dutch Coast. British offensive minelaying was aimed against German convoy routes sailing by the Dutch Coast. Some of these British offensive minefields overlap the area of Investigation.

Different sources show maps and coordinates of German and British minefields within the area of investigation. The German minefields within the area of investigation are well documented. During the war the British authorities were quite aware of the locations of German minefields, as can be seen in Figure 9 several minefields overlapped with the area of investigation. The large minefield 404X consists of many smaller minefields. Detailed information about these, and other, minefields that overlap with the area of investigation can be found in the Bundesarchiv (see Figure 10). The German minefields were also littered with sweeping obstructers, suchs as Exploding floats, *Sprengboje* (with explosive load) and Static cutters/Static Conical Sweep Obstructor, *Reisboje* (without explosive load). It is also known that some Dutch

minefields were laid in the beginning of WW2. Most Dutch and German mines were laid by surface crafts. Although the British used surface craft as well, they also deployed aircraft.

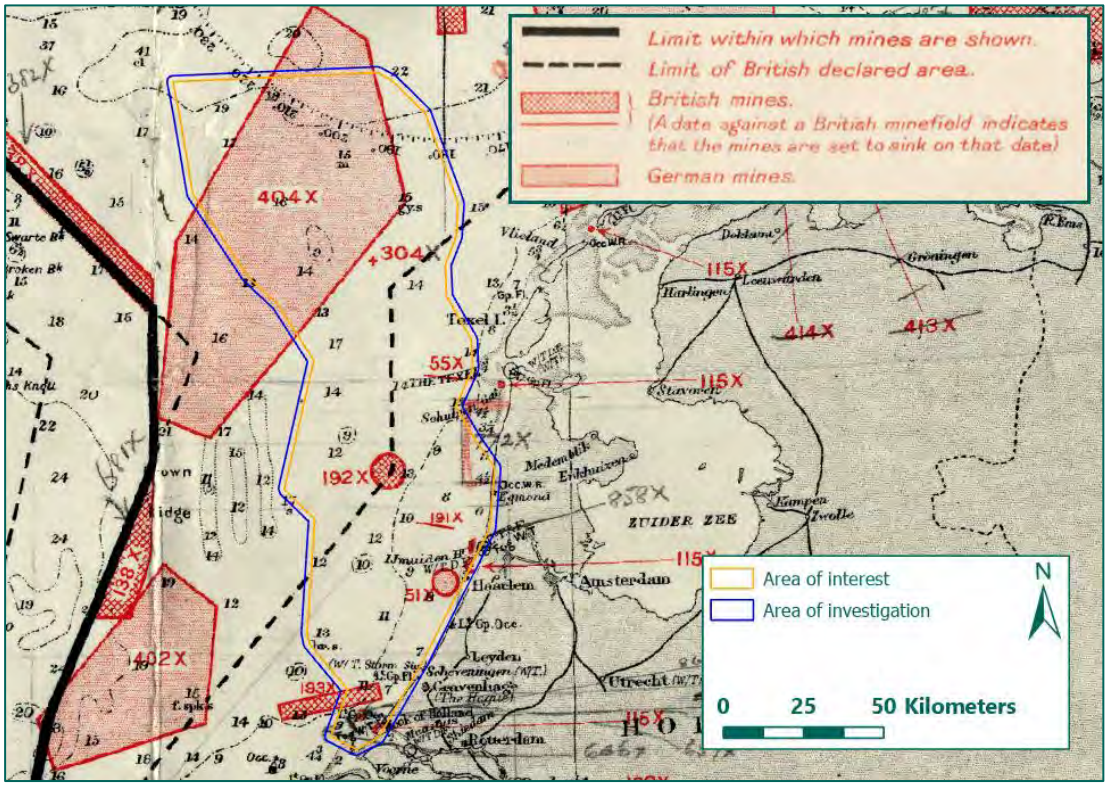


Figure 9: British map showing German and British minefields (Source: TNA, ADM 239/304).

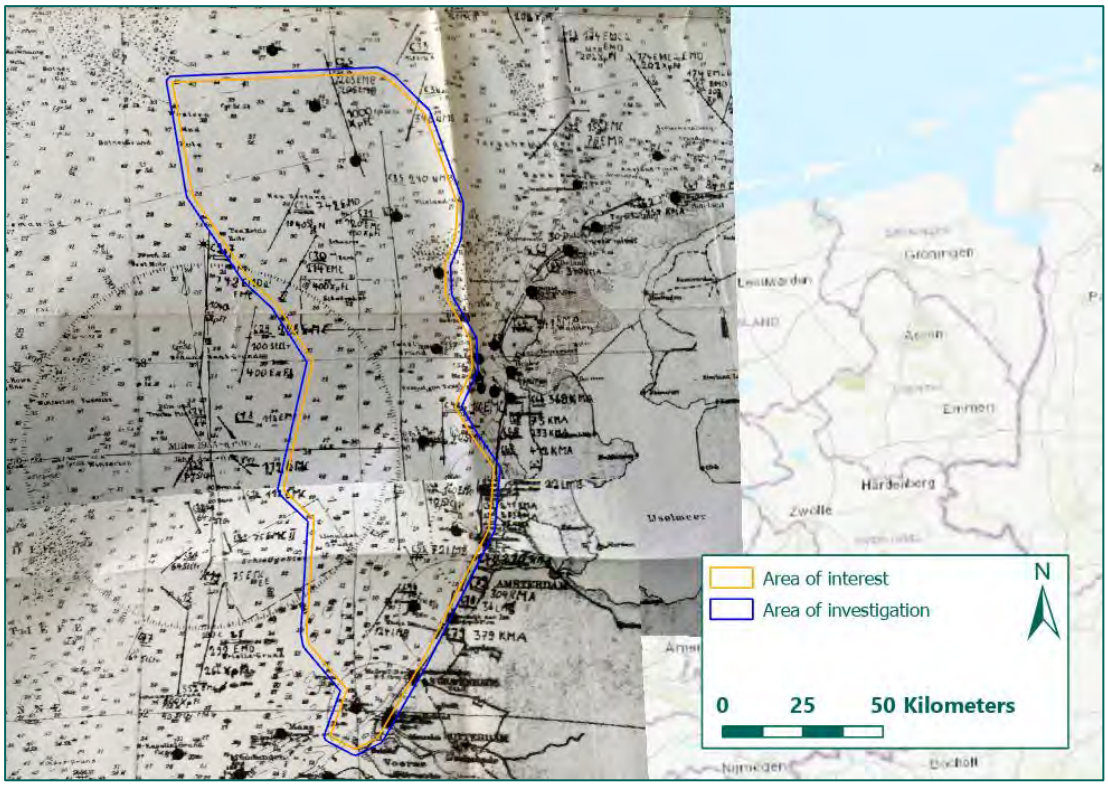


Figure 10: Naval chart showing numbered German minefields. Multiple minefields are present in the area of interest. (Source: BAMA, ZA 5/27).

Another means of minelaying were the "Gardening" operations. These operations were carried out by the Royal Air Force. Planes dropped mines into designated zones. Three zones laid in front of the Dutch coast. Two of these zones, "Whelks" and "Trefoil", have overlap with the area of investigation. The mines laid by planes were ground mines. Over 1200 mines were laid in these 'gardens'.

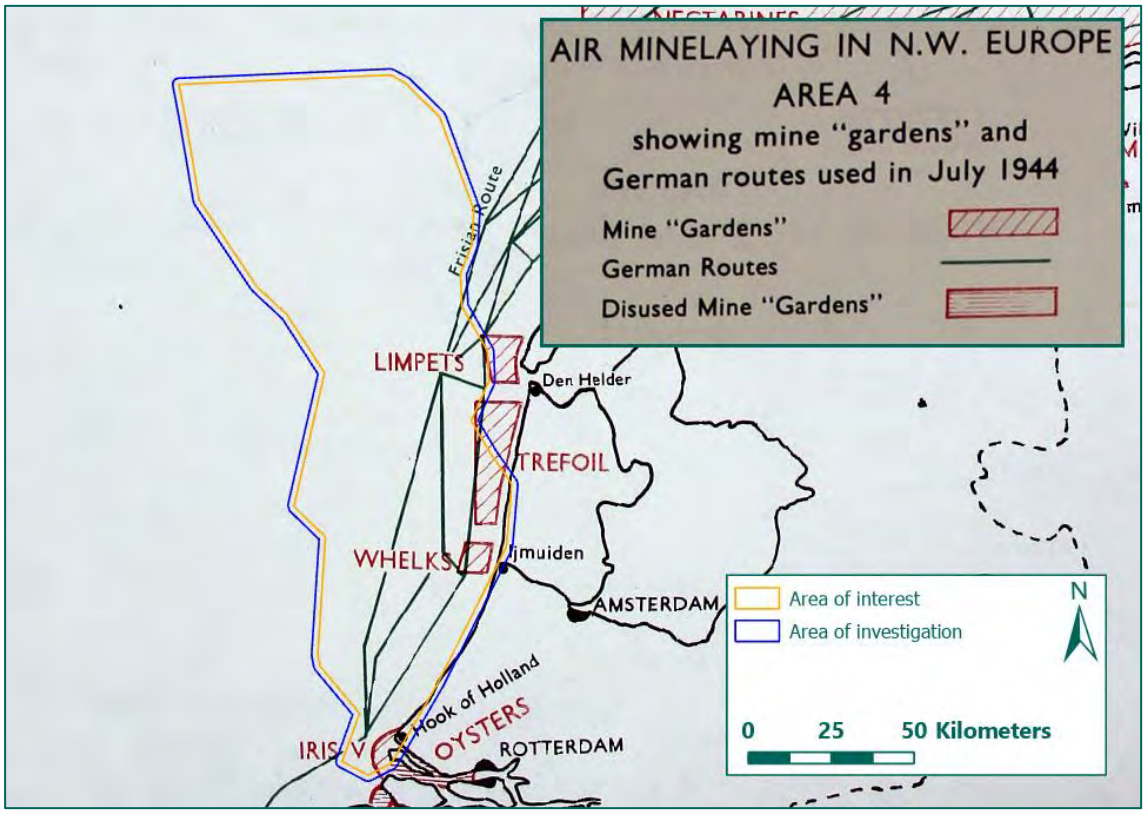


Figure 11: British 'Gardens' within the area of investigation (Source: TNA, ADM 234/561).

All minefields that were mentioned within the consulted sources have been incorporated in our GIS-system. In the figure below all these minefields are shown.

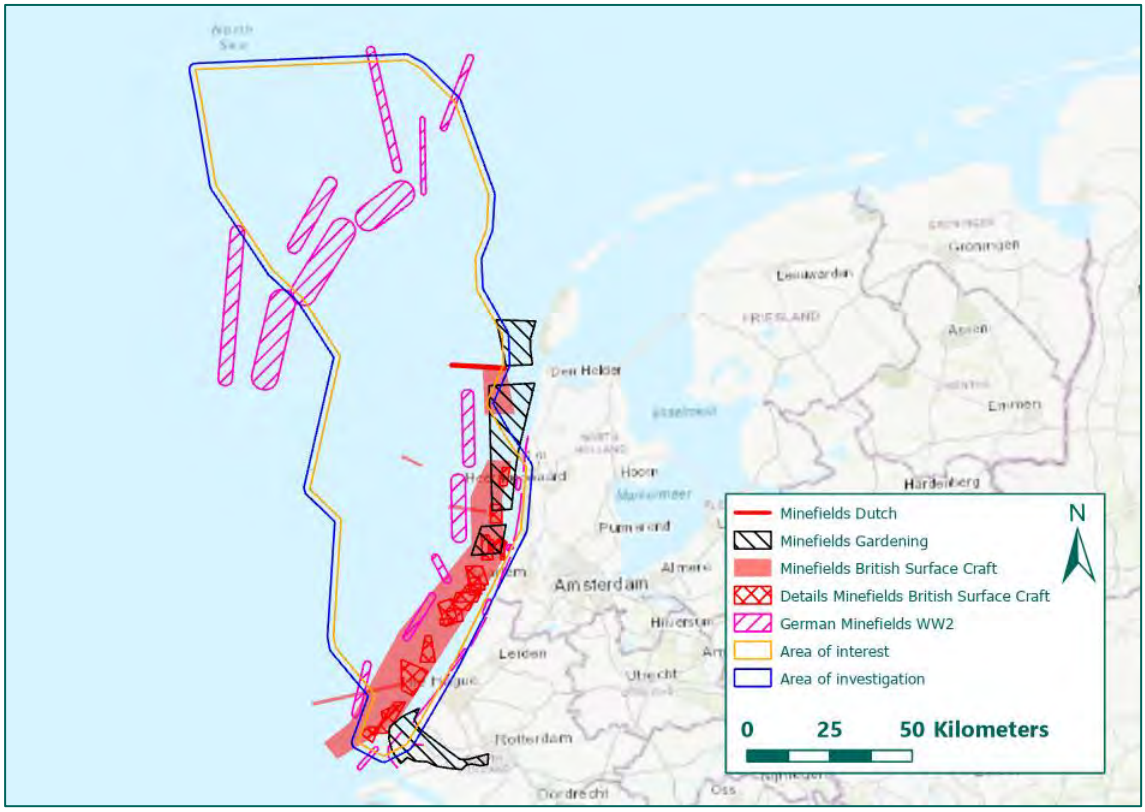


Figure 12: Minefields in WW2 (Source basemap: ESRI).

It is not known what kind of mines were laid in the Dutch and British minefields. Therefore, it is assumed that the most common types of mines were used within these minefields. In the Dutch minefields it is assumed that contact mines from the type 'Model 1921 2e soort' can be encountered. The British minefields consist of minefields laid by surface craft and aircraft. Mines dropped by aircraft were ground mines, mines laid by surface craft are either ground mines or contact mines. The most used types of British ground mines are Mk I-IV. The most common types of British contact mines are Mk VII- VIII and Mk XIV contact mines. The German mines used within the Area of investigation are EMB, EMC, EMD UBA and KMA contact mines, and LMB ground mines. Some German minefields were also fitted with German sweep obstructers: Exploding floats, *Sprengboje* (with explosive load) and Static cutters/Static Conical Sweep Obstructor, *Reisboje* (without explosive load).

4.1.3 Post-war mine clearance

After the First World War, a large effort was made to clear shipping lanes of naval mines. It took several months and a fleet of minesweepers to clear the minefields. Sweeping was carried out by sweeping a cable with anchors below the water surface. The cable was dragged by two ships (see Figure 13).

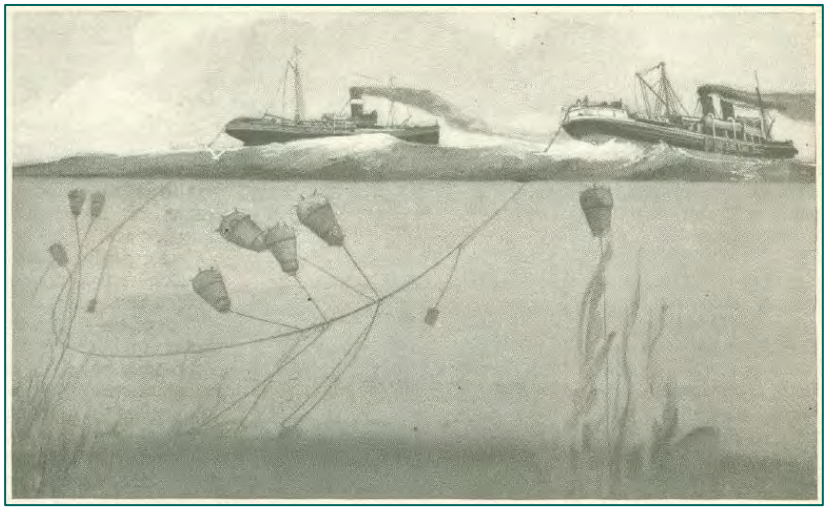


Figure 13: Post WWI-mine sweeping. (Source: http://www.digitalhistoryproject.com/2012/06/submarine-mines-in-world-war-i-byleland.html)

Mines also continued to pose a danger to shipping after the Second World War. In order to combat this threat, a large-scale minesweeping campaign was set up. The area of investigation was situated in the Dutch sweeping zone. Charts of the *Marinemuseum* (see Annex 3) show some details of minesweeping in the area of investigation. Details about minesweeping have not been found in the consulted sources. Minesweeping was conducted with a variety of methods. Moored mines were usually swept with Oropesa sweeping gear[4] (see Figure 14).

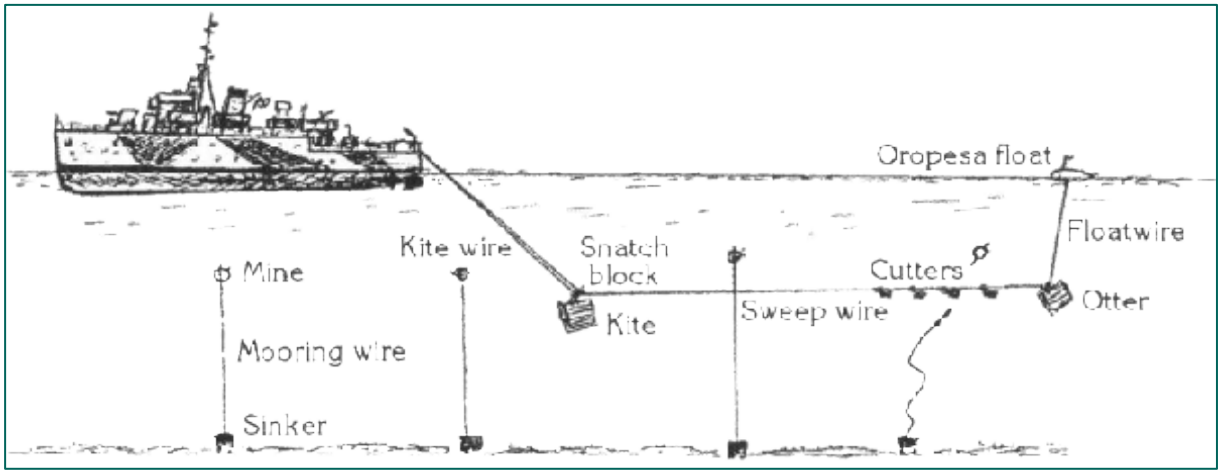


Figure 14: Oropesa sweeping (source: 'The 'Art' of Minesweeping', 27 May 2013, http://www.minesweepers.org.uk/sweeping.htm, consulted 2 August 2019).

The moorings of the mines were cut with cutters dragged on a wire behind a ship. Cutting the mooring wires/cables caused the mines to float to the surface, where the mines could easily be shot with cannon or rifle fire (see Figure 15). Shooting the mines caused them to sink or to detonate. Ground mines were swept with acoustic hammer boxes, triggering the acoustic mines, or by magnetic sweeping gear to trigger magnetic mines.

[4] So named after the World War I trawler in which the technique was first developed. Till then all sweeping was done using two ships joined by a single wire.



Figure 15: Mine disposal team preparing to fire on swept mines. (Source: TNA, ADM 199/154).

Minesweeping was not synonymous to mine clearance. Objective of the operations was to clear the shipping lanes for navigation. The sea bottom is still littered with unexploded mines, including swept and sunken moored mines, self-disarming mines and ground mines with empty batteries[5]. Nowadays, fishermen and dredging ships still encounter these naval mines on a regular basis.

As a result of clearance operations, tidal and other weather conditions, moored mines could break loose from their anchor and migrate. Furthermore, due to extensive pair and beam trawling there is often no clear relation between the positions of encountered mines and the locations of historical minefields. This observation is confirmed in the paragraphs 4.1.1 and 4.1.2. These paragraphs show mine incidents/ encounters outside known minefields. Clearance reports of the Dutch Coast Guard and the OSPAR Commission also show that mines can be found outside the boundaries of known minefields. In Figure 16 the locations of cleared mines are shown relative to the area of investigation.

[5] According to international laws, mines are obligated to include mechanisms to automatically disarm or 'self-sterilize' them after a set time. Moored mines were to sink to the seabed after a given time through, for example, a soluble plug, while ground mines disarmed automatically through a timing mechanism or simply at the end of their battery life. These mechanisms move the mine out of harm's way, but do not disable mechanical fusing mechanisms like *herz horns* and anti-handling devices.

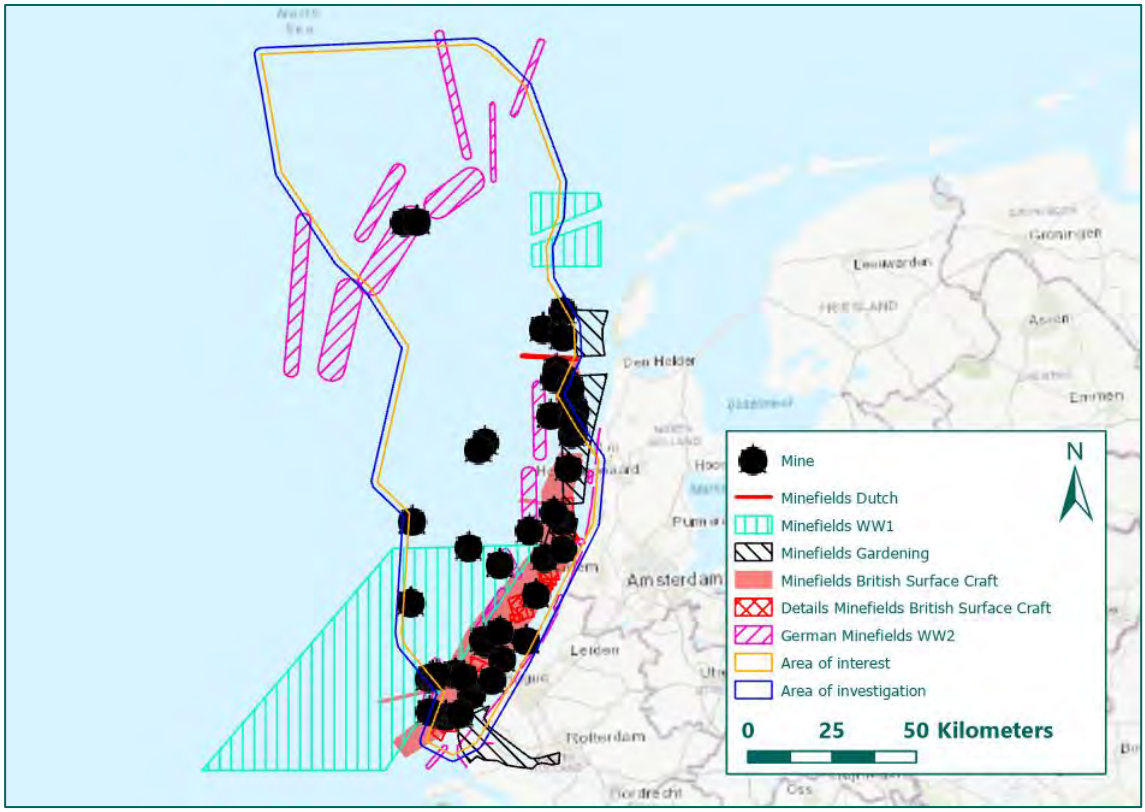


Figure 16: Locations of known minefields and locations where the Dutch Coastguard cleared mines (Source basemap: ESRI).

4.1.4 Conclusion

The area of investigation intersects several minefields. During World War I, British and German minefields overlapped the area of investigation. Within the area of investigation, several mine related incidents occurred during the First World War. Most of these incidents happened outside of known minefields.

During the Second World War the German navy laid 33 minefields that intersect with the area of investigation. No information about the clearance of these fields is known to REASeuro. Several British and two Dutch minefields also overlapped with the area of investigation. Information about the clearance of these fields is also unknown to REASeuro.

Post-war (both World War I and II) minesweeping succeeded in securing the shipping lanes, but did not manage to dispose of all mines. Many mines still litter the seabed, with fuzes still intact. Sweeping, trawling, tides and currents have caused these mines to migrate over the years, resulting in a situation in which there is no longer a clear link between the location of the original minefields and the current positions of the naval mines. As a result of this, it is possible that UXO is still encountered within the area of investigation.

A distinction needs to be made between the likelihood of encountering UXO related to World War I and to World War II. During World War II multiple minefields overlapped the area of investigation. A total of thousands of mines were laid by German surface craft and British surface craft and aircraft. Sweeping operations could have these mines and sweep obstructors (*Sprengboje*) to have sunken to the seabed within the area of investigation. The likelihood of encountering UXO related to World War II minefields is deemed certain within the borders of the minefields and, due to migration, probable outside of these borders.

During World War I the area of investigation only overlapped with a single suspected German minefield and some small British minefields. The consulted sources do not state the amount or types of mines laid in this field. However, factual evidence points out that multiple mine related incidents occurred within the area of investigation. Because of the relative sparse amount of information known about World War I minefields within the area of investigation the likelihood of encountering UXO related to World War I minefields is lower than the World War II minefields. Therefore encountering UXO of WW1 naval mines is deemed probable to within the borders of the WW1 minefields, and feasible outside of these minefields.

UXO type	Reference Nr.	Type/calibre	Condition
Naval Mines	1	German E-Mine moored contact mines	Armed
	2	British Vickers / British Elia and H Mark II moored contact mines	Armed
	Outside the borders of the known minefields all abovementioned types of naval mines can be encountered. The likelihood of presence outside the known minefields is set to feasible.		

Table 1: Expected UXO due to WW1 Minefields.

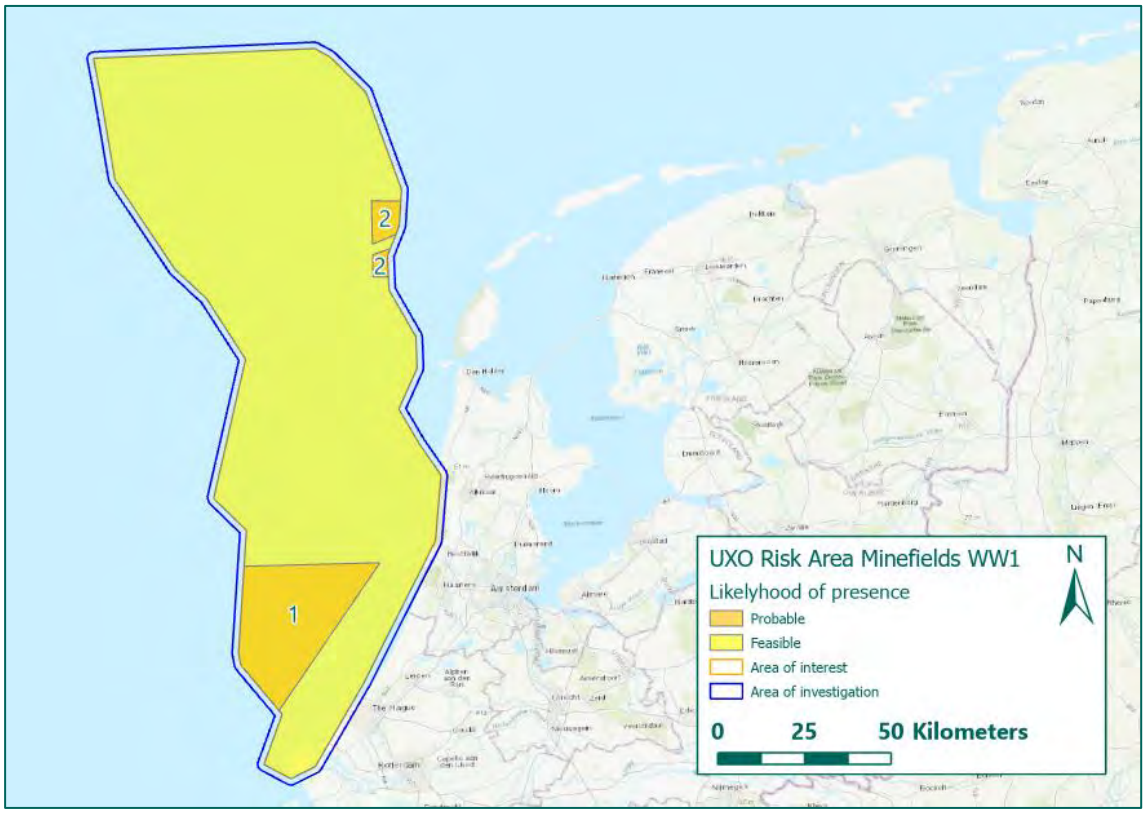


Figure 17: Likelihood of presence of UXO as result of the WW1 minefields. (Source basemap: ESRI).

UXO type	Reference Nr.	Type/calibre	Condition
Naval Mines	1	British ground mines Mk I-IV	Armed
	2	German EMB Contact mines and Exploding Floats	
	3	German EMC Contact mines (also non explosive sweep obstructors)	
	4	German EMC Contact mines and Exploding Floats	
	5	German EMD Contact mines and Exploding Floats	
	6	German KMA Contact mines	
	7	German LMB Ground mines	
	8	German LMB Ground mines and German EMC Contact mines	
	9	German UMB Contact mines	
	10	German RMA Contact mines	
	11	British Mk I-IV ground mines and British Mk VII-VIII and Mk XIV contact mines	
	12	Dutch Model 1921 '2e soort'	
	Outside the borders of the known minefields all abovementioned types of naval mines can be encountered. The likelihood of presence outside the known minefields is set to probable.		

Table 2: Expected UXO due to WW2 Minefields.

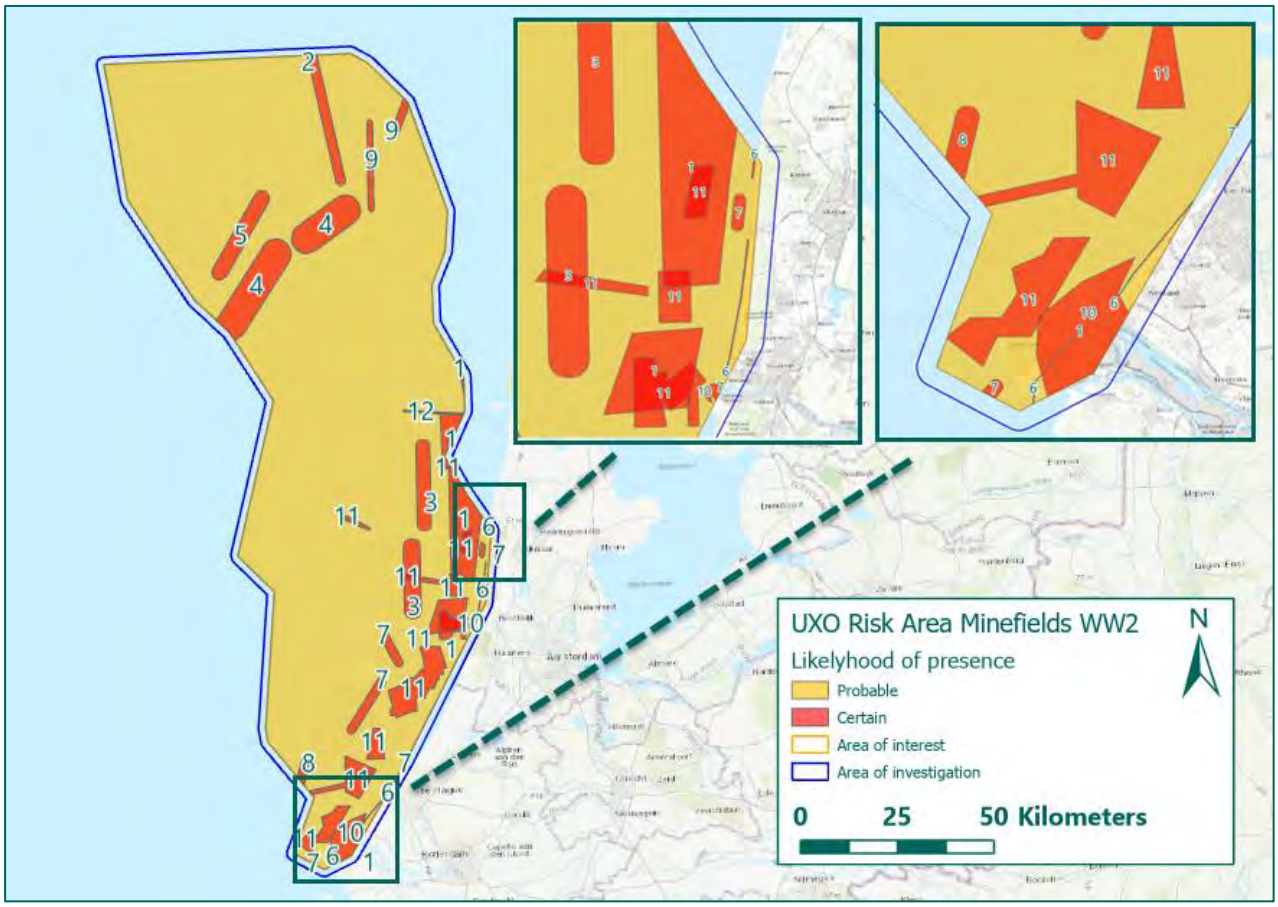


Figure 18: Likelihood of presence of UXO as result of the WW2 minefields. (Source basemap: ESRI).

4.2 AIR WAR

In and in the vicinity of the area of investigation many events relating to the air war did occur. This concerns air strikes on shipping, jettisons of bombs, and anti-aircraft gunfire.

4.2.1 Air strikes on surface vessels

A German convoy route crossed the area of analysis. During the Second World War the British Air Force almost continuously attacked the German convoys and other ships like minesweepers or the *Vorpostenboote*. From November 1944 onwards, attacks were also carried out on submarines and midget submarines (Anti-Seehund missions) which threatened the Allied convoys towards the harbour of Antwerp.

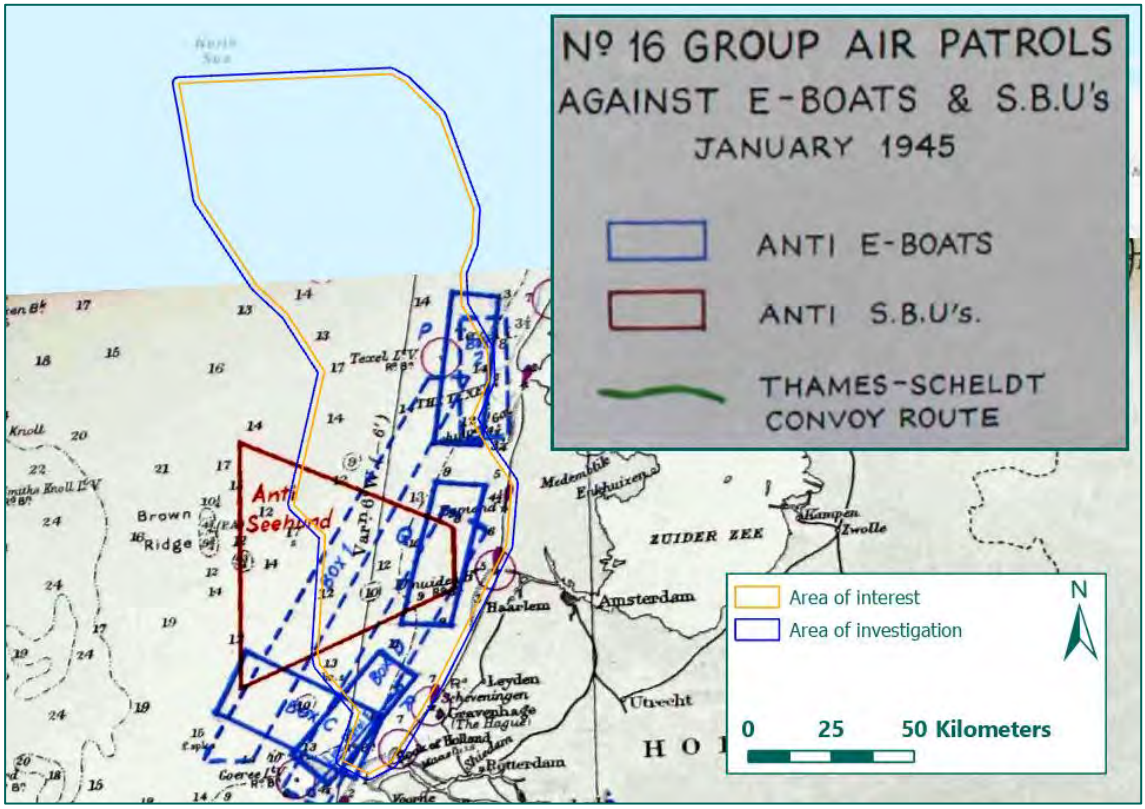


Figure 19: Coastal Command, No.16 Group, Air Patrols against E-Boats & S.B.U.'s January 1945 (Source: CAB 101/324).

The locations of the air strikes are seldom very accurate. Navigating above the sea was not an easy task. The consulted literature (see Annex 2) points out that a lot of ships were attacked along the Dutch coast. It started with the German invasion on 10 May 1940.

The air attacks by the British Bomber Command and Coastal Command are added in a geodatabase, if possible. Coastal Command used a code instead of decimal degrees. According to the information entered in the REASeuro database, a total of 508 attacks were made within the area of investigation by Coastal Command and Bomber Command. It is outside the scope of this research to examine the target and the results of each of these missions. Due to the large amount of attack locations near the known German routes, it is to be expected that a large amount of the attacks by the RAF was targeted at German shipping. In the figure below the relevant locations of attacks by Coastal Command and Bomber Command is shown. The locations of German convoy routes are also shown.

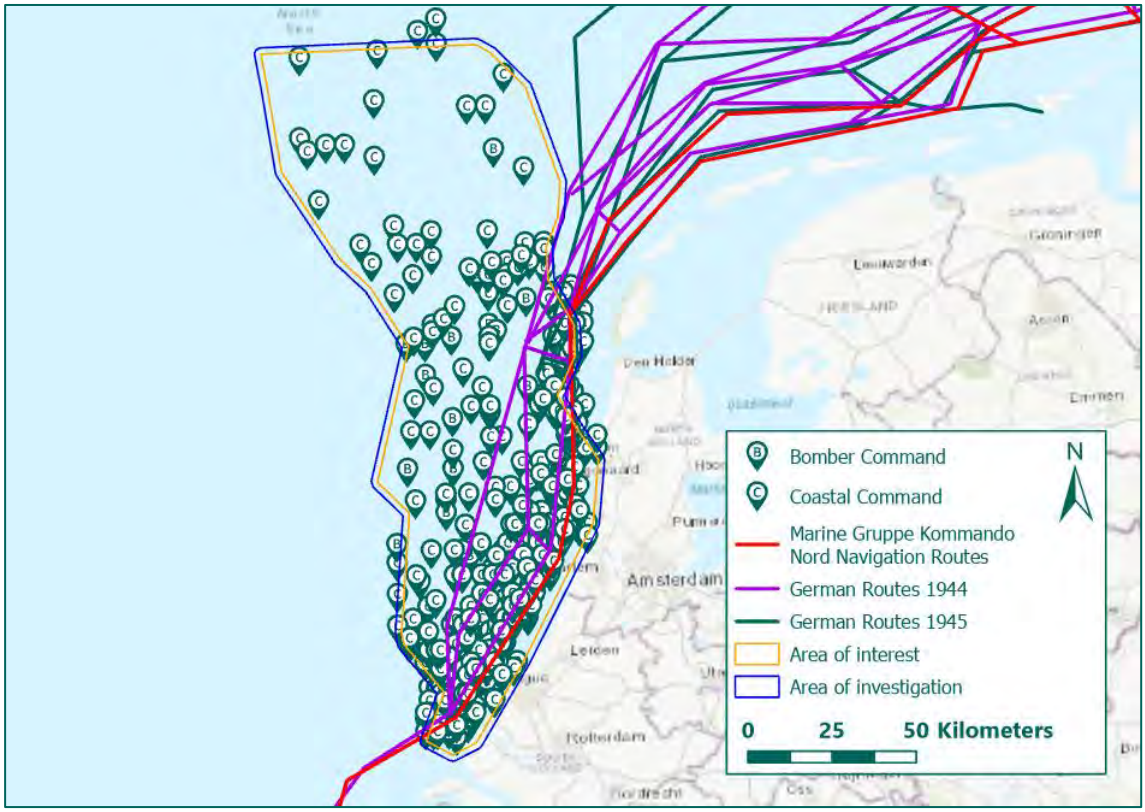


Figure 20: Attacks made by Coastal Command and Bomber Command, and relevant German convoy routes (Source basemap: ESRI).

Since more than 500 attacks took place in the area of investigation, it is expected that UXO remain. Air strikes on ships were carried out with aerial bombs, depth charges, torpedoes, and 3 inch rockets with a 60 lbs warhead semi armour piercing (SAP). The definition of the UXO risk area and the calibres is explained in paragraph 4.2.5.

4.2.2 Jettisoned bombs

During the Second World War groups varying from few to many British and American bombers flew almost on a daily basis (day and night) towards targets in Germany or German-occupied territory. The flight paths towards targets and back to base (in the United Kingdom) ran across the North Sea.

The Allied bombers were often attacked by German fighters in order to prevent the bombers from bombing their targets. Hundreds of planes were hit and/or shot down. When a bomber was involved in an air battle the procedure was to jettison the bombs. This would reduce the weight of the bomber enabling it to increase the speed and manoeuvrability, and thus the crew's chance to survive. Normally, bombs had to be jettisoned in a safe, thus unarmed, condition. This procedure is documented in a record from The National Archives (see annex 3).

Jettisons in the sea also happened when aircraft could not find a suitable target or in other cases when a crew could not drop their bombs. The reason to jettison the bombs was to avoid a landing with the bomb load, which was a risky event. Jettisons were seldom accurately documented. Furthermore, bombs were also jettisoned live, thus without their safety. An example of this is shown in the figure below.

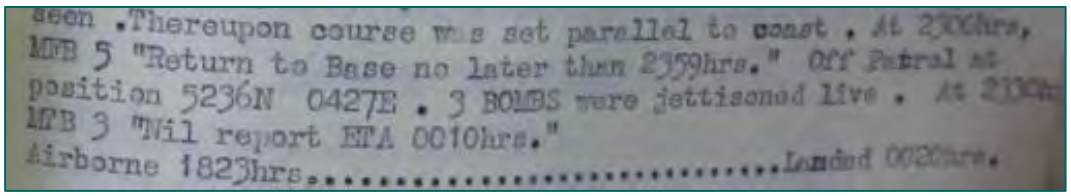


Figure 21: Example of a live jettison within the area of investigation, night 12/13 October 1944. (Source: TNA, AIR 25/367).

It is not clear how many times such jettisons occurred. The figure below gives an example of a flight path that crosses the area of analysis.

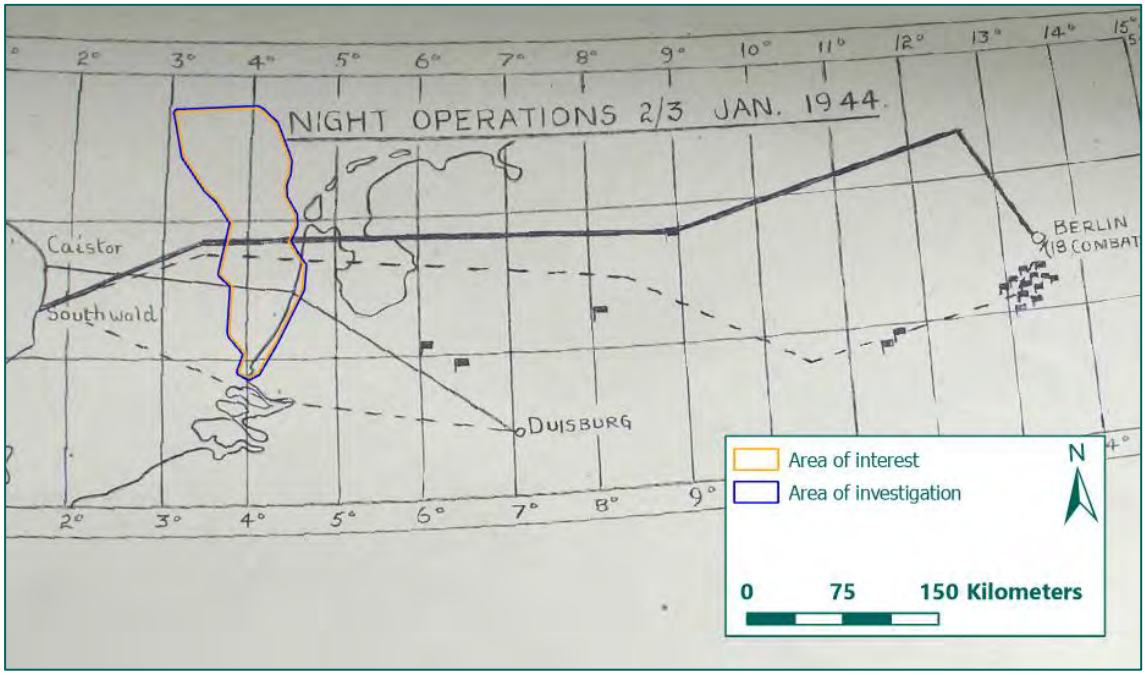


Figure 22: Example of a flight path over the area of investigation of bombers from Bomber Command, 2/3 January 1944 (Source, TNA, AIR 24/264).

Based upon the consulted sources, it is concluded that aerial bombs remain in the area of investigation as a result of jettisons. Because it is not possible to define the calibres specifically, the most common allied bombs are taken into account. The UXO risk area is specified in paragraph 4.2.5. Detailed information on the UXO is given in annex 10.

4.2.3 Anti-aircraft gunfire

The guns which were placed onto the German Vorpostenboote and escort ships were also used against enemy airplanes. The calibres of the guns vary from 2 cm to 8.8 cm. Machine guns (7.92 cm, 13,2 mm, 15 mm) completed the anti-aircraft weaponry on ships. Every time when ships and convoys were attacked, they opened fire.

Taking into account the large amount of air strikes on ships, UXO of anti-aircraft weapons are present in the area of investigation. Unexploded shells could come down and hit the sea level and sink to sea bottom. The UXO risk area is defined in paragraph 4.2.5

4.2.4 Post-war UXO encounters

As showed in annex 5, aerial bombs are encountered throughout the entire area of analysis. A total of 52 bombs have been encountered and disposed of since 2005. These bombs could originate from air strikes

and/or jettisons. The Dutch Coastguard also encountered a lot of UXO that have not been specified. It is therefore unknown whether more bombs have been cleared. It is also unknown how many bombs have been encountered before 2005. Next to aerial bombs, torpedoes, depth charges and artillery shells have also been encountered. The latter were possibly caused by the use of anti-aircraft gunfire. A total of 130 artillery shells have been cleared by the Dutch Coastguard. In the figures below the locations of encountered UXO are specified. A combined total of 31 torpedoes and depth charges were encountered.

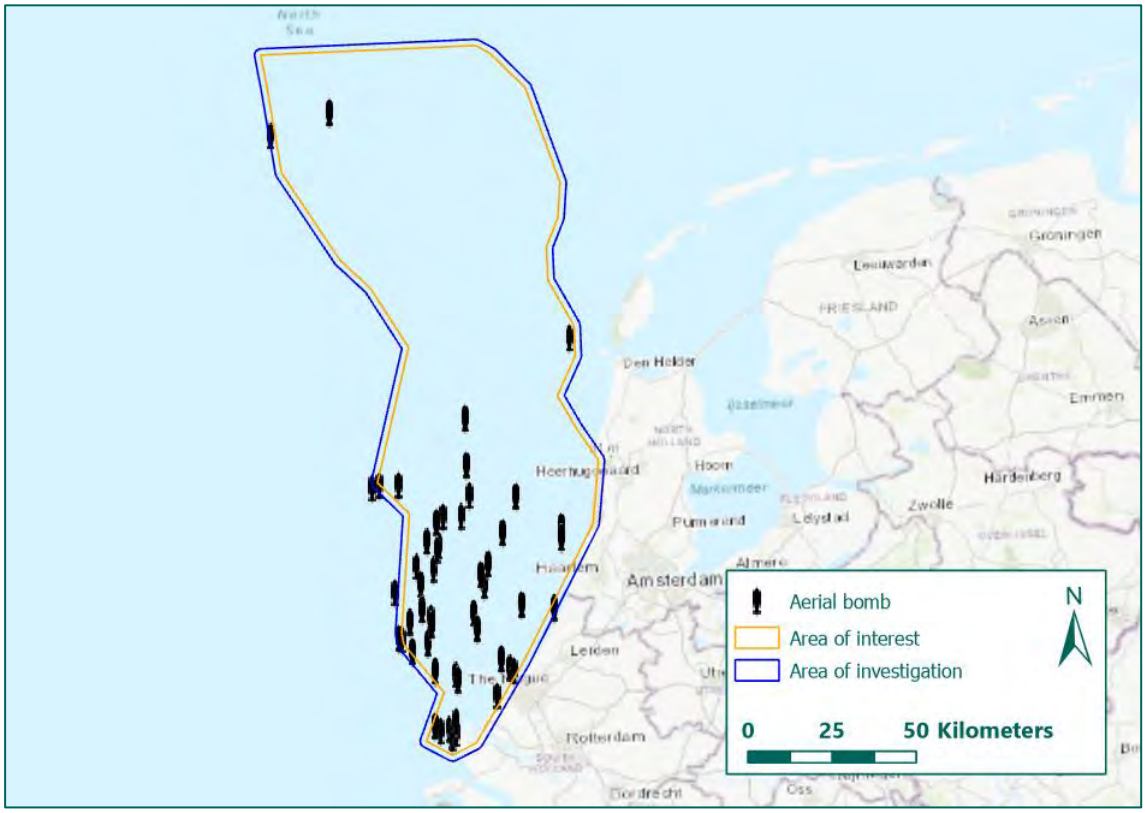


Figure 23: Cleared aerial bombs within the area of investigation (Source basemap: ESRI).

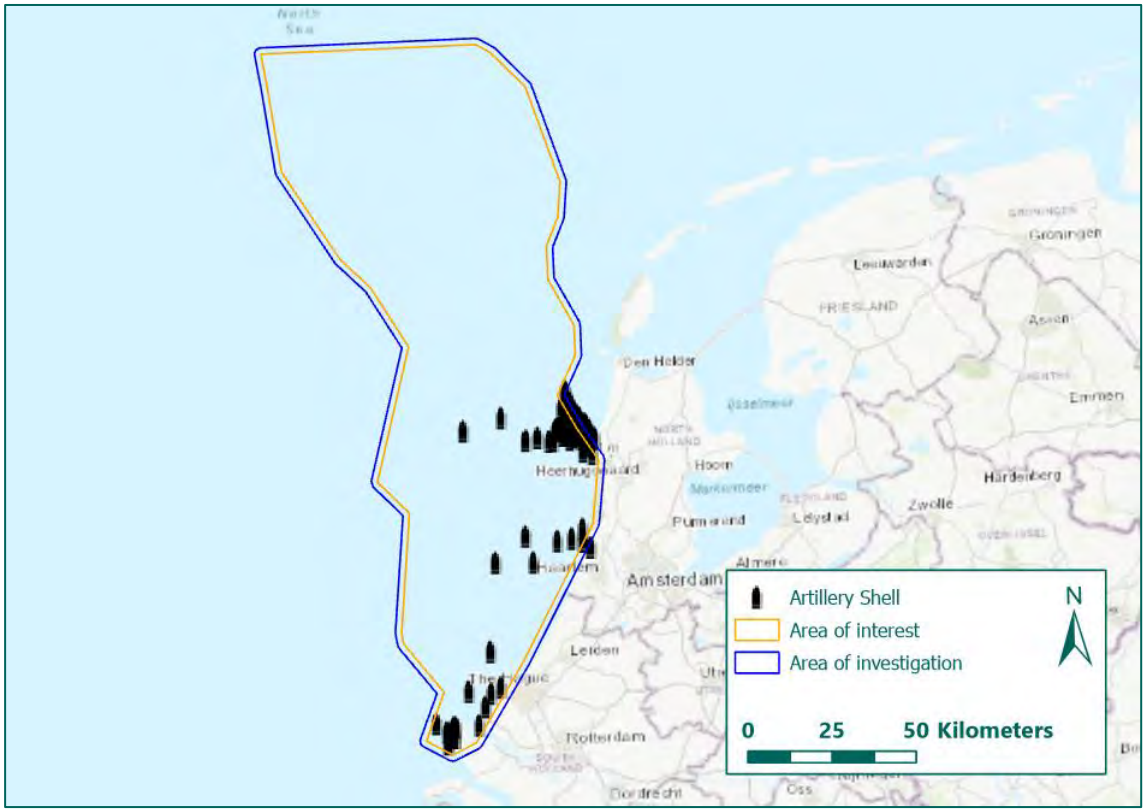


Figure 24: Cleared artillery shells within the area of investigation (Source basemap: ESRI).

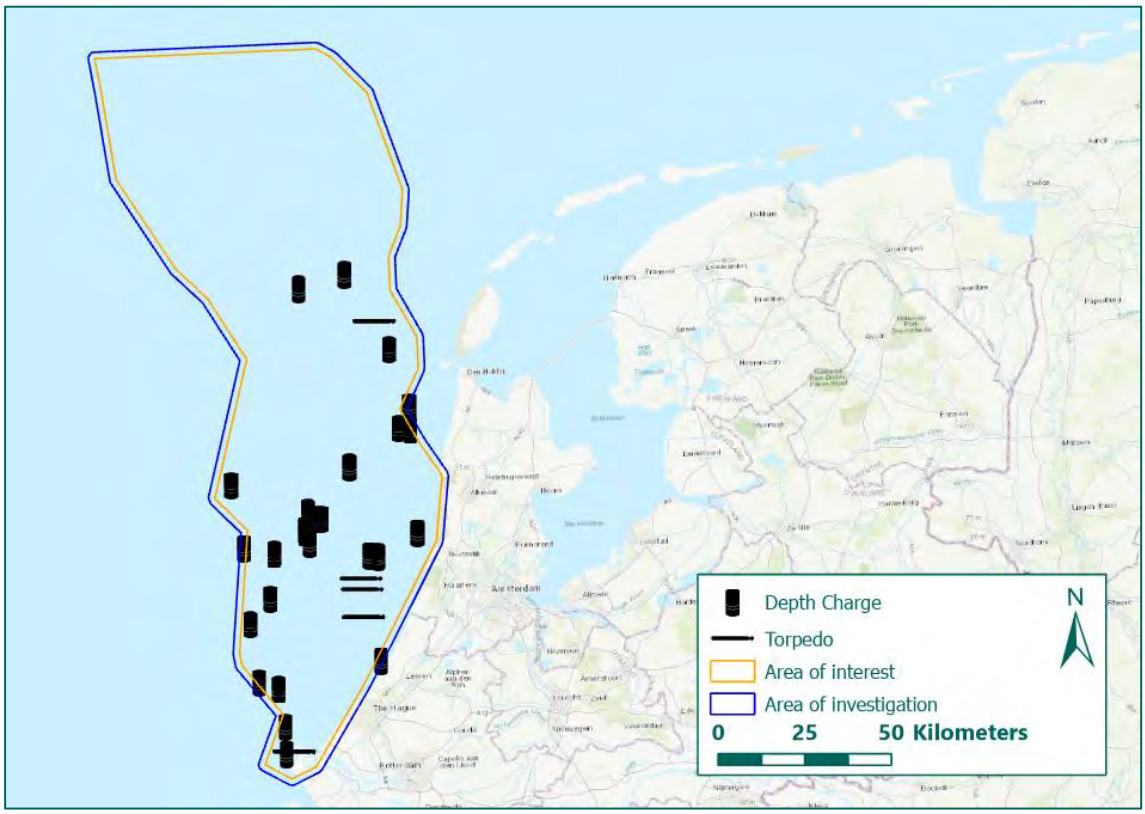


Figure 25: Cleared torpedoes and depth charges within the area of investigation (Source basemap: ESRI).

4.2.5 Conclusion

As a result of the various air strikes and jettisons UXO might still remain in the area of investigation. This is proved by the fact that since 2005 UXO have been encountered and disposed of in the area of investigation. Therefore, a UXO risk area is defined. The most probable locations of attacks are near the German convoy routes. This is confirmed by attack locations specified in the source material. Therefore the likelihood of presence of UXO regarding the air war is deemed certain along the convoy routes. The UXO risk area is projected between the most western route and the Dutch coast. A buffer of 1 nautical mile (1.852 meter) is taken into account for navigational inaccuracy of ships and aircraft. In the rest of the area of investigation the likelihood of presence of UXO is deemed probable due to the large amount of jettisons in the North Sea. In the figure and table below the UXO Risk Area regarding air war is shown. Details about calibres are also specified in the separately supplied shapefiles.

UXO type	Type/calibre	Condition
Aerial bombs	4 lbs, 25 lbs, 30 lbs, 100 lbs, 250 lbs, 260 lbs, 300 lbs, 500 lbs, 1.000 lbs, 4.000 lbs	Armed/not armed (safe)
Under water ammunition	18 inch torpedo Mk XV	Armed
	Depth charge	Armed
Rockets	3 inch rocket with 25 lbs or 60 lbs (SAP) warhead	Armed

Table 3: Expected UXO.

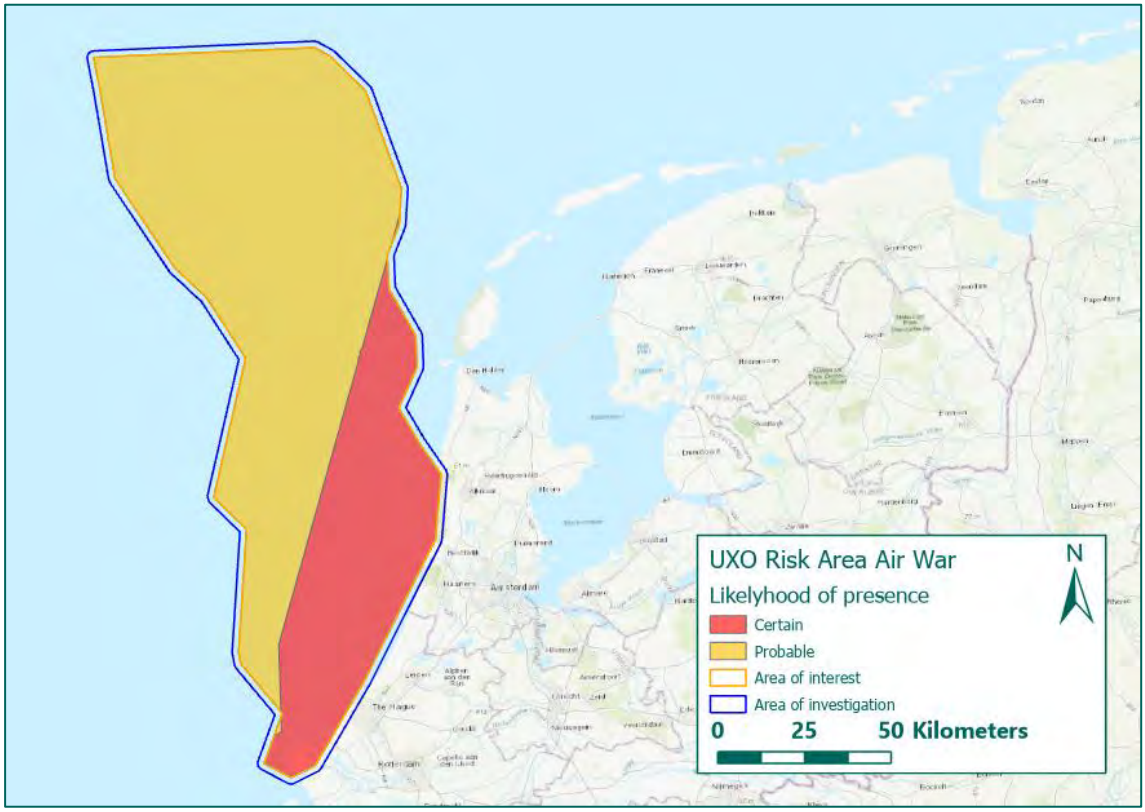


Figure 26: Likelihood of presence of UXO as result of the air war. (Source basemap: ESRI).

As on land, it is not possible to define a UXO risk area in response to the usage of anti-aircraft gunfire. The gunfire was aimed towards a moving target in the air. Unexploded shells could come down almost anywhere. It should be noted that probably most AA-projectiles came down between the shore and to the west of the convoy route. Part of this area was also covered by coastal guns. UXO of artillery shells that might be present in the coastal region will be further analysed in paragraph 4.3 and 4.4.

4.3 COASTAL GUNS

Coastal guns were traditionally used in strongpoints that had to defend harbours from enemy ships. At the start of WW2 some coastal guns were already installed on the Dutch Coast. After the German occupation of the Netherlands, a large amount of coastal guns were installed on the Dutch coast as part of the *Atlantikwall*. Source material shows that the German guns were used to stave off Allied ships nearing the Dutch Coast. Information from The National Archives (TNA) show that within the area of investigation shells fired by coastal guns exploded during an attack of the RAF. Below a strike photo is shown where the impact of a shell is highlighted.



Figure 27: Strike photo showing the impact of a shell, fired by a German coastal battery. 4 May 1942. (Source: TNA, AIR 28/595).

Various sources such as literature, records from the Dutch National Archives, the Bundesarchiv, maps and aerial photographs were used to determine the locations of coastal guns. These positions have been entered in the REASeuro GIS-database. The largest calibre that could strike the Area of investigation are 28 cm guns. They could hit targets at a range of 41100 meter. This range is extraordinary. Besides the 28 cm guns, guns from the calibres 17 cm and smaller were deployed along the coast. The maximum range of these 'smaller' calibre guns was 22000 meters. The known coastal guns near the area of investigation are shown in the figure below

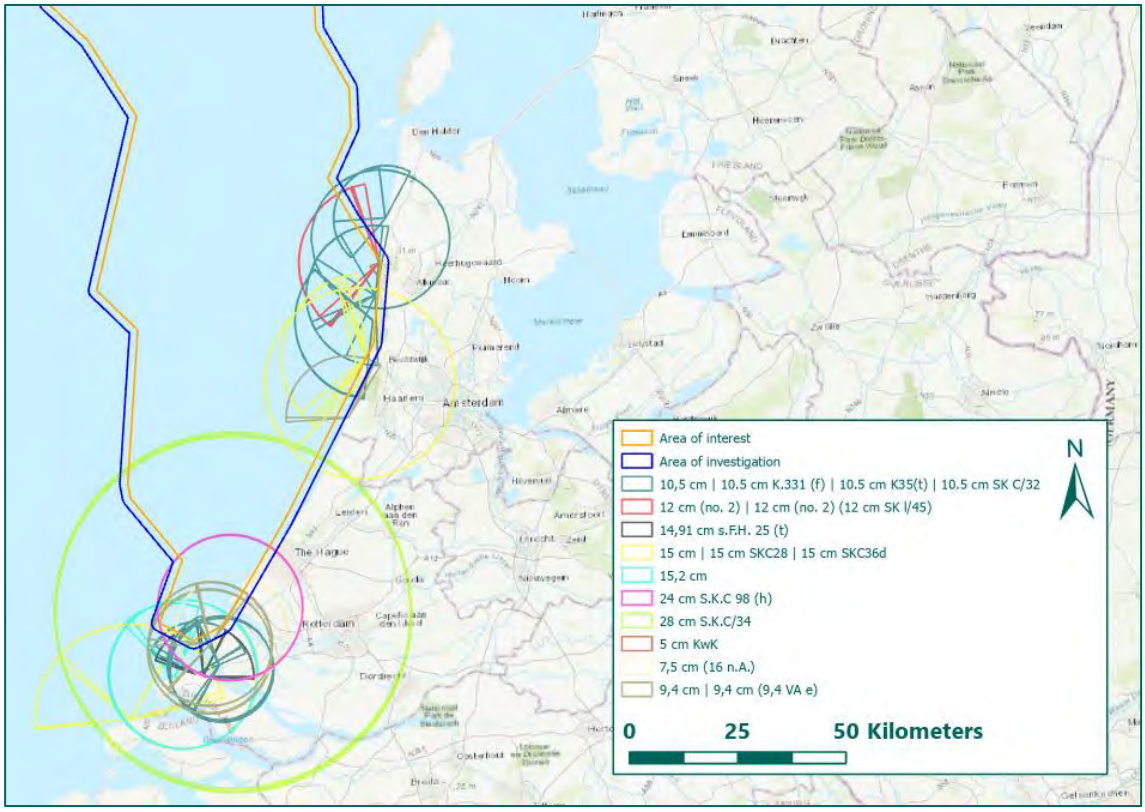


Figure 28: Locations and range of coastal guns near the area of investigation (Source basemap: ESRI).

Entering data in the REASeuro GIS-database is done on a project-by-project basis. Because REASeuro has not yet carried out Offshore Projects near the Dutch coast in the area between IJmuiden and Beverwijk, REASeuro does not yet have data on the coastal guns in this area. Consulting the Dutch 'Nationaal Archief' shows that strongpoints and military infrastructure were constructed on the Dutch coast. In order to find out the locations, calibres and range of the coastal guns on Texel and between IJmuiden and Beverwijk, REASeuro would need to visit the 'Nationaal Archief', analyse additional aerial photographs and consult literature and the internet. This is outside the scope of this research. As an example, a cutout of an 'Blokkaart' of the 'Nationaal Archief' is shown below. The map shows the contours of military infrastructure near Katwijk. Detailed information about the specific types of military infrastructure are not shown on these map, as is already mentioned, additional information is to be consulted separately.

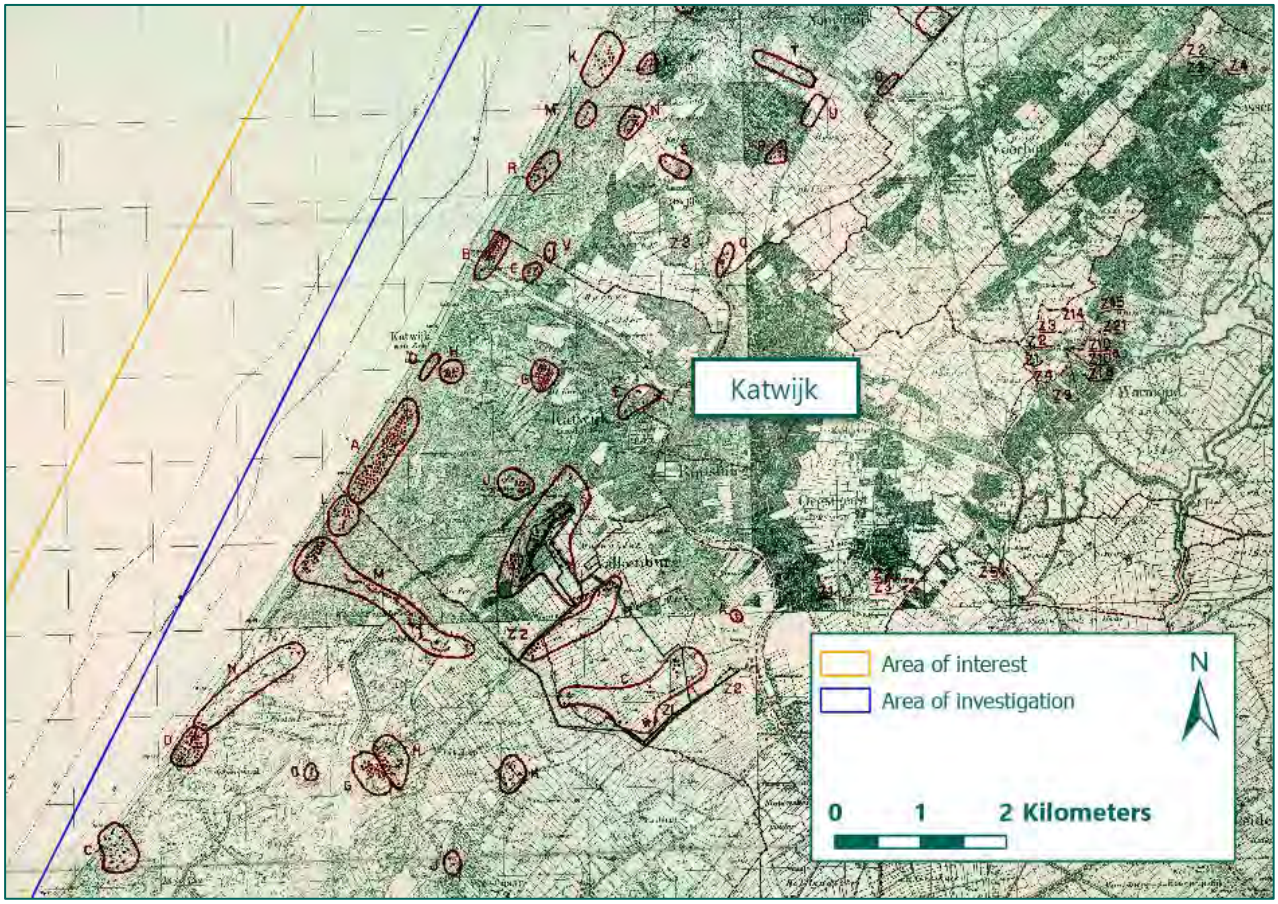


Figure 29: Cutout from a 'Blokkaart' showing the contours of military Infrastructure (Source: Nationaal Archief, 'Blokkaart' 275 3G).

4.3.1 Conclusion

Different guns could reach the area of investigation. Although the sources give only a few hints about the action of the coastal guns, it is estimated that all guns and crews had to practice from time to time. Due to the deployment of- and training with coastal guns it is probable that UXO of artillery shells are present in the area of investigation. These shells could possibly be encountered within, but no farther than, the maximum range of the coastal guns.

To cover the gap in knowledge about the coastal guns on Texel and between IJmuiden and Beverwijk the maximum range of coastal guns, not being 28 cm guns, is projected from the Dutch coast. This range is 22000 meters. Within the range of the known coastal guns and the range projected from the Dutch coast of Texel and between IJmuiden and Beverwijk an UXO Risk Area is projected. This UXO Risk area is shown in the figure below. Details about calibres are specified in the separately supplied shapefiles.

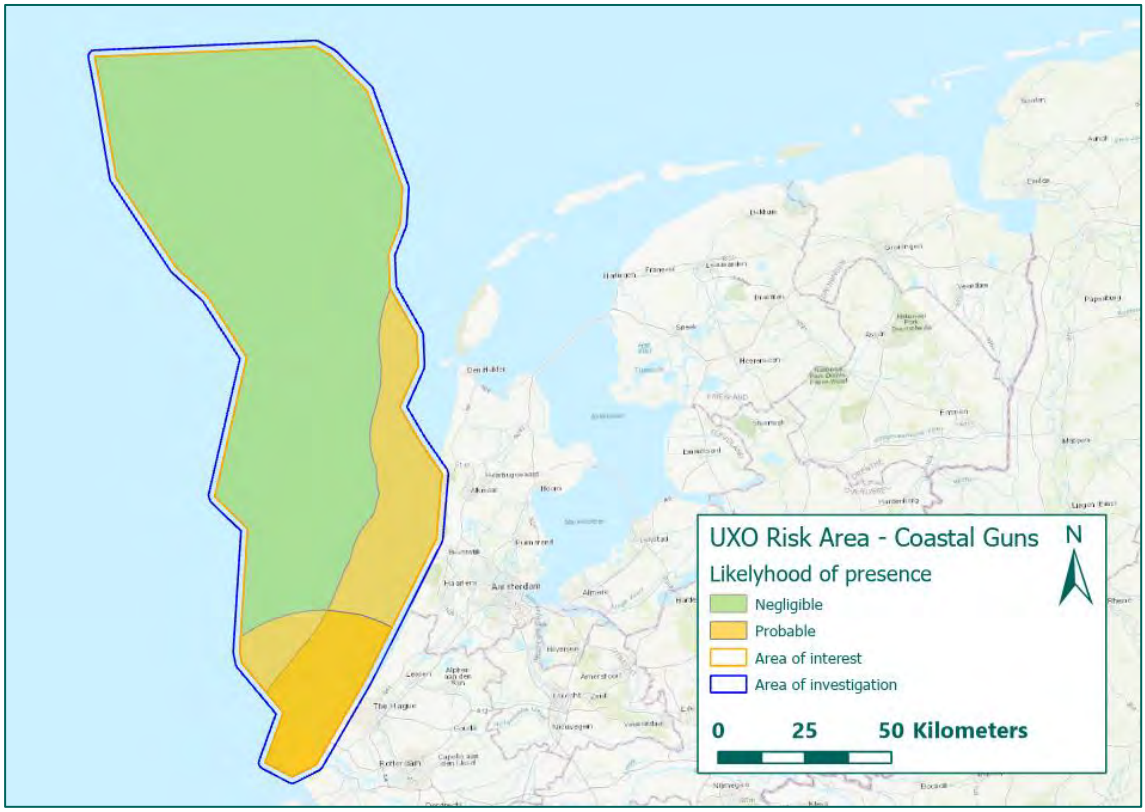


Figure 30: Likelihood of presence of UXO as result of the presence of coastal guns. (Source basemap: ESRI).

4.4 WAR AT SEA

Considering the surface craft battles, a large section of the area of investigation is situated on former German convoy routes. The convoys were accompanied with armed escort ships. Also, the convoy route itself was guarded by armed vessels and trawlers, the so-called "*Vorpostenboote*" that patrolled between checkpoints. The convoy routes are shown in Figure 31. Besides, IJmuiden and its harbour overlap the area of investigation. During the Second World War IJmuiden became an important base for the German fast attack boats (*Schnellboote*, S-Boats), for which a bunker was constructed. Later on, midget submarines also operated from IJmuiden.

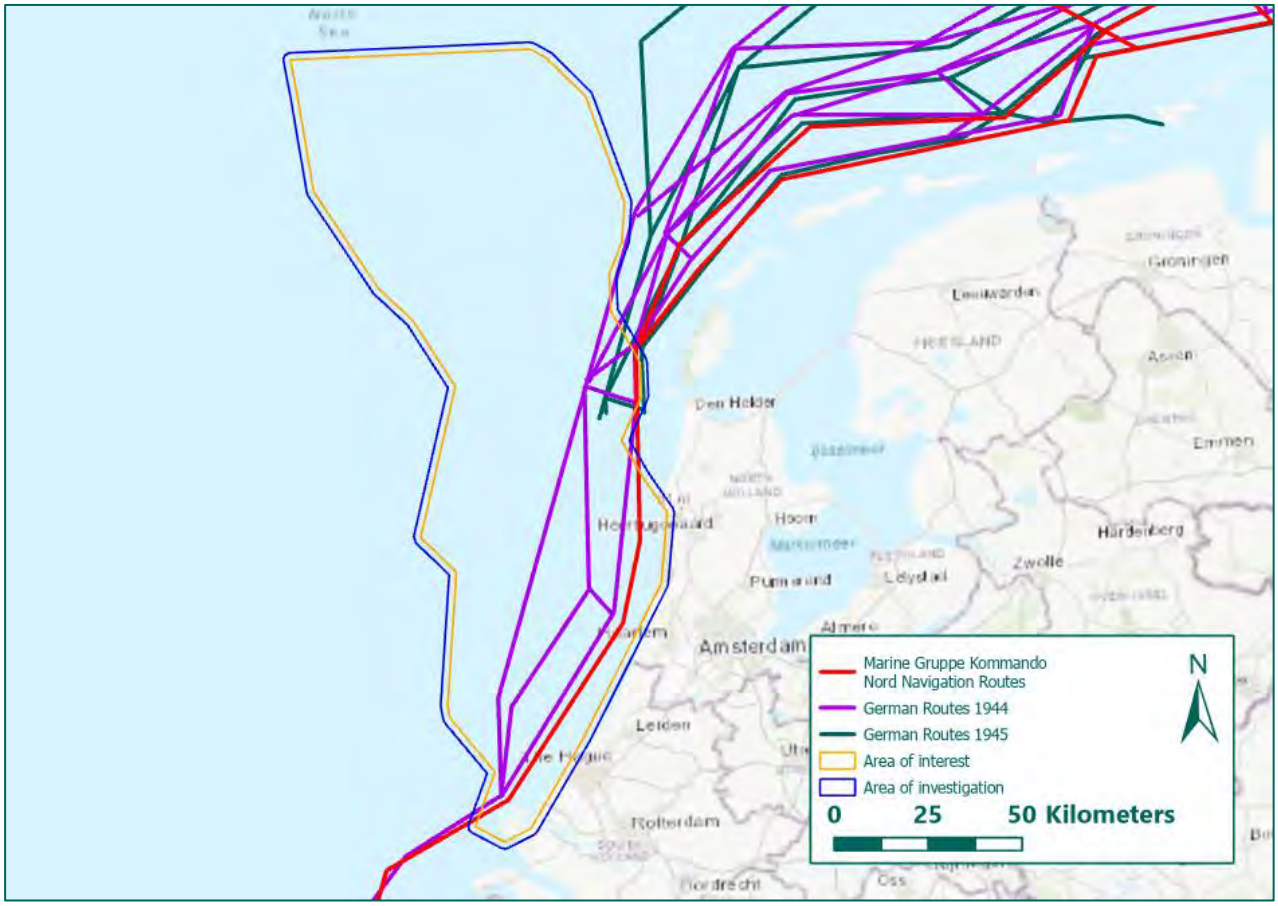


Figure 31: Convoy route "Weg Rot" and the quadrants used by the German navy. (Source basemap: ESRI).

The armed escorts and Vorpostenboote did not prevent the British Coastal Forces from attacking these ships and convoys. Detailed records about armed encounters between British and German ships can be found in German (BAMA), British (TNA) and American (NARA, Captured German Records) archives. Studying these records is outside the scope of this report. However, previously conducted studies by REASeuro (Amongst others 73556/RO-190149 Final Report DTS HKW Beta Export Cable Routes version 1.0) point out that near IJmuiden alone 36 confrontations between British and German vessels took place. The localisation is mainly based on the quadrants used by the German navy. The accuracy of these quadrants is not better than six to six nautical miles. For many of the surface craft battles only one source is available. Nevertheless, the German records show that most battles took place in a zone from the coast to the west of the convoy route.

4.4.1 Conclusion

Because of the large amount of naval battles that took place, an UXO risk area is defined. It is deemed probable that AA-shells and munition that could be used against enemy shipping might still be present in the area of investigation. UXO might be present near the convoy routes used by German ships. Therefore a UXO Risk Area is projected between the Dutch coast and the convoy routes. A buffer of 1 nautical mile (1.852 meter) is taken into account to mitigate the navigational inaccuracy. The likelihood of presence of UXO outside of the area between the Dutch coast and the convoy routes is deemed remote. In the table and figure below the UXO Risk Area is shown.

UXO type	Type	Condition
Small calibre ammunition	.303	Fired
	.50	
	13,2 mm	

	15 mm	
Artillery shells	2 cm/20 mm	
	2 pr. pompom	
	3.7 cm	
	6 pr.	
	8.8 cm	

Table 4: Expected UXO.

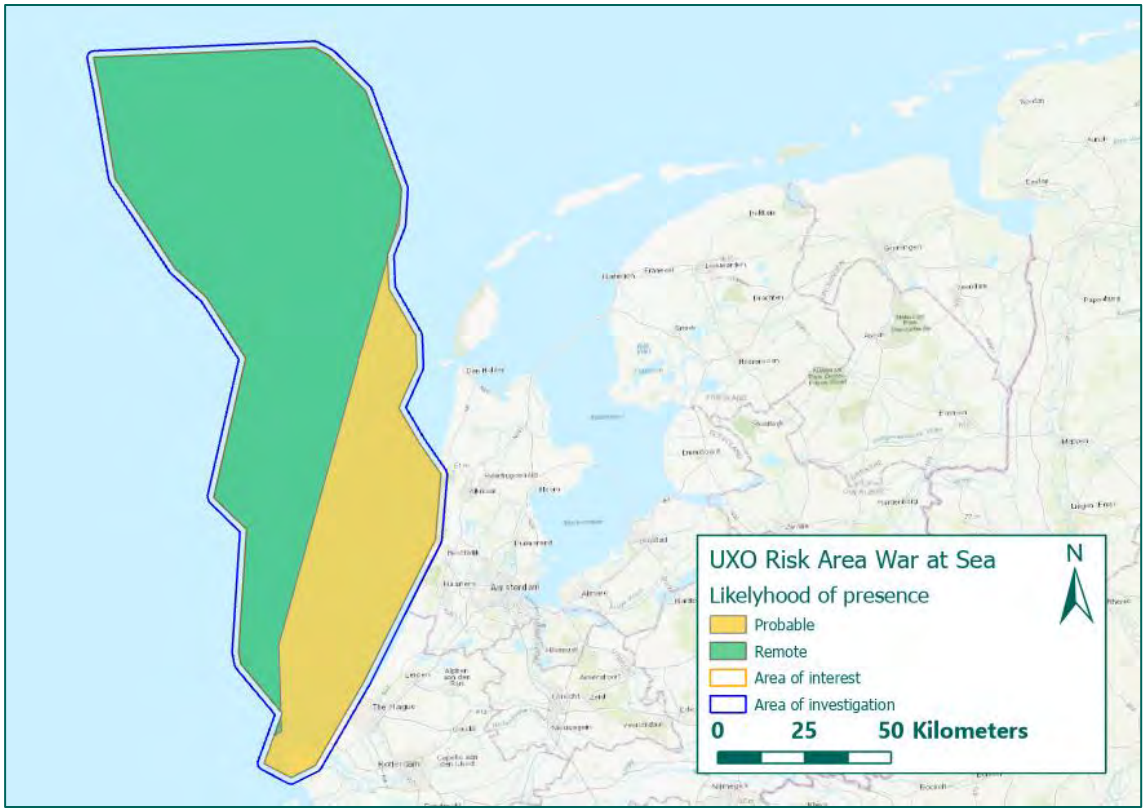


Figure 32: UXO risk area caused by surface craft battles. (Source basemap: ESRI).

4.5 MILITARY EXERCISE

On maps that show German minefields (used in paragraph 4.1.2) a German 'Schießgebiet' ('Shooting area') can be seen that overlaps with the area of investigation. The 'Schießgebiet' was drawn onto a map concerning German minefields in the North Sea. In the consulted sources there is no further mention about the 'Schießgebiet'. It is therefore unclear what kind of exercising took place within this area. It could either be exercises carried out by the Kriegsmarine or the Luftwaffe. It is expected that within this area small arms calibres and artillery shells have been used. It is known that wartime exercises are often carried out with live ammunition, this in contrast to post-war exercises.

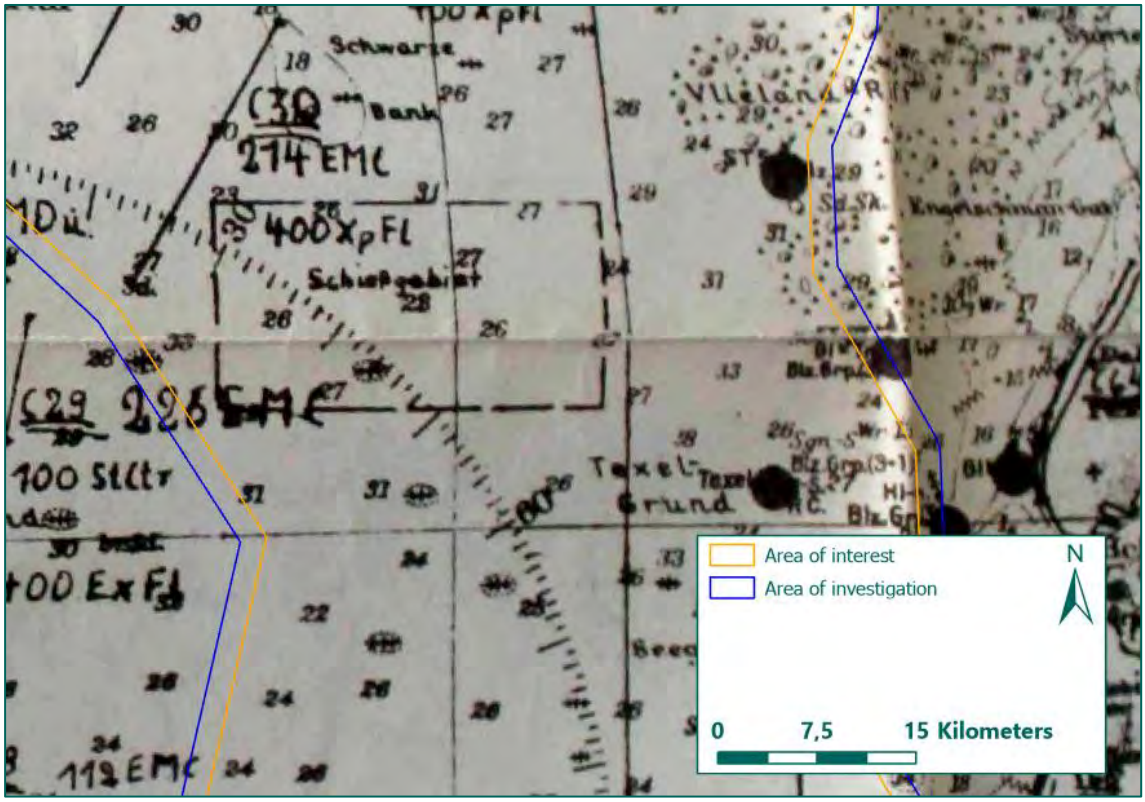


Figure 33: German map showing minefields and a 'Schießgebiet' ('Shooting area') within the area of analysis (Source: BAMA, ZA 5/27).

Based upon information from the 'Nationaal Archief' in the Hague it is known that the above mentioned 'Schießgebiet' was used by the Dutch Navy after World War II. The contours of the military exercise area appear to have an exact overlap with the contours of the German 'Schießgebiet' discussed above. Sources from the Noordzeeloket (see Annex 3) show that this military exercise zone was used as a "laag vlieggebied" (low fly zone) where one of the activities carried out was 'gun fire'[6]. The map on which the military exercise area is drawn dates from 1965. It is not known for how long the Dutch Navy used the area for exercises and whether only 'gun fire' was carried out.

[6] It is expected that in this low fly zone exercises with both machine gun- and cannon fire were carried out with aircraft.

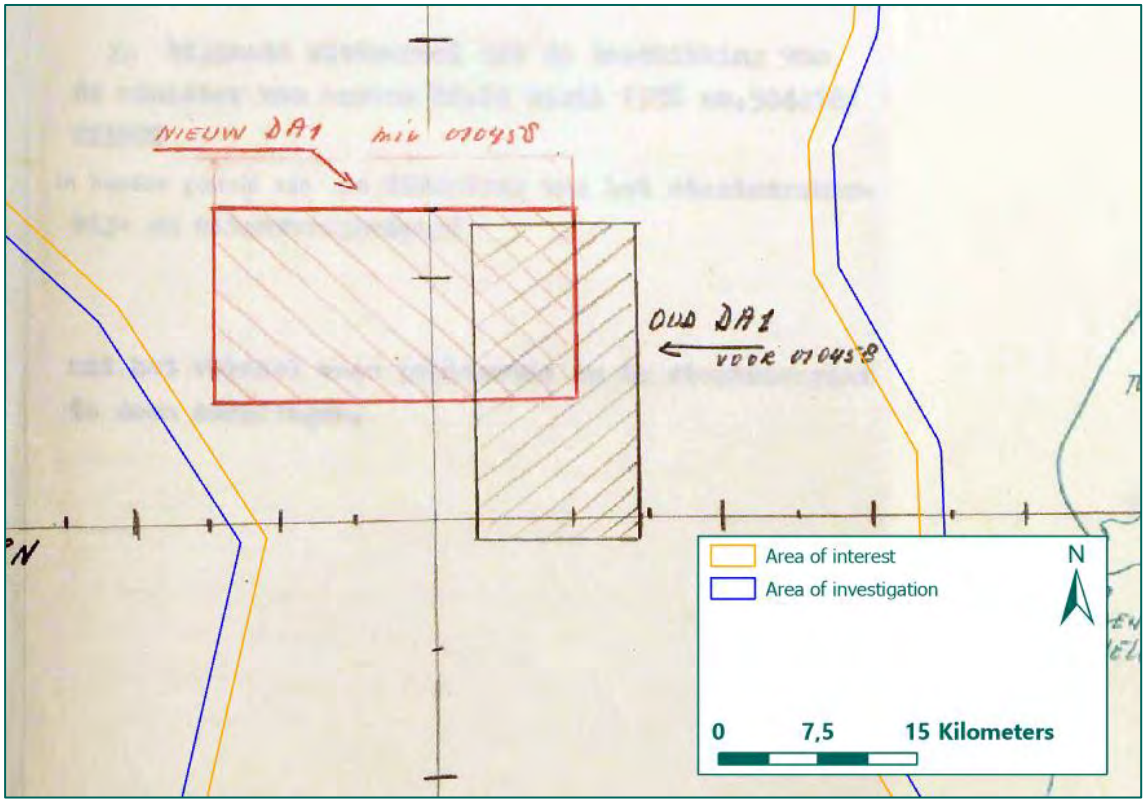


Figure 34: maps showing the location of a Dutch military exercise area within the area of investigation (Source: Nationaal Archief Toegang 2.12.56, folder 939).

Both during and after the war a military exercise area overlapped with the area of analysis. Normally, explosives are no part of exercise ammunition. However, as a result of German wartime practicing within the 'Schießgebiet', UXO could be encountered within the 'Schießgebiet' as wartime exercises were often carried out with live ammunition. It is to be expected that Dutch post-war exercises were carried out with small arms calibres and artillery shells. During peacetime military exercises would often be carried out with practice ammunition. Practice ammunition can incorporate devices to simulate the impact, like smoke markers or relatively small amounts of high explosives.

Besides the abovementioned 'Schießgebiet', several other military exercise zones were located within the Area of investigation. It is known that some of these zones were in use during World War II. However, it is not clear whether this is the case for all exercise zones. It is outside the scope of this HDTS-UXO to conduct research in the usage of each of these zones. Because of the possible usage of live munition within the different exercise areas, it cannot be ruled out that UXO might still be present within the area of investigation.

The different military exercise zones as mentioned in the consulted sources are shown in the figure below.

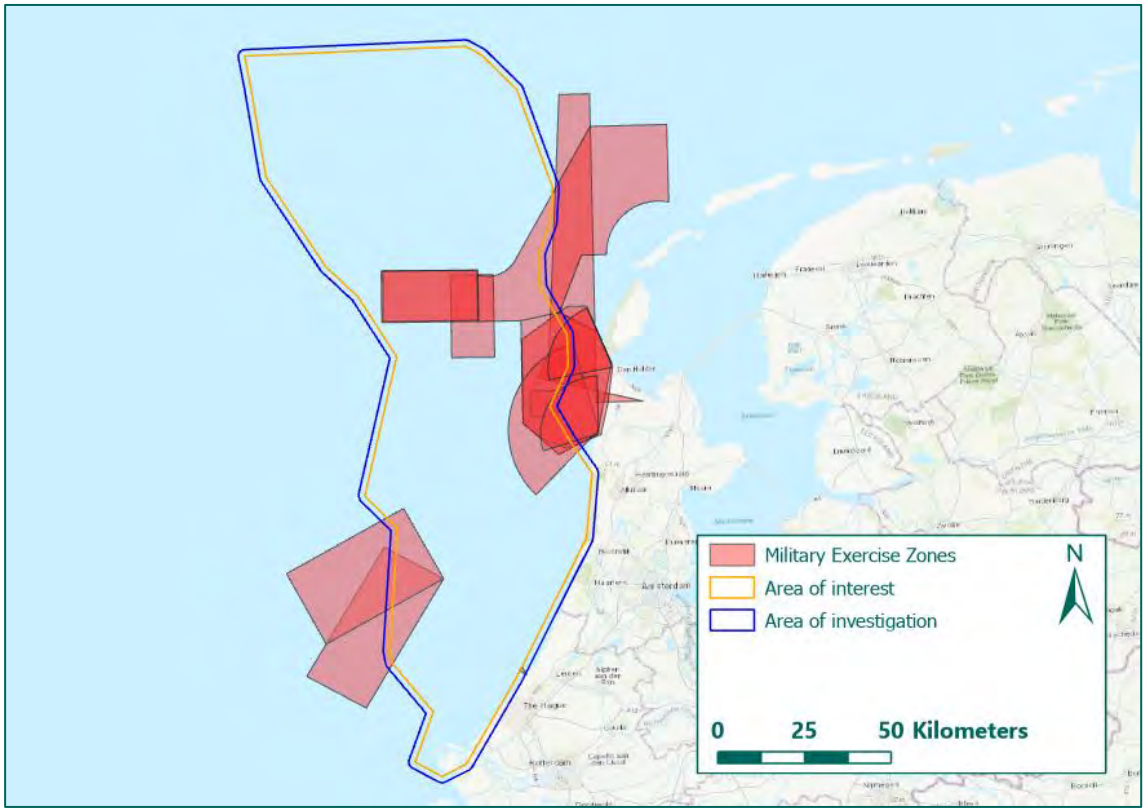


Figure 35: Military exercise zones within the area of investigation (Source basemap: ESRI)

4.5.1 Conclusion

The presence of several military exercise zones within the area of investigation, of which some were used during World War II, leads to the conclusion that UXO (either exercise ammunition or live ammunition) could still be present within the area of investigation. Additional research may be necessary to determine the type of munition used in each of the zones, and to determine whether or not live ammunition was used within the zones. This additional research is outside the scope of this research.

The sort, type, amount and condition of the munition used within the different military exercise zones can, at this time, not be determined. The consulted sources do not provide information about this. However, it cannot be ruled out that UXO might still be present within the area of investigation. Therefore, a UXO Risk Area is projected at the location of these military exercise zones. The likeliness of presence of UXO in these zones is deemed probable. The likeliness of presence of UXO in the other parts of the Area of investigation is deemed negligible.

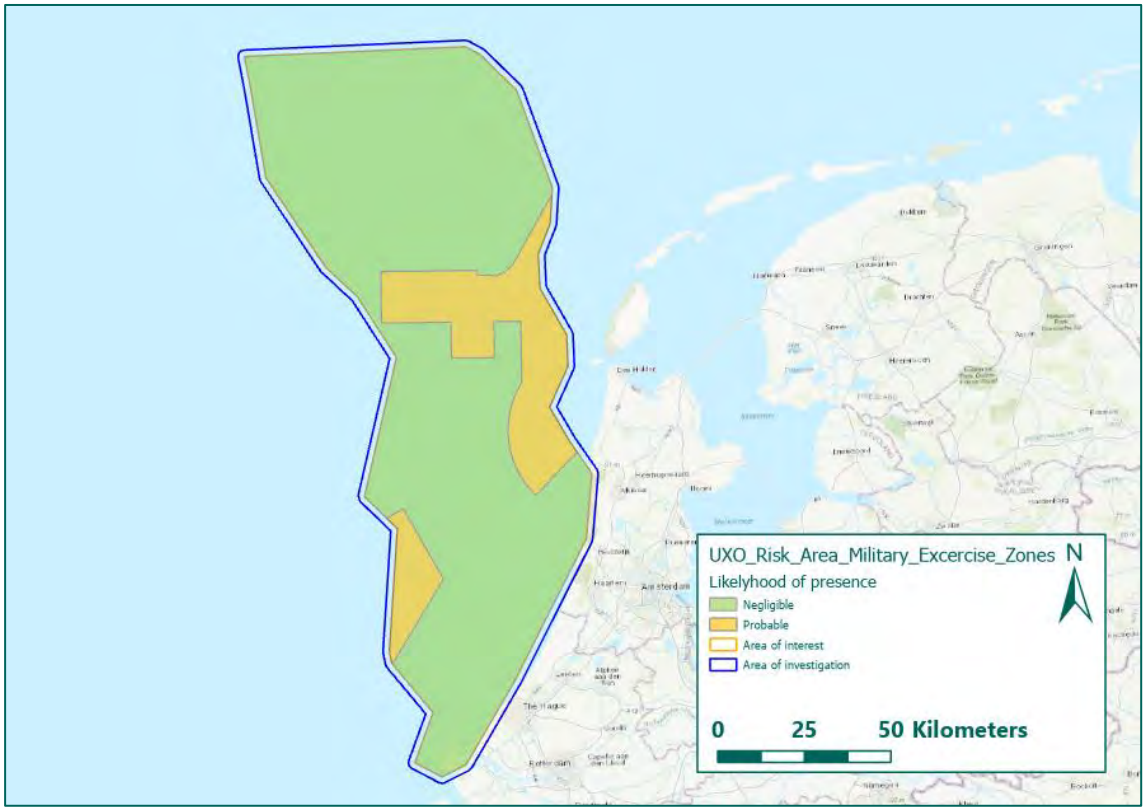


Figure 36: Likelihood of presence of UXO as result of the presence of coastal guns. (Source basemap: ESRI).

4.6 WRECKS

According to consulted sources (website of the Wrecksite and HP39 Wrakkenregister), various airplanes crashed into the area of investigation and boats sunk in the North Sea. For many crashes and shipwrecks the exact location is not known. Some wreck locations are therefore indicatively marked.

The wreck register (HP39 Wrakkenregister) shows 609 shipwrecks in the area of investigation (see annex 5). Detailed information about most wrecks are unknown. However, in some cases the name of the sunken vessel is known. It is possible to research whether or not these vessels sunk due to war related events. However, it is deemed outside the scope of this research to find additional information about 97 wrecks. Therefore, this additional research will not be conducted. In the figure below a total of all wrecks near the Area of investigation is shown.

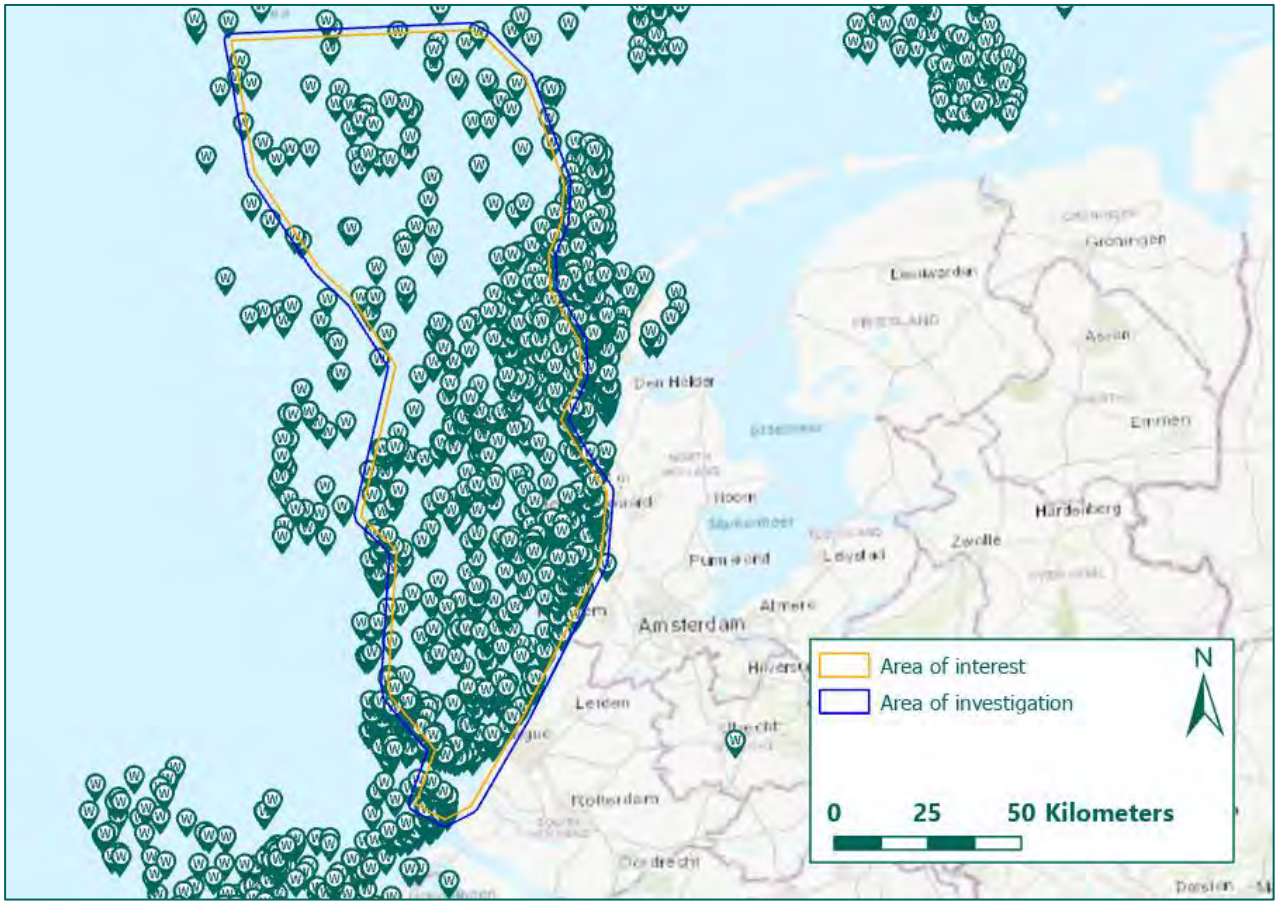


Figure 37: Overview of wrecks within the area of interest according to HP39 (Source: HP39).

The website of 'Wrecksite' also provides a lot of information about wrecks. Near the area of investigation, a total of more than 1800 wrecks lay within and near the area of interest. Plotting all these wrecks in the GIS-system would be too comprehensive and falls outside the scope of this report. In the table below a list of war related causes of sinking of ships/aircraft within the area of interest is shown. It should be mentioned that in most cases, no cause of sinking was mentioned.

Cause of sinking	Total number sunk
Airplane crashes, WW2	75
Air raids, WW2	19
Charges/explosives, WW1 and WW2	8
Depth charges , WW2	2
Explosions, WW2 and after WW2	4
Gunfire – shelled, WW1 and WW2	152
Mine, WW1 and WW2	39
Naval battles, WW1 and WW2	10
Torpedo, WW1 and WW2	21
War loss (Not specified), WW1	1

Table 3: Listing of ships/aircraft sunk by war related events.

4.6.1 Conclusion

As can be seen, most of the wrecks mentioned in this table can be ascribed to war related events described in paragraphs 4.1-4.3. The demarcation of UXO Risk Areas resulting from these war related events is also described in these paragraphs. Additional UXO Risk Areas will not be demarcated because of the possible

presence of wrecks of ships or aircraft. However, if a wreck is encountered during activities in the Maasvlakte the authorities are to be alerted. Wrecks can possibly still house the bodies of fallen troops or might be considered cultural heritage.

4.7 MUNITION DUMPING

As shown on the map of the Noordzeeloket (Figure 38) and the naval chart of the Royal Netherlands Navy Hydrographic service (Figure 39), ammunition dumping sites are situated within the area of investigation. According to archival documents, tons of German left behind ammunition were dumped into this zone shortly after World War II. In the 1960's, it appeared that fishermen encountered also ammunition outside the most northern dumping site, therefore a larger zone was marked as "*dangerous for fishing, intrusive, and seismographic activities*". The centre of the dump ground is marked with a buoy in position 52-33,5N, 04-03,6E. The dangerous area is defined by a radius of three nautical miles around this buoy. For the two southern dumping sites no such 'danger zones' were determined. In the figures below, the location of the dumping sites are indicated.

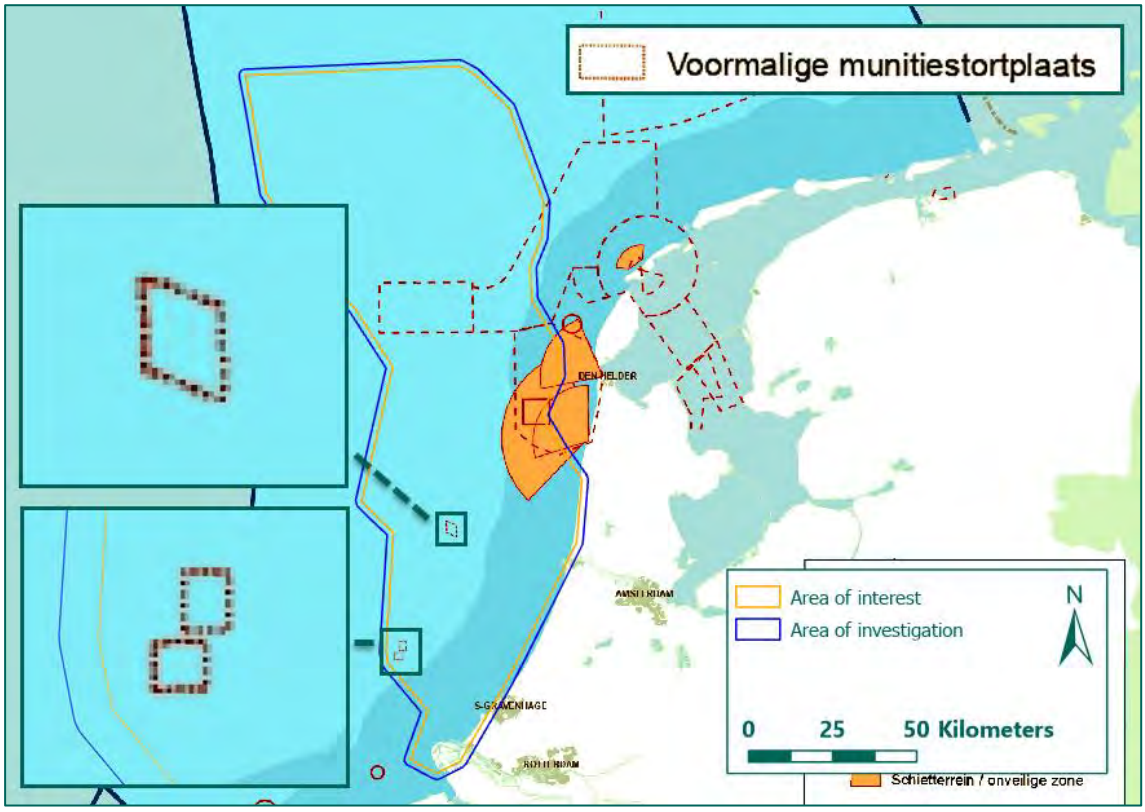


Figure 38: Map showing the military usage of parts of the North Sea, including munition dumping sites (Source: NZL).

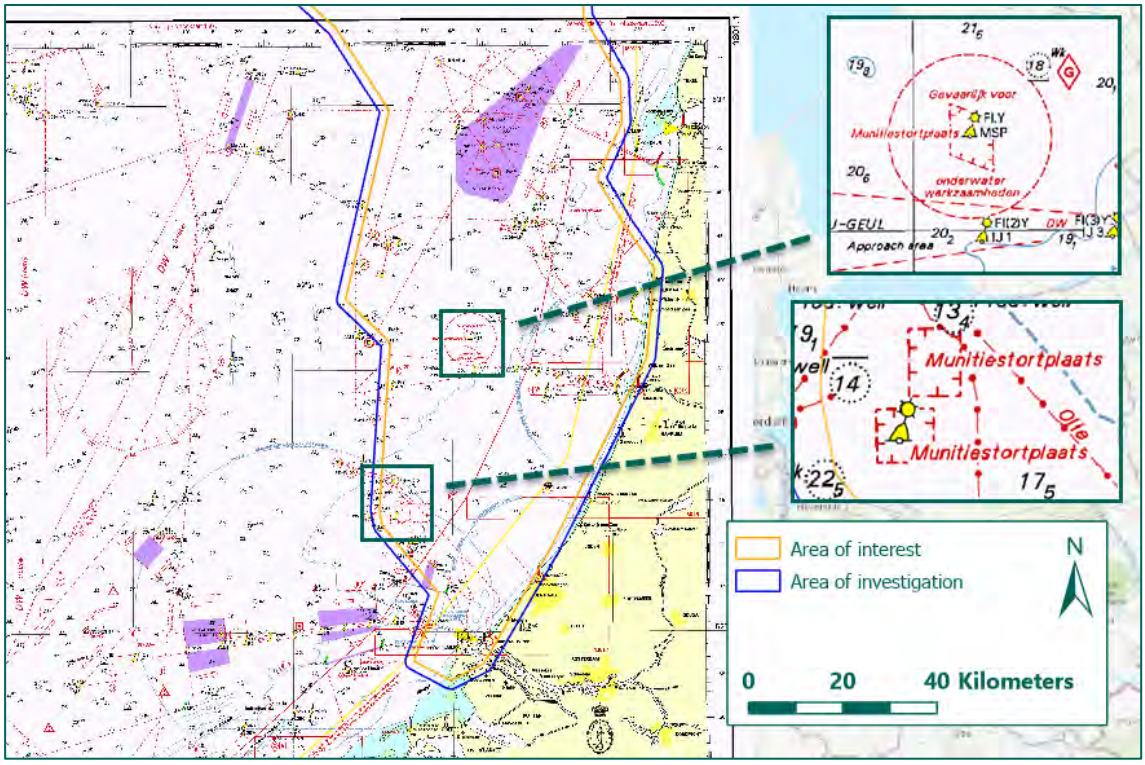


Figure 39: Naval chart (Source: Royal Netherlands Navy Hydrographic service).

4.7.1 Conclusion

Because of the large amounts of munition dumped within these sites, it is certain that UXO is still present within the dumping sites. It is also probable that munition was dumped outside of the determined dumping sites, as was the case near the most northern dumping site. Therefore, a buffer of three nautical miles is projected around these two munition dumping sites as well. Within these buffer zones the likelihood of presence is deemed probable. No information is available on the exact amount and type of the ditched ammunition. Therefore, the sort, type, amount and condition cannot be determined.

The consulted sources do not provide information about munition dumping in other parts of the Area of investigation. Therefore, the likeliness of presence of dumped munition in the other parts of the Area of investigation is deemed negligible.

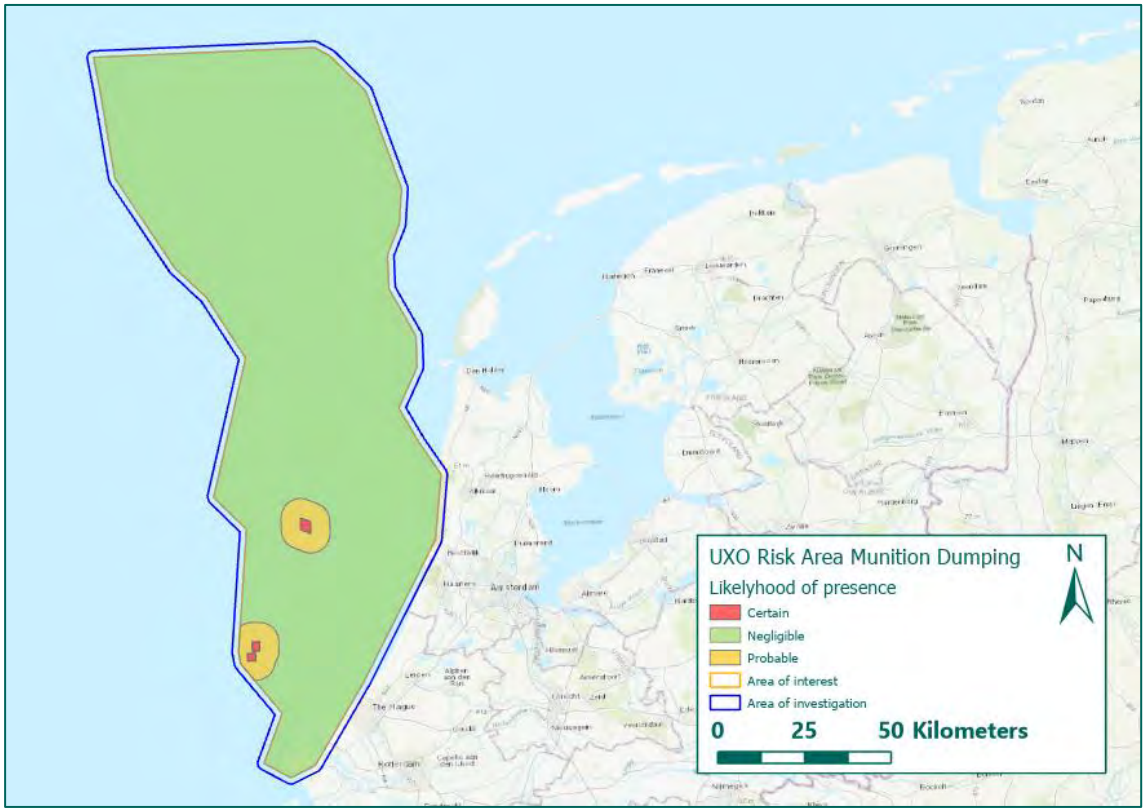


Figure 40: UXO risk area due to munition dumping. (Source basemap: ESRI).

4.8 V1 AND V2 BOMBS

During the last years of World War II, the German High Command started using new weapons with the hopes of stopping the Allied build-up and advance. These new weapons were the Vergeltungswaffe 1 (V1) and Vergeltungswaffe 2 (V2). The V1 was an early cruise missile with a pulsejet for power. The V2 was the world's first long-range guided ballistic missile. These weapons were targeted against, amongst others, Allied cities and harbours.



Figure 41: photographs of a V1 and V2 (Source: REASeuro-database).

V1 and V2 launch sites were constructed all over German-occupied territories. London was one of the main targets of the V1 and V2. Many of the V1s and V2s launched did not reach their target but landed prematurely or overshot their target due to navigational or technical errors. V1s and V2s were also vulnerable to Allied countermeasures such as anti-aircraft guns.

The consulted sources show that V1s and V2s could also land in the sea near the United Kingdom (see Figure 42). It is possible that, either through navigational or technical errors or through Allied countermeasures, UXO of V1s and V2s are left within the Area of investigation. However, in the consulted sources there are no indications that this has occurred.. A UXO Risk Area can therefore not be determined.



Figure 42: V1 and V2 bombs hitting targets in the United Kingdom (Source: V2, See Annex 2)

4.8.1 Conclusion

Although it is known that V1s and V2s could at times strike down at the sea, there are no indications in the consulted sources that this has occured within the area of investigation. It is therefore not possible to determine a UXO Risk Area within the Area of investigation.

5 GAPS IN KNOWLEDGE

During the analysis and review of historical sources some gaps in knowledge occurred that could not be filled in with the consulted sources:

- Knowledge of previous UXO clearance operations is often absent. Therefore, it is not fully known if during the period 1914-2016 UXO were encountered in and/or removed out of the area of investigation.
- It is unclear whether the source material concerning German convoy routes is complete. The consulted sources mention several attacks on convoys sailing outside the convoy routes that are known by REASeuro.
- Pinpointing the locations of all 1800 wrecks within and near the Area of Investigation was considered too comprehensive a task with regards of the scope of this research. Therefore, not all (approximate) locations of wrecks as mentioned in the consulted sources are pinpointed.
- The REASeuro-database did not contain detailed information about all individual coastal guns on the Dutch coast bordering the Area of investigation.
- Detailed records about armed encounters between British and German ships are not yet entered into REASeuro's GIS-Database. Therefore, it was not possible to give an overview of all (approximate) locations of these encounters.
- The type and amount of ammunition used by German and allied submarines, planes and ships is not always known.
- The types, calibres and amounts of munition used in the different military exercise zones are not always known
- It is unclear which types, calibres and amounts of munition were dumped in the munition dumping ground within the area of investigation.
- The REASeuro database does not contain every sortie made by Coastal Command planes during the Second World War.

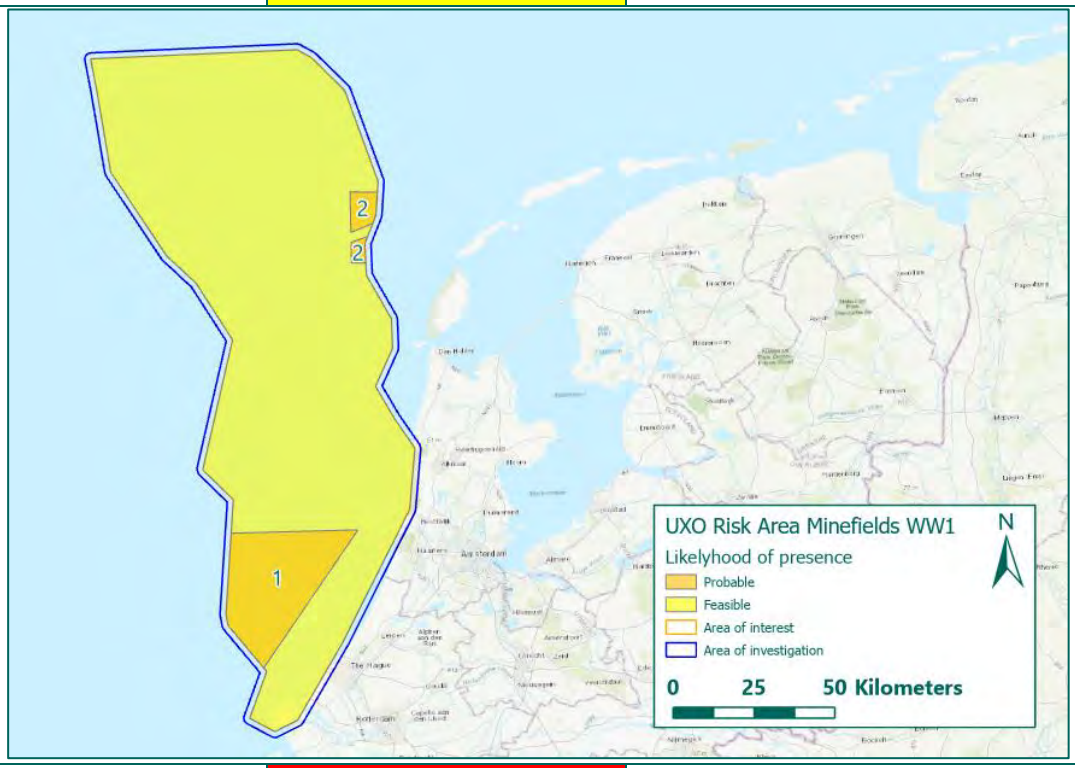
Besides these gaps of knowledge, there are also some uncertainties concerning source material relevant for this report:

- It is not possible to pinpoint exact locations of war-related events at sea. This problem is partly solved by defining a large area of investigation. Events that took place within this area could have led to a UXO risk area.
- Compared to land, the North Sea offers few reference points. Therefore, specific information about locations is often lacking. Furthermore, it must be noted that information can be inaccurate.
- Because of the systematic destruction of the *Luftwaffe* archives, there is only sporadic information available on German Air Force activity.
- Crash locations of planes during World War II are not exactly known. This is also the case for many shipwrecks, which are also unknown on Wrecksite.eu.
- There is no exact information about the locations, amounts, conditions and types of dropped bombs during aerial attacks or jettisoning above the North Sea.

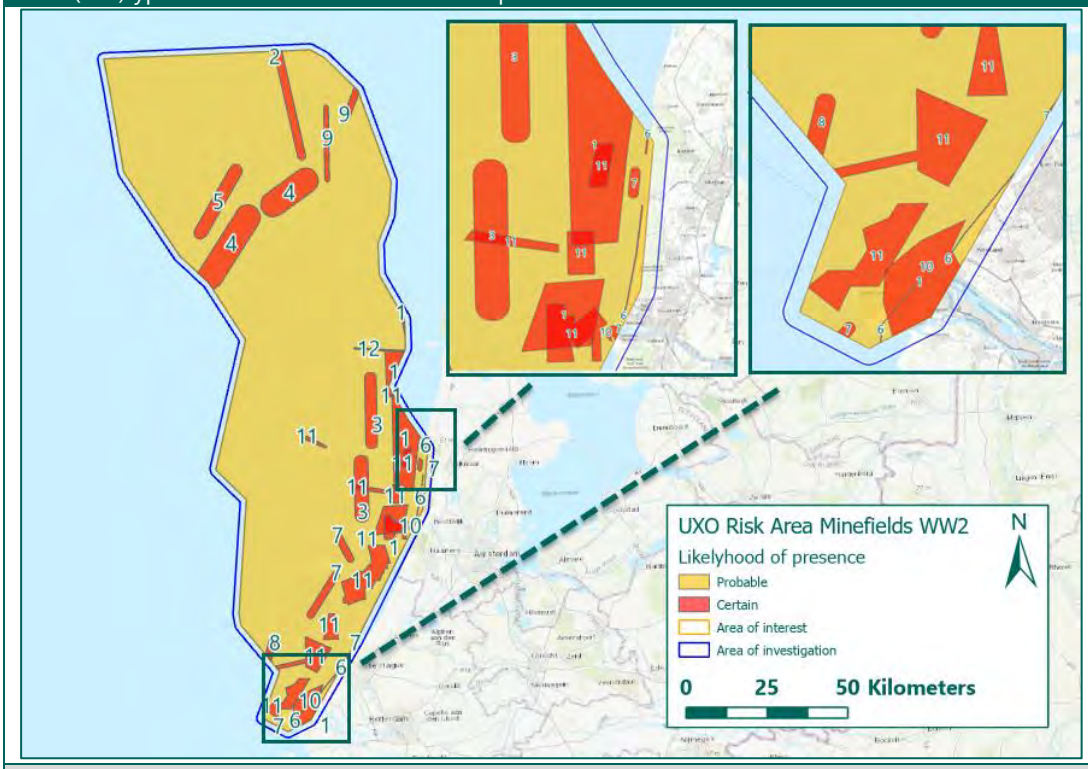
6 OVERVIEW OF UXO RISK AREAS

Based on the assessment and analysis of the source material, several UXO Risk Areas have been identified within the area of investigation. The main types of UXO found in each UXO risk area are outlined in chapter 4. The horizontal demarcation of UXO Risk Areas is discussed per type of warfare in the conclusions of paragraph 4.1, 4.2, 4.3, 4.4, 4.5, 4.7 and are presented in tables below.

UXO Risk Area as a result of the naval mines (paragraph 4.1)

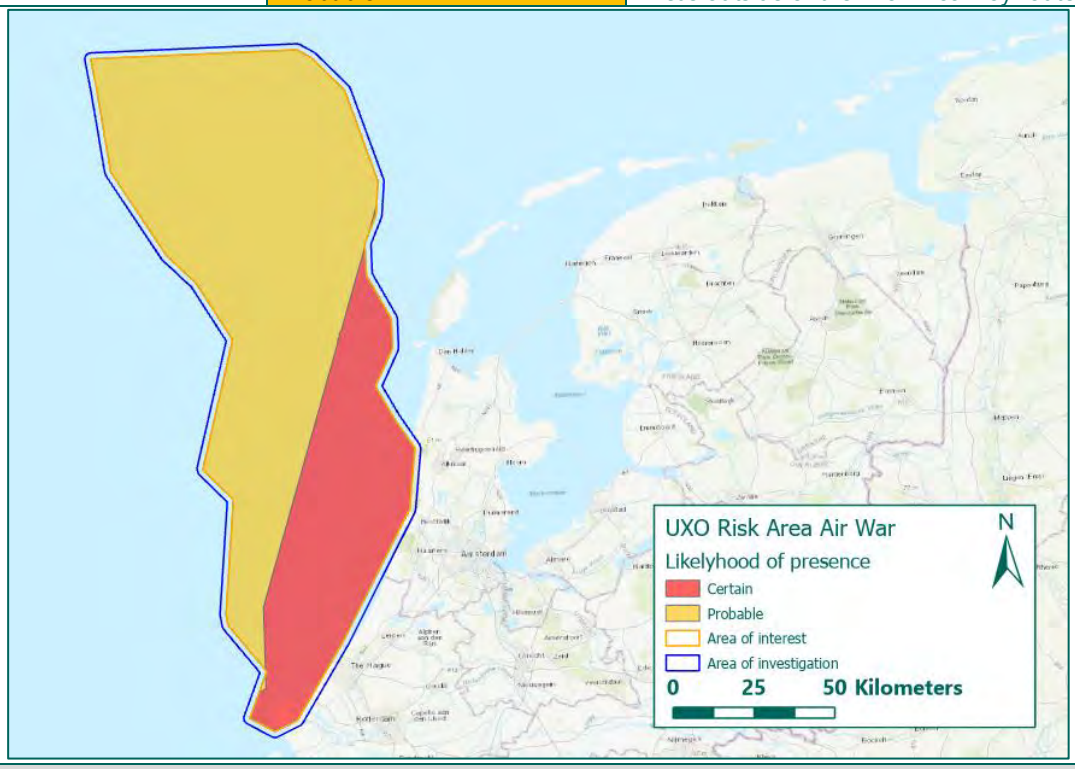
UXO (sub)type and calibre	Likelihood of presence	Demarcation
Naval Mines WW1: German E-Mine moored contact mines, British Vickers / British Elia and H Mark II moored contact mines	Probable	Within the boundaries of known minefields.
	Feasible	Outside the boundaries of known minefields.
		
Naval mines WWII: British Mk I-IV ground mines and British Mk VII- VIII and Mk XIV German EMB, EMC, EMD, UMA, RMA, KMA contact mines German LMB Ground mines German Exploding Floats (and also non explosive sweep obstructors) Dutch Model 1921 '2e soort'	Certain	Within the boundaries of known minefields.
	Probable	Outside the boundaries of known minefields.

UXO (sub)type and calibre	Likelihood of presence	Demarcation



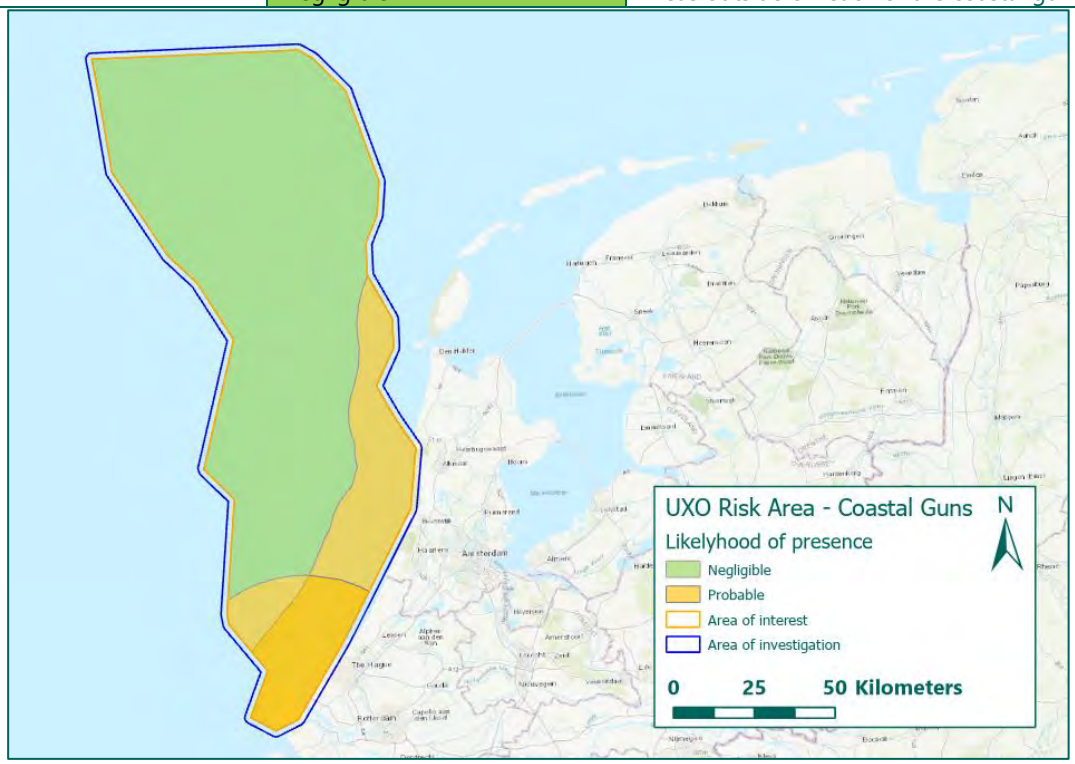
UXO Risk Area as a result of the air war (paragraph 4.2)

UXO (sub)type and calibre	Likelihood of presence	Demarcation
Aerial bombs: 4 lbs, 25 lbs, 30 lbs, 100 lbs, 250 lbs, 260 lbs, 300 lbs, 500 lbs, 1.000 lbs, 4.000 lbs	Certain	The UXO risk area is projected between the most western convoy route and the Dutch coast. A buffer of 1 nautical mile (1.852 meter) is taken into account for navigational inaccuracy of ships and aircraft.
	Probable	Areas outside of the known convoy routes.
Under water ammunition: 18 inch torpedo Mk XV Depth charge	Certain	The UXO risk area is projected between the most western convoy route and the Dutch coast. A buffer of 1 nautical mile (1.852 meter) is taken into account for navigational inaccuracy of ships and aircraft.
	Probable	Areas outside of the known convoy routes.
Rockets: 3 inch rocket with 25 lbs or 60 lbs (SAP) warhead	Certain	The UXO risk area is projected between the most western convoy route and the Dutch coast. A buffer of 1 nautical mile (1.852 meter) is taken into account for navigational inaccuracy of ships and aircraft.
	Probable	Areas outside of the known convoy routes.



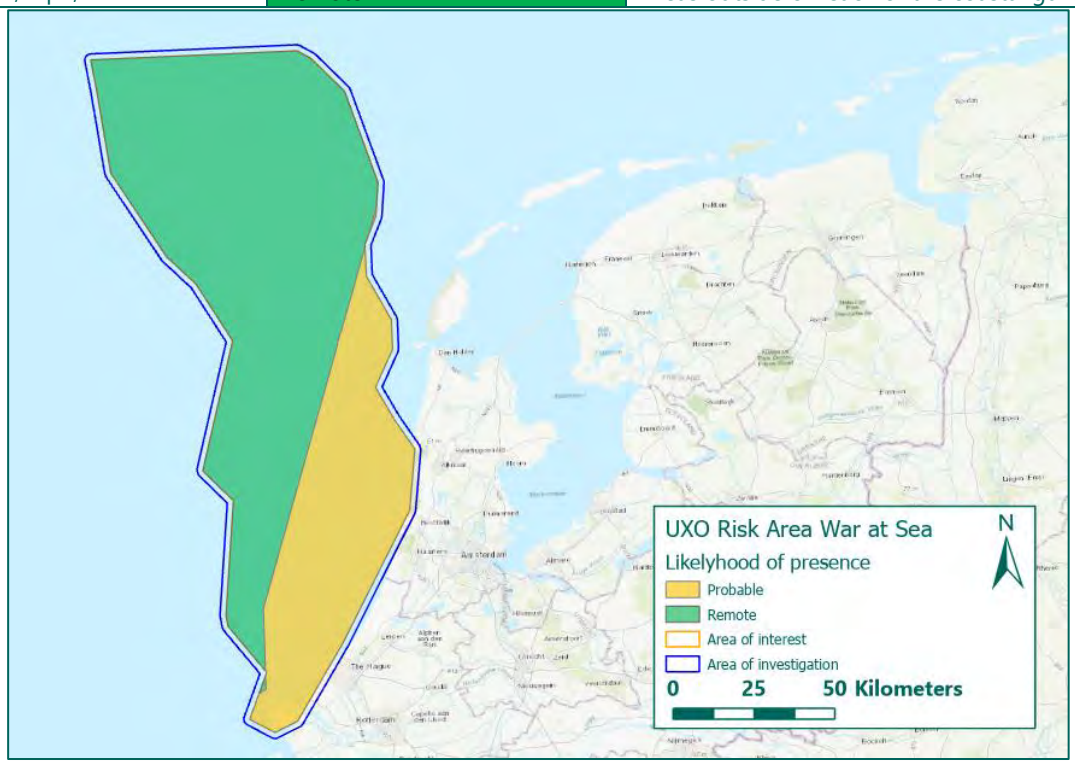
UXO Risk Area as a result of the coastal guns (paragraph 4.3)

UXO (sub)type and calibre	Likelihood of presence	Demarcation
Artillery shells: 5 cm, 7,5 cm, 9,4 cm, 10,5 cm, 12 cm, 14,91 cm, 15 cm, 15,2 cm, 24 cm, 28 cm	Probable	Within reach of the coastal guns. Where the REASeuro Database lacked information about coastal guns, the maximum range of coastal guns, not being 28 cm guns, is projected from the Dutch Coast.
	Negligible	Areas outside of reach of the coastal guns.



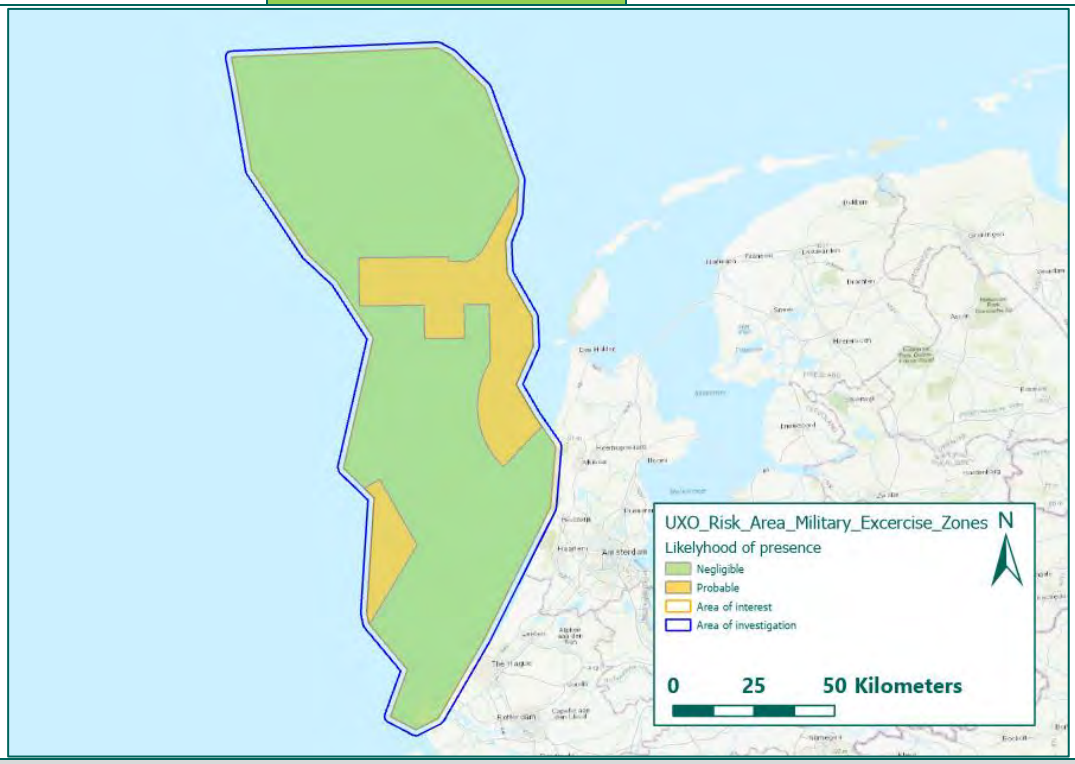
UXO Risk Area as a result of the war at sea (paragraph 4.4)

UXO (sub)type and calibre	Likelihood of presence	Demarcation
Small Calibre Ammunition: .303, .50, 13,2 mm, 15 mm Artillery Shells 2 cm/20 mm, 2 pr. Pompom, 3.7 cm, 6 pr., 8.8 cm	Probable	The UXO risk area is projected between the most western convoy route and the Dutch coast. A buffer of 1 nautical mile (1.852 meter) is taken into account for navigational inaccuracy of ships and aircraft.
	Remote	Areas outside of reach of the coastal guns.



UXO Risk Area as a result of military exercises (paragraph 4.5)

UXO (sub)type and calibre	Likelihood of presence	Demarcation
Unknown (exercise) munition: Each military exercise zone had it's own purpose, it is outside the scope if this research to determine the munition used in each zone.	Probable	Within the boundaries of known military exercise zones.
	Negligible	Outside of the boundaries of known military exercise zones.



UXO Risk Area as a result of munition dumping (paragraph 4.7)

UXO (sub)type and calibre	Likelihood of presence	Demarcation
Unknown dumped munition	Certain	Within the boundaries of known munition dumping sites
	Probable	Three nautical miles around the munition dumping sites due to large amounts of munition being found outside the munition dumping sites
	Negligible	Outside of the boundaries of known munition dumping sites



7 CONCLUSION AND ADVICE

The Historical Desktop Study leads to the conclusion that the presence of UXO within the whole Area of interest ranges from certain to negligible, depending on the type of UXO involved. In particular, the presence of UXO resulting from minefields, aerial warfare and the dumping of munition is deemed certain. Therefore, there is a severe risk of encountering UXO within the Area of interest.

Only a few specific locations wherein certain types of UXO could be present can be demarcated in this HDTS-UXO. Performing a full Historical Research will produce some further results. REASeuro advises to implement an UXO Risk Assessment (RA) alongside full Historical Research. The purpose of the RA is defining the risk that UXO poses to the planned activities in the area of analysis. This risk is a function of the 'Likelihood of Occurrence' and the 'Hazard Severity'. The 'Likelihood of Occurrence' is the product of the 'Likelihood of Presence' as defined in this HDTS-UXO and the likelihood of initiation of an item of UXO, which will be assessed in a RA. Therefore, the likelihood of presence alone is not enough to define the risk of UXO to the planned activities.

Several factors like the burial of UXO, migration of UXO, the planned intrusive activities, hazards of UXO likely to be encountered and effects of detonation are analysed and assessed for use in a Semi Quantitative Risk Assessment (SQRA). The following matrix is used to quantify the risk. Each generic UXO hazard is assessed for severity and likelihood of occurrence. This model is generally considered best practice for assessing risk in the marine environment, although it has been modified where required to ensure it is UXO centric. The risk matrix is presented in Table 3.

Once the risks have been identified fitting mitigation strategies to bring the risk down to an acceptable level will be proposed. The mitigation strategies are focused on bringing the risk down to a level that is defined as 'As Low As Reasonably Practicable' (ALARP).

		Hazard Severity				
Likelihood of Occurrence		1 = Negligible	2 = Slight	3 = Moderate	4 = High	5 = Very High
	1 = Very Unlikely	1 LOW	2 LOW	3 LOW	4 LOW	5 LOW/MODERATE
	2 = Unlikely	2 LOW	4 LOW	6 LOW/MODERATE	8 MODERATE	10 MODERATE/HIGH
	3 = Possible	3 LOW	6 LOW/MODERATE	9 MODERATE	12 MODERATE/HIGH	15 HIGH
	4 = Likely	4 LOW	8 MODERATE	12 MODERATE/HIGH	16 HIGH	20 HIGH
	5 = Very Likely	5 LOW/MODERATE	10 MODERATE/HIGH	15 HIGH	20 HIGH	25 HIGH

	Unacceptable
	ALARP with reduction measures
	ALARP
	Acceptable

Table 3: UXO Risk Assessment Matrix.

8 ANNEXES

ANNEX 1 GLOSSARY TERMS 57
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ANNEX 1 GLOSSARY TERMS

Term	Definition
Historical Desk Study - UXO	Preliminary desk study in which war related events in the 1940-1945 period (including post-war detection and clearance) are being analysed. The aim is to determine whether there can be a UXO risk area in the area of interest. The historical desk study UXO consists of: - Reports. - Affirmative or negative recommendation. - In case of an affirmative recommendation: - Horizontal delimitation UXO-Risk area(s). - UXO risk map.
Historical Quick Scan - UXO	A narrower preliminary desk study than a Historical Desk Study – UXO. The aim of a HQS is to examine whether UXO cannot be excluded within the area of interest and if there are areas with an increased risk of UXO.
Unexploded ordnance (UXO)	- Unexploded ordnance (UXO) is explosive ordnance that has been primed fused, armed, or otherwise prepared for use and used in an armed conflict. It may have been fired, dropped, launched or projected, and should have exploded, but failed to do so. - For the purposes of this publication, the term UXO is used generically to also refer to explosive ordnance that has not been used during an armed conflict, which has been left behind or dumped by a party to an armed conflict, and is no longer under control of that party. Such UXO may or may not have been primed, fused, armed or otherwise prepared for use.
Area of interest	Area of focus for the historical desk study. The area of investigation is wider than the area of investigation in order to get a full view of any war related events which could be relevant.
Area of investigation	The area specified by the client in which regular work unrelated to UXO will be performed or in which a change of function will be implemented.
Detection area	The possibly contaminated area within the area of investigation where UXO detection is recommended prior to commencing regular work activities.
War related event	Events that could possibly have led to the presence of UXO. Examples of war related events are: - Aerial Bombardment - Artillery fire - Ammunition dumping or jettisoning - Ammunition related accidents - Aircraft crashes
UXO Risk map	Cartographic view of the UXO risk area(s).
UXO Investigation (Five phases policy)	REASeuro developed a five phases policy: the integral total approach to UXO related issues comprised of five separate phases. This allows the client to make a well-considered decision for each phase and to plan follow-up actions with the aim of keeping the client in control of the project. Five phases policy: 1. Historical research 2. Project risk assessment 3. Project management plan 4. Execution 5. Clearance certificate and final report
Risk assessment	The process of identifying potential threat and estimating the risks of harm and loss associated with that threat. A risk assessment also contains the evaluation of the acceptability of the assessed risk including the consequences of a materialised risk and identifies potential risk reduction and control measures.
Risk mitigation	Eliminating risk or reducing it from an identified unacceptable risk to an acceptable level.

Term	Definition
As low as reasonably practicable (ALARP)	A risk tolerability principle that has particular connotations in UK health and safety law. It requires a developer to reduce the risks from UXO until or unless the cost of implementing those measures is considered to be grossly disproportionate to the risk averted.
"CS-OOO"	The CS-OOO is the Dutch branch specific certification plan for the system certificate "detection of conventional explosives". This includes guidelines, process requirements and expertise standards. Since January 1st 2020, the CS-OOO has been the successor to the "*Werkveldspecifieke certificatieschema voor het Systeemcertificaat Opsporen Conventionele Explosieven*" (WSCS-OCE) and is legally anchored in the Working Conditions Act (Arbowet). In order to safeguard societal interests – health and safety in relation to work – the government has opted for a mandatory certification plan to guarantee the quality and safety of detecting conventional explosives.

ANNEX 2 LITERATURE

The scope of this research was to insight in the possible chance of encountering UXO within the area of investigation by consulting the REASeuro-Database. In addition several books have been consulted in order to get a clear depiction of war related events within the area of interest. In consulting literature the focus has been placed on the First World War to fill the gaps in the REASeuro-Database. For this research the following literary sources have been consulted:

Abbreviation	Author	Title	Relevant
AAS	Air and Space	*These Amateur Archaeologists Dig Up the Buzz Bombs That Fell on England in WW2* *Two brothers scour the English countryside for remnants of Hitler's vengeance weapons.*	Yes
CRO	Crossley, J.,	*The Hidden Threat. The story of mines and minesweeping by the Royal Navy in World War I* (South Yorkshire 2011).	Yes
SCH	Scheer, R.	*Germany's High Sea Fleet In The World War* (London 1920)	Yes
VER	Vergeltungswaffen	*http://www.vergeltungswaffen.nl/*	Yes
V2	V2 Rocket	*http://www.v2rocket.com*	Yes

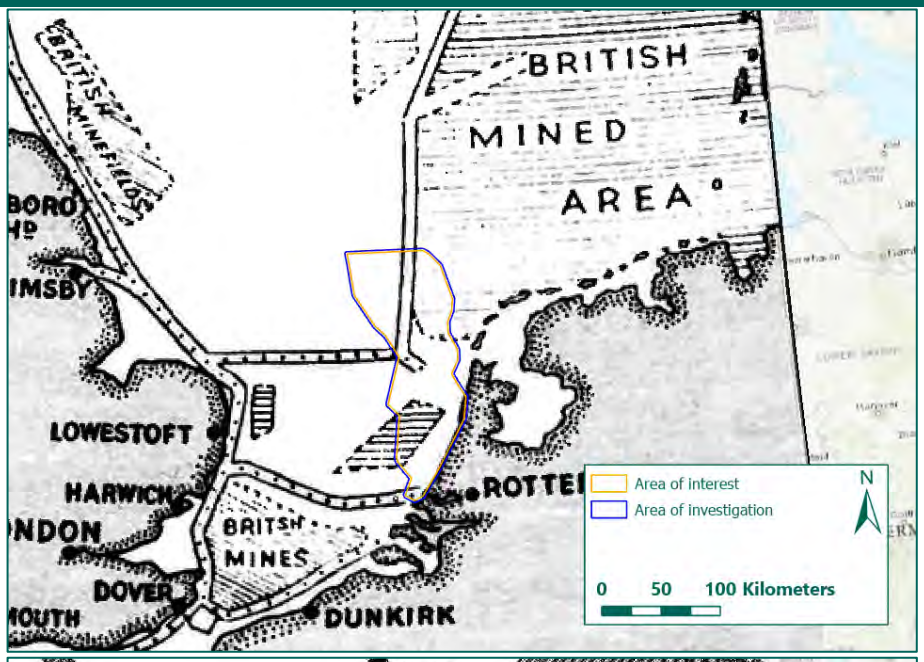
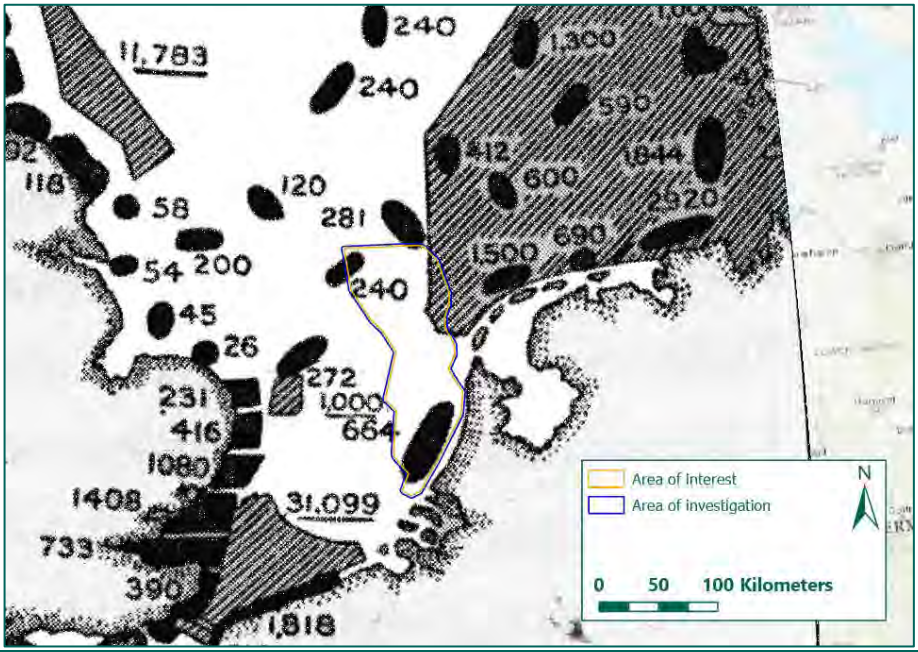
Table 4: Reference to literature.

The annex in this table contain the events that are considered relevant for the area of interest.

First World War mobilization and interbellum, 1914-1939

The First World War forced the armed forces of many nations to mobilize. Coastal guns were installed to protect strategic positions on the coast. Furthermore, shipping took considerable damage from mine and U-vessel warfare. Dozens of merchant vessels were sunk by the thousands of mines laid by the German and British navies. Large scale efforts to clear the minefields after the First World War did not succeed in clearing all these mines. The following literature is relevant for this period:

Date / year	Event	Source	Page
1914-1918	British, German and American mines laid during the war. The German minefields are in black, whereas the Allied fields are shaded. The underlined figures are numbers of Allied mines, and other figures are numbers of German mines. With their vastly greater resources, the Allies laid far more mines in the latter part of the war placing them strategically where they would effectively trap the maximum numbers of U-vessels. German mines were placed mainly close to headlands where ships would make landfalls and around the approach to major ports. From 1916 onwards, most of the German mines were laid by submarines, whereas the Allies were able to use surface ships, especially fast destroyer-minelayers, to operate close to enemy coasts. The chart gives an idea of how dangerous mine laying and minesweeping operations were as both enemy and friendly mines might be laid in the same areas. *Hatched areas in the figure below indicate allied minefields, solid areas indicate German minefields. No minefields are shown within the area of interest.*	CRO	55, 62

Date / year	Event	Source	Page
	 		
1918	Mines, of course, remain deadly irrespective of peace treaties or armistices. No fewer than 240,000 mines were scattered about the seas, some in their original position, some having dragged their moorings and settled in a new location, and some drifting freely. These constituted a major danger to shipping after the end of the war. To clear them up an international committee was formed, which included most belligerent and neutral countries, and was eventually joined by the defeated powers. This was called the International Mine Clearance Committee (IMCC) and was organized principally by the Royal Navy. All members carried out mine clearance activities and reported regularly to the IMCC, who issued regular charts and updates showing safe areas and known danger zones. The main part of the clearance work was divided between the maritime nations, Germany being responsible for sweeping Heligoland Bight, France the waters off the French and Belgian coasts, America the Northern Barrage and the UK, most of the rest, working through a new organization called the Mine Clearance Service. The service	CRO	149-160

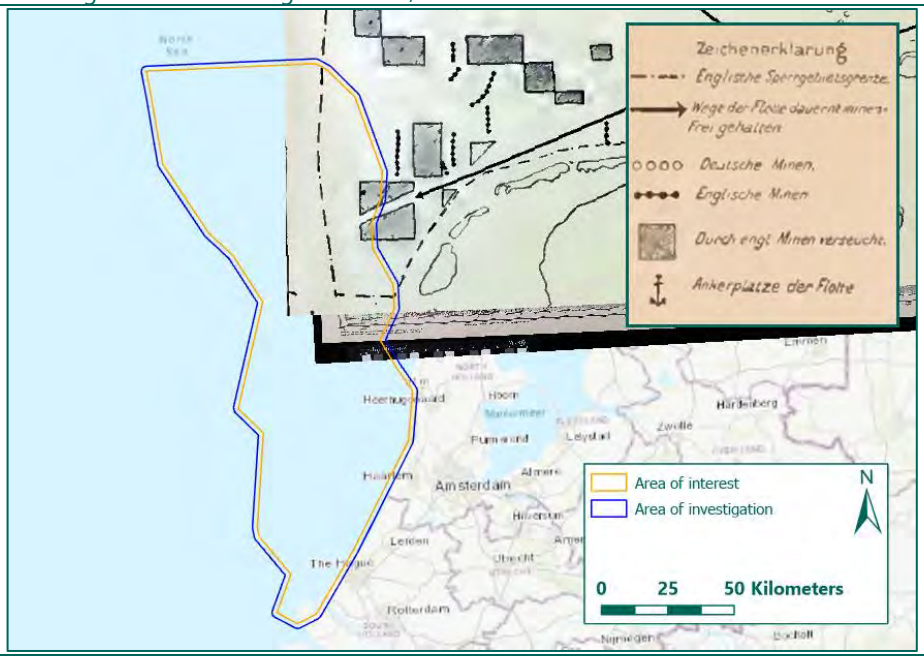
Date / year	Event	Source	Page
	was manned mainly by Royal Navy personnel and fishermen and consisted of 14,500 men and 700 officers at its peak. A particular danger when clearing dense fields was what was known as 'counter mining'. This occurred when exploding one mine would set off others in the vicinity – possibly dangerously close to the sweeper involved. Normally, deep minefields were left until last, as they did not constitute a serious danger to shipping, but sometimes some of the mines were laid incorrectly and finished up close to the surface. It was determined to skim of any of these shallow mines first, and the sweep began in the normal way. The intensive mining of the eastern North Sea also affected the German Navy to such an extent that it could not even undertake exercises safely, the British offensive mining campaign contributed to the collapse of fleet discipline and hence to the popular revolt against the Kaiser's government, which resulted in the Armistice.		
		SCH	288

Table 5: Overview of events World War 1 – Interbellum.

German invasion and subsequent occupation, 1939-1945 and Post-war period

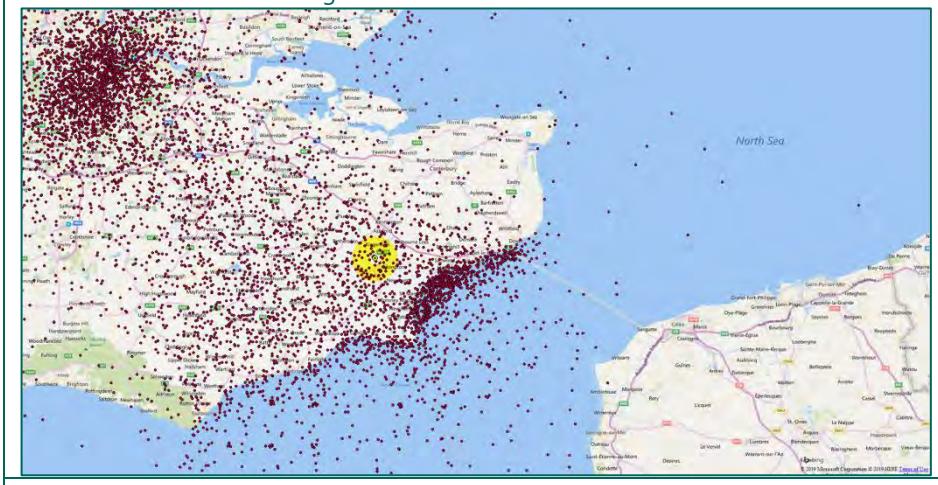
When the inevitability of the Second World War became clear in August 1939, the allied and non-aligned armies of the countries surrounding Germany once again mobilized to prepare for an imminent attack. While serious naval threats were not foreseen, preparations also took place on the coast and the sea. Coastal guns were once again installed, and vital waterways were mined.

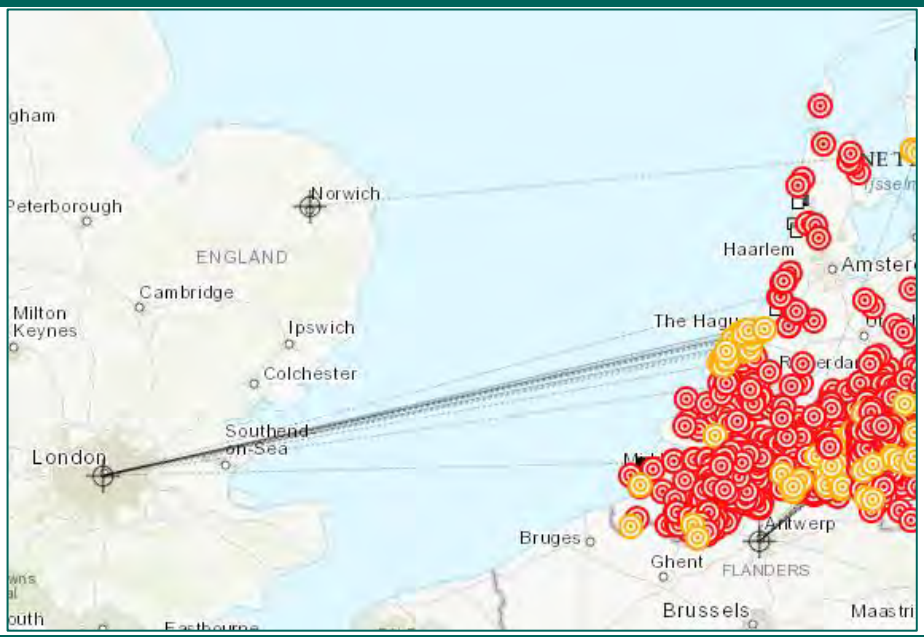
The North Sea became the frontline between Great-Britain and occupied mainland Europe. Fast attack craft from the Royal Navy coastal forces attacked German shipping close to the coast and laid mines to further hamper German navigation of the North Sea. Patrolling allied aircraft attacked convoys, submarines and surface vessels with all possible means, while heavy bombers dropped even more mines in the waters around de occupied European Coast. To make matters worse, thousands of aircraft flew over the North Sea on route to targets in Germany, jettisoning their bombs in the sea when they encountered German fighters or anti-air guns.

Immediately after the war, the reconstruction Europe began. Defensive works, bunkers and remaining UXO were cleaned up.

Literature about this period was not consulted for this report. The REASeuro-Database already contains a large quantity of sources about war related events within the North Sea. Moreover, consulting literature about this period is outside of the scope of this research.

Some information about the locations of V1s and V2s was consulted:

Date / year	Event	Source	Page
1944-1945	V1 and V2 bombs hitting the UK 	V2	-
	Locations of V1 bombs hitting the UK and the North Sea near Kent. 	AAS	-
	V1s and V2s were also launched from the Netherlands to the UK. It is possible that bombs that did not reach the UK landed in the North Sea and possibly within the Area of interest.	VER	-

Date / year	Event	Source	Page
			

ANNEX 3 (INTERNATIONAL) ARCHIVES

Several international archives have been consulted in order to gain information on the war related events in the area of investigation. The REASeuro database contains a large quantity of documents from the British, American and German archives. The following international archives yielded relevant documents for this desk top study:

- Noordzeeloket, The Netherlands.
- Dienst der Hydrografie, Koninklijke Marine, The Netherlands
- Nationaal Archief, The Hague, The Netherlands
- Nederlands Instituut voor Militaire Historie, The Hague, The Netherlands
- Marinemuseum (Navy Museum), Den Helder, The Netherlands
- UK Hydrographic Office (UKHO), Taunton, Somerset, United Kingdom.
- Library of Congress (LOC), Washington D.C., United States.
- The National Archives (TNA) in London, United Kingdom.
- National Archives and Records Administration (NARA) in College Park (MD), United States.
- Bundesarchiv-Militärarchiv (BaMa) in Freiburg, Germany.

Noordzeeloket (NZL)

The Noordzeeloket is a comprehensive website, covering relevant Dutch maritime policy related North Sea information. On the Website relevant information about the locations of Voormalige munitiestortplaatsen (Former munitions dump locations), Oefengebieden Mijnenruimen (Mine clearance training areas), (Laag)vlieggebieden ((Low) flying areas) and Schietterrein / onveilige zone (Shooting site / unsafe area) is available

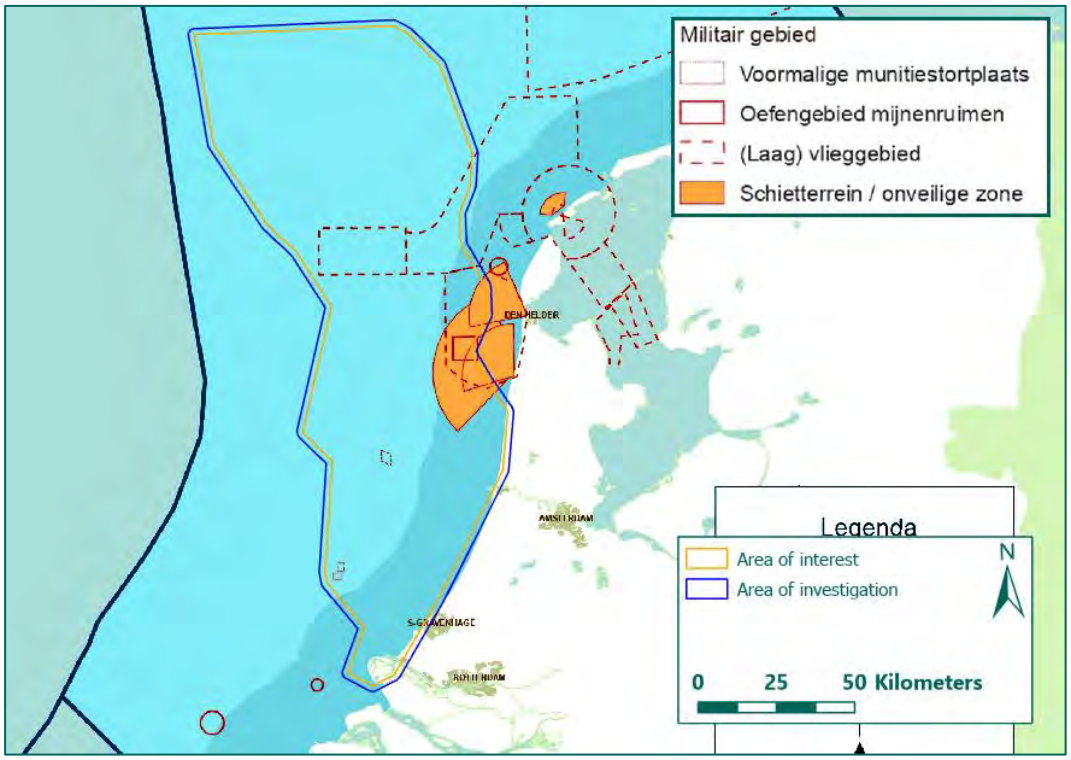


Figure 43: Map showing the military usage of parts of the North Sea (Source: NZL).

Dienst der Hydrografie, Koninklijke Marine (Royal Netherlands Navy Hydrographic service)

Naval charts of the area of analysis have been acquired through the Hydrographic Service. Besides naval charts the HP39 (wreck registry) publication has been consulted to gain information on possible wrecks in the area of investigation.

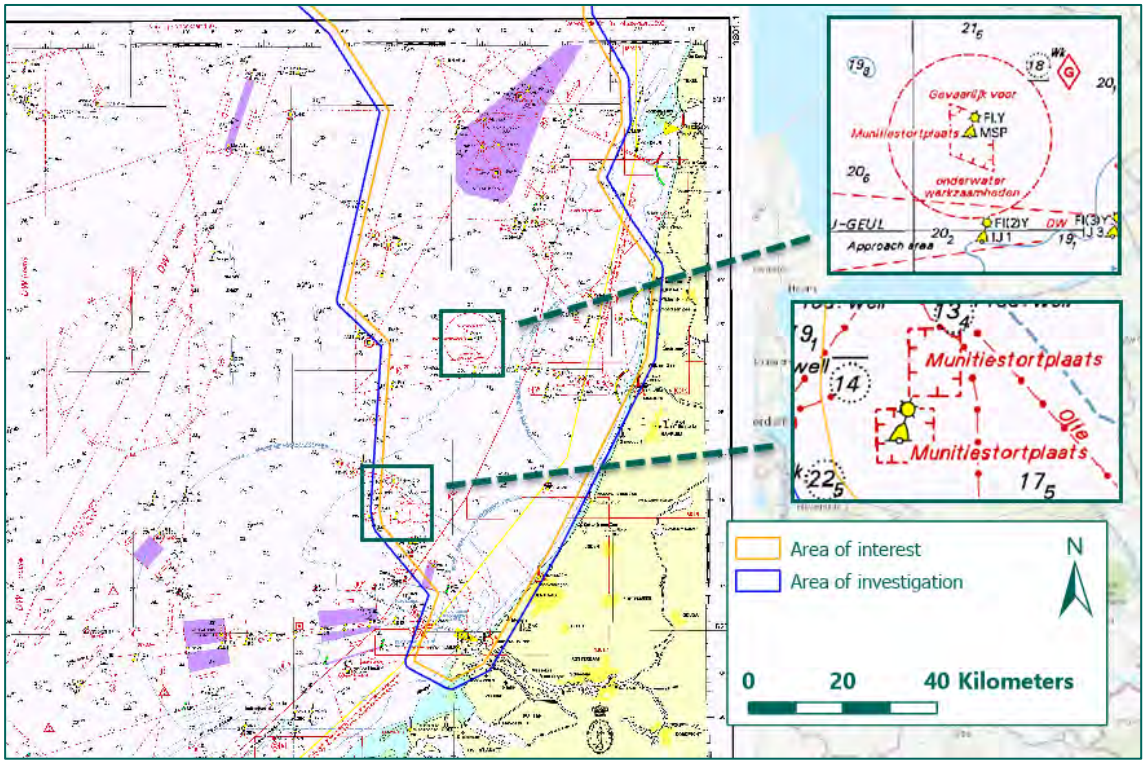


Figure 44: Naval chart (Source: Royal Netherlands Navy Hydrographic service).

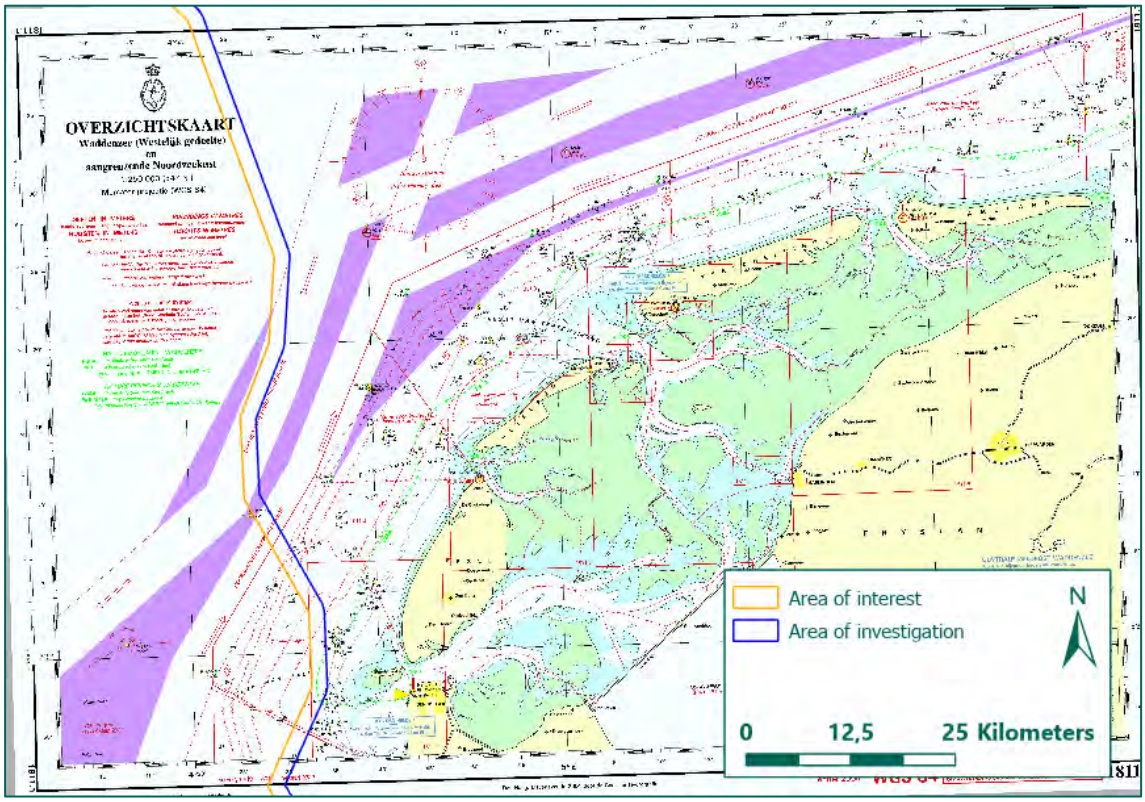


Figure 45: Naval chart (Source: Royal Netherlands Navy Hydrographic service).

Nationaal Archief

The Dutch 'Nationaal Archief' (National Archives) has been consulted for more information on the dumping of explosives, naval minefields and minesweeping, shipwrecks and other relevant information for the area of investigation.

Toegang 2.12.18: Archief van de Koninklijke Marine: Chef van de Marinestaf te ''s-Gravenhage, 1886-1942	
Inventaris 162	Stukken betreffende verboden en gevaarlijke vaargebieden 1914-1939

Map showing area's that are 'gevaarlijk voor de visserij' (Dangerous for fishing activities):

Onder verwijzing naar circulaire Nº. 41 der Visscherij-Inspectie, vestigt de Hoofdinspecteur der Visscherijen de aandacht van belanghebbenden er op, dat vanaf 22 November 1917, het door Duitschland als gevaarlijk aangegeven gebied in de Noordzee, inzooverre is gewijzigd, dat als Oostgrens daarvan dient te worden aangenomen een lijn loopende van het einde der Nederlandsch-Belgische grens over het punt:

	51°	35′	N.B.	2° 57′	O.L.
naar	52°	2′	N.B.	3° 52′	O.L.
„	52°	28′	N.B.	4° 22′	O.L.
„	52°	40′	N.B.	4° 25′	O.L.
„	52°	40′	N.B.	3° 40′	O.L.
„	54°	45′	N.B.	3° 40′	O.L.
„	55°	10′	N.B.	4° 0′	O.L.
„	56°	0′	N.B.	4° 0′	O.L.
„	56°	0′	N.B.	4° 50′	O.L.

verder daarvandaan langs den lengtegraad 4° 50′ O. tot op een punt, dat 10 zeemijlen van den vuurtoren van Udsire af ligt.

Het thans voor de visscherij gevaarlijke gebied in de Noordzee, alsmede de ligging van lichtschepen en lichtbrulboeien, zijn op bijbehoorend kaartje aangegeven.

's-GRAVENHAGE, 26 November 1917.

De Hoofdinspecteur voornoemd,
J. M. BOTTEMANNE.

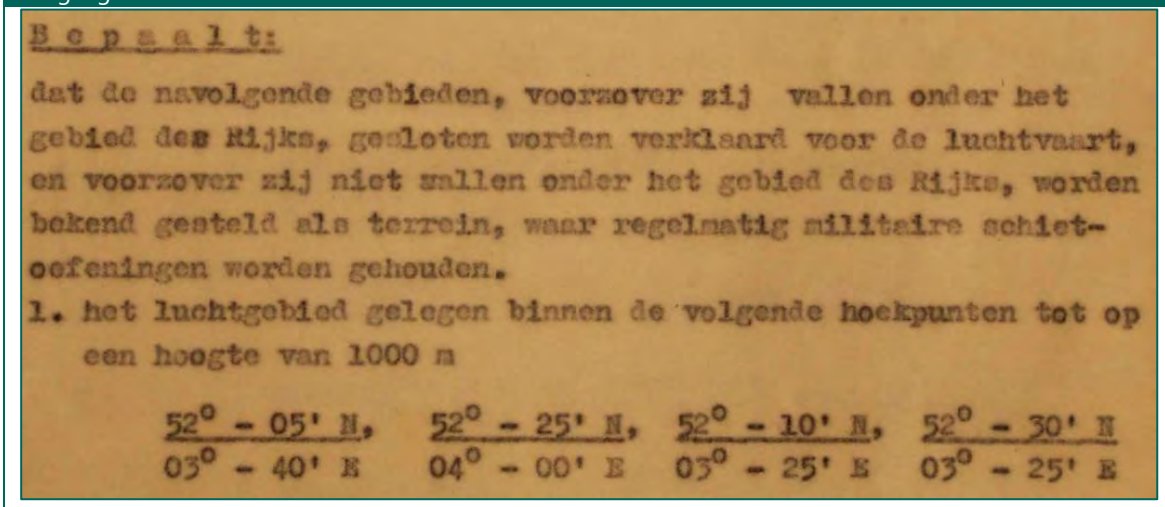
Toegang 2.12.18: Archief van de Koninklijke Marine: Chef van de Marinestaf te ''s-Gravenhage, 1886-1942



Toegang 2.12.56: Marine na 1945	
Inventaris 939	Vaststelling oefengebieden voor schietoefeningen. 1950-1975

Maps and information about Military training area's in the North Sea. Relevant maps and information regarding the area of investigation are shown below:

Training Ground Aircraft:



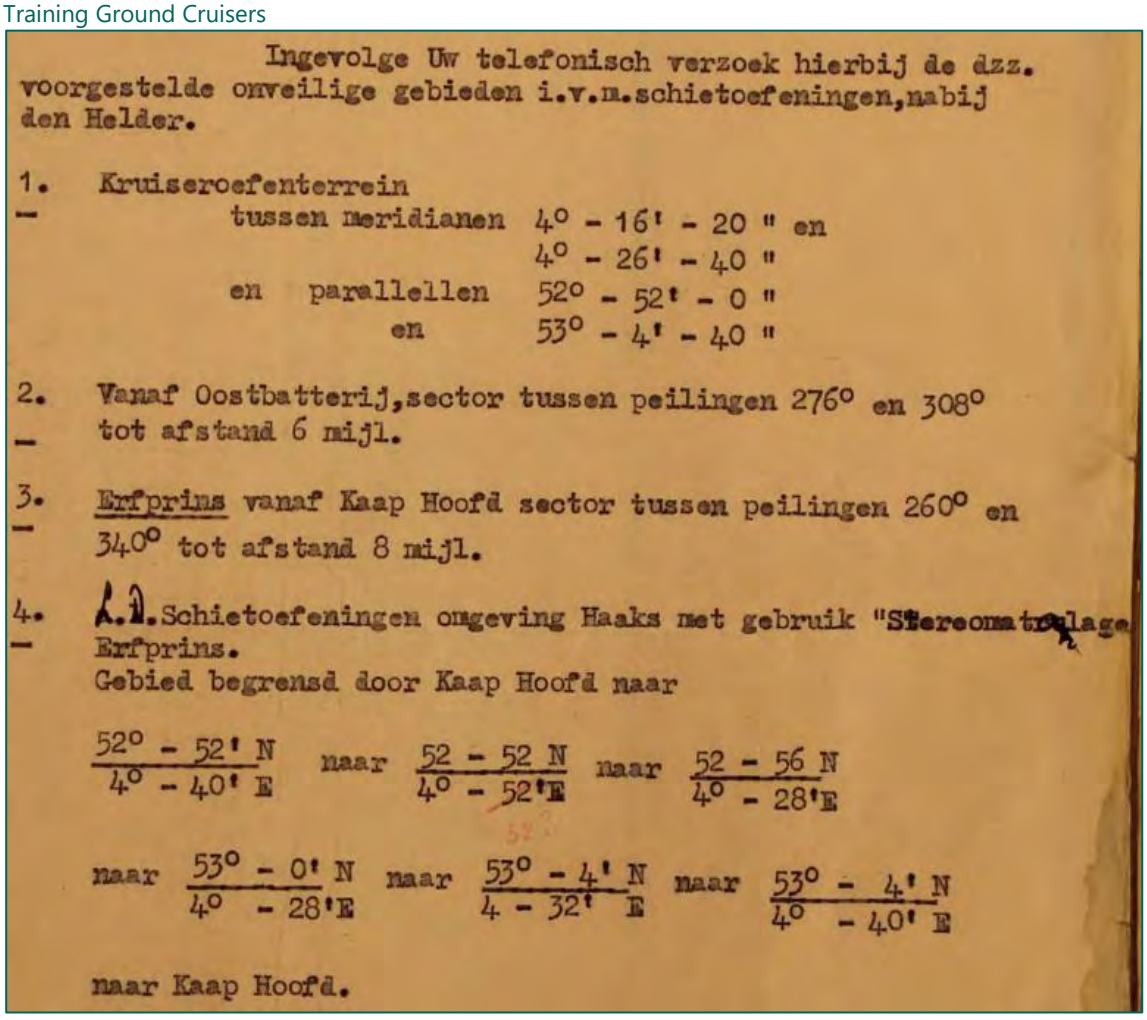
B e p a a l t:

dat de navolgende gebieden, voorzover zij vallen onder het gebied des Rijks, gesloten worden verklaard voor de luchtvaart, en voorzover zij niet vallen onder het gebied des Rijks, worden bekend gesteld als terrein, waar regelmatig militaire schiet-oefeningen worden gehouden.

1. het luchtgebied gelegen binnen de volgende hoekpunten tot op een hoogte van 1000 m

52° - 05' N, 03° - 40' E | 52° - 25' N, 04° - 00' E | 52° - 10' N, 03° - 25' E | 52° - 30' N 03° - 25' E

Training Ground Cruisers



Ingevolge Uw telefonisch verzoek hierbij de dzz. voorgestelde onveilige gebieden i.v.m.schietoefeningen,nabij den Helder.

1. Kruiseroefenterrein
tussen meridianen 4° - 16' - 20 " en 4° - 26' - 40 "
en parallellen 52° - 52' - 0 "
en 53° - 4' - 40 "

2. Vanaf Oostbatterij,sector tussen peilingen 276° en 308° tot afstand 6 mijl.

3. Erfprins vanaf Kaap Hoofd sector tussen peilingen 260° en 340° tot afstand 8 mijl.

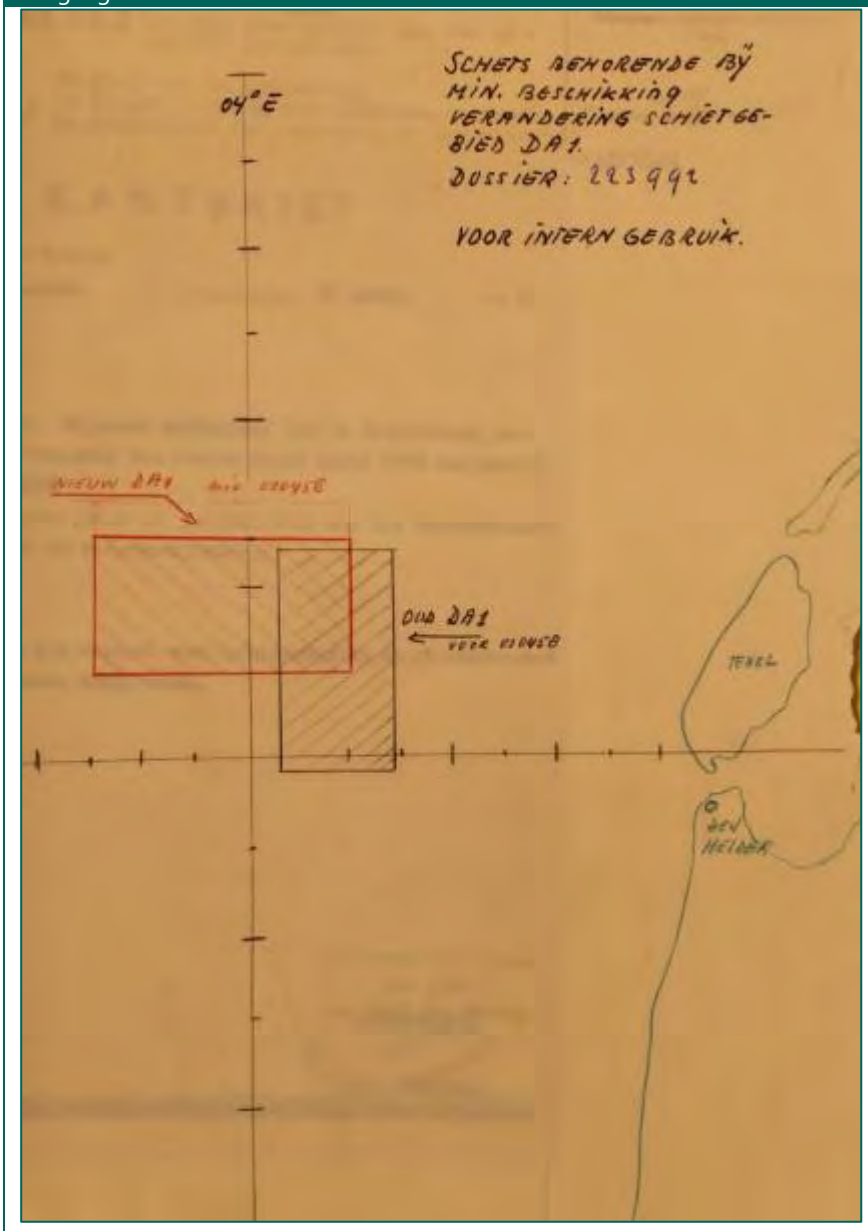
4. L.D. Schietoefeningen omgeving Haaks met gebruik "Stereomatlage Erfprins.
Gebied begrensd door Kaap Hoofd naar

52° - 52' N / 4° - 40' E naar 52 - 52 N / 4° - 52'E naar 52 - 56 N / 4° - 28'E

naar 53° - 0' N / 4° - 28'E naar 53° - 4' N / 4 - 32' E naar 53° - 4' N / 4° - 40' E

naar Kaap Hoofd.

Old en new site of DA1:



Training Grounds in the North Sea:

Besluiten:

I.1. In de hieronder nader omschreven gebieden zijn de Commandant der Zeemacht in Nederland, de Chef van de Generale Staf en de Chef van de Luchtmachtstaf, ieder voor zover hen aangaat, bevoegd om in overleg met de Directeur Generaal van de Rijks-luchtvaartdienst de uitoefening van de burgerlijke luchtvaart in verband met militaire oefeningen te beperken dan wel geheel te verbieden.

DA 1 (Den Helder I)

Het gebied, begrensd door een lijn, welke de volgende posities verbindt:
53.05.00 N — 03.45.00 O; 53.13.00 N — 03.45.00 O;
53.13.00 N — 04.10.00 O; 53.05.00 N — 04.10.00 O,
tot een hoogte van 9150 meter.

DA 2 (Den Helder II)

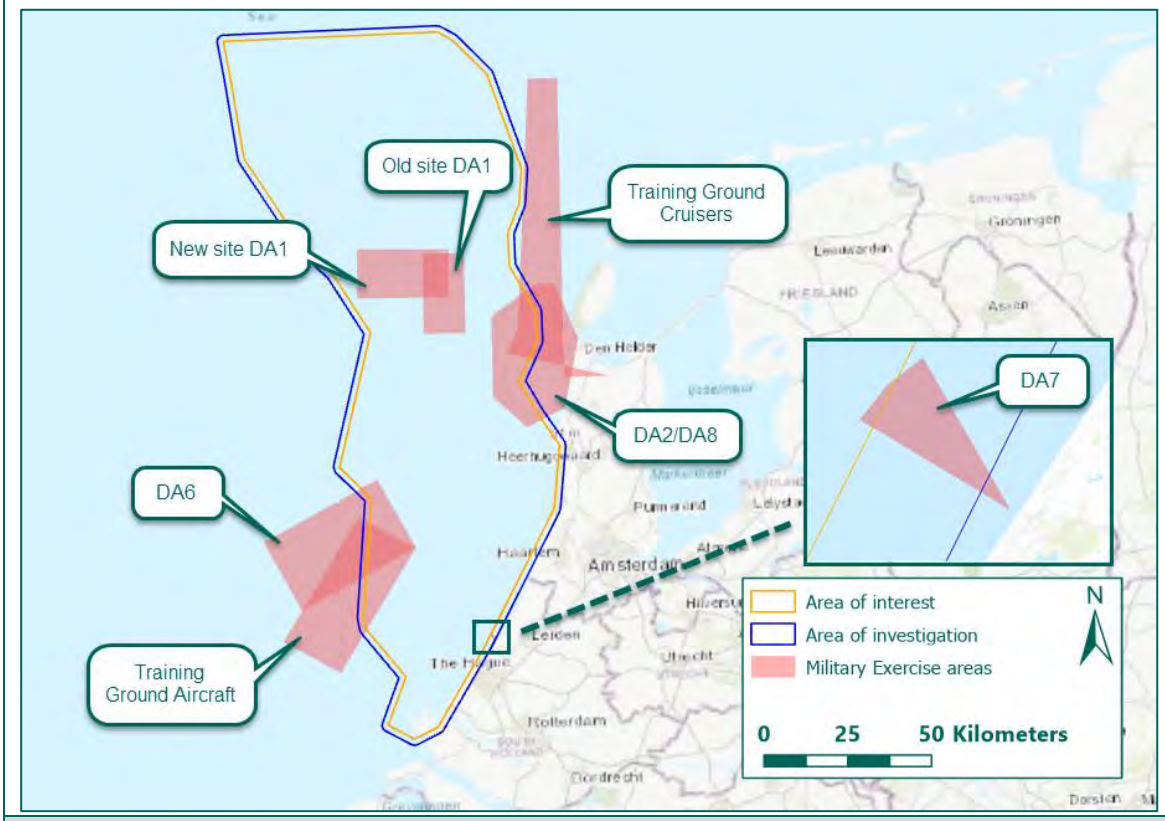
Het gebied, begrensd door een lijn, welke de volgende posities verbindt:
52.58.00 N — 04.44.00 O; 52.47.00 N — 04.40.00 O;
52.44.00 N — 04.30.00 O; 52.49.00 N — 04.21.00 O;
53.02.00 N — 04.21.00 O; 53.07.00 N — 04.33.00 O en
53.07.00 N — 04.38.00 O,
tot een hoogte van 10.000 meter.

DA 6 (Noordzee)

Het gebied, begrensd door een lijn, welke de volgende posities verbindt:
52.26.00 N — 03.20.00 O; 52.36.00 N —03.50.00 O;
52.25.00 N — 04.00.00 O; 52.15.00 N —03.30.00 O,
tot een grootste hoogte van 900 meter.

DA 7 (Wassenaarse slag)

Een sector uit de positie 52.09.48 N — 04.20.45 O, in de richting 300° rechtwijzend door 315° naar 330° rechtwijzend, met een straal van 1,4 zeemijlen, tot een hoogte van 500 meter.



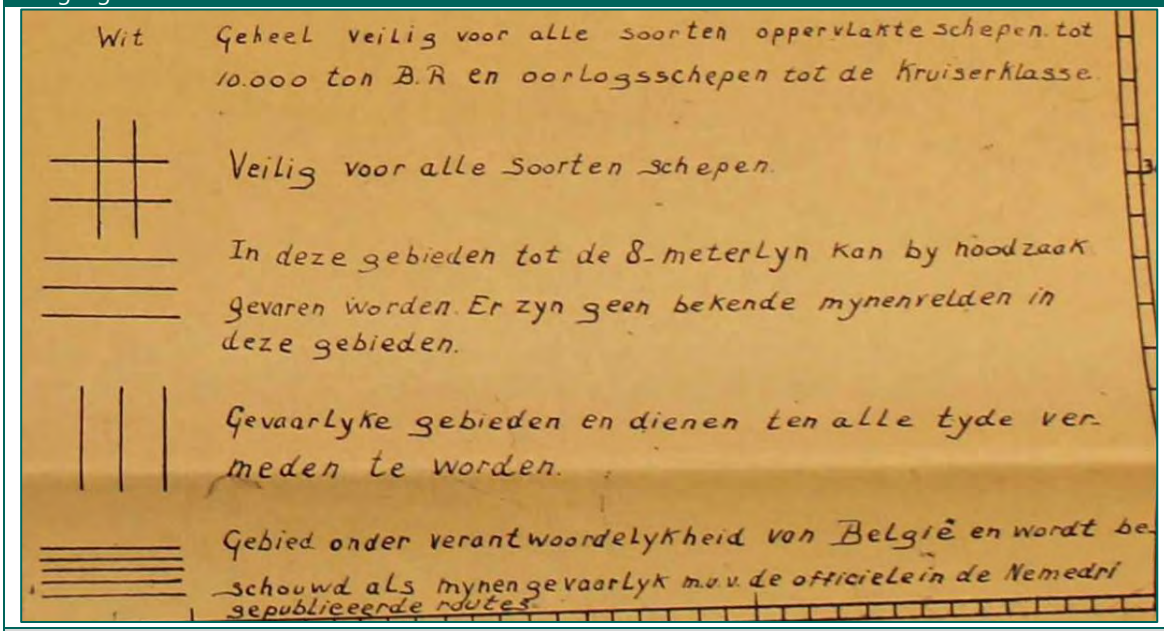
Inventaris 1882	Situatiekaarten van mijnen voor de Nederlandse kust. 1949-1950

Toegang 2.12.56: Marine na 1945





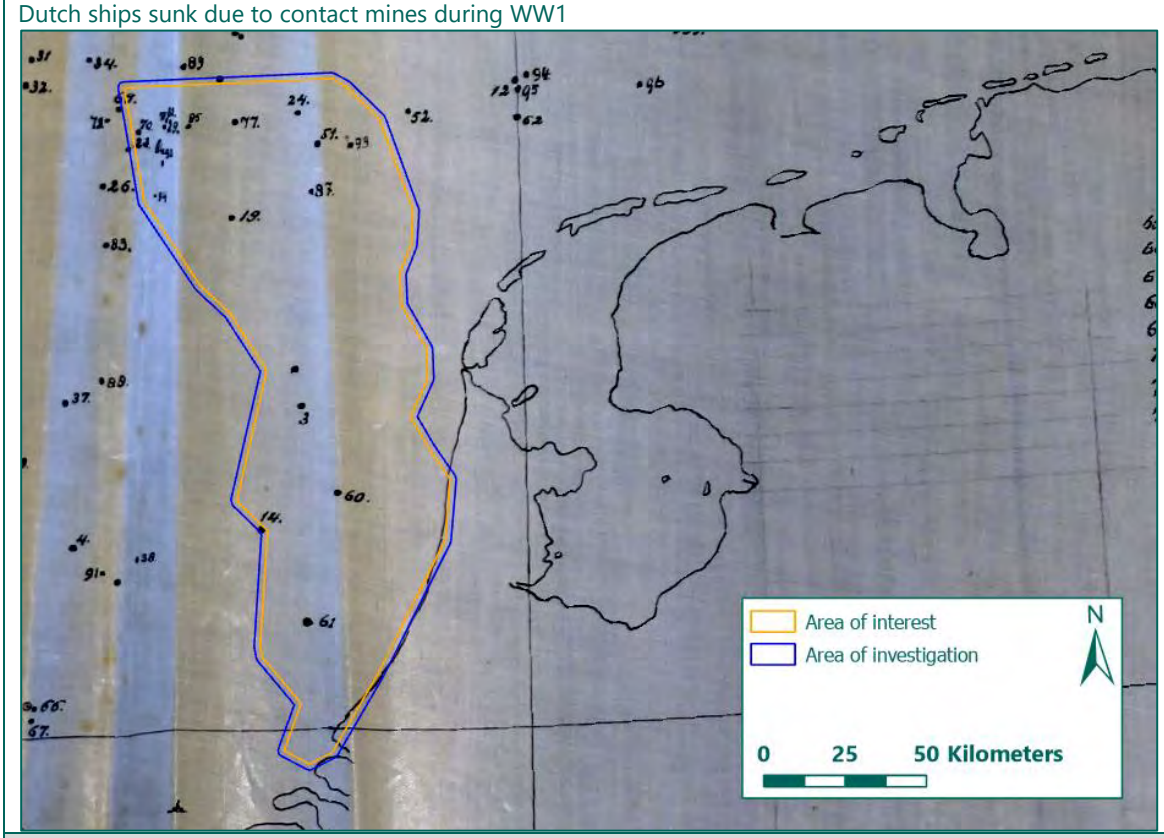
Toegang 2.12.56: Marine na 1945



Toegang 2.05.32.09 BuZa/Zeeoorlogschade

Inventaris 44	Kaart van de Noordzee met opgave van de plaatsen waar verankerde mijnen lagen, waarop Nederlandse schepen zijn gevaren in de jaren 1914-1916, op linnen, zonder datum

Dutch ships sunk due to contact mines during WW1



Nederlands Instituut voor Militaire Historie (NIMH)

The NIMH is a knowledge and research centre in the field of Dutch military history. The institute houses, amongs others, information about Dutch minefields in the North Sea. Some minefields were laid within the area of investigation.

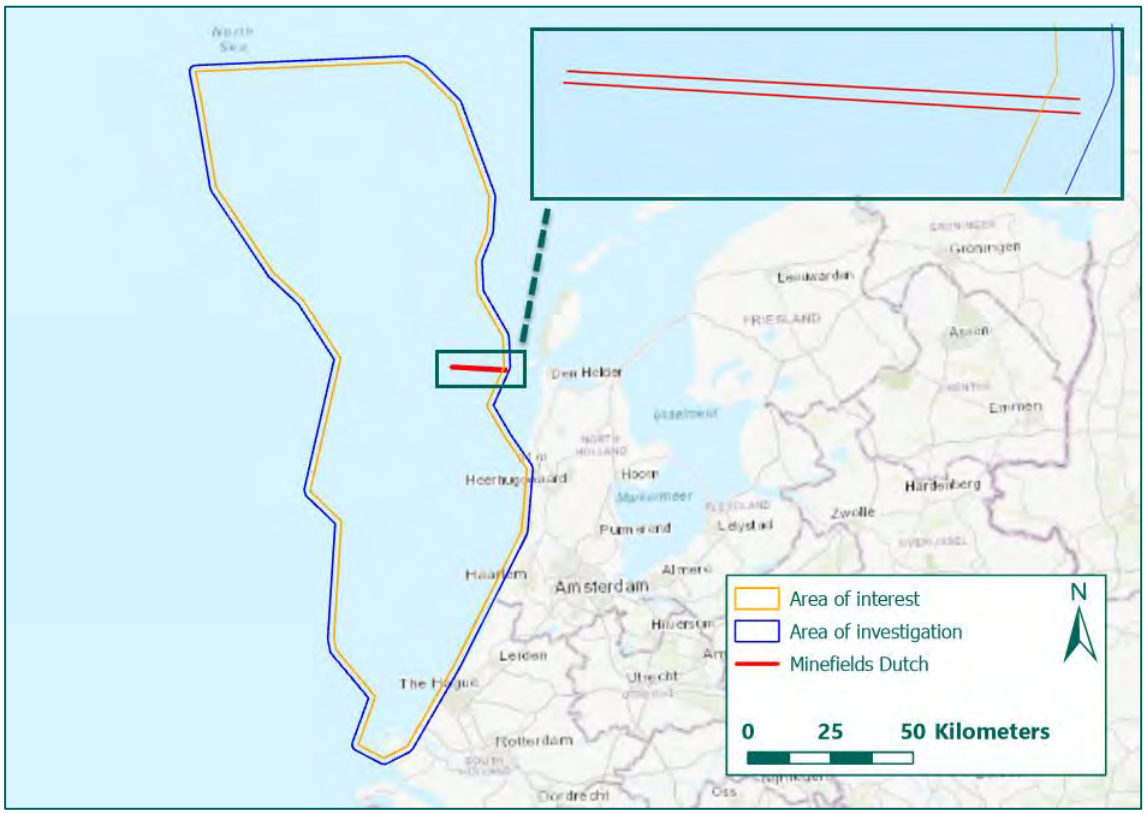
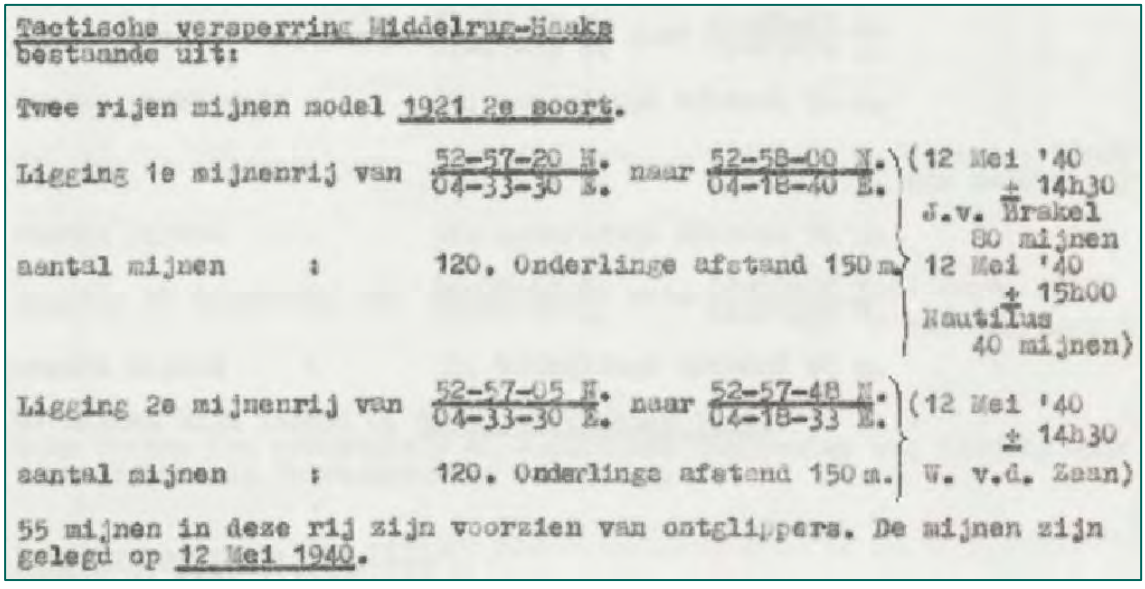


Figure 46: Dutch minefields within the Area of investigation (Source: NIMH 092).



Tactische versperring Middelrug-Haaks
bestaande uit:

Twee rijen mijnen model 1921 2e soort.

Ligging 1e mijnenrij van 52-57-20 N. 04-33-30 E. naar 52-58-00 N. 04-18-40 E. (12 Mei '40 ± 14h30 J.v. Brakel 80 mijnen

aantal mijnen : 120. Onderlinge afstand 150 m. 12 Mei '40 ± 15h00 Nautilus 40 mijnen)

Ligging 2e mijnenrij van 52-57-05 N. 04-33-30 E. naar 52-57-48 N. 04-18-33 E. (12 Mei '40 ± 14h30

aantal mijnen : 120. Onderlinge afstand 150 m. W. v.d. Zaan)

55 mijnen in deze rij zijn voorzien van ontglippers. De mijnen zijn gelegd op 12 Mei 1940.

Figure 47: information about relevant Dutch minefields (Source: NIMH 092).

Marinemuseum (Navy Museum), Den Helder

The map collection of the Marinemuseum (Navy Museum) in Den Helder has been consulted. NEMEDRI-maps were found in this collection. These maps offer information on minesweeping after the Second World War. The NEMEDRI maps show some locations some 'geveegde geulen' (shipping route in which minesweeping took place) within the area

of investigation shortly after the war. The area of investigation is consequently shown in a ubiquitous Danger Area, owing to naval mines.

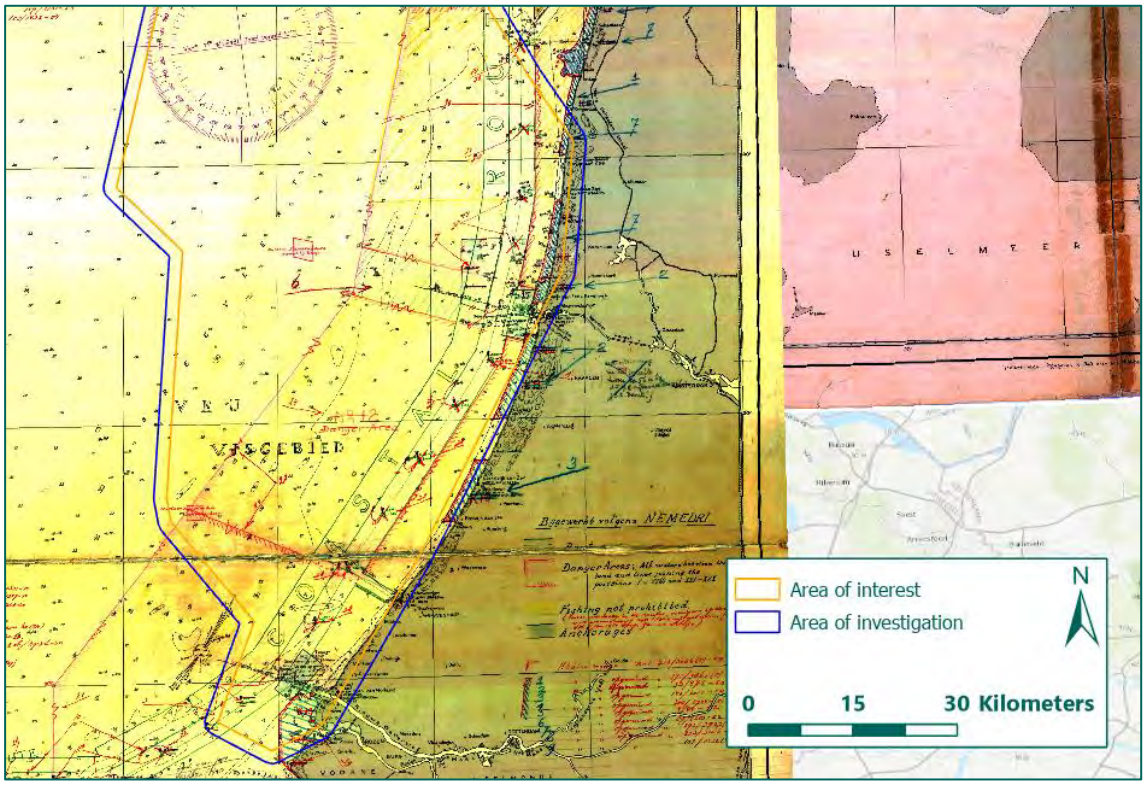


Figure 48: Map offer information on minesweeping after the Second World War (Source: Navy Museum NEMEDRI 227 West-Hinder tot Texel).

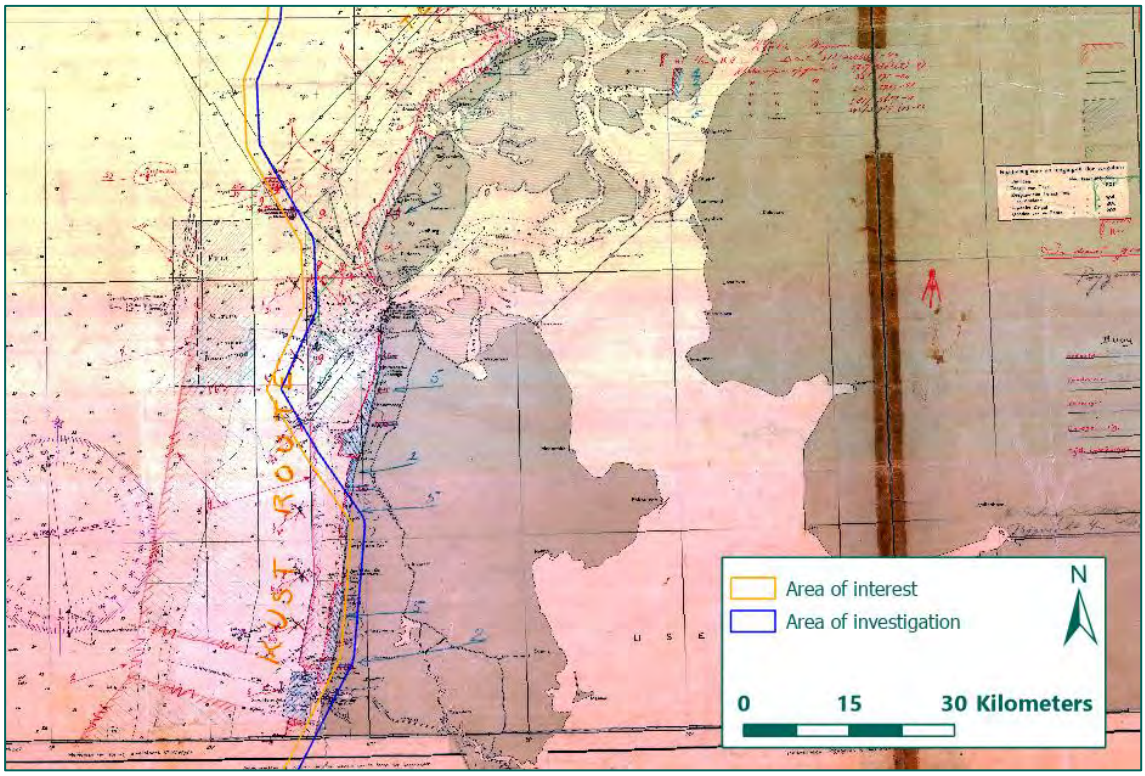


Figure 49: Map offer information on minesweeping after the Second World War (Source: Navy Museum NEMEDRI 226 IJmuiden tot de Weser).

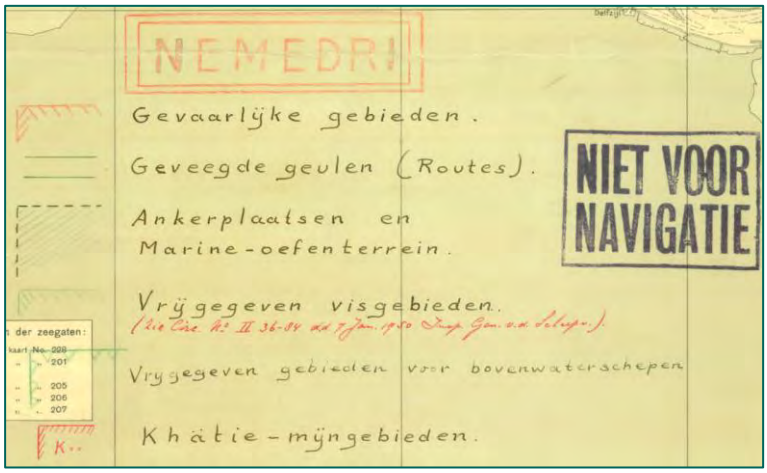


Figure 50: Legend of NEMERDI maps (Source: Navy Museum NEMEDRI 226 IJmuiden tot de Weser).

UK Hydrographic Office (UKHO)

The UK Hydrographic Office has a large amount of historical, maritime maps. This collection also includes maps showing the locations of minefields and shipping routes. These maps have been consulted.

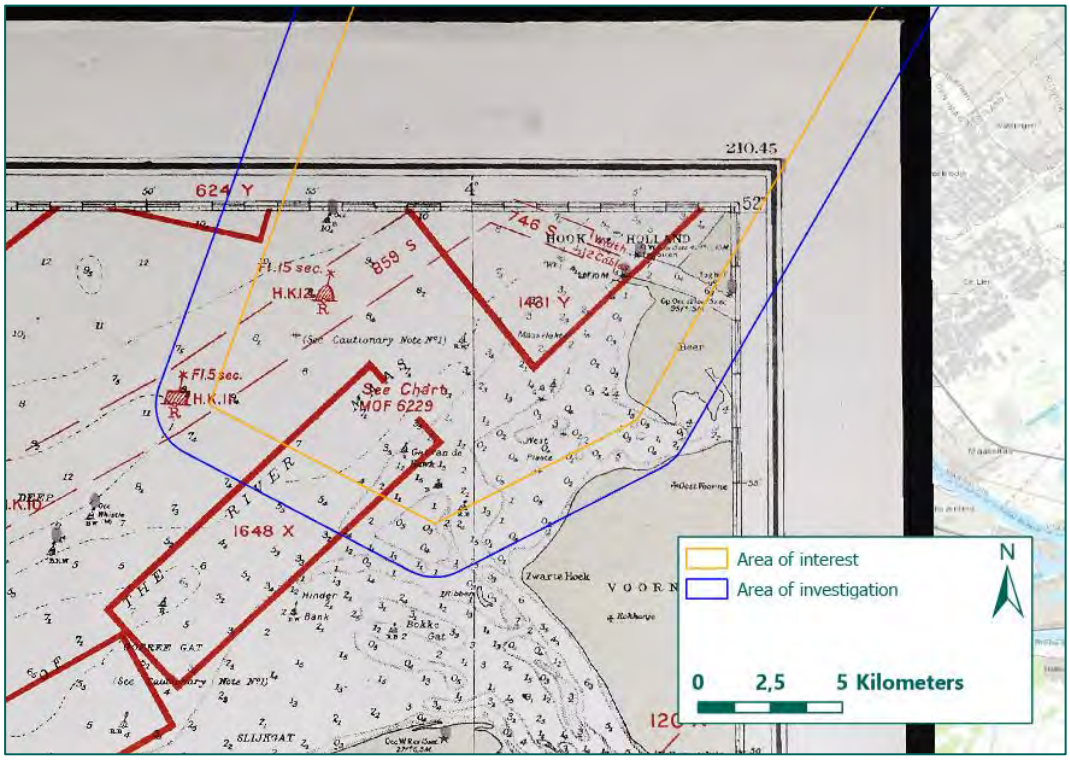


Figure 51: OCB MO F6550 Dunkerque to Hook of Holland, 1945. The red squares indicate minefields (Source: UKHO, Shelf 35).

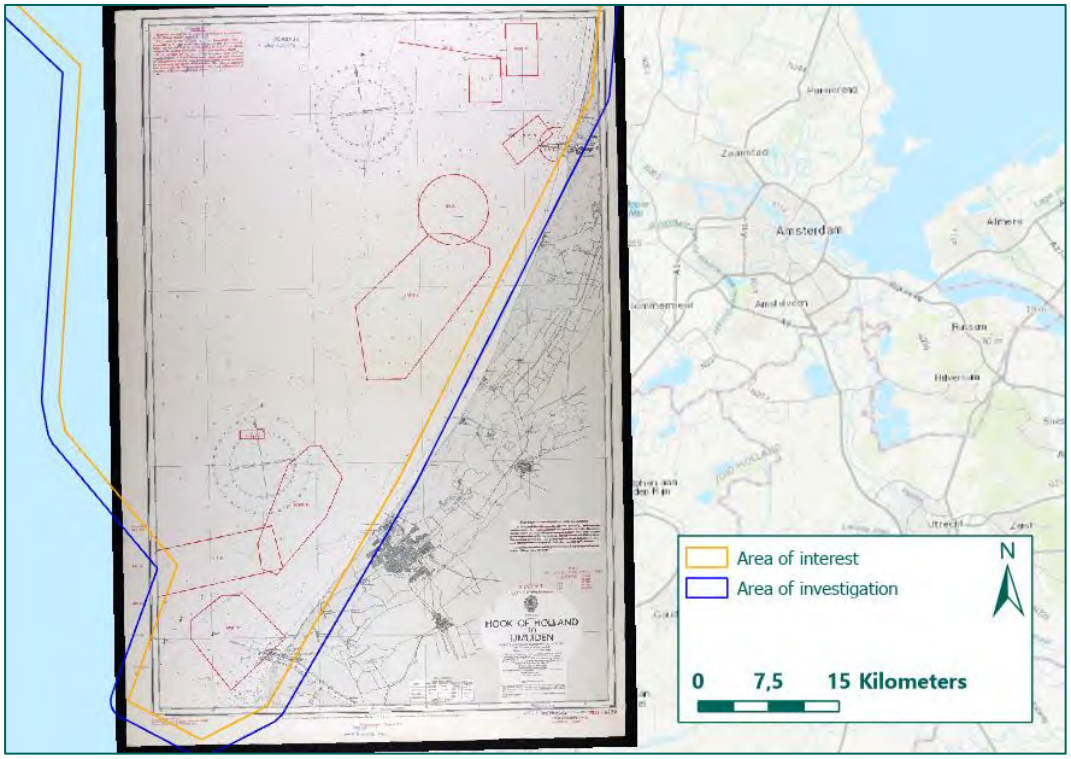


Figure 52: OCB MO F6229 Hook of Holland 1944. The red squares indicate minefields (Source: UKHO, Shelf 35).

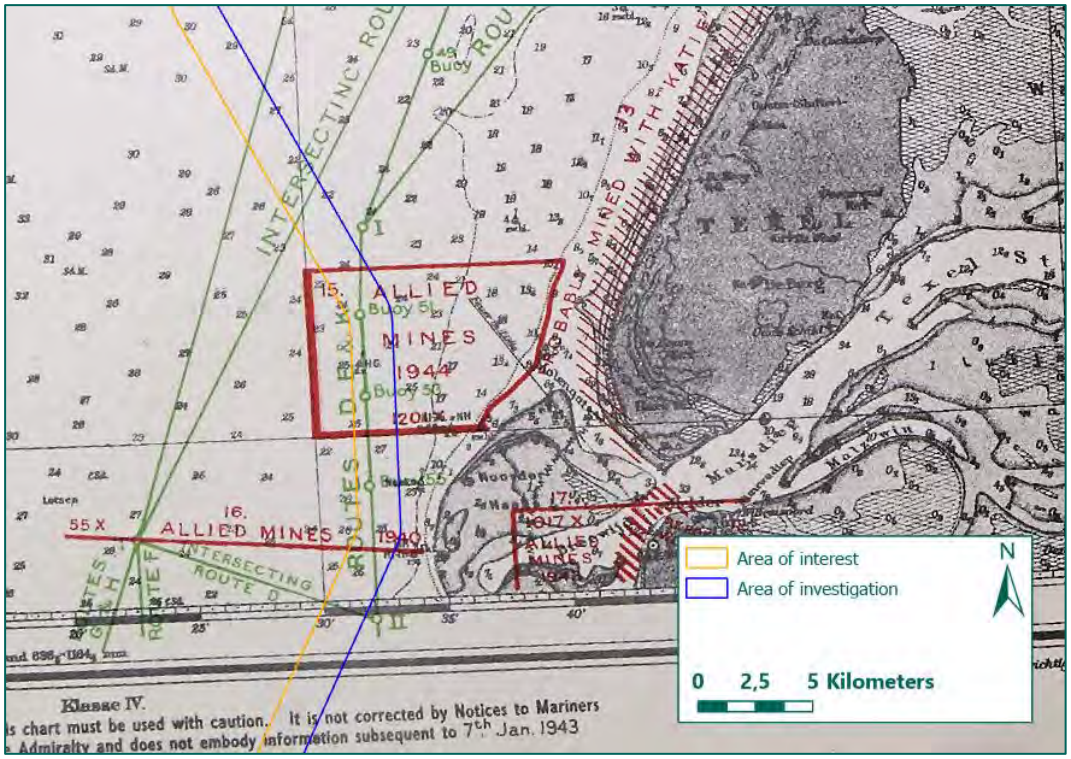


Figure 53: OCB MO 6590 Texel Bis Cuxhaven 1945. The red squares indicate minefields, green lines indicate convoy routes (Source: UKHO, Shelf 35).

Library of Congress

Library of Congress (LOC) has been consulted. Several maps about the First World War have been consulted in the LOC. Relevant maps are shown below.



Figure 54: locations of sunken ships due to submarine attacks between 1 February 1917 – 1 February 1918 (Source basemap: LOC).

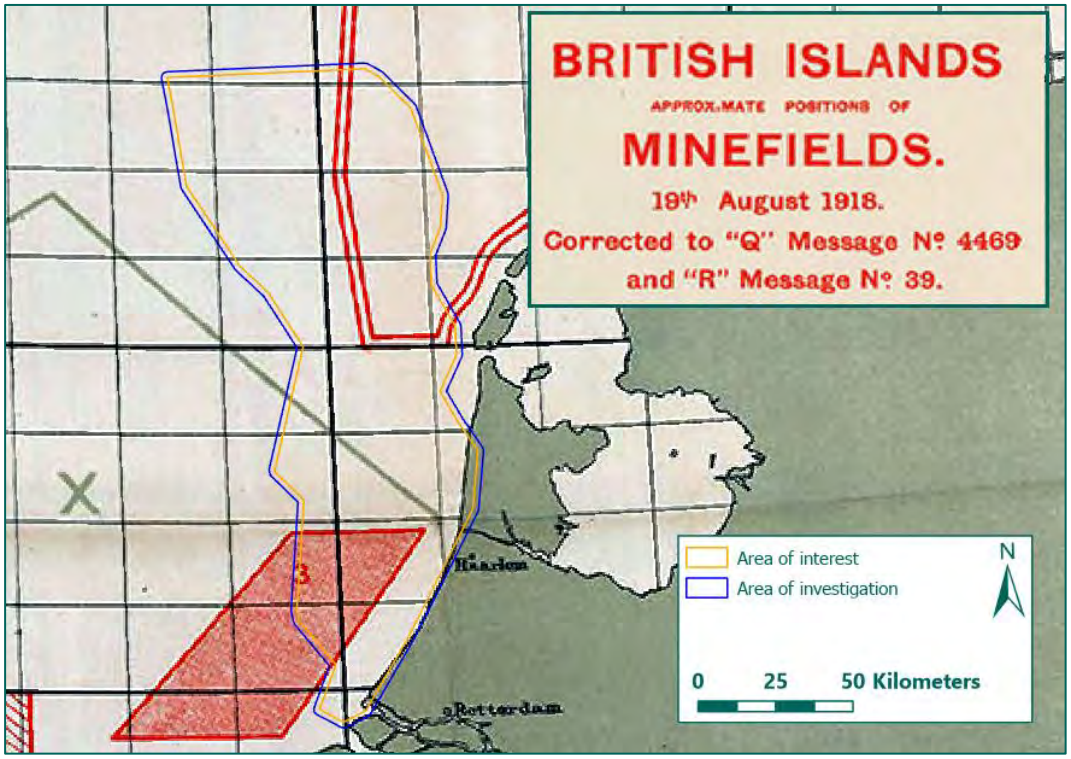


Figure 55: Minefields in the North Sea during 19 August 1918 (Source basemap: LOC).

The National Archives

The National Archives (TNA) have been consulted for more information on maritime and aerial warfare in the area of investigation. This annex contains relevant information from TNA. Information regarding maritime and aerial warfare is mentioned consecutively.

Admiralty series

The admiralty series (ADM) have been consulted for information concerning wrecks, naval combat, minefields and air strikes. Consulting these series yielded several files containing relevant information. These files are shown in the tables below.

Admiralty, and Ministry of Defence, Navy Department: Correspondence and Papers (ADM)	
ADM 1/18996	Results of British minelaying offensive.
General information about total amount of laid/dropped mines, 3rd September 1939 – 5th May 1945:	
MINES LAID IN ENEMY WATERS By Fast Minelayers and Destroyers 11,100 By M.T.Bs, M.Ls and M.G.Bs 6,450 By Submarines 3,000 By Aircraft 53,100 Total 73,650 Mines	
ADM 1/19745	Post-war mine clearance in European waters: first interim report of International Central Board. With charts, 1946-1947.
Relevant information: o Dangerous areas existing in March 1946.	

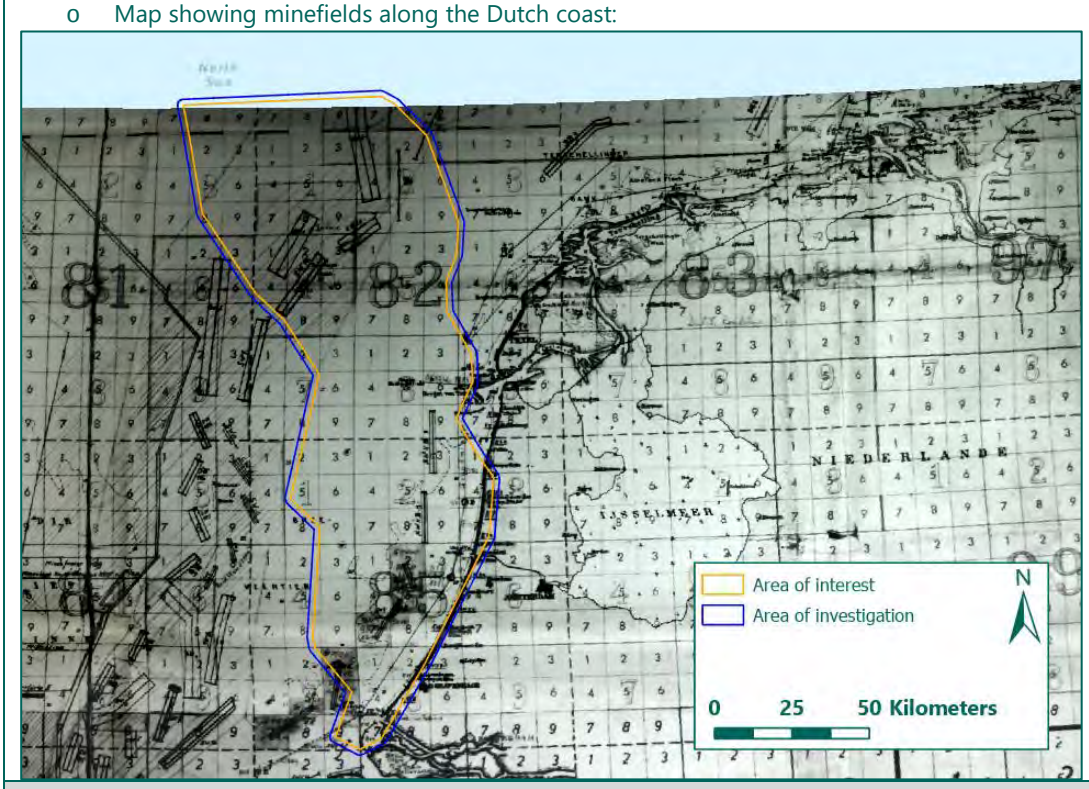
Admiralty, and Ministry of Defence, Navy Department: Correspondence and Papers (ADM)	



ADM 199/154	British mining operations 1939-1945: Vol 1.

Relevant information:

- Map showing minefields along the Dutch coast:

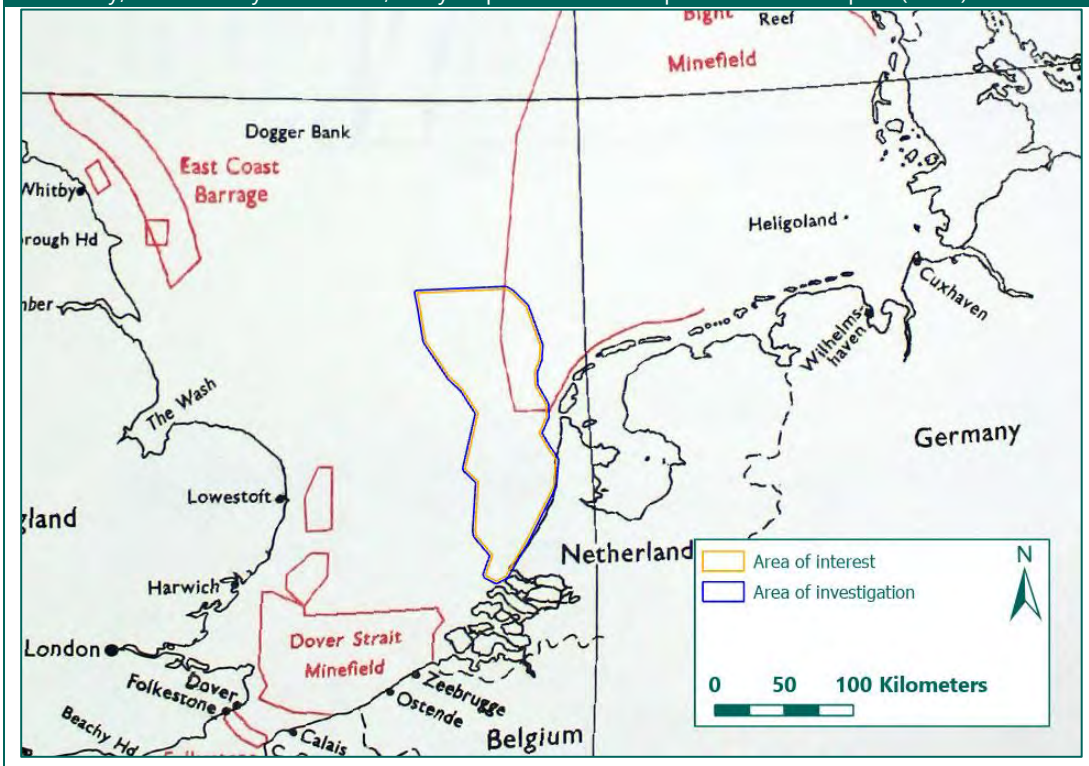


ADM 234/561	British mining operations 1939-1945: Vol 2.

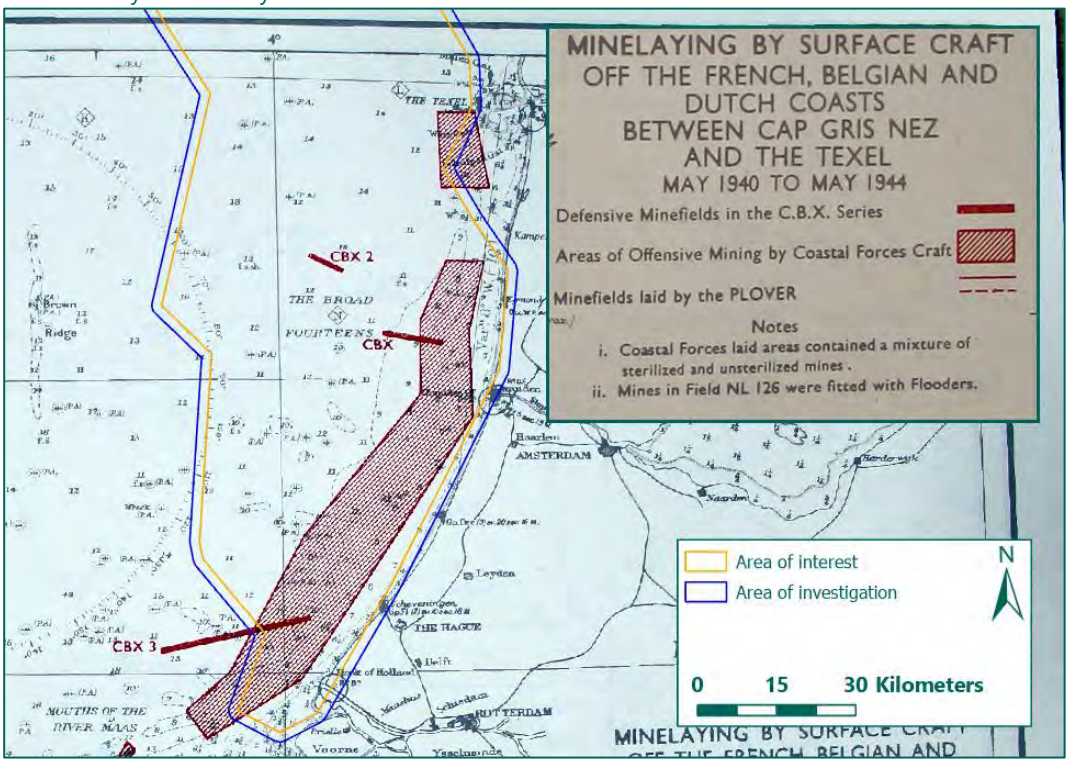
Relevant information:

- Map showing:
  British Minefields laid in the Chanel, North Sea and Kattegat 1914-1918. No minefields within area of interest.

Admiralty, and Ministry of Defence, Navy Department: Correspondence and Papers (ADM)

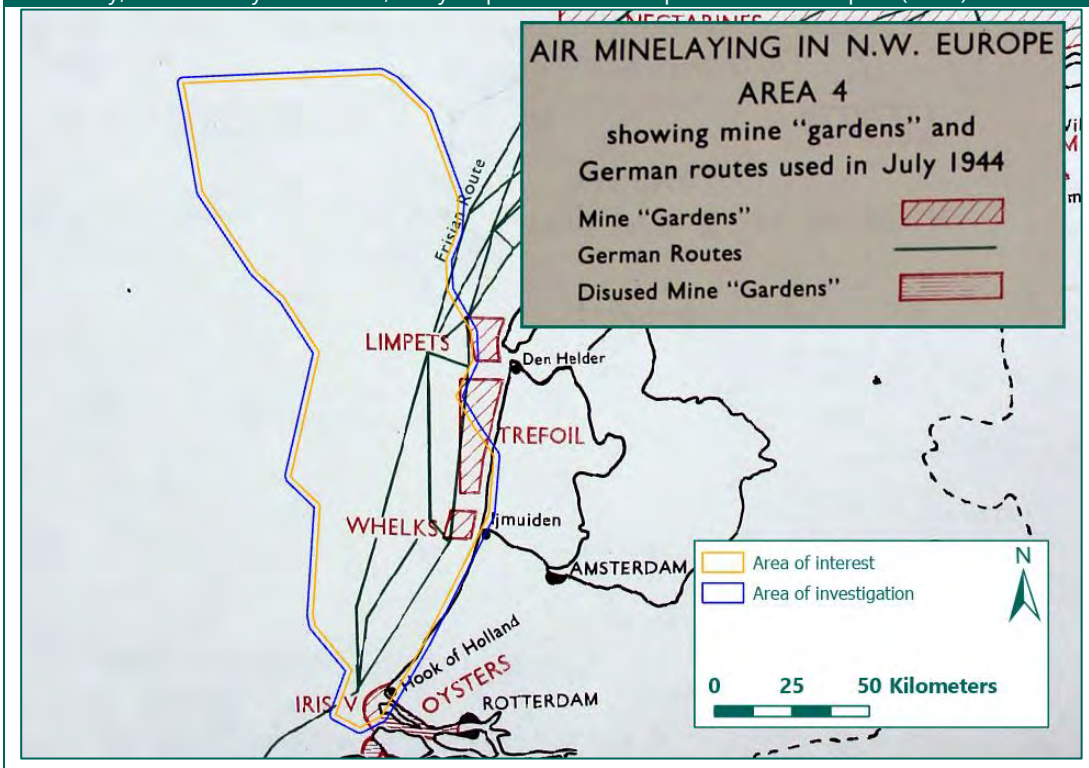


- Map showing:
  Minelaying by surface craft off the French, Belgian and Dutch Coasts between Cap Gris Nez and The Texel, May 1940 – May 1944:



- Map showing:
  Air Minelaying in NW Europe:

Admiralty, and Ministry of Defence, Navy Department: Correspondence and Papers (ADM)



In ADM 234-560 it is stated that mines were laid within the Minefields limpets, Trefoil, Whelks, Iris V and Oyster:

AREA 4

ANALYSIS OF OPERATIONS

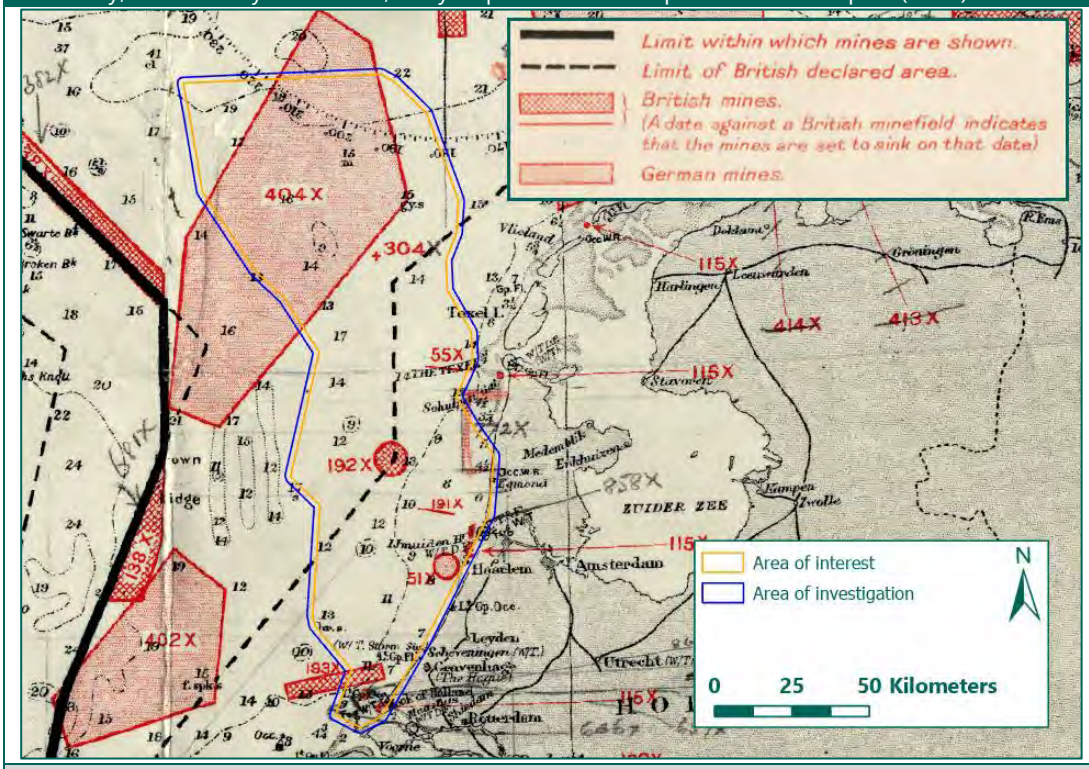
		DANISH COAST Hawthorn Rosemary	ELBE & WESER Eglantine Yams	GERMAN COAST & FRISIAN Is. Xeranthemum Zinnia Mussels Nectarine	DUTCH WEST COAST Limpets Whelks Trefoil	HOOK OF HOLLAND Oysters Iris V	SCHELDT Newts Juniper Iris II Flounders	ALL AREAS
1940	Mines	-	139	127	45	60	70	441
	Casualties	-	8	10	10	7	5	40
	Ratio	-	1:17	1:13	1:4.5	1:8.5	1:14	1:11
1941	Mines	37	116	268	-	2	-	423
	Casualties	1	11	18	4	2	-	36
	Ratio	1:37	1:10.5	1:15	∞	1:1	-	1:11.7
1942	Mines	698	133	3,921	170	-	-	4,922
	Casualties	18	10	67	4	-	-	99
	Ratio	1:39	1:13	1:58	1:42	-	-	1:49.5
1943	Mines	156	63	6,288	372	-	-	6,879
	Casualties	12	4	32	-	-	-	48
	Ratio	1:13	1:16	1:197	∞	-	-	1:143
1944	Mines	1,800	150	1,468	491	88	252	4,249
	Casualties	53	11	19	8	5	8	104
	Ratio	1:34	1:13.6	1:77	1:61	1:18	1:31	1:41
1945	Mines	296	361	-	-	-	-	657
	Casualties	1	14	-	2	-	-	17
	Ratio	1:296	1:26	-	∞	-	-	1:39
OVERALL	Mines	2,987	962	12,072	1,078	150	322	17,571
	Casualties	85	58	146	28	14	13	344
	Ratio	1:35	1:16.6	1:83	1:38.5	1:10.7	1:25	1:51

ADM 239/304	North Sea: chart 736 showing position of British and German minefields.

Relevant information:

- British map showing German and British minefields. There are two German minefields within the area of interest:

Admiralty, and Ministry of Defence, Navy Department: Correspondence and Papers (ADM)

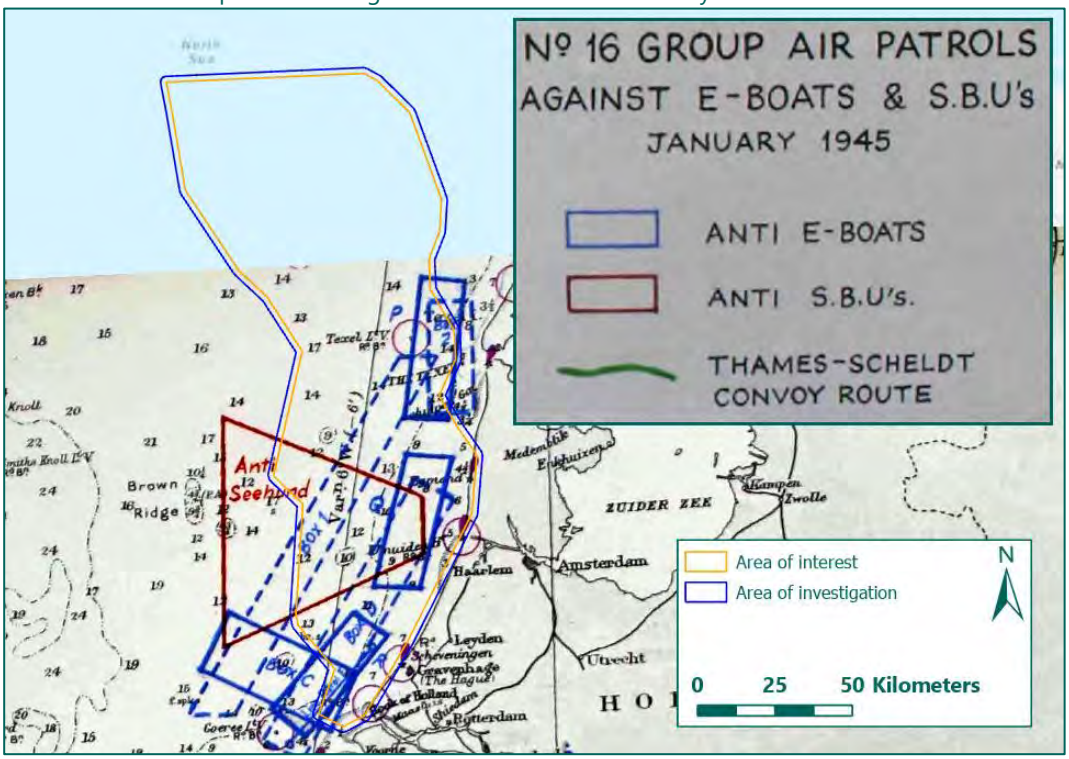


Cabinet and its committees (CAB)

Cabinet and its committees (CAB)	
CAB 101/324	Air Offensive Against Enemy Shipping and Bomber Command Minelaying Operations, 1 September 1944 - 5 May 1945

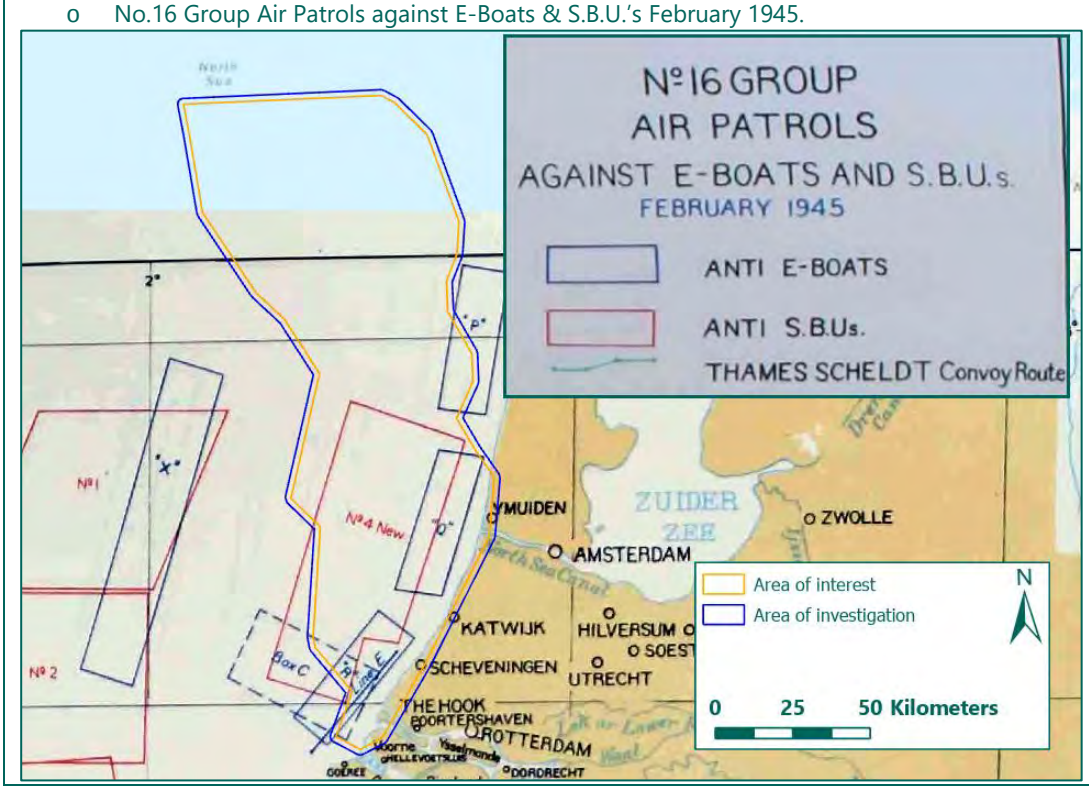
Relevant information:

- No.16 Group Air Patrols against E-Boats & S.B.U.'s January 1945.



Relevant information:

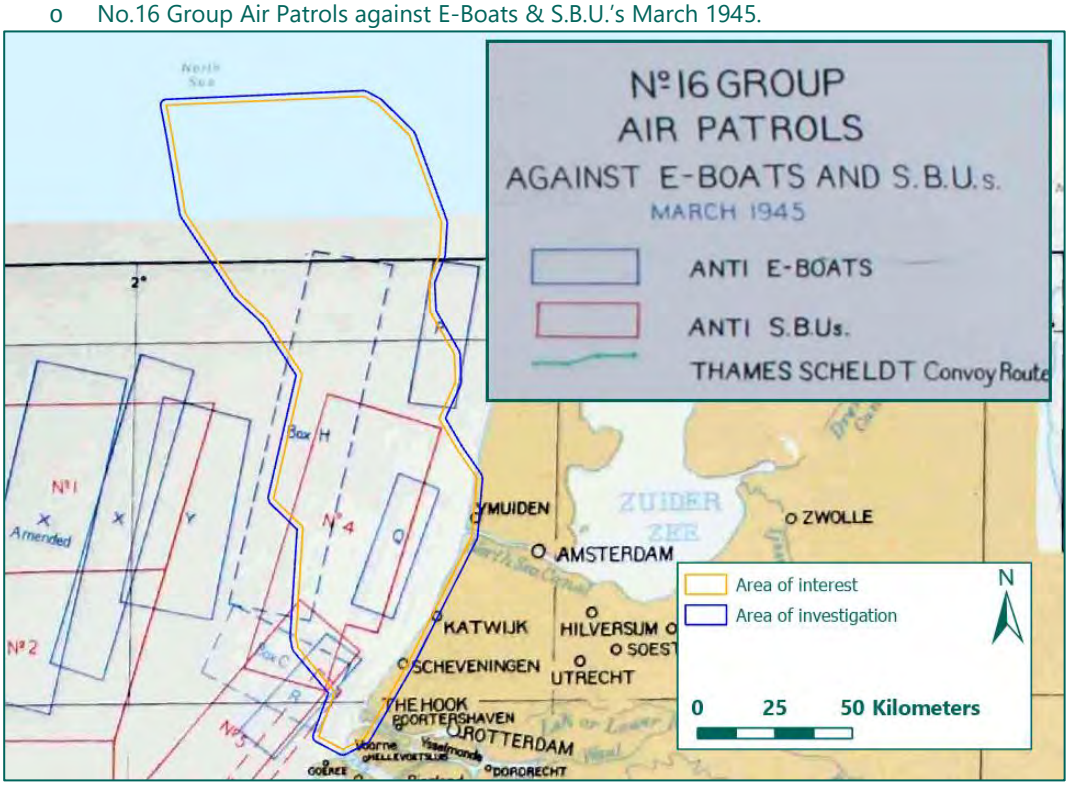
- No.16 Group Air Patrols against E-Boats & S.B.U.'s February 1945.



Cabinet and its committees (CAB)

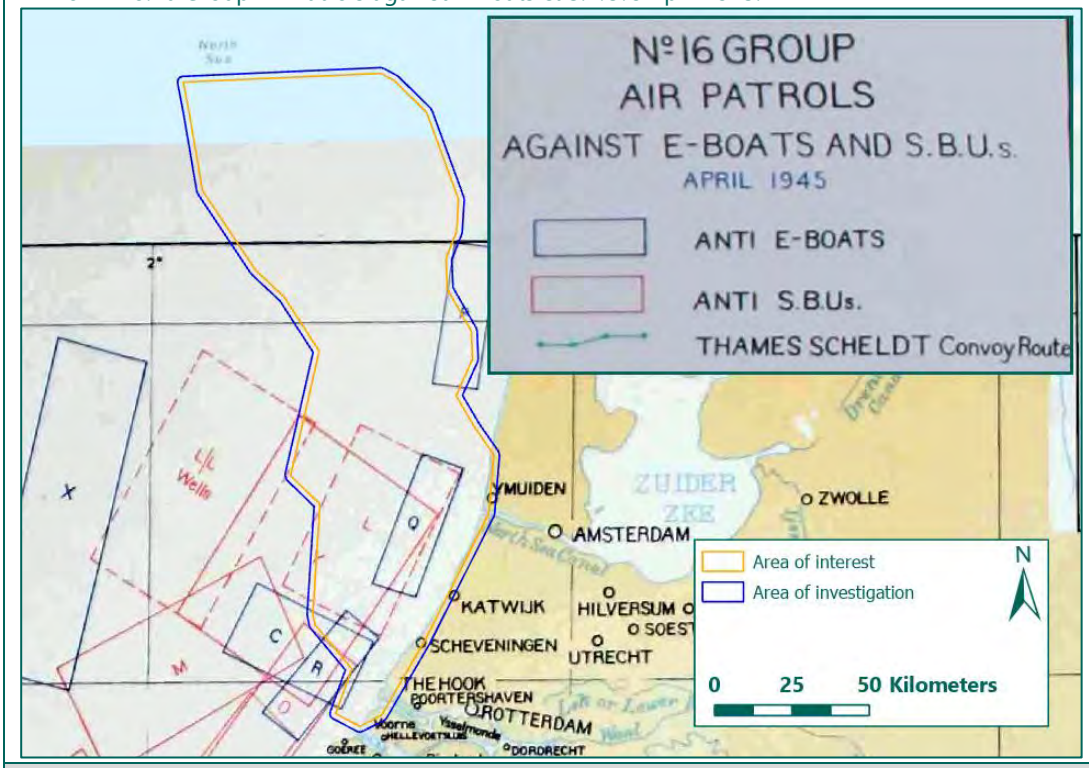
Relevant information:

- No.16 Group Air Patrols against E-Boats & S.B.U.'s March 1945.



Relevant information:

- No.16 Group Air Patrols against E-Boats & S.B.U.'s April 1945.



Air Ministry series

The Air Ministry series (AIR) contain information on aerial warfare during the Second World War. The Operations Record Books (ORBs) of units that operated in or near the area of investigation have been consulted:

- Headquarters Coastal Command, 1940-1945 (AIR 24/372 t/m AIR 24/427)
- 16 Group Coastal Command, 1940-1945 (AIR 25/313 t/m AIR 25/374)
- Headquarters Bomber Command, 1940-1945 (AIR 24/217 t/m AIR 24/319)
- Intelligence on USAAF missions (AIR 40)

16 Group Coastal Command patrolled the North Sea, attacking German shipping and conducting rescue operations. ORBs from this unit contain locations of air strikes, jettisoning, aircraft wreckages and Anti-Aircraft Artillery (AAA). Until halfway through 1942 the locations were noted in Coastal Command cypher which has only partially been decrypted by REAseuro. From 1942 onwards the ORBs mention locations in coordinates, based on decimal degrees. One must take into account that Coastal Command operated during the night as well, severely hampering navigational accuracy. When possible, war related events mentioned in the Coastal Command records have been coupled with records from the German point of view, resulting in more accurate positioning based on multiple sources.

Bomber Command, Coastal Command's famous land-based counterpart, was also active against German shipping during the first years of the war. Besides intentional bombing, Bomber Command aircraft also jettisoned bombs when in trouble. The jettisoning preferably took place over sea, since this dramatically reduced the chance of collateral damage.

In the figure below the attacks, jettisons, crashes and relevant observations from Bomber Command and Coastal Command are shown. Each feature refers to a passage of a primary source.

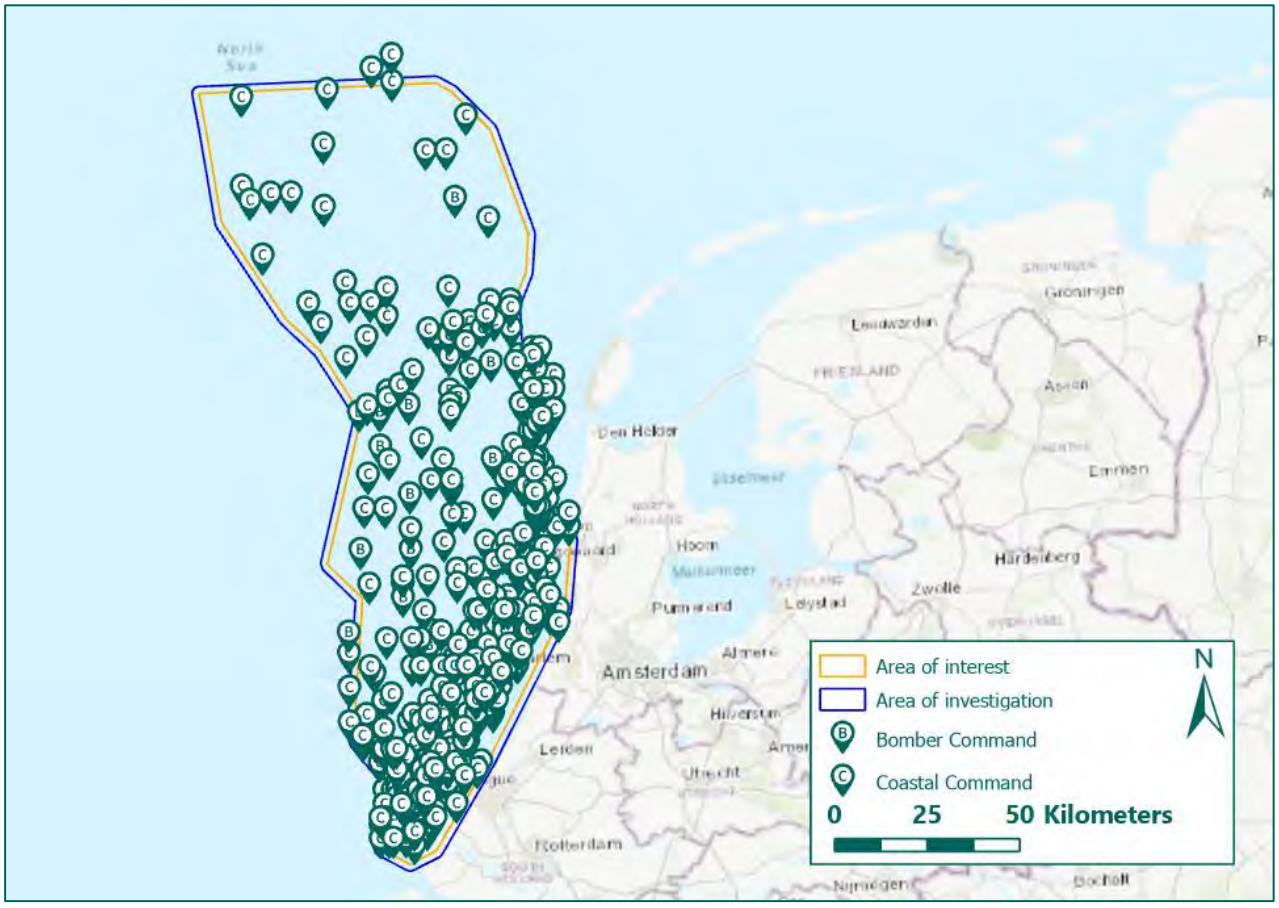


Figure 56: Locations of attacks, jettisons, crashes and relevant observations from Bomber Command and Coastal Command (Source basemap: ESRI).

The North Sea theatre of war saw also action of fighter planes of Fighter Command and 2nd Tactical Air Force (2TAF). Fighter Command patrolled the sea in order to intercept German planes heading for Britain and escorted bombers. From 1944 onward Fighter Command was involved in the war against the German V1 and V2 weapons. 2TAF mainly supported the ground forces by carrying out attacks on tactical ground targets, but also enemy shipping near the shores was attacked. No locations have been found of Fighter Command's and 2TAF's attacks within the area of interest.

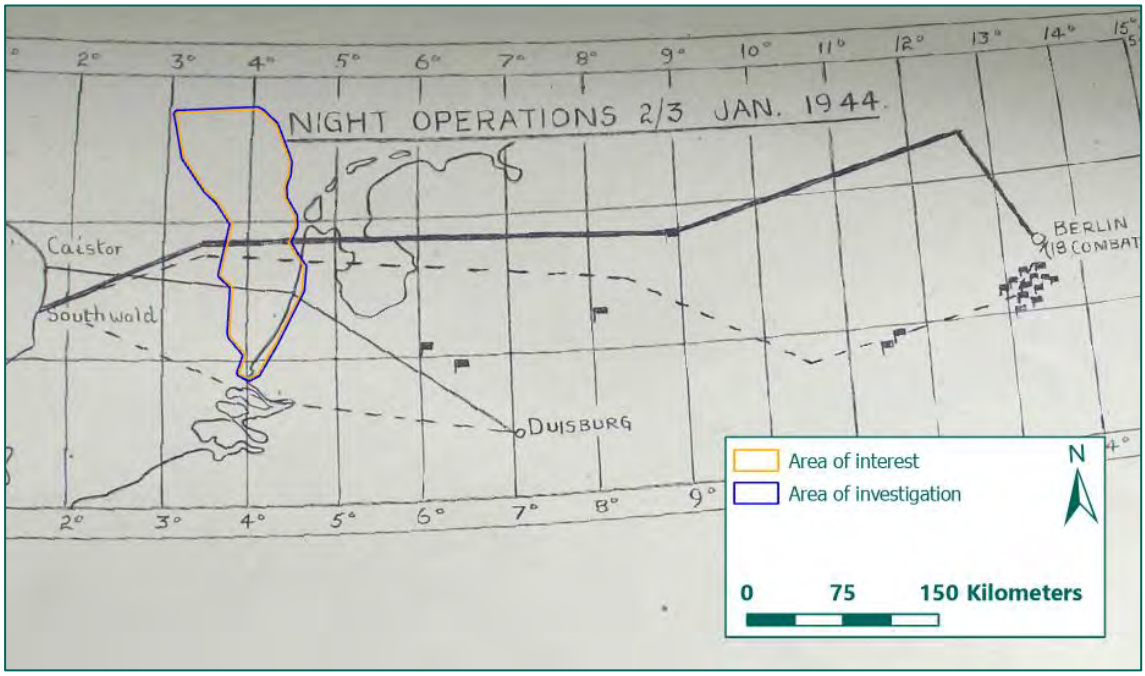


Figure 57: Example of a flight path over the area of investigation of bombers from Bomber Command, 2/3 January 1944 (Source, TNA, AIR 24/264).

Remark on jettisoning and flight paths

Related to the air war are jettisoning of bombs and the numerous flight paths of incoming and outgoing bombers above the North Sea. During bombing raids, allied bombers followed certain routes towards their target and backwards to base. In case of emergency or to avoid landing with the bomb load, the bombs were often released above the North Sea. The figure underneath is a document from The National Archives (AIR 14/110 Disposal of bombs not dropped on allotted targets) that describes what to with the remaining bomb load. It is stated that a captain could decide where ever the bombs are dropped, as long as they are dropped in safe condition. Despite this document, the logs of Coastal and Bomber Command prove that bombs were also jettisoned in live condition.

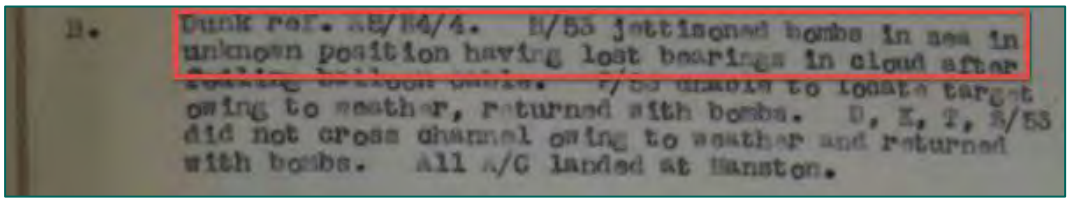


Figure 1: Blenheim Bomber jettisoned its bombs at an unknown position in the Northsea (Bron: TNA, AIR 24/375).

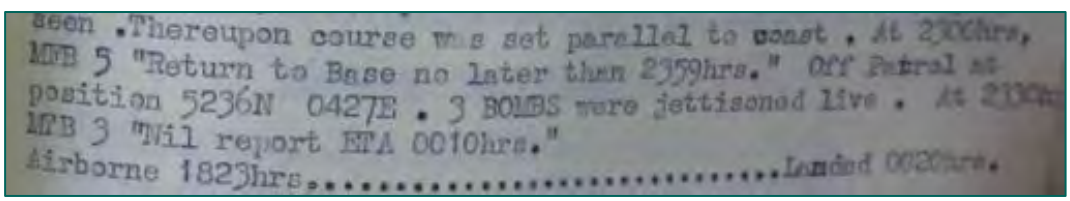


Figure 58: Example of a live jettison within the area of investigation, night 12/13 October 1944. (Source: TNA, AIR 25/367).

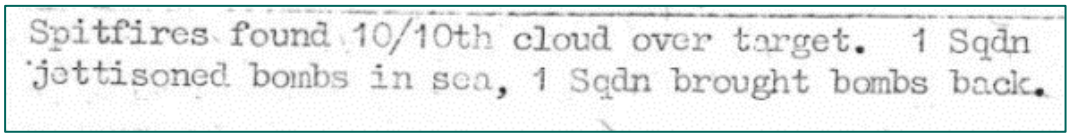

Spitfires found 10/10th cloud over target. 1 Sqdn jettisoned bombs in sea, 1 Sqdn brought bombs back.

Figure 2: A Squadron of Spitfires jettison their bombs in sea after being unable to locate the assigned target (Bron: TNA, AIR 37/713).

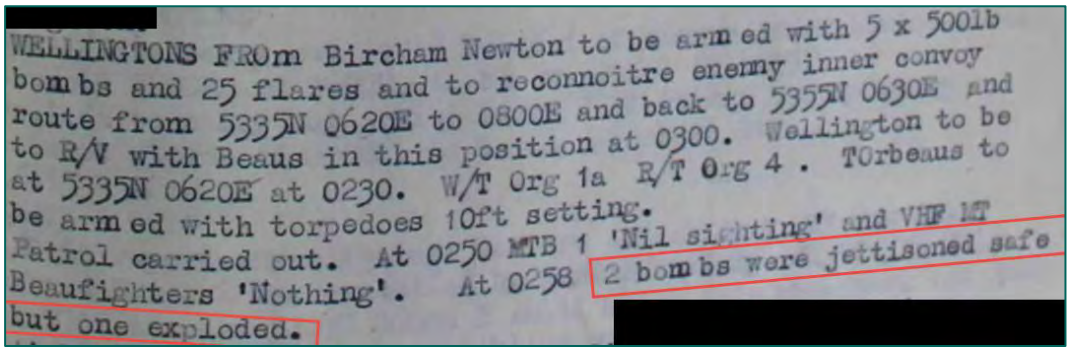
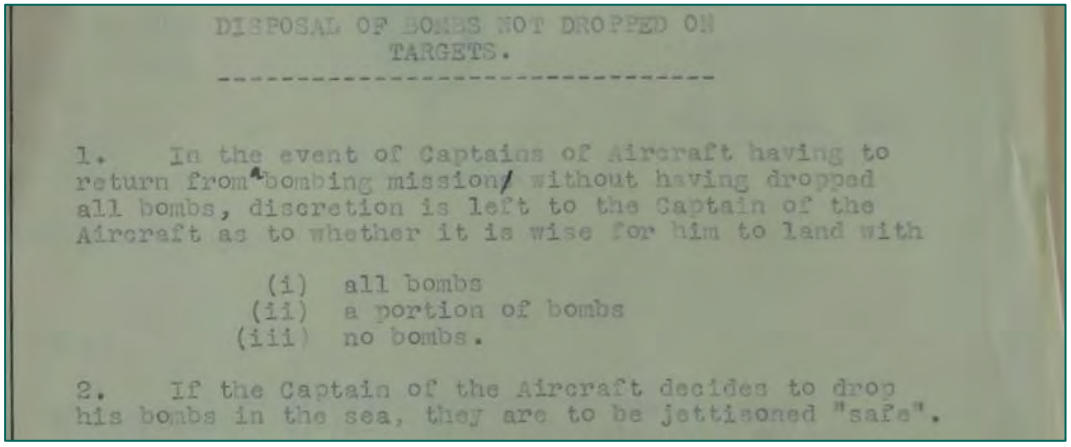

WELLINGTONS FROm Bircham Newton to be armed with 5 x 500lb bombs and 25 flares and to reconnoitre enemy inner convoy route from 5335N 0620E to 0800E and back to 5355N 0630E and to R/V with Beaus in this position at 0300. Wellington to be at 5335N 0620E at 0230. W/T Org 1a R/T Org 4. TOrbeaus to be armed with torpedoes 10ft setting.
Patrol carried out. At 0250 MTB 1 'Nil sighting' and VHF RT
Beaufighters 'Nothing'. At 0258 2 bombs were jettisoned safe but one exploded.

Figure 3: Wellington bombers jettisoned two bombs at an undisclosed location at sea. Although the bombs are jettisoned "safe", one exploded (Bron: TNA, AIR25/363).


DISPOSAL OF BOMBS NOT DROPPED ON TARGETS.

1. In the event of Captains of Aircraft having to return from bombing mission/ without having dropped all bombs, discretion is left to the Captain of the Aircraft as to whether it is wise for him to land with

(i) all bombs
(ii) a portion of bombs
(iii) no bombs.

2. If the Captain of the Aircraft decides to drop his bombs in the sea, they are to be jettisoned "safe".

Figure 4: Extract from AIR 14/110 (Disposal of bombs not dropped on allotted targets) (Source: TNA).

Coastal guns

Coastal guns were traditionally used in strongpoints that had to defend harbours from enemy ships. Shortly before the beginning of World War II, more modern batteries were installed on the Dutch Coast. After the German Occupation the amount of Coastal Guns grew in order to strengthen the *Atlantikwall*. It is known that Coastal guns were active in the area of investigation. In the TNA a photograph showing an explosion of a shell from land battery was consulted. The photograph was dated 4 May 1942 and located at 52 36N, 04 22E (within the area of investigation).



Figure 59: Strike photo showing the impact of a shell, fired by a German coastal battery. 4 May 1942. (Source: TNA, AIR 28/595).

National Archives and Records Administration (NARA)

The following Record Groups have been consulted in the NARA:

- Record Group 18: Mission Reports.
  The mission reports contain detailed information on allied bombing raids, including height, air speed and the deployed munitions.
- Record Group 342: Records of U.S. Air Force Commands, Activities, and Organizations
  Record Group 342 contains additional details not mentioned in Record Group 18.

These Record Groups show several attacks by the USAAF on targets along the Dutch Coast. It is known that these aircraft operated above the area of investigation. No specific targets within the area of investigation were mentioned. It is possible that due to technical or navigational failures war related events took place within the area in investigation. In the figure below an example of a flight path over the area of investigation is shown.

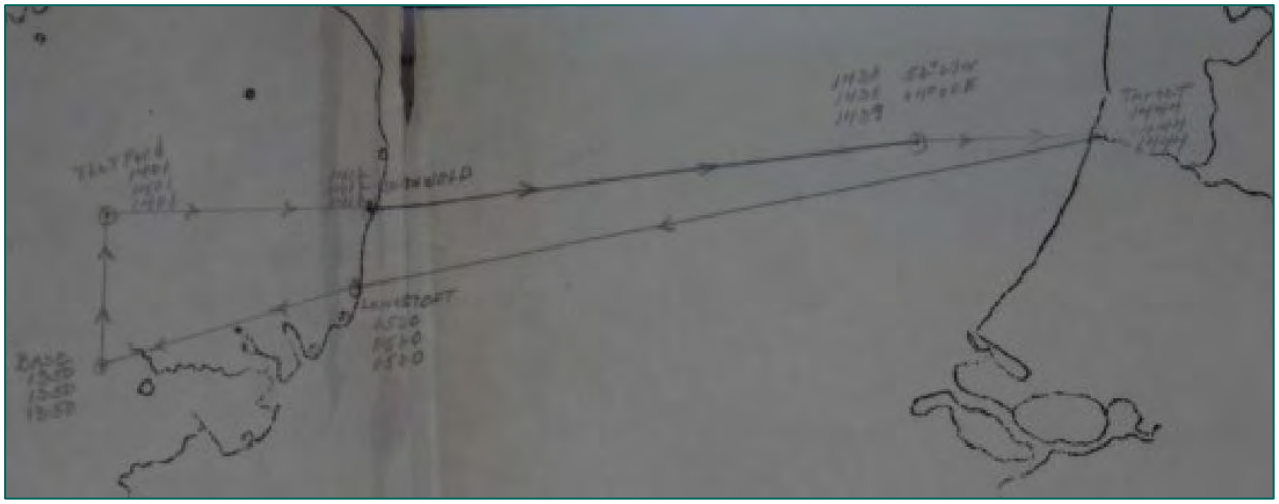


Figure 60: The flightpath of aircraft of USAAF on 26 March 1944 (Source: NARA Box RG18, Box 1388).

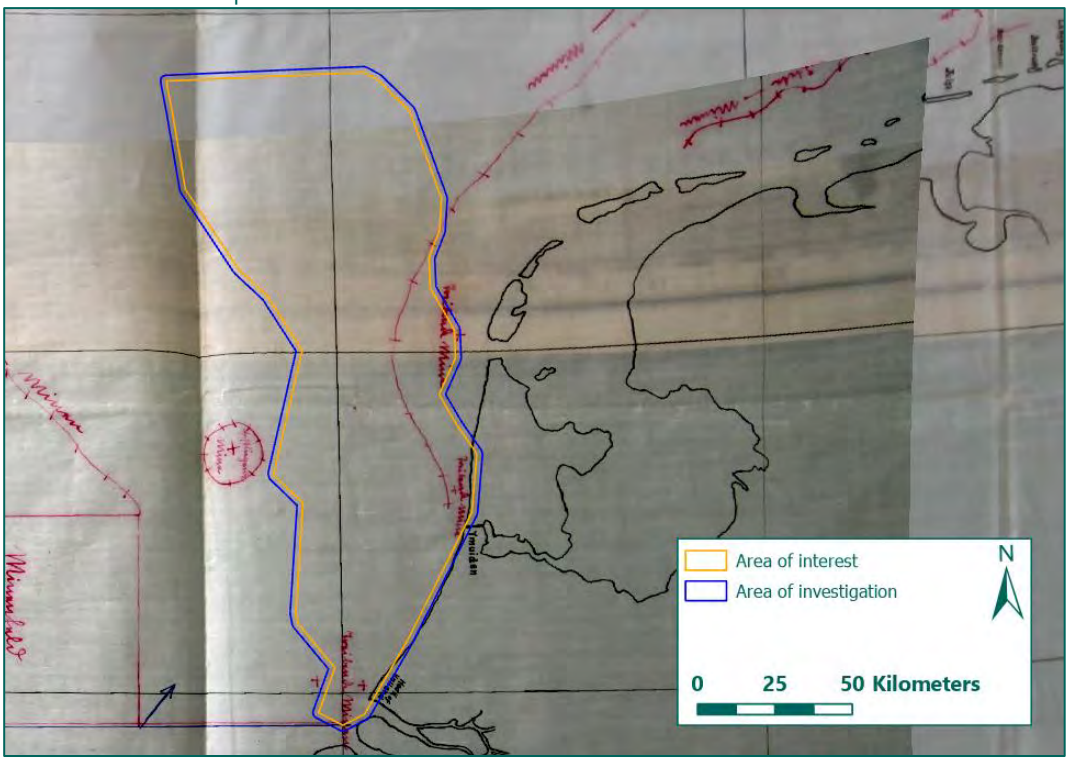
No further files have been consulted with regards of the area of investigation. Consulting these sources is outside the scope of this research.

Bundesarchiv-Militärarchiv (BAMA)

The German military archives have been consulted in the BAMA in Freiburg. This archive contains the documents from the German military in the Second World War. The following record groups have been consulted by REASeuro to gain more information about the German perspective of naval warfare in the area of investigation:

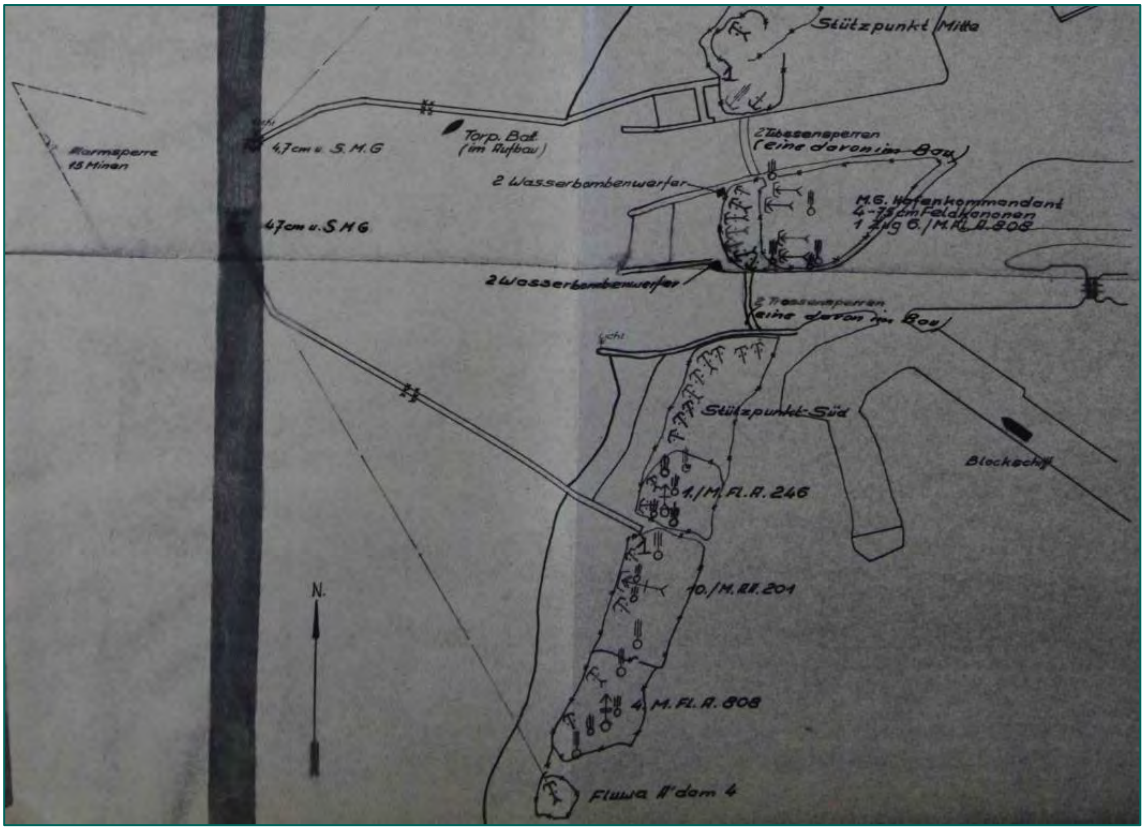
- RM 5: Admiralstab der Marine / Seekriegsleitung der Kaiserlichen Marine.
- ZA 5: Deutscher Minenräumdienst (German Minesweeping Administration).

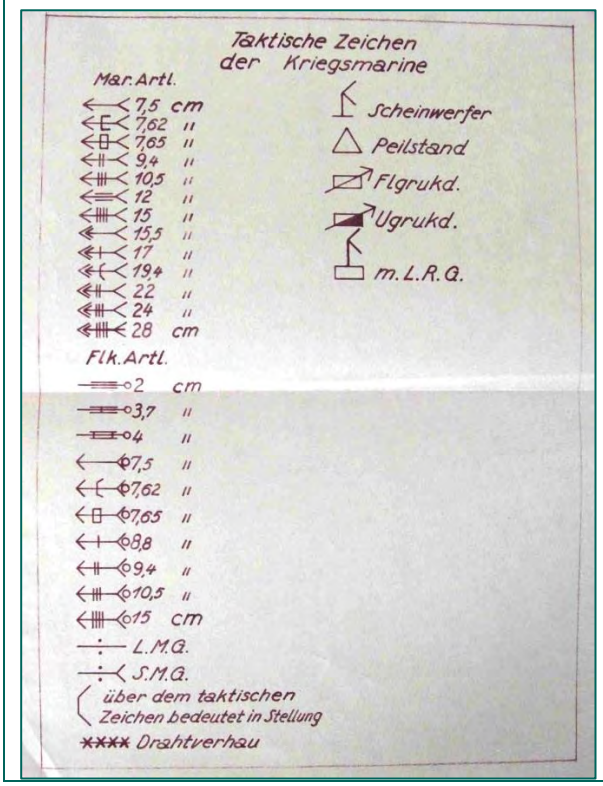
The following documents have been found relevant for the area of investigation:

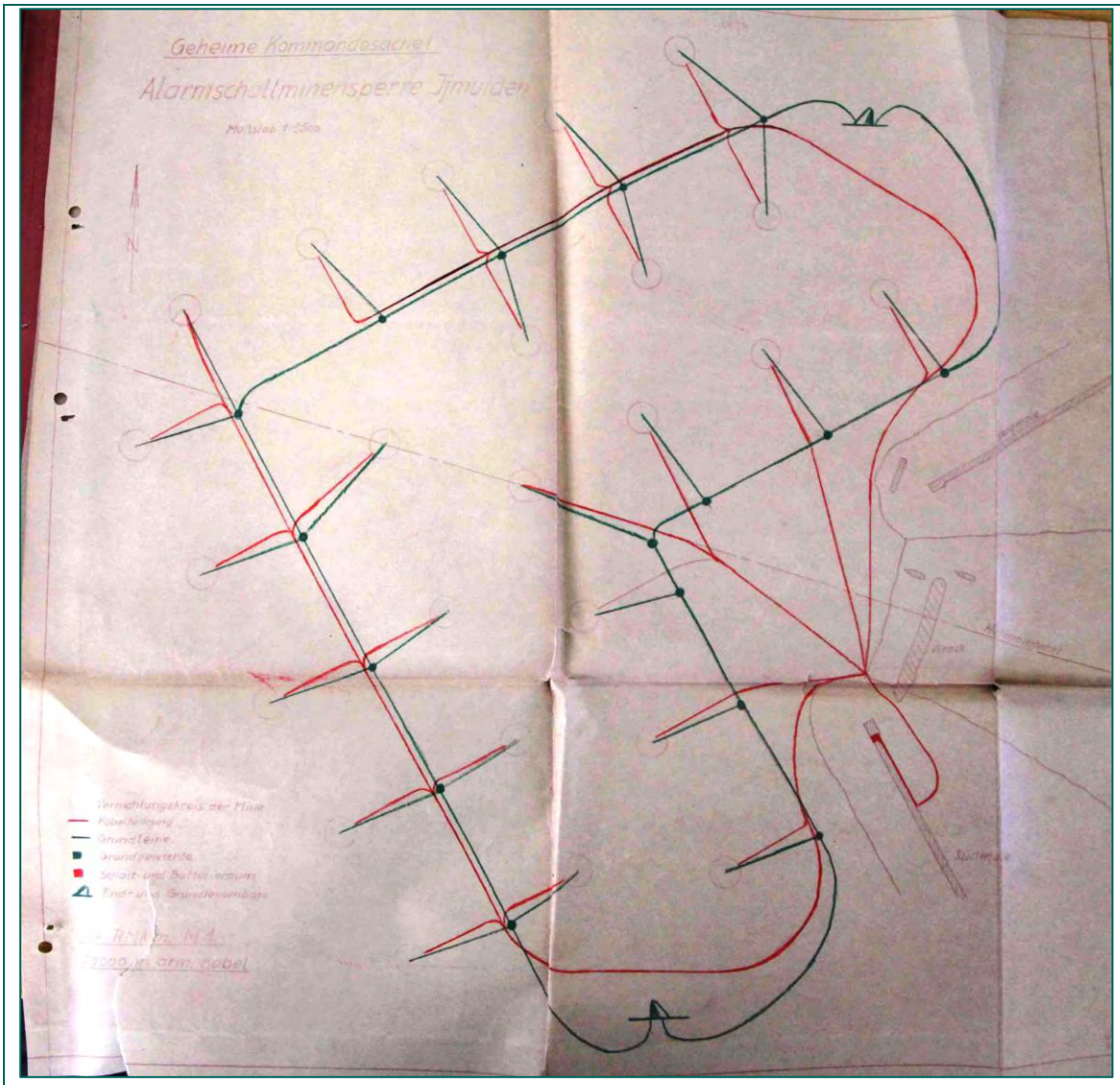
RM 5: Admiralstab der Marine / Seekriegsleitung der Kaiserlichen Marine.	
The Admiralty of the Imperial Navy was the highest level of command of the German Navy during the First World War. Record Group RM5 contains documents from the admiralty. The following documents are considered relevant for the area of investigation.	
RM 5/4721K	Kommando der Hochseestreitkräfte: "Zusammenstellung der bisher bekannten Minensperren und minenverdächtigen Gebiete". Druck, 3.3.1915
Map showing known and suspected allied minefields, situation March 1915. The area of interest has no overlap with an area which was suspected to be mined.  Within the area of investigation the map shows 'Treibende Minen' (Contact mines).	

RM 35-I: Marinegruppenkommando Ost – Nord der Kriegsmarine.	
The *Marinegruppenkommando Ost – Nord* operated as the commander of the units that had to secure the East and North Sea.	
RM 35-I/277	Minenlage Nord (M.L.N.) 1. Mai 1942 - 1. Okt. 1943

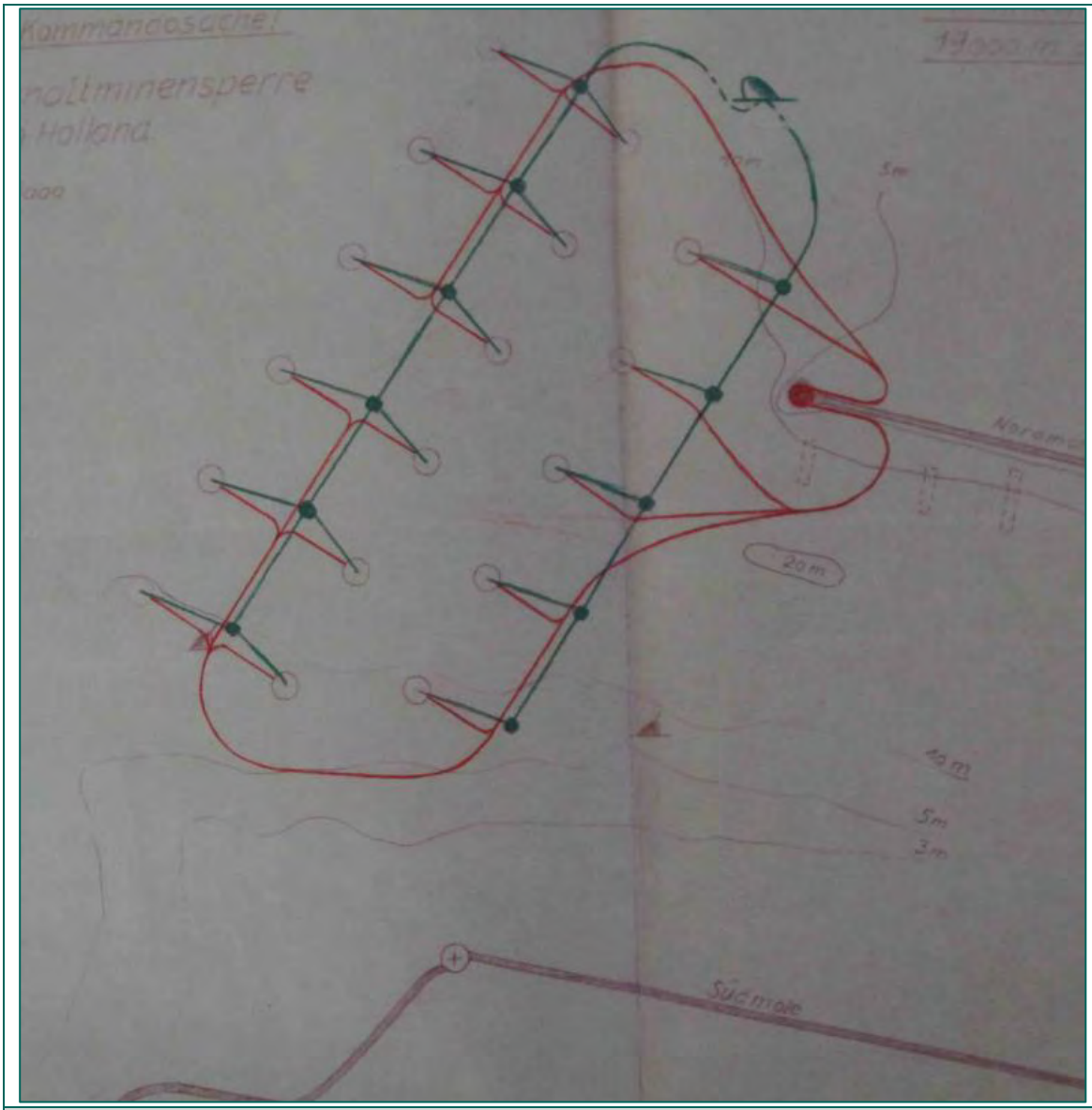
Map showing the defences of IJmuiden harbour. A warning minefield is situated in front of the port entrance. The minefield consisted of 24 RMA magnetic ground mines. The mines had a remote controlled detonator and each mine was coupled to a device on land. This gave the German defender the option to turn the mines on and off.



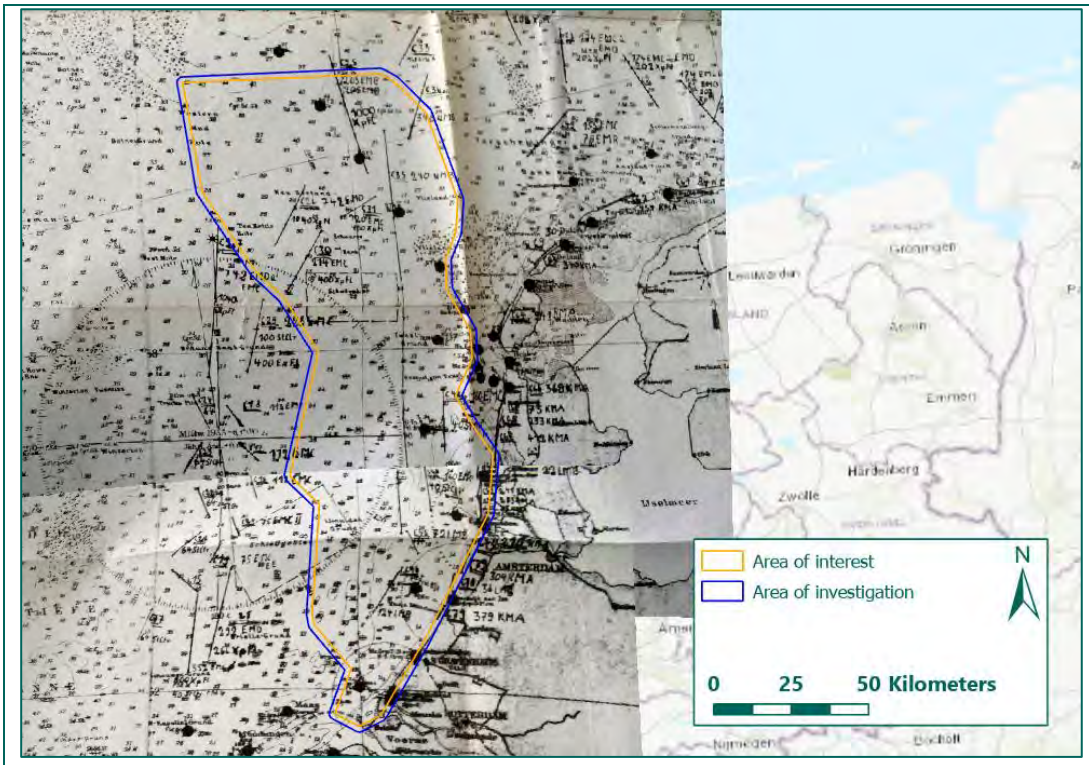




Map showing a minefield consisted of 17 RMA magnetic ground mines at the Hoek van Holland.



ZA 5 Deutscher Minenräumdienst (German Minesweeping Administration)	
The German Minesweeping Administration was responsible for post-war mine clearance of German waters. This administration also summarized and mapped all German minefields laid during the Second World War.	
ZA 5/27	Im Kriege geworfene Minensperren in der Ost- und Nordsee etc.
Naval chart showing numbered German minefields. Multiple minefields are present in the area of interest. For a more detailed map, see ZA 5/47.	



A large amount of minefields were present in the area of investigation:

- C25
- C26
- C27
- C29
- C30
- C31
- C35
- C36
- C44
- C45
- C46
- C47
- C48
- C67
- C69
- C70
- C71
- C72
- C73
- C78
- C79
- E25
- E26
- E38
- E41
- E42
- E43
- E44
- E45
- E46
- E47

ZA 5/44 | Chart B: The North Sea – Central Sheet

C25-C27

C25	SW-0	9/40	53 30.0 N 04 05.0 E 53 49.5 N 03 58.0 E	.5	205 EMB 205 EMB 1000 XpFl		M M M	8 8 17		1) 1)	220- 300	With AE Switch. Without AE Switch. To west of mines. Considered safe.
C26	SW-1	8/40	53 27.8 N 03 46.5 E 53 17.5 N 03 36.5 E	1	742 EMD 1040 XpFl		M M	7 16	65	3	50	AE Switch "OFF" Considered safe.
C27	SW-2	8/40	53 20.0 N 03 21.0 E 52 56.0 N 03 17.5 E	1	742 EMD and EMC 1040 XpFl		M M	7 17	65 50	3		AE Switch "OFF" Considered safe.

C29-C31

C29	SW-9	7/42	53 08.5 N 03 33.1 E 52 56.3 N 03 28.2 E	2	226 EMC 100 StCtr 400 ExFl		M M M	10 20 20		2 1		With 50 feet lower antenna. The 400 Ex-Floats are for lines C.29, C.30 and C.31. They are in the space between the mine lines.
C30	SW10	7/42	53 20.0 N 03 49.7 E 53 10.0 N 03 38.9 E	2	214 EMC 400 XpFl		M M	10 20		2		With 50 feet lower antenna. The 400 Ex-Floats are for lines C.29, C.30 and C.31. They are in the space between the mine lines.
C31	SW11	7/42	53 26.0 N 04 06.0 E 53 22.1 N 03 56.8 E	2	120 EMC 400 XpFl		M M	8 20		2		With 50 feet lower antenna. The 400 Ex-Floats are for lines C.29, C.30 and C.31. They are in the space between the mine lines.

C35-C36

C35	4c	10/43	53 26.0 N 04 12.0 E 53 38.2 N 04 12.0 E	.25	240 UMB		M	12		3	160	(Comment-another version shows 340 UMB). With SNAG LINES. Eight mines are missing from S. end of centre row.
C36	4d	10/43	53 36.6 N 04 17.8 E 53 48.0 N 04 25.7 E	.4	348 UMB		M	12		3		With SNAG LINES.

C44-C48

C44	SWK3	6/44	52 37.5 N 04 36.0 E 52 39.0 N 04 36.3 E	.25	22 LMB		G	30	250	2	165	Mean MINE spacing 125 yds.
C45	SWKA-1b	9/44	52 26.5 N 04 13.5 E 52 22.8 N 04 16.6 E	.5	72 LMB	DM-1	G		240	2	165	Mean MINE spacing 120 yds. Arming delay 24 hours (?)
C46	SWKA-2	9/44	52 20.2 N 04 12.5 E 52 13.6 N 04 05.5 E	.5	124 LMB	DM-1	G		260	2	165	Mean MINE spacing 130 yds. Arming delay 24 hours.
C47	SWKB-1	11/44	52 30.0 N 04 20.0 E 52 39.0 N 04 20.0 E	1	160 EMC 40 StCtr		M) M)	10	270	3	220	With chain 4 mines to 1 obstructor. Mean spacing 135 yards.
C48	SWKB-2	11/44	52 42.0 N 04 23.0 E) 52 53.0 N 04 23.0 E)	½-1	160 EMC) 40 StCtr)		M	10	330	3	330	Mines with chain. Four mines to one obstructor. Mean spacing 150 yards.

C67

C67	K-6	5-7 1944	52 46.0 N 04 39.1 E 52 40.2 N 04 37.5 E	Fairly accurate	412 KMA		G		58	2	33-66	Mean mine spacing 29 yards.

C69-C73

C69	K-7	7-8 1944	52 33.4 N. 04 36.2 E 52 36.7 N 04 37.0 E	Fairly accurate	241 KMA		G	3-8ø	56	2	43-55	ø Below HIGH water springs Mean mine spacing 28 yards.
C70	K-8	5/44	52 28.9 N 04 34.5 E 52 29.9 N 04 35.0 E	Exact	75 KMA		G	7ø	55	2	43-55	ø Below HIGH water springs. Mean mine spacing 27.5 yards.
C71	K-8a	5-7 1944	52 29.9 N 04 35.0 E 52 33.4 N 04 36.2 E	Exact	285 KMA		G	5-11ø	52	2	43-66	ø Below mean HIGH water springs. Mean mine spacing 26 yards.
C72	K-9	5-8 1944	52 24.0 N 04 31.7 E 52 20.0 N 04 29.1 E	Fairly accurate	304 KMA		G	5-8ø	55	2	43-55	ø Below high water springs. Mean mine spacing 27.5 yards.
C73	K-9a	5/44	52 26.4 N 04 33.7 E 52 24.0 N 04 31.7 E	Exact	210 KMA		G		55	2	43	Mean mine spacing 27.5 yards.

C78-C79

C78	SWK-6	6/44	52 17.3 N 04 26.4 E 52 19.3 N 04 27.8 E	.25	36 LMB		G	28	246	2	165-190	Mean mine spacing 123 yards.
C79	K10	8/44	52 16.7 N 04 27.0 E 52 12.0 N 04 22.6 E	Fairly accurate	379 KMA		G	5-10	55		44-55	Mean mine spacing 27½ yards. Below HIGH water springs.

E25-E26

E25	SWK7	6/44	52 08.2 N 04 17.1 E 52 11.4 N 04 21.1 E	.125	78 LMB	M1	G	23-30	210	2	165	Mean mine spacing 105 yds.
E26	SWK9	4/44	51 55.5 N 03 57.1 E 51 52.4 N 03 52.5 E	.25	90 LMB	M1	G		190	2	220	Mean mine spacing 95 yds.

E38

E38	SWK A3	9/44	52 09.2 N 03 55.0 E 52 01.2 N 03 51.7 E	.3	90 LMB 90 EMC	EM1	G M	10	180 180	1 1	165	Mean mine spacing 90 yds. Arming delay 24 hours. EMC with chain.

E41-E47

E41	K10	8/44	52 16.7 N 04 27.0 E 52 12.0 N 04 22.6 E	Fairly exact	739 KMA		G	5-10	55		44-55	Mean mine spacing 27½ yards. Below HIGH water springs.
E42	K11	5-8 1944	52 05.0 N 04 14.0 E 52 07.5 N 04 16.7 E	Exact	179 KMA		G	6-13	55		44	Mean mine spacing 27½ yards. Below HIGH WATER springs.
E43	K12	5/44	51 59.6 N 04 06.8 E 52 01.1 N 04 08.5 E	Exact	135 KMA		G		55	2	44	Mean mine spacing 27½ yards.
E44	K12A	4/44	52 01.1 N 04 08.5 E 52 04.8 N 04 13.6 E	Exact	334 KMA		G		55	2	44	Mean minespacing 27½ yards.
E45	K13	7-8 1944	51 58.4 N 04 04.2 E 51 56.7 N 04 01.8 E	Exact	134 KMA		G	6-8 below H.W.S.	66		44	Mean mine spacing 33 yards.
E46	K14	8/44	51 54.5 N 04 00.1 E 51 55.7 N 04 00.3 E 51 56.7 N 04 01.8 E	Exact	164 KMA		G	6-7 below H.W.S.	55	2	44	Mean mine spacing 27½ yards. (Comment: Alternative version gives 182 KMA).
E47	K15	8/44	51 54.3 N 04 00.1 E 51 52.3 N 04 02.5 E	Exact	182 KMA		G	6 below H.W.S.	55	2	44	Mean mine spacing 27½ yards.

E69

E69		11/44	Brielschegat from net barrage at Seeberg to 04 10E.	Exact	147 KMA		G	to 13 below H.W.S.	70	2	55	Mines scattered.

The information from ZA 5/27 and 5/44 is shown in the figure and table below.

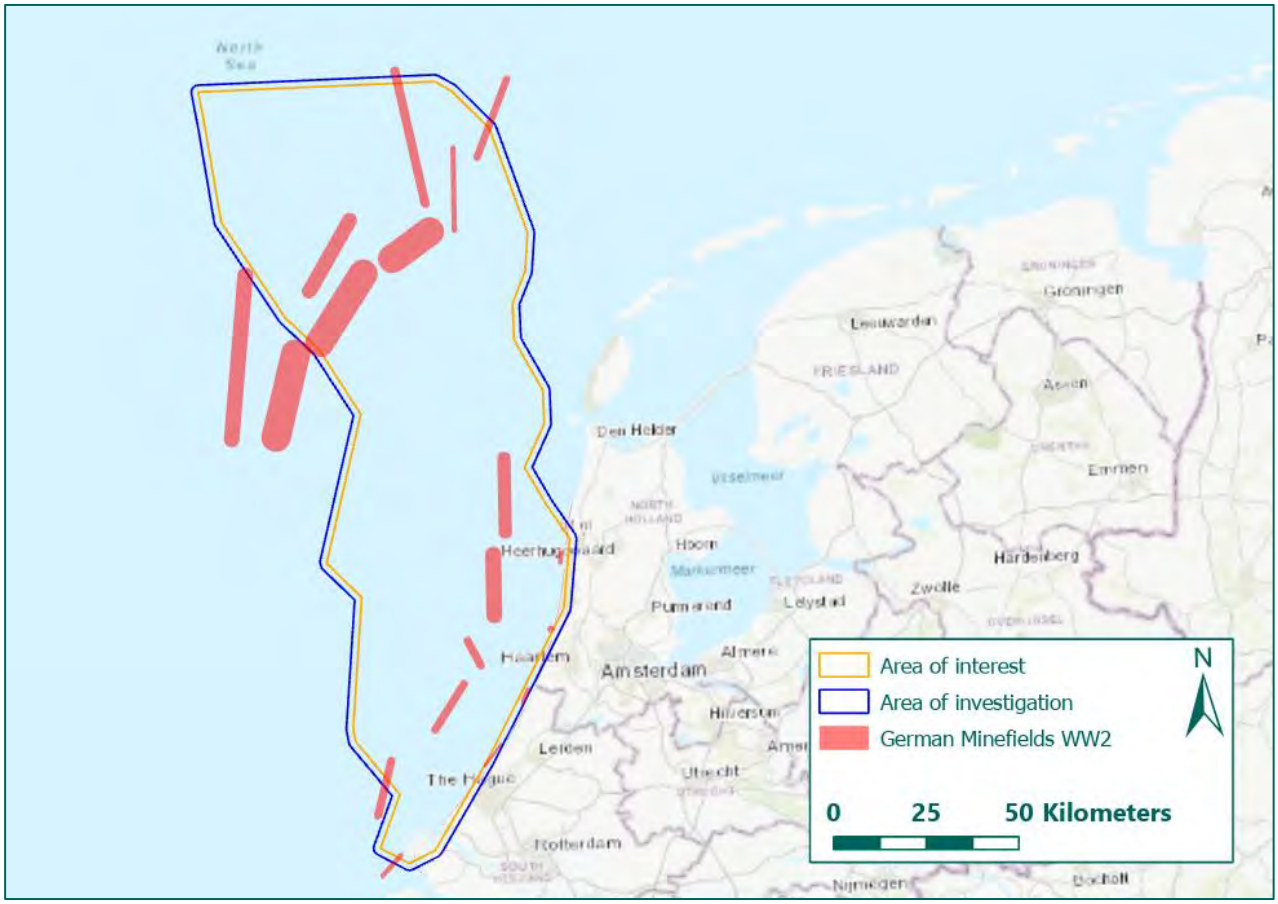


Figure 61: German Minefields within the Area of investigation (Source basemap: ESRI).

Number	Amount of mines	Rows	
		Amount	Spacing
C25	205 x EMB[7], 205 x EMB, 1000 x XpFl[8]	2	220/300 yards
C26	742x EMD[9], 1040 x XpFl	3	65 yards
C27	742 x EMD/EMC[10], 1040 x XpFl	3	65 yards
C29	226 x EMC, 100 x StCtr[11], 400 x XpFl	2, 1	Unknown
C30	214 x EMC, 400 x XpFl	2	Unknown
C31	120 x EMC, 400 x XpFl	2	Unknown
C35	240 x UMB[12]	3	Unknown
C36	348 x UMB	3	Unknown
C44	22 x LMB[13]	2	Unknown
C45	72 x LMB	2	Unknown

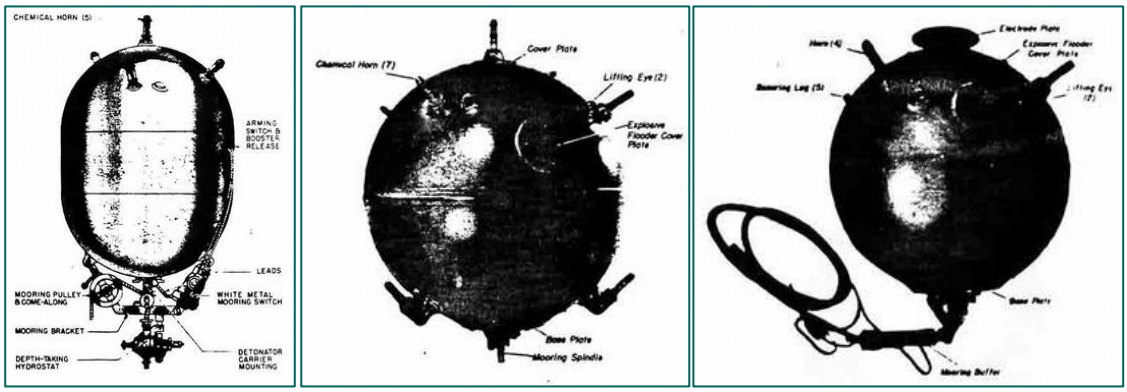
[7] *Einheidsmine* – Type B, Contact mine
[8] Exploding floats, *Sprengboje*
[9] *Einheidsmine* – Type D, Contact mine
[10] *Einheidsmine* – Type C, Contact mine
[11] Static cutters/Static Conical Sweep Obstructor, *Reisboje*
[12] *U-Bootabwehrmine* – Type B, Contact Mine
[13] *Luft Mine* – Type B, Influence Mine

Number	Amount of mines	Rows	
		Amount	Spacing
C46	124 x LMB	2	Unknown
C47	160 x EMC, 40 x StCtr	3	Unknown
C48	160 x EMC, 40 x StCtr	3	Unknown
C67	412 x KMA[14]	2	Unknown
C69	KMA (unknown amount)	2	Unknown
C70	75 x KMA	2	Unknown
C71	285 x KMA	2	Unknown
C72	304 x KMA	2	Unknown
C73	210 x KMA	2	Unknown
C78	36 x LMB	2	Unknown
C79	379 x KMA	Unknown	Unknown
E25	78 x LMB	2	Unknown
E26	90 x LMB	2	Unknown
E38	90 x LMB, 90 x EMC	2	Unknown
E41	739 x KMA	Unknown	Unknown
E42	179 x KMA		Unknown
E43	135 x KMA	2	Unknown
E44	334 x KMA	2	Unknown
E45	134 x KMA	Unknown	Unknown
E46	164 x KMA	2	Unknown
E47	182 x KMA	2	Unknown
E69	147 x KMA	2	Unknown
Unknown, Harbour Hoek of Holland	17 x RMA[15]	-	-
Unknown, Harbour IJmuiden	24 x RMA	-	-
Unknown, Harbour IJmuiden	LMB (unknown amount)	Unknown	Unknown

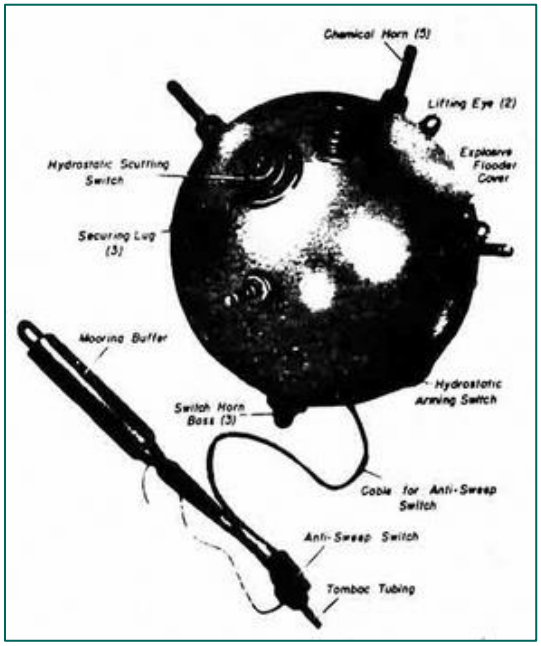
[14] Küstenmine – Type A, Contactmine
[15] Regulare Mine – Type A, Contactmine

German Mines (and sweep obstructors) within the area of investigation)

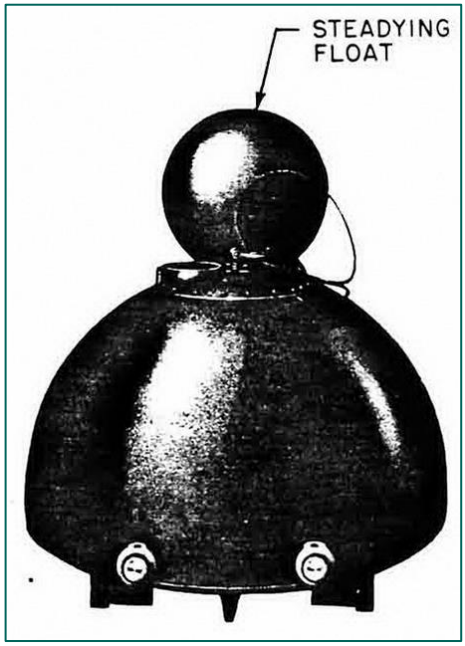
Einheidsmine – Type B, C and D Contact mine



U-Bootabwehrmine – Type A, Contact Mine



Regulare Mine – Type A, Contactmine



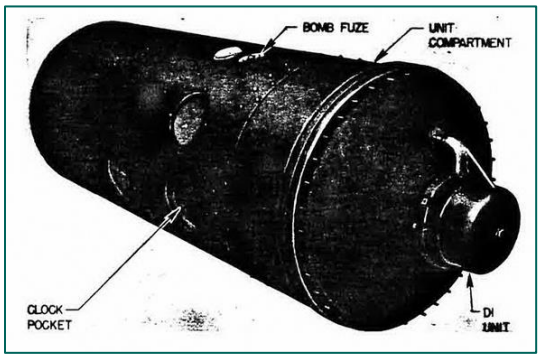
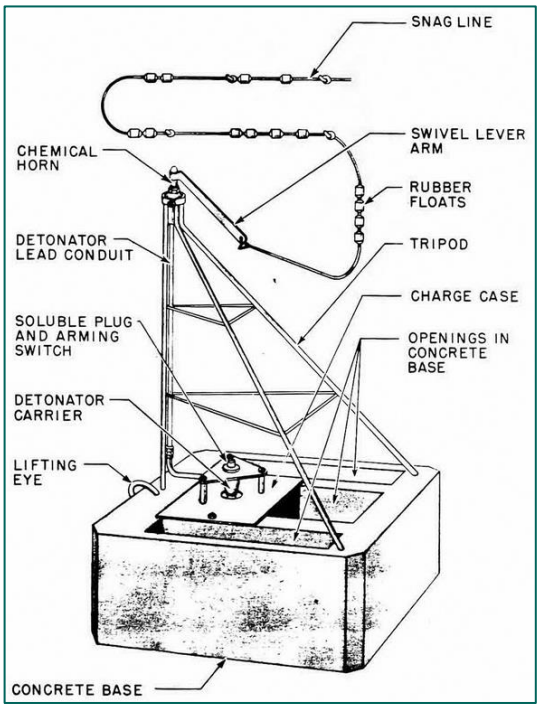
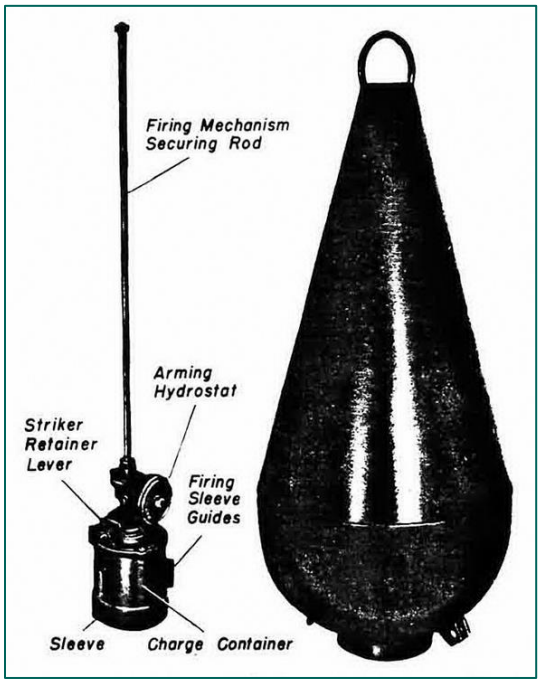
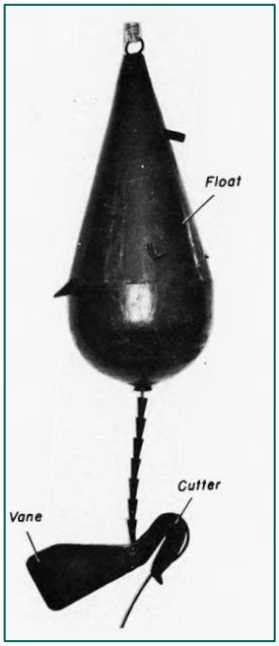
German Mines (and sweep obstructors) within the area of investigation	
Luft Mine – Type B, Influence/Ground Mine  	Küstenmine – Type A, Contactmine 
Exploding floats, *Sprengboje* (Explosive)  	Static cutters/Static Conical Sweep Obstructor, *Reisboje* (Non explosive) 

Table 6: German Mines (and sweep obstructors) within the area of investigation.

ANNEX 4 WRECKS WITHIN THE AREA OF INTEREST

The website 'Wrecksite' and the book 'HP39 Wrakkenregister, Nederlands Continentaal Plat en Westerschelde' (abbreviated to HP39), drawn up by the Dutch navy, show an abundance of wrecks (ships and aircraft) within the area of interest. In HP39 no details are given about the reason/cause of the sinking of the ships or aircraft. However. An overview of all wrecks according to this book is shown below.

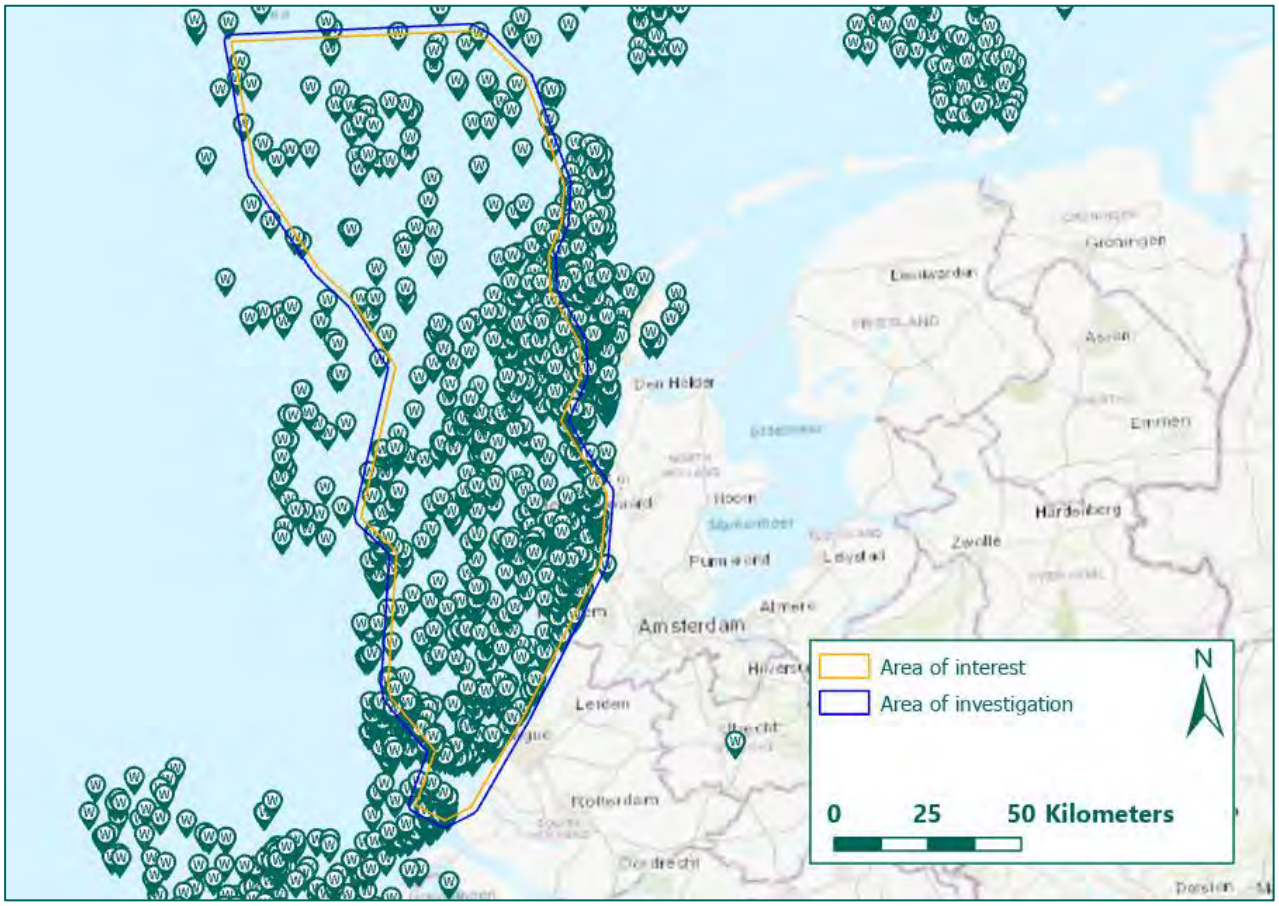


Figure 62: Overview of wrecks within the area of interest according to HP39 (Source: HP39).

The Website 'Wrecksite' shows more details with regards to the wrecks in the North Sea. The website shows a total of more than 1800 wrecks within and near the area of interest. Plotting all these wrecks in the GIS-system would be too comprehensive and would outside the scope of this report. In the table below a list war related causes of sinking of ships/aircraft within the area of interest is shown.

Cause of sinking	Total number sunk
Airplane crashes, WW2	75
Air raids, WW2	19
Charges/explosives, WW1 and WW2	8
Depth charges , WW2	2
Explosions, WW2 and after WW2	4
Gunfire – shelled, WW1 and WW2	152
Mine, WW1 and WW2	39
Naval battles, WW1 and WW2	10
Torpedo, WW1 and WW2	21
War loss (Not specified), WW1	1

Table 7: Listing of ships/aircraft sunk by war related events.

ANNEX 5 POST-WAR UXO CLEARANCE

OSPAR Commission

OSPAR is the mechanism by which 15 governments and the European Union cooperate to protect the marine environment of the North-East Atlantic. Since 1972 the OSPAR Convention has worked to identify threats to the marine environment and has organised, across its maritime area, programmes and measures to ensure effective national action to combat them. One of the Policy Issues of the OSPAR Convention is to report encounters with conventional and chemical munitions in the OSPAR maritime area. These encounters are kept in a database[16]. The munition encounters from 1999 onwards within the area of interest are rendered in Figure 63. Multiple UXOs were lifted from the area of interest. The exact type of UXO lifted is not mentioned in all cases. However, it is known that several aerial bombs, flares, mines, torpedo's and shells were lifted.

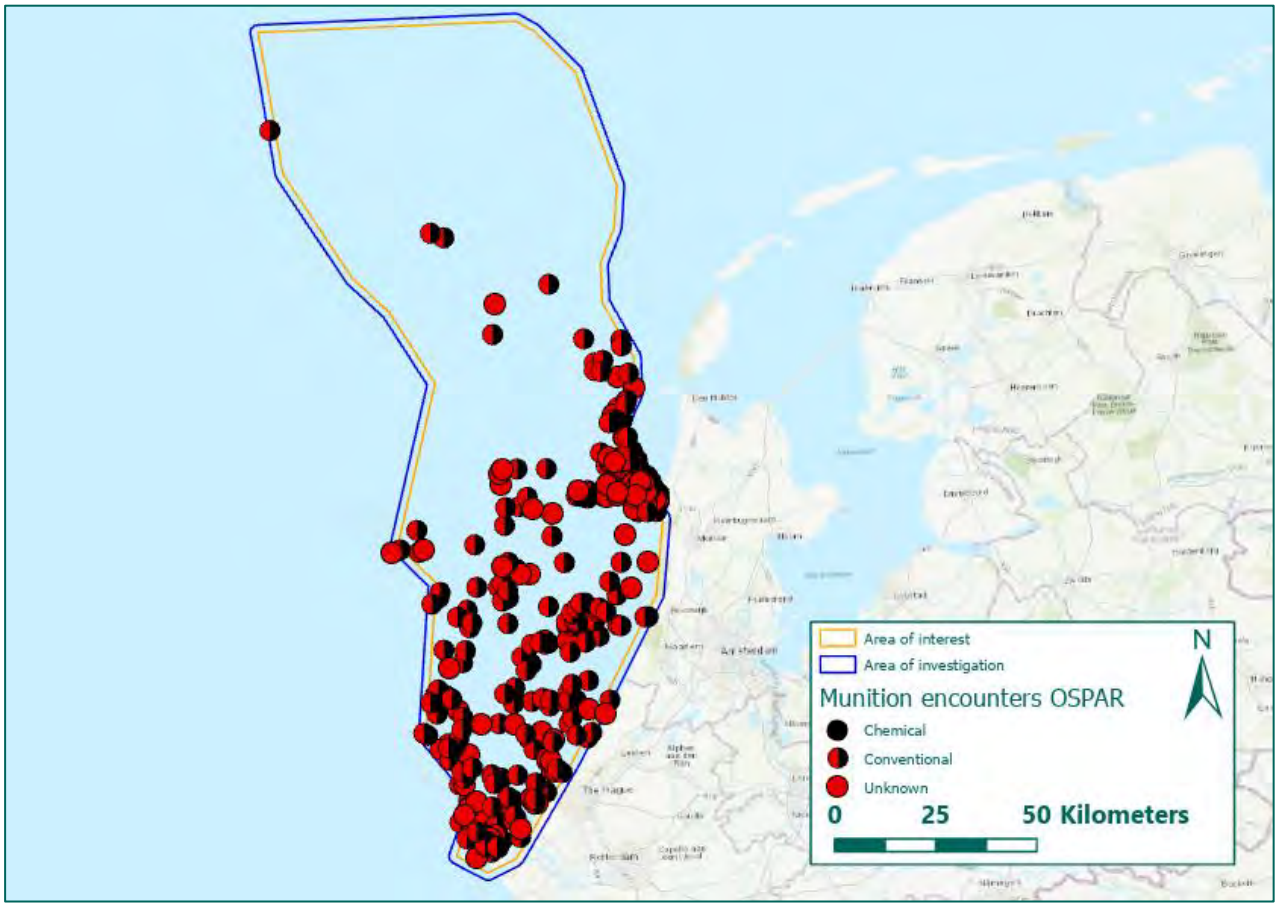


Figure 63: Overview OSPAR ammunition encounters within the area of interest (Source: OSPAR).

Dutch Coastguard (Nederlandse Kustwacht) and Beneficial Cooperation

The Dutch Coastguard (Nederlandse Kustwacht) cleared hundreds of UXO in the North Sea. Coordinates were used to keep track of the locations of encountered UXO. The Dutch Coastguard also cooperated with the Belgian Navy in clearing ammunition. This joint venture operates under the name Beneficial Cooperation.

The Dutch Coastguard manufactured lists that could help citizens (mainly citizens active in the fishing industry) identify any UXO found at sea. This additional information helped the Coastguard to be better prepared. These lists are shown at the end of this annex for clarification. When known, the numbers referring to the different types of UXO are shown in the GIS-shapefiles of the Dutch Coastguard and

[16] This database can be consulted at http://odims.ospar.org/layers/?limit=100&offset=0.

Beneficial Cooperation. The figures below respectively show cleared UXO reported by the Dutch Coastguard and Beneficial Cooperation.

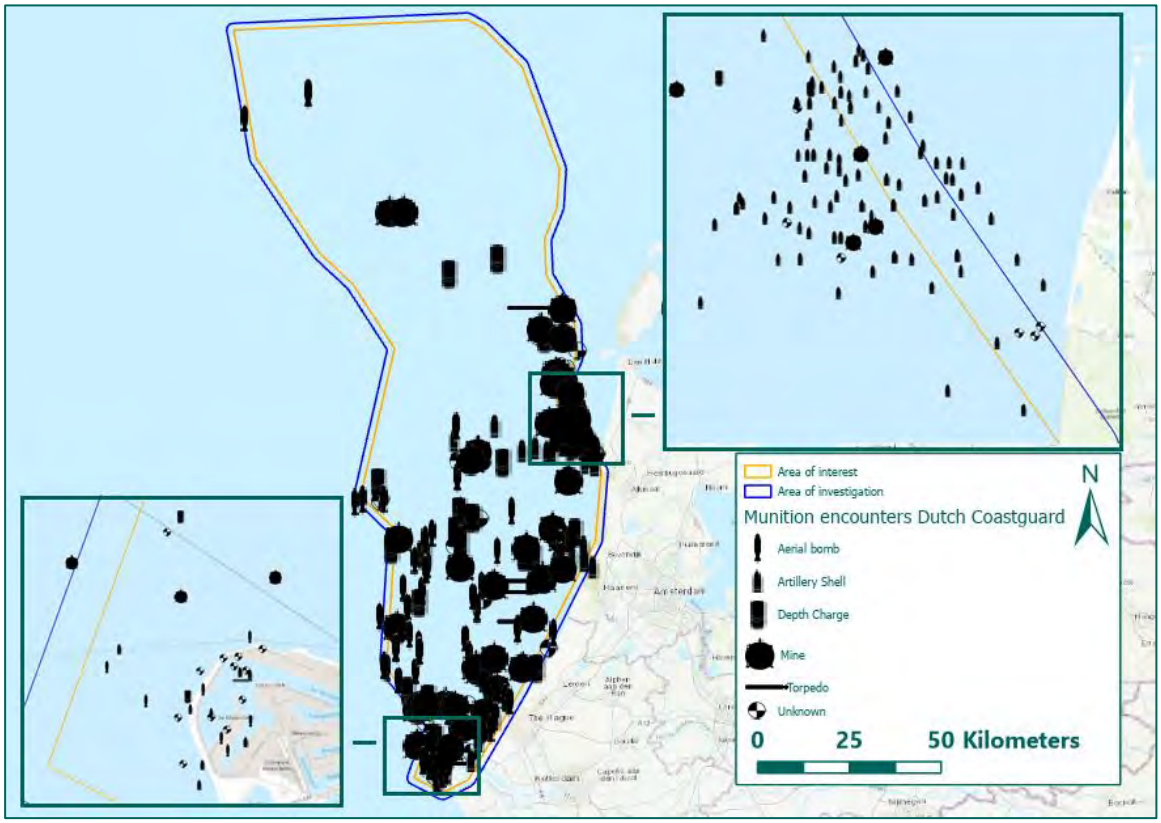


Figure 64: Overview of UXO lifted by the Dutch Coastguard (Source basemap: ESRI).

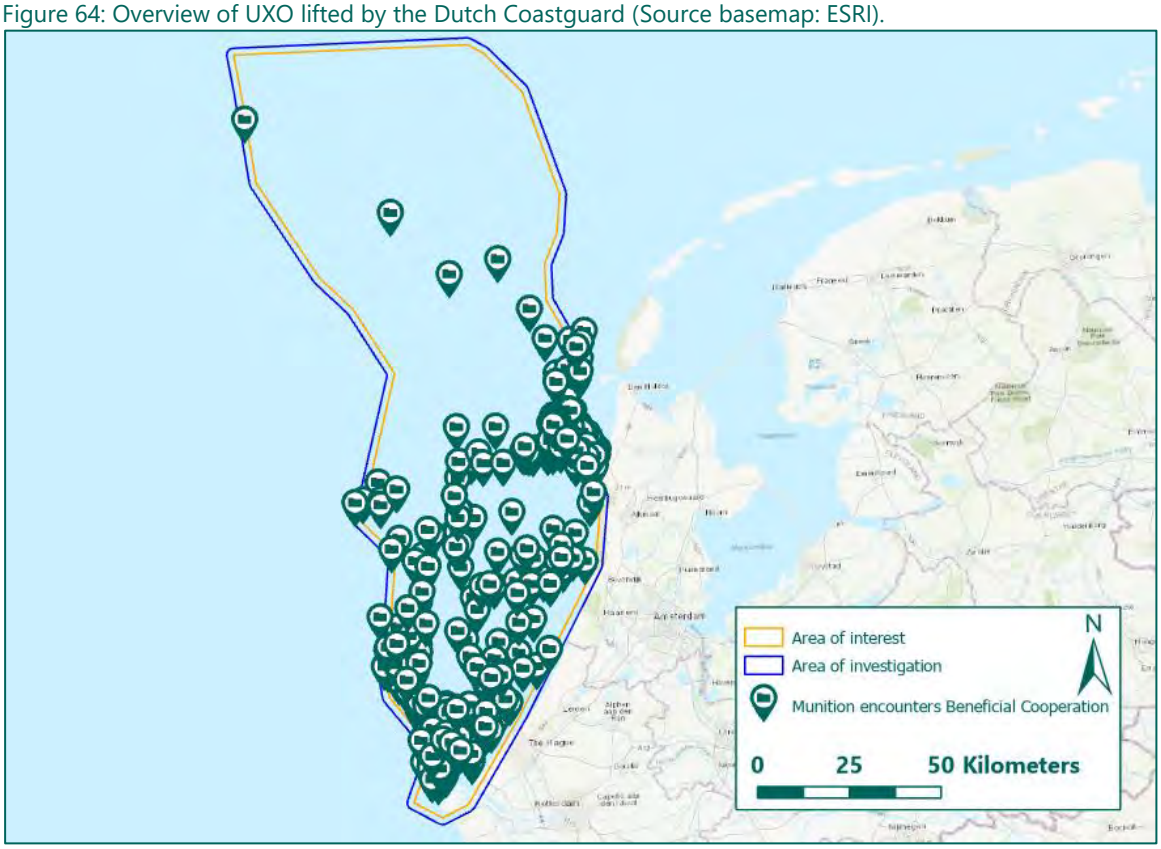
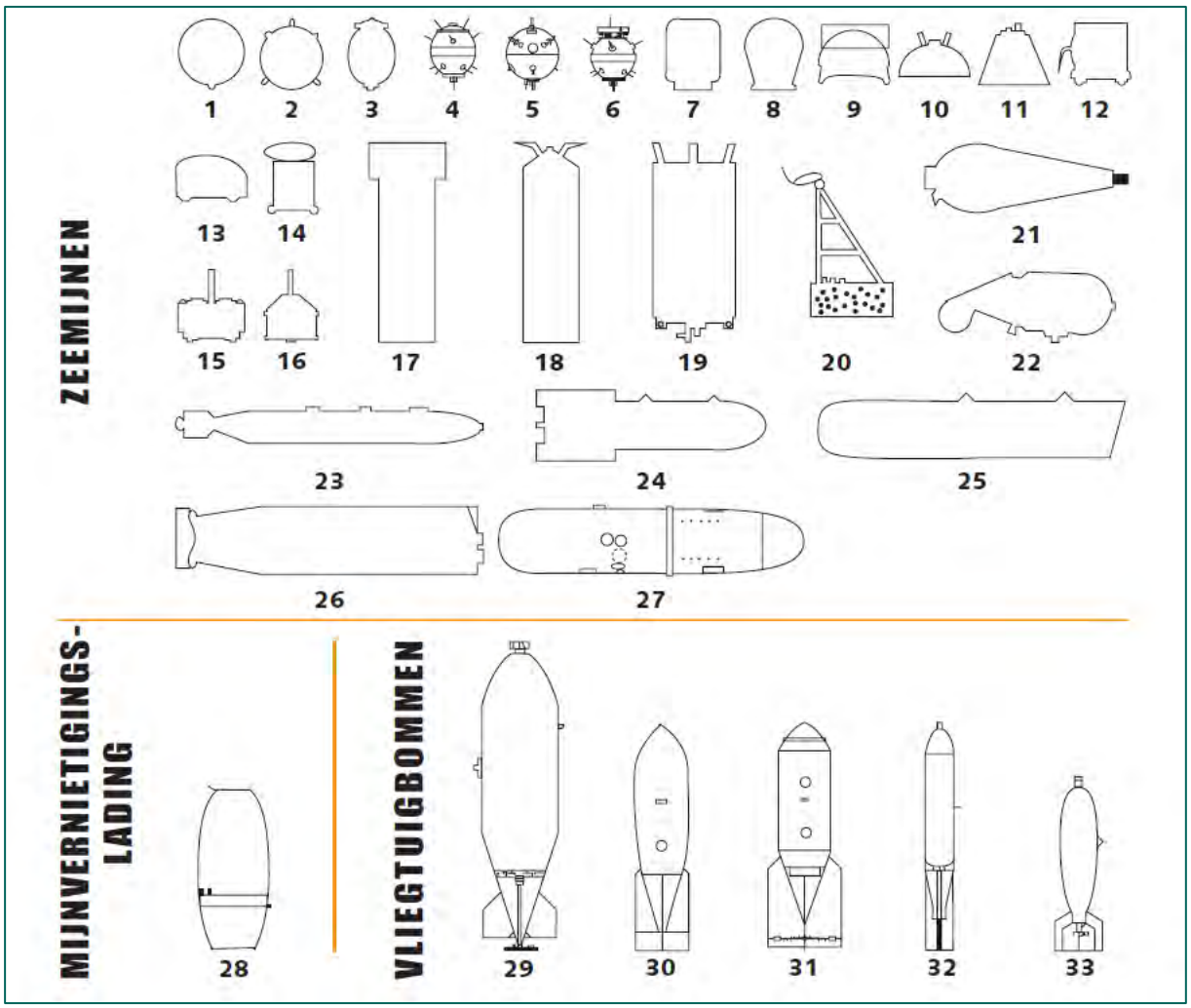


Figure 65: Overview of UXO lifted by the Beneficial Cooperation (Source basemap: ESRI).


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MIJNVERNIETIGINGS-LADING
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VLIEGTUIGBOMMEN
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33

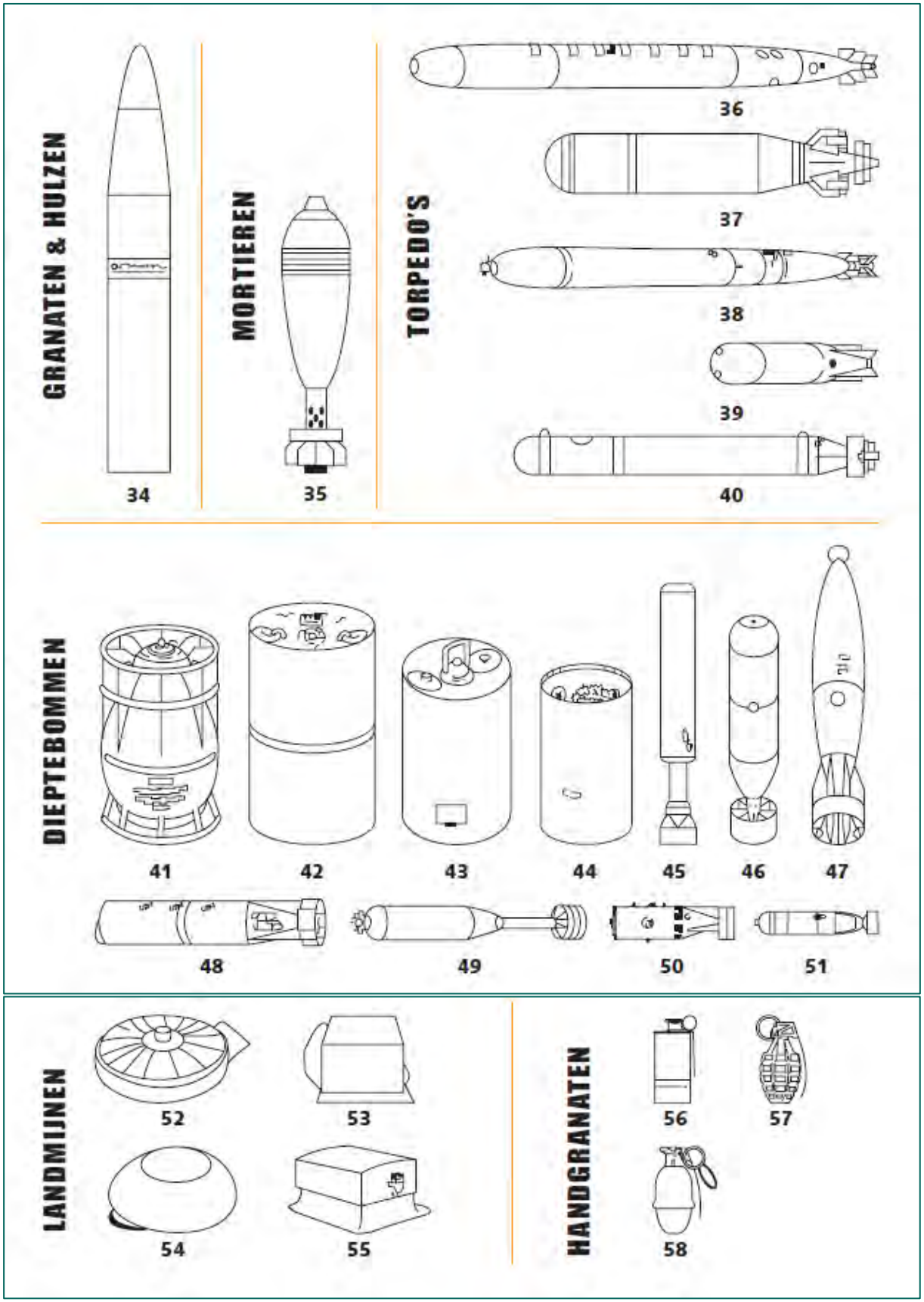


Figure 66: 'Explosievenkaart' (Explosives chart) of the Dutch Coastguard. This chart is used to help identify UXO (Source: Dutch Coastguard).

Dutch 'Explosieven Opruimingsdienst' (EOD)

Every year, the Dutch EOD clears an average of 2,500 explosives from the Second World War in the Netherlands. Most of these clearances take place onshore. However, the Dutch Navy does assist the Coastguard with offshore UXO encounters. In the figure below the locations of multiple UXO encounters are shown. The same 'Explosievenkaart' (Explosives chart) is used to identify these UXO. When known, the numbers referring to the different types of UXO are shown in the GIS-shapefiles of the EOD.

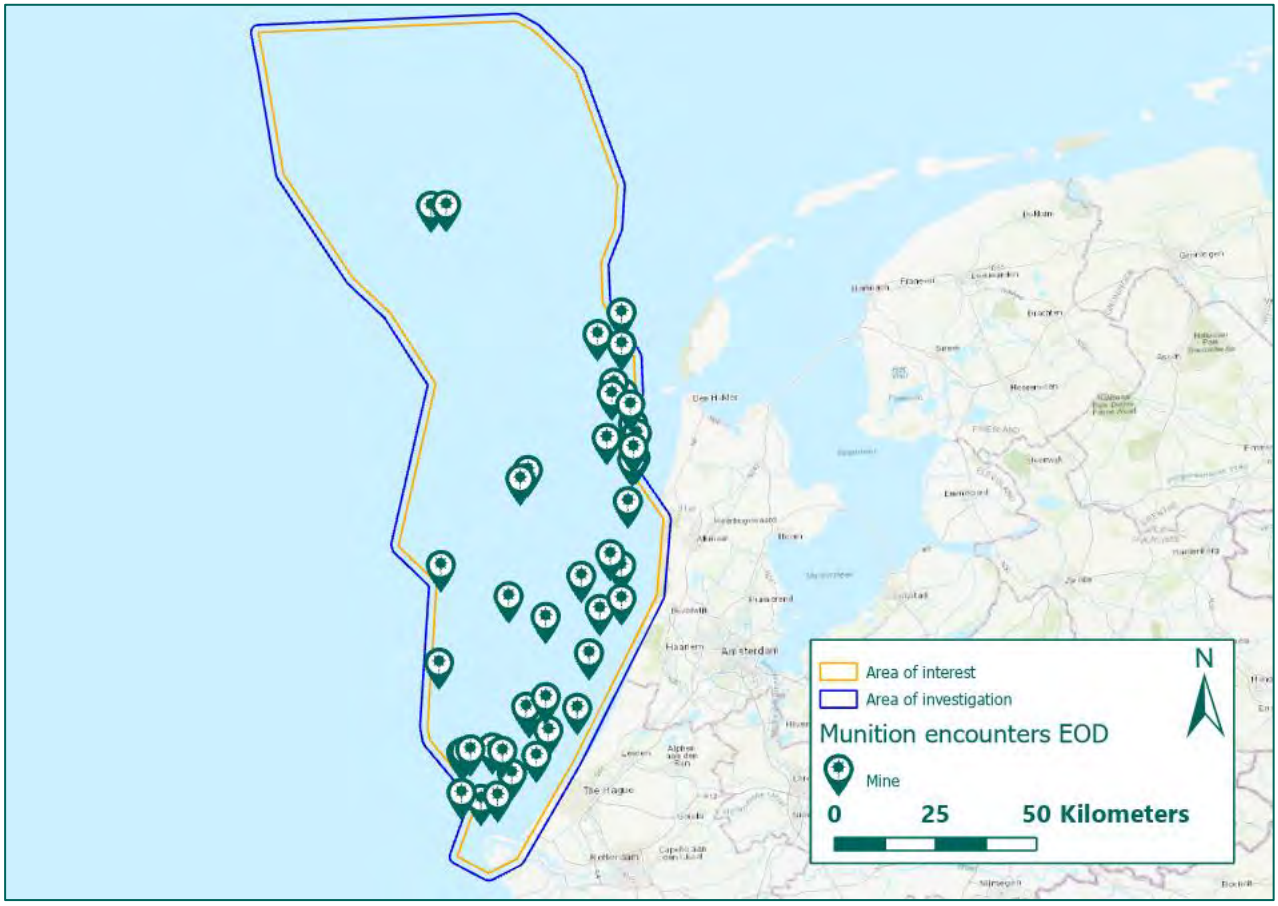


Figure 67: Overview of UXO lifted by the Dutch EOD (Source basemap: ESRI).

Periplus Archeomare

Aramis Pipeline

An archaeological assessment
Of geophysical survey results



Authors

[redacted], [redacted] and [redacted]

At the request of

TotalEnergies EP Nederland 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.
Paleolithic (Early Stone Age)	300.000	B.C.	-	8800	B.C.

Table 2. Administrative details

Location:	North Sea	
Province	Zuid-Holland	
Municipality	Rotterdam	
Toponym Dutch:	Aramis pipeline	
Chart:	1801-01, 1811-01	
Coordinates Geodetic datum: ETRS89 Projection: UTM31N	Geophysical survey area	
	Centre	E 564 944 - N 5 856 821
	Northwest	E 580 104 - N 5 953 697
	Northeast	E 542 599 - N 5 953 697
	Southwest	E 542 599 - N 5 759 945
	Southeast	E 580 104 - N 5 759 945
Depth (LAT):	4.8 to 39.6 meter, average 27.0 meter	
Area (km^2):	Survey area	243.25 km^2
Environment:	Tidal currents, salt water	
Area use:	Shipping, fishing, oil, and gas industry	
Area administrator:	Rijkswaterstaat Zee en Delta	
Competent authority	Rijkswaterstaat Zee en Delta	
Advising body	Cultural Heritage Agency of the Netherlands [redacted]	
ARCHIS-research report (CIS-code):	5330686100	
Periplus-project reference:	22A030-01	
Period	May - August 2023	

Samenvatting (Abstract in Dutch)

In opdracht van TotalEnergies Nederland B.V. heeft Periplus Archeomare een archeologische analyse uitgevoerd van de geofysische onderzoeksresultaten van het Aramis pijpleidingtracé.

Een grote hoeveelheid onderzoeksgegevens (*sidescan-sonar, magnetometer, multibeam echosounder* en *subbottom-profiler*) van een gebied met een totale oppervlakte van 243 km2 is geanalyseerd om een archeologische beoordeling uit te voeren.

Deze analyse van geofysische onderzoeksresultaten is de tweede stap in de AMZ-cyclus, na de bureaustudie. Het doel van deze analyse is het toetsen van de op de bureaustudie gebaseerde verwachting voor archeologische resten in het gebied. De verwachting omvat overblijfselen van scheepvaartgerelateerde resten (wrakken), vliegtuigen uit de Tweede Wereldoorlog en prehistorische nederzettingen.

Sidescan-sonar en multibeam-contacten
Binnen het onderzochte gebied is aan in totaal acht contacten een archeologische verwachting toegekend. In overeenstemming met de Nederlandse wet- en regelgeving mogen hier geen bodemverstoringen plaatsvinden. Indien er binnen een straal van 100 meter van een potentiële archeologische locatie activiteiten plaatsvinden, wordt in overleg met de Rijksdienst voor het Cultureel Erfgoed (RCE) van geval tot geval bekeken of de 100 meter gehandhaafd moet blijven.

Magnetische afwijkingen
In totaal zijn op 2748 locaties magnetische afwijkingen waargenomen. Op tien locaties zijn magnetische afwijkingen met een piek-tot-piekwaarde van meer dan 500 nT in kaart gebracht, die niet gerelateerd kunnen worden aan bekende objecten zoals pijpleidingen of kabels en die van potentieel archeologisch belang kunnen zijn. De objecten die deze afwijkingen veroorzaken, zijn niet zichtbaar op sidescan-sonar- of multibeam-beelden en worden daarom geacht in de zeebodem te zijn begraven. Deze objecten kunnen (naast archeologische objecten) onder meer puin, explosieven, verloren ankers, et cetera zijn. Zolang het karakter van deze objecten niet is vastgesteld, worden de objecten geacht van potentieel archeologisch belang te zijn. Negen van de tien contacten vallen binnen een straal van 100 meter van de voorgestelde route.

In overeenstemming met de Nederlandse wet- en regelgeving mogen geen bodemverstoringen plaatsvinden op deze locaties. Indien binnen een straal van 100 meter van een potentiële archeologische locatie activiteiten plaatsvinden, wordt in overleg met de Rijksdienst voor het Cultureel Erfgoed (RCE) van geval tot geval bekeken of de 100 meter gehandhaafd moet blijven. Alle locaties van potentieel archeologisch belang binnen een straal van 100 meter van de voorgestelde route zijn weergegeven in figuur 1.

Prehistorische resten
De fysieke kwaliteit, dat wil zeggen de integriteit en het behoud van prehistorische resten, is sterk afhankelijk van de mate waarin prehistorische landschappen en archeologische niveaus daarin zijn aangetast door erosie. De seismische gegevens geven aan dat een deel van het Pleistoceen-landschap is geërodeerd tijdens de mariene transgressie in het vroege Holoceen, waardoor de integriteit van mogelijke prehistorische nederzettingen is aangetast. Lokaal kunnen de geologische eenheden die zijn gedefinieerd

als potentiële lagen met prehistorische overblijfselen intact zijn gebleven, vooral in gebieden waar veen is gevonden. De interpretatie van lithostratigrafische eenheden en het karakter van de laaggrenzen (erosief versus niet-erosief) uit de seismische gegevens is gebaseerd op de beschikbare geologische gegevens en het oordeel van deskundigen. De seismische interpretatie moet worden geverifieerd door middel van vibrocore-bemonstering. De werkelijke geologische sequenties die in het gebied aanwezig zijn en de integriteit van de laaggrenzen zullen worden geverifieerd, wat een instrument zal bieden voor verdere analyse van de prehistorische landschappen en het specificeren en testen van het archeologische potentieel.

Advies prehistorie

Periplus Archeomare beveelt aan verder archeologisch onderzoek uit te voeren dat zich richt op het ontstaan en de integriteit van paleo-landschappen langs de Aramis-routetrajecten voor algemene archeologische onderzoeksdoeleinden. Dit onderzoek omvat een inventarisatie van veldonderzoek door middel van vibrocore-bemonstering conform de Nederlandse Kwaliteitsnorm voor Archeologie (KNA Waterbodems 4.1). Er wordt een geotechnische campagne uitgevoerd om een geologisch model te genereren van de ondergrond van de pijpleidingcorridor en om de fysische eigenschappen van de aanwezige sedimentlagen te bepalen. Wij adviseren om een aantal vibrocore-locaties aan te wijzen waar sedimentmonsters worden verzameld die gebruikt kunnen worden voor geo-archeologisch onderzoek.

De intacte monsters moeten door een (senior) prospector worden onderzocht en beschreven volgens de Standaard Boorbeschrijvingsmethode (SBB). Monsters worden geselecteerd en gestabiliseerd om te worden geanalyseerd door specialisten op het gebied van OSL- en radiokoolstofdatering, sedimentpetrografie, palynologie, micropaleontologie (foraminiferen, ostracoden, diatomeeën, et cetera), macroresten van planten en dieren en weekdieren om inzicht te krijgen in de ontwikkeling van landschappen in de loop van de tijd en de mate waarin deze paleolandschappen bewaard zijn gebleven.

Conform de Nederlandse Kwaliteitsnorm voor Archeologie (KNA Waterbodems 4.1) moet er een Programma van Eisen (PvE) en/of Plan van Aanpak (PvA) worden opgesteld. Dit PvE/PvA omvat de doelstelling, de onderzoeksstrategie en -methodiek, de kaders en de praktische uitvoering van het onderzoek, zodat het proces soepel verloopt en meervoudig gebruik van de op uniforme wijze verkregen data wordt bereikt. Geadviseerd wordt om deze PvE/PvA ter goedkeuring voor te leggen aan het Bevoegd Gezag en de RCE. Na afronding van het inventariserend veldonderzoek kunnen tijdens de aanleg van de pijpleiding gegevens worden verzameld die – vanuit archeologisch oogpunt – op gedetailleerd niveau waardevolle informatie opleveren. Het kan zeer nuttig zijn om deze informatie vanuit archeologisch oogpunt verder te onderzoeken. Het verdient aanbeveling om, nadat de plannen zijn uitgewerkt, in overleg met de RCE de mogelijkheden hiervoor te onderzoeken.

Tijdens de installatie van de leiding kunnen archeologische voorwerpen worden ontdekt die volledig zijn begraven of tijdens het geofysisch onderzoek niet als archeologisch object zijn herkend. Wij adviseren passieve archeologische begeleiding op basis van een goedgekeurd Programma van Eisen. Passieve archeologische begeleiding houdt in dat een archeoloog tijdens de uitvoering van de werkzaamheden niet aanwezig is, maar altijd op afroep beschikbaar is. Het opvolgen van deze aanbeveling voorkomt vertragingen tijdens de werkzaamheden wanneer er onverwacht archeologische resten worden aangetroffen. Op grond van de Erfgoedwet is het verplicht om deze bevindingen te melden aan de toezichthouder (Minister van OCW). Deze melding moet ook worden opgenomen in het bestek van het werk.

Summary

TotalEnergies Nederland B.V. has contracted Periplus Archeomare B.V. to conduct an archaeological assessment of geophysical survey results of the Aramis pipeline route survey.

A large quantity of survey data (*side scan sonar, magnetometer, multibeam echosounder* and *subbottom profiling*) covering a total area of 243 km^2 have been analyzed to conduct an archaeological assessment.

The current analysis of geophysical survey results is the second step in the AMZ-cycle, following the desk study. The purpose of this assessment is to test the desk study-based expectancy for archaeological remains in the area. The expectancy covers remains of shipping related objects (wrecks), airplanes from World War II and prehistoric settlements.

Side scan sonar and multibeam contacts

Within the surveyed area, an archaeological expectation was assigned to a total of 8 contacts. In accordance with Dutch Law and Legislation no seabed disturbances should be carried out within 100 meters of each of the marked locations. If any activities will take place within 100 meters of a potential archaeological location, it will be examined on a case-by-case basis whether the 100 meters should be maintained in consultation with the Cultural Heritage Agency of the Netherlands (RCE).

Feature	NCN	Easting	Northing	Route section	Distance
BK_FSEA_SSS_0022	-	551288	5924521	D	**+50**
BK_FSEA_SSS_0179	-	555839	5929168	D	-240
BJ_FD_SSS_0015	-	548443	5894128	F	+230
BB_FS_SSS_0683	219	570384	5762003	East	-540
BH_FSEA_SSS_0104	531	559172	5935317	C	**+25**
BK_FSEA_SSS_0163	967	550165	5921956	D	**-56**
BN_FD_SSS_0025	945	576689	5920367	E Neptune	+220
BB_FS_SSS_0433	-	570711	5761481	East	-210

Three of the eight contacts fall within 100 meters of the proposed route.

Magnetic anomalies

A total of 2748 magnetic anomalies have been observed. At 10 locations magnetic anomalies with a peak-to peak value over 500 nT have been mapped which cannot be related to known objects like pipelines or cables and may be of potential archaeological interest. The objects that cause these anomalies are not visible on side scan sonar or multibeam images and are therefore considered to be buried in the seabed. These objects could, apart from archaeological objects, include debris, UXO, lost anchors, et cetera. As long as the character of these objects has not been determined, the objects are considered to be of potential archaeological interest.

Target	E	N	nT	Section	Distance
BAB_FS_UXO_0010	570711	5761625	808	East	-210
BAB_FS_UXO_0599	570931	5761671	514	East	**+5**
BAB_FS_UXO_0603	570932	5761987	2312	East	**+8**
BAB_FS_UXO_0605	570933	5761957	1158	East	**+8**
BAB_FS_UXO_0618	570936	5761510	729	East	**+11**
BAB_FS_UXO_0657	570948	5761543	1348	East	**+22**
BC_FD_MAG_0121	571170	5763666	666	East	**+4**
BH_FSEA_MAG_0044	559169	5935057	578	C	**-2**
BJ_FD_MAG_0050	563642	5875159	2089	F	**-59**
BP_FD_MAG_0016	559490	5931390	591	B	**-60**

Table 3. Magnetic anomalies over 500 nT with an archaeological expectation.

Nine of the ten contacts fall within 100 meters of the proposed route.

In accordance with Dutch Law and Legislation no seabed disturbances should be carried out within 100 meters of each of the marked locations. If any activities will take place within 100 meters of a potential archaeological location, it will be examined on a case-by-case basis whether the 100 meters should be maintained in consultation with the Cultural Heritage Agency of the Netherlands (RCE). All locations of potential archaeological interest within 100 meters of the proposed route are shown in the next figure.

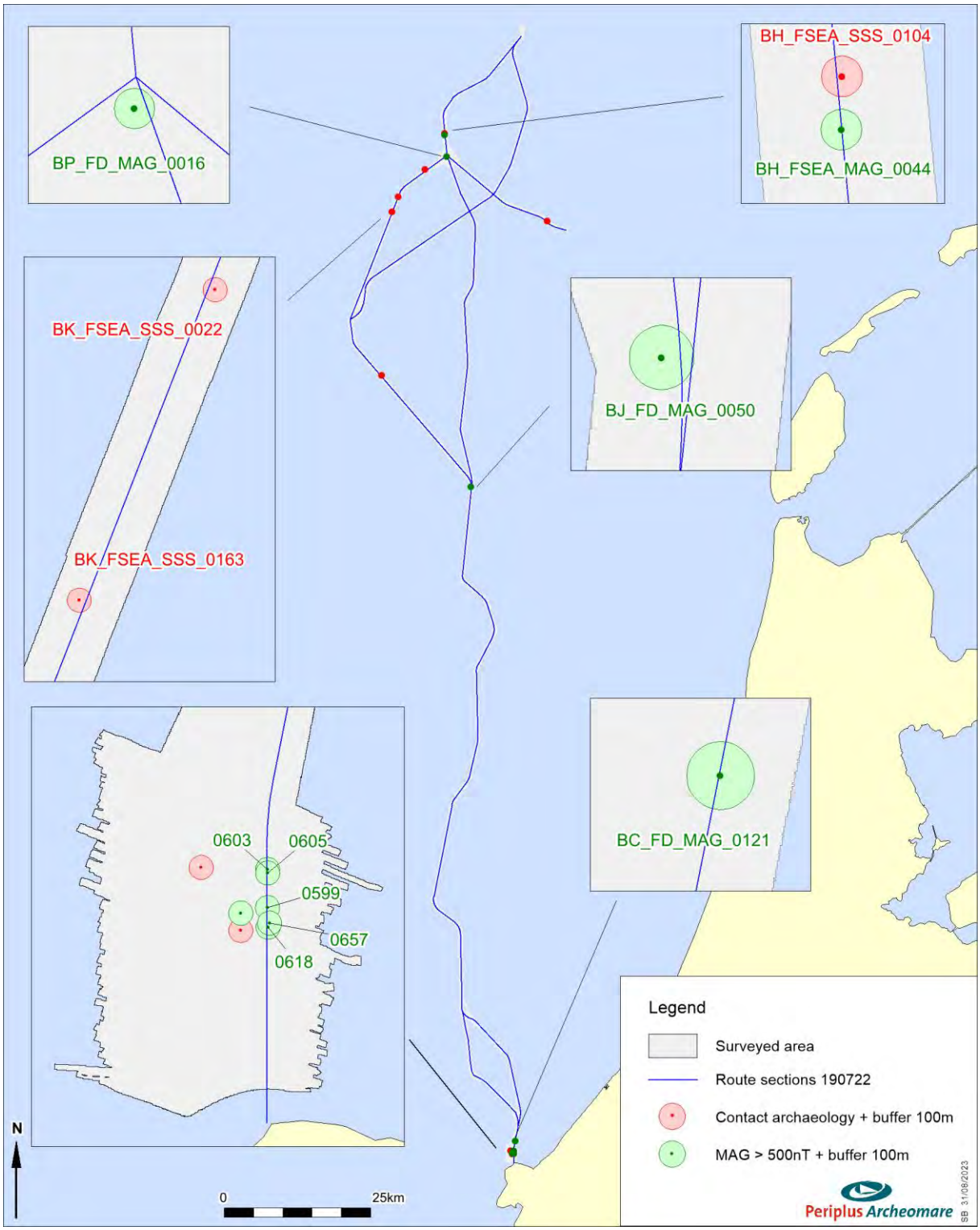


Figure 1. Overview of the potential archaeological targets within 100 meters of the proposed route

Prehistoric remains

Areas of potential archaeological interest listed below.

Depositional environment Areas of potential archaeological interest	Lithostratigraphic Unit	Time of deposition	Archaeological period
Peat-covered aeolian and small scale fluvial deposits	Boxtel Formation	*Late Glacial* and Early *Holocene*	Late Paleolithic and Early Mesolithic
Catchment of the Rhine	Kreftenheye Formation	Pleniglacial	Middle Paleolithic
Shores of lakes and lagoons	Brown Bank Member	Early *Weichselian*	Middle Paleolithic to Early Mesolithic

The physical quality, that is, the integrity and preservation of prehistoric remains is highly dependent on the extent to which prehistoric landscapes and archaeological levels herein have been affected by erosion. The seismic data indicate that part of the *Pleistocene* landscape has eroded during the Early *Holocene* marine ingression, thus affecting the integrity of possible prehistoric settlements. Locally the geological units defined as potential containers of prehistoric remains may have been preserved intact, especially in areas where peat has been found. The interpretation of lithostratigraphic units and the character of the layer boundaries (erosive versus non-erosive) from the seismic data is based on the geological data available and expert judgement. The seismic interpretation shall be ground-truthed by vibrocore sampling. The actual geological sequences present in the area and the integrity of layer boundaries will be verified, thus offering a tool for further analysis of the prehistoric landscapes and specify and test the archaeological potential.

Recommendation

Prehistory

Periplus Archeomare recommends conducting further archaeological research that focuses on the genesis and integrity of paleo-landscapes along the Aramis route trajectories for general archaeological research purposes. This research comprises an inventory of field research by means vibrocore sampling in accordance with the Dutch Quality Standard for Archaeology (KNA Waterbodems 4.1). A geotechnical campaign is carried out to generate a geological model of the subsurface of the pipeline corridor and to determine the physical properties of the sediment layers present. We recommend designating a number of vibrocore locations where sediment samples are collected that can be used for geo-archaeological research.

The intact samples must be examined by a (senior) prospector and described in accordance with the *Standaard Boorbeschrijvingsmethode* (SBB). Samples are selected and stabilized to be analyzed by specialists in the field of OSL and radiocarbon age dating, sediment petrography, palynology, micropaleontology (foraminifera, ostracods, diatoms, et cetera), macro-remains of plants and animals and molluscs to gain insight into the development of landscapes over time and the extent to which these paleolandscapes have been preserved.

In accordance with the Dutch Quality Standard for Archaeology (KNA Waterbodems 4.1), a Program of Requirements (PvE) and / or Plan of Action (PvA) must be drawn up. The PvE/PvA includes the objective, the research strategy and methodology, the frameworks and the practical implementation of the research, so that the process runs smoothly, and multiple use of the data acquired in a uniform manner is achieved. It is advised to submit this PvE / PvA for approval to the Competent Authorities and the RCE. After completion of the inventory field research, during the construction of the pipeline, data can be collected

that - from an archaeological point of view - provides valuable information at a detailed level. It can be very useful to investigate this information further from an archaeological point of view. It is advised to investigate the possibilities for this in consultation with the RCE, once the plans have been worked out.

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. We recommend passive archaeological supervision based on an approved Program of Requirements. Passive archaeological supervision means that an archaeologist is not present during the execution of the work but always available on call. Following this recommendation would prevent delays during the work when unexpectedly archaeological remains are found. In accordance with the Erfgoedwet, it is required to report those findings to the enforcing authority (Minister of OCW). This notification must also be included in the Scope of Work.

1 Introduction

TotalEnergies Nederland B.V. has contracted Periplus Archeomare B.V. to conduct an archaeological assessment of geophysical survey results of the Aramis pipeline route survey.

The area of investigation (243 km^2) is located in the North Sea, and runs from Maasvlakte II to offshore block L4 over a distance of 192 km.



Figure 2. Location map of the area of investigation

1.1 Background

TotalEnergies plans to build a new pipeline from Maasvlakte 2 to offshore blocks L4/K6 as part of the Carbon Capture and Storage (CCS) project Aramis. The CCS system will consist of an onshore pipeline, the compressor station, an offshore pipeline and the storage of CO_2 in the deep subsoil of the North Sea (figure 3). The capture of CO_2 from the harbour's industries and the use of CO_2 of the storage of it underground is one of the measures to achieve the climate objectives. The area to be surveyed encompasses:

(1) the shore approach/Landfall pipeline routing for HDD and dredging part at Maasvlakte
(2) the offshore rigid pipeline routing from Maasvlakte to blocks L4/K6
(3) the offshore distribution hub[1].

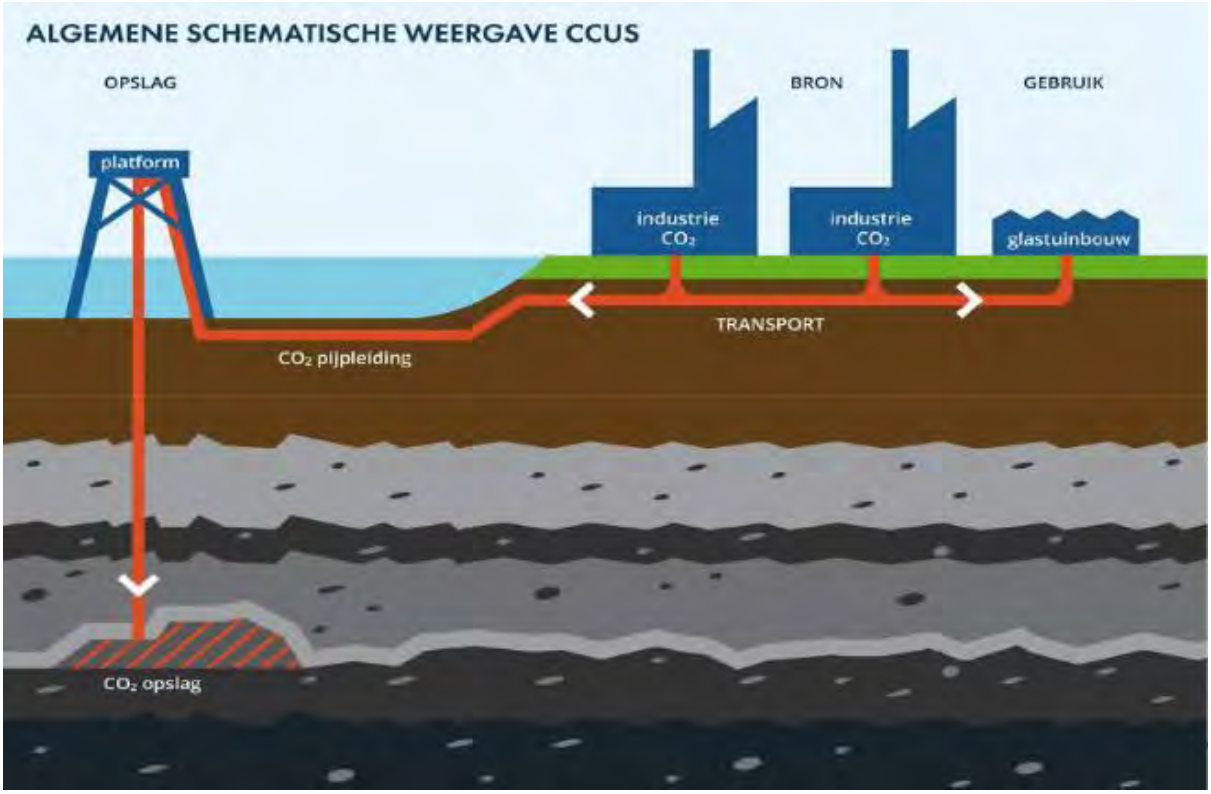


Figure 3: Schematic representation of the transport and storage system.

Offshore, the proposed 32 inch pipeline will be trenched into the seabed to a maximum depth of one meter[2].

In the Erfgoedwet[3] the protection of the archaeological heritage is embedded. Planned activities, such as the installation of a pipeline in the North Sea, may affect the archaeological values if present. If the remains are in jeopardy, there is a statutory obligation to conduct archaeological research. In line with this obligation an archaeological desk study has been carried out.

[1] Porthos project

[2] Concept Notitie Reikwijdte en Detailniveau Aramis CO2-transportinfrastructuur

[3] De Erfgoedwet became effective on the 1st of July 2016.

An archaeological desk study is the first step in the so-called *AMZ* cycle (Archeologische Monumenten Zorg). The *AMZ* cycle includes a description of procedures for subsequent phases of archaeological research to be performed in order to ensure the protection of archaeological heritage in the Netherlands.

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. The survey executed by Fugro was not primarily set to provide data to be used in the course of archaeological research. However, a scan of the survey data acquired, prove these data to be fit for an archaeological assessment.

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 4.

1.2 Results desk study

In January 2022 an archaeological desk study has resulted in specific information on the archaeological remains which are to be expected within the entire area of interest of the Aramis pipeline[4]. The results of the desk study will be discussed below.

The area of interest has high expectations for the presence of (remains of) ship wrecks and WWII plane wrecks. Intact prehistoric landscapes and related *in situ* remains of Palaeolithic and Early Mesolithic camp sites and inhumations are expected to have been preserved in places.

The proposed pipeline routes have not been investigated by detailed geophysical surveys yet. These areas may contain more undiscovered shipwrecks or remains of shipwrecks than are currently known.

At this stage little is known about the integrity of the *Pleistocene* landscape. By means of subbottom profiling the occurrence geological units (both horizontal as vertical) and archaeological levels herein can be mapped. The character of layer boundaries (erosive or non-erosive) can be interpreted. It is unlikely however that archaeological remains of Paleolithic and Mesolithic camp sites can be identified with sufficient certainty (based on the geophysical and geotechnical surveys) to impose restrictions on pipeline development. At this stage focus should therefore not be put on tracing prehistoric camp sites but on a pragmatic employment of geophysical techniques in order to obtain a better insight in (the integrity of) the *Pleistocene* landscape. The insights gained shall be used to a) refine the archaeological expectancy model and b) allocate areas with a high expectancy for *in situ* prehistoric remains.

In accordance with the AMZ cycle it is advised to conduct a field investigation (in Dutch '*Inventariserend veldonderzoek opwaterfase*') in order to test the archaeological predictive model and further specify the type, vertical and lateral extent, age, integrity and preservation of shipwrecks, prehistoric landscapes and potential archaeological levels.

[4] Van den Brenk en van lil, 2022

Archaeological Expectancy	Method		Goal	Remarks
Ship and aircraft wrecks	Geophysical	Side Scan Sonar	detect and map wreck sites	wrecks exposed at, or protruding from the seabed
		Multibeam	characterize wreck sites morphologically; detect (partially) buried wrecks by the occurrence of scours	in addition to side scan sonar
		Sub-bottom Profiler	detect buried objects including possible shipwrecks and remains of aircraft	nature of the buried object cannot be determined directly
		Magnetometer		
Prehistoric settlements (camp sites)		Sub-bottom Profiler	map the Pleistocene landscape; specify expectancy	supported by, and validated with drill data
	Geotechnical	Geological Sampling	determine lithostratigraphy, soil layer boundaries (erosive or gradual) and characteristics of soil formation and maturation; specify expectancy	designation of borehole and/or vibrocore locations for geo-archaeological research based on SBP data
		Cone Penetration Test	determine lithostratigraphy	correlate with drilling data

In general, similar investigations carried out in the past consist of a geophysical survey with *side scan sonar*, *magnetometer* and *subbottom profiler* and a geotechnical survey. The resulting data should be assessed after the general processing, interpretation and reporting has been performed by the survey contractor.

The archaeological assessment of the data shall be conducted by a geophysical specialist (KNA prospector Waterbodems). The data quality from the surveys needs to match the demands for this archaeological assessment. To ensure compatibility between the site investigation and the required quality for this assessment it is recommended to define a Program of Requirements (In Dutch: 'Programma van Eisen') in accordance with the 'KNA' (the Dutch quality standards for archaeological research), to be authorized by the competent authority.

1.3 Objective

The purpose of the archaeological assessment is to test the desk study-based expectancy for archaeological remains in the area. The expectancy covers remains of shipping related objects (wrecks), airplanes from World War II and prehistoric settlements.

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;
- Assess the prehistoric landscape based on seismic data.

1.4 Research questions

For the inventory archaeological field study, the following research questions have been defined in the Program of Requirements[5].

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 marine 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? Based on this relationship can risk-prone areas be marked selectively?
- 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 the seismic data:

- What is the depth of the top of the Pleistocene and Holocene landscape(s) relative to a) LAT and b) the present seabed?
- What lithostratigraphic units can be distinguished along the pipeline routes?

The answer to this question shall include information on:

- the classification,
- the occurrence (lateral extent and depth),
- the lithologic and stratigraphic characteristics,
- the age and depositional environment,
- the character of the layer boundaries (gradual or instantaneous |erosive) of these units.

- Are channel-like features observed?

If so:

- What are the characteristics of the channel-like features in terms of spacial distribution (width, depth, shape, extent), channel infill composition, stratigraphic position and age.

- Are occurrences of peat and/or organic clay observed?

[5] Van den Brenk and van Lil, 2022.

If so:

- What is the spacial distribution (depth, extent) stratigraphic position and age of these deposits.

- Are intact prehistoric landscapes 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 their correlation with side scan sonar, magnetometer en multibeam data can something be said about the nature of these buried objects?

2 Methodology

2.1 Introduction

As part of the installation of the pipeline, a geophysical and geotechnical survey has been carried out by Fugro. The aim of the survey was to contribute to the bathymetrical, morphological, and geological understanding of area of interest, as defined in the scope of work. The results have been compiled in a survey report[6].

This geophysical survey provides the information needed for the planning and preparation of the geotechnical survey. The outcome of the geotechnical survey will be combined with the seismic data to create an Integrated Ground Model (IGM).

The following methods have been deployed:

- Side scan sonar (SSS)
- magnetometer (MAG)
- multibeam echo sounder (MBES)
- sub-bottom profiler (SBP)
- ultra-high resolution seismic (UHR)

The results of the survey and geotechnical activities have been recorded in reports, listings, drawings, and images. Prior to the execution of the archaeological assessment the quality and completeness of the delivered survey data have been judged. It is concluded that the data is of high quality and that the data are fit for the purpose of this archaeological assessment.

SSS	- event listings containing all contacts observed. - Geotiffs mosaics of all contacts listed
MAG	- event listings containing all anomalies observed
MBES	- validated *multibeam* XYZ point cloud dataset (grid 25x25cm)
SBP/UHR	- representative subbottom profiles
Report	- survey reports

Table 4. Data used for archaeological assessment.

[6] Fugro report F192961_REP_007 01, rev 00, 23 September 2022.

2.2 Geophysical survey

The geophysical survey was carried out by Fugro between July 2022 and April 2023. For the execution of the survey the vessels '*MV Fugro Discovery*', '*MV Fugro Seeker*', and the '*Fugro Searcher*' were employed. An overview of the survey campaign and the employed methods is presented in the table below.

Region	Survey Type	Vessel	Survey		Survey Methods
			Start	End	
Offshore	Geophysical	MV Fugro Discovery	11-11-2022	12-12-2022	Multibeam (MBES), Sub Bottom Profiler (SBP), Side Scan Sonar (SSS), Two-dimensional Ultra-heigh Resolution (2DUHR), and Magnetometer
Nearshore	Geophysical	MV Fugro Seeker	11-07-2022	22-09-2022	Multibeam (MBES), Sub Bottom Profiler (SBP), Side Scan Sonar (SSS), and Two-dimensional Ultra-heigh Resolution (2DUHR)
Offshore	Geophysical	MV Fugro Searcher	09-10-2022	23-01-2023	Multibeam (MBES), Sub Bottom Profiler (SBP), Side Scan Sonar (SSS), and Two-dimensional Ultra-heigh Resolution (2DUHR), and a Sparker
Offshore & Nearshore	Geotechnical	MV Normand Mermaid	11-11-2022	24-01-2023	CPT and Vibrocore
Offshore & Nearshore	Geotechnical	MV Kommandor Orca	02-12-2022	12-12-2022	CPT and Vibrocore

Table 5. Overview of the survey campaigns and the employed survey methods (source: Fugro report F197217-REP-001 | 01 | 18 April 2023).

77 geotechnical locations were investigated during the geotechnical surveys. All locations comprise of Vibrocore (VC) and Cone Penetration Test (CPT).

Details about the geophysical and geotechnical surveys can be found in the integrated Geophysical and Geotechnical reports in Appendix 3

2.3 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 a number of objects within the area is known, as described in the desk study[7]. 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 SR database);
- The Dutch Cultural Heritage Agency database ARCHIS;
- The Dutch Nationaal Contact Nummer database (hereafter referred to as NCN);
- 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.

[7] Van den Brenk en van lil, 2022

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 Zee en Delta).

In addition to shipwrecks, information on contacts referred to as 'foul' or 'obstruction' are included. From these objects the origin is not always known, but information on the location, dimensions and other valuable information is listed. Besides the databases other sources containing information on wrecks and historic finds are consulted for comparison with the survey results.

All known data is combined and plotted in 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.

2.4 Archaeological assessment of survey data

The geophysical and hydrographic survey techniques employed include *side scan sonar* (SSS), *magnetometer* (MAG), *multibeam* (MBES), subbottom profiling (SBP) and ultra-high resolution multi-channel seismic (UHRS). The natures of those methods differ, with coherent strengths and weaknesses.

Table 6 provides a summary of the objective(s) the methods employed and the nature of those methods in terms of seabed penetration and coverage. Data are cross correlated because the methods are complementary. E.g., *multibeam* data can aid in the interpretation of a *side scan sonar* contact by providing information on its height with respect to the surrounding seabed, the occurrence of scouring next to the contact, and the accuracy and precision of the object. CPT's, borehole and vibrocore data will aid in the determination of geological units from seismic strata.

Method	Objective	Seabed		Accuracy and Precision	Cross Correlation
		Penetration	Coverage		
SSS	Identification of outcropping objects; seabed classification	No	Full	High	MBES / MAG
MBES	Charting of seabed morphology; identification of scours	No	Full	Very high	SSS
MAG	Identification of magnetic anomalies induced by ferromagnetic objects	Yes*1	Full*2	Accuracy = high Precision = poor*3	SSS
SBP/UHRS	Identification of seismic strata and buried objects such as pipelines, cables and boulders	Yes	No Profile data beneath sailed line	High	BH/VC/CPT*4 MAG
BH/VC	Determination physical properties of sediments and lithostratigraphy	Yes VC appr. 5 m bsb BH 60 to 80 m bsb	No Point location	High	CPT/ SBP/UHRS
CPT	Determination of physical properties of sediments and lithostratigraphy	Yes Up to 50 to 80 m bsb	No Point location	High	BH/VC/ SBP/UHRS

Table 6. Characteristics of geophysical and geotechnical methods employed.

NOTE:

*1 detection dependent on size of the ferromagnetic object, depth of burial, height of *magnetometer* above the seabed and distance cross course.

*2 distant and/or deeply buried objects can be missed.

*3 accuracy: perpendicular to ship heading = ½ * spacing of sailed lines; parallel to ship heading = approximately 1 m.

*4 interpretation of geology through correlation of seismic data with BH/VC/CPT-data.

With *side scan sonar* all objects and structures on the seabed can be made visible. Seabed sediment of different composition can be distinguished by their characteristic reflection. *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.

The strength of *side scan sonar* resides in the ability to visualize differences in reflectivity of seabed sediments and exposed objects. Variations in seabed composition cannot be observed in *multibeam* data, unless those variations are accompanied by morphological changes. This also applies for objects which are barely elevated above the seabed. Another strength of *side scan sonar* is the full coverage which is accomplished with a limited number of survey lines. A limitation of *side scan sonar* buried objects cannot be found with this technique.

The strength of *multibeam* lies in the high accuracy and high precision images of the seabed morphology the technique provides. Sand waves and current ripples can clearly be observed in *side scan sonar* data, but the height of those sedimentary structures can far better be established by means of *multibeam*. However, buried objects generally cannot not be traced with *multibeam*, scours caused by shallowly buried objects can lead to the identification of buried objects.

In this study *side scan sonar* and *multibeam* data were combined in the identification of objects which are of potential archaeological interest. The listing of potential archaeological objects is considered to be complete as far as it concerns exposed objects, although the presence of buried non-ferro-magnetic archaeological objects or objects which erroneously have been labelled as non-archaeological, can never be fully excluded.

Magnetometer contacts are identified by the presence of ferro-metallic objects which induce an anomaly in the earth magnetic field. These objects can be buried or lying 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 70-meter spacing of the run lines the precision perpendicular to the line is in the order of 35 meter. The precision parallel to the run line is in the order of one meter.

The strength of a *magnetometer* lies in its ability to trace buried objects, if those objects are ferro-magnetic. The technique provides a strong tool in mapping continuous linear structures like buried cables and pipelines. Also, an indication of the presence and distribution of isolated ferro-magnetic objects in an area of investigation is obtained.

An important limitation of the *magnetometer* is the poor accuracy and precision of the positions, size and weight of the objects found. An object must be boxed in by sailing additional lines with a *magnetometer* to pinpoint the location of the object. The measured amplitude of a magnetic anomaly is determined by different parameters, such as the size of the object, the depth of burial, the height of the *magnetometer* above the seabed and the distance cross course. Because the measured anomaly is influenced by multiple unknown parameters it is a priori not possible to deduce the size | iron content of the object from the measured anomaly. Magnetic anomalies are in many cases induced by buried objects. From the character of the magnetic anomaly (monopole or dipole) it is not possible to identify the nature of this buried object.

The listing of *magnetometer* anomalies is expected to be complete as far as it concerns large ferro-magnetic objects. As the line spacing employed is 100 meters it cannot be excluded that especially small distant buried objects have been missed.

Fugro processed their survey data and produced detailed event listings of the *side scan sonar* and *magnetometer* contacts encountered within the survey areas. Like the known objects the locations of the contacts are plotted in a GIS.

In the course of this archaeological assessment a selection was 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 (4) meters is investigated in more detail, because these objects are considered to be more likely to be related to wreck sites than the smaller contacts. This choice is based on best professional judgment and not prescribed by legislation or the KNA. The 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;
- raw *side scan sonar* data (XTF-files);
- raw *multibeam*-data (xyz-files);
- 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 considered 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 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) and an ultra-high resolution multi-channel sparker (UHR). The processing involved an analysis of seismic profiles which had a line spacing of 70 m for both the main lines and the cross lines. Observed seismic strata have been digitized and – based on known geological data from the area – lithostratigraphic units have been identified. The base of each lithostratigraphic unit has been interpolated into a grid. The results have been summarized and reported. In addition to the identification and occurrence of lithostratigraphic units, seismic anomalies which are expected to reflect potential hazardous phenomena have been identified.

2.5 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 cross-reference it was assumed that all present possible contacts and anomalies have been reported and described by the survey contractor. The raw data was used only 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. For the *magnetometer* contacts that corresponded with the *side scan sonar* contacts within 50 meters of each other, these contacts were related. When in the vicinity of a magnetic anomaly no visible object was found the size of the anomaly defines whether the buried object causing the magnetic anomaly is of potential archaeological interest. If the magnetic anomaly of a contact is more than 500 nT (nano-Tesla) then it is stated that the contact could possibly be of archaeological value[8]. All the *magnetometer* contacts above 500 nT but within 25 meters of the existing cable and pipeline routes are exempt for further investigation. It must 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 the best 'professional judgment'.

The interpreted seismic data have been assessed 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 grids produced by Fugro have been used to get an insight in 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, zones along the pipeline route which are expected to contain archaeological remains are mapped and presented. The results are reviewed in the context of the activities planned to predict possible influence on the potential archaeological remains.

The analysis was executed in June 2023 by R.W. Cassée (KNA Archaeologist Ma specialism Waterbodems), R. van Lil and S. van den Brenk (both KNA senior prospector). The investigation is carried out according to specifications set up within the Dutch Quality Standard for Archaeology (*KNA Waterbodems 4.1; protocol 4103*).

[8] The designated value of 50 nT to discriminate between anomalies that are induced by objects of possible archaeological value (>50nT) and that are not (<50 nT) is arbitrary. Given the employed lines spacing of 70 m, an anomaly that solely is observed on one survey line could be located within 35 m on either side of this survey line. It is estimated that an iron mass of 1000 kg located at 10 m from the magnetometer will result in a 50 nT magnetic anomaly. On the other hand, an iron mass of 1 kg located within 3 m of the magnetometer will also result in a 50 nT anomaly, albeit that the anomaly with will be less. It is estimated that an iron mass of 100 kg that is located at 30 m from the magnetometer will result in an anomaly of less than 2 nT. This value is often below the limit of detection. If those small values were to be labelled as anomalies caused by objects of possible archaeological interest all magnetic anomalies found in the survey area were to be labelled as such. Therefore, the arbitrary value of 50 nT is chosen, given the current line spacing. If a closer line spacing is used a larger value shall be considered.

2.6 Used Sources

The following sources were used for the analysis:

- Survey data Fugro, original survey data and reported interpretations;
- Archaeological desk study Periplus (19A029-01);
- ARCHIS database Cultural Heritage Agency;
- Archeomare Database;
- Nlhono database Hydrographic Service of the Royal Netherlands Navy;
- Wrecksite.eu;
- Database, Nationaal Contact Nummer (NCN).

For a complete list of used sources and literature see the reference list at page 67.

Italic written words are explained in the glossary at page 65.

3 Results

3.1 Seabed bathymetry and morphology

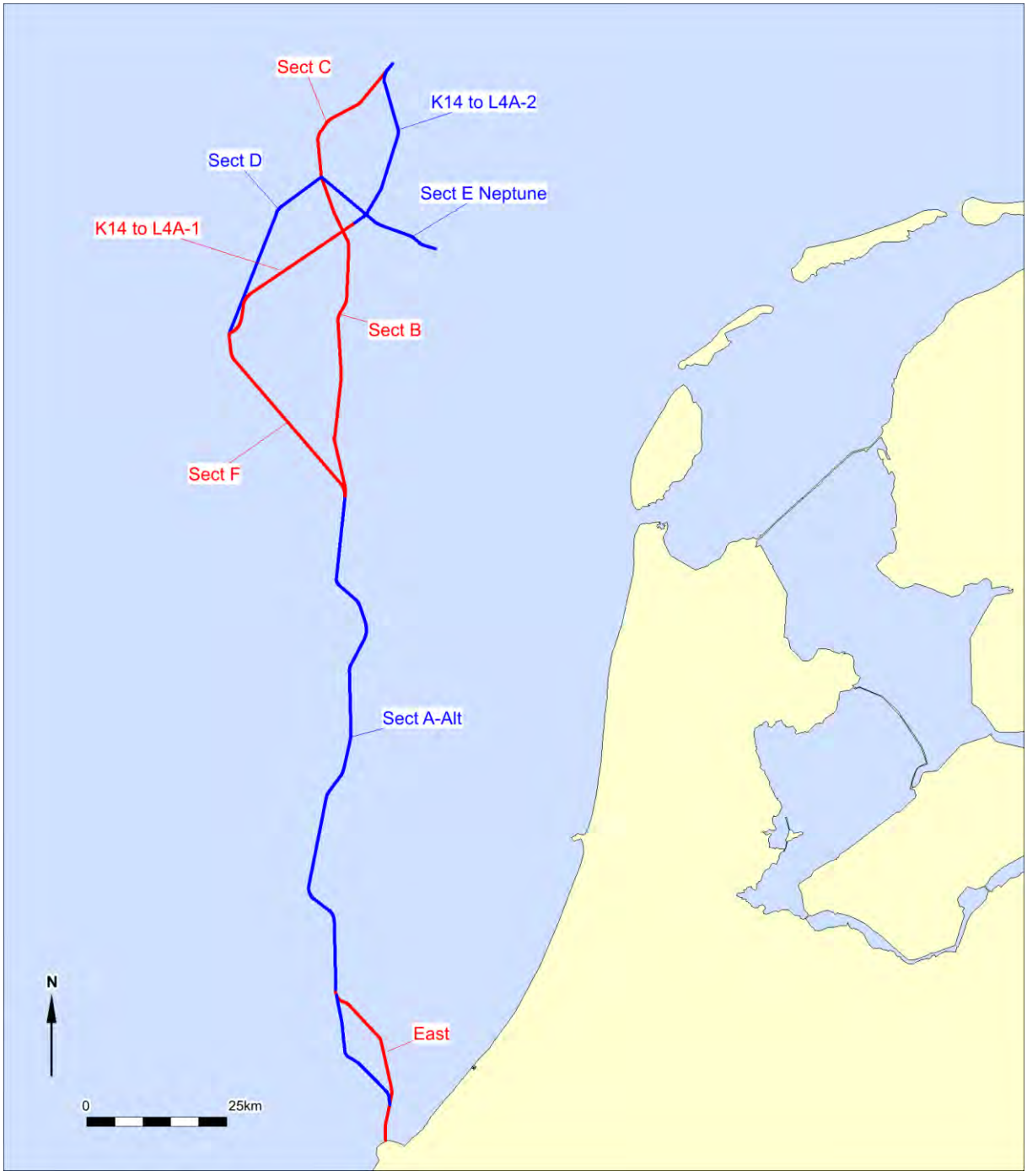


Figure 4. Sections bathymetric profiles based on the multibeam recordings (source data: Fugro 2022)

Based on the 2022 survey data the water depth within the survey corridor varies from 4.8 to 39.6 m, with an average depth of 27.0 m LAT. Bathymetric profiles along the different sections are presented in the next figure.

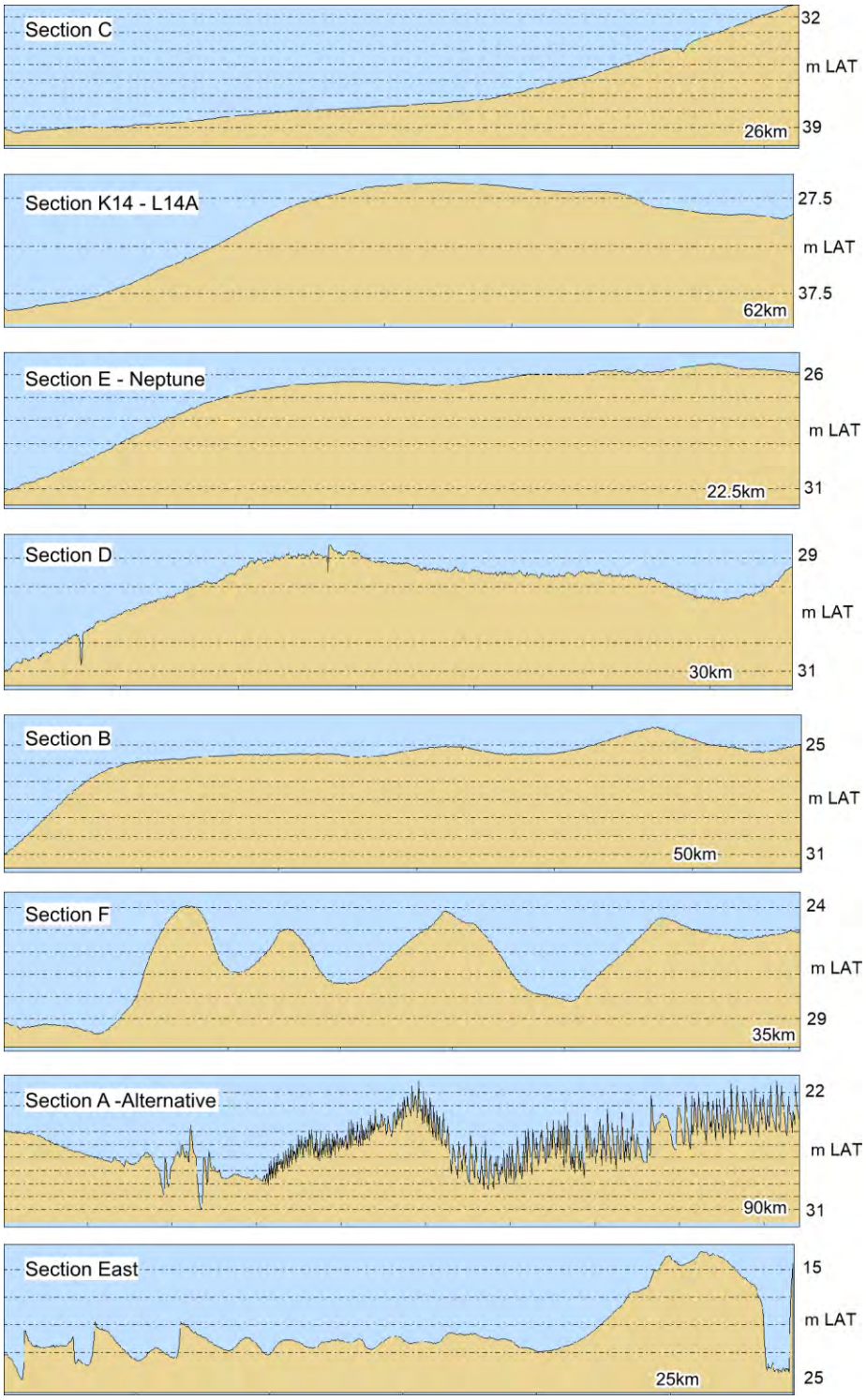


Figure 5. The seabed profiles along the different sections from north to south.

Seabed morphology

The seabed along the route is characterized by a complex pattern of bedforms of various orders. Those bedforms include very large ridges (hereafter sand banks), sand dunes, mega ripples and small ripples. The sand banks are some 2 to 2.5 km wide and stretch more or less north - south. The sand banks are separated by low-lying areas. The difference in height between the troughs and crests of the sand banks is up to 7.5 m. The wavelength of the sand dunes varies, the height of the ranges from 1 m to 3 m. Superimposed on the major sand dunes and sand banks lie mega ripples with an average wavelength of 20 m. The height of the mega ripples ranges from 0.2 m to 0.4 m. The mega ripple crests stretch west northwest - east.

Migration rate

The mobility of the seabed sediments imparts major implications to the prospection of archaeological remains in the area. Wreck remains can be covered by a layer of sandy seabed sediments, as a result the remains are not exposed to the seabed and cannot be traced with *side scan sonar.* Remains can become exposed at a later stage due to the ongoing migration of the sand dunes.

Each of the morphological features in the area has its typical migration rate. The position of the north-south oriented sand banks is fairly stable. Van der Meulen et al. (2004) reported a migration rate for sand dunes of over 20 m/year near the island of Texel, with typical migration rates decreasing southwards to a stationary (0 – 3 m/year) field near the entrance of the Rotterdam Harbour[9]. Deltares studied the migration rate of sand dunes in the Prinses Amalia WFZ and concluded that the dunes in this area migrate some 4 m/year[10].

To assess the migration rate of sand dunes in the IJmuiden Ver wind farm zone a comparison of *multibeam* data acquired 30 days apart was made. Within this short period of time a sand dune had migrated two meters and the shape of the sand dune had altered[11].

[9] Meulen, M.J. van der, et al. 2004.

[10] Fugro survey report P904162, Volume 3.

[11] Van Lil et al. 2023

3.2 Known objects: As Found positions versus database positions.

In the archaeological desk study report a total of 316 archaeological records, 458 shipwrecks, and 3494 other known objects have been reported.

However, the survey area (243 km^2) is considerably smaller than the area which had been defined as area of investigation for the archaeological desk study (11.355 km^2). Additionally, since the finalization of the archaeological desk study, new objects have been added to the NCN-database. The known objects which, according to their database positions are located within the survey area are listed in the table below.

Type	amount
Anchor with chain	2
Seabed distortion	9
Cable or chain	27
Unidentified object	124
Boulder	1
Wreck and wreck remains	8
Total	**171**

Table 7. Known objects within the surveyed area.

The SSS and MBES contacts and the 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. To conduct this comparison all SSS contacts and MAG anomalies found within a range of 25 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.

Known NCN objects found

A total of 37 out of 171 known NCN objects were found during the survey.

NCN	Contact type	E	N	Survey_ID
219	Wreck remains	570384	5762003	BB_FS_SSS_0683
531	Wreck	559172	5935317	BH_FSEA_SSS_0104
967	Wreck remains	550165	5921956	BK_FSEA_SSS_0163
4543	Unidentified object	571058	5762056	BB_FS_MAG_0458
4547	Unidentified object	570585	5761590	BB_FS_SSS_0483
4559	Unidentified object	570645	5763097	BC_FD_MAG_0089
4623	Unidentified object	571139	5761040	BB_FS_MAG_0080
8099	Unidentified object	570782	5761179	BB_FS_MAG_0083
8104	Cable / Chain	570716	5761482	BB_FS_SSS_0433

NCN	Contact type	E	N	Survey_ID
8111	Unidentified object	569849	5761781	BB_FS_MAG_0129
8120	Unidentified object	570177	5761705	BB_FS_MAG_0164
8121	Cable / Chain	570729	5761506	BAB_FS_UXO_0074
13434	Unidentified object	571042	5761479	BB_FS_SSS_0431
13881	Unidentified object	570170	5761683	BB_FS_MAG_0139
13882	Unidentified object	570722	5761528	BAB_FS_UXO_0033
17443	Cable / Chain	570751	5760384	BB_FS_SSS_0019
17446	Unidentified object	569970	5761679	BB_FS_SSS_0513
17852	Unidentified object	570668	5761516	BB_FS_MAG_0147
17863	Unidentified object	570285	5761300	BB_FS_SSS_0307
17866	Unidentified object	570283	5761184	BB_FS_SSS_0241
17870	Seabed distortion	569820	5761550	BB_FS_SSS_0465
17873	Cable / Chain	570079	5761633	BB_FS_MAG_0106
17883	Unidentified object	571009	5761365	BB_FS_SSS_0355
19203	Unidentified object	570846	5761183	BB_FS_MAG_0089
19214	Unidentified object	570608	5761553	BB_FS_SSS_0464
19222	Unidentified object	571021	5761490	BB_FS_SSS_0439
19585	Unidentified object	562818	5899439	BF_FD_SSS_0019
20270	Unidentified object	571246	5761234	BB_FS_MAG_0141
20279	Seabed distortion	570157	5761591	BB_FS_SSS_0481
20280	Unidentified object	570772	5761331	BB_FS_SSS_0328
20282	Unidentified object	570154	5761363	BB_FS_SSS_0374
20283	Seabed distortion	570757	5760383	BB_FS_SSS_0019
20288	Unidentified object	571165	5761318	BB_FS_MAG_0143
29706	Unidentified object	569875	5762289	BB_FS_SSS_0835
33006	Unidentified object	563254	5896797	BF_FD_SSS_0026
33416	Unidentified object	558944	5814439	BD_FD_SSS_0218
33993	Cable / Chain	570971	5761365	BB_FS_SSS_0363

Table 8. As Found NCN objects

Known wrecks found and not found

NCN	E	N	Description	Arch value	Survey_ID
219	570384	5762003	Fishing vessel reported lost in 1945	Unknown	BB_FS_SSS_0683
531	559172	5935317	Wreck reported in 2011. 24x11x2.5m	Unknown	BH_FSEA_SSS_0104
967	550165	5921956	HMS Ivanhoe, sunk 01-09-1940 (ARCHIS ID 4030384100)	Yes	BK_FSEA_SSS_0163
1133	564181	5917118	Wreck reported in 1941, not found during several surveys	No	(not found)
1822	571084	5760899	Sailing vessel Lindis Farne, sunk 03-01-1908. Wreck cleared away according to Hydrographic service	No	(not found)
1902	569952	5777662	Wreck reported in 1945, not found during several surveys	No	(not found)

NCN	E	N	Description	Arch value	Survey_ID
2113	566176	5846859	Steam ship Nipponia, sunk 13-10-1908. Wreck cleared away to a depth of 17 m in 1909. Remains not found during several surveys	No	(not found)
32851	570262	5762370	Motorvessel Clearwater, sunk 29-08-1968. Wreck raised in 1968 according to Hydrographic service	No	(not found)

Table 9. Known shipwrecks found and not found

The five shipwrecks that have not been found during the survey are probably in a different location or completely salvaged in the past, because they were also not found during previous surveys. If they were covered in the seabed, this would have resulted in magnetic anomalies at the locations.

Examples of the shipwrecks that have been found are presented below.

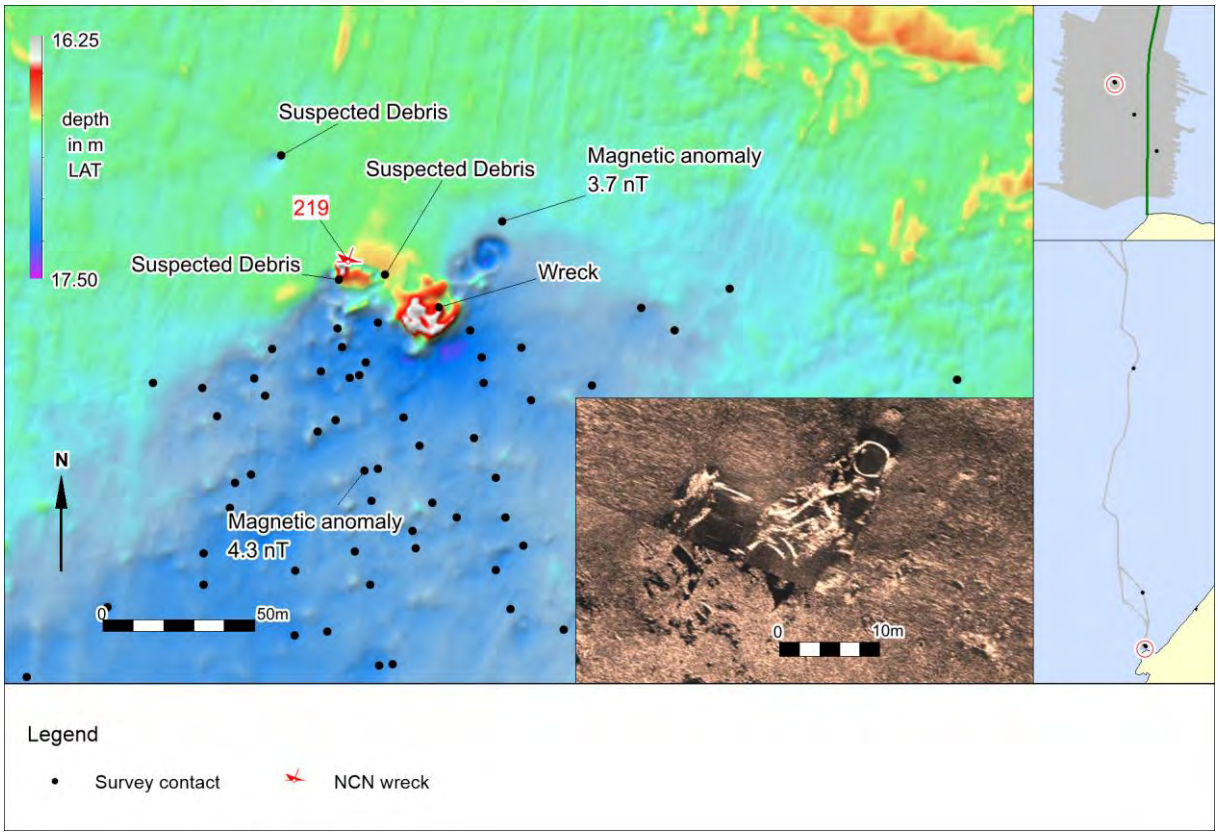


Figure 6. Multibeam image of NCN 219

NCN 219 represents the location of a fishing vessel reported lost in 1945. Both side scan sonar en multibeam images show an area of 22 x 20m scattered with debris at a depth of 17m LAT. Relatively small magnetic anomalies are observed in the surroundings of the area. The location is situated 544 meter west of the proposed route section C-East. The possible wreck remains have not been identified yet, so the archaeological value is not known. It is advised to avoid this location including a buffer zone of 100 meters during pipeline construction.

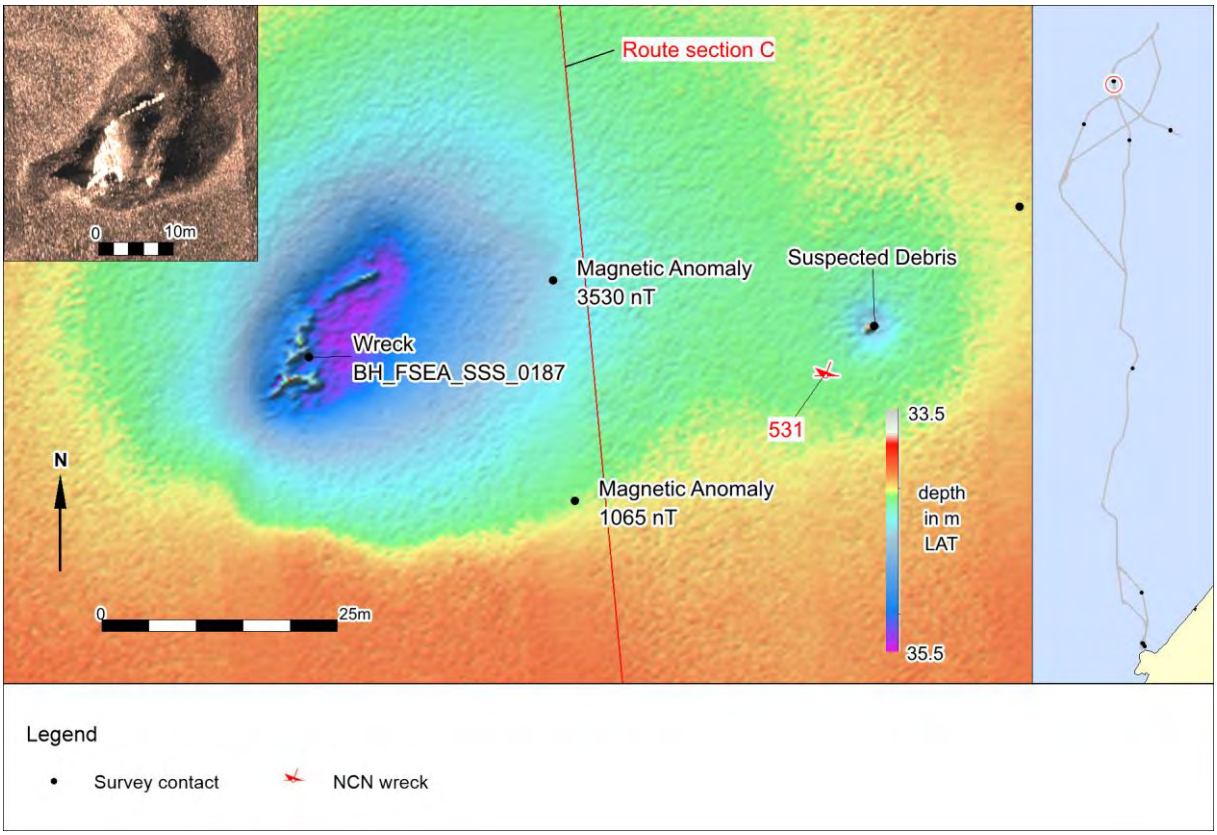


Figure 7. Sonar and multibeam image of NCN 531

NCN 531 is an unidentified wreck reported by the Hydrographic Office in 2011. Both side scan sonar en multibeam images show an area of 63 x 18m at the theoretical location of NCN 531 with a large structure in the west and a smaller object in the east at a depth of 34m LAT. Both locations lie within 30 meters of the proposed route (Section C) In between, very large magnetic anomalies are observed suggesting buried remains. The possible wreck remains have not been identified yet, so the archaeological value is not known. It is advised to avoid this location including a buffer zone of 100 meters during pipeline construction.

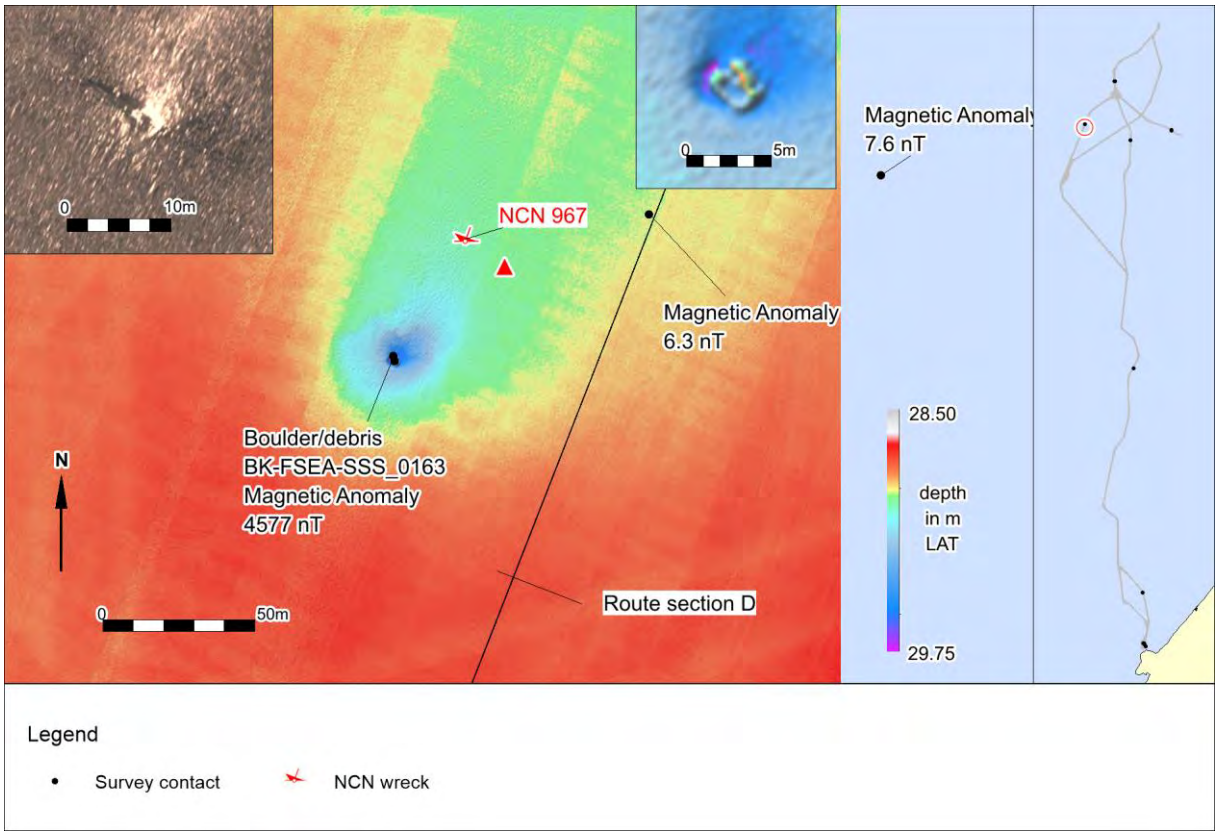


Figure 8. Sonar and multibeam image of NCN 967

Contact BK-FSEA-SSS-0163 is a square object of 2.9 x 2.6 m at a depth of 29m LAT surrounded by scouring. At the location, a very large magnetic anomaly of 4577 nT was observed. Smaller anomalies lie to the east of the object and may present buried wreck remains. The object is located within 50 meters of the theoretical position of NCN 967. This represents the wreck of the HMS *Ivanhoe*, a British destroyer built for the Royal Navy in the mid-1930's. Together with sistership HMS *Esk* it hit a mine on August 31, 1940 and sunk. The location of the wreck of the HMS ESk is confirmed and lies 2900m to the east.

The location is situated 63 meter west of the proposed route section D. If these are the remains of the HMS Ivanhoe, it is considered to be of archaeological value. It is advised to avoid this location including a buffer zone of 100 meters during pipeline construction.

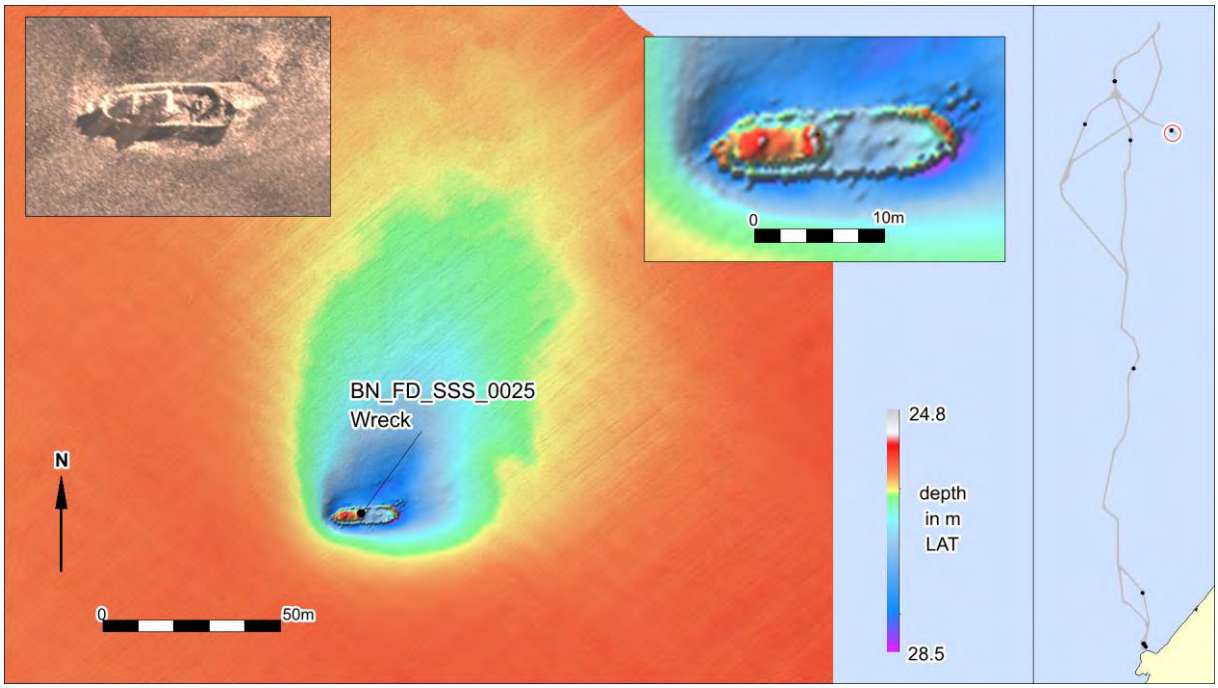


Figure 9. Sonar and multibeam image of contact BN_FD_SSS_0025

Contact BN-FD-SSS-0025 is an unidentified wreck. Both side scan sonar en multibeam images show a clear shipwreck with dimensions of 19.7 x 5.1 x 1.0 m at a depth of 25 m LAT. The location lies 220 m northeast of proposed pipeline section E.

The wreck has the characteristics of a fishing trawler. This might be a known wreck (NCN 945) which theoretical location is situated 200 meters to the north, just outside of the surveyed area. NCN 945 represents the fishing trawler *Stormvogel* (IJM 9) sunk at 7-04-1981 and has no archaeological value.

3.3 Side scan sonar

Fugro has identified 3806 *side scan sonar* contacts within the surveyed corridor. The classification of the contacts is listed below.

Classification	Amount
Boulder	3010
Debris	159
Depression Pockmark	5
Fishing Gear	7
Mattress	2
Pipeline	4
Seabed Mound	98
Suspected Debris	517
Wreck	4
Total	**3806**

Table 10. Side scan sonar contacts identified by Fugro

The objects classified as '*Boulder*' are found throughout the whole surveyed area. These probably also include clay boulders, because known stone boulders in the North Sea only occur north of the city of Den Helder.
All contacts which match known objects have been discussed in the previous paragraph. The remaining *side scan sonar* contacts and images have been scanned and checked for the presence of potential archaeological contacts. This is done by analyses of:

- *Side scan sonar* geotiffs;
- *Multibeam* grids;
- 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.

All side scan sonar contacts greater than four meters in any dimension, 117 in total, have been examined in detail, because these objects are considered to be more likely to be related to wreck sites than the smaller contacts. The purpose of this analysis is to identify contacts that could reflect potential archaeological sites.

A summary of the outcome of the detailed inspection of selected contacts larger than four meters is presented in the table below. It should be noted that the seven contacts that are classified as '*wreck*' refer to four different wrecks, which are already discussed in the previous paragraph. Appendix 3 contains a complete listing of the results of this assessment.

Category	Amount
Anchor	1
Buoy anchor	1
Cable/chain	10
Matress	3
Natural ridge	1
Pipeline	4
Seabed disturbance	11
Shell bed	1
Shipwreck	7
Spudcan depression	4
Unidentified object	74
Total	**117**

Table 11. Results of the assessment of selected side scan sonar contacts

At total of seven side scan sonar contacts larger than four meters are attributed to four different wreck sites (which have been discussed in section 3.2) and three possible new wreck sites. Additionally, one side scan sonar contact is attributed to a large anchor. The summary of the side scan sonar records with potential archaeological interest is listed below.

Feature	Easting	Northing	Fugro	L	W	H	Z	Interpretation PPA
BK_FSEA_SSS_0022	551288	5924521	Boulder	5.6	2.9	5.2	-29.8	Buried remains with magnetic anomalies - wreck remains
BK_FSEA_SSS_0179	555839	5929168	Boulder	6.7	5.7	1.0	-30.3	Large anchor shaft 3.2m arms 2.1m with scouring
BJ_FD_SSS_0015	548443	5894128	Debris	5.6	1.8	0.0	-26.4	Elongated object 5.6m - wreck remains
BB_FS_SSS_0433	570711	5761481	Wreck	4.3	2.4	0.3	-18.9	Oval contact, possibly wreck remains

Table 12. Listing of side scan sonar records with potential archaeological interest.

The results with examples of the four objects are discussed below.

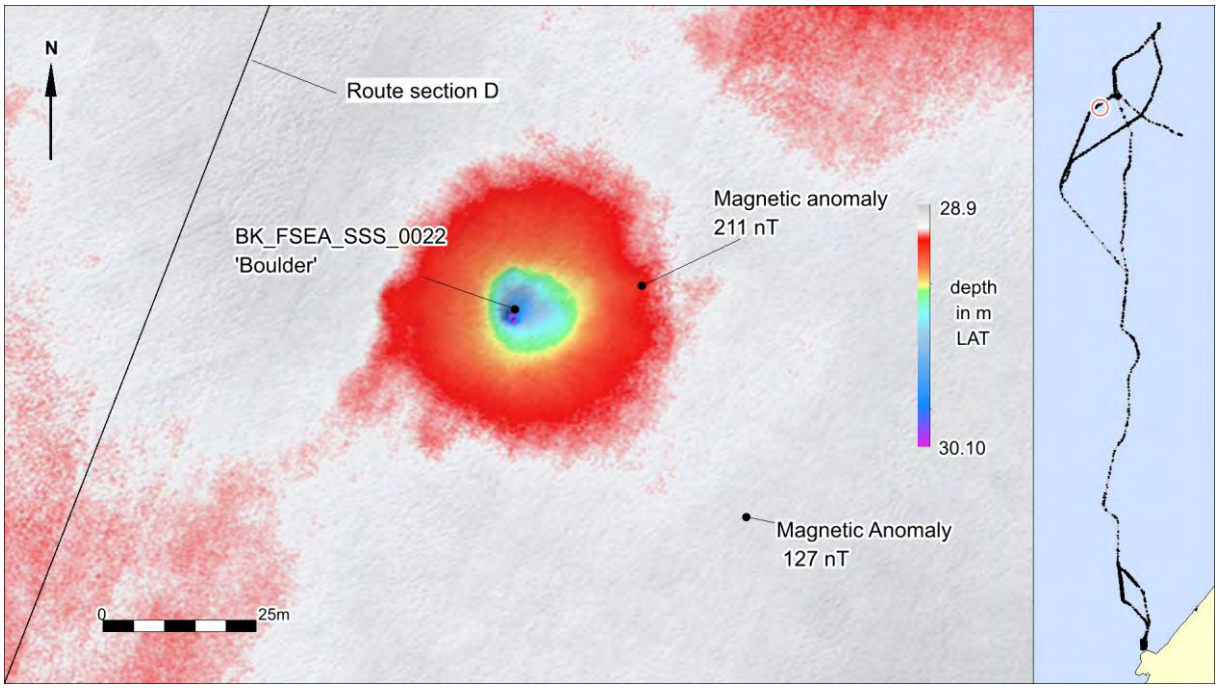


Figure 10. Multibeam image of survey contact BK-FSEA-SSS-022

Contact BK-FSEA-SSS-0022 was interpreted by Fugro as a '*boulder*'. The multibeam image shows an object surrounded by a round scour depression with a diameter of 30 meters and a relative depth of one meter.

Two large magnetic anomalies have been observed to the east of the contact. These might represent a buried structure; possibly unidentified wreck remains. The location lies 55 meters east of route section D.

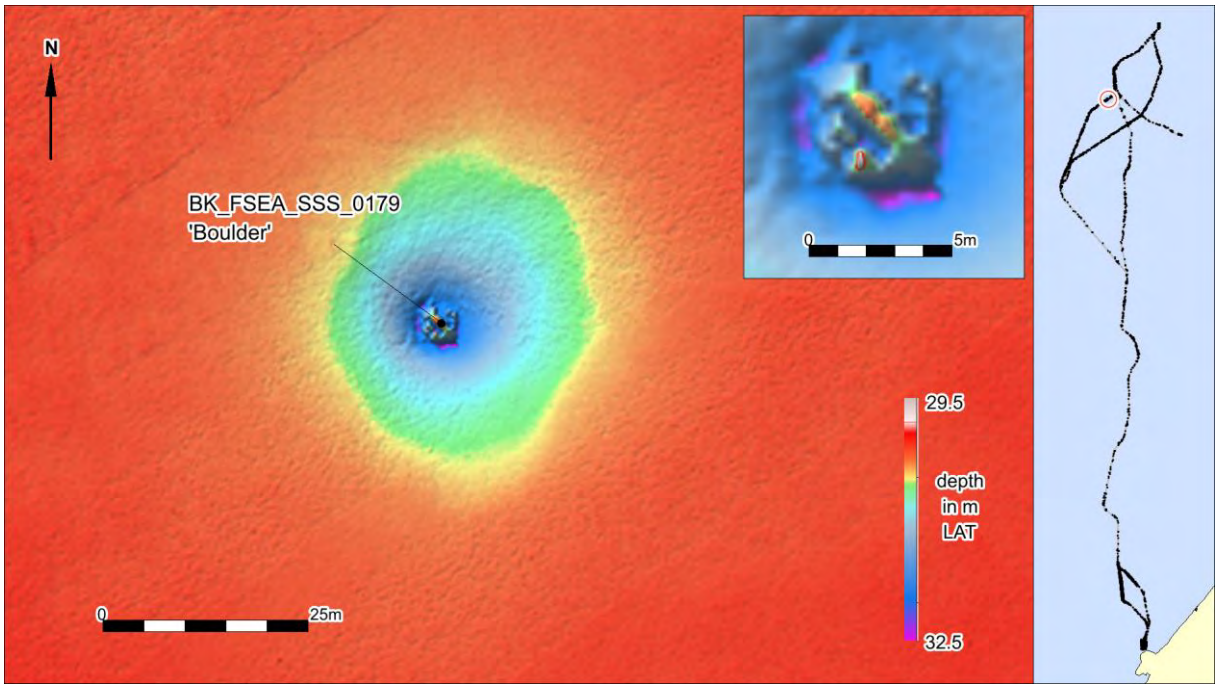


Figure 11. Multibeam image of survey contact BK-FSEA-SSS-0179

Contact BK-FSEA-SSS-0179 was interpreted by Fugro as a '*boulder*'. The multibeam image shows a triangular object surrounded by a round scour depression with a diameter of 20 meters and a relative depth of 1.5 meter. In more detail, the object resembles an anchor with a shaft length of 3.2 meters and arms of 2.1 meters. This might be an historical Admiralty Pattern anchor, or simply "Admiralty", commonly used in the 17th and 18th century. The location lies 240 meters west of route section D.

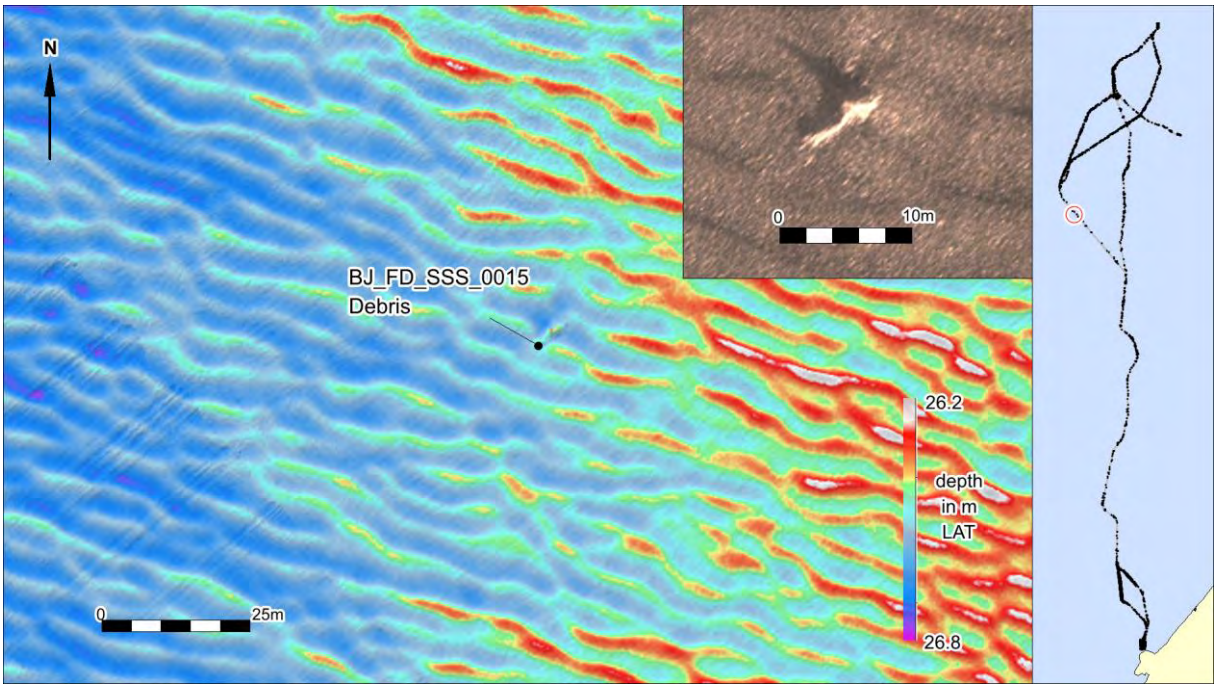


Figure 12. Sonar and multibeam image of survey contact BJ-FD-SSS-015

Contact BJ-FD-SSS-0015 was interpreted by Fugro as a '*debris*'. Both multibeam and side scan sonar images show an elongated irregular object of 5.6 x 1.5 x 1.0 meters perpendicular to the surrounding sand ripples. No magnetic anomalies have been observed in the surrounding area. The object might be the remains of a wreck. The location lies 232 meters east of route section F.

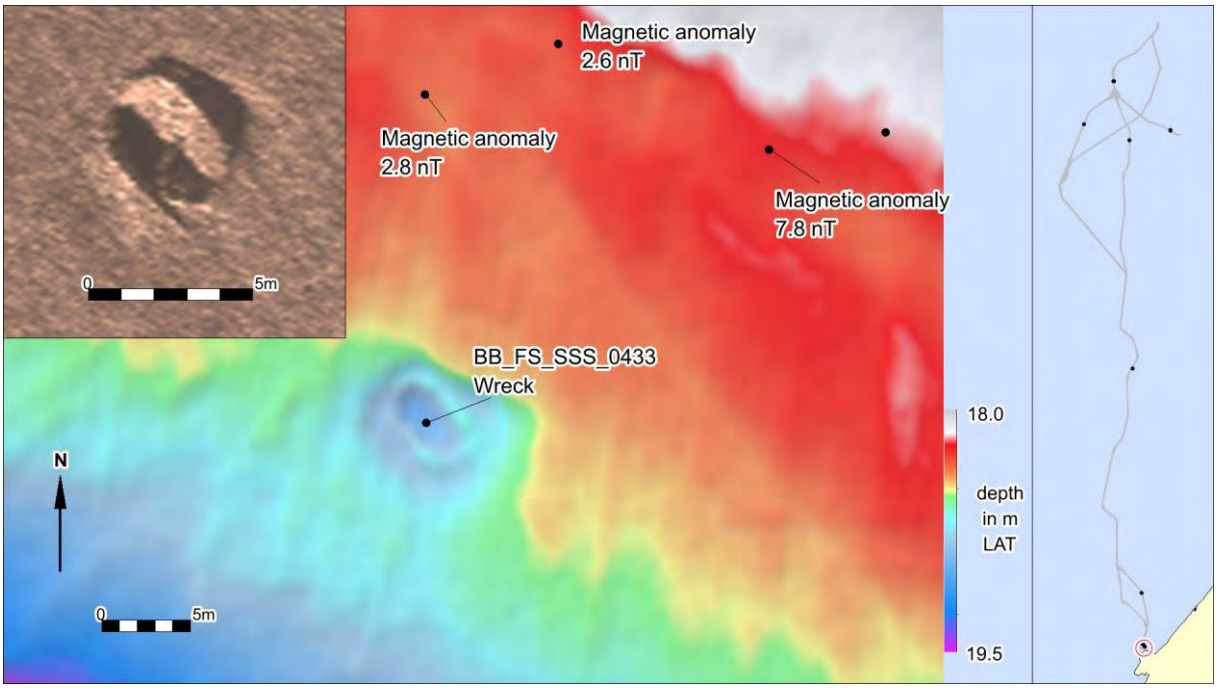


Figure 13. Multibeam image of survey contact BB-FS-SSS-0433

Contact BB-FS-SSS-0433 was interpreted by Fugro as a 'wreck'. Both multibeam and side scan sonar images show an oval object of 4.3 x 2.4 x 0.3 meters surrounded by (relatively small) magnetic anomalies. The object might be the remains of a wreck. The location lies 216 meters west of route section West.

Summary of side scan sonar / multibeam contacts

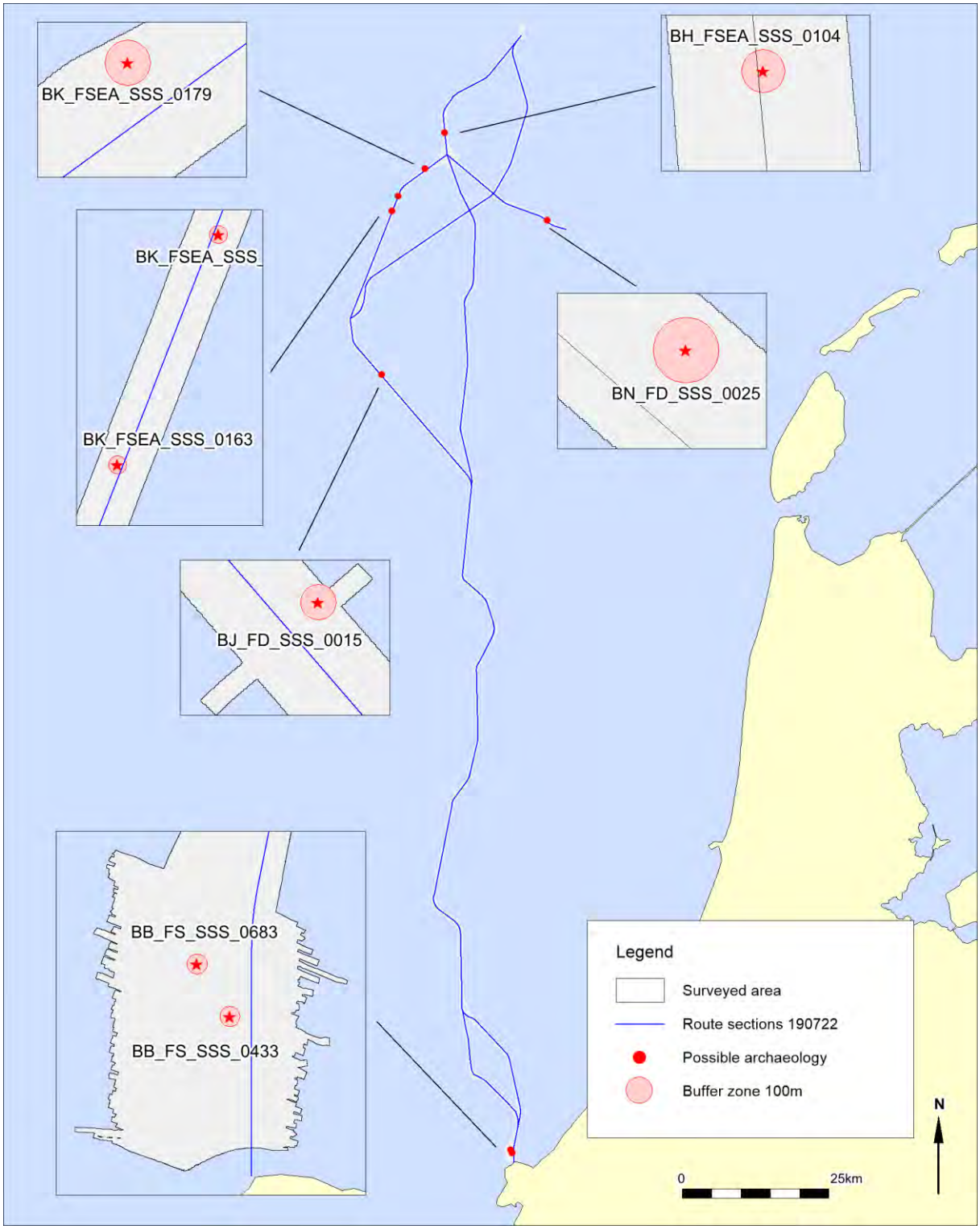


Figure 14. Overview of all side scan sonar / multibeam contacts with an archaeological expectation

3.4 Multibeam

Apart from the *multibeam* images discussed in the previous sections no *multibeam*-features have been observed outside the side scan sonar contacts which are interpreted to reflect the presence of archaeological objects or structures.

3.5 Magnetometer

A total of 2748 magnetic anomalies have been observed within the area of investigation. An overview is given in the next figure.



Figure 15. Spatial distribution of all magnetic anomalies

A number of these anomalies can be related to infrastructure (cables and pipelines), but the majority have an unknown origin. 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. The average line spacing for the magnetometer was 20 to 40 meters. A minimum value of 500 nT has been used to classify the objects as potentially archaeological targets.

Note on magnetic anomalies and value of 500 nT.
A magnetic anomaly is a local deviation from the natural magnetic field, expressed in nanoTesla. The measured value depends on the mass of the iron contained by an object, but also largely on the distance between magnetometer and the object. With a relatively large line spacing (>= 100m) chances are, that objects are missed or have an apparent lower reading on the magnetometer.

For example: a mass of 1000 kg iron results in a value of 50 nT at 12 meters, and 500 nt at 5 meters. The term 'large anomaly' is therefore subjective and depends mainly on the line spacing of the magnetometer survey.

For archaeological assessments, as a rule of thumb, the following minimum values for unidentified deviations are therefore considered to be of archeological interest:
Line spacing ~100 meters: 50 nT
Line spacing ~50 meters: 500 nT

According to Fugro, 212 anomalies with an unknown origin are larger than 500 nT. After re-examination, 202 anomalies can be associated with known present objects like pipelines and wellheads.

Association	Amount
Cable	1
Pipeline	194
Wellhead	2
Known NCN	5
Unknown	10
Total	**212**

Table 13. Magnetic anomalies over 500 nT

The remainder, a total of 10 magnetic anomalies, cannot be related to known pipelines and cables, or visible objects at the seabed surface. These anomalies are induced by unknown ferrous objects buried in the seabed, covered by sediments. These objects could consist of pieces of cable, chain, debris, lost anchors, UXO, iron parts of shipwrecks, et cetera. The 10 objects which induced anomalies of more than 500 nT are considered to be of potential archaeological interest, until proven differently.

An overview is presented in the figure below.

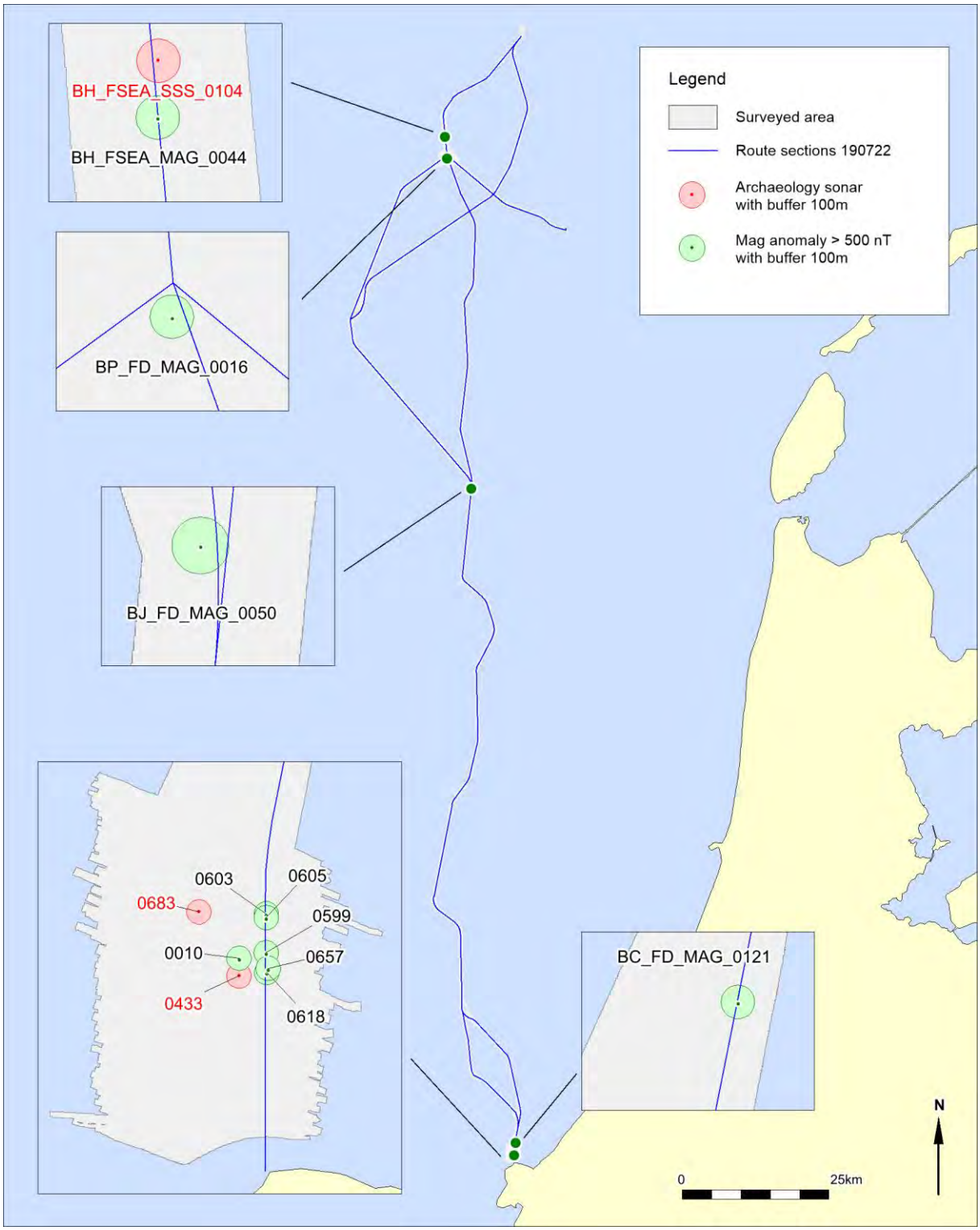


Figure 16. Magnetic anomalies larger than 500nT not related to known objects, infrastructure or objects found with side scan sonar.

3.6 Subbottom data

Desk study results

The archaeological desk study has indicated that the combined thickness of the *Holocene* sequence is expected to range from 0 to 30 meters in the area.

The variations in thickness are due to:

- lateral variations in water depth, mobility of the seabed, sediment supply and sedimentation rate from the onset of the Early Holocene till present day.
  general trend:
  a) near coastal shallow waters with high mobility of seabed in the southern part: high thickness of Holocene cover;
  b) distal parts of trajectories with deep waters and low mobility of seabed: thin Holocene cover;

- the morphology of the seabed
  a) in part of the trajectory sand ridges and sand waves occur (Pleistocene deep-seated), which alternate with:
  b) low-lying areas in between those ridges and sand waves (Pleistocene more roximate to seabed surface);

- the original morphology Pleistocene landscape which was present prior to the Holocene marine ingression in the area;

- the various extent to which the Pleistocene landscape has eroded during the Holocene marine ingression.

The *Holocene* units include the surface sediments of the Bligh Bank Member (south) and Terschellingerbank Member| Southern Bight Formation and the Urania Formation (north). Those units locally cover deposits of the Wormer Member | Velsen Bed | Naaldwijk Formation and/or the Basal Peat Bed | Nieuwkoop Formation.

Just north of the Maasgeul a more than one-meter-thick bed of stiff Early to Mid-Holocene river clay is present. This clay is part of the Echteld Formation and wedges out to the north. Stratigraphically this clay of the Echteld Formation is positioned in between the Basal Peat Bed and lagoonal and marine deposits of the Wormer Member | Naaldwijk formation. Further, in the Maasgeul area Early Holocene overbank deposits of the Rhine can be present. These stiff ripened clays and silts are classified as the Wijchen Bed | Kreftenheye Formation. On top of the Wijchen Member locally Early Holocene wind-blown deposits (river dunes) of the Delwijnen Member can be present. The flanks of these river dunes are covered by the Basal Peat bed and Echteld Formation.

The *Holocene* deposits cover *Pleistocene* units of:

- the Eem Formation (Eemian marine)
- the Brown Bank Member | Eem Formation (Early Weichselian lagoonal and shallow marine)
- the Kreftenheye Formation (Pleniglacial river), and
- the Boxtel Formation (Late Glacial terrestrial - stream deposits and aeolian).

To illustrate the variations in the subsurface geology we present in figure 17 the Top Pleistocene Map by TNO | Laban from 2004 and the Geological Map of the Netherlands produced by Geological Survey of The Netherlands in 2021. This image provides a reference framework for the interpretation of the subbottom profiler data.

In the left panel of figure 17 the 2004 Top Pleistocene map is displayed. This map shows the Pleistocene units that subcrop below a cover of Holocene deposits. Those Holocene deposits include the mobile sands of the Bligh Bank Member | Southern Bight Formation and towards the north the Terschellingerbank Member | Southern Bight Formation and Urania Formation which are exposed at the seabed over the full extent of the route. Locally these recent deposits cover Early Holocene deposits of the Basal Peat Bed | Naaldwijk Formation and Wormer Member | Naaldwijk Formation.

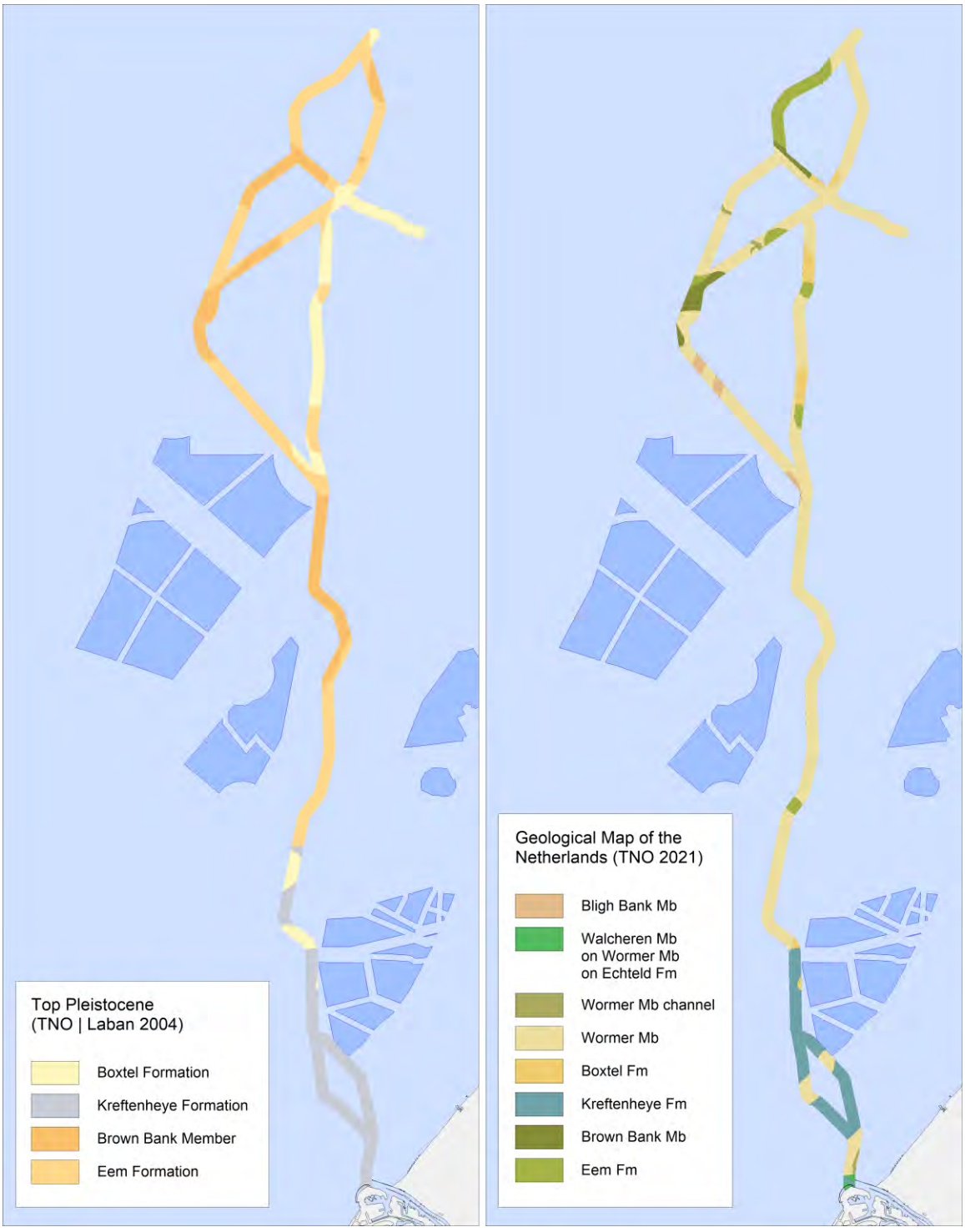


Figure 17. Subcropping Pleistocene units within 2000-meter corridor along the optional Aramis routes according to the 2004 Top Pleistocene Map and 2021 Geological map of the Netherlands; wind farm sites displayed to provide some spatial context.

As described above, in the Maasmond area Early to Middle Holocene fluvial clays of the Echteld Formation are present. Also, local occurrences of Early Holocene river dunes of the Delwijnen Member | Boxtel Formation and repined overbank clays of the Wijchen Member | Kreftenheye Formation could be encountered.

The Geological Map of the Netherlands is shown in the right panel of figure 17. This image shows the units that are subcropping below the Southern Bight Formation and Urania Formation. Contrary to TNO | Labans' map those subcropping deposits also include Holocene units.

In the online explanatory document that comes along with the Geological map the following is stated: '*Coversand (BX4: Boxtel Fm, Wierden Mb) and loess (BX5: Boxtel Fm, Schimmert Mb) are only shown if more than 2 m thick. The ubiquitous layer of actively transported open-marine sand (SB2: Bligh Bank Mb) is only shown if it is more than 7 m thick. Anthropogenic deposits are not shown on the map.*'

Occurrences of the Boxtel Formation are very often less than 2 meter thick. It should therefore be borne in mind that in areas where other units such as the Brown Bank Member are mapped the Boxtel Formation can still be present as a thin bed topping this unit.

Another important note is that recent research in the IJmuiden Ver Wind Farm Zone and personal communication with Cees Laban indicates that offshore deposits that in the past - based on seismic data - were classified as the Wormer Member[12] also include small-scale fluvial and aeolian deposits of the Late Glacial Boxtel Formation. The Boxtel Formation is often found offshore in stream valleys. Stream valleys were low-lying parts of the paleo-landscape. Because of this relative low-lying position and the presence of firm beds of the Early Holocene Basal Peat Bed and clayey Velsen Bed the Boxtel Formation was better protected against erosion in the stream valleys than in the surrounding landscape.[13]

[12] In the 20th Century the units that currently are classified as the Wormer Member and Basal peat Bed were mapped as the 'Elbow Formation'.

[13] Pers. Comm. F. Busschers 2023.

Assessment of seismic data

Table 14 shows the shallow seismic units which have been identified by Fugro along the Aramis route trajectories. The table contains an interpretation of the lithostratigraphic units that according to Fugro could be part of the identified seismic units.

Dataset	Unit	Horizon Top	Horizon Base	Seismic Signature and Character of the Base	Distribution	Lithology[1]	Geological Formation / *Member*	Depositional Environment
SBP	DS	H00	H_DS	Semi-transparent and chaotic. The basal reflector marks the change from chaotic to acoustically transparent or structured seismic facies.	Present in nearshore part only (Maaskanaal)	Clayey sand to sandy clay	-	-
	A	H00	H10	Acoustically transparent to chaotic, with locally high amplitude reflections. Base is marked by a medium to high amplitude, flat reflector.	Present across the entire route	Sand	Southern Bight	Marine
SBP, 2D-UHRS	B	H00, DS, H10	H15	Various; semi-transparent and structureless to locally bedded with low to medium amplitude parallel reflectors; locally, internal channels with high amplitude parallel reflectors observed; locally internal erosion surfaces observed. The base is locally channelised and the infill of these channels has typically chaotic or structured (layered) character with high amplitude reflections. The basal reflector has a medium to high amplitude, irregular to undulating. High amplitude (negative on the 2D-UHRS) reflectors may indicate layers/pockets of peat / organic clay frequently present in this unit.	Present basically across the entire route; locally absent in the southern part of the route	Sand, clay, locally laminated sand and clay, locally thin beds or laminae of peat	Naaldwijk Boxtel Kreftenheye	Coastal to tidal-flat, locally lagoonal; locally periglacial to fluvial
2D-UHRS	C	H15	H20	Mostly structured (layered) with low to medium-amplitude parallel reflectors. Locally, in the upper part of the unit, structureless, semi-transparent interval locally semi-transparent, structureless. In the north-eastern part of the route, the unit is characterised by overall semi-transparent seismic facies with local high amplitude negative reflectors of various extent. The high amplitude reflectors may indicate layers of pockets of peat and/or organic clay. Base forms a sub-horizontal erosional surface, locally forming broad channels/depressions.	Present in the central and large portion of the northern part of the route	Laminated sand and clay, locally sand, locally thin beds or laminae of peat	*Brown Bank*	Lagoonal, estuarine, tidal flat
	D	H15, H20	H25	Acoustically transparent to semi-transparent, structureless. Locally, layered intervals, internal erosion surfaces marked by strong undulating or inclined reflectors. Internal channelling features are locally present. The infill of these channels is various from chaotic to structured (layered). Base forms a sub-horizontal erosional surface, locally forming channels.	Present almost across the entire route, except small area in the centre and in the most southern part of the route	Sand	Eem Kreftenheye (nearshore)	Marine
	E	H25	H30	Acoustically transparent to semi-transparent, structureless; locally chaotic. Base forms a sub-horizontal erosional surface, locally forming channels.	Present in the northern part of the route	Sand	Egmond Ground	Marine
	F	H25, H30	H35	Semi-transparent infill with occasional amplitude anomalies. locally discontinuous, wavy and steeply inclined medium-amplitude reflectors. Internal channels near the top. The basal reflector forms U-shaped channel / valley.	Present locally in the northern and central part of the route	Sand with clay interbeds	Peelo	Fluvio-glacial, glacio-lacustrine (subglacial valley infill)
	G	H20, H25, H30, H35	H40 (internal) BPD	Chaotic to acoustically semi-transparent, locally discontinuous, inclined medium-amplitude reflectors. Locally, internal erosion surfaces and internal channels / channelling features. Horizon H40 marks internal erosion surface, at which locally high amplitude negative reflectors are present, indicating a thin bed or laminae of peat /organic clay.	Present across the entire route	Sand with local clay interbeds	Yarmouth Roads	Fluvio-deltaic to marine

Notes:
DS = disturbed sediments
Hyphen = not applicable
BPD = (lower) penetration depth of seismic reflection data
1) [illegible] full type name detailed information will be provided in the Interpretation Report # 197217-REP-0071 which will include data of the geotechnical investigation

Table 14. Overview of seismostratigraphic units (source: Fugro survey report F197217-REP-001)

The result of the assessment of the prehistoric landscapes from the subbottom profiler and UHRS data is described below. A geological x-section from south to north along the sections nearshore east, A, B, and C is included as Appendix 3 in this report. Focus is put on the upper 5 meters below the seabed plane that marks the base of the mobile seabed sediments, because the As Planned pipeline installation foresees a burial depth of 1 m below the seabed after a pre-sweep of sand waves have been carried out. This does not mean that geological units that occur at greater depths are fully disregarded. Phenomena of interest for the evolution of prehistoric landscapes are looked into.

Section Nearshore East

This x-section covers:

- the landfall of the pipeline at the Maasvlakte 2,
- the pipeline crossing of the Maasgeul,
- the shallow parts of the seabed with depths less than 15 meters north of the Maasgeul between KP 1.5 and KP 8.5 in a section that can be described as a bulge, and
- the trajectory between KP8.5 and KP 30.6 with depths varying from 20 to 30 meters.

Both on the southern and northern edge of the Maasgeul Pleistocene en Holocene units are exposed at the intersection of these layers and beds with the Maasgeul. North of the Maasgeul the top of Unit B likely consists of Mid-Holocene fresh-water fluvial tidal deposits of firm to stiff clay with plant remains. This bed of clay is part of the Echteld Formation.

To illustrate the different sediment beds and lithostratigraphic units that are contained in Unit B in the Maasgeul area we projected the lithological column of DINO borehole B37A0952 onto the x-section of the Nearshore East section. The borehole lies 46 m west of the route trajectory. No lithostratigraphic interpretation is given in DINO.

We interpret the sequence from bottom to top as:

- medium coarse sand of the Kreftenheye Formation,
- peat and organic clay of the Basal Peat Bed,
- very coarse sand with clay bed of Wormer Member (?),
- clay of the Echteld Formation.

Between KP 1.5 and KP 6.5 the Echteld Formation is covered by tidal deposits of the Wormer Member and the Walcheren Member | Naaldwijk Formation, and mobile sands of the Bligh Bank Member | Southern Bight Formation (Unit A). Within this KP 1.5 to KP 6.5 section the Echteld Formation wedges out towards the north.

Further north, around KP 5.0 foresets are observed in the upper part of Unit B (see figure 18 below). We interpret the upper part of Unit B as estuarine deposits of the Naaldwijk Formation. At the base Fugro mapped acoustic blanking. It is not known if the blanking is related to occurrences of peat in the subsurface.

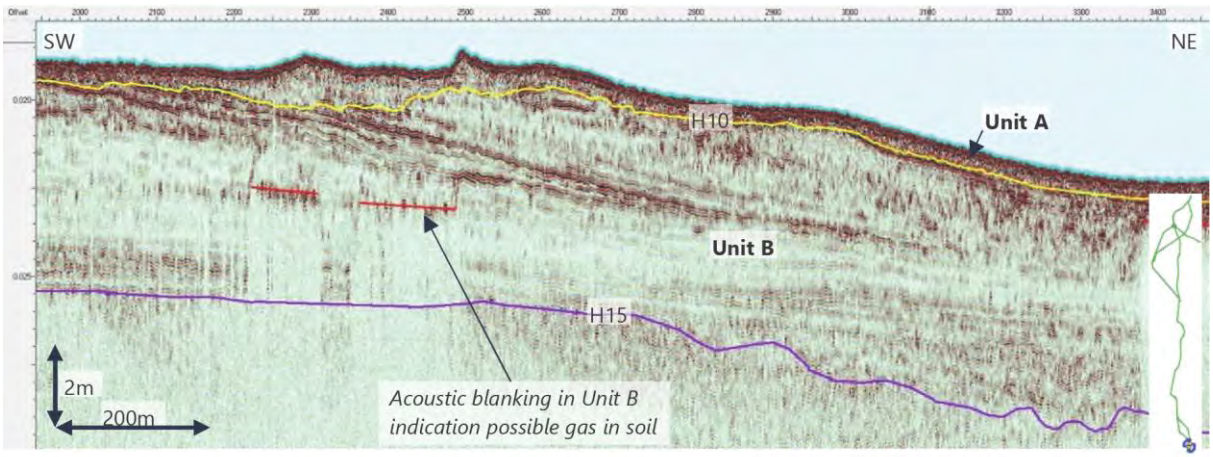


Figure 0.12: SBP data example of acoustic blanking in Unit B. (Line SBP_TA3C2020P1)

Figure 18. Wormer Member | Naaldwijk Formation in the upper part of Unit B around KP 5.0 of the Section Nearshore East

The section between KP 8.5 and the end of Section Nearshore East at KP 30.5 shows a gradual thickening of Unit A. The thickness of Unit B varies from 1 to 4 meters. Possibly Unit B represents tidal deposits of the Wormer Member. However, this is not certain. As can be seen in figure 19 Unit B has a (semi)transparent character, while the underlying Unit C has a more homogenous character with occasional anomalies. It might be possible that both Unit B and Unit C consist of Pleistocene deposits of the river Rhine that are classified as the Kreftenheye Formation, with H15 being an internal reflector.

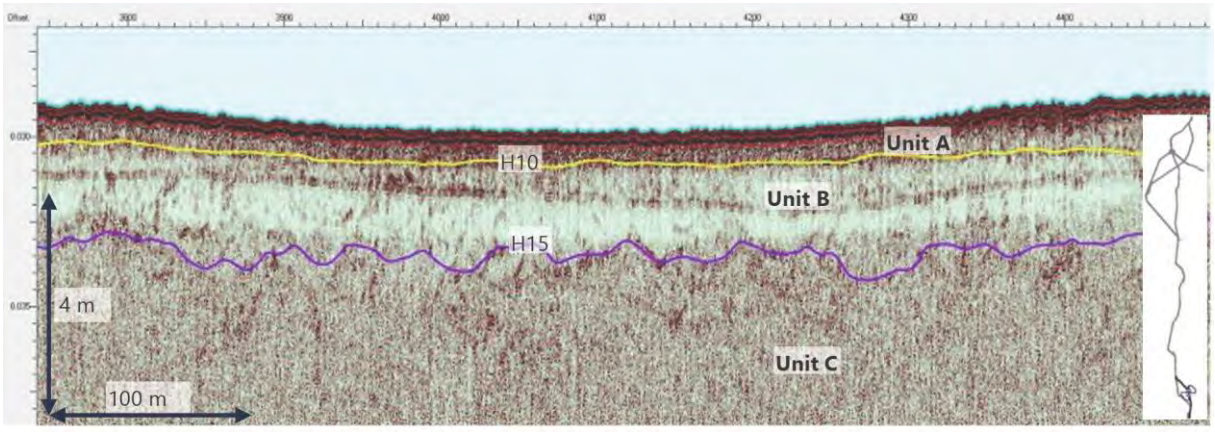


Figure 0.9: SBP data example of route section Export Route East MT. (Line SBP_TA3C2016P2)

Figure 19. River sands of the Kreftenheye Formation (Unit C). The interpretation of Unit B is uncertain. Unit B could also consist of the Kreftenheye Formation with H15 as an internal reflector or Unit B consists of Holocene tidal deposits of the Wormer Member.

Section A

In this section the seabed morphology is characterized by up sand dunes with elevations up to 5 meter relative to the surrounding seabed. The sand dune crests lie on average some 500 meters apart. The sands from which the dunes are built are classified as the Southern Bight Formation | Bligh Bank Member. The base of the Unit A (reflector H10) likely coincides with the base of the Bligh Bank Member. However, in places where the Bligh Bank Member covers sandy deposits of the Wormer Member, the layer boundary between those two lithostratigraphic units might not show as a reflector in the subbottom profile. Where a classic Early Holocene bottom to top sequence of the Nieuwkoop Formation | Basal Peat Bed, organic clay of the Naaldwijk Formation | Velsen Bed and coarsening upward fine sand of the Naaldwijk Formation | Wormer Member has been preserved intact, the transition from the generally thin layers of the Basal Peat Bed and Velsen Bed to underlying Pleistocene sands will show as a distinct reflector in the subbottom profile. Therefore, it is possible that Unit A also includes those Early Holocene organic and argillaceous deposits. Intermittent occurrences of peat and/or organic clay have been mapped at the transition from Unit A to Unit B. We interpret these occurrences of peat and organic clay as the Basal Peat Bed and Velsen Bed. An example is shown in figure 20.

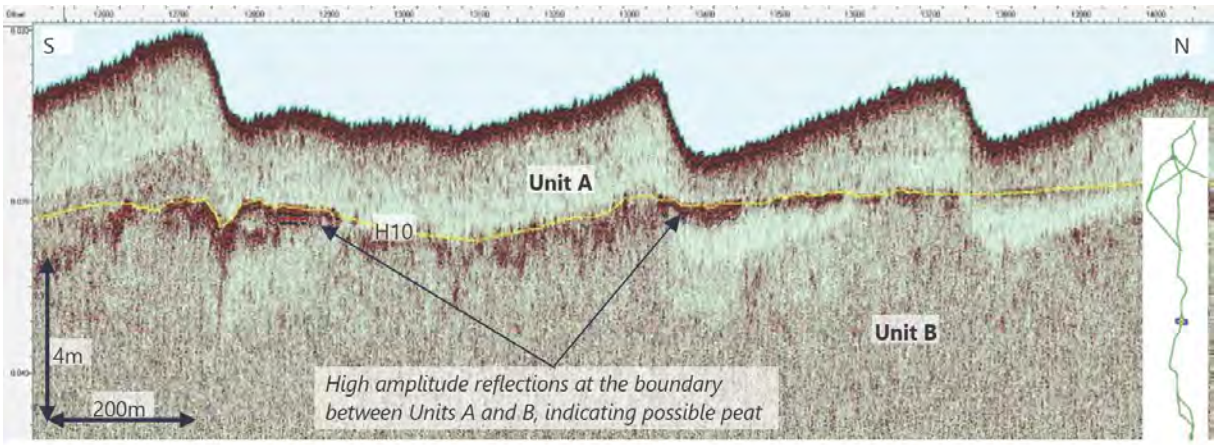


Figure 0.11: SBP data example of anomalies indicating possible peat in Unit B. (Line SBP_TA3E2134P1)

Figure 20. Possible peat the transition from Unit B to Unit A

As can be seen in x-section A in Appendix X, peat also occurs as beds covering the layered infills of channel features. Because of the stratigraphic position of the channels relative to the Basal Peat Bed we conclude that the channels are older than the Basal Peat Bed.[14] Because the channels incised the surrounding sediments that are part of the seismic Unit B, we also conclude that the channel infills are younger than the surrounding sediments. This age difference can be large or small. We interpret the channel features as Late Glacial (?) stream valleys that are infilled with fine sandy or loamy fluvial deposits of the Boxtel Formation | Singraven Member with possible intercalations or topping of fine well-sorted aeolian sand (cover sand) of the Boxtel Formation | Wierden Member. An example of a channel feature that incised Unit B is shown in figure 21. The seismic facies of Unit B in this part of the pipeline route trajectory is described as transparent and semi-transparent with rare high amplitude reflectors. This seismic facies points, together with the known geological constellation of the area, at the presence of fluvial deposits of the Kreftenheye Formation. These fluvial deposits consist of poorly sorted Early Pleniglacial river sands of the Rhine.

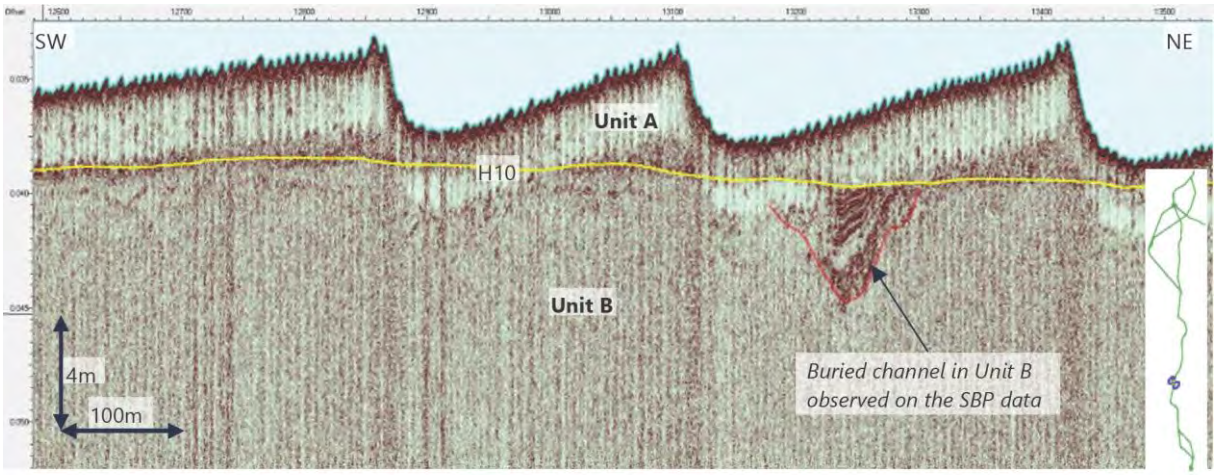


Figure 0.10: SBP data example of buried channels in Unit B. (Line SBP_TA3D2118P1)

Figure 21. Channel-like feature in top of Unit B (source: Fugro survey report F197217-REP-001)

At KP 63.2 a change in seabed morphology is observed. South of this point sand waves are present; north of this point the seabed is generally flat with few ridges. These ridges are elevated some 2.8 meters relative to the surrounding seabed. The fading sand dunes coincide with the appearance of high-amplitude parallel reflectors and high negative amplitude anomalies at relatively shallow depths in the seismic profile. For instance, at KP 67.9 the top of this sequence lies at approximately 1.3 m below the seabed. This coherent layered seismic facies is mapped as Unit C. We interpret Unit C as Early Weichselian layers and laminae of (organic) clay, silt, fine sand, and detritus of the Eem Formation | Brown Bank Member. The fine clastic layered sediments have been deposited in a brackish water lagoonal and shallow marine environment.

Between KP 67.5 and KP 81.0 the top of Unit C, the presumed Brown Bank Member, is found proximate to the seabed surface, and the overlying Unit B is very thin. According to the Geological Map of the Netherlands (2021) partly reworked Early Holocene tidal deposits of the Wormer Member | Naaldwijk Formation are present below the mobile deposits of the Bligh Bank Member. However, if a bed of peat and/or organic clay that was mapped by Fugro around KP 79.4 at the interface between Unit A and Unit B indeed is there, this bed of peat and/or organic clay likely comprise the Basal Peat Bed and/or Velsen Bed. This implies that - at this location - the deposits of Unit B cannot be part of the Wormer Member but shall

[14] In other words: the channel infill is covered by a layer of peat.

be classified as Late Glacial deposits of the Boxtel Formation or a veneer of Early Pleniglacial river deposits of the Kreftenheye Formation.

Between KP 80.7 and KP 87.3 the base of Unit B has a basin-like shape and reaches a thickness of 5 meters. The lithostratigraphic interpretation is uncertain. In this interval Unit C, that is the Brown Bank Member | Eem Formation, has eroded during the deposition of the sediments that are now contained in Unit B. Possibly, sedimentation took place during the Early Pleniglacial, when the catchment area of the Rhine reached far into North Sea area. At KP 87.3 a peat bed has been identified in the upper section of Unit B that probably is part of the Basal Peat Bed.

Between KP 80.7 and the end of section A around KP 94.0 the seabed surface is flat with minor decimeter high current ripples. Unit A has a very consistent thickness of 2.8 meters. If the pipeline is installed at 1 meter below the seabed, the seabed disturbance will be limited to the Holocene top layer. The underlying Pleistocene landscapes will not be affected.

Section B

Between KP 0.0 and KP 12.5 Unit A is 2.5 meters thick. The seabed morphology and thickness of Unit A form a continuation of what is observed in Section A.

Between KP 0.0 and KP 45.0 Unit B is present throughout. The thickness of Unit B varies from a few decimeters to nearly 3 meters. Between KP 30.0 and KP45.0 Unit A is thinner than in other parts of Section B. The interpretation of Unit B is not straightforward. According to the TNO | Laban 2004 Top Pleistocene map the Boxtel Formation occurs as subcropping unit in major part of Section B. On the 2021 Geological Map of the Netherlands the Wormer Member | Naaldwijk Formation is mapped as subcropping unit below the Bligh Bank Member. From KP 45.0 northward Unit B thickens to 8 meters around KP 50.0. Along with Unit B, Unit A also thickens to some 2.5 meters.

Fugro has mapped occurrences of peat at the top of Unit B, (around KP 42.2), as intraformational beds within Unit B (between KP 44.0 and 48.0), and at the base of Unit B (between KP 51.0 and 58.0). The peat that was identified at the base of Unit B lies around -37 m LAT. The seismostratigraphic position of this peat bed (base of Unit B) is different from the stratigraphic position of the peat in Section A (top of Unit B). The interpretation is therefore not straightforward. Possibly the peat bed is again the Basal Peat Bed, but now covered by a thick sequence of tidal deposits of the Wormer Member. Another, possibly more likely option, is that the peat bed was deposited during an interstadial period of the latest ice age, the Weichselian. The peat could be part of the Boxtel Formation or the Early Weichselian Woudenberg Formation.

Section C

The general trend in Section C is an overall deepening of the seabed surface from 31 meters in the south (KP 0.0) to 39 meters in the northern part of this section (KP 26.2). The combined thickness of Unit A and Unit B is less than 2 meters between KP 12.8 and the end of Section C.

Intermittent peat is found at the base of Unit B. As mentioned above the timing of deposition and the lithostratigraphic unit where these peat layers are part of is uncertain. The base of Unit B (= top of Unit C) is a straight plane that very gently dips from -39 m LAT at KP 0.0 to -41 m LAT at KP 26.2.

Distinct channel features have been mapped at the base of Unit B. The incision depth of these channels ranges from 2 to 4 meters. The intermittent peat beds at the base of Unit B cover the channel infills. The development of the channels and the later deposition of peat represent different phases in the development of the landscape. These phases could either be separated by a time hiatus or have followed shortly after each other.

Figure 22 shows a subbottom data example of section C including a channel feature and intermittent occurrences of peat at the base of the well-bedded sequence of Unit B (source: Fugro survey report F197217-REP-001). Clearly visible is the thinning of Unit B from south (left side of the image) to north (right side of the image. Figure 23 shows a subbottom data example of section K14-L4A in which channel features are visible that are also encountered in section C.

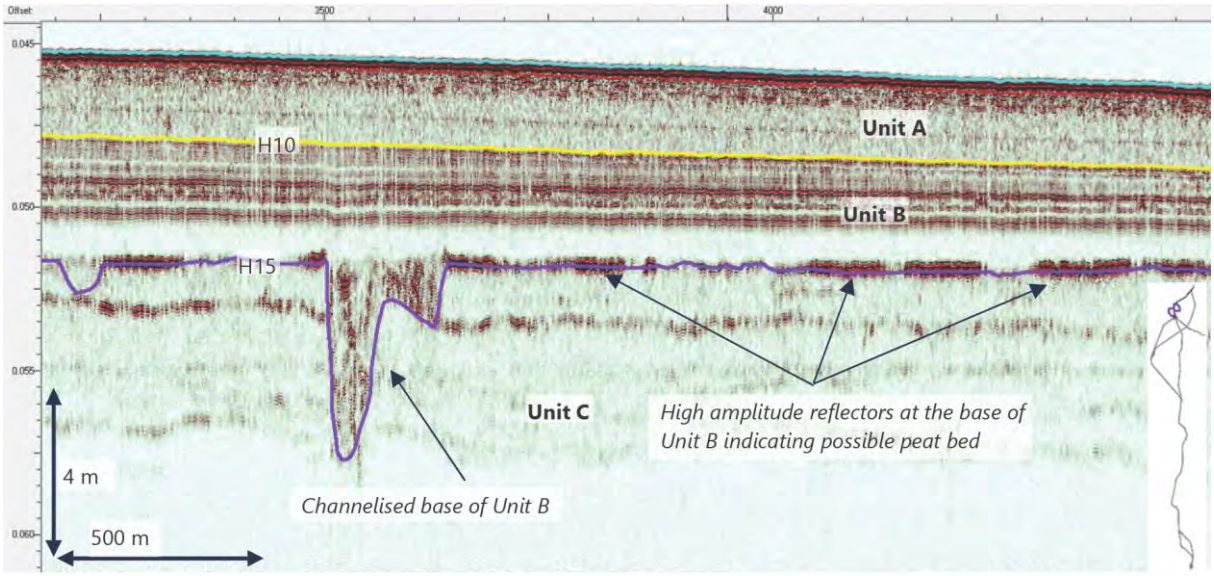


Figure 0.8: SBP data example of route section C. (Line SBP_TA3H23321P1_1)

Figure 22. Channel feature and intermittent occurrences of peat at the base of the parallel bedded sequence of Unit B (source: Fugro survey report F197217-REP-001)

The upper part of Unit C has a (semi)transparent character with a faint plan-parallel sub-horizontal bedding. Although the deposits within Unit C appear to be bedded, this bedding does not show as clear reflectors in the subbottom profile. The top of Unit C probably consists of sandy deposits with little difference and/or gradual changes in grain-size and composition. We interpret the top of Unit C as Eemian marine deposits of the Eem Formation.

The channels that incised Unit C have been infilled with sediments that, at least in figure 23, have not resulted in clear reflectors in the subbottom profile. Probably the absence of clear reflectors is due to limited variation in the lithological composition of the channel infills, which could point to an infill with predominantly (fine) sandy sediments.

The channel infills are truncated by discrete sub-horizontal plan-parallel reflectors at the base of Unit B. These clear reflectors relate to alternating beds with different acoustic impedances. Likely, these differences in acoustic impedance are caused by lithological variations such as alternating beds of fine sand, silt, clay, and peat.

If Unit B consists of Early Holocene tidal deposits of the Wormer Member | Naaldwijk Formation, the peat bed at the base is of Unit B is the Early Holocene Basal Peat Bed. The layered to laminated character of Unit B would fit an Early Holocene tidal setting. The truncated channel features could then represent Late Glacial stream valleys that are infilled with fine sandy or loamy sediment. However, it should be noted that the plan-parallel alternations of fine sand, silt, clay, and detritus also are characteristic of the Early Weichselian Brown Bank Member | Eem Formation. The option that Unit B represents the Brown Bank Member can therefore not be excluded.

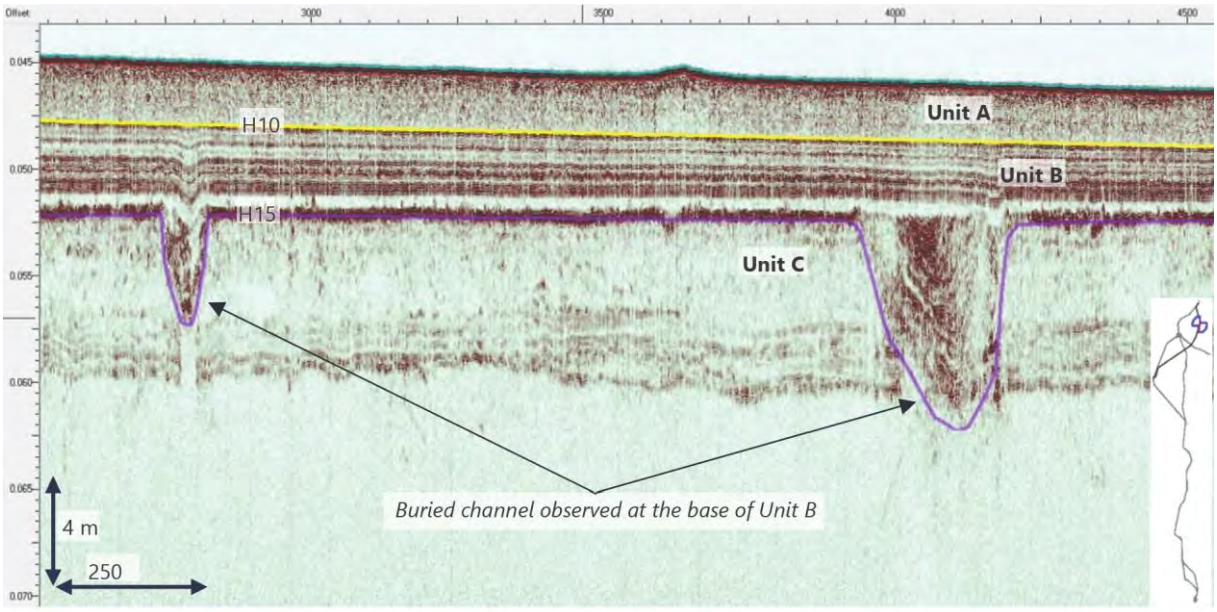


Figure 13.7: SBP data example of route section K14-L4A. (Line SBP_TA3M2321P1_1)

Figure 23. Channel features that are truncated by parallel beds of Unit B (source: Fugro survey report F197217-REP-001)

4 Synthesis

For this investigation different research questions are defined in the Program of Requirements[15]. Based on the results of de 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?

Yes. At 19 locations objects have been found with a possible archaeological value. Eight of these objects are related to visible contacts at the seabed and may represent shipwreck remains. At 10 locations magnetic anomalies with a peak-to peak value over 500 nT have been mapped which cannot be related to known objects like pipelines or cables and may be of potential archaeological interest. The objects that cause these anomalies are not visible on side scan sonar or multibeam images and are therefore considered to be buried in the seabed. These objects could, apart from archaeological objects, include debris, UXO, lost anchors, et cetera. As long as the character of these objects has not been determined, the objects are considered to be of potential archaeological interest.

With respect to side scan sonar, magnetometer and multibeam survey:
Are there any phenomena visible on the seabed?
Yes. With side scan sonar and multibeam a total of 3806 contacts have been mapped. With magnetometer, a total of 2748 magnetic anomalies have been observed within the area of investigation.

If so: What is the description of these phenomena?
Fugro has identified 3806 *side scan sonar* contacts within the surveyed corridor. The classification of the contacts is listed below.

Classification	**Amount**
Boulder	3010
Debris	159
Depression Pockmark	5
Fishing Gear	7
Mattress	2
Pipeline	4
Seabed Mound	98
Suspected Debris	517
Wreck	4
Total	**3806**

Do these phenomena have a man-made or natural origin?
The majority of the contacts have been classified as man-made.

If these phenomena can be designated to be man-made: What classification can be attached?
See the table above.

[15] Van Lil and van den Brenk, 2022

If these phenomena can be classified as archaeological: Is it possible to interpret the nature of the archaeological objects?
Eight of these objects are related to visible contacts at the seabed and may represent shipwreck remains.
At 10 locations magnetic anomalies with a peak-to peak value over 500 nT have been mapped which cannot be related to known objects like pipelines or cables and may be of potential archaeological interest. The objects that cause these anomalies are not visible on side scan sonar or multibeam images and are therefore considered to be buried in the seabed. These objects could, apart from archaeological objects, include debris, UXO, lost anchors, et cetera. As long as the character of these objects has not been determined, the objects are considered to be of potential archaeological interest.

If these phenomena can be identified as natural: What is the nature of these natural phenomena?
Over 3000 contacts are classified as 'boulder'. These probably also include clay boulders, because known stone boulders in the North Sea only occur north of the city of Den Helder.

Based on the acoustic image is it possible to designate zones of high, middle or low marine activity on the seabed?
Along the route sand waves have been mapped which are known to migrate a few meters per year northwards. Sand ripples originated by tidal currents are present along the entire route.

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?
Larger objects like the shipwrecks show scouring but are largely embedded in the seabed sediments. This appears to be the case throughout the area. Therefore, it is not possible to mark risk-prone areas selectively.

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 given the results of the investigation not applicable.

With respect to the seismic data: What is the depth of the top of the Pleistocene and Holocene landscape(s) relative to a) LAT and b) the present seabed?
The depth of the Pleistocene landscapes relative to both LAT and the present seabed could not always be determined, because the boundaries of the identified seismic units do not always coincide with those of the lithostratigraphic units. The lithostratigraphic sequences along the routes cannot always be deduced from the seismic data. The presence of peat found by Fugro does help in determining the top of the Pleistocene. The Basal Peat Bed is a bed of peat that has been deposited throughout the North Sea area when groundwater levels rose in response to the rising of the sea level from the beginning of the Holocene to present. The timing of the deposition of the Basal Peat Bed differs with the elevation of the landscape at the moment of inundation.

We produced a south to north x-section utilizing the seismic data delivered by Fugro to provide a context of the geological constellation in the area. The x-section includes the sections Nearshore East, A, B and C. The findings for these sections are also applicable for the other route options.

Section Nearshore East

In the nearshore section, no occurrences of peat were reported. Based on the known geological constellation in this part of the route trajectory we expect the top of the Pleistocene landscape to be buried by tidal deposits of the Naaldwijk Formation, at multiple meters below the seabed. An exception is the Maasgeul where the top of the Pleistocene sequence is expected to intersect with edge of the Maasgeul at or below -20 m LAT.

Section A

In section A occasional peat has been mapped at the base of Unit A | top of Unit B. We interpret these beds of peat as the Basal Peat Bed that covers Pleistocene deposits that are contained in Unit B. The Basal Peat Bed has an intermittent character. The reason for this can be two-fold: 1) peat has never been deposited, and 2) peat has initially been deposited, but has eroded at a later stage. Yet, in between the peat occurrences we expect the top of the Pleistocene landscape in Section A to be located at the same stratigraphic level, that is the top of the seismic Unit B (= H10), albeit that the change that the top of these deposits has eroded is significantly larger than in areas where peat has been found. Along with the occurrence of peat, the top of the Pleistocene sequence has been found at 25 to 30 meters relative to LAT in Section A. The depth of the Pleistocene sequence relative to the seabed varies with the thickness of Unit A. This means that in between sand waves the top of the Pleistocene can be close to being exposed at the seabed or solely covered by a veneer of sand. At the locations of sand wave crests the top of the Pleistocene can be located up to 7 meters below the seabed.

Section B

Given the seismic character of Unit C, including clear subhorizontal subparallel reflectors we interpret Unit C as the Eem Formation, including the Brown Bank Member. The interpretation of Unit B is uncertain. Unit B can include Late Glacial terrestrial deposits of the Boxtel Formation, Early Holocene deposits of the Naaldwijk Formation and even also shallow marine deposits of the Eem Formation and Brown Bank Member. Beds of peat or organic clay are also identified in Section B. The amount and continuity of the peat increases from south to north. Most peat occurs at a different stratigraphic level than in Section A. In Section B peat is often found at the base of the seismic Unit B. This peat could either be the Basal Peat Bed or peat from a deeper stratigraphic level such as the Boxtel Formation or Woudenberg Formation. If the Pleistocene landscape coincides with the base of Unit A, the top of the Pleistocene lies -26.5 m to -34 m LAT and 1 to 3 meters below the seabed. If the Pleistocene landscape coincides with the base of Unit B, the top of the Pleistocene lies -28 m to -40 m LAT and 2.5 to 11 meters below the seabed. Ground truthing is necessary to make a better judgement.

Section C

The very flat seabed in Section C deepens to the north from -32 m LAT to -39 m LAT. Towards the north the combined thickness of Unit A and Unit B decreases to less than 2 meters. The base of Unit B gently dips towards the north from -39 m LAT in the south to -41 m LAT in the north. Intermittent peat is found in many locations at the base of Unit B. Discrete channel features have been mapped that incise Unit C. The peat beds cover these channel features. If the Pleistocene landscape coincides with the base of Unit A, the top of the Pleistocene lies -34 m to -40 m LAT and 0.7 to 3 meters below the seabed. If the Pleistocene landscape coincides with the base of Unit B, the top of the Pleistocene lies -39 m to -41 m LAT and 1.3 to 7.5 meters below the seabed. Ground truthing is necessary to make a better judgement.

What lithostratigraphic units can be distinguished along the pipeline routes?
It is not possible to distinguish lithostratigraphic units based on the seismic data alone. The dominant lithostratigraphic units that are expected to be present are listed in the table below.

Classification	**Occurrence Section**	**Lithology**	**Age**	**Environment**	**Layer boundary**
Naaldwijk Fm	Nearshore	sand and clay	holocene	tidal, estuarine	erosive
Basal Peat Bed Nieuwkoop Fm	Nearshore A, B and C	peat	holocene	Marsh, swamp	conformable
Boxtel Fm	Nearshore A, B and C	Homogeneous fine sand loam, peat, clay	Late Glacial	polar desert, small stream	erosive
Kreftenheye Fm	Nearshore A, poss. B	poorly sorted sand	Pleniglacial	braided river	erosive
Brown Bank Mb	A, B and C	layered and laminated fine sand, silt, clay, and detritus	Early Weichselian	lagoon, lake	conformable
Eem Fm	A, B and C	sand and clay	Eemian	marine	erosive

Table 15. Lithostratigraphic units along the pipeline routes

Have channel-like features been observed?
Yes.

If so: What are the characteristics of the channel-like features in terms of spatial distribution (width, depth, shape, extent), channel infill composition, stratigraphic position and age.
Channel features are observed at two seismostratigraphic levels:

1- As incisions into the top of Unit B
2- As incisions into the top of Unit C

The depth of incision is limited to a few meters or less. At both stratigraphic levels the channel features are covered by peat. From this we conclude that the channel infills are older than the peat depositions. We interpret the channels that incised the top of Unit B as Late Glacial stream valleys that are filled-in with fine sand or loam and later covered by Early Holocene peat of the Basal Peat Bed.

The channel features that incised Unit C could also be Late Glacial with a cover of the Basal Peat Bed, but the interpretation of the peat at this stratigraphic level is uncertain (possible Boxtel Fm or Woudenberg Fm?).

Are occurrences of peat and/or organic clay observed?
Yes.

If so: What is the spatial distribution (depth, extent) stratigraphic position and age of these deposits.
Please refer to the answers to the previous questions.

The Basal Peat Bed is expected to occur at the base of Unit A in Section A. The peat beds that are found at the base of Unit B could be the Basal Peat Bed, but older peat from the Boxtel Formation or Woudenberg Formation cannot be excluded.

Are intact prehistoric landscapes affected by the installation of the pipeline based on their vertical position related to the seabed?
Yes, even if the trenching depth is limited to one meter below the seabed intact prehistoric landscapes could be affected by the installation of the pipeline. Risk-prone areas are sections where peat beds occur proximate to the seabed surface. Those areas have been identified in Section A in where peat occurs in low-lying areas in between sand dunes and in the northern parts where peat occurrences a wide-spread and the combined thickness of Unit A and Unit B is less than two meters.

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 en multibeam data can something be said about the nature of these buried objects?
This question is not applicable.

.

5 Summary and recommendations

A large quantity of survey data (*side scan sonar, magnetometer, multibeam echosounder* and *subbottom profiling*) covering a total area of 243 km^2 have been analyzed to conduct an archaeological assessment.

The current analysis of geophysical survey results is the second and step in the AMZ-cycle, following the desk study. The purpose of this assessment is to test the desk study-based expectancy for archaeological remains in the area. The expectancy covers remains of shipping related objects (wrecks), airplanes from World War II and prehistoric settlements.

Side scan sonar and multibeam contacts

Within the surveyed area, an archaeological expectation was assigned to a total of 8 contacts. In accordance with Dutch Law and Legislation no seabed disturbances should be carried out within 100 meters of each of the marked locations. If any activities will take place within 100 meters of a potential archaeological location, it will be examined on a case-by-case basis whether the 100 meters should be maintained in consultation with the Cultural Heritage Agency of the Netherlands (RCE).

Feature	NCN	Easting	Northing	Route section	Distance
BK_FSEA_SSS_0022	-	551288	5924521	D	**+50**
BK_FSEA_SSS_0179	-	555839	5929168	D	-240
BJ_FD_SSS_0015	-	548443	5894128	F	+230
BB_FS_SSS_0683	219	570384	5762003	East	-540
BH_FSEA_SSS_0104	531	559172	5935317	C	**+25**
BK_FSEA_SSS_0163	967	550165	5921956	D	**-56**
BN_FD_SSS_0025	945	576689	5920367	E Neptune	+220
BB_FS_SSS_0433	-	570711	5761481	East	-210

Table 16. Objects with an archaeological expectation.

Three of the eight contacts fall within 100 meters of the proposed route.

Magnetic anomalies

A total of 2748 magnetic anomalies have been observed. At 10 locations magnetic anomalies with a peak-to peak value over 500 nT have been mapped which cannot be related to known objects like pipelines or cables and may be of potential archaeological interest. The objects that cause these anomalies are not visible on side scan sonar or multibeam images and are therefore considered to be buried in the seabed. These objects could, apart from archaeological objects, include debris, UXO, lost anchors, et cetera. As long as the character of these objects has not been determined, the objects are considered to be of potential archaeological interest.

Target	E	N	nT	Section	Distance
BAB_FS_UXO_0010	570711	5761625	808	East	-210
BAB_FS_UXO_0599	570931	5761671	514	East	**+5**
BAB_FS_UXO_0603	570932	5761987	2312	East	**+8**
BAB_FS_UXO_0605	570933	5761957	1158	East	**+8**
BAB_FS_UXO_0618	570936	5761510	729	East	**+11**
BAB_FS_UXO_0657	570948	5761543	1348	East	**+22**
BC_FD_MAG_0121	571170	5763666	666	East	**+4**
BH_FSEA_MAG_0044	559169	5935057	578	C	**-2**
BJ_FD_MAG_0050	563642	5875159	2089	F	**-59**
BP_FD_MAG_0016	559490	5931390	591	B	**-60**

Table 17. Magnetic anomalies over 500 nT with an archaeological expectation.

Nine of the eleven contacts fall within 100 meters of the proposed route.

In accordance with Dutch Law and Legislation no seabed disturbances should be carried out within 100 meters of each of the marked locations. If any activities will take place within 100 meters of a potential archaeological location, it will be examined on a case-by-case basis whether the 100 meters should be maintained in consultation with the Cultural Heritage Agency of the Netherlands (RCE). All locations of potential archaeological interest within 100 meters of the proposed route are shown in the next figure.

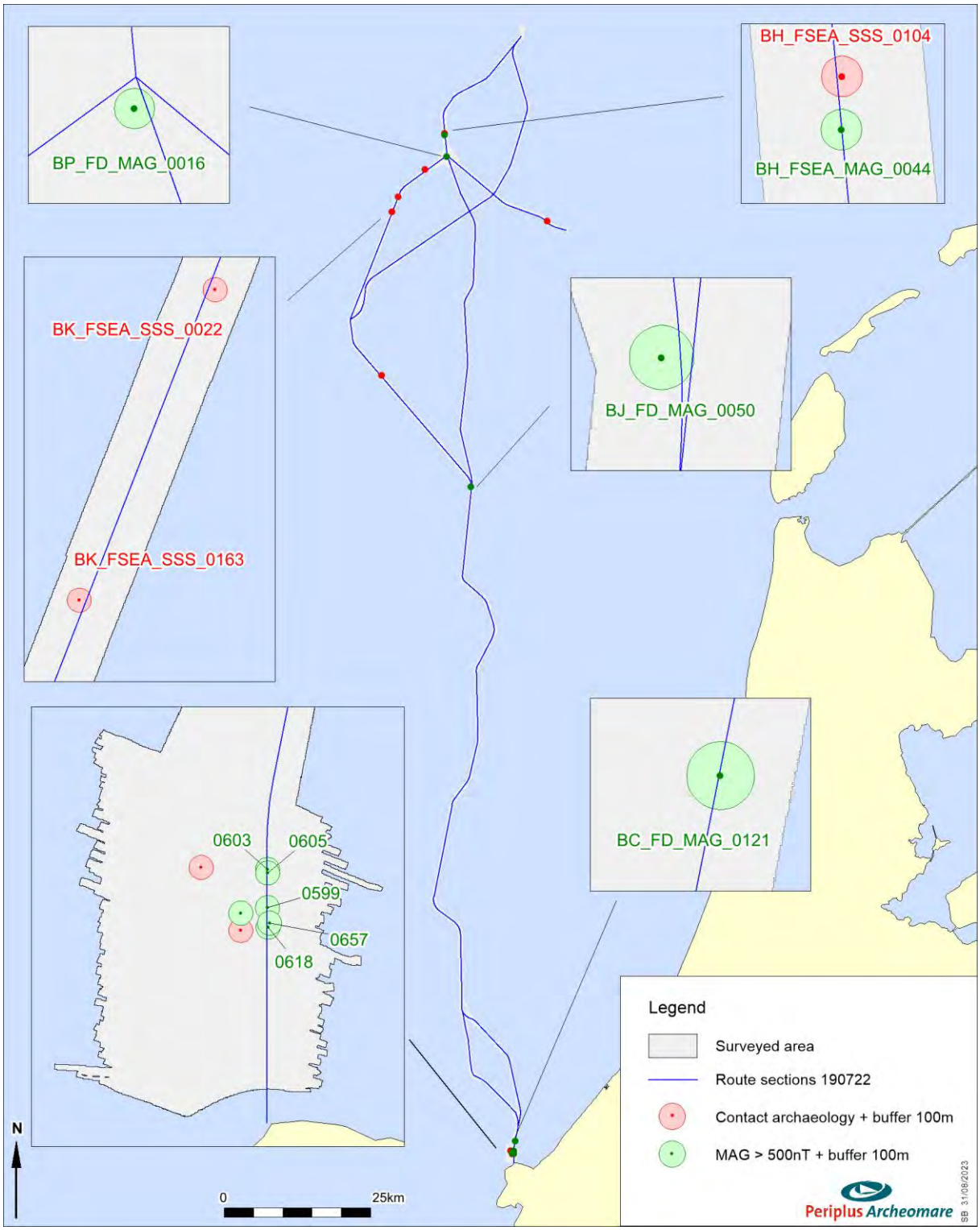


Figure 24. Overview of the potential archaeological targets within 100 meters of the proposed route

Prehistoric remains

Areas of potential archaeological interest listed below.

Depositional environment Areas of potential archaeological interest	Lithostratigraphic Unit	Time of deposition	Archaeological period
Peat-covered aeolian and small scale fluvial deposits	Boxtel Formation	*Late Glacial* and Early *Holocene*	Late Paleolithic and Early Mesolithic
Catchment of the Rhine	Kreftenheye Formation	Pleniglacial	Middle Paleolithic
Shores of lakes and lagoons	Brown Bank Member	Early *Weichselian*	Middle Paleolithic to Early Mesolithic

Table 18. Areas of potential archaeological interest

The physical quality, that is, the integrity and preservation of prehistoric remains is highly dependent on the extent to which prehistoric landscapes and archaeological levels herein have been affected by erosion. The seismic data indicate that part of the *Pleistocene* landscape has eroded during the Early *Holocene* marine ingression, thus affecting the integrity of possible prehistoric settlements. Locally the geological units defined as potential containers of prehistoric remains may have been preserved intact, especially in areas where peat has been found. The interpretation of lithostratigraphic units and the character of the layer boundaries (erosive versus non-erosive) from the seismic data is based on the geological data available and expert judgement. The seismic interpretation shall be ground-truthed by vibrocore sampling. The actual geological sequences present in the area and the integrity of layer boundaries will be verified, thus offering a tool for further analysis of the prehistoric landscapes and specify and test the archaeological potential.

Recommendation

Prehistory

Periplus Archeomare recommends conducting further archaeological research that focuses on the genesis and integrity of paleo-landscapes along the Aramis route trajectories for general archaeological research purposes. This research comprises an inventory of field research by means vibrocore sampling in accordance with the Dutch Quality Standard for Archaeology (KNA Waterbodems 4.1). A geotechnical campaign is carried out to generate a geological model of the subsurface of the pipeline corridor and to determine the physical properties of the sediment layers present. We recommend designating a number of vibrocore locations where sediment samples are collected that can be used for geo-archaeological research.

The intact samples must be examined by a (senior) prospector and described in accordance with the *Standaard Boorbeschrijvingsmethode* (SBB). Samples are selected and stabilized to be analyzed by specialists in the field of OSL and radiocarbon age dating, sediment petrography, palynology, micropaleontology (foraminifera, ostracods, diatoms, et cetera), macro-remains of plants and animals and molluscs to gain insight into the development of landscapes over time and the extent to which these paleolandscapes have been preserved.

In accordance with the Dutch Quality Standard for Archaeology (KNA Waterbodems 4.1), a Program of Requirements (PvE) and / or Plan of Action (PvA) must be drawn up. The PvE/PvA includes the objective,

the research strategy and methodology, the frameworks and the practical implementation of the research, so that the process runs smoothly, and multiple use of the data acquired in a uniform manner is achieved. It is advised to submit this PvE / PvA for approval to the Competent Authorities and the RCE. After completion of the inventory field research, during the construction of the pipeline, data can be collected that - from an archaeological point of view - provide valuable information at a detailed level. It can be very useful to investigate this information further from an archaeological point of view. It is advised to investigate the possibilities for this in consultation with the RCE, once the plans have been worked out.

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. We recommend passive archaeological supervision based on an approved Program of Requirements. Passive archaeological supervision means that an archaeologist is not present during the execution of the work but always available on call. Following this recommendation would prevent delays during the work when unexpectedly archaeological remains are found. In accordance with the Erfgoedwet, it is required to report those findings to the enforcing authority (Minister of OCW). This notification must also be included in the scope of work.

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Glossary and abbreviations

Terminology	Description
AMZ	Archeologische Monumenten Zorg, a description of procedures to ensure the protection of National archaeological Cultural Heritage
Allerød	Warm period (*interstadial*) within the *Late Glacial*, 13,900 to 12,900 cal years BP
Bioturbation	Disturbance of sediment layers by burrowing animals
Bølling	Warm period (*interstadial*) within the *Late Glacial*, 14,700 to 14,000 cal years BP
CPT	Cone penetration test
Cryoturbation	Disturbance of sediment layers due to freezing and thawing
Diffraction Hyperbola	Isolated point reflectors induced by e.g. boulders or pipelines show as hyperbola in a seismic profile, because the reflections of these objects are not only registered during the crossing of the object (top of hyperbola), but also before and after the crossing (arms of hyperbola)
Eemian	Warm period (*interglacial*) between *Saalian* and *Weichselian* from 130,000 to 115,000 years ago
Erratic	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.
Ferrous	Material, which is magnetic or can be magnetized, and well-known types are iron and nickel
Glacial	Ice-age
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
Interglacial	Warm period in between two ice-ages
Interstadial	Warm period within an ice-age
Late Glacial	Last part of the Weichselian, 15,000 to 12,000 years ago
ka	Kiloanus or kiloyear, a period of 1,000 years
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
Odderade	Warm period (*interstadial*) within the Early *Weichselian*, 85,000 to 75,000 years ago
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*
Pleniglacial	Coldest part of the *Weichselian*, 75,000 ka to 15,000 years ago
PvE	Program of Requirements (Dutch: Programma van Eisen)
RCE	Ministry of Cultural Heritage (Dutch: Rijksdienst voor het Cultureel Erfgoed)
ROV	Remotely Operated Vehicle
Saalian	Second last Ice age (glacial), 240,000 to 130,000 years ago
Sandr	Fan shaped outwash plain in front of a glacier

Terminology	Description
Side scan sonar	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
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 subsurface
Trenching	Construction of a trench for the purpose of burying a cable or pipeline
Vibrocore	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
Weichselian	Last Ice Age (glacial) from 115,000 to 12,000 years ago

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Appendix 1. Listing of selected side scan sonar contacts

The table below contains a selection of 117 *side scan sonar* contacts with a possible archaeological expectation, based on the comparison with known objects (NCN), their size (larger than four meters) and characteristics.

After reviewing, an archaeological expectation has been assigned to 9 contacts marked with a light green colour, presented in the table below.

Feature_name	Easting	Northing	Feature description Fugro	L	W	H	Z	Description PPA
BH_FSEA_SSS_0036	572394	5953350	Mattress	18.7	2.3	0.0	-32.8	Mattress
BH_FSEA_SSS_0003	572516	5953431	Depression Pockmark	7.7	6.6	0.0	-39.6	Spudcan depression
BH_FSEA_SSS_0007	572470	5953396	Depression Pockmark	8.2	6.2	0.0	-39.6	Spudcan depression
BH_FSEA_SSS_0004	572548	5953407	Depression Pockmark	6.1	5.9	0.0	-39.5	Spudcan depression
BH_FSEA_SSS_0005	572529	5953379	Depression Pockmark	7.0	6.1	0.0	-39.5	Spudcan depression
BH_FSEA_SSS_0016	572402	5952674	Depression Pockmark	4.3	4.1	0.0	-39.4	oval contact
BH_FSEA_SSS_0001	572373	5953287	Mattress	16.0	0.8	0.1	-39.3	mattress
BM_FSEA_SSS_0354	571321	5945854	Suspected Debris	4.4	0.3	0.0	-38.1	Elongated contact
BM_FSEA_SSS_0042	572235	5942929	Suspected Debris	4.3	0.9	0.2	-36.8	Oval contact, clustered with other oval contacts
BH_FSEA_SSS_0245	558780	5937355	Suspected Debris	12.7	3.1	0.0	-35.1	irregular contact, possibly a seabed disturbance
BM_FSEA_SSS_0030	573164	5939530	Seabed Mound	5.6	1.5	0.0	-34.7	Elongated thin contact, possible cable or chain
BH_FSEA_SSS_0117	558891	5936096	Suspected Debris	4.0	1.3	0.4	-34.2	Irregular contact in depression.
BM_FSEA_SSS_0078	572899	5938204	Suspected Debris	11.5	7.2	0.0	-33.8	Matrasses Pipeline Total L7-A to L7-P
BH_FSEA_SSS_0107	559378	5933267	Suspected Debris	4.3	0.3	0.4	-32.3	Elongated straight contact
BP_FD_SSS_0003	560054	5931344	Debris	5.7	1.0	0.0	-31	Seabed disturbance
BP_FD_SSS_0010	559575	5930614	Debris	7.5	3.2	0.0	-30.6	no contact visible
BK_FSEA_SSS_0290	543796	5905721	Boulder	4.3	4.7	0.0	-29.6	Seabed disturbance
BK_FSEA_SSS_0108	551298	5924649	Boulder	28.8	1.2	0.2	-29.4	buoy anchor with cable
BK_FSEA_SSS_0174	544378	5904424	Boulder	4.3	2.4	0.0	-29.4	elongated contact
BK_FSEA_SSS_0154	546697	5913055	Boulder	9.8	0.6	0.2	-29.3	Patch of shells
BK_FSEA_SSS_0044	547294	5914807	Boulder	4.5	2.2	0.0	-29.2	Nothing Visible on SSS and MBES
BK_FSEA_SSS_0120	547879	5915829	Boulder	6.8	0.8	0.0	-29.2	Nothing Visible on SSS and MBES
BK_FSEA_SSS_0196	545707	5909928	Boulder	4.3	3.1	0.0	-29.2	oval contact
BK_FSEA_SSS_0260	545890	5910411	Boulder	4.2	1.1	0.0	-29.2	oval contact
BK_FSEA_SSS_0274	547617	5914888	Boulder	5.2	5.6	0.0	-29.2	oval contact

Feature_name	Easting	Northing	Feature description Fugro	L	W	H	Z	Description PPA
BK_FSEA_SSS_0075	549384	5919899	Boulder	6.0	3.3	0.0	-29.1	Elongated straight contact
BK_FSEA_SSS_0175	545656	5908303	Boulder	4.3	1.0	0.1	-29.1	oval contact
BM_FSEA_SSS_0086	570587	5931442	Suspected Debris	4.0	0.5	0.0	-29.1	Seabed disturbance
BE_FD_SSS_0003	561690	5822980	Suspected Debris	5.7	2.7	0.1	-28.9	oval contact
BN_FD_SSS_0039	562547	5929173	Debris	4.1	1.0	0.0	-28.9	no contact visible
BE_FD_SSS_0002	560603	5821138	Suspected Debris	8.3	4.3	0.4	-28.8	oval contact in depression
BM_FSEA_SSS_0292	546644	5910321	Suspected Debris	7.8	0.2	0.1	-28.8	Elongated contact
BK_FSEA_SSS_0286	542892	5903521	Boulder	9.8	0.5	0.0	-28.7	thin straight contact, possibly depression
BM_FSEA_SSS_0377	547318	5911315	Suspected Debris	6.4	0.3	0.0	-28.7	Elongated contact, cable or chain
BM_FSEA_SSS_0098	570182	5930164	Suspected Debris	4.6	0.6	0.0	-28.3	Elongated contact
BG_FD_SSS_0014	561067	5926853	Pipeline	25.1	0.8	0.1	-28.2	Pipeline
BG_FD_SSS_0021	561279	5926721	Pipeline	53.6	0.5	0.0	-28.1	Pipeline
BG_FD_SSS_0010	561476	5926599	Pipeline	87.8	0.6	0.0	-27.8	Pipeline
BG_FD_SSS_0017	561489	5926592	Pipeline	53.9	0.5	0.3	-27.6	Pipeline
BG_FD_SSS_0009	561534	5926360	Suspected Debris	5.7	3.4	0.0	-27.3	Nothing Visible on SSS and MBES
BN_FD_SSS_0025	576689	5920367	Wreck	17.5	5.2	1.5	-27	See NCN 945 / Contact bn_fd_sss_0025
BE_FD_SSS_0035	562830	5824316	Suspected Debris	24.6	1.0	0.0	-26.9	Elongated contact, possibly cable or chain
BJ_FD_SSS_0004	545175	5897731	Debris	4.5	2.3	0.0	-26.9	Nothing Visible on SSS and MBES
BE_FD_SSS_0015	561724	5823492	Suspected Debris	15.9	0.7	0.0	-26.8	Elongated contact, possibly cable or chain
BE_FD_SSS_0031	564689	5840888	Suspected Debris	6.0	1.1	0.0	-26.8	Elongated contact, possibly cable or chain
BM_FSEA_SSS_0082	567876	5925957	Suspected Debris	4.0	0.4	0.0	-26.6	Elongated contact
BG_FD_SSS_0020	562256	5924505	Suspected Debris	13.2	0.4	0.0	-26.4	Long Small Bended Contact, Nothing on Mbes, Possible Rope or Chain
BN_FD_SSS_0010	566548	5925589	Debris	5.7	3.1	0.0	-26.4	no contact visible
BM_FSEA_SSS_0014	566988	5924284	Suspected Debris	4.6	0.4	0.1	-26.3	no contact visible
BF_FD_SSS_0026	563257	5896796	Seabed Mound	6.6	3.2	0.7	-26.2	oval contact, possibly a stone
BM_FSEA_SSS_0130	559140	5919286	Suspected Debris	4.9	0.4	0.0	-26.2	cable/chain
BM_FSEA_SSS_0283	566066	5924076	Suspected Debris	4.3	0.7	0.0	-26.2	Elongated contact
BM_FSEA_SSS_0279	565452	5923640	Suspected Debris	10.1	0.8	0.0	-26.1	Elongated contact

Feature_name	Easting	Northing	Feature description Fugro	L	W	H	Z	Description PPA
BN_FD_SSS_0017	571919	5922297	Debris	4.1	0.8	0.0	-26.1	elongated curved contact
BM_FSEA_SSS_0263	560640	5920327	Suspected Debris	5.7	0.6	0.0	-26	Elongated contact
BM_FSEA_SSS_0277	561266	5920672	Suspected Debris	4.7	0.8	0.0	-26	Elongated contact
BM_FSEA_SSS_0333	561394	5920909	Suspected Debris	5.3	0.7	0.0	-26	Elongated contact
BM_FSEA_SSS_0367	564897	5923160	Suspected Debris	4.9	0.6	0.0	-26	Elongated contact
BG_FD_SSS_0023	563609	5921710	Debris	5.7	0.5	0.0	-25.9	Cluster of small oval contacts
BM_FSEA_SSS_0221	562349	5921382	Suspected Debris	4.2	0.4	0.0	-25.9	Elongated contact
BM_FSEA_SSS_0256	562509	5921591	Suspected Debris	6.1	0.4	0.0	-25.9	Elongated contact
BM_FSEA_SSS_0273	562187	5921340	Suspected Debris	5.7	0.7	0.0	-25.9	Elongated contact
BM_FSEA_SSS_0317	563598	5922366	Suspected Debris	8.0	0.9	0.0	-25.9	Elongated contact
BN_FD_SSS_0034	574301	5921805	Debris	6.7	2.5	0.0	-25.9	Seabed disturbance
BF_FD_SSS_0002	562271	5906303	Seabed Mound	6.5	4.0	0.2	-25.8	oval contact
BF_FD_SSS_0004	562337	5906463	Debris	4.8	1.4	0.1	-25.8	oval contact
BF_FD_SSS_0005	562372	5906435	Seabed Mound	4.1	1.3	0.1	-25.8	oval contact
BF_FD_SSS_0009	562478	5906537	Seabed Mound	5.1	1.0	0.0	-25.8	oval contact
BE_FD_SSS_0033	564696	5841065	Suspected Debris	6.7	0.4	0.0	-25.7	Elongated contact, possibly cable or chain
BF_FD_SSS_0007	562431	5905891	Seabed Mound	11.9	3.3	0.3	-25.7	Elongated triangular contact, with a grinding channel
BF_FD_SSS_0008	562436	5905902	Seabed Mound	6.8	3.0	0.2	-25.7	oval contact, with a depression
BF_FD_SSS_0015	562631	5906896	Seabed Mound	4.3	2.2	0.1	-25.7	Oval contact in a cluster of smaller oval contacts
BF_FD_SSS_0021	562712	5906802	Seabed Mound	5.6	1.4	0.1	-25.7	oval contact
BF_FD_SSS_0027	563122	5908014	Suspected Debris	13.3	2.4	0.2	-25.7	Elongated contact
BG_FD_SSS_0008	564555	5919314	Suspected Debris	5.3	0.5	0.0	-25.7	Elongated contact
BF_FD_SSS_0006	562395	5905025	Debris	4.7	1.2	0.2	-25.6	Two oval contacts, possibly stones
BF_FD_SSS_0013	562585	5906295	Seabed Mound	12.9	2.5	0.1	-25.6	Elongated, curved contact, possibly a depression
BF_FD_SSS_0023	562758	5906789	Seabed Mound	6.3	1.5	0.0	-25.6	Nothing Visible on SSS and MBES
BG_FD_SSS_0030	564078	5914876	Debris	16.5	5.2	0.0	-25.6	Nothing Visible on SSS and MBES

Feature_name	Easting	Northing	Feature description Fugro	L	W	H	Z	Description PPA
BF_FD_SSS_0030	563476	5908191	Seabed Mound	13.6	2.8	0.1	-25.5	Elongated contact
BF_FD_SSS_0032	563600	5908415	Seabed Mound	5.3	1.9	0.1	-25.5	Oval contact in a cluster of smaller oval contacts
BF_FD_SSS_0034	563664	5908420	Seabed Mound	4.0	2.6	0.0	-25.5	Oval contact in a cluster of smaller oval contacts
BF_FD_SSS_0035	563664	5908843	Seabed Mound	7.9	1.2	0.1	-25.5	Elongated contact
BF_FD_SSS_0038	563778	5908537	Seabed Mound	12.4	3.1	0.1	-25.5	Elongated, curved contact, possibly a depression
BF_FD_SSS_0041	563849	5908905	Seabed Mound	11.2	3.1	0.1	-25.5	Elongated contact in a cluster of smaller oval contacts
BF_FD_SSS_0042	563897	5908744	Seabed Mound	8.3	2.8	0.1	-25.5	Elongated contact
BF_FD_SSS_0049	564270	5910802	Seabed Mound	4.2	0.8	0.0	-25.5	no contact visible
BG_FD_SSS_0004	564261	5911517	Debris	8.2	1.4	0.0	-25.5	Nothing Visible on SSS and MBES
BJ_FD_SSS_0010	553035	5888675	Debris	4.3	0.7	0.0	-25.4	elongated curved contact
BF_FD_SSS_0025	562976	5899476	Fishing Gear	84.9	0.6	0.0	-25.3	Elongated contact, cable or chain
BJ_FD_SSS_0008	549409	5892980	Debris	4.0	1.6	0.0	-25	oval contact in depression
BE_FD_SSS_0026	564436	5829719	Suspected Debris	5.0	0.6	0.0	-24.2	Seabed disturbance
BB_FS_SSS_0147	569907	5761041	Suspected Debris	6.5	0.9	0.4	-24	Seabed disturbance
BE_FD_SSS_0009	564748	5833956	Suspected Debris	4.2	2.0	0.1	-23.9	oval contact lying on a sand wave
BE_FD_SSS_0028	564355	5830266	Suspected Debris	4.5	3.2	0.0	-23.9	Oval contact, possibly stone
BD_FD_SSS_0642	563132	5781065	Debris	5.1	0.8	0.1	-23.7	Nothing Visible on SSS and MBES
BB_FS_SSS_0481	570154	5761583	Suspected Debris	6.0	2.2	0.1	-23.2	Nothing Visible on SSS and MBES
BE_FD_SSS_0020	563657	5826463	Suspected Debris	11.0	2.7	0.0	-23.2	Seabed disturbance
BD_FD_SSS_0224	557171	5805022	Debris	4.1	1.0	0.0	-23.1	No contact on the SSS, in the Mbes an elongated contact parallel to the sand golf
BB_FS_SSS_0419	570165	5761433	Suspected Debris	8.9	0.6	0.4	-22.6	Elongated straighht contact, partially cut off by the mosaic
BE_FD_SSS_0008	564243	5829215	Suspected Debris	5.9	1.1	0.3	-20.7	No contact on the SSS, in the Mbes an elongated contact parallel to the sand golf
BB_FS_SSS_0433	570711	5761481	Wreck	4.3	2.4	0.3	-18.9	oval contact

Feature_name	Easting	Northing	Feature description Fugro	L	W	H	Z	Description PPA
BB_FS_SSS_0444	570947	5761501	Suspected Debris	4.4	0.5	0.1	-18.4	Natural Ridge
BB_FS_SSS_0025	570853	5760453	Suspected Debris	7.9	1.1	0.2	-18.1	Seabed disturbance
BB_FS_SSS_0705	569990	5762046	Suspected Debris	7.3	0.9	0.2	-17	Elongated contact, possibly cable or chain
BB_FS_SSS_0835	569874	5762289	Suspected Debris	4.1	1.2	0.3	-17	irregularly formed contact
BB_FS_SSS_0937	569719	5762832	Suspected Debris	7.2	0.6	0.2	-16.4	oval contacts, possibly stones
BB_FS_SSS_0019	570760	5760382	Suspected Debris	4.9	1.2	0.5	-14.9	NCN 20283, Seabed disturvance
BA_FS_SSS_0035	570150	5760234	Suspected Debris	4.8	0.5	0.3	-11.5	Elongated contact
BB_FS_SSS_0620	570364	5761961	Suspected Debris	4.1	0.4	0.3	-17	See Wreck NCN 219
BB_FS_SSS_0678	570397	5761996	Wreck	31.9	20.5	1.6	-17	See Wreck NCN 219
BB_FS_SSS_0684	570389	5762001	Suspected Debris	4.3	0.6	0.4	-17	See Wreck NCN 219
BH_FSEA_SSS_0187	559117	5935318	Wreck	17.1	3.9	1.7	-34	See Wreck NCN 531
BJ_FD_SSS_0015	548443	5894128	Debris	5.6	1.8	0.0	-26.4	Elongated object 5.6 perpendicular to sand waves
BK_FSEA_SSS_0022	551288	5924521	Boulder	5.6	2.9	5.2	-29.8	Buried Remains with Magnetic Anomalies
BK_FSEA_SSS_0163	550142	5921916	Boulder	0.0	2.5	2.5	-29	See NCN 967
BK_FSEA_SSS_0179	555839	5929168	Boulder	6.7	5.7	1.0	-30.3	Large Anchor Shaft 3.2 M Arms 2.1m With Scouring

Appendix 2. 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 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)**

   a. **Geophysical survey**
   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 echo sounder 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 (**3**) must be carried out.

   b. **Geotechnical survey**
   In order to reconstruct prehistoric landscapes and refine and test the archaeological expectation related to those landscapes a geotechnical survey can be carried out. A geotechnical survey comprises penetration tests (CPT's) and/or bottom sampling (*vibrocore*, Acqualock, Begemann, grab sampling, etcetera). The sample strategy and sample locations are based on the geological constellation of the area and interpreted subbottom profiling data. The requirements of the survey shall be listed in a program of requirements which must be approved by the competent authorities.

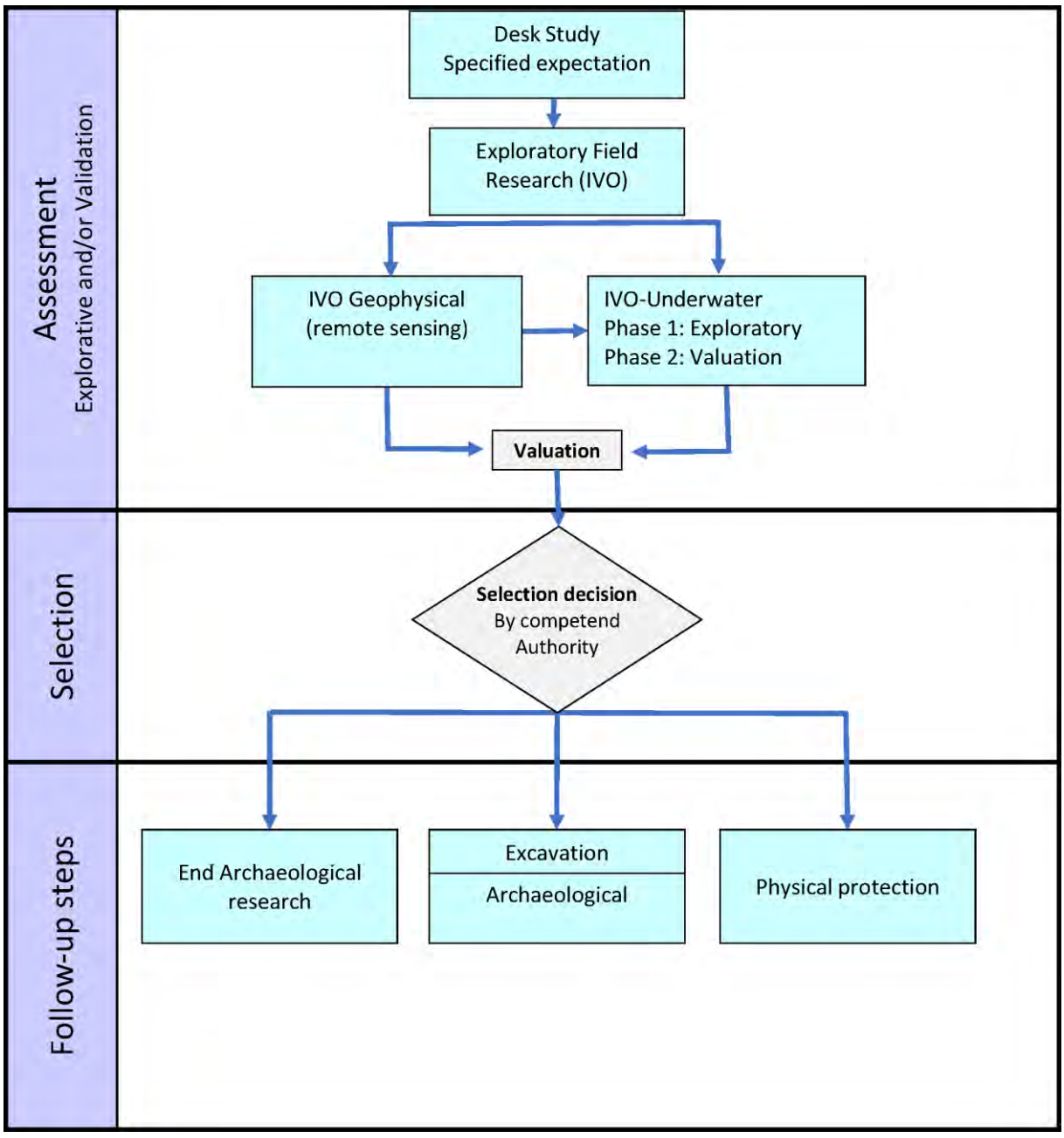
3. **Exploratory field research (onderwaterfase verkennend)**
   The suspected sites are investigated by specialized divers in order to identify the objects. The requirements of the underwater research are included in a program of requirements which must be approved by the competent authorities.

   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:

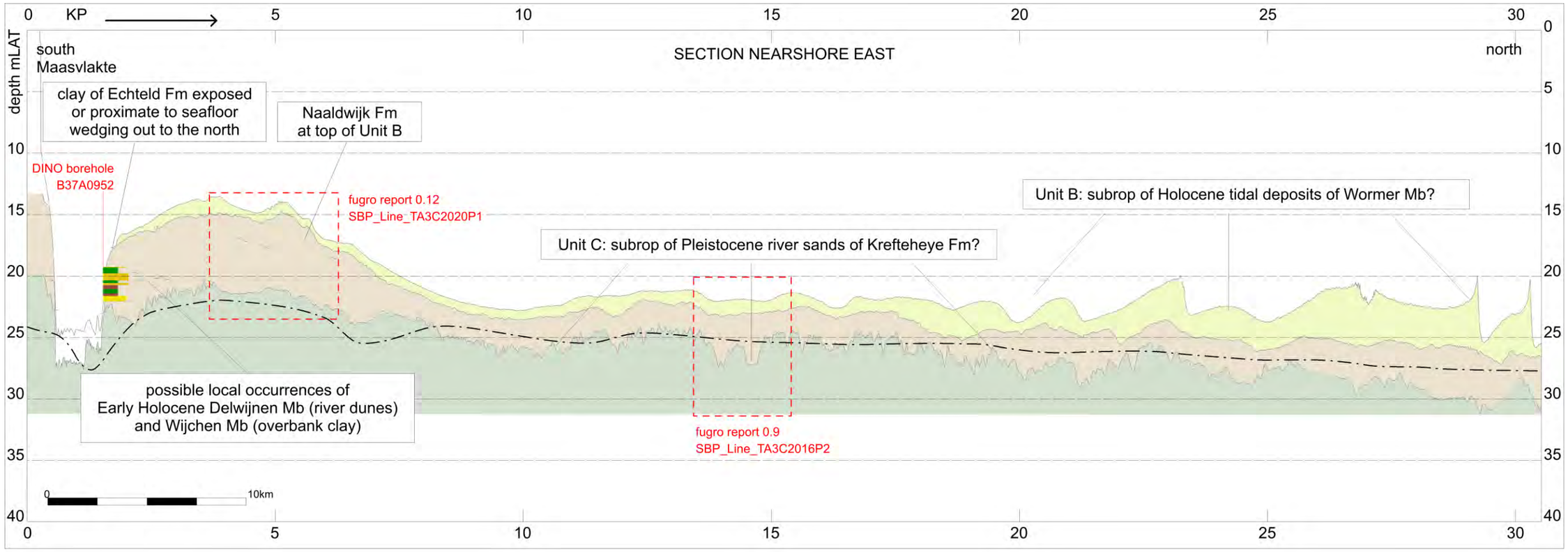
5. **Archaeological excavation**
   The archaeological remains are excavated under supervision of a senior maritime archaeologist. All remains need to be documented, registered, and conserved. The requirements of the underwater research are included in a program of requirements which must be approved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

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



Appendix 3. X-sections

Section Nearshore East, A, B and C



Legend

Seismic Unit

- A
- B
- C

Features

- peat and/or organic clay
- channel feauture

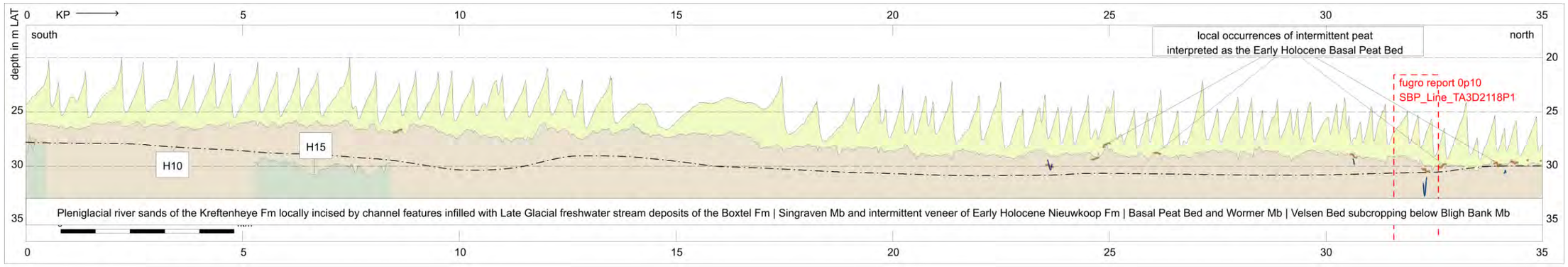
fugro report 0p10
SBP_Line_TA3D2118P1

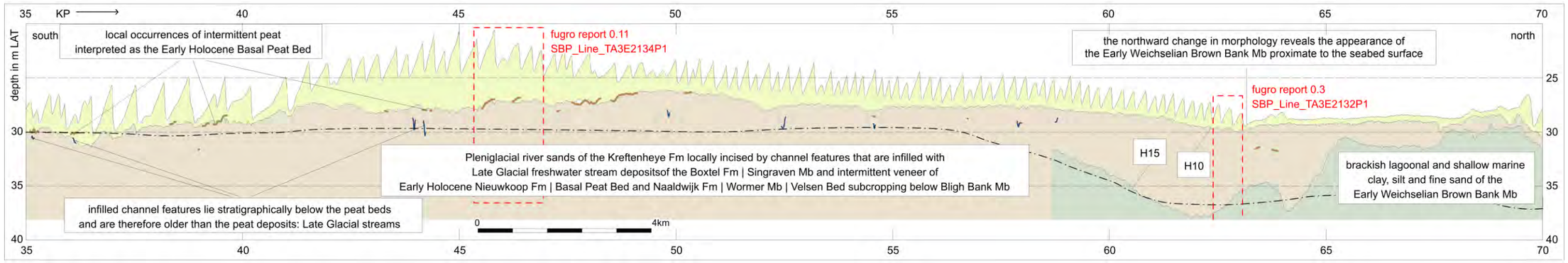
apprixiamate location of SBP data example from Fugro Survey Report F197217-REP-001

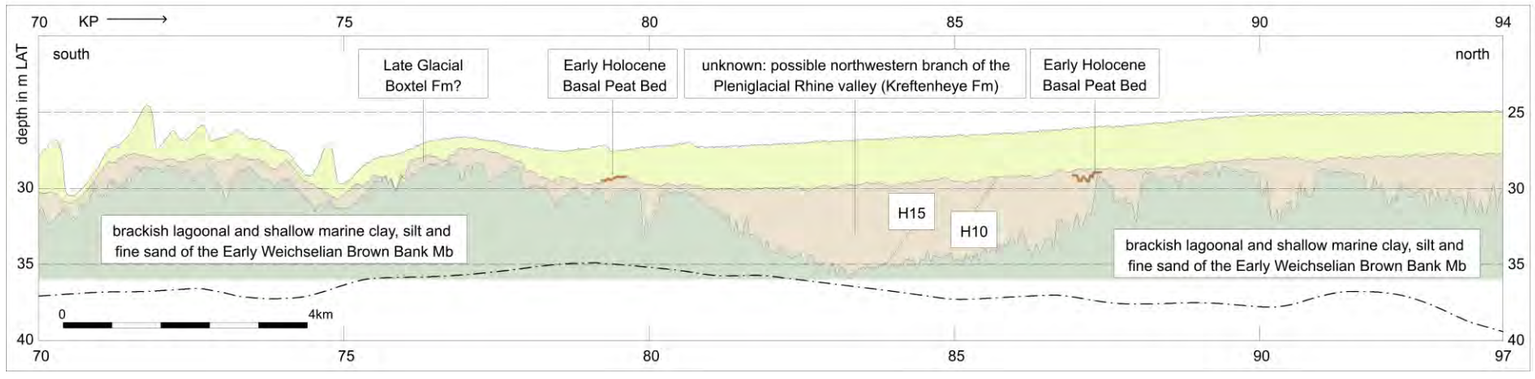
TNO 2007 Top Pleistocene

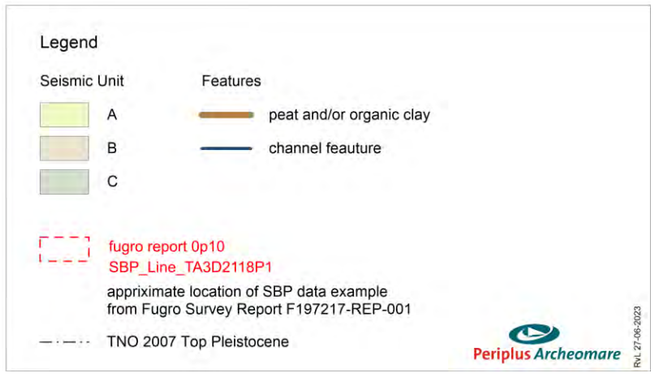
Periplus Archeomare

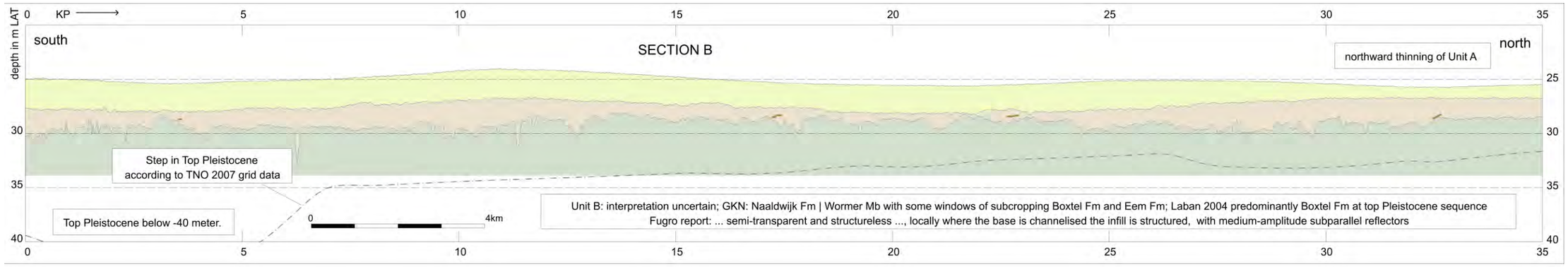
Rvl. 27-06-2023

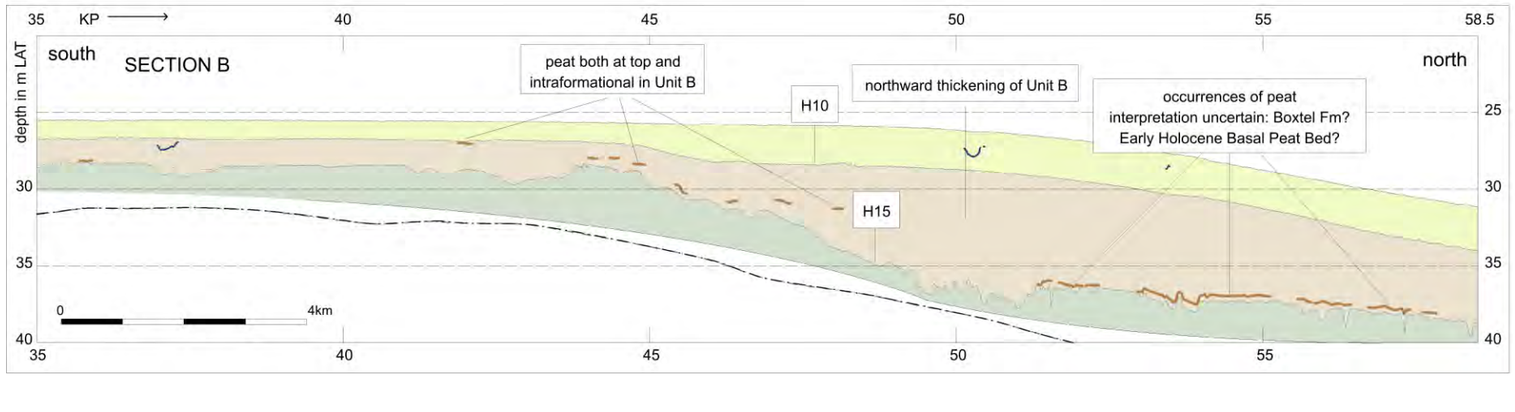

KP
south
north
depth in m LAT
local occurrences of intermittent peat
interpreted as the Early Holocene Basal Peat Bed
fugro report 0p10
SBP_Line_TA3D2118P1
H15
H10
Pleniglacial river sands of the Kreftenheye Fm locally incised by channel features infilled with Late Glacial freshwater stream deposits of the Boxtel Fm | Singraven Mb and intermittent veneer of Early Holocene Nieuwkoop Fm | Basal Peat Bed and Wormer Mb | Velsen Bed subcropping below Bligh Bank Mb

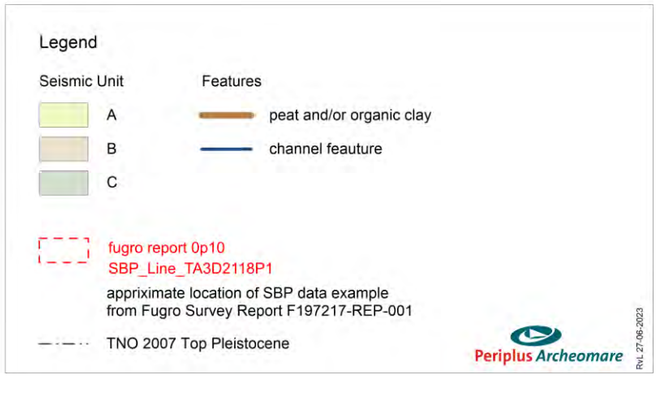

KP
south
north
depth in m LAT
local occurrences of intermittent peat
interpreted as the Early Holocene Basal Peat Bed
fugro report 0.11
SBP_Line_TA3E2134P1
the northward change in morphology reveals the appearance of
the Early Weichselian Brown Bank Mb proximate to the seabed surface
fugro report 0.3
SBP_Line_TA3E2132P1
H15
H10
Pleniglacial river sands of the Kreftenheye Fm locally incised by channel features that are infilled with
Late Glacial freshwater stream depositsof the Boxtel Fm | Singraven Mb and intermittent veneer of
Early Holocene Nieuwkoop Fm | Basal Peat Bed and Naaldwijk Fm | Wormer Mb | Velsen Bed subcropping below Bligh Bank Mb
brackish lagoonal and shallow marine
clay, silt and fine sand of the
Early Weichselian Brown Bank Mb
infilled channel features lie stratigraphically below the peat beds
and are therefore older than the peat deposits: Late Glacial streams
0
4km

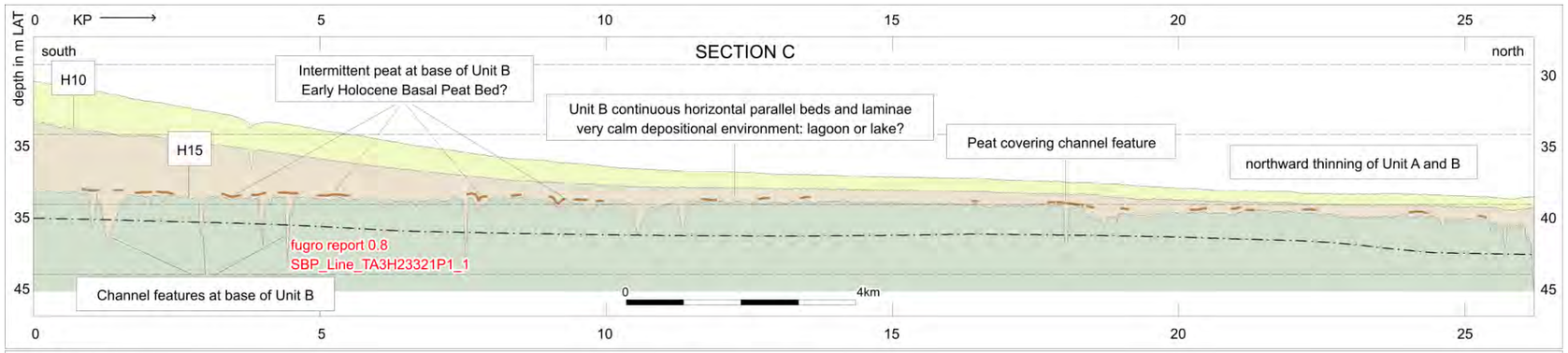

KP
south
north
depth in m LAT
Late Glacial
Boxtel Fm?
Early Holocene
Basal Peat Bed
unknown: possible northwestern branch of the
Pleniglacial Rhine valley (Kreftenheye Fm)
Early Holocene
Basal Peat Bed
H15
H10
brackish lagoonal and shallow marine clay, silt and
fine sand of the Early Weichselian Brown Bank Mb
brackish lagoonal and shallow marine clay, silt and
fine sand of the Early Weichselian Brown Bank Mb
0
4km

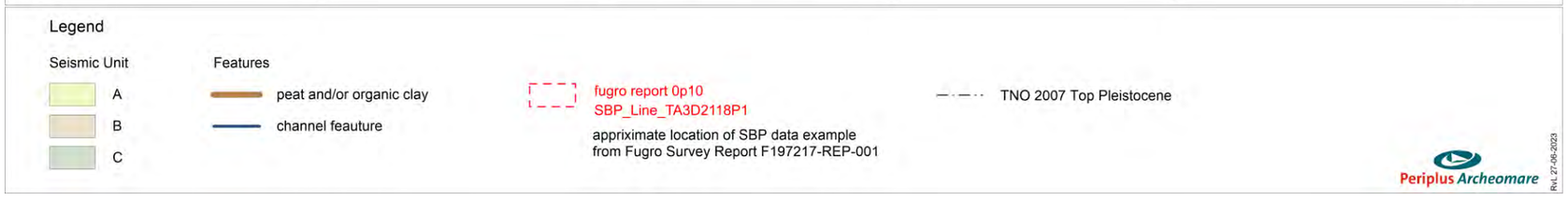

Legend
Seismic Unit
A
B
C
Features
peat and/or organic clay
channel feauture
fugro report 0p10
SBP_Line_TA3D2118P1
appriximate location of SBP data example
from Fugro Survey Report F197217-REP-001
TNO 2007 Top Pleistocene
Periplus Archeomare
Rvl. 27-06-2023


SECTION B
south
north
KP
depth in m LAT
northward thinning of Unit A
Step in Top Pleistocene
according to TNO 2007 grid data
Top Pleistocene below -40 meter.
0
4km
Unit B: interpretation uncertain; GKN: Naaldwijk Fm | Wormer Mb with some windows of subcropping Boxtel Fm and Eem Fm; Laban 2004 predominantly Boxtel Fm at top Pleistocene sequence
Fugro report: ... semi-transparent and structureless ..., locally where the base is channelised the infill is structured, with medium-amplitude subparallel reflectors


SECTION B
south
north
KP
depth in m LAT
peat both at top and
intraformational in Unit B
H10
H15
northward thickening of Unit B
occurrences of peat
interpretation uncertain: Boxtel Fm?
Early Holocene Basal Peat Bed?
0
4km


Legend
Seismic Unit
A
B
C
Features
peat and/or organic clay
channel feauture
fugro report 0p10
SBP_Line_TA3D2118P1
appriximate location of SBP data example
from Fugro Survey Report F197217-REP-001
TNO 2007 Top Pleistocene
Periplus Archeomare
Rvl. 27-06-2023


SECTION C
south
north
KP
depth in m LAT
H10
H15
Intermittent peat at base of Unit B
Early Holocene Basal Peat Bed?
Unit B continuous horizontal parallel beds and laminae
very calm depositional environment: lagoon or lake?
Peat covering channel feature
northward thinning of Unit A and B
fugro report 0.8
SBP_Line_TA3H23321P1_1
Channel features at base of Unit B
0
4km


Legend
Seismic Unit
A
B
C
Features
peat and/or organic clay
channel feauture
fugro report 0p10
SBP_Line_TA3D2118P1
appriximate location of SBP data example
from Fugro Survey Report F197217-REP-001
TNO 2007 Top Pleistocene
Periplus Archeomare
Rvl. 27-06-2023

Appendix 4. Integrated Geophysical and Geotechnical reports

F197217-REP-001_(01) Geophysical Results Report.pdf

By Fugro

Aramis Pipeline

An archaeological assessment Of geophysical survey results

Final report 31-08-2023

Periplus Archeomare reference 22A030-01

Samenvatting (Abstract in Dutch)

In opdracht van TotalEnergies Nederland B.V. heeft Periplus Archeomare een archeologische analyse uitgevoerd van de geofysische onderzoeksresultaten van het Aramis pijpleidingtracé.

Een grote hoeveelheid onderzoeksgegevens (*sidescan-sonar, magnetometer, multibeam echosounder* en *subbottom-profiler*) van een gebied met een totale oppervlakte van 243 km2 is geanalyseerd om een archeologische beoordeling uit te voeren.

Deze analyse van geofysische onderzoeksresultaten is de tweede stap in de AMZ-cyclus, na de bureaustudie. Het doel van deze analyse is het toetsen van de op de bureaustudie gebaseerde verwachting voor archeologische resten in het gebied. De verwachting omvat overblijfselen van scheepvaartgerelateerde resten (wrakken), vliegtuigen uit de Tweede Wereldoorlog en prehistorische nederzettingen.

Sidescan-sonar en multibeam-contacten

Binnen het onderzochte gebied is aan in totaal acht contacten een archeologische verwachting toegekend. In overeenstemming met de Nederlandse wet- en regelgeving mogen hier geen bodemverstoringen plaatsvinden. Indien er binnen een straal van 100 meter van een potentiële archeologische locatie activiteiten plaatsvinden, wordt in overleg met de Rijksdienst voor het Cultureel Erfgoed (RCE) van geval tot geval bekeken of de 100 meter gehandhaafd moet blijven.

Feature	NCN	Easting	Northing	Route section	Distance
BK_FSEA_SSS_0022	-	551288	5924521	D	**+50**
BK_FSEA_SSS_0179	-	555839	5929168	D	-240
BJ_FD_SSS_0015	-	548443	5894128	F	+230
BB_FS_SSS_0683	219	570384	5762003	East	-540
BH_FSEA_SSS_0104	531	559172	5935317	C	**+25**
BK_FSEA_SSS_0163	967	550165	5921956	D	**-56**
BN_FD_SSS_0025	945	576689	5920367	E Neptune	+220
BB_FS_SSS_0433	-	570711	5761481	East	-210

Tabel 1. Side scan sonar contacten met een archeologische verwachting.

Drie van de acht contacten vallen binnen 100 meters van de geplande route.

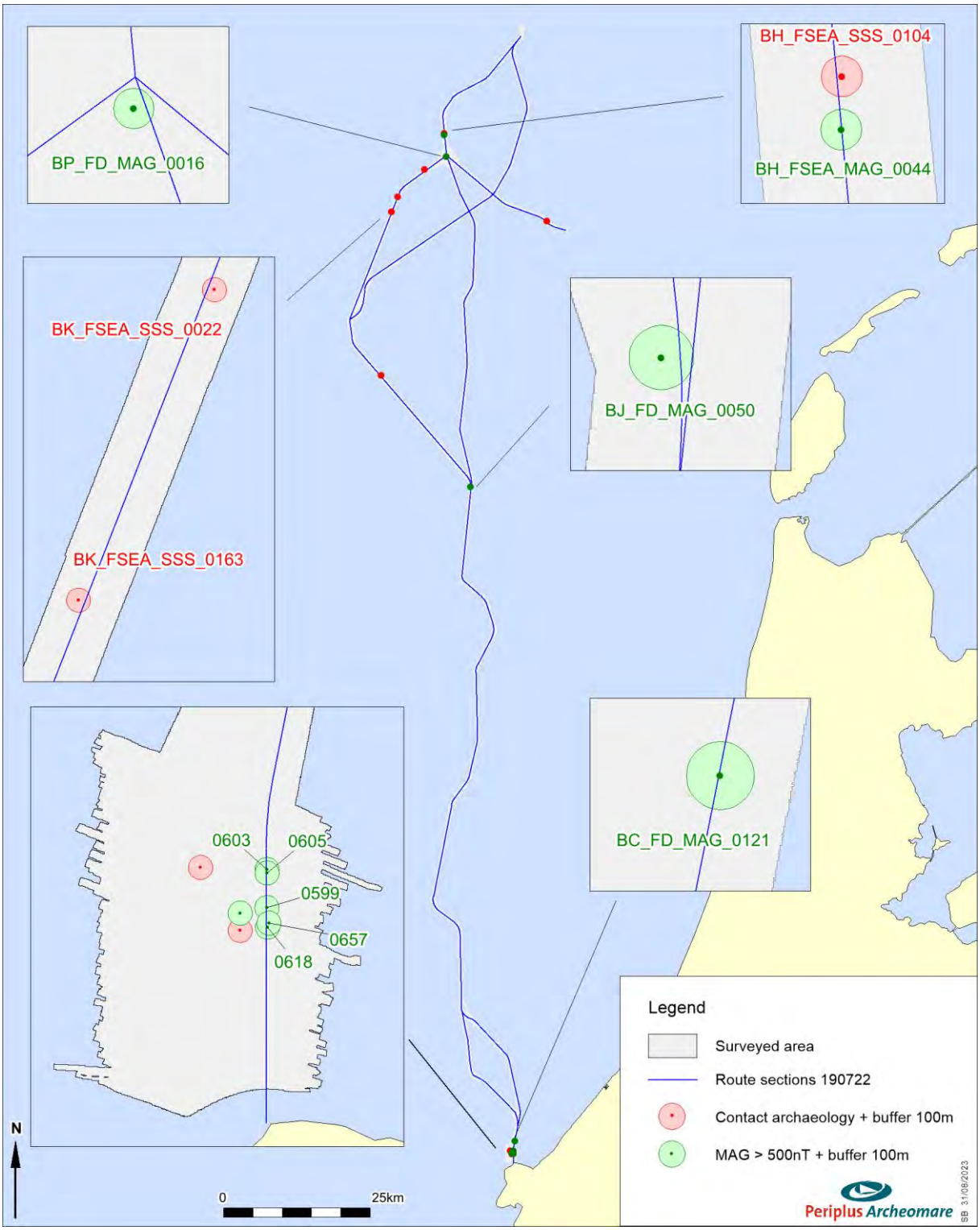
Magnetische afwijkingen

In totaal zijn op 2748 locaties magnetische afwijkingen waargenomen. Op tien locaties zijn magnetische afwijkingen met een piek-tot-piekwaarde van meer dan 500 nT in kaart gebracht, die niet gerelateerd kunnen worden aan bekende objecten zoals pijpleidingen of kabels en die van potentieel archeologisch belang kunnen zijn. De objecten die deze afwijkingen veroorzaken, zijn niet zichtbaar op sidescan-sonar- of multibeam-beelden en worden daarom geacht in de zeebodem te zijn begraven. Deze objecten kunnen (naast archeologische objecten) onder meer puin, explosieven, verloren ankers, et cetera zijn. Zolang het karakter van deze objecten niet is vastgesteld, worden de objecten geacht van potentieel archeologisch belang te zijn. Negen van de tien contacten vallen binnen een straal van 100 meter van de voorgestelde route.

Target	E	N	nT	Section	Distance
BAB_FS_UXO_0010	570711	5761625	808	East	-210
BAB_FS_UXO_0599	570931	5761671	514	East	**+5**
BAB_FS_UXO_0603	570932	5761987	2312	East	**+8**
BAB_FS_UXO_0605	570933	5761957	1158	East	**+8**
BAB_FS_UXO_0618	570936	5761510	729	East	**+11**
BAB_FS_UXO_0657	570948	5761543	1348	East	**+22**
BC_FD_MAG_0121	571170	5763666	666	East	**+4**
BH_FSEA_MAG_0044	559169	5935057	578	C	**-2**
BJ_FD_MAG_0050	563642	5875159	2089	F	**-59**
BP_FD_MAG_0016	559490	5931390	591	B	**-60**

Tabel 2. Magnetische anomalieën groter dan 500 nT met een archeologische verwachting.

Een overzicht van de contacten en magnetische anomalieën is weergegeven in de volgende figuur.



Figuur 1 Overzicht van de potentieel archeologische contacten binnen het onderzochte gebied.

In overeenstemming met de Nederlandse wet- en regelgeving mogen geen bodemverstoringen plaatsvinden op deze locaties. Indien binnen een straal van 100 meter van een potentiële archeologische locatie activiteiten plaatsvinden, wordt in overleg met de Rijksdienst voor het Cultureel Erfgoed (RCE) van geval tot geval bekeken of de 100 meter gehandhaafd moet blijven. Alle locaties van potentieel archeologisch belang binnen een straal van 100 meter van de voorgestelde route zijn weergegeven in figuur 1.

Prehistorische resten

Gebieden met een archeologische potentie voor prehistorische vondsten zijn hieronder samengevat

Depositional environment Areas of potential archaeological interest	**Lithostratigraphic Unit**	**Time of deposition**	**Archaeological period**
Peat-covered aeolian and small scale fluvial deposits	Boxtel Formation	*Late Glacial* and Early *Holocene*	Late Paleolithic and Early Mesolithic
Catchment of the Rhine	Kreftenheye Formation	Pleniglacial	Middle Paleolithic
Shores of lakes and lagoons	Brown Bank Member	Early *Weichselian*	Middle Paleolithic to Early Mesolithic

De fysieke kwaliteit, dat wil zeggen de integriteit en het behoud van prehistorische resten, is sterk afhankelijk van de mate waarin prehistorische landschappen en archeologische niveaus daarin zijn aangetast door erosie. De seismische gegevens geven aan dat een deel van het Pleistoceen-landschap is geërodeerd tijdens de mariene transgressie in het vroege Holoceen, waardoor de integriteit van mogelijke prehistorische nederzettingen is aangetast. Lokaal kunnen de geologische eenheden die zijn gedefinieerd als potentiële lagen met prehistorische overblijfselen intact zijn gebleven, vooral in gebieden waar veen is gevonden. De interpretatie van lithostratigrafische eenheden en het karakter van de laaggrenzen (erosief versus niet-erosief) uit de seismische gegevens is gebaseerd op de beschikbare geologische gegevens en het oordeel van deskundigen. De seismische interpretatie moet worden geverifieerd door middel van vibrocore-bemonstering. De werkelijke geologische sequenties die in het gebied aanwezig zijn en de integriteit van de laaggrenzen zullen worden geverifieerd, wat een instrument zal bieden voor verdere analyse van de prehistorische landschappen en het specificeren en testen van het archeologische potentieel.

Advies prehistorie

Periplus Archeomare beveelt aan verder archeologisch onderzoek uit te voeren dat zich richt op het ontstaan en de integriteit van paleo-landschappen langs de Aramis-routetrajecten voor algemene archeologische onderzoeksdoeleinden. Dit onderzoek omvat een inventarisatie van veldonderzoek door middel van vibrocore-bemonstering conform de Nederlandse Kwaliteitsnorm voor Archeologie (KNA Waterbodems 4.1). Er wordt een geotechnische campagne uitgevoerd om een geologisch model te genereren van de ondergrond van de pijpleidingcorridor en om de fysische eigenschappen van de aanwezige sedimentlagen te bepalen. Wij adviseren om een aantal vibrocore-locaties aan te wijzen waar sedimentmonsters worden verzameld die gebruikt kunnen worden voor geo-archeologisch onderzoek.

De intacte monsters moeten door een (senior) prospector worden onderzocht en beschreven volgens de Standaard Boorbeschrijvingsmethode (SBB). Monsters worden geselecteerd en gestabiliseerd om te worden geanalyseerd door specialisten op het gebied van OSL- en radiokoolstofdatering, sedimentpetrografie, palynologie, micropaleontologie (foraminiferen, ostracoden, diatomeeën, et cetera), macroresten van planten en dieren en weekdieren om inzicht te krijgen in de ontwikkeling van landschappen in de loop van de tijd en de mate waarin deze paleolandschappen bewaard zijn gebleven.

Conform de Nederlandse Kwaliteitsnorm voor Archeologie (KNA Waterbodems 4.1) moet er een Programma van Eisen (PvE) en/of Plan van Aanpak (PvA) worden opgesteld. Dit PvE/PvA omvat de doelstelling, de onderzoeksstrategie en -methodiek, de kaders en de praktische uitvoering van het onderzoek, zodat het proces soepel verloopt en meervoudig gebruik van de op uniforme wijze verkregen data wordt bereikt. Geadviseerd wordt om deze PvE/PvA ter goedkeuring voor te leggen aan het Bevoegd Gezag en de RCE. Na afronding van het inventariserend veldonderzoek kunnen tijdens de aanleg van de pijpleiding gegevens worden verzameld die – vanuit archeologisch oogpunt – op gedetailleerd niveau waardevolle informatie opleveren. Het kan zeer nuttig zijn om deze informatie vanuit archeologisch oogpunt verder te onderzoeken. Het verdient aanbeveling om, nadat de plannen zijn uitgewerkt, in overleg met de RCE de mogelijkheden hiervoor te onderzoeken.

Tijdens de installatie van de leiding kunnen archeologische voorwerpen worden ontdekt die volledig zijn begraven of tijdens het geofysisch onderzoek niet als archeologisch object zijn herkend. Wij adviseren passieve archeologische begeleiding op basis van een goedgekeurd Programma van Eisen. Passieve archeologische begeleiding houdt in dat een archeoloog tijdens de uitvoering van de werkzaamheden niet aanwezig is, maar altijd op afroep beschikbaar is. Het opvolgen van deze aanbeveling voorkomt vertragingen tijdens de werkzaamheden wanneer er onverwacht archeologische resten worden aangetroffen. Op grond van de Erfgoedwet is het verplicht om deze bevindingen te melden aan de toezichthouder (Minister van OCW). Deze melding moet ook worden opgenomen in het bestek van het werk.

Rijksdienst voor het Cultureel Erfgoed
Ministerie van Onderwijs, Cultuur en Wetenschap

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Datum 21 augustus 2023
Betreft 22A030-01 Geofysisch conceptrapport Aramis

[redacted]

Hierbij deel ik mede dat de Rijksdienst voor het Cultureel Erfgoed (RCE) het conceptrapport Aramis geofysisch van d.d. 03-08-2023 met referentienummer 22A030-01 goedkeurt.

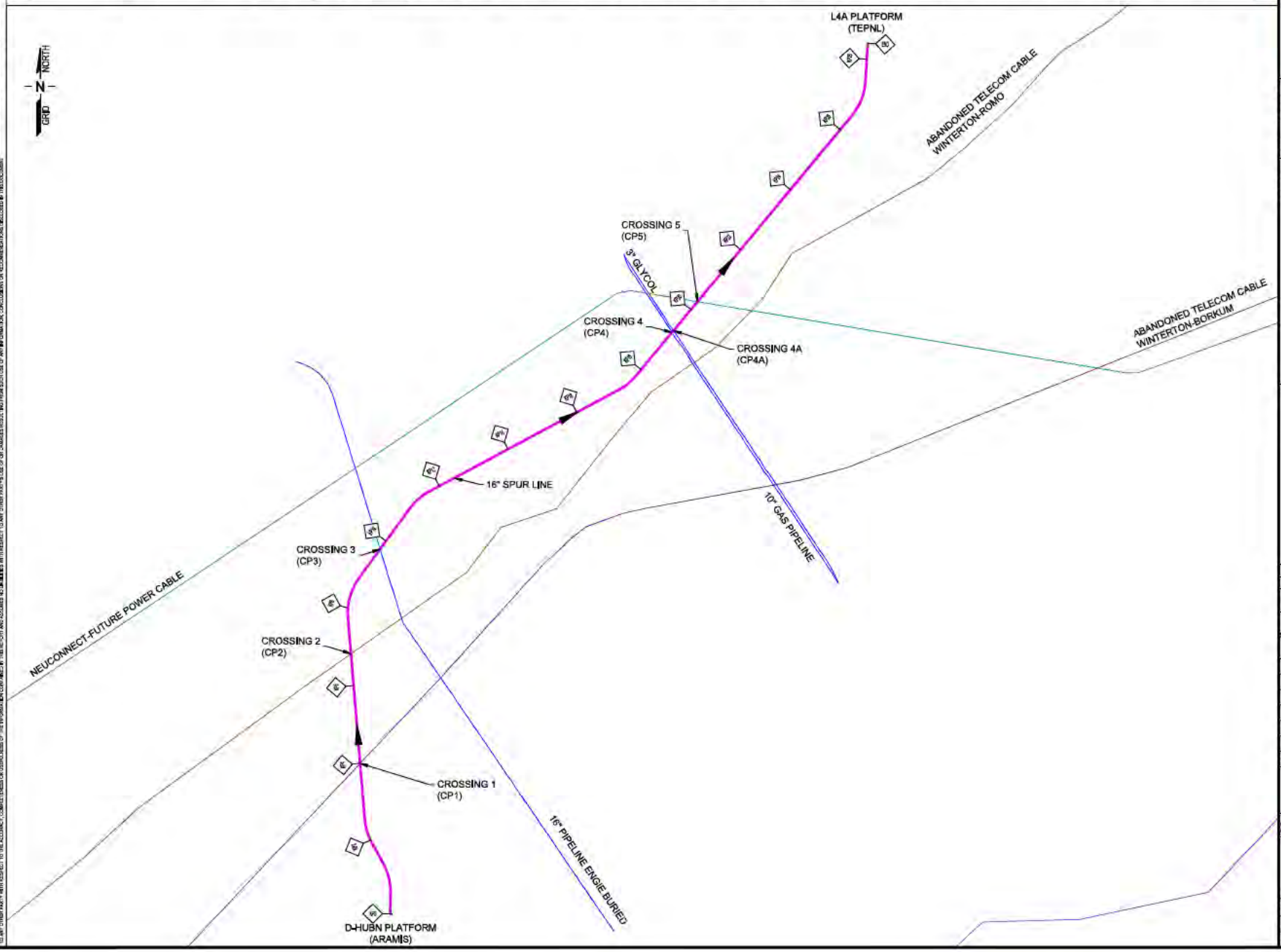
Dit advies is verzorgd door:
[redacted]

Mochten er naar aanleiding van dit advies nog vragen zijn, neem dan gerust contact op via de contactgegevens aan de rechterzijde.

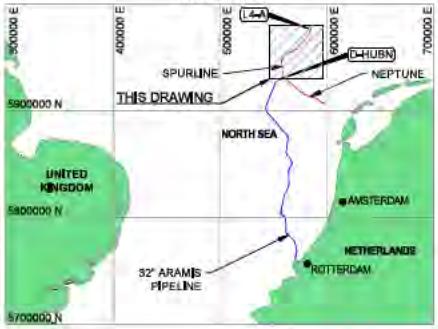
Met vriendelijke groet,

[redacted]

FEED CROSSING POINT REF.	PRE-FEED CROSSING REF.	ID	KP (km)	NORTHING	EASTING	WATER DEPTH (m)	CROSSING ANGLE (deg)	BURIAL DEPTH	TYPE	SERVICE	STATUS	BURIAL DATA	ROUTE DATA	OWNER / OPERATOR	DRG NUMBER
CROSSING 1 (CP1)	C1	KB0010	3,997	5 934 909,51	559 327,02	33,42	48,04	1,0	CABLE	TELECOM	ABANDONED	NOTE 2	NOTE 1	UNKNOWN (MOST LIKELY DEUTSCHE TELEKOM AG)	NL-ARM-070-PTC1-114031
CROSSING 2 (CP2)	C2	KB0025	6,817	5 937 719,98	559 090,87	35,29	59,84	1,0	CABLE	TELECOM	ABANDONED	NOTE 2	NOTE 1	UNKNOWN (MOST LIKELY DANISH PTT)	NL-ARM-070-PTC1-114032
CROSSING 3 (CP3)	C3	PL0064_PR	9,747	5 940 407,42	559 843,05	36,79	51,78	0,5	PIPELINE	16" GAS	IN SERVICE	NOTE 2	NOTE 1	NEPTUNE ENERGY	NL-ARM-070-PTC1-114033
CROSSING 4 (CP4)	C4	PL0047_PR	19,240	5 945 964,56	567 328,51	38,27	67,22	0,5	PIPELINE	10" GAS	IN SERVICE	NOTE 2	NOTE 1	TOTAL E&P	NL-ARM-070-PTC1-114034
CROSSING 4A (CP4A)	C5	PL0048_HS	19,306	5 946 014,70	567 370,10	38,28	74,22	0,5	PIPELINE	3" GLYCOL	IN SERVICE	NOTE 2	NOTE 1	TOTAL E&P	NL-ARM-070-PTC1-114034
CROSSING 5 (CP5)	C6	KB0112	20,266	5 946 753,90	567 983,11	38,52	59,76	1,5	CABLE	POWER	FUTURE	NOTE 3	NOTE 1	NEUCONNECT BRITAIN LIMITED	NL-ARM-070-PTC1-114035



KEYPLAN



NOTES:
1. IN ABSENCE OF DATA FROM ASSET OWNERS, THE CROSSING LOCATION IS TAKEN FROM THE GIS DATA SUPPLIED BY ARAMIS.
2. IN ABSENCE OF DATA FROM ASSET OWNERS, BURIAL DEPTH IS ASSUMED AS 1m FOR CABLES AND 0.5M FOR PIPELINES.
3. PLANNED BURIAL DEPTH FOR FUTURE CABLE FROM THE OWNER

REFERENCES:
[1] NL-ARM-070-PTC1-113818 ARAMIS DHUB-N TO L4-A SPURLINE ROUTE
[2] NL-ARM-070-PTC1-113820 L4-A SPURLINE ALIGNMENT SHEETS

LEGEND
- FLOW DIRECTION
- 2 Km KP MARKER

GEODETIC PARAMETERS					
DATUM	EPSG CODE	25831	PROJECTION	NAME	UTM
	HORIZONTAL	ETRS 1989		ZONE	31 NORTH
	VERTICAL	LAT		CENTRAL MERIDIAN	3° EAST
SPHEROID	NAME	GRS 1980		LATITUDE OF ORIGIN	EQUATOR
	SEMI MAJOR AXIS	6 378 137,000		FALSE EASTING	500000m
	SEMI MINOR AXIS	6 356 752,314		FALSE NORTHING	0m
	INVERSE FLATTENING	298,257222101		SCALE FACTOR	0,9996

Rev.	Date	Status	Revision Description	Iss.	Check.	Appr.
00	10.06.24	FR	ISSUED FOR REVIEW			
A	29.05.24	IDC	INTER DISCIPLINE CHECK			

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L4-A SPURLINE CROSSING ARRANGEMENT DRAWING

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ARAMIS



Aramis Constructability Study

Crossing inventory

Total E&P Nederland B.V.

19 March 2023

416010-00257 - ARM-CPT-BB3-PLR-REP-0048_2

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Appendix A Crossing matrix

Appendix B Crossing Overview Drawings

Acronyms and abbreviations

Acronym/abbreviation	Definition
AIS	Automatic Identification System
BOD	Basis of Design
CAPEX	Capital Expenditure
CCUS	Carbon Capture Utilization and Storage
DNV	Det Norske Veritas
DSV	Diving Support Vessel
EN	European Norm
FEED	Front End Engineering & Design
HDD	Horizontal Directional Drilling
ID	Inside Diameter
MEG	Monoethylene Glycol
NAM	Nederlandse Aardolie Maatschappij B.V.
NS	Nearshore
MSV	Multi-Service Vessel
MTE	Microtunnel East
NEN	Nederlandse Norm (Nederlands Normalisatie Instituut)
OD	Outside Diameter
SI	Système International (d'unités)
TEPNL	Total E&P Nederland B.V.
WP	Work Package

1 Introduction

1.1 Aramis development

TotalEnergies, Shell Netherlands, Energie Beheer Nederland (EBN) en NV Nederlandse Gasunie have agreed to cooperate to review and de-risk the possibility to make use of existing gas fields and facilities in their offshore operated K- & L-blocks to develop together a low-cost CCS project, named Aramis, and progressing it further.

The Aramis offshore backbone or trunkline, a 28 or 32-inch nominal OD subsea pipeline will transport dense phase CO_2 from an onshore terminal to depleted gas fields offshore The Netherlands.

The trunkline will be designed to transport up to 22 MTPA CO_2 and will incorporate several tie-in points to facilitate future third-party tie-in and expansion of the offshore distribution network as illustrated in Figure 1.1.



Figure 1.1 Aramis outline schematic

The Aramis project will consist of:

- CO_2 supply. The project aims to develop a competitive transportation and offshore storage service to European CO_2 emitters.
- Onshore hub. Captured CO_2 would be transported from emitters' sites either by shipping (including barges) and / or pipeline and delivered to an onshore hub.

- Offshore transportation network. The intention is to construct a new pipeline, running from the onshore hub to offshore platforms. This new pipeline will in principle be designed on a third-party access basis to transport the CO_2 to the storage complexes.
- CO_2 storage in the central sector of the Dutch North Sea in (almost) depleted gas fields.

The study to be performed is part of the early concept studies to define a suitable offshore route and identify main cost drivers.

1.2 Scope of the Document

Various route sections have been developed that can be combined to form the Aramis backbone route, depending on different system development scenarios (Ref. [10]). Based on the present offshore pipeline route sections as defined by Aramis, an inventory of crossed cables and pipelines has been made based on public domain information. The identified crossings have been distributed over 10 groups and for each group a typical crossing design has been made, consisting of a number of pre-lay supports and estimate of post-lay volume of rock cover. Based on a price per installed mattress and per installed m^3 of rock, a cost per crossing has been estimated. For the presently envisaged Aramis backbone route a separate summary of crossings is given.

The crossing lay-out will depend on the burial condition of Aramis and of crossed pipe (assuming all cables are buried). As a result, it is required to make assumptions on the burial requirement of each Aramis pipeline section. Based on cost per meter post lay trenching the cost of trenching the Aramis pipeline is included as well.

1.3 Definitions

1.3.1 System of Units

All dimensional data and results presented shall be expressed in SI (metric) units. In addition, other units may be used where they are universally accepted standards, such as for standard flow rates, temperature (°C), pressure (bar), or pipeline diameters (inch).

1.3.2 Other Definitions

Table 1-1: Definitions

CLIENT	Total E&P Nederland B.V. [TEPNL]
PROJECT	Aramis backbone 32-inch pipeline
INTECSEA	Intecsea Netherlands BV supporting Aramis with concept studies
HOLD	Data to be established, determined or to be received,

1.4 HOLD Record

Location	Description of HOLD
None	N/A

2 Summary and Conclusions

For the Aramis backbone pipeline system, ten (10) different crossing configurations were developed as shown in Table 2.1.

Table 2.1 – Crossing Types

Crossed infrastructure	Aramis buried	Aramis on seabed
Pipeline buried, < 16-inch	Type 1	Type 2
Pipeline on seabed, 16 to 24-inch	Type 3	Type 4
Pipeline on seabed, 24 to 36-inch	Type 5	Type 6
cable buried	Type 7	Type 8
cable abandoned/OOS	Type 9 cut and remove section	Type 10 no action

When the proposed Aramis backbone route sections are cross referenced with the information on the existing North Sea infrastructure Ref. [4], a total of 76 crossing locations were identified for all route sections combined (see Table 4.2). For the sections that presently are envisaged to form the Aramis backbone a total of 47 crossings are identified, sub-divided into 9 different types (from the ten defined) as shown in Table 2.2 (assuming the preferred near shore route associated with an HDD sea defence crossing).

Table 2.2 – Number of Crossings per Section and Type (present most likely backbone route)

Section	Type 1	Type 2	Type 4	Type 5	Type 6	Type 7	Type 8	Type 9	Type 10	Total
NS HDD	1		1	1				2	1	6
A	5				1	9	1	7	5	28
C		2	1				1		2	6
D		1			1				1	3
F			3		1					4
Total	6	3	5	1	3	9	2	9	9	47

Costs were developed for each individual crossing as presented in Appendix A which resulted in an overall cost number of about € 29.7 million for the total crossing costs of the combined route sections, or € 17.2 million for the envisaged backbone route (sections NS HHD, A, C, D and F).

In addition, costs for post-lay trenching were estimated to be € 15.4 million for the envisaged backbone route. Mostly associated with the crossing of the sand wave area of route section A (part of all considered development scenarios).

It must be realized that not all assessed route sections may become part of the final Aramis backbone system. All presented information, such as the information on existing infrastructure from Ref. [4], burial status for Aramis backbone etc. will require verification from surveys, FEED design and contacts with stakeholders.

The FEED safety study and QRA, with the input of a dedicated shipping study, will need to demonstrate whether all the identified crossings will be feasible or alternatively some further re-routing is required.

3 Study Basis

The basis for the study is the offshore pipeline route(s)-sections as provided by Aramis. The digitized route (shape files) obtained from Aramis (Ref. [2]) was imported in the commercial GIS software Global Mapper. For the route section close to the Maasvlakte, both the HDD nearshore route and the Microtunnel East nearshore route were included. This resulted in route sections NS HDD, NS MTE and A through F and K, as shown in Figure 3.1, see also Ref. [10].

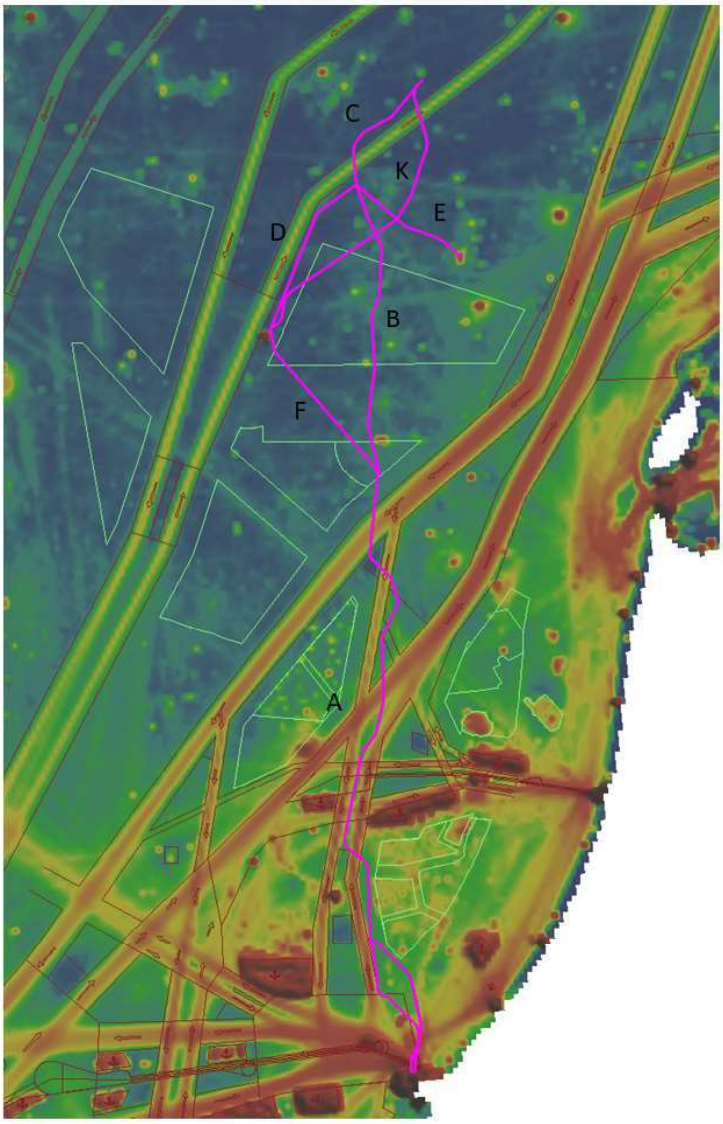


Figure 3.1 Offshore route(s)-sections

Note that the Aramis provided crossing location coordinates (63 crossings) in Ref. [1] were based on ED50 projection. However, the selected projection system for the project was changed to ETRS 89 projection in line with NEN 3656 requirements Ref. [3].

In Global Mapper a number of data sources were loaded such as the public domain data on offshore pipelines, telecom and electricity cables, water depth data (from EMODnet) as well as information on shipping activity to allow visual identification of the crossings and local circumstances.

4 Crossing Identification and Grouping

4.1 Introduction

The routing information as provided by Aramis have been combined with public domain data from RWS (Ref. [4]). This allows assigning specific information to each crossing location including:

- Identifier crossed infrastructure: PL number for pipelines and KB number for cables
- Start and end location of crossed infrastructure
- Status (active, planned or abandoned)
- Use: telecom, electrical, oil, gas, methanol, glycol
- Type of cable or pipe diameter

This provides useful information for grouping of the crossings and development of typical crossing lay-outs for each group.

Information on shipping density and areas with migrating sand dunes has been used to obtain a first estimate of sections where Aramis may have to be buried for safety reasons. Burial of Aramis can then be considered in determining the crossing configuration. Burial of Aramis is assumed mainly where the pipeline crosses sand dune/wave areas and major shipping lanes, this results in the following sections where burial of Aramis is likely required:

- Route section A:
    - A length of 10 km, starting at the landfall, because of shipping activity
    - A length of 75 km, starting around P18-A, because of migrating sand dunes/waves
    - A length of 20 km, crossing of the shallow water route between Rotterdam area and north of the Netherlands, southward bound
- Route section C: crossing of deep-water shipping lane between central southern North Sea and north of the Netherlands, a length of 5 km
- Route section K: crossing of deep-water shipping lane between central southern North Sea and north of the Netherlands, a length of 5 km

The total length of Aramis pipeline assumed buried is 110 km (105 km Section A, 5 km Section C), the 5 km for Section K is not part of the presently preferred route.

Note that for this study, it is conservatively assumed that the pipeline is buried in the whole area with (travelling) sand waves, with the objective to avoid future free spans. This will need to be confirmed during FEED and may result in reduced requirements for burial of pipeline sections.

4.2 Crossing Types

The following logic is used to define crossing types under which each crossing can be placed, resulting in several crossing groups for which typical lay outs can be defined that are representative for each crossing within that group.

Distinction is made between crossings in sections where the Aramis pipeline will likely be buried and where the Aramis pipeline will be installed on the seabed. In addition, the following five groups are defined as likely resulting in significantly different crossing lay-outs:

- Small diameter pipelines, < 16 inch, these are always buried
- Medium size pipelines of 16 to 24-inch, installed on seabed
- Large diameter pipelines of 24 to 36-inch, installed on seabed
- Cables in use, these are always buried
- Cables out of use

The five groups in combination with the options Aramis buried or Aramis on seabed results in a total of 10 types as shown in Table 4.1. It is noted that not every type of identified crossing will actually occur (see Section 4.3).

Table 4.1 – Crossing Groups

Crossed infrastructure	Aramis buried	Aramis on seabed
Pipeline buried, < 16-inch	Type 1	Type 2
Pipeline on seabed, 16 to 24-inch	Type 3	Type 4
Pipeline on seabed, 24 to 36-inch	Type 5	Type 6
cable buried	Type 7	Type 8
cable abandoned/OOS	Type 9 cut and remove section	Type 10 no action

Each type of crossing will be discussed briefly below.

4.3 Typical Crossing Lay-out

For each type of crossing a lay-out is defined below, except for type 3 since no crossing of this type is identified.

Each crossing will consist of a number of mattresses, sufficient to bring the Aramis pipeline to the required height above seabed to guarantee the required free space between Aramis and crossed object, and to support the Aramis pipeline to avoid unacceptable spanning along the pipe axis (additional supports between crossing point and touch-down point on the seabed if needed).

The total length of the crossing pipeline section is determined based on the natural curvature of a raised pipeline, using:

$$\delta := \frac{q\,L^4}{72\,E\,I}$$

Where:

δ is the height of the pipeline above seabed at the crossing location

q is the weight of the pipeline per meter

L is the distance from crossing location to touch down on seabed (1/2 of crossing length)

E is Young's modulus

I is the second moment of area

The height above seabed at crossing location, length of crossing and assumed rock cover cross-section (2 m width at top and 1:5 side slopes) provide the basis for calculating the required volume of rock. Where the Aramis pipeline is assumed buried, the burial requirements is assumed to be 0.6 m to top of pipe. When the pipeline has to be raised to the surface to cross existing infrastructure it is assumed that this cover is provided by rock dump. For crossing angles deviating 20 degrees or more from perpendicular a factor of 1.2 is applied on the required rock volume.

4.3.1 Type 1 and 2

Type 1 and 2 crossings are crossings of small diameter pipelines (< 16-inch), which are required to be buried. Type 1 is where Aramis is also buried, Type 2 when Aramis is not buried. Even when the crossed pipeline is buried it is common practise to guarantee separation of the two pipelines by placement of a mattresses at the crossing location. To provide sufficient lay corridor width for Aramis pipeline installation, a 10 meter mattress is used or alternatively two 6 meter mattresses are placed next to each other. Considering similarity of Type 1 and Type 2, see Figure 4.1 for crossing lay-out.

The difference between Type 1 and 2 is that Aramis has to be raised from below seabed to mattress level (a larger vertical displacement), resulting in a larger crossing length. Also, cover that is provided by soil in the buried sections must be replaced by rock cover at the crossing location. Therefore, the rock cover is not limited to top of pipe but will provide an additional cover for protection (assumed 0.6 m).

This crossing requires one 10 meter or two 6 meter wide mattresses per crossing and rock cover to fill the gap between pipeline and seabed and provide replacement protective cover.

In case Aramis is not buried (type 2) there is no need for a rock cover on top of the pipeline at the crossing location.

This is a very basic crossing layout (see Figure 4.1) with two 6 meter or one 10 meter (shown) mattresses and rock cover to top of pipeline level. The selection of mattress dimensions is usually made on, amongst other things, commercial grounds (reduced lay speed versus mattress procurement and installation cost) in consultation with the installation contractor.

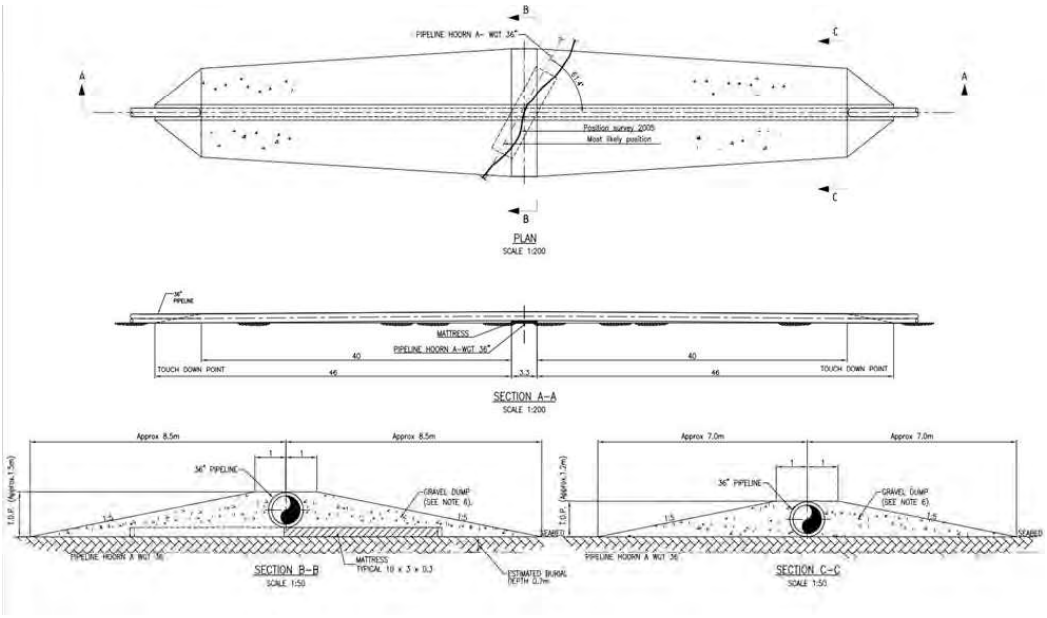


Figure 4.1 Typical lay-out of crossing type 2

4.3.2 Type 3 to 6

In this case the Aramis pipeline crosses a medium (16 to 24-inch) or large (24 to 36-inch) pipeline that is positioned on the seabed. This type of crossing requires a larger number of stacked mattresses to achieve the required height to cross the existing pipeline. A crossing with more vertical height will also become longer and it will require additional pre-installed intermediate supports between crossing point and touch down point to support the spanning pipeline at distinct locations. Depending on the size of crossed pipeline this will result in 24 (type 4) to 28 (type 5 and 6) mattresses (6m wide) per crossing. Note that there is no type 3 crossing identified.

The general lay-out principle is demonstrated in Figure 4.2. This is actually a type 5 crossing for a small diameter pipeline (Total K5F-K6N 8-inch pipeline crossing 36-inch NGT pipeline, approved for

construction drawing by installation contractor). The general lay-out principal applies for all types 3 to 6.

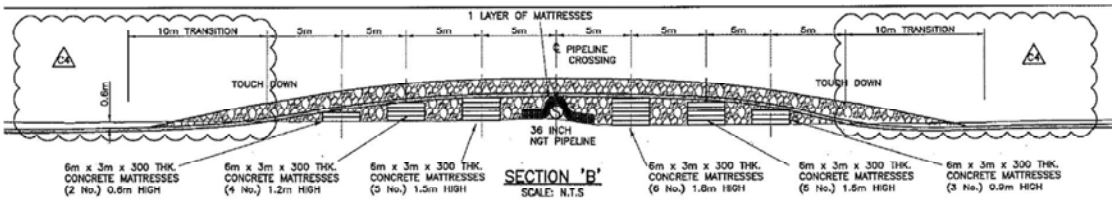


Figure 4.2 Typical lay-out of crossing representative for types 3 to 6 (actual type 5, buried line over a 36-inch pipe)

Note that in this case the crossing pipeline is a small diameter pipeline (8-inch) with a limited allowable span length requiring supports at relative short distances. For Aramis the spacing between supports can be larger (instead of 5 m, it can be 20 to 30 m) and this has been taken into account in determining the required number of mattresses.

4.3.3 Type 7 and 8

Type 7 concerns crossings where the unburied Aramis pipeline is crossing an active, buried cable. For cables in use, it is assumed that a separation between cable and pipeline of 0.3 m has to be guaranteed by placement of a mattress (irrespective of the burial depth of the cable). It is also assumed that the mattresses have to be placed adjacent to the crossed cable to avoid additional overburden on top of the cable. To provide sufficient corridor width and sufficient distance from pipe position to the edge of the mattresses it is assumed that two mattresses of 6 m each or one mattress of 10 m are placed each side of the cable. This results in a typical crossing lay-out as shown in Figure 4.3. This type requires 4 mattresses (6 m) or 2 mattresses (10m) per crossing.

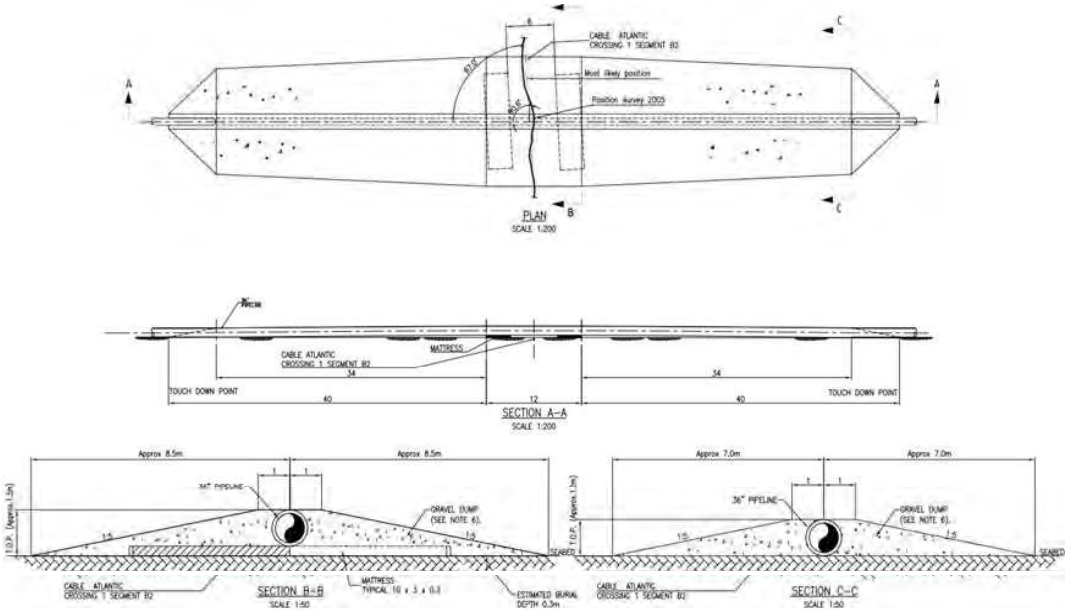


Figure 4.3 Typical lay-out of crossing type 7

Type 8 is in principle the same as type 7. Because the Aramis pipeline is buried the length of the crossing is larger and the soil cover has to be replaced by rock cover. This crossing also requires 4 (6m) or 2 (10m) mattresses, and the required rock volume is more than for type 7.

4.3.4 Type 9

Type 9 are crossings where the buried Aramis pipeline crosses an out of use cable. This will require removal of a section of the cable.

For the removal of the cables, a vessel is used with a grapnel, a hydraulic cutter and a reel on board. With the help of the grapnel, a cable is located and pulled on board. Then the cable is cut with the hydraulic cutter and attached to the reel on the deck and a section recovered. As soon as the cable has been removed beyond the future cable corridor, the cable is cut again. The ends of the cut cables are all provided with a counterweight and placed back on the seabed. The coordinates are recorded and shared with the Hydrography Service.

No crossing design is required, a fixed amount of 150,000 € per crossing is included for cutting and removal of the cable section.

4.3.5 Type 10

This is the type where the Aramis pipeline is installed on the seabed and the crossed abandoned cable is assumed buried and no remedial action is required. There are no costs associated with this type of crossing.

4.4 Crossing Statistics

The total number of crossings identified for all route sections is 76, being 74 unique crossings: NS MTE 4 and 5 are the same as NS HDD 5 and 6. The number per group and type are given in Table 4.2.

Table 4.2 – Number of Crossings per Section and Type (all route sections)

Section	Type 1	Type 2	Type 4	Type 5	Type 6	Type 7	Type 8	Type 9	Type 10	Total
NS HDD	1		1	1				2	1	6
NS MTE	1			1				2	1	5
A	5				1	9	1	7	5	28
B		2	3		3				1	9
C		2	1				1		2	6
D		1			1				1	3
E		2	2						1	5
F			3		1					4
K		3	1		1		1		4	10
Total	7	10	11	2	7	9	3	11	16	76

There are 29 crossings in the sections where Aramis is expected to be buried (type 1, 5, 7 and 9). Of those 29 crossings, 21 are in Section A; 5 small diameter buried pipelines (type 1), and 16 cable crossings (type 7 and 9). The other 8 are in the near shore area.

The other 47 crossings are in sections where Aramis is not buried (type 2,4,6,8 and 10), of those 47 crossings 19 are for cables and 28 are pipeline crossings.

If only the route sections are considered that are presently the most likely sections to form the Aramis backbone, a list as provided in Table 4.3 is obtained (based on HDD sea defence crossing and most preferred near shore route, 1 more crossing than microtunnel solution).

Table 4.3 – Number of Crossings per Section and Type (present most likely backbone route)

Section	Type 1	Type 2	Type 4	Type 5	Type 6	Type 7	Type 8	Type 9	Type 10	Total
NS HDD	1		1	1				2	1	6
A	5				1	9	1	7	5	28
C		2	1				1		2	6
D		1			1				1	3
F			3		1					4
Total	6	3	5	1	3	9	2	9	9	47

5 Cost Estimate

5.1 Cost Estimate Basis

The basis for the cost estimate is:

- Cost per installed mattress, including: production, transportation to quay side, vessel mobilization, transit to location and installation at location, survey. For the estimate, mattress dimensions 6 m * 3 m * 0.3 m are assumed.
- Cost per installed m^3 of rock, including: purchase of rock material of different sizes, fall pipe vessel mobilization, loading, transit and placement at location, survey
- For out of use cable crossings, no cost is included if Aramis is expected to be installed on the seabed, in case Aramis is likely to be trenched, a lump sum of € 150,000 is included for cutting and removal of a section of the out of use cable (See Section 4.3.4)
- Cost of post-trenching per length of pipeline, including: vessel mobilization, trenching and survey

Table 5.1 shows the cost assumed per item. Note that the values are based on in-house values from previous projects with corrections to obtain present day values.

Table 5.1 - Cost Basis

Cost item	Cost [€]
Mattress, installed, each	20,000
Rock, installed, m^3	130
Out of use cable cutting and removal, each	150,000
Post-lay trenching, m	140

5.2 Cost Estimate

Based on required number of supports and volume of rock cover, combined with a cost per installed mattress and per m^3 of installed rock costs are determined per crossing. The cost will be different per crossing, this is the result of additional rock dump required for unfavourable crossing angles. As a result, small variations can occur for crossings that are of the same crossing type. Table 5.2 gives the range per crossing type

Table 5.2 – Cost per Crossing Type

Crossing type	Cost range [€]
1	450,000
2	175,000-200,000
4	650,000-850,000
5	1,290,000
6	890,000-1,150,000
7	420,000-490,000
8	210,000-240,000
9	150,000
10	0

Table 5.3 gives the cost per route section.

Table 5.3 – Cost per Route Section

Route section	Total number	Number with no cost	Cost [€]
NS HDD	6	1	2,834,000
NS MTE	5	1	2,036,000
A	28	5	8,617,000
B	9	1	5,826,000
C	6	2	1,355,000
D	3	1	1,218,000
E	5	1	1,916,000
F	4	0	3,224,000
K	10	4	2,643,000
Total	76	16	29,669,000

Assumptions have been made on Aramis sections that possibly have to be trenched for safety reasons (shipping interaction) and free span control (moving sand wave area). This was required to identify the different types of crossing that occur on the route sections. The trenched section lengths per route section with the cost associated with post lay trenching (based on rate per length as given in Table 5.1) are given in Table 5.4. For the envisaged Aramis backbone route only the cost for sections A and C are relevant.

Table 5.4 – Cost of Trenching per Route Section

Route section	Total length, [m]	Cost [€]
A	105,000	14,700,000
C	5,000	700,000
K	5,000	700,000

6 References

Ref. [1] PLR 21-029 Aramis – Scope of Work for Constructability Study Crossing list with co-ordinates and angles and shape file routes from Aramis, WP8 – Pipeline and Cable Crossings and MTO, 22 March 2022

Ref. [2] Aramis SHP (West A - West Central routes - Installations), Route shapefiles, e-mail Stéphanie Pasquet (TotalEnergies SE Data Tech/BDO/Geospatial) to F. van der Linden (Intecsea)

Ref. [3] E-mail D. Rudge (Total energies) to F. van der Linden (Intecsea) dd 13/4/2022, ARAMIS: PLR 21-029 Addendum - WP8 - Pipeline and Cable Crossings and MTO - Approved

Ref. [4] Noordzeeloket, https://www.noordzeeloket.nl/en/up-date-atlas/

Ref. [5] NEN 3650 part 1 and 2, 2020 Requirements for pipeline systems

Ref. [6] NEN 3651, 2020 Additional requirements for pipelines in or nearby important public works

Ref. [7] NEN 3656, 2015 Requirements for submarine pipeline systems in steel

Ref. [8] Aramis Constructability Study Preliminary installation analyses, ARM-CPT-BB3-PLR-REP-0037, Rev 1.0, Intecsea 16/02/2022

Ref. [9] Aramis Pipeline Routing Desktop Study - Expected Site Conditions Consultancy Report Dutch Sector of the North Sea, Fugro R201644, Rev. 03, 10 February 2022

Ref. [10] INTECESA, Routing, ARM-CPT-BB3-PLR-REP-0066



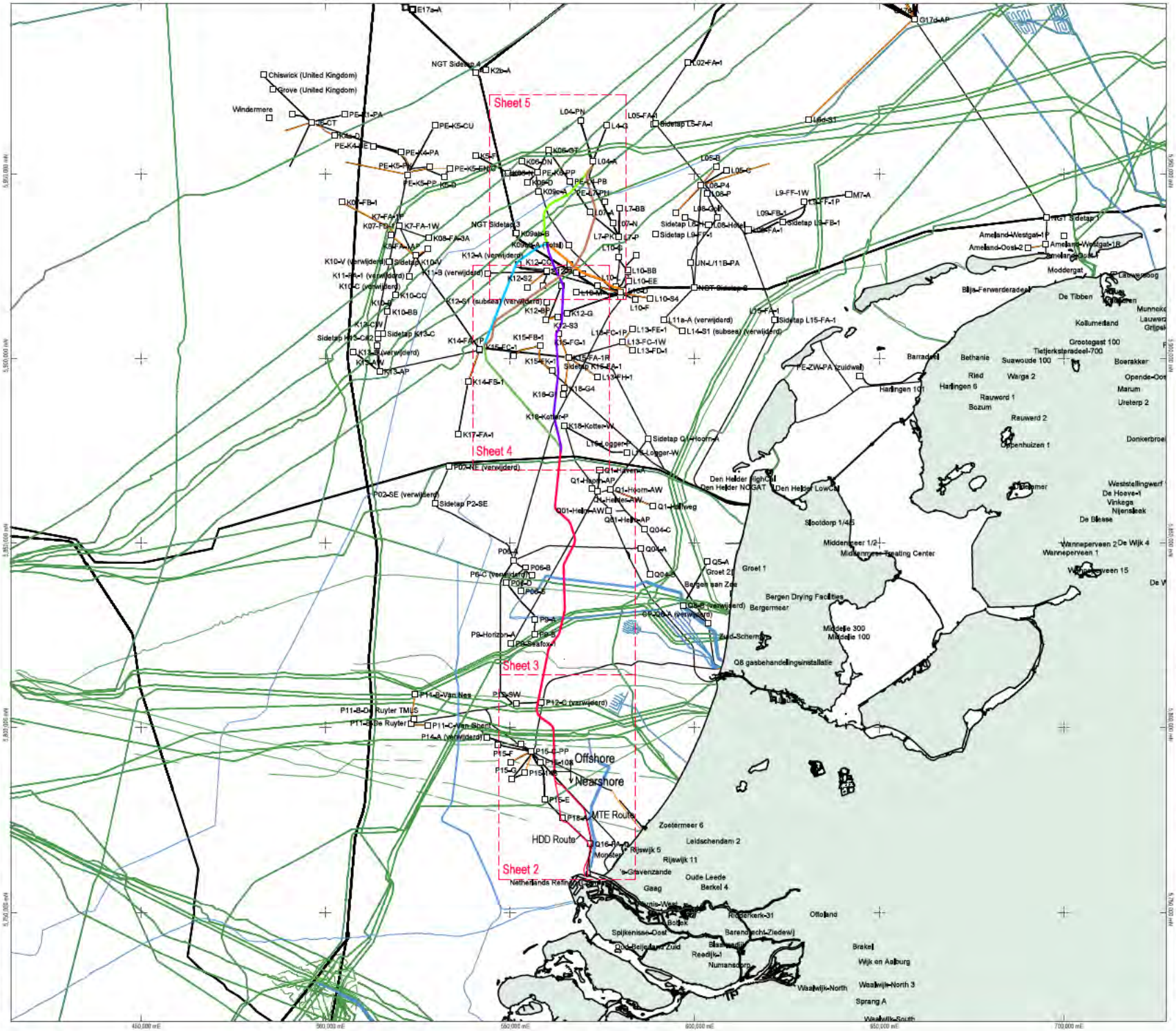
Appendix A Crossing matrix

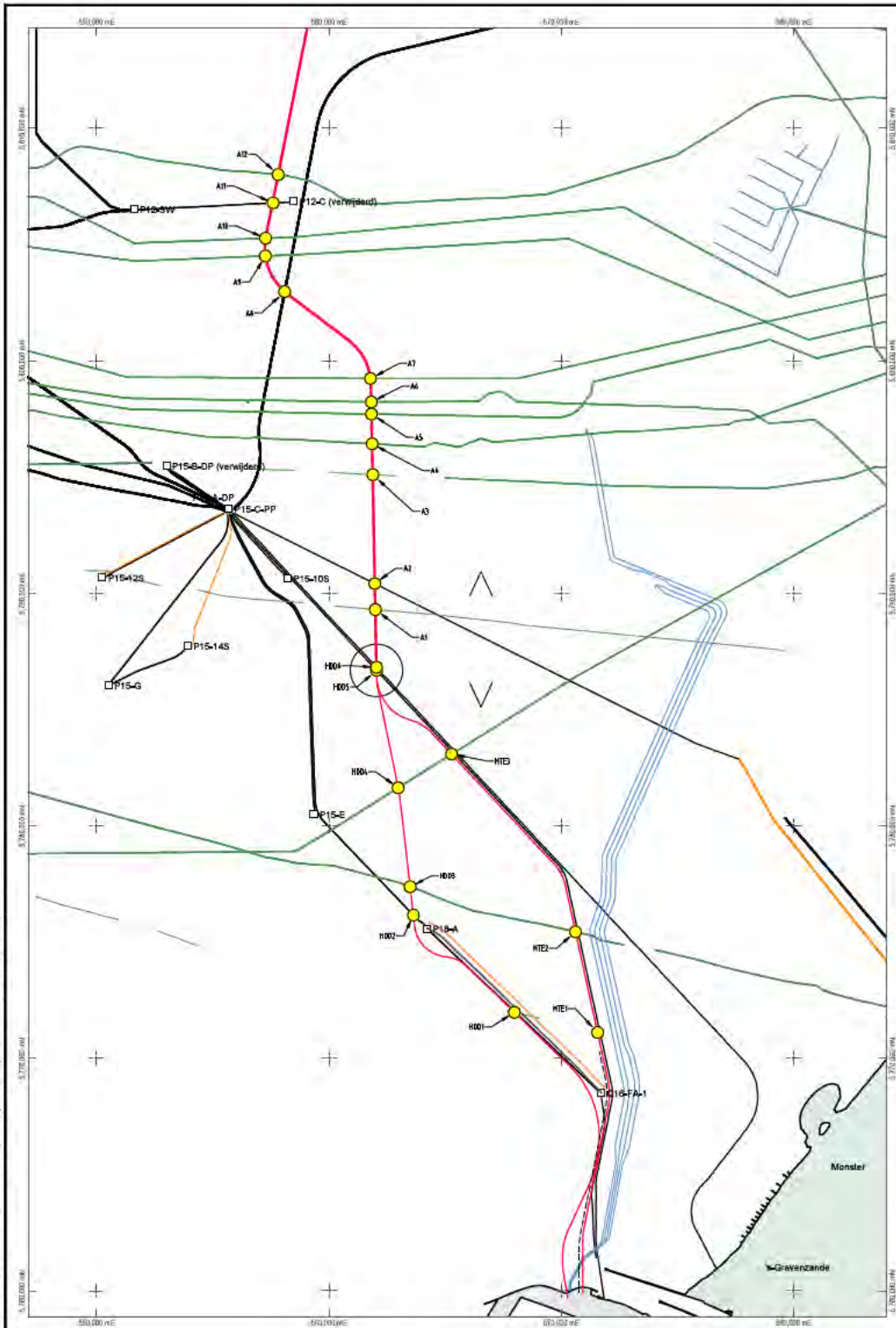
OVERVIEW CROSSING ARAMIS BACKBONE

OLD ID	ID	Total Section	ITS RWS No	ITS Crossing of	ITS Operator/ Owner	ITS Line or Cable Name	ITS From	ITS To	ITS Status	ITS Content	ITS Diameter pipe Cable Type (in)	Buried Aramis	Buried crossed P/C	Crossing ITS Type	Crossing Total Angle (deg)	ETRS89 31N Easting m	ETRS89 31N Northing m	Distance to previous	Crossing design Vert. Displ (m)	Crossing design 20000 Support No.	Crossing design euro per mat Length X-ing (2L)	Crossing design 130 m^3 rock	euro per m3 Cost, euro	Comment
HDD 1	HDD 1	NS HDD	KB0051	Cable	BT	UK - NL 4	Scheveningen (NL)	Lowesoft (GB)	Abandoned (partly) removed	Telecom	Coaxiaal	N	Y	10	x	567980	5771981		0,0	0	0,0	0	0	no action
HDD 2	HDD 2	NS HDD	PL0106_HS	Pipeline	TAQA Energy B.V.	16inch gas + 3inch methanol	P15-A	P15-D	Active	Gas	16	N	N	4	60	563632	5776158	6029	0,7	24	108,6	2447	798,151	* 1,2 m3 rock for angle
HDD 3	HDD 3	NS HDD	KB0001	Cable	Unknown	UK - NL 5	Scheveningen (NL)	Lowesoft (GB)	Abandoned (partly) removed	Telecom	Coaxiaal	Y	Y	9	x	563481	5777384	1234	0,0	0	0,0	0	150,000	cost for cut and remove
HDD 4	HDD 4	NS HDD	KB0002	Cable	Flute Ltd	Concerto 1 Segment 1 East	Zandvoort (NL)	Zeebrugge (B)	Abandoned (partly) removed	Telecom	Glassfiber / buried	Y	Y	9	x	562977	5781540	4287	0,0	0	0,0	0	150,000	cost for cut and remove
HDD 5	HDD 5	NS HDD	PL0099_PR	Pipeline	TAQA Energy B.V.	P/15-D - Maasvlakte	P15-D	Maasvlakte	Active	Gas	26	Y	N	5	60	562047	5786690	5135	1,6	24	132,4	6207	1,286,853	* 1,2 m3 rock for angle
HDD 6	HDD 6	NS HDD	PL0039_PR	Pipeline	TAQA Energy B.V.	P/15-C - Hoek van Holland	P15-C	Hoek van Holland	Active	Oil	10	Y	Y	1	60	562045	5786822	132	0,9	2	115,4	3148	449,280	* 1,2 m3 rock for angle
MTE 1	MTE 1	NS MTE	KB0051	Cable	BT	UK - NL 4	Scheveningen (NL)	Lowesoft (GB)	Abandoned (partly) removed	Telecom	Coaxiaal	N	Y	10	x	571559	5771114		0,0	0	0,0	0	0	no action
MTE 2	MTE 2	NS MTE	KB0001	Cable	Unknown	UK - NL 5	Scheveningen (NL)	Lowesoft (GB)	Abandoned (partly) removed	Telecom	Coaxiaal	Y	Y	9	x	570610	5775441	4430	0,0	0	0,0	0	150,000	cost for cut and remove
MTE 3	MTE 3	NS MTE	KB0002	Cable	Flute Ltd	Concerto 1 Segment 1 East	Zandvoort (NL)	Zeebrugge (B)	Abandoned (partly) removed	Telecom	Glassfiber / buried	Y	Y	9	x	565275	5783087	9323	0,0	0	0,0	0	150,000	cost for cut and remove
MTE 4	MTE 4	NS MTE	PL0099_PR	Pipeline	TAQA Energy B.V.	P/15-D - Maasvlakte	P15-D	Maasvlakte	Active	Gas	26	Y	N	5	60	562047	5786690	4838	1,6	24	132,4	6207	1,286,853	* 1,2 m3 rock for angle
MTE 5	MTE 5	NS MTE	PL0039_PR	Pipeline	TAQA Energy B.V.	P/15-C - Hoek van Holland	P15-C	Hoek van Holland	Active	Oil	10	Y	Y	1	60	562045	5786822	132	0,9	2	115,4	3148	449,280	* 1,2 m3 rock for angle
A1	A1	A	KB0063	Cable	Unknown	UK - NL 7	Katwijk (NL)	Covehite (GB)	Abandoned (partly) removed	Telecom	Coaxiaal	Y	Y	9	x	561997	5789301	2479	0,0	0	0,0	0	150,000	cost for cut and remove
A2	A2	A	PL0228_PR	Pipeline	ENGIE E&P Nederland B.V.	Q/13A (Amsell) - P15-C	Q/13a-A	P15-C	Active	Oil	8	Y	Y	1	60	561976	5790420	5119	0,9	2	115,4	3148	449,280	* 1,2 m3 rock for angle
A3	A3	A	KB0019	Cable	KPN	UK-NL6	Katwijk (NL)	Covehite (GB)	Abandoned	Telecom	Coaxiaal	Y	Y	9	x	561884	5795104	4686	0,0	0	0,0	0	150,000	cost for cut and remove
A4	A4	A	KB0033	Cable	GTS	Hermes 1	Zandvoort (NL)	Aldeburgh (GB)	Abandoned	Telecom	Glassfiber/buried	Y	Y	9	x	561859	5796431	1327	0,0	0	0,0	0	150,000	cost for cut and remove
A5	A5	A	KB0076	Cable	Pipiper	COAM	Cork	Katwijk	Planned	Telecom	Glassfiber/buried	Y	Y	10	x	561834	5797711	1280	0,0	0	0,0	0	0	no action
A6	A6	A	KB0018	Cable	British Telecom	Telecomkabel TAT14 Segment I	Katwijk (NL)	Saint Valery en Caux	Active	Telecom	Glassfiber/in de bodem en op de bodem	Y	Y	7	90	561824	5798228	517	0,9	4	115,4	2624	421,066	
A7	A7	A	KB0030	Cable	MCI World Com	Ulysses 2 (1997)	Lowestoft (GB)	Ijmuiden (NL)	Active	Telecom	Glass fiber	Y	Y	7	90	561788	5799242	1015	0,9	4	115,4	2624	421,066	
A11	A8	A	PL0234_PR	Pipeline	Tulip Oil	Q/10 - P/15 Rijn	Q/10-FA	P15-A-DP	Active	Gas	12.75	Y	Y	1	60	558094	5802975	5252	0,9	2	115,4	3148	449,280	* 1,2 m3 rock for angle
A8	A9	A	KB0045	Cable	Viatel UK Ltd	Circe 1 North (1998)	Zandvoort (NL)	Lowesoft (GB)	Active	Telecom	Glassfiber	Y	Y	7	75	557265	5804507	1742	0,9	4	115,4	2624	421,066	
A9	A10	A	KB0003	Cable	Flute Ltd	Concerto 1 Segment 1 North (Laid 1999)	Sizewell (GB)	Zandvoort (NL)	Active	Telecom	Unknown / buried	Y	Y	7	75	557275	5805273	766	0,9	4	115,4	2624	421,066	
X	A11	A	PL0084_HS	Pipeline	Wintershall Noordzee B.V.	P/12-SW - P/12-C	P12-SW	P12-C	Abandoned	Gas	8	Y	Y	1	75	557599	5806796	1557	0,9	2	115,4	2624	381,066	
A10	A12	A	KB0115	Cable	Zayo	Circe north 2 replacement	Zandvoort (NL)	UK	Planned	Telecom	Fiberglass	Y	Y	10	x	557816	5808008	1231	0,0	0	0,0	0	0	no action
A12	A13	A	KB0113	Cable	euNetworks	Scylla HDD	Ijmuiden (NL)	Lowestoft (UK)	Active	Telecom	Fiberglass	Y	Y	7	60	560079	5819417	11631	0,9	4	115,4	3148	489,280	* 1,2 m3 rock for angle
A13	A14	A	KB0074	Cable	Global Crossing	Atlantic Crossing 1 Segment B1 (Laid 1998)	Castlioum (NL)	Whitesand (GB)	Active	Telecom	Glassfiber/buried	Y	Y	7	60	563576	5826580	7971	0,9	4	115,4	3148	489,280	* 1,2 m3 rock for angle
A14	A15	A	KB0066	Cable	KPN	Rioja 3 (laid 1994)	Veurne (B)	Egmond (NL)	Abandoned	Telecom	Glassfiber/in de bodem en op de bodem	Y	Y	9	x	563807	5827581	1027	0,0	0	0,0	0	150,000	cost for cut and remove
A15	A16	A	KB0117	Cable	TenneT	NOZ HKW Beta (Part 2)	Hollandse Kust (west B)	Wijk aan Zee	Planned before Aramis	Elektra	Copper	Y	Y	7	60	564177	5829163	1625	0,9	4	115,4	3148	489,280	* 1,2 m3 rock for angle
A16	A17	A	KB0015	Cable	KPNQwest	Rembrandt 1 (1998)	Beverwijk (NL)	Lowesoft (GB)	Abandoned	Telecom	Glassfiber/in de bodem en op de bodem	Y	Y	9	x	564226	5829376	219	0,0	0	0,0	0	150,000	cost for cut and remove
A17	A18	A	KB0116	Cable	TenneT	NOZ HKWB (Part 1)	Hollandse Kust (west B)	Wijk aan Zee (NL)	Planned before Aramis	Elektra	Copper	Y	Y	7	60	564301	5829994	327	0,9	4	115,4	3148	489,280	* 1,2 m3 rock for angle
A18	A19	A	KB0029	Cable	Alcatel Submarine Networks Ltd c/f/c Telecom CPC	PANGEA Segment 2 (South)	Lowestoft (GB)	Egmond (NL)	Active	Telecom	Glassfiber/in de bodem en op de bodem	Y	Y	7	60	564366	5829975	288	0,9	4	115,4	3148	489,280	* 1,2 m3 rock for angle
A19	A20	A	KB0065	Cable	Unknown	UK - NL 10	Egmond (NL)	Lowesoft (GB)	Abandoned	Telecom	Coaxiaal / surface laid in de bodem en op de bodem	Y	Y	9	x	564651	5837126	7157	0,0	0	0,0	0	150,000	cost for cut and remove
A20	A21	A	KB0067	Cable	Cable and Wireless	UK -NL 14	Egmond (NL)	Winterton (GB)	Abandoned	Telecom	Glassfiber/buried	Y	Y	9	x	564601	5838798	1673	0,0	0	0,0	0	150,000	cost for cut and remove
A21	A22	A	KB0100	Cable	Tennet	noz hkw+kn Hollandse Kust west - HK noord	hkw	hkn	Planned	Elektra	Copper	Y	Y	10	x	564563	5840046	1249	0,0	0	0,0	0	0	no action
A22	A23	A	KB0102	Cable	Tennet	noz hkw+kn Hollandse Kust west - HK noord	hkw	hkn	Planned	Elektra	Copper	Y	Y	10	x	564557	5840248	202	0,0	0	0,0	0	0	no action
A23	A24	A	KB0101	Cable	Tennet	noz hkw+kn Hollandse Kust west - HK noord	hkw	hkn	Planned	Elektra	Copper	Y	Y	10	x	564550	5840450	202	0,0	0	0,0	0	0	no action
A25	A25	A	PL0148_PR	Pipeline	Wintershall Noordzee B.V.	Q/04-A - P/06	Q/4-A	P6-A	Active	Gas	14	Y	Y	1	60	567025	5848050	8949	0,9	2	115,4	3148	449,280	* 1,2 m3 rock for angle
A24	A26	A	PL0109_PR	Pipeline	Petrogas E&P LLC	Horizon A - Helder A	P9-Horizon-A	Q/1-Helder-AW	Active	Oil	10	Y	Y	1	60	567309	5852050	3043	0,9	2	115,4	3148	449,280	* 1,2 m3 rock for angle
A26	A27	A	KB0107	Cable	British Telecom	BT North Sea	Callantsoog	Winterton	Planned before Aramis	Telecom	Glassfiber/buried	N	Y	8	75	563412	5872009	20306	0,3	4	87,7	1025	213,196	
A27	A28	A	PL0178_PR	Pipeline	BBL Company V.O.F.	BBL	Balgzand (NL)	Bacton (GB)	Active	Gas	36	N	N	6	75	563639	5873202	1199	1,2	28	124,4	3727	1,044,454	
B1	B1	B	PL0032_PR	Pipeline	Wintershall Noordzee B.V.	P/06-A - L/10-A	P6-A	L10-AR	Active	Gas	20	N	N	4	60	582149	5883230	10123	0,8	24	112,3	2805	844,609	* 1,2 m3 rock for angle
B2	B2	B	PL0030_PR	pipeline	NAM B.V.	K15-FB-1 - Den Helder (Local)	K15-FB-1	Den Helder	Active	Gas	24	N	N	6	60	582908	5884903	11698	0,9	24	115,7	3185	894,086	* 1,2 m3 rock for angle
B3	B3	B	PL0004_PR	Pipeline	Wintershall Noordzee B.V.	West Gas Transport (WGT)	K13-AP	Den Helder	Active	Gas	36	N	N	6	90	582795	5900486	5584	1,2	28	124,4	3727	1,044,454	
B4	B4	B	PL0062_PR	Pipeline	NAM B.V.	K/15-FA-1 - K/14-FA1	K15-FA-1	K14-FA-1C	Active	Gas	18	N	N	4	90	582785	5900545	159	0,8	24	110,5	2186	764,173	
B5	B5	B	PL0063_PR	Pipeline	Noordgastransport B.V.	K12-BP - L10-AR	K12-BP	L10-AR	Active	Gas	18	N	N	4	75	584095	5912099	11529	0,8	24	110,5	2186	764,173	
B7	B6	B	KB0073	Cable	Unknown	UK - Germany 3	Winterton (GB)	Borkum (D)	Abandoned	Telecom	Coaxiaal	N	Y	10	x	583737	5921189	9097	0,0	0	0,0	0	0	no action
B6	B7	B	PL0029_PR+HS	Pipeline	ENGIE E&P Nederland B.V.	K/12-A - L/10-AP	K12-A	L10-AP	Active	Gas+Methanol	14+2	N	Y	2	60	583085	5922488	1453	0,3	2	87,7	1229	199,835	* 1,2 m3 rock for angle
X	B8	B	PL0056_PR	Pipeline	ENGIE E&P Nederland B.V.	K/12-E - K/12-C	K12-E	K12-C	Abandoned	Gas	10	N	N	2	75	582161	5924330	2061	0,3	2	87,7	1025	173,196	
X	B9	B	PL0142_PR	Pipeline	Noordgastransport B.V.	D/15-A - L/10-A / PL0142_PR	D15-FA-1	L10-AC	Active	Gas	36	N	N	6	60	581204	5926764	2615	1,2	28	124,4	4472	1,141,345	* 1,2 m3 rock for angle
G4	C1	C	KB0010	Cable	Unknown	Winterton - Borkum 1 (Laid 1963)	Winterton (GB)	Borkum (D)	Abandoned	Telecom	Unkown	N	Y	10	x	559298	5934755	8215	0,0	0	0,0	0	0	no action
G5	C2	C	KB0025	Cable	Unknown	UK - DK 3 (laid 10980)	Winterton (GB	Romo (DK)	Abandoned	Telecom	Coaxiaal	N	Y	10	x	559191	5937666	2913	0,0	0	0,0	0	0	no action
G6	C3	C	PL0064_PR	Pipeline	ENGIE E&P Nederland B.V.	K/09-C-A - L/10-AR	K9c-A	L10-AR	Active	Gas	16	N	N	4	60	559648	5940388	2801	0,7	24	108,6	2447	798,151	* 1,2 m3 rock for angle
G7	C4	C	PL0047_PR	Pipeline	Total E&P Nederland B.V.	L4-B - L7-A	L-4B	L-7A	Active	Gas	10	N	Y	2	75	567334	5945955	9328	0,3	2	87,7	1025	173,196	
G8	C5	C	PL0048_HS	Pipeline	Total E&P Nederland B.V.	L4-B - L7-A	L-4B	L-7A	Active	Gas+	3	N	Y	2	75	567376	5946006	66	0,3	2	87,7	922	143,889	0,9* for double
G9	C6	C	KB0112	Cable	NeuConnect Britain Limited	NeuConnect (Western Part)	Isle of Grain (UK)	Wilhelmshaven (GER)	Planned before Aramis	Elektra	Copper	N	Y	8	60	567829	5946553	710	0,3	4	87,7	1229	239,835	* 1,2 m3 rock for angle
G1	D1	D	KB0073	Cable	Unknown	UK - Germany 3	Winterton (GB)	Borkum (D)	Abandoned	Telecom	Coaxiaal	N	Y	10	x	544609	5907585	5154	0,0	0	0,0	0	0	no action
G2	D2	D	PL0119_HS	Pipeline	ENGIE E&P Nederland B.V.	K11-B - K12-C	K11-B	K12-C	Abandoned	Gas	14+2	N	Y	2	75	550753	5923197	16777	0,3	2	87,7	1025	173,196	
G3	D3	D	PL0142_PR	Pipeline	Noordgastransport B.V.	D/15-FA-1 - L/10-AC	D15-FA-1	L10-AC	Active	Gas	36	N	N	6	90	556711	5929510	8681	1,2	28	124,4	3727	1,044,454	
B7	E1	E	KB0073	Cable	Unknown	UK - Germany 3	Winterton (GB)	Borkum (D)	Abandoned	Telecom	Coaxiaal	N	Y	10	x	568126	5924348		0,0	0	0,0	0	0	no action
K5	E2	E	PL0064_PR	Pipeline	ENGIE E&P Nederland B.V.	K/09-C-A - L/10-AR	K9c-A	L10-AR	Active	Gas	16	N	N	4	60	574942	5921252	4437	0,7	24	108,6	2447	798,151	* 1,2 m3 rock for angle
E4	E3	E	PL0012_PR	Pipeline	Total E&P Nederland B.V.	L7-P - L10-A	L7-P	L10-A	Abandoned	Gas	16	N	N	4	60	578824	5919103	38	0,7	24	108,6	1835	718,814	0,9 * for double xing
X	E4	E	PL0057_PR+HS	Pipeline	ENGIE E&P Nederland B.V.	L10-L - L10-AP	L10-L	L10-AP	Active	Gas+ Methanol	10 + 2	N	Y	2	60	578861	5919093	316	0,3	2	87,7	1229	199,835	* 1,2 m3 rock for angle
X	E5	E	PL0002_HS	Pipeline	ENGIE E&P Nederland B.V.	L10-B - L10-AP	L10-B	L-10-AP	Abandoned	Methanol	2	N	Y	2	60	579165	5919008	43560	0,3	2	87,7	1229	199,835	* 1,2 m3 rock for angle
F1	F1	F	PL0032_PR	Pipeline	P/06-A - L/10-A // PL0032_PR	P6-A	L10-AR	Active	Gas	20	N	N	4	60	580758	5879528	6909	0,8	24	112,3	2805	844,609	* 1,2 m3 rock for angle
F2	F2	F	PL0004_PR	Pipeline	Wintershall Noordzee B.V.	West Gas Transport (WGT)	K13-AP	Den Helder	Active	Gas	36	N	N	6	90	543151	5902498	28942	1,2	28	124,4	3727	1,044,454	
F3	F3	F	PL0062_PR	Pipeline	NAM B.V.	K/15-FA-1 - K/14-FA1	K15-FA-1	K14-FA-1C	Active	Gas	18	N	N	4	90	543146	5902624	126	0,8	24	110,5	2186	687,756	
F4	F4	F	PL0130_PR	Pipeline	NAM B.V.	K/14-FA-1 - K15-FB-1	K14-FA-1P	K15-FB-1	Active (mothballed)	Gas	18	N	N	4	90	543126	5902649	32	0,7	24	108,6	1835	646,752	0,9 * for double xing
D1	K1	K	KB0073	Cable	Unknown	UK - Germany 3	Winterton (GB)	Borkum (D)	Abandoned	Telecom	Coaxiaal	N	Y	10	x	545526	5908226	6071	0,0	0	0,0	0	0	no action
D2	K2	K	PL0029_PR+HS	Pipeline	ENGIE E&P Nederland B.V.	K/12-A - L/10-AP	K12-A	L10-AP	Active	Gas+ Methanol	14+2	N	Y	2	60	563759	5922310	23039	0,3	2	87,7	1229	199,835	* 1,2 m3 rock for angle
C1	K3	K	PL0142_PR	Pipeline	Noordgastransport B.V.	D/15-A - L/10-A / PL0142_PR	D15-FA-1	L10-AC	Active	Gas	36	N	N	6	60	565990	5923636	2703	1,2	28	124,4	4472	1,141,345	* 1,2 m3 rock for angle
C2	K4	K	BK002_UM	Cable	ENGIE E&P Nederland B.V.	Umbilical from L10-B3 to K12_E	L10-S1	K12-E	Abandoned	Service	Umbilical	N	Y	10	x	567164	5924665	1437	0,0	0	0,0	0	0	no action
C3	K5	K	PL0064_PR	Pipeline	ENGIE E&P Nederland B.V.	K/09-C-A - L/10-AR	K9c-A	L10-AR	Active	Gas	16	N	N	4	75	568795	5927180	2998	0,7	24	108,6	2039	745,126	
C4	K6	K	PL0049_PR	Pipeline	Total E&P Nederland B.V.	L/07-A - L/07-P	L7-A	L7-P	Active	Gas	10	N	Y	2	75	572919	5938184	11752	0,3	2	87,7	1025	173,196	
C5	K7	K	PL0059_HS	Pipeline	Total E&P Nederland B.V.	L/07-A - L/07-P	L7-A	L7-P	Active	Gas+	3	N	Y	2	75	572934	5938231	49	0,3	2	87,7	922	143,889	0,9*for double
C6	K8	K	KB0010	Cable	Unknown	Winterton - Borkum 1 (Laid 1963)	Winterton (GB)	Borkum (D)	Abandoned	Telecom	Unkown	N	Y	10	x	572461	5942622	4416	0,0	0	0,0	0	0	no action
C7	K9	K	KB0112	Cable	NeuConnect Britain Limited	NeuConnect (Western Part)	Isle of Grain (UK)	Wilhelmshaven (GER)	Planned before Aramis	Elektra	Copper	N	Y	8	60	571481	5945947	3466	0,3	4	87,7	1229	239,835	* 1,2 m3 rock for angle
C8	K10	K	KB0025	Cable	Unknown	UK - DK 3 (laid 10980)	Winterton (GB	Romo (DK)	Abandoned	Telecom	Coaxiaal	N	Y	10	x	570843	5948109	2254	0,0	0	0,0	0	0	no action

Appendix B Crossing Overview Drawings

(Drawings included for reference only, for latest revision refer to separate drawing file ARM-CPT-BB3-PLR-LAY-0054)


Sheet 5
Sheet 4
Sheet 3
Sheet 2
Offshore
Nearshore
MTE Route
HDD Route
Chiswick (United Kingdom)
Grove (United Kingdom)
Windermere
NGT Sidetap 4
NGT Sidetap 3
NGT Sidetap 2
NGT Sidetap 1
Ameland-Westgat-1P
Ameland-Oost-2
Ameland-Westgat-1R
Moddergat
Blija-Ferwerderadeel
De Tibben
Kollumerland
Grootegast 100
Tietjerksteradeel-700
Barradeel
Bethanie
Suawoude 100
Ried
Warga 2
Harlingen 6
Harlingen 101
Rauwerd 1
Bozum
Rauwerd 2
Openhuizen 1
Marum
Ureterp 2
Boerakker
Donkerbroek
Den Helder HighCal
Den Helder NOGAT
Den Helder LowCal
Den Oever
Weststellingwerf
De Hoeve-1
Vinkega
Nijensleek
De Blesse
Slootdorp 1/4/5
Middenmeer 1/2
Middenmeer Treating Center
Wanneperveen 2
Wanneperveen 1
De Wijk 4
Groet 1
Groet 2
Bergen aan Zee
Bergen Drying Facilities
Bergermeer
Middelie 300
Middelie 100
Zuid-Scharwoude
Q8 gasbehandelingsinstallatie
Zoetermeer 6
Leidschendam 2
Rijswijk 5
Rijswijk 11
Oude Leede
Berkel 4
Gaag
Bolsek
Ridderkerk-31
Ottoland
Spijkenisse-Oost
Barendrecht-Ziedewij
Brakel
Wijk en Aalburg
Waalwijk-North
Waalwijk-North 3
Sprang A
Waalwijk-South
Numansdorp
Readtjk-1
Netherlands Refinery
Monster
's-Gravenzande
Windmill-West
E17-A
K2b-A
G17d-AP
L02-FA-1
L04-PN
L05-FA-1
L6d-S1
L4-G
Sidetap L5-FA-1
L05-B
L05-C
L08-P4
L08-P
L08-G-1
L08-Horst
L09-FB-1
L9-FF-1W
L12-F-1P
M7-A
L07-A
L7-BB
07-N
L7-PK
L7-P
L10-B
L10-BB
L10-EE
L10-S4
L10-F
L10-A
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L10-S39
L10-S40
L10-S41
L10-S42
L10-S43
L10-S44



CROSSING TABLE								
Crossing #	Name	ID	TYPE	STATUS	UTM Zone 31N (ETRS89)		Geographical (ETRS89)	
					Easting (m)	Northing (m)	Lat	Long
HDD1	UK – NL 4	KB0051	C	Abandoned	567,979.93	5,771,981.09	52° 05' 38.16" N	3° 59' 39.98" E
HDD2	TAQA Energy B.V. 16-inch gas + 3-inch Methanol	PL0106_HS	P	Active	563,631.89	5,776,158.27	52° 07' 56.20" N	3° 55' 46.79" E
HDD3	UK – NL 5	KB0001	C	Abandoned	563,495.67	5,777,364.02	52° 08' 35.34" N	3° 55' 40.15" E
HDD4	Concerto 1 Segment 1 East	KB0002	C	Abandoned	562,977.21	5,781,640.35	52° 10' 53.86" N	3° 55' 16.51" E
HDD5	TAQA Energy B.V. 26-inch Gas	PL0093_PR	P	Active	562,046.76	5,786,680.29	52° 13' 37.69" N	3° 54' 30.31" E
HDD6	TAQA Energy B.V. 10-inch Oil	PL0038_PR	P	Active	562,044.61	5,786,822.25	52° 13' 41.36" N	3° 54' 30.29" E
MTE1	UK – NL 4	KB0051	C	Abandoned	571,558.56	5,771,113.88	52° 05' 09.47" N	4° 02' 39.76" E
MTE2	UK – NL 5	KB0001	C	Abandoned	570,610.26	5,775,441.58	52° 07' 29.94" N	4° 01' 53.17" E
MTE3	Concerto 1 Segment 1 East	KB0002	C	Abandoned	565,274.80	5,783,067.26	52° 11' 35.75" N	3° 57' 17.89" E
A1	UK – NL 7	KB0063	C	Abandoned	561,997.28	5,785,300.52	52° 15' 02.18" N	3° 54' 59.43" E
A2	ENGIE E&P Nederland B.V. 6-inch Gas	PL0228_PR	P	Active	561,975.50	5,790,420.37	52° 15' 36.43" N	3° 54' 29.02" E
A3	UK – NL 6	KB0016	C	Abandoned	561,884.37	5,795,104.40	52° 18' 10.05" N	3° 54' 27.31" E
A4	Hermes 1	KB0033	C	Abandoned	561,858.55	5,796,481.44	52° 18' 53.21" N	3° 54' 26.42" E
A5	CGAM	KB0078	C	Future	561,835.66	5,797,711.19	52° 19' 34.42" N	3° 54' 26.36" E
A6	Telecomkabel TAT14 Segment I	KB0018	C	In Service	561,829.80	5,798,228.07	52° 19' 51.17" N	3° 54' 26.17" E
A7	Ulysses 2	KB0030	C	In Service	561,788.23	5,799,242.47	52° 20' 24.01" N	3° 54' 24.97" E
A8	Tuba Ø12.75 inch Gas	PL0234_PR	P	In Service	558,094.31	5,802,974.55	52° 22' 26.25" N	3° 51' 12.13" E
A9	Cross 1 North	KB0045	C	In Service	557,264.70	5,804,507.04	52° 23' 16.15" N	3° 50' 25.21" E
A10	Concerto 1 Segment 1 North	KB0003	C	In Service	557,275.09	5,805,273.27	52° 23' 40.94" N	3° 50' 25.25" E
A11	Wintershall Pipelaying	PL0084_HS	P	Abandoned	557,595.45	5,806,756.57	52° 24' 30.68" N	3° 50' 46.39" E
A12	Cross North 2 replacement	KB0115	C	Future	557,616.24	5,808,008.04	52° 25' 09.24" N	3° 51' 00.68" E

NOTES

LEGEND

- PIPELINE ROUTE SECTION A
- PIPELINE ROUTE SECTION B
- PIPELINE ROUTE SECTION C
- PIPELINE ROUTE SECTION D
- PIPELINE ROUTE SECTION E
- PIPELINE ROUTE SECTION F
- PIPELINE ROUTE SECTION K (K14 - L4A)

- PIPELINE
- TELECOM CABLE
- POWER CABLE
- CONTROL CABLE

1 CROSSING POINT

REFERENCE DRAWINGS

DRAWING NUMBER	DESCRIPTION

GEODETIC & PROJECTION PARAMETERS

GEODETIC DATUM	ETRS89
Ellipsoid	GRS1980
Semi Major Axis	6378137.0 m
Inverse Flattening	298.257 222 100
PROJECTION	Universal Transverse Mercator (UTM)
Zone	31 North
Central Meridian	3° 00' 00" East
Latitude of Origin	0° 00' 00" North (EQUATOR)
False Easting	500,000.00 m
False Northing	0.00 m
Scale	0.9996
Units	Meters

REV	DATE	DESCRIPTION	DRWN	DSGN	ENGR	APPR
1	16 MAR 2023	ISSUED FOR APPROVAL				
0	04 AUG 2022	ISSUED FOR REVIEW				

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PROJECT: Aramis Constructability Study

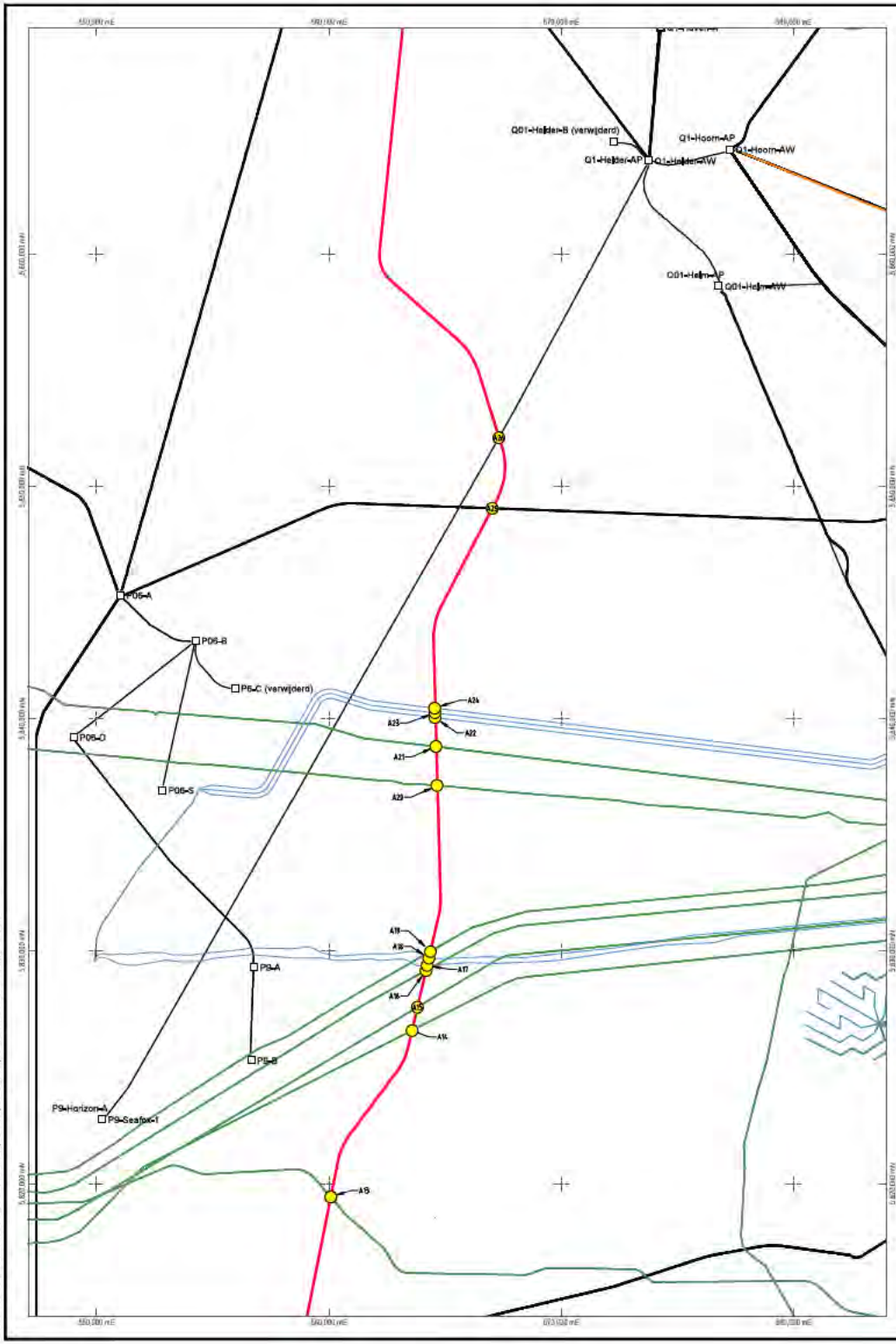
CLIENT: ARAMIS

TITLE:
PIPELINE ROUTE SECTIONS
CROSSING OVERVIEW MAP (KP 00 to 58)

DRAWN BY:	DATE:	CHECKED BY:	DATE:	APPROVED BY:	DATE:	SHEET	OF
JDJ	04 JUL 2022	EK/FvdL	15 MAR 2023	FvdL	16 MAR 2023	002	005

SCALE AT A1 SIZE	DRAWING NUMBER	REV
1:100,000	ARM-CPT-BB3-PLR-LAY-0054	1

FILE NAME: Y:\INTECSEA WP\416910000\57 ARAMIS\CAD\01\DWG\ARM-CPT-BB3-PLR-LAY-0054(ARM-CPT-BB3-PLR-LAY-0054_0).DWG
PLOT DATE: 17 Mar 2023 15:27 PM BY: VAN KUIJK, FRANK (THE HAGUE) / LAST SAVED BY: FRANK.VANKUIJK



CROSSING TABLE								
Crossing #	Name	ID	TYPE	STATUS	UTM Zone 31N (ETRS89)		Geographical (ETRS89)	
					Easting (m)	Northing (m)	Lat	Long
A13	Scylla Cable	KS0113	C	In Service	560,078,57	5,819,416,24	3° 53' 07,70" E	52° 31' 17,55" N
A14	Atlantic Crossing 1 Segment B1	KS0074	C	In Service	563,576,23	5,826,576,63	3° 56' 18,20" E	52° 35' 07,92" N
A15	Rijke 3	KS0065	C	Abandoned	563,861,26	5,827,561,16	3° 56' 31,17" E	52° 35' 40,23" N
A16	NOZ HKWB 2	KS0117	C	Future	564,176,05	5,828,163,26	3° 56' 51,80" E	52° 36' 31,27" N
A17	Rembrandt 1	KS0015	C	Abandoned	564,226,24	5,828,375,81	3° 56' 54,88" E	52° 36' 38,19" N
A18	NOZ HKWB 1	KS0116	C	Future	564,305,58	5,828,694,21	3° 56' 59,86" E	52° 36' 48,62" N
A19	PANGEA Segment 2	KS0029	C	In Service	564,366,11	5,828,974,82	3° 57' 03,54" E	52° 36' 57,45" N
A20	UK - NL 10	KS0065	C	Abandoned	564,651,36	5,837,125,99	3° 57' 22,75" E	52° 40' 46,74" N
A21	UK - NL 14	KS0097	C	Abandoned	564,600,56	5,838,786,14	3° 57' 21,20" E	52° 41' 42,47" N
A22	NOZ HKWA-HKN	KS0100	C	Future	564,562,66	5,840,045,37	3° 57' 20,09" E	52° 42' 23,26" N
A23	NOZ HKWA-HKN	KS0102	C	Future	564,556,51	5,840,246,10	3° 57' 19,81" E	52° 42' 29,81" N
A24	NOZ HKWA-HKN	KS0101	C	Future	564,559,37	5,840,450,23	3° 57' 19,72" E	52° 42' 36,35" N
A25	Winterstall Noordzee BV, 14-inch Gas	PL0148_PR	P	Active	567,024,53	5,848,940,52	3° 59' 37,87" E	52° 47' 13,54" N
A26	Petrogas E&P LLC 16-inch Oil	PL0109_PR	P	Active	567,309,26	5,852,979,62	3° 59' 55,31" E	52° 48' 51,49" N

NOTES

LEGEND

- PIPELINE ROUTE SECTION A
- PIPELINE ROUTE SECTION B
- PIPELINE ROUTE SECTION C
- PIPELINE ROUTE SECTION D
- PIPELINE ROUTE SECTION E
- PIPELINE ROUTE SECTION F
- PIPELINE ROUTE SECTION K (K14 - L4A)
- PIPELINE
- TELECOM CABLE
- POWER CABLE
- CONTROL CABLE
- 1 CROSSING POINT

REFERENCE DRAWINGS

DRAWING NUMBER	DESCRIPTION

GEODETIC & PROJECTION PARAMETERS

GEODETIC DATUM	ETRS89
Ellipsoid	GRS1980
Semi Major Axis	6378137,0 m
Inverse Flattening	298,257 222 100
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Central Meridian	3° 00' 00" East
Latitude of Origin	0° 00' 00" North (EQUATOR)
False Easting	500.000,00 m
False Northing	0,00 m
Scale	0,9996
Units	Meters

REV	DATE	DESCRIPTION	DRWN	DSGN	ENGR	APPR
1	16 MAR 2023	ISSUED FOR APPROVAL				
0	04 AUG 2022	ISSUED FOR REVIEW				

Intecsea

PROJECT: Aramis Constructability Study

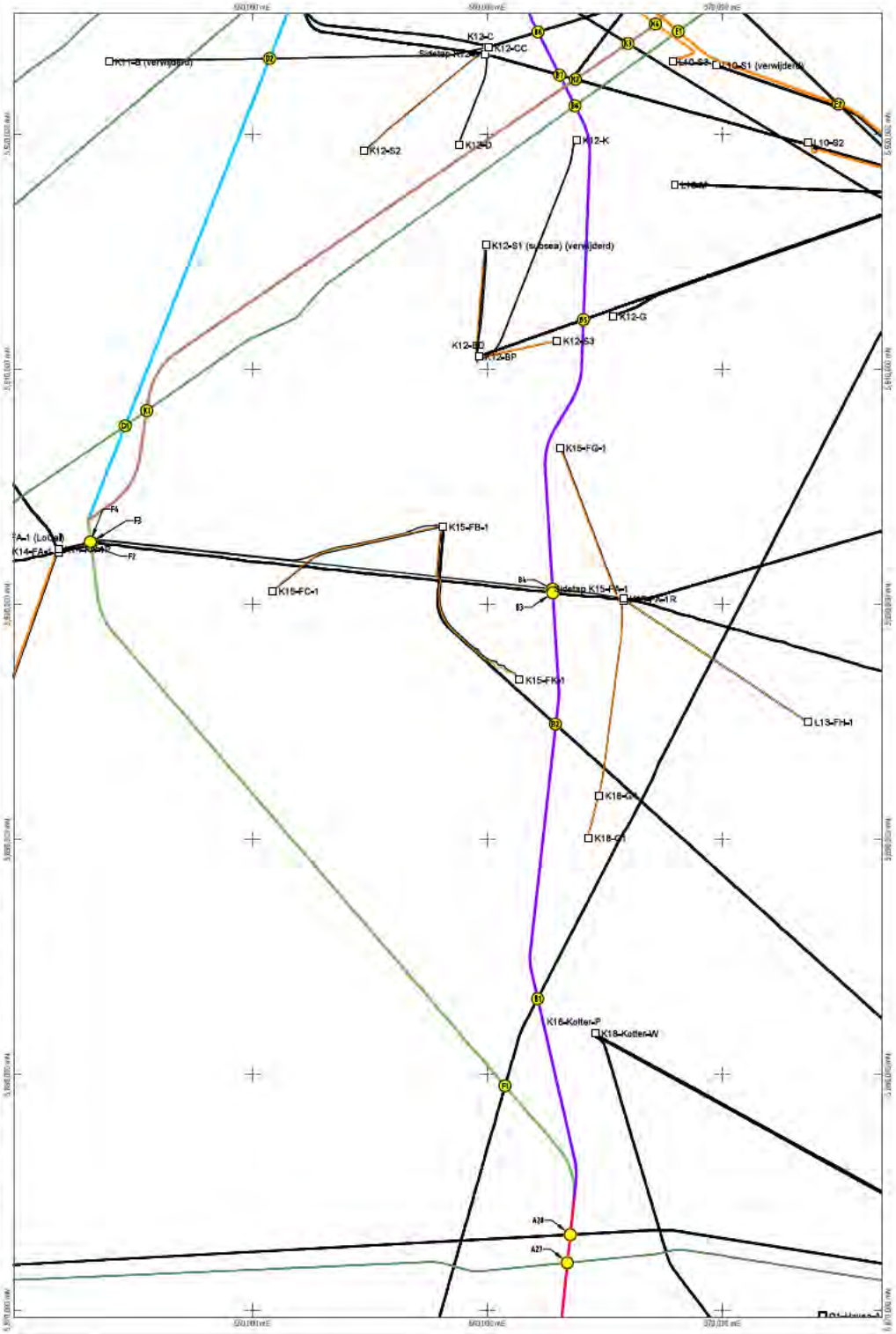
CLIENT: ARAMIS

TITLE:
PIPELINE ROUTE SECTIONS
CROSSING OVERVIEW MAP (KP 58 to 116)

DRAWN BY	DATE	CHECKED BY	DATE	APPROVED BY	DATE	SHEET	OF
JDJ	04 JUL 2022	EK/FvdL	15 MAR 2023	FvdL	16 MAR 2023	003	005

SCALE AT A1 SIZE	DRAWING NUMBER	REV
1:100,000	ARM-CPT-BB3-PLR-LAY-0054	1

FILE NAME: Y:\INTECSEA WP\41801000\057 ARAMIS\CAD\SU\DWG\ARM-CPT-BB3-PLR-LAY-0054(ARM-CPT-BB3-PLR-LAY-0054).DWG
PLOT DATE: 17 Mar 2023 12:27 PM BY: VAN KUIJK, FRANK (THE HAGUE) / LAST SAVED BY: FRANK.VANKUIJK



CROSSING TABLE								
Crossing #	Name	ID	TYPE	STATUS	UTM Zone 31N (ETRS89)		Geographical (ETRS89)	
					Easting (m)	Northing (m)	Lat	Long
A27	BT North Sea	K20157	C	Future	563,412	5,972,068	53° 59' 58,01" N	3° 58' 41,58" E
A28	BBL Company VOF, 36-inch Gas	PL0176_PR	P	Active	563,536	5,972,252	53° 00' 16,68" N	3° 58' 46,67" E
B1	Wintershall Noordzee B.V., 24-inch Gas	PL0032_PR	P	Active	562,749,69	5,965,230,29	53° 00' 43,85" N	3° 58' 41,25" E
B2	Nederlandse Aardolie Maatschappij B.V., 24-inch Gas	PL0036_PR	P	Active	562,964,24	5,964,997,02	53° 11' 59,3" N	3° 58' 38,29" E
B3	Wintershall Noordzee (K), 36-inch Gas	PL0094_PR	P	Active	562,764,93	5,964,480,23	53° 12' 16,72" N	3° 58' 28,19" E
B4	Nederlandse Aardolie Maatschappij B.V., 18-inch Gas	PL0047_PR	P	Active	562,764,93	5,964,640,61	53° 12' 21,89" N	3° 58' 27,27" E
B5	Noordgastransport B.V., 18-inch Gas	PL0045_PR	P	Active	564,064,42	5,972,849,24	53° 21' 14,87" N	3° 57' 46,25" E
B6	UK - Germany 3	K00073	C	Abandoned	563,791,83	5,971,190,03	53° 20' 19,17" N	3° 57' 33,65" E
B7	ENGIE E&P Nederland B.V., 16-inch Gas	PL0125_PR	P	Active	563,065,15	5,972,485,24	53° 20' 31,49" N	3° 56' 59,39" E
C1	UK - Germany 3	K00073	C	Abandoned	544,668,24	5,967,585,08	53° 18' 16,26" N	3° 38' 15,99" E
D2	K14-D-K13-K2	PL0118_PR	P	Abandoned	560,752,59	5,972,168,08	53° 21' 13,21" N	3° 48' 5,04" E
E1	UK - Germany 3	K00073	C	Abandoned	569,135,61	5,974,349,27	53° 22' 43,41" N	4° 01' 36,28" E
F2	ENGIE E&P Nederland B.V., 14-inch Gas	PL0164_PR	P	Active	574,943,29	5,971,251,91	53° 20' 15,68" N	4° 07' 41,18" E
F4	Wintershall Noordzee B.V., 20-inch Gas	PL0032_PR	P	Active	560,758,45	5,978,127,06	53° 03' 42,42" N	3° 54' 23,68" E
F5	Wintershall Noordzee (L), 24-inch Gas	PL0094_PR	P	Active	563,151,06	5,963,497,08	53° 10' 11,84" N	3° 56' 48,33" E
F6	Nederlandse Aardolie Maatschappij B.V., 18-inch Gas	PL0047_PR	P	Active	563,145,39	5,963,623,55	53° 10' 15,94" N	3° 56' 48,15" E
F7	Nederlandse Aardolie Maatschappij B.V., 18-inch Gas	PL0132_PR	P	Active	563,133,47	5,963,648,85	53° 10' 16,77" N	3° 56' 48,3" E
G1	UK - Germany 3	K00073	C	Abandoned	565,524,26	5,969,276,08	53° 13' 10,52" N	3° 41' 49,47" E
H2	ENGIE E&P Nederland B.V., 14-inch Gas	PL0099_PR	P	Active	563,784,39	5,962,993,91	53° 09' 45,47" N	3° 57' 35,87" E
H3	Noordgastransport B.V., 36-inch Gas	PL0142_PR	P	Active	565,995,98	5,963,495,68	53° 09' 33,01" N	3° 59' 39,04" E
K4	ENGIE E&P Nederland B.V., 3,5-inch Control	EW003_EM	U	Abandoned	561,161,75	5,974,884,04	53° 23' 15,19" N	4° 00' 43,31" E

NOTES

LEGEND

- PIPELINE ROUTE SECTION A
- PIPELINE ROUTE SECTION B
- PIPELINE ROUTE SECTION C
- PIPELINE ROUTE SECTION D
- PIPELINE ROUTE SECTION E
- PIPELINE ROUTE SECTION F
- PIPELINE ROUTE SECTION K (K14 - L4A)

- PIPELINE
- TELECOM CABLE
- POWER CABLE
- CONTROL CABLE

1 CROSSING POINT

REFERENCE DRAWINGS

DRAWING NUMBER	DESCRIPTION

GEODETIC & PROJECTION PARAMETERS

GEODETIC DATUM	ETRS89
Ellipsoid	GRS 1980
Semi Major Axis	6378137,0 m
Inverse Flattening	298,257 222 100
PROJECTION	Universal Transverse Mercator (UTM)
Zone	31 North
Central Meridian	3° 00' 00" East
Latitude of Origin	0° 00' 00" North (EQUATOR)
False Easting	500.000,00 m
False Northing	0,00 m
Scale	0,9996
Units	Meters

REV	DATE	DESCRIPTION	DRWN	DSGN	ENGR	APPR
1	16 MAR 2023	ISSUED FOR APPROVAL	[redacted]			
0	04 AUG 2022	ISSUED FOR REVIEW				

Intecsea

PROJECT: Aramis Constructability Study

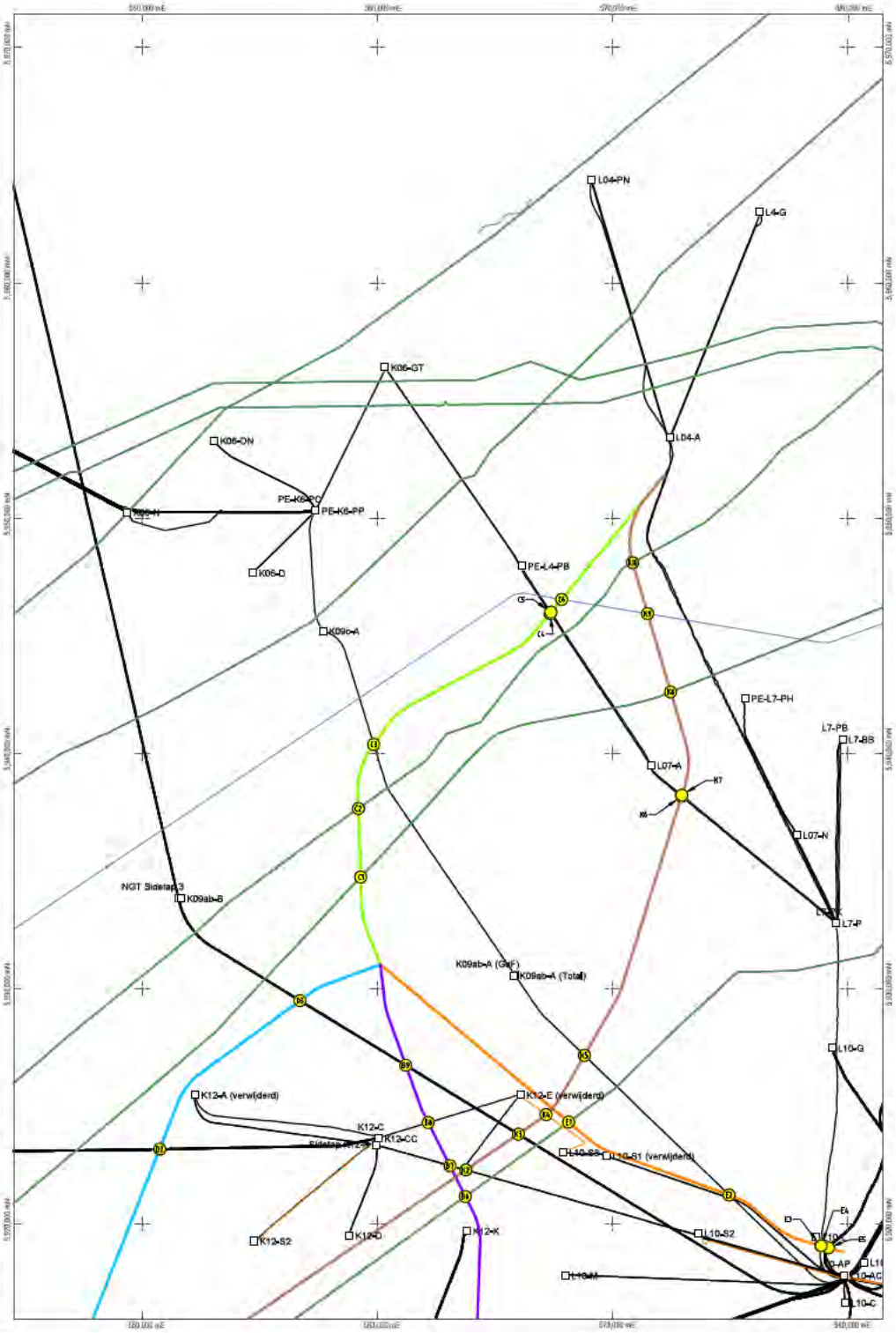
CLIENT: ARAMIS

TITLE:
PIPELINE ROUTE SECTIONS
CROSSING OVERVIEW MAP (KP 116 to 171)

DRAWN BY	DATE	CHECKED BY	DATE	APPROVED BY	DATE	SHEET	OF
JDJ	04 JUL 2022	TZ	15 MAR 2023	FvdL	16 MAR 2023	004	005

SCALE AT A1 SIZE	DRAWING NUMBER	REV
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FILE NAME: Y:\INTECSEA WP\416910000\57 ARAMIS\CAD\SU\DWG\ARM-CPT-BB3-PLR-LAY-0054(R0)\ARM-CPT-BB3-PLR-LAY-0054.DWG
PLOT DATE: 17 Mar 2023 12:27 PM BY: VAN KLAK, FRANK (THE HAGUE) / LAST SAVED BY: FRANK.VANKLAK



CROSSING TABLE

Crossing #	Name	ID	TYPE	STATUS	UTM Zone 31N (ETRS89)		Geographical (ETRS89)	
					Easting (m)	Northing (m)	Lat	Long
B6	UK – Germany 3	KB0073	C	Abandoned	562,736,69	5,921,185,68	53° 26' 09,17" N	3° 57' 33,95" E
B7	ENGIE E&P Nederland B.V. 14-inch Gas	PL0029_PR	P	Active	565,085,15	5,922,468,04	53° 26' 51,48" N	3° 55' 59,59" E
B8	ENGIE E&P Nederland B.V. 10-inch Gas	PL0056_PR	P	Abandoned	562,161,16	5,924,330,42	53° 27' 51,49" N	3° 58' 10,82" E
B9	Noordgastransport B.V. 36-inch Gas	PL0142_PR	P	Active	561,294,16	5,925,763,81	53° 28' 10,62" N	3° 59' 20,64" E
C1	Wintershall – Borkum 1	KB0010	C	Abandoned	559,297,75	5,934,755,26	53° 33' 29,07" N	3° 59' 42,67" E
C2	UK – DK 3	KB0025	C	Abandoned	559,191,35	5,937,695,31	53° 35' 04,20" N	3° 59' 39,89" E
C3	ENGIE E&P Nederland B.V. 16-inch Gas	PL0064_PR	P	Active	559,866,27	5,941,399,01	53° 36' 32,07" N	3° 54' 16,48" E
C4	Total E&P Nederland B.V. 10-inch Gas	PL0047_PR	P	Active	567,333,53	5,946,954,94	53° 39' 28,83" N	4° 01' 08,04" E
C5	Total E&P Nederland B.V. 3-inch Glycol	PL0048_HS	P	Active	567,375,99	5,946,606,15	53° 39' 30,47" N	4° 01' 10,28" E
C6	Neuconnect West	KB0112	C	Future	567,826,47	5,946,552,26	53° 39' 47,95" N	4° 01' 35,52" E
D2	K11-B – K12-C	PL0119_HS	P	Abandoned	550,762,69	5,923,186,96	53° 27' 10,21" N	3° 45' 51,56" E
D3	Noordgastransport B.V. 36-inch Gas	PL0142_PR	P	Active	556,711,21	5,929,510,12	53° 30' 41,29" N	3° 51' 18,70" E
E3	Total E&P Nederland B.V. 16-inch Gas	PL0012_PR	P	Abandoned	576,624,21	5,919,103,07	53° 24' 54,34" N	4° 11' 06,52" E
E4	ENGIE E&P Nederland B.V. 10-inch Gas	PL0062_PR	P	Active	576,861,22	5,919,082,82	53° 24' 53,66" N	4° 11' 11,51" E
E5	ENGIE E&P Nederland B.V. 10-inch Gas	PL0002_PR	P	Abandoned	575,165,40	5,919,006,29	53° 24' 51,09" N	4° 11' 27,90" E
K2	ENGIE E&P Nederland B.V. 14-inch Gas	PL0029_PR	P	Active	563,756,69	5,922,310,01	53° 26' 45,43" N	3° 57' 35,97" E
K3	Noordgastransport B.V. 36-inch Gas	PL0142_PR	P	Active	565,986,96	5,923,635,86	53° 27' 33,01" N	3° 59' 38,04" E
K4	ENGIE E&P Nederland B.V. 3,5-inch Control	BK002_UM	U	Abandoned	567,163,75	5,924,664,84	53° 28' 00,10" N	4° 00' 42,31" E
K5	ENGIE E&P Nederland B.V. 16-inch Gas	PL0064_PR	P	Active	568,796,12	5,927,179,75	53° 29' 20,70" N	4° 02' 12,61" E
K6	Total E&P Nederland B.V. 10-inch Gas	PL0048_PR	P	Active	572,916,96	5,936,164,29	53° 35' 14,74" N	4° 06' 05,69" E
K7	Total E&P Nederland B.V. 3-inch Glycol	PL0050_HS	P	Active	572,930,05	5,936,291,37	53° 35' 19,25" N	4° 06' 06,53" E
K8	Wintershall – Borkum 1	KB0010	C	Abandoned	572,460,63	5,942,822,18	53° 37' 38,54" N	4° 05' 44,00" E
K9	Neuconnect West	KB0112	C	Future	571,460,06	5,946,946,28	53° 39' 26,59" N	4° 04' 53,90" E
K10	UK – DK 3	KB0025	C	Abandoned	570,842,95	5,948,109,10	53° 40' 36,86" N	4° 04' 29,95" E

NOTES

LEGEND

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1	16 MAR 2023	ISSUED FOR APPROVAL				
0	04 AUG 2022	ISSUED FOR REVIEW				

Intecsea

PROJECT: Aramis Constructability Study

CLIENT: ARAMIS

TITLE: PIPELINE ROUTE SECTIONS CROSSING OVERVIEW MAP

DRAWN BY:	DATE:	DESIGNED BY:	DATE:	APPROVED BY:	DATE:	SHEET	OF
JDJ	04 JUL 2022	TZ	15 MAR 2023	FvdL	16 MAR 2023	005	005

SCALE AT A1 SIZE	DRAWING NUMBER	REV
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FILE NAME: Y:\INTECSEA WP\41801000\057 ARAMIS\CAD\SU\DWG\ARM-CPT-BB3-PLR-LAY-0054(ARM-CPT-BB3-PLR-LAY-0054).DWG
PLOT DATE: 17 Mar 2023 15:27 PM BY: VAN HULK, FRANK (THE HAGUE) / LAST SAVED BY: FRANK.VANHULK

PARTICIPATIEPLAN

ARAMIS-INITIATIEF

Fase milieueffectrapportage t/m voorkeursalternatief

Herziene versie
Oktober 2023
Documentnummer
NL-ARM-PFE-B10-ENV-GEA-0299

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ALGEMEEN

Voor u ligt het geactualiseerde participatieplan van het Aramis-initiatief (hierna: Aramis). Het plan is opgesteld door Aramis in afstemming met CO_2next en het ministerie van Economische Zaken en Klimaat (EZK). In het participatieplan leest u hoe u en andere belanghebbenden worden geïnformeerd over en betrokken bij het Aramis-project.

Bij elke fase van het project actualiseren initiatiefnemers TotalEnergies, Shell, Energie Beheer Nederland (EBN) en Gasunie het participatieplan. Dat doen zij op basis van voortschrijdend inzicht, ontwikkelingen in het project, gesprekken met stakeholders, reacties op het participatieplan en een evaluatie van de voorgaande periode.

- De eerste versie van het participatieplan is samen met de kennisgeving *Voornemen en Voorstel Participatie voor het project Aramis* (kennisgeving van het V&P)[1] gepubliceerd in januari 2022.
- Naar aanleiding van gesprekken met stakeholders en reacties op de kennisgeving van het V&P is in juni 2022 een tweede versie van het plan gepubliceerd, gelijktijdig met de publicatie van de conceptversie van de Notitie Reikwijdte en Detailniveau (concept-NRD).
- In november 2022 werd de derde versie uitgebracht, die in het teken stond van de definitieve Notitie Reikwijdte en Detailniveau (NRD).
- Deze vierde versie van het participatieplan omvat het tijdvak juni 2023 tot eind 2023. In deze periode wordt de Integrale Effectenanalyse (IEA) opgesteld (onder behoud van het concept-milieueffectrapport (MER) fase 1), die de basis vormt voor de keuze van een voorkeursalternatief (VKA).

Het MER wordt medio 2024 samen met de ontwerpbesluiten ter inzage gelegd. Dan is er weer mogelijkheid tot reageren. Begin 2024 zal het participatieplan opnieuw worden geüpdatet, waarbij de mogelijkheid van reageren en de wijze waarop dit kan expliciet worden vermeld.

De invoering van de nieuwe Omgevingswet per 1 januari 2024 is een van de aanleidingen van deze nieuwe update. Aangezien de vergunningaanvragen na 1 januari 2024 worden ingediend, verandert de RCR-planning (Rijkscoördinatieregeling) en wijzigen daarmee ook de inspraakmomenten en de bijbehorende terminologie. Met deze update wordt u hiervan op de hoogte gebracht.

LEESWIJZER

- Hoofdstuk 1 introduceert het Aramis-project en de rol van EZK in de te volgen procedure.
- Hoofdstuk 2 licht de doelen, uitgangspunten en het kader van het participatieplan toe.
- Hoofdstuk 3 beschrijft hoe de participatie aan het MER en de IEA tot en met de VKA er concreet uitziet.
- Hoofdstuk 4 geeft een overzicht van alle geplande participatiemomenten.

Voor aanvullende informatie ziet u een verwijzing naar websites en documenten.

[1] https://www.rvo.nl/sites/default/files/2021/12/Notitie-Voornemen-en-Voorstel-Participatie-CCS-Aramis.pdf

1. INLEIDING

1.1 OVER ARAMIS

Het klimaat verandert snel door de toename van CO_2- en andere broeikasgassen in de atmosfeer. In het Klimaatakkoord van Parijs zijn ambitieuze doelen vastgelegd om de CO_2-uitstoot te verlagen. Hierin is afgesproken de opwarming van de atmosfeer te beperken tot maximaal 2°C, maar bij voorkeur onder 1,5°C te houden. Het vormt een grote uitdaging om de uitstoot zodanig te verlagen dat de klimaatdoelstellingen voor 2050 worden behaald.

Verduurzaming van de industrie is een van de maatregelen om CO_2-uitstoot te verminderen. De komende decennia wordt het aandeel van fossiele brand- en grondstoffen in productieprocessen afgebouwd. Voor deze transitie is tijd nodig: het is niet mogelijk in één keer volledig fossielvrij te worden en alle industriële processen om te zetten naar groene waterstof en/of groene stroom.

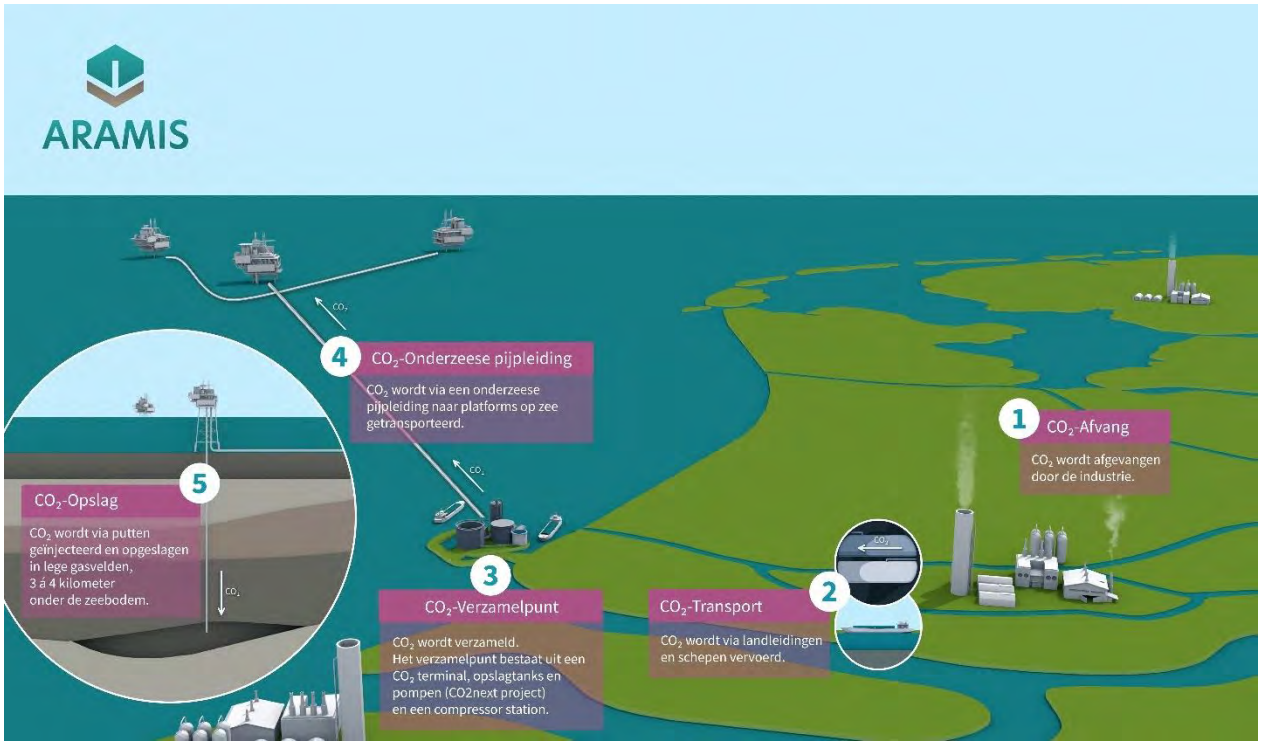
Totdat het gebruik van fossiele brandstoffen in industriële processen tot nul is gereduceerd, kan CO_2-uitstoot fors worden verminderd door afvang en ondergrondse opslag van vrijkomende CO_2. Deze techniek wordt Carbon Capture and Storage (CCS) genoemd en vermindert de hoeveelheid broeikasgassen die in de atmosfeer terechtkomt.

Rapportages van het Intergovernmental Panel on Climate Change (IPCC) en het Internationale Energie Agentschap (IEA)[2] laten zien dat – zolang er onvoldoende alternatieven zijn – permanente CO_2-opslag noodzakelijk is voor moeilijk te verduurzamen industrie. In de Klimaatnota 2022 en de Klimaat- en Energieverkenning (KEV) 2023 staat aangegeven dat het grootste gedeelte van de industriële CO_2-reductie tot 2030 uit CCS zal komen. De overheid ziet het afvangen en opslaan van CO_2 als een belangrijke (overgangs)technologie en stimuleert daarom CO_2-opslag onder de Noordzee.

De opslag van de afgevangen CO_2 is voorzien in lege gasvelden diep onder de zeebodem. Om de bij de industrie afgevangen CO_2 naar deze opslaglocaties te brengen, wordt een nieuwe, open transportinfrastructuur ontwikkeld. ‘Open’ betekent dat andere partijen de mogelijkheid hebben om op de CCS-keten aan te sluiten, zowel aan de voorkant (de afvang) als aan de achterkant (de opslag).

Bij een open CO_2-transportinfrastructuur zijn veel verschillende partijen betrokken, elk met een eigen rol en elk met een eerder of later moment waarop zij aansluiten. Samen vormen deze partijen de integrale CCS-keten: van de afvang van CO_2 tot permanente opslag in lege gasvelden diep onder de Noordzee. De keten bestaat veelal uit zelfstandige onderdelen, die voor een goed functionerend geheel nauw op elkaar moeten zijn afgestemd (zie afbeelding 1).

[2] IPPC rapportage 2022, Mitigation of Climate change



Afbeelding 1. Overzicht componenten van de CCS-keten, waar het Aramis-initiatief onderdeel van uitmaakt.

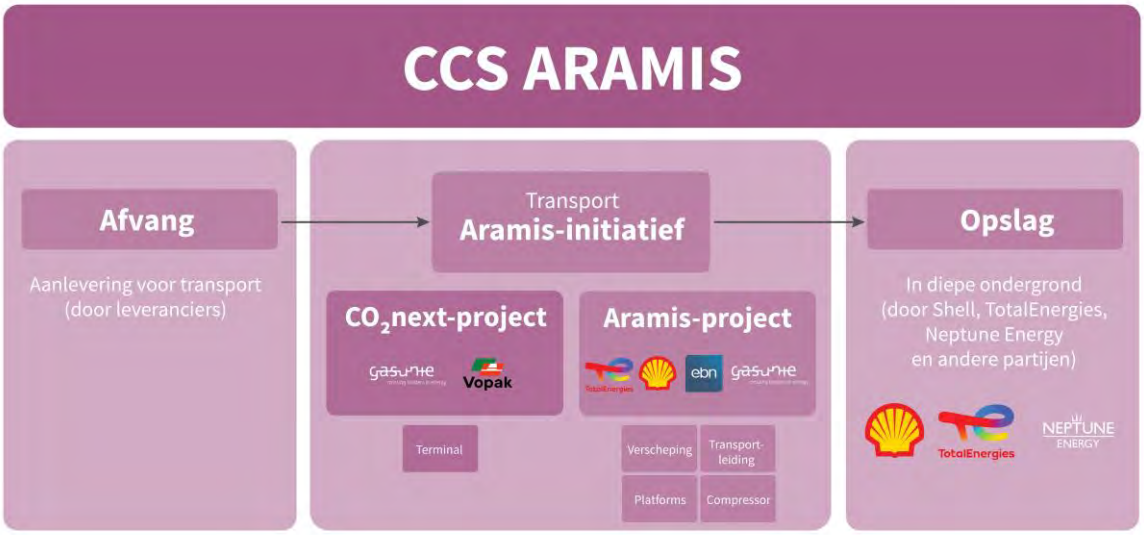
1. CO_2-afvang bij industrie en geschikt maken voor transport;
2. CO_2-transport naar de Maasvlakte via Porthos-landleiding, binnenvaart en zeevaart;
3. CO_2-verzamelpunt op de Maasvlakte met terminal en compressorlocatie. De terminal omvat steigers, tanks voor tijdelijke opslag van per schip aangevoerde CO_2, en hogedrukpompen voor levering aan de zeeleiding (CO_2next-project). De compressorlocatie ontvangt CO_2 via de landleiding en brengt dit op druk voor het transport per zeeleiding;
4. CO_2-transport door de centrale CO_2-zeeleiding naar platforms op de Noordzee;
5. Platform met leidingen vanaf de centrale CO_2-zeeleiding en met putten naar lege gasvelden diep onder de Noordzee.

Aramis heeft betrekking op het transport van CO_2 (onderdeel 2) naar het CO_2-verzamelpunt (onderdeel 3) en het transport via een zeeleiding naar de platforms op zee (onderdeel 4). In de CCS-keten van afvang, transport en opslag richt Aramis zich op het transportdeel: de CO_2-transportinfrastructuur. De CO_2-afvang (onderdeel 1) en de CO_2-opslag (onderdeel 5) vallen weliswaar buiten Aramis, maar vormen een samenhangend geheel met Aramis. Zodoende worden deze onderdelen in het verlengde van Aramis beschreven.

De transportinfrastructuur biedt andere partijen de mogelijkheid om op de CCS-keten aan te sluiten, zowel aan de voorkant (de afvang) als aan de achterkant (de opslag). Aramis voorziet daarmee in een cruciaal onderdeel van de CCS-keten. Het is niet mogelijk om op voorhand aan te geven welke partijen zich aansluiten en wanneer. Dat is inherent aan de aard van een open infrastructuur, die is gericht op toekomstige uitbreiding en aanpassing.

1.2 PROJECTORGANISATIE EN INITIATIEFNEMERS

Afbeelding 2 geeft weer hoe de verschillende onderdelen van Aramis zich verhouden tot elkaar en tot de Aramis-CCS-keten.



Afbeelding 2. Aramis binnen de Aramis-CCS-keten.

TotalEnergies, Shell, Energie Beheer Nederland (EBN) en Gasunie zijn de initiatiefnemers van de ontwikkeling van de Aramis- CO_2-transportinfrastructuur. Zij zijn zelf verantwoordelijk voor de compressie van CO_2 die afkomstig is van de landleiding, de centrale CO_2-zeeleiding en de platforms.

Door verschillende bedrijven zal CO_2 worden afgevangen. Vervolgens verzorgen verschillende leveranciers de aanlevering van CO_2 via leiding (gas) of schip (vloeibaar) naar het CO_2-verzamelpunt. Op het verzamelpunt worden de terminalfaciliteiten verzorgd door CO_2next. In CO_2next werken Gasunie en Koninklijke Vopak samen aan de bouw van een nieuwe CO_2-terminal op de Maasvlakte.

De aanleg van de centrale CO_2-zeeleiding is onderdeel van het Aramis-project, evenals de bouw van het compressorstation op het verzamelpunt. Voor het overige (steigers, tanks voor tijdelijke opslag van per schip aangevoerde CO_2, en hogedrukpompen voor levering aan de zeeleiding) valt het verzamelpunt onder CO_2next.

De opslagpartijen (onder meer Shell, TotalEnergies en Neptune Energy) zijn verantwoordelijk voor de opslag van CO_2, inclusief het transport vanaf hun platforms naar de ondergrondse reservoirs.

1.3 ROL VAN HET MINISTERIE EN KORTE TOELICHTING OP DE PROCEDURE

Het ministerie van Economische Zaken en Klimaat (EZK) en Aramis werken nauw samen aan dit project en hebben hierin elk een eigen taak en rol.

Rollen van EZK

Voordat Aramis en CO_2next kunnen worden gerealiseerd, is er een ruimtelijk besluit nodig en moeten de vereiste vergunningen zijn verleend. EZK coördineert de besluitvorming van energieprojecten met een nationaal belang. Dit heet nu nog de Rijkscoördinatieregeling (RCR). Onder de nieuwe Omgevingswet die op 1 januari 2024 ingaat heet dit projectprocedure. Aangezien de vergunningaanvragen na 1 januari 2024 worden ingediend, hebben we het hier verder over de projectprocedure.

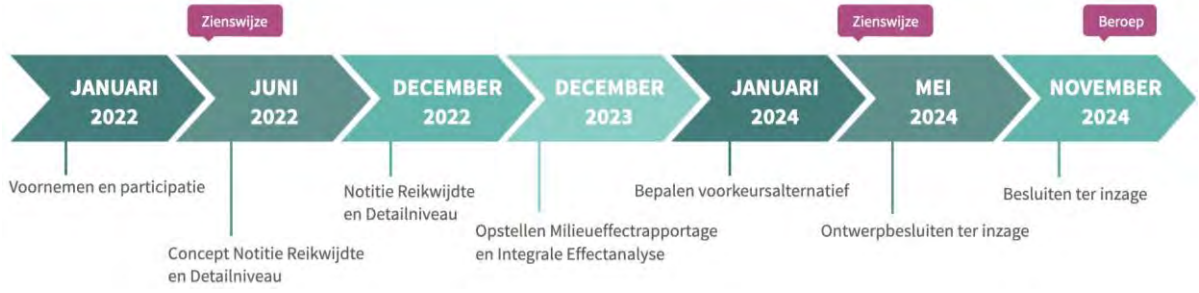
EZK coördineert de projectprocedure, waarbij de verschillende benodigde besluiten (vergunningen en eventueel ontheffingen) gelijktijdig worden genomen in afstemming met de overheden. Het gaat dan om zowel het ruimtelijk besluit als de uitvoeringsbesluiten. De coördinatie betekent ook dat alle stukken tegelijk ter inzage worden gelegd. Tegen de definitieve besluiten kan beroep worden aangetekend. Er is een beperkt aantal momenten waarin om een reactie wordt gevraagd, of men een zienswijze of beroep kan indienen.

Het ruimtelijk besluit wordt genomen door de minister voor Klimaat en Energie in overeenstemming met het ministerie van Binnenlandse Zaken en Koninkrijksrelaties. Het ruimtelijke besluit (in de nieuwe Omgevingswet: projectbesluit) wijzigt de huidige bestemmingen. Ook zijn er omgevingsvergunningen nodig, waaronder bouwvergunningen voor installaties op het verzamelpunt en voor de aanpassingen aan de platforms.

Andere vergunningen vallen onder de verantwoordelijkheid van andere bevoegde gezagen, bijvoorbeeld gemeente Rotterdam, Rijkswaterstaat en het ministerie van Landbouw, Natuur en Voedselkwaliteit (LNV). Vergunningen voor de afvang en opslag van CO_2 vallen buiten Aramis en worden aangevraagd door de opslagpartijen.

Nieuwe Omgevingswet en projectprocedure

Op 1 januari 2024 treedt de nieuwe Omgevingswet in werking. De formele besluiten voor Aramis worden niet voor deze datum genomen. Het ruimtelijk besluit van het Rijk heet onder de Omgevingswet niet meer rijksinpassingsplan (zoals in de Wet ruimtelijke ordening), maar projectbesluit. Aramis doorloopt de projectprocedure zoals weergegeven in afbeelding 3.



Afbeelding 3. Overzicht procedurestappen en tijdlijn.

Voornemen en voorstel participatie
Met de publicatie van de kennisgeving *Voornemen en Voorstel Participatie voor het project Aramis* (kennisgeving van het V&P) in de *Staatscourant* op 6 januari 2022 ging de projectprocedure officieel van start. EZK ontving zes reacties naar aanleiding van de kennisgeving. Op 19 en 24 januari 2022 heeft Aramis werksessies georganiseerd voor stakeholders van de Maasvlakte en de Noordzee. Bijlage 1 beschrijft de reacties en op welke manier die zijn gebruikt voor het actualiseren van dit participatieplan.

Concept-NRD
Bijlage 2 bevat het verslag van de stakeholdersessie op 21 juni 2022 waar de inhoud van de concept-NRD (Notitie Reikwijdte en Detailniveau) is besproken. In reactie op dit concept zijn acht zienswijzen ingediend. Op basis van deze zienswijzen is bekeken welke aanvullingen er nodig waren in de definitieve NRD. De definitieve NRD is in december 2022 vastgesteld.
Zowel de beantwoording van de vragen als de definitieve NRD is terug te vinden op de website van de RVO (https://www.rvo.nl/sites/default/files/2022-11/Vaststelling-NRD-en-Nota-van-Antwoord-concept-NRD-Aramis.pdf).

De inspraakprocedure heeft geresulteerd in twee aanpassingen aan de concept-NRD:

1. Als gevolg van de zienswijze van Neptune Energy worden de opslagfaciliteiten en bijbehorende infrastructuur van Neptune Energy als gelijkwaardig meegenomen in het MER, conform de opslagfaciliteiten voor TotalEnergies en Shell;
2. Het tracé van de zeeleiding is verder geoptimaliseerd, wat heeft geleid tot drie alternatieven en een variant, die alle in het MER worden getoetst.

IEA en MER
De volgende stap in het proces vindt momenteel plaats en behelst de voorbereidingen voor één integraal MER (fase 1 en fase 2 in één MER): een inventarisatie van de milieueffecten aan de hand van bureaustudies, onderzoeken en surveys. Op basis van de eerste resultaten van de milieuonderzoeken, evenals de aspecten kosten, omgeving, techniek en toekomstvastheid, stelt Aramis een Integrale Effectenanalyse (IEA) op. Deze analyse van de effecten van de verschillende routealternatieven en -varianten biedt tevens een uitgebreide analyse van zaken als de ruimtelijke inpassing. De resultaten van alle milieuonderzoeken worden samengevoegd in het MER, die naar verwachting in december 2023 gereed is. Het MER onderbouwt zowel de vergunningaanvragen als het projectbesluit en wordt in 2024 bij de ontwerpbesluiten ter inzage gelegd.

In overeenstemming met de minister van Binnenlandse Zaken en Koninkrijksrelaties kiest de minister voor Klimaat en Energie op basis van de IEA het voorkeursalternatief (VKA). Over het VKA vindt afstemming plaats met andere overheden en belangenorganisaties. Het VKA wordt gepubliceerd op de website van de RVO: Bureau Energieprojecten. Het VKA vormt de grondslag voor het ruimtelijk besluit (projectbesluit) en de vergunningen. Naar verwachting worden in het derde kwartaal van 2024 alle besluiten in ontwerp ter inzage gelegd, waarop ieder die dat wenst een zienswijze kan indienen. De zienswijzen worden betrokken bij het opstellen van de definitieve besluiten, waartegen beroep openstaat.

2 DOELEN EN KADER VAN PARTICIPATIE

2.1 DOELEN VAN PARTICIPATIE

Participatie gaat in brede zin over het betrekken van belanghebbenden en belangstellenden bij een project (zie de uitleg van de participatieladder in paragraaf 2.3). Dit participatieplan loopt vooruit op de nieuwe Omgevingswet door naast de wettelijk geregelde inspraak op het projectbesluit (formele procedure) een bredere betrokkenheid te organiseren. Aramis betrekt ieder die dat graag wil bij het project en handelt daarmee nu al in de geest van de aankomende wet. Hiermee hebben wij de volgende doelen voor ogen:

1. We willen burgers, bedrijven en maatschappelijke organisaties op een passende wijze bereiken;
2. We willen hun vragen, kansen en zorgen kennen en begrijpen;
3. We willen bij de ontwikkeling van het project rekening houden met ieders belangen;
4. We willen heldere keuzes maken en daarbij duidelijk laten zien hoe we omgaan met belangen, aandachtspunten, kansen en zorgen vanuit de omgeving.

Bij het behalen van deze doelen zijn we altijd bereid tot een constructieve dialoog. Onze projectorganisatie gaat uiteraard zorgvuldig om met persoonsgegevens, conform de AVG.

2.2 UITGANGSPUNTEN VAN PARTICIPATIE

We vinden het belangrijk dat participatie met betrekking tot Aramis begrijpelijk, betrouwbaar en toegankelijk is. Om te zorgen dat onze participatieaanpak zo goed mogelijk aansluit op de informatiebehoefte en wensen van belanghebbenden en belangstellenden, hanteren we de volgende uitgangspunten:

- We communiceren duidelijk, begrijpelijk en op maat;
- We bieden verschillende communicatiemiddelen aan, zodat iedereen de mogelijkheid heeft om onze informatie tot zich te nemen en indien gewenst met ons in dialoog te gaan;
- We communiceren tijdig en proactief;
- We kiezen voor een toegankelijke vorm die interactie en deelname aan inspraak stimuleert;
- We zijn goed bereikbaar en we reageren snel op vragen, klachten en verzoeken;
- We koppelen inhoud, toon en vorm aan elkaar, zodat we iedereen zo passend mogelijk bereiken.

2.3 KADER VAN PARTICIPATIE: HIER GAAT HET WEL/NIET OVER

Voor geslaagde participatie moet het duidelijk zijn waar belanghebbenden en belangstellenden wel en niet over kunnen meepraten en waar zij wel en geen invloed op hebben. De volgende drie vragen spelen hierbij een belangrijke rol: *waarom* we dit project willen doen, *waar* we dit project willen doen en *hoe*. Dit participatieplan maakt onderscheid tussen deze vragen en geeft per vraag de mate van participatie aan. Participatie kent namelijk verschillende gradaties, zoals hierna weergegeven in de participatieladder. Hoe hoger op de ladder, hoe meer invloed. Toch is ook op de onderste trede (informeren) sprake van participatie. Participatie is dus een heel breed concept.



Afbeelding 4. Participatieladder.

Waarom we dit willen doen?

De vraag waarom we Aramis willen uitvoeren is een vraag over nut en noodzaak van het initiatief. Aramis sluit aan op het regeringsbeleid, zoals geformuleerd in de brief van het kabinet aan de Tweede Kamer van 10 december 2021. In deze brief staat dat het afvangen, transporteren en opslaan van CO_2 een belangrijke (overgangs)technologie vormt voor de verduurzaming van Nederland en essentieel is om de CO_2-reductiedoelstelling voor 2030 te halen[3]. Ook in het Klimaatakkoord wordt verwezen naar CCS als een van de oplossingen om deze reductiedoelstelling te halen. Zie de Notitie Reikwijdte en Detailniveau (NRD) voor meer informatie over het Europese en Nederlandse klimaatbeleid en de rol van CCS hierin.

PARTICIPATIENIVEAU: INFORMEREN

Waar we dit willen doen?

De vraag waar we Aramis willen uitvoeren heeft betrekking op alternatieven en varianten van onder andere het tracé. De procedure voor de ruimtelijke inpassing, evenals de voorbereiding van het voorkeursalternatief, krijgt vorm in nauwe cocreatie met bevoegde instanties en betrokkenen bij andere activiteiten en ontwikkelingen in de buurt van Aramis. Met hen wordt ook gesproken over de gevolgen van de aanleg van onderdelen van het initiatief. Dit participatieplan beschrijft de verschillende manieren die belanghebbenden en belangstellenden hebben om hun suggesties kenbaar te maken. Ieder heeft de mogelijkheid om alternatieven aan te dragen, waarna deze worden afgewogen en mogelijk meegenomen. De uiteindelijke besluitvorming over het voorkeursalternatief is een taak van de ministers van EZK en BZK.

PARTICIPATIENIVEAUS: CONSULTEREN EN ADVISEREN

Hoe we dit willen doen?

De vraag hoe we Aramis willen uitvoeren is met name relevant in de dialoog met belanghebbenden en betrokkenen in de buurt van het project. Participatie draait hier om de gevolgen voor enerzijds de directe leef- en werkomgeving van mensen, en anderzijds de bedrijfsvoering van ondernemingen op de Maasvlakte en de Noordzee. Het gaat dus vooral om de impact van Aramis tijdens de uitvoering en ingebruikname. Naarmate het project zich verder ontwikkelt, concreter wordt en de uitvoering nadert, neemt de betrokkenheid van stakeholders in de directe omgeving toe. Gesprekken verplaatsen we dan naar lokaal niveau. Onderwerpen die hierbij aan bod komen zijn bijvoorbeeld de planning (start en duur) en uitvoering (tijdelijke overlast van bouwactiviteiten en veiligheid).

PARTICIPATIENIVEAU: CONSENSUS

[3] https://open.overheid.nl/repository/ronl-8fded76b-4d2c-4e79-817d-06bb14d9bb3a/1/pdf/kamerbrief-over-stand-van-zaken-ccs.pdf

3 PARTICIPATIEAANPAK

We betrekken graag personen en partijen bij Aramis wanneer het project hun belangen beïnvloedt, wanneer zij zich inhoudelijk betrokken voelen en/of wanneer zij belangrijk zijn voor de realisatie van Aramis. Hierbij onderscheiden we de volgende groepen:

- Burgers: mensen die dicht bij het project wonen of verblijven en om die reden vragen of zorgen hebben of anderzijds geïnteresseerd zijn. Wij denken dan vooral aan omwonenden;
- Bedrijven in de omgeving: bedrijven die dicht in de buurt van het project gevestigd zijn of daar werkzaamheden uitvoeren, zoals buurbedrijven op de Maasvlakte en op de Noordzee;
- Inhoudelijk betrokkenen: maatschappelijke organisaties en stakeholders die zich, los van de locatie, inhoudelijk betrokken voelen. Dit zijn bijvoorbeeld vertegenwoordigers van de scheepvaart, kustwacht, visserij, kabelexploitanten en operators van windparken. Wij denken verder aan ngo's die zich sterk maken voor natuur en milieu. Ook kennisinstellingen en organisaties die zich bezighouden met klimaat en CCS horen hierbij;
- Bestuursorganen: overheden op landelijk, provinciaal en lokaal niveau, zoals de provincie Zuid-Holland, gemeenten, Rijkswaterstaat (kruising zeewering, zandwinning, scheepvaart) en het waterschap Hollandse Delta. Ook semipublieke instellingen zoals ProRail, TenneT en Havenbedrijf Rotterdam zijn belangrijke stakeholders;
- Offshore storage-operators: operators van platforms op de Noordzee die in de toekomst wellicht toegang willen tot de CO_2-transportinfrastructuur van Aramis.

Deze personen en partijen hebben keuze uit individuele gesprekken en groepsbijeenkomsten, zowel online als live. De mate van participatie (informeren, consulteren, adviseren of verkrijgen van consensus) wordt vastgelegd en duidelijk gecommuniceerd. Zo willen wij een brede vertegenwoordiging van de samenleving bereiken en iedereen passend bedienen. Het is onze hoop dat deze werkwijze leidt tot meer betrokkenheid en meer waardering voor en acceptatie van Aramis.

We bieden de volgende informatiekanalen om geïnformeerd te blijven (informeren):

- Publicaties in de *Staatscourant* en huis-aan-huisbladen;
- Informatie op de websites van Aramis, CO_2next en Bureau Energieprojecten;
- (In)formele bijeenkomsten: (online) informatiebijeenkomst/seminar/kennissessie;
- Digitale nieuwsbrief;
- Persoonlijke of geclusterde gesprekken.

We bieden de volgende manieren om betrokken te blijven (consulteren of adviseren):

- (Online) informatiebijeenkomst;
- Bestuurlijke, regionale en landelijke overleggen;
- Persoonlijke of geclusterde gesprekken;
- Schriftelijke reactie op plannen.

Hieronder lichten we deze kanalen toe voor de periode vanaf het vaststellen van het milieueffectrapport (MER) en de Integrale Effectenanalyse (IEA) tot de publicatie van de ontwerpbesluiten.

3.1 MANIEREN OM GEÏNFORMEERD TE BLIJVEN (INFORMEREN)

In deze en de volgende paragraaf leest u hoe wij personen en partijen in de komende periode bij Aramis willen betrekken. Bijlage 3 beschrijft welke stappen in eerdere fases zijn genomen.

a. Publicaties Staatscourant en huis-aan-huisbladen
Formele stappen in de projectprocedure worden vooraf gepubliceerd in de *Staatscourant* en in huis-aan-huisbladen. Naar verwachting wordt in het derde kwartaal van 2024 de terinzagelegging van de ontwerpbeschikkingen in de *Staatscourant* gepubliceerd, waarop zienswijzen kunnen worden ingediend. Eind 2024/begin 2025 volgt naar verwachting de publicatie in de *Staatscourant* dat de definitieve besluiten op de vergunningaanvragen ter inzage liggen voor beroep.

b. Websites Aramis, CO_2next en Bureau Energieprojecten
Iedereen heeft toegang tot onze websites www.aramis-ccs.com/nl en CO2next.nl. Hier delen wij regelmatig updates en mijlpalen, waarbij we verwijzen naar de officiële documenten op de website van Bureau Energieprojecten. Het is voor iedereen mogelijk om een reactie achter te laten. De websites vermelden ook de e-mailadressen en telefoonnummers voor rechtstreeks contact. Wanneer het MER, de IEA en de (ontwerp)besluiten gereed zijn, worden die op de website van Bureau Energieprojecten gepubliceerd.

c. (In)formele bijeenkomsten: (online) informatiebijeenkomsten en symposia
In de komende periode worden de milieuonderzoeken uitgevoerd. Tijdens eerdere sessies hebben verschillende stakeholders aandachtspunten (eisen en wensen) aangedragen. Op basis van deze aandachtspunten bespreken we de tussentijdse resultaten van de milieuonderzoeken met de stakeholders. Zo kunnen we stakeholders met zorgen en vragen, bijvoorbeeld over geluid, Natura 2000-gebieden, veiligheid, gezondheid of de impact op de omgeving, specifiek en gedetailleerd informeren. Eventueel vindt er een informatiebijeenkomst of symposium plaats. Vooraf peilen we hiervoor de interesse en informatiebehoefte bij stakeholders. Bij voldoende interesse bepalen we een datum, die we tijdig aan de stakeholders kenbaar maken.

d. Digitale nieuwsbrief
Zo'n vier tot vijf keer per jaar verschijnt een nieuwsbrief waarvoor iedereen zich via onze website kan aanmelden. De aankomende nieuwsbrieven staan gepland voor september en november. Deze planning staat niet vast en hangt onder andere af van de vraag of er voldoende nieuws is om te communiceren.

e. Persoonlijke of geclusterde gesprekken
De komende periode vinden zowel individuele als geclusterde gesprekken plaats met de diverse stakeholders. Deze gesprekken kunnen het gehele Aramis-initiatief tot onderwerp hebben, dus inclusief het onderdeel waarvoor CO_2next verantwoordelijk is. Maar het is ook mogelijk dat het gesprek zich beperkt tot uitsluitend het deel waarvoor Aramis of CO_2next verantwoordelijk is. Dit is afhankelijk van het onderwerp en de organisatie waarmee het gesprek plaatsvindt, bijvoorbeeld omliggende bedrijven, gemeenten, ngo's, Kamerleden enzovoort.

Tijdens deze gesprekken worden de eisen en wensen van de gesprekspartners zo concreet mogelijk gemaakt. Eisen en wensen die betrekking hebben op het tracé en de exacte ligging worden in deze fase meegenomen, eisen en wensen die betrekking hebben op de uitvoering volgen in een later realisatiecontract.

De Integrale Effectenanalyse (IEA) brengt de effecten in kaart die de verschillende alternatieven hebben op milieu, kosten, omgeving, techniek en toekomstvastheid. Hier krijgen de opgehaalde eisen en wensen hun beslag. Belanghebbenden worden geïnformeerd over de uitkomsten van de IEA en geconsulteerd over de beoogde voorkeursalternatieven voor het Aramis initiatief.

3.2 MANIEREN OM BETROKKEN TE BLIJVEN (CONSULTEREN/ADVISEREN)

a. (Online) informatiebijeenkomst
In de komende periode vinden de milieuonderzoeken plaats. Aramis organiseert dan een of meer MER-kennissessies met als onderwerp: wat houden deze milieuonderzoeken precies in en wat zijn de eerste bevindingen?

b. Bestuurlijke, regionale en landelijke overleggen
Aramis en EZK vinden het belangrijk om direct betrokken overheden, adviesorganen en belangenorganisaties te betrekken bij de besluitvorming over het project. Voor zowel de ruimtelijke procedure als de uitvoeringsvergunningen vinden afstemmingsoverleggen plaats. Zo wordt in het Noordzeeoverleg met enige regelmaat een update gegeven van de onderzeese routealternatieven van Aramis en het overleg dat daarover heeft plaatsgevonden. Deze updates hebben tot doel de aanwezige organisaties mee te nemen in de totstandkoming van de IEA en het VKA, de basis voor het (ruimtelijk) projectbesluit. Daarnaast worden ook andere regionale overheden en belangenorganisaties geïnformeerd over het project.

c. Stakeholders
Aramis is in een eerder stadium geïntroduceerd bij onder meer programmamanagers, regioadviseurs, beleidsadviseurs en projectleiders van ministeries (EZK Wind-op-zee, Landbouw, Natuur en Voedselkwaliteit (LNV), Defensie, Binnenlandse Zaken en Koninkrijksrelaties (BZK), Infrastructuur en Waterstaat (IenW)), de Rijksdienst voor het Cultureel Erfgoed (RCE), lokale gemeenten (Rotterdam, Voorne aan Zee), de provincie (Zuid-Holland), Veiligheidsregio Rotterdam-Rijnmond (VRR), water(veiligheid)beheerders (waterschap Hollandse Delta, RWS Zee & Delta, Kustwacht), omgevingsdiensten (DCMR, ODH), wegbeheerder (RWS WNZ), railbeheerder (ProRail), belangengroepen (Deltalinqs, KVNR, Element NL, Nexstep, de Nederlandse Vissersbond, Nederlands Loodswezen, H-vision, NWEA, Verontruste Burgers van Voorne), ngo's (Bellona, Stichting de Noordzee, Natuur & Milieu, Greenpeace, Milieufederatie Zuid-Holland, Vogelbescherming, WNF), raakvlakprojecten (Porthos, Eneco), kabel- en pijpleidingeigenaren (TenneT, Stedin), offshore operators (o.a. Neptune Energy, Petrogas) en bedrijven op de Maasvlakte (Havenbedrijf Rotterdam, MOT, Euromax). Met deze stakeholders worden een-op-een- of clustergesprekken gevoerd.

d. Schriftelijke reactie op plannen
Iedereen krijgt in 2024 de mogelijkheid om schriftelijk een reactie te geven op het ontwerpbesluit en op het MER. De publicatie van het ontwerpbesluit staat gepland voor het derde kwartaal van 2024 en men heeft dan zes weken de tijd om te reageren. Aramis brengt de stakeholders te zijner tijd op de hoogte van de publicatie, zodat zij in de gelegenheid zijn om tijdig een zienswijze op het ontwerpbesluit (inclusief het MER) in te dienen.

4. PARTICIPATIEKALENDER

4.1 PARTICIPATIEKALENDER

De onderstaande tabel geeft op hoofdlijnen de stappen van besluitvorming en participatie weer conform de projectprocedure (zie paragraaf 1.3 hierboven). In de tabel staat wanneer officiële documenten worden gepubliceerd en ter inzage worden gelegd, en wanneer ieder die dat wil kan meedenken, bijdragen en inspreken.

PROCESSTAP	WIJZE VAN PARTICIPATIE	STATUS
Voornemen en voorstel participatie (januari 2022)	**Informeren, consulteren en adviseren** EZK en Aramis hebben de brede omgeving van overheden, bevoegde instanties, inwoners, bedrijven en professionele stakeholders geïnformeerd over het projectvoornemen en de voorgestelde invulling van participatie. Iedereen kon een formele reactie geven met betrekking tot: 1. andere oplossingen voor de geschetste opgave, bijvoorbeeld andere manieren om CCS toe te passen (denk aan alternatieven en varianten); 2. andere voorstellen voor de wijze waarop derden worden betrokken. Alle verzamelde reacties zijn waar mogelijk verwerkt in de concept-NRD (Notitie Reikwijdte en Detailniveau). Participatie-instrumenten: • Publicatie in Staatscourant en huis-aan-huisbladen; • Openbare informatiebijeenkomst.	**Gereed**
Inventarisatie alternatieven en varianten en het beoordelingskader (januari-mei 2022)	**Consulteren en adviseren** EZK en Aramis hebben andere overheden, bevoegde instanties en belangenorganisaties geconsulteerd om op verschillende manieren mee te denken, informatie aan te leveren over tracé-alternatieven, en varianten en aandachtspunten aan te dragen voor de NRD en het MER. Participatie-instrumenten: • Geïntegreerde interactieve werksessies; • Een-op-een- of clustergesprekken; • Nieuwsbrief Aramis.	**Gereed**
Concept Notitie Reikwijdte en Detailniveau (concept-NRD) (juni 2022)	**Informeren, consulteren en adviseren** Iedereen kon een formele zienswijze indienen over de vragen: • of de participatie beter kan; • of er iets ontbreekt bij de onderzoeken; • of de juiste onderdelen worden onderzocht; • of er andere tracé-alternatieven en/of -varianten onderzocht moeten worden. Waar relevant zijn deze meegenomen in de definitieve NRD. Participatie-instrumenten: • Publicatie in Staatscourant en huis-aan-huisbladen; • Publicatie op www.rvo.nl/onderwerpen/bureau-energieprojecten;	**Gereed**

	• Websites Aramis en CO_2next; • Raadpleging Commissie MER; • Een-op-een- of clustergesprekken; • Formele en informele informatiebijeenkomst op 21 juni 2022; • Nieuwsbrief Aramis.	
Vaststellen definitieve NRD (december 2022)	**Informeren** EZK en Aramis hebben de brede omgeving geïnformeerd over de definitief vastgestelde NRD. Participatie-instrumenten: • Publicatie op www.rvo.nl/onderwerpen/bureau-energieprojecten; • Websites Aramis en CO_2next; • Nieuwsbrief Aramis.	**Gereed**
Integrale Effectenanalyse (IEA) (december 2023)	**Informeren, consulteren en adviseren** EZK en Aramis consulteren de brede omgeving over de afwegingen van de IEA op basis van de aspecten milieu, kosten, omgeving, techniek en toekomstvastheid. Participatie-instrumenten onder andere: • Publicatie op www.rvo.nl/onderwerpen/bureau-energieprojecten; • Websites Aramis en CO_2next; • Overleggen (door EZK); • Een-op-een- of clustergesprekken; • Nieuwsbrief Aramis.	*Gepland*
Keuze voorkeursalternatief (VKA) (januari 2024)	**Informeren, consulteren en adviseren** EZK en Aramis raadplegen decentrale overheden en andere departementen over het VKA. De minister van EZK bepaalt op basis van dit advies het voorkeursalternatief. Participatie-instrumenten onder andere: • Een-op-een- of clustergesprekken met belanghebbenden; • Overleggen (door EZK); • Websites Aramis en CO_2next; • Nieuwsbrief Aramis.	*Gepland*

Milieueffectrapport (MER) als onderdeel van de vergunningaanvragen (eind 2024)	**Informeren, consulteren en adviseren** EZK en Aramis consulteren de brede omgeving over het MER. Reageren op het MER is mogelijk bij de terinzagelegging van de ontwerpbesluiten (zie de stap Publicatie ontwerp-projectbesluit en ontwerp-vergunningen hieronder). Participatie-instrumenten onder andere: • Resultaten van het MER zullen aan het eind worden gedeeld; • Een-op-een- of clustergesprekken met belanghebbenden; • Websites Aramis en CO_2next; • Nieuwsbrief Aramis.	*Gepland*
Publicatie ontwerp-projectbesluit en ontwerp-vergunningen (eind 2024)	**Informeren en horen** De bevoegde instanties stellen op basis van de aanvragen van Aramis het ontwerp-projectbesluit en de ontwerp-vergunningen op. EZK publiceert het ontwerp-projectbesluit en de ontwerp-vergunningen, inclusief het MER. Iedereen die dat wil kan een formele zienswijze indienen. De commissie van de m.e.r. geeft een advies over het MER. Participatie-instrumenten onder andere: • Publicatie in Staatscourant en huis-aan-huisbladen; • Publicatie op www.rvo.nl/onderwerpen/bureau-energieprojecten; • Openbare informatiebijeenkomst(en); • Een-op-een- of clustergesprekken met belanghebbenden; • Websites Aramis en CO_2next; • Nieuwsbrief Aramis.	*Gepland*
Publicatie definitief projectbesluit en definitieve vergunningen (eind 2024/begin 2025)	**Informeren en beroep** EZK publiceert het definitief projectbesluit en de definitieve vergunningen. Iedereen kan reageren op het projectbesluit en de vergunningen door hiertegen beroep in te stellen. Participatie-instrumenten onder andere: • Publicatie in Staatscourant en huis-aan-huisbladen; • Publicatie op www.rvo.nl/onderwerpen/bureau-energieprojecten; • Hoger beroep; • Websites Aramis en CO_2next; • Nieuwsbrief Aramis.	*Gepland*
Onherroepelijk projectbesluit en vergunningen (zonder beroep)	Uitspraak Raad van State na behandeling van mogelijke beroepen.	n.t.b.

4.2 WE HOREN GRAAG UW REACTIE OP DIT PARTICIPATIEPLAN

Zoals in paragraaf 1.1 aangeven, actualiseren we het participatieplan minstens eenmaal per projectfase. Het volgende participatieplan verschijnt naar verwachting in het voorjaar van 2024, voorafgaand aan de publicatie van het projectbesluit.

Heeft u vragen of suggesties voor verbetering van dit plan? Wij horen graag van u!
U kunt uw reactie per e-mail sturen naar: info@aramis-ccs.com.

BIJLAGES

BIJLAGE 1 SAMENVATTING INBRENG STAKEHOLDERS

Het doel van de stakeholderparticipatie is het ophalen van informatie, gebiedskennis, aandachtspunten, ideeën en kansen uit de omgeving. Zo hebben er sinds zomer 2021 kennismakingsgesprekken met stakeholders, één-op-één overleggen en persoonlijk contact met verschillende belanghebbenden plaatsgevonden. Van 7 januari tot 17 februari 2022 heeft de notitie 'Voornemen en Voorstel Participatie' ter inzage gelegen. In die periode was het mogelijk om te reageren door een schriftelijke reactie te geven op deze notitie. Er zijn zes reacties binnengekomen bij EZK. Er is formeel een antwoord gegeven op deze reacties via de nota van antwoord die is opgesteld door EZK in afstemming met het Aramis initiatief. Deze nota van antwoord is tegelijkertijd met de concept NRD en dit Participatieplan gepubliceerd.

Daarnaast werden er op 19 en 24 januari 2022 werksessies met verschillende stakeholders op respectievelijk 'land' en op 'zee' georganiseerd en heeft het ministerie van Economische Zaken en Klimaat op 26 januari 2022 een informatieavond gehouden. Een aantal aanwezigen bij de informatieavond heeft aangegeven de Aramis nieuwsbrief te willen ontvangen: zij hebben inmiddels de eerste Aramis nieuwsbrief ontvangen en worden op de hoogte gehouden door volgende nieuwsbrieven. Tijdens de verschillende gesprekken en werksessies zijn de plannen toegelicht en is er veel gebiedskennis verzameld. In het onderstaande wordt een samenvatting van aandachtspunten gegeven die door stakeholders zijn benoemd. Hierbij is onderscheid gemaakt tussen het onderdeel 'aanlanding en landdeel' (A) en het onderdeel 'zeedeel' (B). Daarnaast volgt een lijst van geraadpleegde stakeholders per onderdeel.

1 Samenvatting aandachtspunten Maasvlakte – aanlanding en landdeel

Omgevingsveiligheid, geluid & stikstof depositie
Veel partijen stellen vragen over omgevingsveiligheid, geluid en stikstofdepositie door de aanleg en aanwezigheid van de terminal en het compressor station, pompen en andere installaties. Ook over het 'entry' punt van de micro-tunnel (één van de twee voorlopige aanlandingslocaties op de Maasvlakte) stellen partijen vragen met het oog op het risico op calamiteiten, aangezien de 'vuurwerk ompak' locatie op de Prinses Maximaweg zich nabij bevindt. Verder wordt voor de stikstofdepositie in relatie tot scheepvaartbewegingen (ten behoeve van de vloeibare intake van CO_2) aandacht gevraagd.

Overslag CO_2 na aanlanding per schip
De terminalfaciliteiten, bestaande uit de overslag van CO_2 van schepen, tijdelijke opslag en verpomping van vloeibaar CO_2 naar de zeeleiding worden door CO_2next uitgevoerd.

Aanlanding vanuit zee op Maasvlakte
Voor de aanlanding van de pijpleiding vanuit zee naar de Maasvlakte zijn twee opties in beeld. Ten eerste via een Horizontale boring (HDD) onder de harde zeewering of ten tweede via een micro-tunnel die op diepte ligt onder de Maasgeul. De stakeholders vragen aandacht voor het feit dat beide aanlegmethodes ook op het land van de Maasvlakte permanente ruimte en werkterreinen behoeven. Hiervoor is tijdige afstemming met meerdere stakeholders, onder meer Port of Rotterdam van belang.

De suggestie wordt gedaan om een overleg te hebben met de stakeholders die gebiedskennis hebben over de aanlanding middels een HDD op de Maasvlakte. De beschikbare ruimte is beperkt gezien de ligging van TenneT kabels (Net op zee HKZ), de voorziene ligging van de Porthos CO_2 leiding, de aanwezige leidingenstrook op de Maasvlakte en het voorziene windpark van Eneco op de zeewering.

Een van de opties, een microtunnel, zou mogelijkheden en kansen kunnen bieden voor medegebruik zoals het 'Net op zee' van TenneT voor nog toekomstige windparken.
Ongeacht de aanlandingsopties wordt aandacht gevraagd voor dat de scheepvaart in de Maasgeul geen hinder mag ondervinden.

Andere functies en industrie op de Maasvlakte
In veel gesprekken komt naar voren dat de industrie volcontinu in bedrijf is. De dagelijkse werkzaamheden moeten 24/7 door kunnen gaan tijdens de aanlegfase van de projecten. Ook dient de toegang van hulpdiensten te allen tijde zijn gegarandeerd. Eveneens dient de bereikbaarheid van de kazerne van de Gezamenlijke Brandweer aan de Prinses Maximaweg 24/7 gegarandeerd te blijven.
De leiding komt deels binnen en buiten de leidingenstrook te liggen. Dit vergt afstemming met zowel Port of Rotterdam als het Leidingenbureau van gemeente Rotterdam. De krappe ligging in de leidingenstrook en de drukte in de ondergrond zijn aandachtspunten.

Autoriteiten en andere stakeholders – aanlanding en landdeel
Autoriteiten: Het Ministerie van EZK, DCMR, ProRail regio Randstad-Zuid, Gemeente Rotterdam (RO, leidingenbureau Rotterdam), Veiligheidsregio Rotterdam-Rijnmond, Rijkswaterstaat (WNZ, Zee & Delta), Omgevingsdienst Haaglanden, Provincie Zuid-Holland
Ngo's: Vereniging Natuurmonumenten Zuid Holland, Natuur- en Milieufederatie Zuid-Holland
Kabel en pijplijn eigenaren: TenneT
Industrie & Business & andere projecten Maasvlakte: Deltalinqs, Havenbedrijf Rotterdam, Divisie Havenmeester van het Havenbedrijf Rotterdam, Eneco, Euromax, Gate terminal, Porthos , MOT, ProRail, ECT Rotterdam
Scheepvaart: het Nederlands Loodswezen
Overige: Gezamenlijke brandweer Prinses Maxima kazerne

1 Samenvatting aandachtspunten - zeedeel

Zeeleiding op of in de zeebodem
Partijen hebben vragen over de installatie van de zeeleiding op of in de zeebodem. Dit heeft te maken met verschillende belangen van verschillende stakeholders. Zo dient de leiding overvisbaar te zijn en moet scheepvaartveiligheid gegarandeerd zijn in geval van (nood)ankeren boven de leiding. Daarnaast zijn er vragen over de gevolgen van meerdere leidingen en kabels die gekruist worden in de aanlooproute voor de scheepvaart; ontstaan er dan niet lokale verondiepingen op de zeebodem als gevolg van de kruisingsconstructies op de zeebodem?
Nautische partijen vragen verder om het beperken van hinder voor de scheepvaart door het vermijden van ankergebieden en het zoveel mogelijk haaks kruisen van hoofdvaarroutes en geulen. Daarnaast wordt er aandacht gevraagd voor het mogelijke effect van CO_2 lekkage op het milieu. Ook is er sprake van de aanwezigheid van mogelijke obstakels op de zeebodem (zoals wrakken en mogelijk WO II resten).

Andere functies op de Noordzee
Partijen geven aan dat er nieuwe windparken op zee worden gepland. Dit heeft mogelijk ook gevolg voor een militair oefengebied op zee dat verplaatst moeten worden. Partijen vragen of er bij de tracering van de leiding rekening wordt gehouden met deze ontwikkelingen. Dit betekent ook nieuwe hoogspanningskabels van het net op zee, waarin in de tracering rekening gehouden moet worden (t.a.v. minimumafstanden en kruisingen).
Andere olie- en gasoperators hebben interesse getoond voor het eveneens aansluiten op de centrale leiding, zodat ook van hun opslagmogelijkheden gebruik gemaakt kan worden. Voor deze groep van stakeholders is op 9 maart 2022 een aparte bijeenkomst georganiseerd.
Partijen vragen aandacht voor andere gebruiksfuncties op de drukke Noordzee; zoals zandwinning. Deze gebieden dienen zo veel mogelijk vermeden te worden.
Met de stakeholders zijn twee tracé opties (Opties A en B) in het noordelijke deel op zee besproken. Alleen vanuit de toekomstige windpark belangen is er een voorkeur uitgesproken voor route-optie A omdat deze route-optie minder impact heeft op het toekomstige windenergiegebied. Overige partijen hebben geen onderscheidende aandachtspunten per tracé optie aangegeven.

Natuurversterkende maatregelen en andere kansen
In de contacten met partijen werden ook kansen benoemd voor de Noordzee; zoals het natuur-inclusief aanleggen van de benodigde infrastructuur op de zeebodem en een eventuele koppeling met andere CCS projecten.

Autoriteiten en andere stakeholders - zeedeel
Autoriteiten: Ministerie van EZK, Rijkswaterstaat (Zee & Delta), Ministerie van LNV, Ministerie van Defensie/ Dienst der Hydrografie, Ministerie van I en W
Ngo's: Vereniging Natuurmonumenten Zuid Holland, Natuur- en Milieufederatie Zuid-Holland, Stichting de Noordzee, Natuur & Milieu
Kabel en pijplijn eigenaren: TenneT, Stedin
Industrie & Business: Divisie Havenmeester van het Havenbedrijf Rotterdam
Scheepvaart: het Nederlands Loodswezen, Scheepvaart Adviesgroep Noordzee, KVNR
Visserij: Nederlandse Vissersbond, Voormalig VisNED
Olie en gas: Element NL
Zandwinning: LaMER
Overig: Kustwacht

Terugkoppeling werksessies
In de terugkoppeling naar deze stakeholders hebben we initieel een korte reactie gegeven op alle aandachtspunten. Hierin is aangeven dat we contact opnemen om een afspraak te maken en in individuele gesprekken hun aandachtspunten verder willen bespreken. Het Aramis initiatief heeft na de werksessie contact gehad met het Havenbedrijf Rotterdam, Euromax, Deltalinqs (bij de Klimaattafel) en DCMR. Op 7 april 2022 is er ook een gezamenlijk gesprek geweest met de gemeente Rotterdam, EZK, Gate terminal, MOT, Aramis en CO_2next over de aanpak voor het wijzigen van het huidige bestemmingsplan van Gate terminal en MOT en de rol van de bevoegde gezagen. Er is een vervolgoverleg ingepland om helderheid te verschaffen aan de te volgen procedure. Alle reacties zijn als input meegewogen voor de concept NRD en het technisch ontwerp waar we momenteel mee bezig zijn.

BIJLAGE 2 VERSLAG STAKEHOLDERSESSIE 21 JUNI 2022

Onderwerp	Stakeholderbijeenkomst Aramis en CO_2next
Project	Aramis
Datum bijeenkomst	21 juni 2022
Plaats	Hoek van Holland
Bijlage(n)	Presentatie Aramis
Aanwezig	Ministerie van EZK, EZK Wind-op-zee, TenneT, RWS, Koninklijke Vereniging van Nederlandse Reders, Kustwacht, Neptune, Carbon Collectors, Noordgastransport, Porthos, AECOM, Buis Consultancy, TNO, Port of Rotterdam (nautisch beheer), Omgevingsdienst Haaglanden, DCMR, Provincie Zuid- Holland, RWS (WNZ), LNV, Veiligheidsregio Rotterdam -Rijnmond.

Verslag stakeholderbijeenkomst

Algemeen

Op 21 juni jl. heeft een stakeholderbijeenkomst plaatsgevonden. Het doel van de bijeenkomst was het ophalen van informatie, gebiedskennis, aandachtspunten voor het MER ideeën, zorgen, wensen en kansen uit de omgeving. Onderstaand het verslag van de bijeenkomst.

Plenaire opening

Er wordt gestart met een toelichting op de concept Notitie Reikwijdte en Detailniveau en de stand van zaken van Aramis. Er wordt aangegeven wat de planning is en op welke momenten er nog ruimte is voor participatie.

Thematafels

Na het plenaire gedeelde wordt er uiteen gegaan in drie thematafels: de Maasvlakte, de Aflanding en de Noordzee.

Samenvatting aandachtspunten Maasvlakte

Aan deze tafel gingen vragen onder meer over:

- technisch gerelateerde zaken zoals de aanleg van pijpleidingen: land-trace's en de constante flow van de CO_2 in relatie tot een flexibel aanbod van de CO_2
- de schepen: emissieloos bouwen, stikstofdepositie en duur van het bouwen, soort schepen, capaciteit steigers, en aanbod walstroom
- het bevoegd gezag voor het deel van de aanlanding en de Maasvlakte (in dit geval gecoördineerd door EZK).
- de situatie met betrekking tot het compressorstation en de relatie tussen Aramis, Porthos en CO_2next.
- de scope tussen Aramis emitters en andere emitters, als ook over de capaciteit en prioritering voor de opslagvelden en voldoende beschikbaarheid van schepen voor de aan- en afvoer van vloeibare CO_2.
- punten in relatie tot de veiligheid, zoals het meenemen van de windturbines in de risicoanalyse, de gevolgen voor Hoek van Holland, aanvaringsrisico's, tankrisico's, de ligging van de brandweer kazerne bij een verkeerde wind.

Samenvatting aandachtspunten Aflanding
Aan deze tafel is onder andere gevraagd naar de technische uitdaging in dit project, en de beschikbare ruimte in relatie tot de beoogde Porthos leiding. Verder hebben TenneT en Porthos vooral hun ervaringen gedeeld, opgedaan bij eerdere aanleg van leidingen in het gebied, respectievelijk bij de voorbereiding daarop. Zo is uitdrukkelijk meegegeven aandacht te hebben in het vervolgtraject voor aanwezige niet gesprongen explosieven, archeologische waarden, bodemgesteldheid, stabiliteit van de zeewering, en beschermde soorten. Dit zowel uit technisch oogpunt als voor wat betreft de benodigde vergunningen en toestemmingen en de tijd die daarmee gemoeid is. Aangeboden wordt waar mogelijk gegevens van bijvoorbeeld boringen te delen, zonder daarbij de eigen verantwoordelijkheid van Aramis uit het oog te verliezen. Vanuit Nautisch Beheer van Port of Rotterdam wordt aandacht gevraagd voor het veilig en ongestoord doorgang vinden van de scheepvaart en de eisen die daaraan worden gesteld. In dat kader is als aandachtspunt meegegeven dat het Port of Rotterdam niet altijd duidelijk is op welke wijze de verschillende initiatiefnemers in de Maasmond met elkaar samenwerken.

Samenvatting aandachtspunten Noordzee
Aan deze tafel werd de ligging van de leiding toegelicht aan de hand van een tracétekening. Daarna is er de mogelijkheid gegeven aan de aanwezigen om te reageren op deze tekening.

Veel van de ingebrachte punten waren suggesties ter verbetering van de ligging van de leiding en het kaartmateriaal.

- EZK Wind-op-zee merkt op dat de zoekgebieden voor Hollandse Kust Zuidwest en Noordwest vervallen. Deze moeten nog van de tracétekening worden afgehaald.
- De Kustwacht geeft aan dat in de bepaling van de tracékeuze aandacht moet zijn voor multifunctioneel ruimtegebruik, bijvoorbeeld gaswindgebieden en bijbehorende aanvliegroutes en defensie oefengebied.
- De Kustwacht geeft als suggestie dat bestaande pijpleidingen gevolgd kunnen worden om een corridor te creëren.
- Neptune Energy geeft aan dat de Riser Tower of site tap op ‘gelijke’ afstand van hun velden moet liggen als van de velden van TotalEnergies en Shell.
- De Kustwacht geeft aan dat de leiding overvisbaar moet zijn, geen ankerplekken mag kruisen en zoveel mogelijk parallel moet liggen aan de vaarroutes.
- EZK Wind-op-zee ziet graag dat de leiding wordt gelegd buiten de (beoogde) windgebieden.

Daarnaast worden er verschillende punten ingebracht ter verbetering van de c-NRD en om mee te nemen in het MER:

- EZK Wind-op-zee vindt dat de ruimtelijke keuzes voor de ligging van het tracé nog beter omschreven mogen worden in de c-NRD.
- Neptune Energy voegt daaraan toe dat ze graag nog beter de mogelijkheden voor toekomstige aan- en aftakkingen op de leiding omschreven zien.
- De Kustwacht geeft aan dat er in het MER onderzocht moet worden wat het effect van lekkage is.

KNVR geeft tot slot de tip om MARIN te benaderen voor meer informatie over hun onderzoek naar de mogelijkheden om windmolens te beschermen tegen op drift geraakte schepen, omdat de uitkomsten hiervan ook nuttig voor Aramis kunnen zijn.

De middag is afgerond met een plenaire terugkoppeling, waarbij de gevoerde gesprekken per thematafel zijn samengevat, en is benadrukt dat op meerdere momenten in het vervolg van het proces participatie mogelijk is. Aramis zal de opgehaalde informatie verwerken in het MER en zal het gesprek van de thematafels voort zetten met de verschillende stakeholders.

BIJLAGE 3 AFGERONDE ACTIES VAN PARTICIPATIE (UIT H3)

MANIEREN OM GEÏNFORMEERD TE BLIJVEN (INFORMEREN)

a. Publicaties Staatscourant en huis-aan-huis bladen
Op 9 juni 2022 is in de Staatscourant (en in diezelfde week ook in huis-aan-huis bladen) gepubliceerd dat de concept NRD en dit participatieplan ter inzage lagen voor reacties. Op 2 december 2022 is in de Staatscourant gepubliceerd dat de definitieve NRD is vastgesteld.

b. Websites projecten Aramis, CO_2next en Bureau Energieprojecten
Op 10 juni 2022 is de concept NRD gepubliceerd op de website van Bureau Energieprojecten. Hierop kon iedereen de concept NRD en het geactualiseerde participatieplan inzien. Iedereen had de mogelijkheid tot het indienen van een zienswijze. Er zijn acht zienswijze ingediend die formeel zijn beantwoord. Op 2 december 2022 is de definitieve NRD inclusief de nota van antwoord gepubliceerd op de website van Bureau Energieprojecten.

c. (In)formele bijeenkomsten: Informatiebijeenkomst, symposium en kennissessies
Op 21 juni 2022 hebben EZK en het Aramis initiatief een formele informatiebijeenkomst gehouden, ten tijde van de terinzagelegging van de concept NRD. We hebben de concept NRD toegelicht, welke alternatieven en varianten we in het MER gaan onderzoeken, hoe we dat gaan doen en in welk detailniveau. Tijdens deze bijeenkomst waren projectleden van het Aramis initiatief aanwezig om vragen over het project en de concept NRD te beantwoorden. Medewerkers van EZK waren ook aanwezig om vragen over de procedure te beantwoorden.

Naast de formele bijeenkomst heeft Aramis een informele bijeenkomst georganiseerd voor alle (zakelijke) stakeholders. Doel was om de deelnemers van deze bijeenkomst te informeren over de status van het project aan de hand van de concept NRD en om alle vragen die er leven te beantwoorden. Met deze bijeenkomst heeft het Aramis initiatief ook voldaan aan de verplichting van een openbare raadpleging die volgt uit de PCI-status (Project of Common Interest).

d. Digitale nieuwsbrief
We hebben eind april 2022 de eerste nieuwsbrief en in juli 2022 de tweede nieuwsbrief uitgebracht. De eerste twee nieuwsbrieven waren in het Nederlands. De derde nieuwsbrief (in het Engels) is in november 2022 verspreid en de vierde in april 2023. Alle nieuwsbrieven zijn toegankelijk via de Aramis website.

e. Persoonlijk of geclusterde gesprekken
Afgelopen periode zijn individuele en ook geclusterde gesprekken met de diverse stakeholders gevoerd. Uitkomsten daarvan zijn en worden verwerkt in Dialog.

MANIEREN OM BETROKKEN TE BLIJVEN (INFORMEREN/CONSULTEREN/ADVISEREN)

a. Informatiebijeenkomst
Tijdens de informatiebijeenkomst op 21 juni 2022 konden de aanwezigen op een laagdrempelige manier in gesprek gaan met projectmedewerkers van het Aramis initiatief en het ministerie van EZK. Ook was het voor de aanwezigen mogelijk tijdens deze bijeenkomst een mondelinge reactie (zienswijze) in te dienen. Uiteindelijk zijn er acht schriftelijke reacties ingediend op de concept NRD.

b. Bestuurlijke en landelijke overleggen
Het Aramis initiatief en het ministerie van EZK vinden het belangrijk om gemeenten, provincie en andere bestuursorganen actief te betrekken bij de besluitvorming over het project.

Het Aramis initiatief en het ministerie van EZK betrekken bestuurlijke partners van de gemeenten, de provincie Zuid-Holland en andere departementen met betrekking tot de Noordzee actief bij het besluitvormingsproces van het projectbesluit. Bestuurders van deze partners worden bij elke formele zienswijze periode op de hoogte gehouden van de voortgang in een op te richten Bestuurlijk Overleg (BO), geïnitieerd door EZK.

Op 15 november 2022 heeft het eerste coördinatieoverleg vergunningen plaatsgevonden. Dit is een tweemaandelijks overleg met alle bevoegde gezagen in het kader de vergunningen onder de Rijkscoördinatieregeling (RCR).

c. Persoonlijke of geclusterde gesprekken
Wij hebben het project al eerder geïntroduceerd o.a. aan programma-managers, regioadviseurs, beleidsadviseurs en projectleiders van ministeries (EZK Wind, Landbouw, Natuur en Voedselkwaliteit (LNV), Rijksdienst voor het Cultureel Erfgoed (RCE) , Defensie, Binnenlandse Zaken en Koninkrijksrelaties (BZK), Infrastructuur en Waterstaat (IenW)), lokale gemeenten (Rotterdam, Brielle, Westvoorne), Provincie (Zuid-Holland), VRR, water(veiligheid)beheerders (Waterschap Hollandse Delta, RWS Zee & Delta, Kustwacht), omgevingsdiensten (DCMR, ODH), wegbeheerder (RWS WNZ), railbeheerder (ProRail), belangengroepen (Deltalinqs, KVNR, Element NL, Bellona, Nexstep, de Nederlandse Vissersbond, Stichting de Noordzee, Nederlands Loodswezen, H-vision, NWEA, Verontruste Burgers van Voorne), ngo's (Natuur & Milieu, Greenpeace, Milieufederatie Zuid-Holland), raakvlakprojecten (Porthos, Eneco), kabel- en pijpleiding eigenaren (TenneT, Stedin), offshore operators (o.a. Neptune Energy , Petrogas) en bedrijven op de Maasvlakte (Havenbedrijf Rotterdam, MOT, Euromax). Dit ambtelijke en persoonlijke contact zetten wij voort in deze komende fase.

Hieronder staat een overzicht met welke belanghebbenden en over welke onderwerpen wij spreken.

- Havenbedrijf Rotterdam: de aanlanding, uitwerking verschillende tracés en locatie alternatieven en varianten in het havengebied;
- Provincie Zuid-Holland: de ruimtelijke kwaliteit (o.a. openheid en natuur) van het gebied in relatie tot het tracé en locatiealternatieven en -varianten, vergunningen;
- RWS Zee & Delta en Kustwacht: nautische veiligheid, het kruisen van scheepvaartroutes, de tracering en locatie alternatieven en varianten, vergunningen op zee;
- RWS WNZ: uitwerking van tracé- en locatiealternatieven en varianten bij kruising van waterkeringen, hoofdwatergangen, aandachtspunten van diverse uitvoeringsmethodes en vergunningen;
- Waterschap Hollandse Delta, DCMR en ODH: benodigde water vergunningen, vergunningen in het kader van de wet algemene bepalingen omgevingsrecht en natuurvergunningen en ontheffingen;
- Gemeente Rotterdam: voor de benodigde vergunningenoverzicht en rol van bevoegde gezag en invloed op CCS op de energietransitie;
- TenneT, Stedin: raakvlakken projecten en invloeden van tracé- en locatiekeuzes, met name bij de kruising van de waterkering (TenneT) en energievoorziening en beschikbare ruimte in de Leidingenstrook (Stedin);
- Eneco: raakvlakken en veiligheidsrisico's van windmolens op de Maasvlakte;

- MOT, ECT Rotterdam, Euromax: impact op 24/h bedrijfsvoering en overlast (geluid, trillingen);
- Ministeries: raakvlakken (toekomstige) windparken op de Noordzee zoals Lagelander, impact op het milieu en visserij, raakvlakken (toekomstige) zandwinningsgebieden, gebieden van hoge cultuur-historische waarde en vergunningen;
- Wij informeren de bij ons bekende maatschappelijke organisaties (Milieufederatie Zuid-Holland, Natuur & Milieu, Greenpeace, Milieudefensie en Stichting de Noordzee) rechtstreeks over het project en de procedures. In de studies die we uitvoeren voor de vergunningen en het milieueffectrapport (MER) besteden we nadrukkelijk aandacht aan milieu, natuur en andere belangrijke maatschappelijke waarden. Daarnaast onderzoeken we met Stichting de Noordzee, Natuur & Milieu, het Koninklijk Nederlands Instituut voor Onderzoek der Zee, de Wageningen University & Research en het Nederlandse Organisatie voor Wetenschappelijk Onderzoek of we het project Aramis natuurversterkend kunnen aanleggen;
- Porthos: afstemming omgevingsmanagement en aansluiting op Porthos;
- Commissie MER: afstemming en advies voor concept NRD en MER;
- ProRail: impact op kruising van en werken nabij het spoor (veiligheid en bedrijfsvoering);
- Veiligheidsregio's: veiligheidsrisico's in het havengebied en de nabije omgeving (toegangswegen);
- Het Aramis initiatief is meermalen aangeschoven bij het Noordzeeoverleg (NZO). De NZO-leden zijn: de ministeries (Infrastructuur en Waterstaat, Economische Zaken en Klimaat, en Landbouw, Natuur en Voedselkwaliteit), Energiesector (Nederlandse Wind Energie Associatie, TenneT, Element NL, Energie Beheer Nederland), Zeevaartsector (Branche Organisatie Zeehavens, Koninklijke Vereniging Nederlandse Rederijen, Havenmeesters), natuur en milieuorganisaties (WNF Nederland, Greenpeace (geen permanent lid), Stichting De Noordzee, Vogelbescherming Nederland, Natuur & Milieu) en Voedsel&Visserij (NetVisWerk en Producentenorganisaties Urk & Delta Zuid). Het project Aramis informeert regelmatig over de stand van zaken tijdens dit NZO-overleg. Aanwezigen van dit overleg wordt gevraagd om input te leveren vanuit hun organisatie, bijv. over scheepvaartbelemmering op zee of kruising Maasgeul, gevoelige infrastructuur op de zeebodem, raakvlak (toekomstige) windmolenparken, impact op natuur, onderwater geluid, etc.);
- NEa (Nederlandse Emissieautoriteit): onafhankelijke autoriteit voor toezicht op de uitstoot van broeikasgassen;
- Er is een gezamenlijke bijeenkomst geweest waarin het project Aramis gepresenteerd werd aan alle operators en waar operators kenbaar konden maken of men wilde aansluiten, en zo ja, wanneer. Met operators met concrete belangstelling en betrokkenheid zijn er individuele overleggen gevoerd;
- Eind 2021 is door CO_2next een Open Season proces gestart. Het primaire doel van het Open Season was het verkrijgen van een beter inzicht in het marktpotentieel. Dit is mede van belang voor de vergunningaanvraag waarin de eindsituatie dient te worden omschreven. Bovendien is waardevolle informatie verzameld voor het verdere engineering proces zodat al vroegtijdig kan worden nagedacht over bijvoorbeeld tie-in point en over-dimensionering. Een secundair doel van het Open Season proces was om te voldoen aan de criteria voor Open Access en Non-discriminatory Access. Hierdoor wordt gerechtvaardigd dat er een of enkele launching customers zijn.

In een intensieve samenwerking en onder speciale voorwaarden kan met deze launching customers de keten worden opgezet. In een volgende fase zouden andere partijen dan onder de dan geldende voorwaarden kunnen aansluiten.

d. Schriftelijke reactie op de plannen geven
Iedereen heeft in 2022 de mogelijkheid gehad een schriftelijke reactie te geven op de concept NRD (een zienswijze indienen). Er zijn acht zienswijzen ingediend. Al deze zienswijzen zijn gebundeld (zienswijzebundel) en in de nota van antwoord is een toelichting gegeven of en hoe deze zijn meegenomen bij het opstellen van de definitieve NRD of in het verdere proces.

Het Aramis initiatief heeft advies aan de commissie MER op de concept NRD gevraagd. Dit advies is op de site van de commissie op 18 augustus 2022 gepubliceerd. Het ministerie van EZK heeft op basis van de ingekomen zienswijzen en het advies van de commissie MER de definitieve NRD vastgesteld en gepubliceerd op 2 december 2022.

RAPPORT

Natuurtoets Aramis CCS soortenbescherming

Natuurtoets in het kader van de Omgevingswet

Klant: Aramis

Referentie: ARM-PFE-B10-ENV-EIA-2005

Status: Definitief/1

Datum: 9 februari 2024

ARAMIS	**CCS-ARAMIS Project**
	Environment Impact Assessment – Baseline report
	Document No. ARM-PFE-B10-ENV-EIA-2005 Document title Nature report species Revision Final 4.0

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Enhancing Society Together

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Sub titel: Natuurtoets in het kader van de Omgevingswet
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Projectnummer: BH8744

Classificatie

Projectgerelateerd

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Afkortingenlijst

ADD	Acoustic Deterrent Device
Bal	Besluit Activiteiten Leefomgeving
CCS	Carbon Capture and Storage
EEZ	Exclusieve Economische Zone
HbR	Havenbedrijf Rotterdam
HSD	Hydro Sound Damper
MER	Milieueffectrapportage
MMO	Marine Mammal Observer
MOT	Maasvlakte Olie Terminal
NCP	Nederlands Continentaal Plat
NDFF	Nationale Databank Flora en Fauna
Ow	Omgevingswet
PAM	Passive Acoustic Monitoring
PTS	Permanent Threshold Shift
TTS	Temporary Threshold Shift
Wnb	Wet natuurbescherming

1. Inleiding

Voor u ligt het detailrapport soortenbescherming, onderdeel van het het MER voor het Aramis initiatief.

Dit detailrapport heeft betrekking op soortenbescherming. Hierbij zijn de mogelijke effecten op onder de Omgevingswet beschermde soorten beschreven. Het rapport dient tevens als onderlegger voor de vergunningaanvraag.

De effecten op onder de Omgevingswet beschermde Natura 2000-gebieden zijn in een andere rapportage beschreven, te lezen in detailrapport gebiedsbescherming.

Dit detailrapport bevat een gedetailleerde beschrijving en beoordeling van de effecten in de aanleg- en gebruiksfase van alle onderdelen van het Aramis initiatief, en een globale beschrijving en beoordeling van de effecten van onderdelen die niet tot het Aramis initiatief behoren, maar wel tot de CCS-keten.

1.1 Korte introductie van het Aramis initiatief

Integrale Aramis CCS-keten

Om de klimaatdoelstellingen te behalen, is er behoefte aan additionele transportinfrastructuur voor CO_2, waarmee meerdere opslaglocaties op zee worden ontsloten voor verschillende industriële emissiebronnen. Het Aramis initiatief speelt in op die behoefte door een nieuwe integrale en open CCS-keten mogelijk te maken. Het Aramis initiatief vormt een onderdeel van deze CCS-keten en bestaat uit de aanleg en exploitatie van een open CO_2-transportinfrastructuur. Het Aramis initiatief wordt in de rapportage dan ook wel aangeduid als Aramis CO_2-transportinfrastructuur. Samen met de afvanginfrastructuur en opslaginfrastructuur vormt dit de integrale CCS keten met onderstaande samenhangende onderdelen (zie Figuur 1-1).

CO_2-afvanginfrastructuur

1. CO_2-afvang bij industrie, en geschikt maken voor transport.
2. CO_2-transport naar het verzamelpunt op de Maasvlakte, middels de Porthos landleiding of per schip.

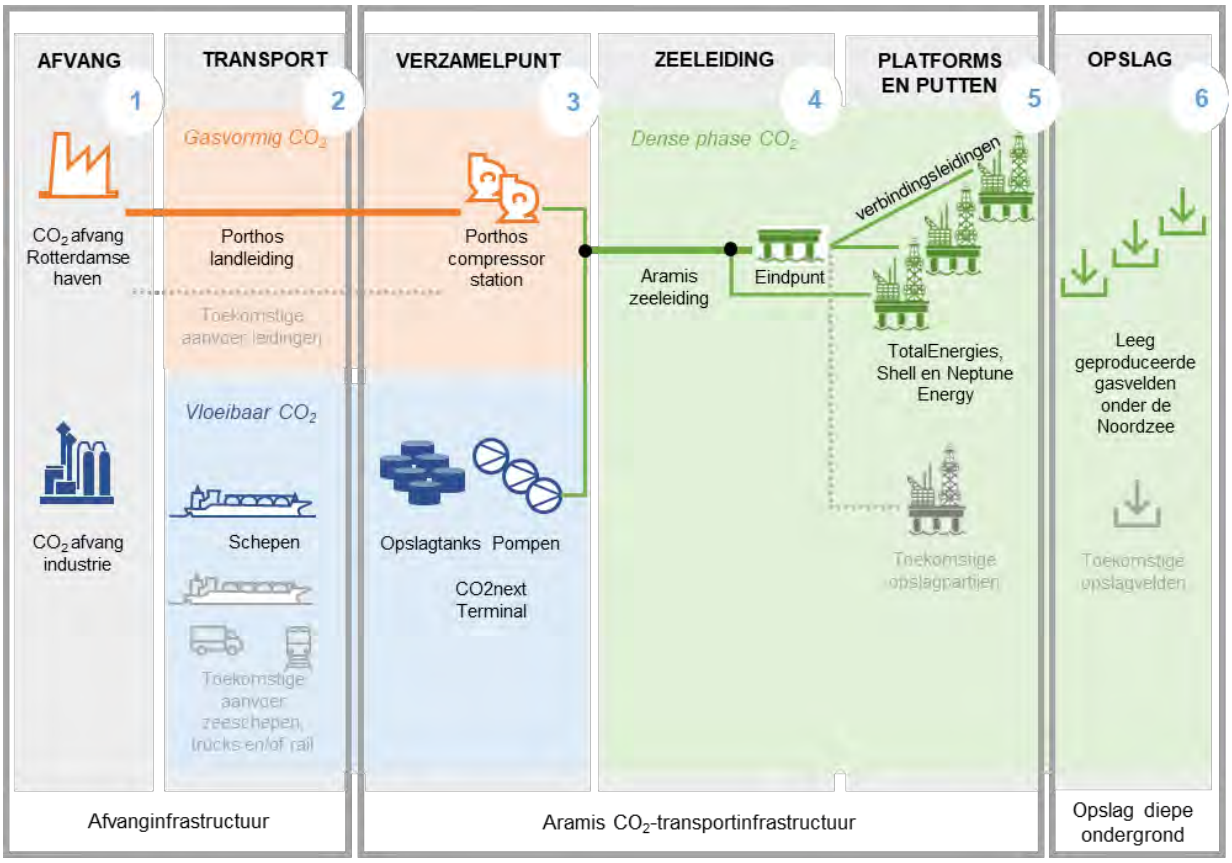
CO_2-transportinfrastructuur (Aramis initiatief)

3. CO_2-verzamelpunt op de Maasvlakte met een compressorstation en een terminal.
   - Het compressorstation ontvangt gasvormig CO_2 dat aangevoerd wordt per landleiding (via de Porthos-landleiding) en brengt het op druk voor het transport per zeeleiding.
   - De terminal ontvangt vloeibaar CO_2 aangevoerd per schip. De terminal locatie bevat steigers, opslagtanks voor tijdelijke opslag van CO_2 en hogedrukpompen voor levering aan de zeeleiding. CO_2 uit het compressorstation en vanaf de terminal komen samen in de CO_2-zeeleiding.
4. CO_2-transport door de centrale CO_2-zeeleiding naar het distributieplatform op de Noordzee. Dit platform is uitgerust met een verdeelstation voor toevoer van CO_2 naar de verschillende platforms. Er zijn tevens connectiepunten in de zeeleing waar vandaan CO_2 aan platforms geleverd kan worden.
5. CO_2-injectie: via verbindingsleidingen komt de CO_2 vanaf de zeeleiding bij injectieplatform. Middels putten bij deze platforms wordt CO_2 geïnjecteerd in leeg geproduceerde gasvelden in de diepe ondergrond van de Noordzee.

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CO_2-opslag diepe ondergrond

6 CO_2-opslag: permanente CO_2 opslag in de diepe ondergrond.



Figuur 1-1. Overzicht van de integrale CCS-keten met daarin de componenten die onderdeel zijn van de voorgenomen activiteit, namelijk: transport per schip, terminal CO2next, uitbreiding compressorstation Porthos, zeeleiding met eindpunt en connectiepunten, aansluitleidingen en platforms.

Het Aramis initiatief

Het Aramis initiatief heeft als doel het verzamelpunt (onderdeel 3), de zeeleiding (onderdeel 4) en de injectie (onderdeel 5) te realiseren. Hiervoor wordt door het Aramis consortium (bestaande uit Shell, TotalEnergies, Gasunie en EBN) samengewerkt met CO2next (voor de terminal) en Porthos (voor het compressorstation). De opslag vindt plaats vanaf de platforms van Shell, TotalEnergies en Neptune Energy.

De afvang (onderdeel 1) en transport van CO_2 naar het verzamelpunt (onderdeel 2) vallen buiten het Aramis initiatief[1]. In het MER worden deze aspecten wel benoemd en op hoofdlijnen beschreven, omdat ze integraal onderdeel uitmaken van de integrale Aramis CCS keten.

De opslag in de diepe ondergrond (onderdeel 6) valt eveneens buiten het initiatief. Voor de diepe ondergrond gelden geen milieuregels. De mogelijke gevolgen van opslag in de diepe ondergrond wordt echter wel apart beschreven in het MER middels de deelrapporten opslag diepe ondergrond.

Bij de aanleg van Aramis wordt rekening gehouden met toekomstige uitbreiding met meer leveranciers van CO_2 en meer opslagpartijen. In eerste instantie wordt vergunning aangevraagd voor een startsituatie

[1] *Een deel van de schepen die CO_2 leveren aan de terminal is afkomstig van Aramis-initiatiefnemers.*

en de eerste uitbreidingssituatie. Dit wordt in het MER getoetst. Toekomstige initiatieven *na* de eerste uitbreidingssituatie behoren niet tot de vergunningaanvraag maar worden in het MER wel (globaal) beschreven.

De ingebruikname verwachten de Aramis initiatiefnemers in 2028, waarbij tegelijk al de eerste activiteiten zoals beschreven in de eerste uitbreidingsituatie kunnen starten. Voor het bereiken van de maximale doorvoercapaciteit is enkele jaren later als uitgangspunt in het MER aangehouden.

Het voorkeursalternatief (VKA) voor de onderdelen van het Aramis initiatief staat weergeven in Tabel 1-1. Op basis van het VKA zijn effecten op beschermde flora en fauna beoordeeld. Het VKA is dan ook leidend voor de effectbeoordeling.

Tabel 1-1. Alternatieven voor ketenonderdelen van het Aramis initiatief.

Ketenonderdeel	Voorgenomen activiteit (voorkeursalternatief)	Alternatieven
Locatie van de terminal	Op het MOT-terrein, ten zuidoosten van de meest oostelijke opslagtanks voor aardolie.	Op het GATE Tank 5 terrein ten noordoosten van de Yukonhaven.
Kruising Maasgeul	Tunnel vanaf Haaievin bij Edisonbaai.	Direct pipe-techniek nabij de kruising met de Porthos-zeeleiding.
Tracé van de zeeleiding	Westelijke route 2 langs K14-platform.	Westelijke route 1.
		Centrale route.
Type eindpunt op zee	Platform installatie als eindpunt.	Eindpunt op de zeebodem.

Een uitgebreide beschrijving van het Aramis initiatief is opgenomen in het deelrapport technische beschrijving en het hoofdrapport MER.

Voor de realisatie van de Aramis CO_2-infrastructuur zijn meerdere vergunningen nodig. Bij een deel van de vergunningen geldt een m.e.r.-plicht, wat inhoudt dat een milieueffectrapportage opgesteld moet worden ter onderbouwing van de vergunningsaanvragen. Voor het verkrijgen van deze vergunningen is een project-MER nodig. Tevens zal voor de aanleg van de Aramis CO_2-infrastructuur het huidige bestemmingsplan gewijzigd moeten worden. Hiervoor is een besluit over de planologische inpassing nodig. Dit besluit is tevens m.e.r.-plichtig, middels een Plan-MER. Het Plan-MER is in deze gecombineerd met het Project-MER. Het plan kan alleen worden vastgesteld, als gedeputeerde staten voor het project een vergunning kan verlenen. Dit is alleen mogelijk indien uit de Soortentoets de zekerheid is verkregen dat het plan, onderscheidenlijk het project, de gunstige staat van instandhouding van beschermde flora en fauna niet zal aantasten. Om deze onderzoeksvraag te beantwoorden is onderhavige Soortentoets opgesteld.

1.2 Fasering en uitbreidingsmogelijkheden

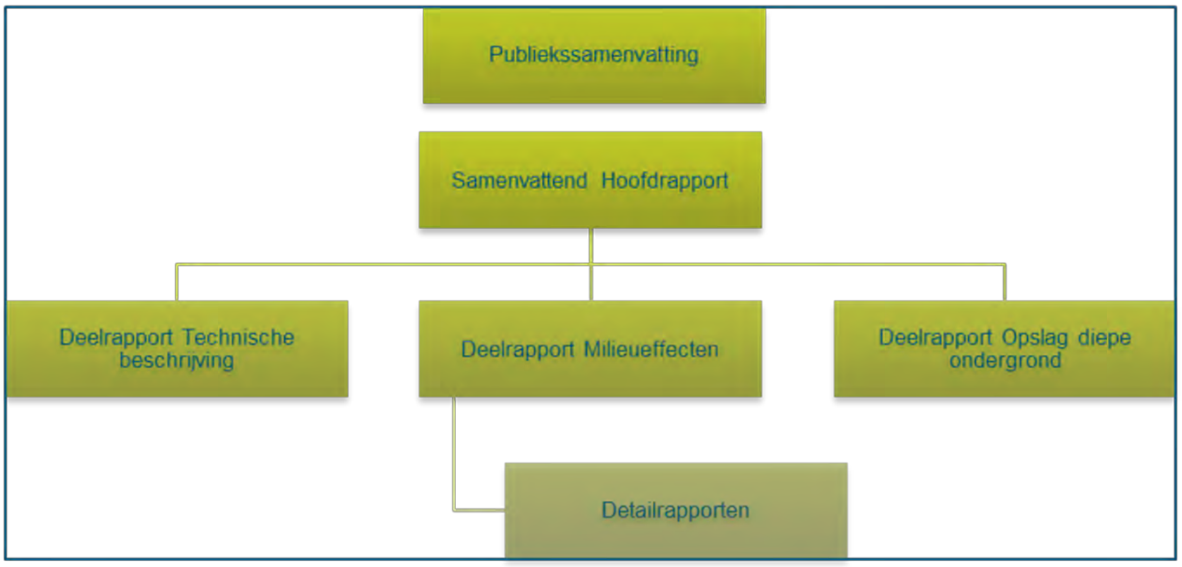
De CCS-keten wordt stapsgewijs uitgebreid. In het MER zijn drie fases onderscheiden: startsituatie, eerste uitbreidingssituatie en eindsituatie. De capaciteit per fase is gegeven in Tabel 1-2.

Tabel 1-2. Capaciteit per fase.

Fase	Capaciteit (Mton CO_2 per jaar)	Toelichting
Startsituatie	5	Deze capaciteit is gebaseerd op de huidige vraag van CO_2-leveranciers naar opslagcapaciteit.
Eerste uitbreidingssituatie	14	Deze waarde is gebaseerd op een verwachte groei van de vraag naar CO_2-transportcapaciteit binnen enkele jaren na de startsituatie.
Eindsituatie	22	Deze waarde is gebaseerd op een verwachte maximale vraag naar CO_2-transportcapaciteit voor opslag van CO_2 in leeggeproduceerde gasvelden op zee.

1.3 Opbouw van het MER en dit detailrapport

Voor het Aramis initiatief is een MER opgesteld. Figuur 1-2 geeft de rapportagestructuur van het MER Aramis. Het MER bestaat uit een Samenvattend Hoofdrapport, voorzien van een Publiekssamenvatting. Ter onderbouwing van het Samenvattend Hoofdrapport zijn deelrapporten opgesteld. Dit betreft het deelrapport Technische beschrijving van Aramis, het deelrapport Milieueffecten met daarbij de onderliggende technische detailstudies en de deelrapporten Opslag diepe ondergrond. Doordat CO_2 in meerdere geologische voorkomens wordt opgeslagen, zijn er voor de opslag diepe ondergrond meerdere deelrapporten opgesteld. Het voorliggende rapport is het detailrapport Soortenbescherming. De bevindingen uit dit detailrapport zijn opgenomen in het Deelrapport Milieueffecten, en op hoofdlijnen in het Samenvattend Hoofdrapport.



Figuur 1-2. Overzicht rapportagestructuur MER Aramis.

Opbouw van dit detailrapport

In hoofdstuk 2 is het wettelijke kader opgenomen. Vervolgens is in hoofdstuk 3 de onderzoeks- en beoordelingsmethodiek beschreven. In hoofdstuk 4 is de fasering van het project kort toegelicht, ook is het plangebied beschreven. In hoofdstuk 5 is per soortgroep beschreven welke beschermde of bedreigde soorten in of nabij het plangebied voorkomen of verwacht kunnen worden. In hoofdstuk 6 zijn de voorzorgs- en mitigerende maatregelen voor de voorkomende soorten uitgewerkt. In hoofdstuk 7 wordt een samenvatting van de bevindingen gegeven en wordt er getoetst aan wet- en regelgeving voor soortenbescherming.

2. Wettelijk & ruimtelijk natuurbeschermingskader

In Nederland wordt voor behoud en herstel van biodiversiteit de natuur via twee sporen beschermd, namelijk het wettelijk spoor en het planologisch spoor geregeld in de Wet op de Ruimtelijke Ordening. In de wetgeving zijn de Europese habitat- en vogelrichtlijnen geïmplementeerd. Dit omvat de soortenbescherming van inheemse flora en fauna en specifiek gebiedsbescherming van Natura 2000-gebieden. Daarnaast is bescherming van overige nationaal beschermde soorten en houtopstanden in het buitengebied wettelijk geregeld.

Bescherming van natuurgebieden en andere specifieke gebieden met bijzondere natuurwaarden zoals weidevogelleefgebieden in agrarisch gebied is planologisch vastgelegd in nationaal, provinciaal en gemeentelijk niveau in omgevingsverordeningen en/of omgevingsplan. De planologische bescherming van gebieden heeft ruimtelijk gezien overlap met de wettelijk beschermde natuurwaarden.

Natuurwaarden en biologische diversiteit zijn per 1 januari 2024 beschermd via de Omgevingswet. In deze wet worden alle wetten voor de leefomgeving opgenomen, waaronder de Wet natuurbescherming (Wnb) en Wet op de Ruimtelijke Ordening (RO) waarin de planologische bescherming van natuur is geregeld.

Dit rapport geeft een algemene indruk van het plangebied en de daar mogelijk voorkomende onder de Omgevingswet beschermde soorten. Het doel van het rapport is een QuickScan Soortenbescherming. Uit de QuickScan volgt of er in het kader van soortenbescherming vervolgstappen zoals het uitvoeren van een aanvullend onderzoek en een aanvraag van een omgevingsvergunning noodzakelijk zijn.

2.1 Wettelijke bescherming natuur

De Wnb (vigerend 2017-2023) en bijbehorende wetsartikelen zijn als algemene rijksregels opgenomen in het Besluit activiteiten leefomgeving (Bal) van de omgevingswet (vigerend per 1 januari 2024). De werking van de Wnb ten aanzien van natuur wijzigt hierdoor niet.

De omgevingswet omvat rijksregels die de volgende algemene doelen hebben:

- het beschermen en ontwikkelen van de natuur;
- het behouden en herstellen van biologische diversiteit;
- het doelmatig beheren, gebruiken en ontwikkelen van de natuur en het verzekeren van een samenhangend beleid gericht op het behoud en beheer van waardevolle landschappen.

Deze algemene doelenbepaling beoogt actieve soortenbescherming anders dan de vorm van passieve soortenbescherming via de verbodsbepalingen gericht op een nalaten. De opdracht aan bestuursorganen is om actief beleid te voeren teneinde een gunstige staat van instandhouding van de soorten te bereiken. Deze verplichting om aan actieve soortenbescherming te doen, vloeit voort uit de Vogel- en Habitatrichtlijn.

De zorgplicht van het Wnb is in het Bal nader geconcretiseerd in een specifieke zorgplicht voor Natura 2000 (art. 11.6) en inheemse soorten (art. 11.27).

Specifieke zorgplicht
(art. 11.6 Natura 2000-activiteit; art 11.27 Flora en fauna activiteit)
1) Degene die een *Natura 2000 of flora en fauna activiteit* verricht en weet of redelijkerwijs kan vermoeden dat die activiteit nadelige gevolgen kan hebben voor het belang, is verplicht:
a) alle maatregelen te nemen die redelijkerwijs van diegene kunnen worden gevraagd om die gevolgen te voorkomen;
b) voor zover die gevolgen niet kunnen worden voorkomen: die gevolgen zoveel mogelijk te beperken of ongedaan te maken; en
c) als die gevolgen onvoldoende kunnen worden beperkt: die activiteit achterwege te laten voor zover dat redelijkerwijs van diegene kan worden gevraagd.

De Omgevingswet en bijbehorende Bal regelt activiteiten die met natuur te maken hebben. Deze natuuractiviteiten gaan over dieren en planten in het wild en gebieden waarin ze leven. In het Bal zijn drie beschermingstypen met een eigen toetsingskader te onderscheiden:

- Natura 2000-gebieden;
- Flora en fauna (inheems);
- Houtopstanden (buiten de bebouwde kom).

In deze rapportage wordt getoetst aan het toetsingskader voor flora en fauna.

Het bevoegd gezag, voor het al dan niet verlenen van vergunningen en/of vrijstellingen, is de provincie of de rijksoverheid. Bij wie de bevoegdheid ligt is vastgelegd in het Besluit natuurbescherming artikel 1.3. De rijksoverheid blijft het bevoegd gezag voor onder andere de rijks- en spoorwegen, grote wateren en defensieterreinen. Voor dit project is de minister van LNV het bevoegd gezag.

2.2 Toetsingskader Flora en fauna

De kern van de bescherming van inheemse soorten is dat de gunstige 'staat van instandhouding' van in het wild levende planten- en diersoorten wordt beschermd en behouden. Deze bescherming volgt ook direct uit de Europese Habitat- en Vogelrichtlijn die verder met soorten is aangevuld met voor Nederland bijzondere en bedreigde soorten. Een activiteit mag geen blijvende negatieve invloed hebben op de staat van instandhouding van soorten (SvI). Dat houdt in dat de soort ook op langere termijn kan blijven bestaan. Het effect is afhankelijk van de omvang van het project en moet beoordeeld worden op lokaal, regionaal en/of landelijk niveau.

Anders dan bij de gebiedsbescherming is bij inheemse flora en fauna het leefgebied beschermd. Dat kan overal zijn en is niet strikt verbonden aan een natuurgebied.

Rijksregels

De bescherming van inheemse soorten was tot 1 januari 2024 in de Wet natuurbescherming (hoofdstuk 3) geregeld en is nu geregeld in Bal § 11.2. Het beschermingsregime van soorten en verbodsbepalingen is hierdoor niet gewijzigd (Tabel 2-1).

Voor de inheemse soorten gelden verschillende beschermingsregimes. Deze zijn:

- Vogelrichtlijnsoorten — Ow Bal § 11.2.2 (voorheen Wnb § 3.1 Wnb)
- Habitatrichtlijnsoorten — Ow Bal § 11.2.3 (voorheen Wnb § 3.2 Wnb)
- Andere soorten — Ow Bal § 11.2.4 (voorheen Wnb § 3.3 Wnb)

De bescherming van Vogel- en Habitatrichtlijnsoorten kent een zwaardere bescherming dan de andere soorten die van nationaal belang zijn. De andere soorten betreffen soorten die van nationaal belang zijn en onder druk staan (o.a. Rode lijst). Voor de inheemse soorten die niet in de bijlagen van de Omgevingswet zijn opgenomen geldt de specifieke zorgplicht (Ow Bal § 11.27).

Tabel 2-1. Soortenbescherming: overzicht verbodsartikelen Wet natuurbescherming (Wnb), wordt vervangen door Omgevingswet met Besluit activiteiten leefomgeving (Ow Bal). HR: Habitatrichtlijn. VR: Vogelrichtlijn. N.v.t.: Niet van toepassing.

Verbodsbepalingen Vogelrichtlijn Ow Bal art.11.37	Verbodsbepalingen Habitatrichtlijn Ow Bal art.11.46	Verbodsbepalingen Andere soorten Ow Bal art. 11.54
Bal art. 11.37 1a. Het is verboden opzettelijk van nature in Nederland in het wild levende vogels van soorten als bedoeld in artikel 1 van de Vogelrichtlijn te doden of te vangen.	**Bal art 11.46 1a** Het is verboden in het wild levende dieren HR IV soorten (Verdrag Bern en Bonn) in hun natuurlijk verspreidingsgebied opzettelijk te doden of te vangen.	**Bal art. 11.54 1a** Onverminderd artikel 3.5, eerste, vierde en vijfde lid, is het verboden in het wild levende dieren, genoemd in Wnb bijlage A/Bal bijlage IX onder A, opzettelijk te doden of te vangen.
Bal art. 11.37 1b Het is verboden opzettelijk nesten, rustplaatsen en eieren van vogels als bedoeld in het eerste lid te vernielen of te beschadigen, of nesten van vogels weg te nemen.	**Bal art 11.46 1d** Het is verboden de voortplantingsplaatsen of rustplaatsen van dieren als bedoeld in het eerste lid te beschadigen of te vernielen.	**Bal art. 11.54 1b** Onverminderd artikel 3.5, eerste, vierde en vijfde lid, is het verboden de vaste voortplantingsplaatsen of rustplaatsen opzettelijk te beschadigen of te vernielen.

Verbodsbepalingen Vogelrichtlijn Ow Bal art.11.37	Verbodsbepalingen Habitatrichtlijn Ow Bal art.11.46	Verbodsbepalingen Andere soorten Ow Bal art. 11.54
Bal art. 11.37 1c Het is verboden eieren van vogels als bedoeld in het eerste lid te rapen en deze onder zich te hebben.	**Bal art. 11.46 1c** Het is verboden eieren van dieren als bedoeld in het eerste lid in de natuur opzettelijk te vernielen of te rapen.	N.v.t.
Bal art. 11.37 1d Het is verboden vogels als bedoeld in het eerste lid opzettelijk te storen. **Bal art. 11.37 3** Het verbod geldt niet als de storing niet van wezenlijke invloed is op de staat van instandhouding van de desbetreffende vogelsoort.	**Bal art 11.46 1b** Het is verboden dieren als bedoeld in het eerste lid opzettelijk te verstoren.	N.v.t.
N.v.t.	**Bal art. 11.46 1e**. Het is verboden planten HR (en Verdrag van Bern) in hun natuurlijke verspreidingsgebied opzettelijk te plukken en te verzamelen, af te snijden, te ontwortelen of te vernielen.	**Bal art. 11.54 1c** Onverminderd artikel 3.5, eerste, vierde en vijfde lid, is het verboden vaatplanten genoemd in Wnb bijlage B/ Bal bijlage IX onder B, in hun natuurlijke verspreidingsgebied opzettelijk te plukken en te verzamelen, af te snijden, te ontwortelen of te vernielen.

Toelichting bescherming broedvogels en jaarrond beschermde vogels (11.37 lid 1b Bal)

Via de Europese vogelrichtlijn zijn alle Europese wilde vogels door de wet zelfs uitdrukkelijk als beschermde diersoort aangewezen. Strenge bescherming geldt voor:

- Broedvogels;
- Jaarrond beschermde vogels.

Het verstoren van broedende vogels en hun nesten tijdens de broedtijd is verboden, tenzij de storing niet van wezenlijke invloed is op de staat van instandhouding van de vogelsoort.

Nesten of holten die ieder jaar opnieuw gebruikt worden of ook buiten het seizoen van belang zijn voor de instandhouding van de soort, vallen ook buiten het broedseizoen onder de definitie van ‘vaste rust- of verblijfplaatsen’. Deze nesten zijn jaarrond beschermd tenzij ze permanent verlaten zijn. In 2009 heeft Dienst Regelingen een aangepaste lijst jaarrond beschermde vogelnesten gepubliceerd met onderverdeling in vijf categorieën. Deze categorieën zijn in onderstaand kader toegelicht.

Vogelnesten die het gehele jaar door zijn beschermd

Op de volgende categorieën gelden de verbodsbepalingen van artikel 11.37 lid 1b Bal het *gehele* jaar:

1. Nesten die, behalve gedurende het broedseizoen als nest, buiten het broedseizoen in gebruik zijn als vaste rust- en verblijfplaats (voorbeeld: steenuil).
2. Nesten van koloniebroeders die elk broedseizoen op dezelfde plaats broeden en die daarin zeer honkvast zijn of afhankelijk van bebouwing of biotoop. De (fysieke) voorwaarden voor de nestplaats zijn vaak zeer specifiek en limitatief beschikbaar (voorbeeld: roek, gierzwaluw en huismus).
3. Nesten van vogels, zijnde geen koloniebroeders, die elk broedseizoen op dezelfde plaats broeden en die daarin zeer honkvast zijn of afhankelijk van bebouwing. De (fysieke) voorwaarden voor de nestplaats zijn vaak zeer specifiek en limitatief beschikbaar (voorbeeld: ooievaar, kerkuil en slechtvalk).
4. Vogels die jaar in jaar uit gebruik maken van hetzelfde nest en die zelf niet of nauwelijks in staat zijn een nest te bouwen (voorbeeld: boomvalk, buizerd en ransuil).
5. Nesten die niet jaarrond beschermd vanwege voldoende flexibiliteit, tenzij er sprake is van zwaarwegende feiten of ecologische omstandigheden, die jaarronde bescherming van de nesten eisen.

Bron: DLG 2009. Landelijke lijst. Provincies kunnen deze lijst aangepast hebben gebaseerd op provinciale omstandigheden.

Vrijstellingsmogelijkheden 'andere soorten'

Voor de 'andere soorten' van artikel art. 11.54 Bal kunnen provincies en het ministerie van LNV een algemene vrijstelling van de ontheffingsplicht vaststellen middels een verordening. De provincie is doorgaans het bevoegd gezag voor het al dan niet verlenen van vergunningen. Wanneer het ruimtelijke ingrepen betreft waarmee grote nationale belangen zijn gemoeid, is het rijk in de vorm van de minister voor Natuur en Stikstof bevoegd gezag en gelden de nationale regels. Het bevoegd gezag voor dit project is de minister voor Natuur en Stikstof. In Tabel 2-2 zijn de door LNV vrijgestelde soorten weergegeven.

Tabel 2-2. Overzicht van de soorten met een algemene vrijstelling

Vrijgestelde soorten Minister van LNV	
Aardmuis	Hermelijn
Bastaardkikker	Huisspitsmuis
Bosmuis	Kleine watersalamander
Bruine kikker	Konijn
Bunzing	Meerkikker
Dwergmuis	Ree
Dwergspitsmuis	Rosse woelmuis
Egel	Veldmuis
Gewone bosspitsmuis	Vos
Gewone pad	Hazelworm
Haas	

Toetsing van een activiteit aan flora en fauna

Om te kunnen beoordelen of een activiteit leidt tot overtreding van een verbodsbepaling, moet enerzijds de aanwezigheid van wettelijk beschermde soorten worden bepaald en moet anderzijds worden bepaald of de activiteit leidt tot overtreding van verbodsbepalingen en/of hierdoor de SvI van de soort in gevaar wordt gebracht (zie kader). Dit is eerst in de vorm van een Quickscan. In beginsel moet met voorzorgsmaatregelen ervoor worden gezorgd dat de functionaliteit van het leefgebied niet wordt aangetast en soorten niet worden verwond of gedood. Lukt dat niet, dan moeten mitigerende en/of compenserende maatregelen genomen worden en is een omgevingsvergunning nodig.

De Staat van Instandhouding van een soort wordt niet in gevaar gebracht wanneer:

- uit onderzoek blijkt dat de soort op de locatie kan blijven bestaan, ook op de lange termijn;
- het natuurlijk verspreidingsgebied van die soort niet kleiner wordt of snel kleiner gaat worden;
- het leefgebied groot genoeg is en zal blijven bestaan. Of als het op een alternatieve plek wordt ingericht. Zo blijven de populaties van de soort op lange termijn bestaan.

De beoordeling van de SvI van Europees beschermde soorten (VR en HR) vindt op plaatselijk en regionaal populatieniveau plaats. Voor de andere soorten gebeurt dit op landelijk niveau.

Uit de quickscan flora en fauna kan naar voren komen dat de activiteit leidt tot overtreding van verbodsbepalingen en/of dat er onvoldoende gegevens zijn en dat nader gericht veldonderzoek op basis van onderzoeksprotocollen nodig is. Vervolgens vindt opnieuw een effectbeoordeling plaats van de activiteit op basis van deze onderzoeksgegevens.

Voor het verkrijgen van een omgevingsvergunning worden de benodigde gegevens veelal vastgelegd in een projectplan (voorheen activiteitenplan). Het projectplan omvat onder meer de beschrijving en het belang van de activiteit, de soorten waarvoor een vergunning wordt aangevraagd, de onderzochte alternatieven, de mitigerende en/of compenserende maatregelen.

Omgevingsvergunning, gebiedsontheffing gedragscodes en belang

Voor soorten van de Vogelrichtlijn en Habitatrichtlijn kan alleen een omgevingsvergunning worden verleend op basis van de in deze richtlijnen genoemde belangen (bijvoorbeeld openbare veiligheid of dwingende reden van groot openbaar belang) en dat de staat van instandhouding van de soort niet in gevaar wordt gebracht.

In specifieke gevallen geldt een vrijstelling van ontheffingsplicht als ruimtelijke ontwikkelingen, beheer en onderhoudswerkzaamheden en bestendig beheer uitgevoerd worden volgens een goedgekeurde gedragscode. De specifieke zorgplicht (Ow Bal art. 11.27) blijft wel te allen tijde van toepassing.

Voor grotere gebieden en terugkerende activiteiten over een langere periode kan een gebiedsontheffing aangevraagd worden. Dit gebeurt onder meer op basis van een Soorten Management Plan (SMP) op basis waarvan de staat van instandhouding van soorten door het treffen van maatregelen minimaal behouden blijft alsook verbetert.

Omgevingsvergunning Havenbedrijf Rotterdam

Het havenbedrijf Rotterdam heeft het Managementplan beschermde soorten voor de omgang met beschermde flora en fauna in het havengebied, in het kader van ruimtelijke ontwikkeling, inrichting, bestendig gebruik, beheer en onderhoud[2]. Dit betreft een gebiedsgerichte ontheffing gebaseerd op de volgende goedkeuringsbesluiten:

- Goedkeuringsbesluit gedragscode (RVO/2020/61, geldig t/m 31 augustus 2025);
- Ontheffing (FF/75C/2013/0027, inclusief toegekende wijziging in mei 2017 met kenmerk FF/75c/2013/0027A, geldig t/m december 2023) op basis van het Managementplan beschermde soorten Havengebied Rotterdam 2015' en inclusief de toegekende wijziging april 2021 met kenmerk ODH-2021-00052289.

Dit managementplan heeft betrekking op beschermde soorten die voorkomen in het beheergebied van het havenbedrijf en bundelt alle voorwaarden van zowel de gedragscode voor bestendig gebruik, beheer en onderhoud, als die in de gebiedsontheffing waarin de bescherming van soorten bij ruimtelijke ontwikkeling of inrichting is geregeld.

Het managementplan van het havenbedrijf Rotterdam is eind vorig jaar verlopen, en is hierna weer met één jaar verlenging vergund tot en met 23 december 2024 (Omgevingsdienst Haaglanden, 2023). Het havenbedrijf Rotterdam heeft inmiddels een nieuwe gebiedsontheffing aangevraagd gebaseerd op een nieuw managementplan. Deze is gebaseerd op (vrijwel) dezelfde werkprotocollen als in het huidige managementplan. De aanvraag ligt momenteel ter goedkeuring bij het bevoegd gezag. De verwachting is dat de nieuwe gebiedsontheffing dit jaar wordt verleend met een geldigheid van tien jaar (Persoonlijke communicatie, Robbert Wolf, Adviseur Natuur & Milieu Havenbedrijf Rotterdam N.Z., 29-01-2024). Het uitgangspunt in deze beoordeling is dat er bij Aramis gewerkt kan worden onder de aanstaande gebiedsontheffing.

De type ruimtelijke ingrepen zoals beoogd voor het project Aramis, vallen onder "Activiteiten in het kader van ruimtelijke ontwikkeling of inrichting verbonden aan de gebiedsontheffing:

- Aanleggen van infrastructuur (kabels en leidingen, wegen, spoorlijnen);
- Realiseren van gebouwen, bouwwerken en installaties (waaronder ook kademuren).

Als eis vanuit de vrijstelling en ontheffing, is het nodig dat er ecologische werkprotocollen (werkbeschrijvingen) uit het managementplan worden gehanteerd voor de praktische uitvoering. In het geval van ruimtelijke ontwikkeling is het nodig om deze werkprotocollen per project apart in een beschrijving op te nemen, waarbij de locatiespecifieke omstandigheden en een kaart extra worden toegevoegd. Er moet altijd nog een kaart worden geraadpleegd wáár de beschermde soorten zich bevinden. Dit kan via de Havenscan, de Natuurwijzer van HbR via de online ArcGis kaart, of volgt uit een (aanvullend) veldbezoek of actuele onderzoeksrapportage.

[2] *Bureau Stadsnatuur, juli 2021.Managementplan beschermde soorten Havenbedrijf Rotterdam 2021. In opdracht van Port of Rotterdam.*

In geval van strikt beschermde soorten waarvoor de gebiedsontheffing van kracht is, dienen werkzaamheden altijd te worden uitgevoerd na goedkeuring van HbR en onder begeleiding van een erkende ecoloog. Hiervan dient verslag uitgebracht te worden in woord en beeld aan HbR, in verband met de periodieke evaluatie van het gebruik van de ontheffing.

Soorten van de Rode lijst & Provinciale aandachtsoorten (bedreigd -gevoelig- kwetsbaar)
In Nederland zijn nog diverse soorten en soortgroepen die bedreigd worden, en op de zogenaamde Rode lijst[3] staan, die niet actief beschermd worden door de natuurwet- en regelgeving. Een voorbeeld zijn de verschillende insectengroepen zoals bijen, sprinkhanen en krekels, haften en steenvliegen waarvan een groot deel bedreigd worden. Deze groepen zijn voor bestuiving van planten en als voedselvoorziening voor soorten hoger in de voedselpiramide van essentieel belang. De egel is een voorbeeld van een nog vrij algemene soort die qua verspreiding in de afgelopen tien jaar met 50% is gedaald door verstedelijking, versnippering en wijziging in landbouwkundig gebruik.

Om de negatieve trend in biodiversiteit te keren volgt uit de Omgevingswet dat er voor alle inheemse soorten waaronder soorten van de Rode Lijst of lokale aandachtsoorten een nadrukkelijke zorgplicht voor geldt. Provincies besteden extra aandacht voor regionale soorten (zoals aandachtsoorten) en gebieden en stellen subsidies beschikbaar. Vanuit de Europese Unie wordt gewerkt aan een Europese strategie voor biodiversiteit met een wetsvoorstel met bindende hersteldoelen.

De opgave voor biodiversiteitsherstel gaat verder dan de huidige wet- en regelgeving en is een actieve oproep om gezamenlijk het tij van daling in biodiversiteit te keren. Dit is in het onderstaande kader toegelicht.

Biodiversiteitsherstel
Op nationaal en provinciaal niveau wordt in de Nationale omgevingsvisie (2020) ingestoken op bescherming en versterking van biodiversiteit en duurzaam benutten van het natuurlijk kapitaal. Biodiversiteit en natuurlijk kapitaal moeten een integraal onderdeel zijn van visies op stedelijke en infrastructurele ontwikkelingen, klimaatadaptatie, waterbeheerplannen, omgevingsvisies (Natuurambitie NL/Natuurpositief 2019). Natuur moet niet alleen binnen natuurgebieden versterkt worden, maar overal. Dit betreft in steden, op het platteland en in de grote wateren (Nationale agenda natuurbeleid).

Diverse partijen onderschrijven de urgentie voor biodiversiteitsherstel en zijn partner van het Deltaplan Biodiversiteitsherstel (https://www.samenvoorbiodiversiteit.nl/). Royal HaskoningDHV is partner van het Deltaplan.

[3] Een Rode lijst is een overzicht van soorten die uit Nederland zijn verdwenen of dreigen te verdwijnen op basis van zeldzaamheid en/of negatieve trend. De lijst wordt periodiek vastgesteld door de Minister van Economische Zaken: zie https://minez.nederlandsesoorten.nl/soorten. De indeling is verdwenen, ernstig bedreigd, bedreigd, kwetsbaar, gevoelig.

3. Beschrijving onderzoeks- en beoordelingsmethodiek

Om na te gaan wat het belang is van het plangebied voor de wettelijk beschermde soorten die in of nabij het plangebied voorkomen, zijn de volgende stappen doorlopen:

3.1 Inventarisatie van beschermde soorten

Landdeel
Het landdeel betreft het in hoofdstuk 4 nader beschreven verzamelpunt op de Tweede Maasvlakte, waar aanlegsteigers voor schepen, opslagtanks en andere installaties als hogedrukpompen zullen worden gerealiseerd. Het voorkomen van soorten op dit landdeel is gebaseerd op verspreidingsgegevens van de Nationale Databank Flora en Fauna (NDFF) en informatie uit de database van de monitoring van Bureau Stadsnatuur. Op 3 januari 2023 zijn verspreidingsgegevens van beschermde soorten opgevraagd uit de NDFF voor het plangebied en enkele kilometers rondom het plangebied van de afgelopen tien jaar. Bureau Stadsnatuur heeft in het kader van het Managementplan beschermde soorten jaarlijks onderzocht op verschillende terreinen in het havengebied. Daarbij zijn ook de gegevens van het broedvogelmonitoringsprogramma opgenomen. Deze gegevens zijn geraadpleegd middels de Natuurwijzer (2023 update) van het havenbedrijf. Door deze verspreidingsgegevens te raadplegen, is inzicht verkregen in de aanwezige beschermde soorten in of in de directe omgeving van het plangebied. Op 17 januari en 16 februari 2023 is aanvullend op het voorgaande door twee ter zake kundige ecologen van RHDHV (een expert op het gebied van Natuurwetgeving en -beleid, en een marien ecoloog) een oriënterend veldbezoek aan het landdeel gebracht. Het terrein is al lopende onderzocht op het voorkomen van soorten en/of geschikte biotopen. Hierbij zijn het terrein waar de installaties gebouwd worden gecontroleerd, inclusief het dijklichaam en de achterliggende Maasgeul (visueel vanaf de dijk). Aan de hand van de verspreidingsgegevens en de veldbezoeken is beoordeeld voor welke beschermde soorten geschikt leefgebied aanwezig is in het plangebied.

Zeedeel
Op basis van literatuuronderzoek is het voorkomen van beschermde soorten in het zeedeel van het plangebied in kaart gebracht en zijn de effecten van de geplande activiteiten van het Aramis project op deze soorten bepaald. Op 16 februari 2023 is door twee ter zake kundige ecologen van RHDHV een aanvullend veldbezoek aan het landdeel gebracht, waarbij met name de focus lag op het waarnemen van zeehonden (zie Bijlage 1 voor de verslagen van de veldbezoeken). Ook is de Natuurwijzer (2023 update) geraadpleegd, waarin waarnemingen van zeehonden zijn geregistreerd voor het havengebied van Rotterdam.

Daarnaast is er in de periode van 11 juli 2022 t/m 24 januari 2023 onderzoek gedaan door Fugro naar vogelsoorten in het plangebied (Fugro, 2023). Resultaten uit dit onderzoek zijn gebruikt als onderbouwing van het wel of niet voorkomen van vogelsoorten in of nabij het plangebied op zee.

3.2 Effectbeoordeling soorten

Aan de hand van de verspreidingsgegevens is beoordeeld voor welke beschermde soorten er geschikt leefgebied aanwezig is in het plangebied. Door middel van een analyse van het project in relatie tot de biotoopeisen van de beschermde soorten uit het plangebied is beoordeeld welke negatieve effecten de voorgenomen werkzaamheden kunnen hebben op de mogelijk in het plangebied voorkomende beschermde soorten. Indien de onderzoeksresultaten voldoende zekerheid geven over het voorkomen van beschermde soorten, zijn de mogelijke (negatieve) effecten van de voorgenomen ingreep op deze soorten bepaald. De resultaten van het onderzoek zijn voor het landdeel en het zeedeel beschreven.

In deze stap is voor het landdeel ook gekeken in hoeverre het voornemen afbreuk doet aan de gestelde randvoorwaarden opgenomen in de bestaande ontheffingen (Wnb) van het Havenbedrijf Rotterdam N.V, samengevat in het document: Managementplan beschermde soorten Havenbedrijf Rotterdam 2021[4].

[4] *Bureau Stadsnatuur, juli 2021.Managementplan beschermde soorten Havenbedrijf Rotterdam 2021. In opdracht van Port of Rotterdam.*

3.3 Vervolgstappen

De conclusies uit het onderzoek zijn beschreven. Ook zijn de te nemen vervolgstappen beschreven, zoals het nemen van voorzorgs- of mitigerende maatregelen. Indien de aanwezigheid van beschermde soorten op basis van het onderzoek is aangetoond, is bepaald of overtredingen van verbodsbepalingen te verwachten zijn, en of een omgevingsvergunning in het kader van de Ow, noodzakelijk is.

4. Plangebied en afbakening Aramis initiatief

De eerste twee fasen vinden gedeeltelijk gelijktijdig plaats (Tabel 4-1). In de startsituatie worden twee aanlegsteigers aangelegd. De aanlegsteigers zijn ontworpen voor schepen met volumes variërend van 2.200 m^3 tot 12.000 m^3 en een maximale lengte van 165 m. Door de snelle ontwikkeling van vloeibare CO_2-tankers is het mogelijk dat in de toekomst schepen met een maximale lengte van 200 m worden ontwikkeld voor volumes van 18.000 tot 30.000 m^3. Afhankelijk van de ontwikkeling van dergelijk grote schepen zal in de eerste uitbreidingssituatie ofwel één extra grote aanlegsteiger worden aangelegd of zullen er twee extra aanlegsteigers komen voor schepen tot 150 m.

Voor de beoordeling wordt uitgegaan van twee aanlegsteigers. Hetzelfde geldt voor de pompen. Na de eerste uitbreiding is verdere uitbreiding tot de eindsituatie voorzien. Voor alle fases worden nu vergunningaanvragen voorbereid. Het MER beschrijft en toetst de effecten van de eerste twee fasen. In het deelrapport Technische Beschrijving zijn de aanleg en het gebruik van deze fasen expliciet beschreven. Voor de eindsituatie zullen te zijner tijd waar nodig vergunningen worden aangevraagd met aanvullend milieuonderzoek.

Tabel 4-1. Fasering uitbreiding CCS-keten.

Fase	Ketenonderdelen Aramis initiatief	Overige onderdelen CCS-keten	Capaciteit (Mton CO_2 per jaar)	Ingebruikname
Startsituatie	Transport per schip, terminal, compressorstation, zeeleiding en platforms TotalEnergies, Shell.	Afvang, transport Porthos-landleiding, opslag in diepe ondergrond.	5	2028
Eerste uitbreidingssituatie	Uitbreiding transport per schip, terminal en compressorstation, platforms Neptune Energy en mogelijk andere operators.	Aanvullende afvang en transport, uitbreiding opslaglocaties in diepe ondergrond.	14	2028 - 2032
Eindsituatie	Uitbreiding transport, terminal en compressorstation en platforms op zee tot maximale capaciteit van de zeeleiding.	Uitbreiding afvang en transport en aanvullende opslag in de diepe ondergrond en uitbreiding CO2Next.	22	Na 2028

In de startsituatie wordt de afgevangen CO_2 aangeleverd met binnenvaartschepen en de Porthos landleiding. Voor de opslag wordt gebruik gemaakt van de platforms van Shell en TotalEnergies. In de eerste uitbreidingssituatie vindt aanvullend transport naar het verzamelpunt plaats met extra schepen en met de Porthos landleiding en wordt het verzamelpunt uitgebreid met steigers, compressoren, pompen en opslagcapaciteit. Neptune Energy is als extra opslagpartij onderdeel van de eerste uitbreidingssituatie, waarbij de verwachting is dat ze gelijktijdig starten met de partijen in de startsituatie.

Toekomstige initiatieven, na de eerste uitbreiding, behoren niet tot het Aramis initiatief. Maar de opzet van de CO_2-transportinfrastructuur is wel zodanig flexibel en ruim, dat er voldoende ruimte is voor toekomstige uitbreiding, tot een maximale capaciteit van 22 Mton CO_2 per jaar. Voorbeelden van mogelijke toekomstige ontwikkelingen zijn:

- Aanvullend transport naar het verzamelpunt met extra landleidingen, schepen of via spoor- en weg;
- Verdere uitbreiding van de terminal en het compressorstation;
- Nieuwe platforms en/of opslagvelden;

- Uitvoeren van seismisch onderzoek (e.g. nullijnonderzoek)[5];
- Het Aramis initiatief biedt op termijn ook de mogelijkheid om CO_2 uit het buitenland te verwerken;
- Het verzamelpunt biedt na uitbreiding mogelijkheden voor hergebruik van CO_2, aangeduid als CCUS (Carbon Capture, Utilisation and Storage)[6].

Om toekomstige uitbreidingen mogelijk te maken is de zeeleiding gedimensioneerd op de maximale uiteindelijke capaciteit. Overige onderdelen zijn of uit te breiden (terminal en compressorstation) of aan te koppelen (toevoerleidingen op land en verbindingsleidingen naar nieuwe platforms/opslagvelden). Om de terminal en het compressorstation in de toekomst uit te kunnen bereiden, is nu extra ruimte gereserveerd. Voor het aankoppelen van leidingen op land en op zee zijn verbindingspunten voorzien.

Voor een gedetailleerde en volledige omschrijving van alle onderdelen wordt verwezen naar het apart bijgeleverde technische beschrijvingsdocument (Deelrapport Technische Beschrijving, 2023).

4.1 Locatie

Het plangebied, welke beschouwd wordt ten behoeve van de onderhavige Soortentoets, bestaat uit twee deelgebieden:

- Het **landdeel**, bestaande uit het Rotterdamse havengebied, en Maasvlakte (Figuur 4-1).
- Het **zeedeel**, bestaande uit de Noordzee, het passeren van de Voordelta en de Maasgeul, Noordzeekustzone, Klaverbank, Bruine Bank en Friese Front (Figuur 4-2).

Landdeel
De Aramis transportleiding op de Maasvlakte is gepland in de leidingstrook van Leidingenbureau Rotterdam en wordt beheerd door het Havenbedrijf Rotterdam (HbR). De Maasvlakte is onderdeel van het Rotterdamse havengebied. Het gebied is ontwikkeld door zand vanuit zee aan te brengen tot een hoogte van ongeveer vijf meter +NAP. Aan de noordwestzijde van de Maasvlakte bevindt zich ook een harde zeewering ter bescherming tegen golfslag.

Het uitgangspunt in deze Soortentoets is dat het compressorstation van Porthos (groen omlijnd) vergund is en dat de fundering er al staat. Voor de aanlegfase van Aramis wordt er enkel mechaniek bijgeplaatst en er is geen sprake van extra ruimtebeslag. Voor de gebruiksfase geldt dat het compressorstation is uitgevoerd als onbemand station dat op afstand bestuurd wordt door de centrale commandopost van Porthos. Indien noodzakelijk kan het station ook lokaal bediend worden. Voor onderhouds- en controlewerkzaamheden zullen er technici aanwezig zijn.

Het leidingwerk van de terminal naar het Porthos compressorstation is bovengronds voorzien over het MOT terrein. De CO2next terminal is gepland aan de oostzijde van de MOT. Hier vindt permanent ruimtebeslag plaat in verband met installatie van ofwel bolvormige (*spheres*) ofwel langwerpige (*bullets*) opslagtanks.

Het overige leidingwerk is ondergronds voorzien, het in Figuur 4-1 in groen weergegeven deel komt in de aanwezige leidingstrook. Het in rood weergegeven deel is een nieuwe leiding ingegraven voor het al vergunde Porthos project. De bodem wordt in de aanlegfase open gegraven en nadien weer gedicht. Er is geen sprake van permanent ruimtebeslag. De in Figuur 4-1 weergegeven jetties vragen niet om ruimtebeslag op land. Wel zullen er in de gebruiksfase meer schepen aanleggen dan in de huidige situatie.

[5] Seismische surveys als noodzakelijke baseline en monitoringsverplichting vanuit de CO2 opslagvergunningen worden qua impact behandeld in het MER en specifiek in het achtergrondrapport onderwatergeluid.
[6] De terminal biedt de mogelijkheid CO2 door te voeren naar derde partijen, naast Aramis. Daarmee kan CO2 aan andere opslagpartijen worden geleverd of ingezet worden voor hergebruik (CCUS, Carbon Capture, Utilisation and Storage).



Figuur 4-1. Locaties van het compressor station, de terminal en de pijplegroute.

Voor de gebruiksfase geldt dat er calamiteiten kunnen optreden. Er is rekening gehouden met gemiddeld ééns in de vijftien jaar een calamiteit waarbij een relief van CO_2 plaats vindt bij de nieuw te installeren aanlegsteigers. Er ontstaat dan een luchtstroom die onder hoge druk naar buiten spuit. Dit geeft een verstorend geluid en een grote concentratie CO_2. Een hoge concentratie CO_2 kan verstikkend werken zowel voor mens als dier. Omdat het gaat om een calamiteit is deze relief niet beoordeeld en behandeld als uitgangspunt in deze soortentoets. Hetzelfde geldt voor de relief valve die wordt geplaatst op het centrale eindpunt (zee-deel).

Zeedeel

Het gemeentelijke bestemmingsplan van de gemeente Rotterdam eindigt na één kilometer vanaf de kust, zodat het leidingtracé onder de Maasgeul in het bestemmingsplan moet worden opgenomen. De twaalf mijls-zone (zeemijlen[7]) geeft de territoriale grens van Nederland aan. Voorbij deze zone bevindt zich de exclusieve economische zone (EEZ), een gebied dat zich tot 200 zeemijl (370,4 km) buiten de kust uitstrekt.

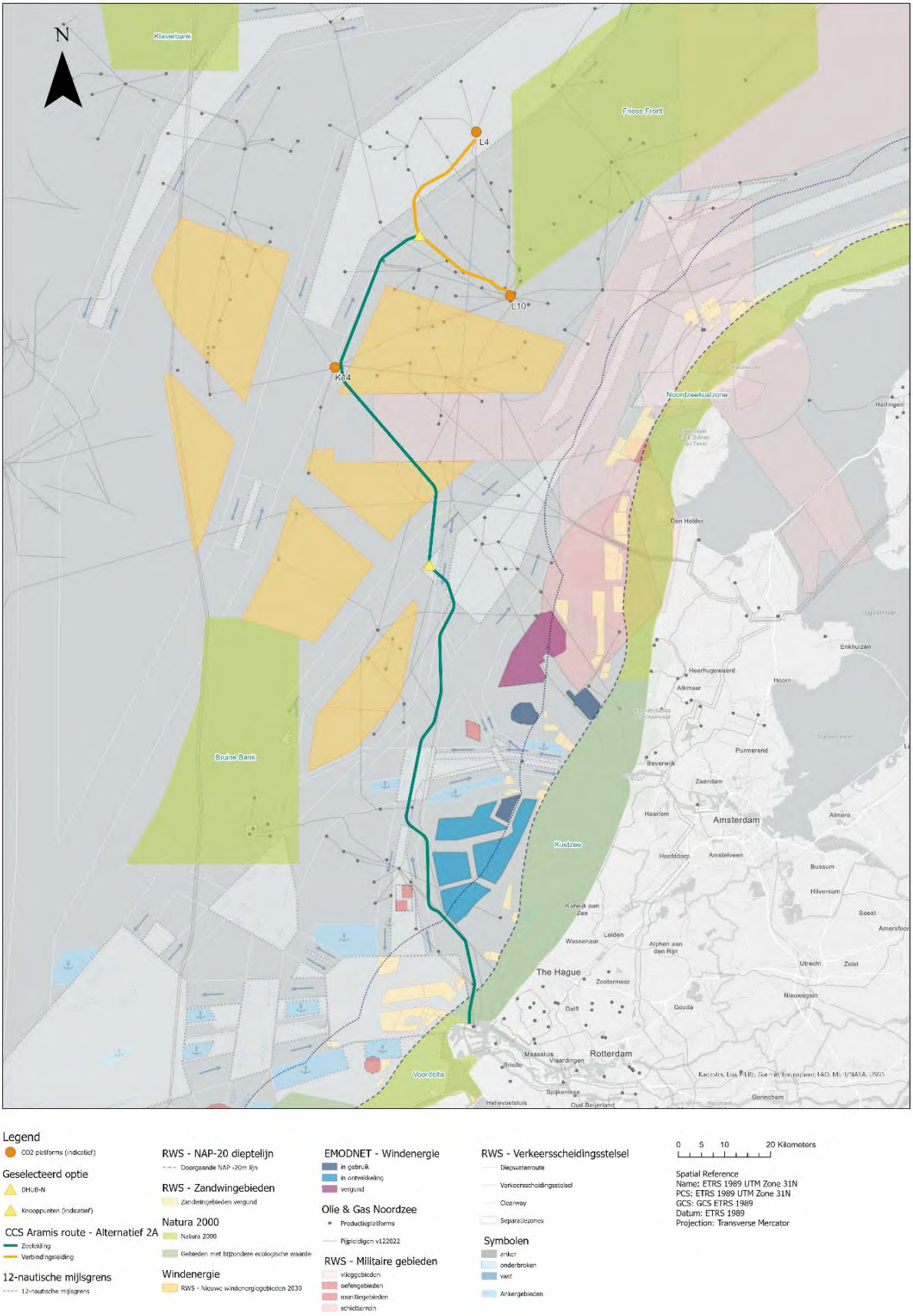
De transportroute van CO_2 schepen gaat via binnenlands waterbinnenwater en/of kustwateren. De zeeleiding bevindt zich deels binnen de territoriale wateren en het grootste gedeelte in de EEZ. De platforms bevinden zich binnen de EEZ. De EEZ wordt ook aangeduid als het Nederlands Continentaal Plat (NCP).

Direct ten noorden van de Maasvlakte bevindt zich de vaargeul naar de Rotterdamse haven. Deze wordt aangeduid als de Maasgeul (gelegen in de Maasmond) en is circa 30 meter diep. De diepte van het geplande traject van de zeeleiding is maximaal 31 m. De zeeleiding bevindt zich op de Noordzee en zodoende dient Aramis rekening te houden met de andere functies op de Noordzee. Relevante andere functies bestaan uit scheepvaart, visserij en militaire oefenruimte. Daarnaast worden in toenemende mate windturbines op de Noordzee ontwikkeld. Ook zijn delen van de Noordzee aangewezen als Natura2000-gebied. De afstanden van de pijpleiding en platforms ten opzichte van de Natura 2000-gebieden is weergegeven in Tabel 4-2.

[7] *Een zeemijl komt overeen met 1,852 kilometer.*

Tabel 4-2. Overzicht minimale afstanden van de platforms en zeeleiding tot de Natura 2000-gebieden.

Type infrastructuur	Afstand tot Natura 2000-gebieden in km				
	Voordelta	Bruine Bank	Noordzeekust-zone	Friese Front	Klaverbank
Platform L4-A	192	116	69	7,8	53
Platform L10-zuid	156	87	41	1,6	77
Platform K14-FA	143	58	70	43	68
Eindpunt	170	91	65	20	53
Zeeleiding Alternatief 1A West	0	23	37	2,1	40



Figuur 4-2. Overzicht van Aramis initiatief met aanwezige Natura 2000-gebieden.

4.2 Overzicht activiteiten

In Tabel 4-3 zijn de werkzaamheden samengevat uit de technische beschrijving die worden meegenomen in de Soortentoets (Deelrapport Technische Beschrijving, 2023).

Tabel 4-3. Overzicht van de te beoordelen activiteiten van het Aramis initiatief.

Activiteit		Verstoringsfactoren	Technische aandachtspunten van belang bij de toetsing
Pijpleiding leggen	Baggeren zeeleiding inclusief twee alternatieven: Microtunnel en Direct Piping [1].	Vertroebeling, oppervlakteverlies, beweging/optiek, verandering dynamiek substraat, onderwatergeluid.	▪ Diameter leiding is circa 80 cm. ▪ Het volume grondverzet als gevolg van de baggerwerkzaamheden wordt grotendeels gebruikt om de gebaggerde sleuf weer dicht te maken (voor microtunneling: 1.967 m^3, voor direct piping: 706.756 m^3) een deel wordt afgevoerd naar een stortplaats op zee (voor microtunneling: 53 m^3, voor direct piping: 996 m^3).
	Aftoppen zandgolven met sleephopperzuiger.	Vertroebeling, verandering dynamiek substraat, onderwatergeluid/trillingen.	▪ Zes weken vóór de installatie van de zeeleiding worden de zandgolven afgetopt. ▪ Opties zijn ter plaatse storten, elders storten of nuttig gebruiken als suppletie- of ophoogzand.
	Leggen zee- en verbindingsleidingen.	Vertroebeling, oppervlakteverlies, beweging/optiek, verandering dynamiek substraat, onderwatergeluid/trillingen.	**Verbindingsleidingen** ▪ Ieder platform wordt met een verbindingsleiding (spurline) verbonden aan de zeeleiding, via het noordelijke distributieplatform of één van de connectiepunten van de zeeleiding. ▪ K14-FA; Er komt een 800 m lange 16” (circa 40 cm diameter) verbindingsleiding naar het connectiepunt. ▪ L4-A: Er komt een 24 km lange 20” (circa 50 cm diameter) verbindingsleiding naar het noordelijke distributieplatform van de zeeleiding. ▪ L10-zuid: Er komt een 24 km lange 20” (circa 50 cm diameter) verbindingsleiding naar het noordelijke distributieplatform van de zeeleiding. ▪ Verbindingsleiding wordt (gedeeltelijk) ingegraven en, bij kruisingen met andere leidingen, gedeeltelijk afgedekt met stortsteen.

Activiteit		Verstoringsfactoren	Technische aandachtspunten van belang bij de toetsing
			Zeeleiding ▪ Het tracé van de zeeleiding loopt vanuit de doorkruising met de Maasgeul in noordelijke richting naar het eindpunt dat zich ongeveer op 230 kilometer afstand in noordelijke richting op de Noordzee bevindt. ▪ Gemiddelde aanleg één km per dag. ▪ De leiding wordt opgebouwd uit leidingsegmenten met een lengte van ongeveer twaalf meter. De leidingsegmenten worden met bevoorradingsschepen vanuit het depot aan wal naar het pijpenlegschip aangevoerd en op zee op het pijpenlegschip overgeladen. Op het pijpenlegschip wordt steeds een nieuw segment aan de opgebouwde leiding gelast.
	Ingraven of begraven zee- en/of verbindingsleidingen.	Vertroebeling, oppervlakteverlies, beweging/optiek, verandering dynamiek substraat, onderwatergeluid/trillingen.	▪ 70 kilometer vanaf de kruising met de Maasgeul wordt de zeeleiding ingegraven in de zeebodem, met dekking van circa 1 meter. De kruising van de Maasgeul vindt plaats door middel van microtunneling/direct piping (zie Activiteit Baggeren zeeleiding inclusief twee alternatieven: Microtunnel en Direct Piping). ▪ Voor kruisingen van shipping lanes en zandgolven wordt mogelijk eerst een sleuf gebaggerd voor een verdiepte aanleg, als de benodigde ingraafdiepte te groot is voor een ingraafmachine (trencher).
	Rock dump kruisingen.	Vertroebeling, oppervlakteverlies, beweging/optiek, verandering dynamiek substraat, onderwatergeluid.	▪ Naar verwachting gaat dit om circa 45 kruisingen van gemiddeld 500 meter lengte waar stenen worden gestort bij bestaande leidingen/ kabels. De verwachting is dat na het storten van het steen geen verdere stortingen nodig zijn gedurende de levensduur van het Aramis initiatief.

Activiteit		Verstoringsfactoren	Technische aandachtspunten van belang bij de toetsing
Scheepvaart en helikoptervluchten	Schepen, langer op één locatie, baggerschip, pijplegschip, bevoorradingsschepen, trenchschip, begeleidingsschepen, helikopters.	Onderwatergeluid/trillingen, verstoring door licht, verstoring door beweging/optiek.	Bijlage 2: Scheepvaart- en helikopterbewegingen.
Platform en putten L4-A	Nieuwe putten boren bij de sloten van L4-A3 en L4-A4.	Onderwatergeluid/trillingen, verstoring door licht, verstoring door beweging/optiek.	▪ 100 dagen per put.
	Aanpassen platform L4-A.	Onderwatergeluid/trillingen, verstoring door licht, verstoring door beweging/optiek.	▪ Verwijderen van compressie- en accommodatiemodules met een heavy lift vaartuig ▪ Aanbrengen van de riser (beschermd met staalconstructie) langs een van de staanders van het platform ▪ Plaatsen productiemanifold, injectie- en meteringskid ▪ Plaatsen van voorzieningen voor de duurzame energievoorziening (e.g. zonnepanelen. windturbines) ▪ Aanbrengen van entree punten waar personeel vanaf onderhouds- en inspectieschepen (Walk-to-Work (W2W) vessels) op het platform kan komen ▪ Aanpassen en waar nodig vervangen van de leidingen op het platform.
Platforms en putten nabij K14-FA en bij L10-zuid	Plaatsen platforms K14-FA en L10-zuid (inclusief heien verankeringspalen).	Oppervlakteverlies, versnippering leefgebied, onderwatergeluid/trillingen, verstoring door licht, verstoring door beweging/optiek.	▪ Plaatsen nieuw platform duurt totaal 7 dagen. ▪ 4 verankeringspalen; diameter 1 - 1.7 m; diepte 35 - 60 m. ▪ Heien verankeringspalen duurt circa twee-drie dagen per locatie.
	Heien conductors voor putten.	Onderwatergeluid/trillingen, verstoring door licht, verstoring door beweging/optiek.	▪ K14-FA; 40-80 m diepte, vier of zes conductors, drie dagen per 4-6 conductors, diameter is 0,76 m.

Activiteit		Verstoringsfactoren	Technische aandachtspunten van belang bij de toetsing
			▪ L10-zuid; 40-80 m diepte, vier of zes conductors, drie dagen per vier-zes conductors, diameter is 0,76 m. ▪ L4-A; 2 conductors. ▪ Het heien van een conductor duurt circa zes uur (hei energie bedraagt circa 90 kJ).
	Boren putten.	Onderwatergeluid/trillingen, verstoring door licht, verstoring door beweging/optiek.	▪ K14-FA; in totaal 400 dagen boorwerkzaamheden vanaf een zelfheffend booreiland, 4 nieuwe injectieputten Shell, 2500 m diepte bovenste deel put. ▪ L10-zuid; 100 dagen per put, vier-zes nieuwe putten. ▪ L4-A; 2 nieuwe putten en twee sidetracks.
Centrale eindpunt	Heiwerkzaamheden centrale eindpunt.	Onderwatergeluid/trillingen, verstoring door licht, verstoring door beweging/optiek.	▪ Diameter twee m, lengte 45 m. ▪ Vier of zes verankeringspalen. ▪ Drie dagen per vier-zes verankeringspalen.
Lozingen	Lozing van boorvloeistof en boorgruis.	Verontreiniging, vertroebeling, verandering dynamiek.	▪ K14-FA: De restanten van de boorvloeistof en het boorgruis worden volgens de gangbare praktijk op zee geloosd bij de desbetreffende put. Het gaat om circa 10.371 ton waterbasisboorgruis, en 7.909 ton waterbasis boorvloeistof (in totaal voor alle putten). Er wordt ongeveer 6.500 ton schoon regen- en spoelwater van de dekken en 250 ton sanitair afval (septic tank) op zee geloosd (in totaal). ▪ L10-zuid: De lozing van schoon regen- en spoelwater bedraagt 6.500 ton en voor het sanitaire afval 250 ton (in totaal). Water wordt tot beneden de wettelijk vastgestelde concentraties ontdaan van koolwaterstoffen en vervolgens geloosd. Geloosd water voldoet aan de emissie eisen van H9 van de mijnbouwregeling (30 ppm olie in water). Bij de werkzaamheden aan platform L10-zuid worden nieuwe putten geboord, waarbij Water Based Mud (WBM)-houdende boorvloeistof

Activiteit		Verstoringsfactoren	Technische aandachtspunten van belang bij de toetsing
			wordt gebruikt. Het gaat om circa 1.700 tot 2.000 ton waterbasisboorgruis en 1.700 tot 3.500 ton waterbasis boorvloeistof per put (vier-zes putten). De boorvloeistof en het boorgruis worden volgens de gangbare praktijk op zee geloosd. ▪ L4-A: het gaat in totaal om 2.000 ton waterbasisboorgruis en 1.900 ton waterbasis boorvloeistof. ▪ Het onderste deel van de putten wordt geboord met boorvloeistof op lage toxiciteit oliebasis (LTOBM, Low toxicity oil based mud). Deze boorvloeistof en boorgruis worden afgevoerd naar land.
Terminal	Aanleg aanlegsteigers (jetties) en vaarbewegingen in de aanlegfase.	Onderwatergeluid/trillingen, oppervlakteverlies.	▪ In de startsituatie worden twee aanlegsteigers aangelegd. De aanlegsteigers zijn ontworpen voor schepen met volumes variërend van 2.200 m^3 tot 12.000 m^3 en een maximale lengte van 165 m. ▪ Het heien van fundering bij de aanlegsteigers geeft onderwatergeluid. Dit vindt plaats binnen het Yangtzekanaal en staat niet in direct contact met de Noordzee. Vaarbewegingen in de aanlegfase, onderdeel van verkeer in de Maasgeul en in het Yangtzekanaal.
Leidingtracé	Aanleg onshore leiding.	Oppervlakteverlies.	▪ Het leidingwerk van de terminal naar het Porthos compressor station is bovengronds voorzien over het MOT terrein. De CO2next terminal is gepland aan de oostzijde van de MOT. ▪ Vanaf het compressorstation wordt de leiding in de bestaande leidingstrook ondergronds geplaatst naast andere leidingen, waaronder de Porthos-zeeleiding. Hiervoor moet de leidingstrook bij de expansieloops en over de hele lengte langs de Aziëweg worden verbreed.

Activiteit		Verstoringsfactoren	Technische aandachtspunten van belang bij de toetsing
Compressorstation	Aanpassingen aan het compressorstation.	Oppervlakteverlies.	▪ Gasvormig CO2 wordt aangeleverd via de Porthos landleiding aan het compressorstation. ▪ Tijdens de bouwfase van het Porthos compressorstation zal er een verbrede fundering worden aangelegd voor de toekomstige plaatsing van de compressoren voor Aramis, Het compressorstation wordt uitgebreid met drie extra compressoren voor Aramis.

[1] In dit rapport wordt gesproken over de microtunnel. Maar mogelijk wordt in plaats van de microtunnel boortechniek (over delen van de tunnel) gebruik gemaakt van een iets ander boortechniek, de segmented tunnel boortechniek of een hybride vorm. Daar waar dat tot verschillen in milieueffecten leidt, is dat aangegeven in de MER en Soortentoets.

5. Aanwezigheid en beoordeling van beschermde natuurwaarden

Hieronder is per soortgroep beschreven welke beschermde of bedreigde soorten in of nabij het plangebied voorkomen of verwacht kunnen worden. De voorkomende soorten en effectbeoordeling in of nabij het plangebied voor het land-deel zijn beschreven in paragraaf 5.1 en voor het zee-deel in paragraaf 5.2. In hoofdstuk 6 is voor de optredende negatieve effecten beschreven hoe deze te voorkomen dan wel te verzachten zijn, en of het aanvragen van een omgevingsvergunning noodzakelijk is of dat gewerkt kan worden conform een vigerende gedragscode.

5.1 Voorkomende soorten en effectbeoordeling (land)

5.1.1 Vaatplanten

Voorkomen
Er zijn binnen het plangebied in de NDFF en de Natuurwijzer waarnemingen bekend van glad biggenkruid (*Hypochaeris glabra*). Glad biggenkruid wordt zeer algemeen aangetroffen in de leidingstrook, langs het MOT terrein en op verschillende plaatsen in de berm in het plangebied. Het voorkomen van beschermde vaatplanten in en nabij het plangebied is daarmee aangetoond. Het is bekend dat glad biggenkruid wijdverspreid en plaatselijk massaal voor komt in halfopen vegetaties in bermen en leidingstroken op het terrein van het havenbedrijf[8].

Glad biggenkruid is een éénjarige soort die zich telkens opnieuw vanuit zaad moet ontwikkelen en die zowel in het voor- als najaar kiemt. Daardoor is behoud en bescherming van glad biggenkruid veel meer een zaak van het beschermen van de zaadbank in de bodem en een geschikt leef- en vestigingsmilieu dan van de bescherming van individuele exemplaren.

Effectbeoordeling
Als gevolg van de werkzaamheden kunnen tijdelijk standplaatsen van glad biggenkruid worden geschaad. Mogelijk gaan als gevolg van de nieuwe ruimtelijke inrichting ook permanent groeilocaties verloren. Hetgeen leidt tot overtreding van artikel 11.54 1a en 1b van het Bal. Aanvullende maatregelen zijn noodzakelijk.

Vervolgstappen
Om aan te sluiten op de gebiedsontheffing van het havenbedrijf, dienen de werkzaamheden te worden uitgevoerd volgens de werkprotocollen zoals vastgelegd in het Managementplan van het havenbedrijf. De noodzakelijke maatregelen zijn toegelicht in paragraaf 6.1. Als aan alle eisen van het managementplan kan worden voldaan is het aanvragen van een omgevingsvergunning niet noodzakelijk.

5.1.2 Grondgebonden (land)zoogdieren

Voorkomen
Er zijn binnen het plangebied in de NDFF en de Natuurwijzer waarnemingen van de volgende land-zoogdieren bekend: bever (*Castor fiber*), bunzing (*Mustela putorius*), haas (*Lepus europaeus*), konijn (*Oryctolagus cuniculus*) en veldmuis (*Microtus arvalis*). Het voorkomen van andere nationaal beschermde soorten als vos (*Vulpes vulpes*) of ree (*Capreolus capreolus*) is tevens niet uitgesloten. Het voorkomen van zeezoogdieren wordt in paragraaf 5.2.2 behandeld.

Van de in de literatuur vermelde soorten, valt de bever onder het beschermingsregime van de Habitatrichtlijn. Bevers hebben hun leefgebied in het overgangsgebied tussen land en water zoals moerassen, langs beken, rivieren en meren. De aanwezigheid van bossen of bosschages op de oevers is een vereiste. De soort is voor zover bekend alleen zwemmend waargenomen. De waarneming van de bever betreft vrijwel zeker een zwervend exemplaar op zoek naar een geschikt leefgebied. Voor de bever is in of nabij het plangebied geen geschikt leefgebied aanwezig. Dit komt voornamelijk door de verharde oevers en het

[8] *Bureau Stadsnatuur, juli 2021.Managementplan beschermde soorten Havenbedrijf Rotterdam 2021. In opdracht van Port of Rotterdam.*

ontbreken van houtopstanden. Het plangebied maakt geen onderdeel uit van het leefgebied van de bever. Overtreding van de verbodsbepalingen van de Ow is voor deze soort uitgesloten.

De overige soorten betreffen nationaal beschermde soorten. Het aanwezige biotoop in het plangebied betreft lage begroeiing die hoofdzakelijk uit gras bestaat. In de directe omgeving van het plangebied is ook weinig beschutting aanwezig waardoor het plangebied en de directe omgeving hiervan voor veel grondgebonden zoogdieren als bunzing, haas, ree en veldmuis hooguit marginaal leefgebied betreft. Negatieve effecten en daarmee een overtreding van de Ow ten aanzien van deze soorten kunnen op voorhand uitgesloten worden.

Konijnen komen echter veel voor in en rondom het plangebied en hebben op verschillende plaatsen een hol. Hetzelfde geldt voor de vos. De soort wordt ook veel waargenomen door personeel dat aanwezig is op het terrein. Mogelijk heeft ook de vos een hol in of nabij het plangebied.

Effectbeoordeling
Als gevolg van de beoogde aanlegwerkzaamheden kunnen verblijfplaatsen van meer algemeen voorkomende beschermde zoogdieren als konijnen en vossen beschadigd of vernietigd worden, daarbij kunnen ook mogelijk dieren worden gedood. Hetgeen leidt tot overtreding van artikel 11.54 1a en 1b van het Bal. Aanvullende maatregelen zijn noodzakelijk.

Het plangebied vormt echter geen essentieel leefgebied voor konijn of vos, in de directe omgeving is voldoende uitwijkmogelijkheid. Ruimtebeslag in de gebruiksfase is beperkt en na inrichting kan het plangebied vrijwel dezelfde ecologische functie vervullen als voorheen. Permanent negatieve effecten worden op voorhand uitgesloten.

Vervolgstappen
Omdat konijn en vos zijn opgenomen in de lijst van vrijgestelde soorten (AMvB RN art 3.31), hoeft voor de optredende negatieve effecten en daarmee overtreding van verbodsbepalingen, geen omgevingsvergunning te worden aangevraagd. Negatieve effecten op konijn en vos en hun leefomgeving moeten wel zoveel als mogelijk voorkomen dan wel beperkt worden. De noodzakelijke maatregelen zijn toegelicht in paragraaf 6.1.

5.1.3 Vleermuizen

Voorkomen
Er zijn binnen het plangebied waarnemingen in de NDFF en in de Natuurwijzer bekend van vleermuizen. Dit betreffen de gewone dwergvleermuis (*Pipistrellus pipistrellus*) en ruige dwergvleermuis (*Pipistrellus nathusii*). Daarnaast worden ook soorten als laatvlieger (*Eptesicus serotinus*), en myotis-soorten als meervleermuis (*Myotis dasycneme*) en watervleermuis (*Myotis daubentonii*) vermeld.

Vleermuizen maken op verschillende manieren gebruik van het landschap. Vleermuizen hebben vaste rust- en verblijfplaatsen in gebouwen of bomen. Ze maken gebruik van lijnvormige structuren in het landschap om zich te oriënteren en zich daarlangs te verplaatsen tussen verblijfplaatsen en foerageergebieden.

Omdat er voor de werkzaamheden op land geen gebouwen gesloopt of bomen gekapt worden, zijn effecten op rust- en/of verblijfplaatsen van vleermuizen binnen het plangebied op voorhand uitgesloten. In het plangebied ontbreekt het aan lange aaneengeschakelde, lijnvormige elementen als bomenrijen. Een functie als vliegroute voor vleermuizen over land is daarom tevens uitgesloten. Mogelijk komen er wel passerende individuen voor langs de zuidelijke oever (het Yangtzekanaal). De noordelijke oever is door de aanwezigheid van windmolens niet geschikt om veilig langs te vliegen. De zuidelijke oever is echter niet essentieel, gezien de aanwezige uitwijkmogelijkheden in de direct omgeving, zoals bijvoorbeeld de overkant van het Yangtzekanaal. Aanwezigheid van essentiële vliegroutes is daarom uitgesloten. De begroeiing in het plangebied is schraal en bestaat geheel uit grassen en kruiden. Deze vegetatie heeft een lage aantrekkende werking op insecten. Daarbij wordt het plangebied door de aanwezige lantaarnpalen grotendeels verlicht. Het plangebied biedt dan ook hooguit marginaal geschikt foerageergebied voor vleermuizen.

Effectbeoordeling
Het plangebied en de directe omgeving daarvan voorziet op grond van de geraadpleegde verspreidingsgegevens en de aanwezige habitats niet in essentieel leefgebied of verblijfsmogelijkheden van krachtens de Ow beschermde vleermuizen. Negatieve tijdelijke en/of permanente effecten en een overtreding van de Ow ten aanzien van vleermuizen kunnen uitgesloten worden.

5.1.4 Vogels

Voorkomen
Uit de verspreidingsgegevens van de NDFF is gebleken dat in het plangebied of in de omgeving daarvan waarnemingen bekend zijn van verschillende soorten broedvogels welke jaarrond of niet-jaarrond beschermde nesten kunnen hebben. Deze soorten zijn vaak overvliegend, maar ook rustend of foeragerend waargenomen. Tijdens het veldbezoek zijn de volgende vogelsoorten waargenomen: ekster (*Pica pica*), houtduif (*Columba palumbus*) en kauw (*Corvus monedula*) en verschillende meeuwensoorten. Op basis van de NDFF-data is het aannemelijk dat soorten zoals de drieteenmeeuw (*Rissa tridactyla*), dwergmeeuw (*Hydrocoloeus minutus*), kokmeeuw (*Chroicocephalus ridibundus*), stormmeeuw (*Larus canus*), kleine mantelmeeuw (*Larus fuscus*) en zilvermeeuw (*Larus argentatus*) voorkomen.

Vogels kunnen op verschillende manieren gebruik maken van het plangebied: als broedlocatie, plek om te foerageren of om te rusten. In het plangebied zijn geen bomen, waardoor jaarrond beschermde nesten van boombroedende soorten als roek, buizerd en boomvalk op voorhand uitgesloten zijn. Door het ontbreken van gebouwen is tevens het voorkomen van jaarrond beschermde nesten van gebouwbroedende soorten als huismus of gierzwaluw uitgesloten.

Vanwege het grotendeels ontbreken van opgaande beplanting zijn de vrijwel kale terreinen alleen geschikt voor grondbroeders. Deze hebben geen van allen een jaarrond beschermd nest. Zo is bijvoorbeeld de kleine mantelmeeuw op vergelijkbare locaties in de Maasvlakte een talrijke broedvogelsoort, net als de zilvermeeuw en visdief. De toenemende aanwezigheid van de vos maakt het plangebied en omgeving steeds minder geschikt voor grondbroedende vogels. Verder zouden opportunistische en voor verstoring relatief ongevoelige soorten (zonder jaarrond beschermd nest) als kauw, houtduif en ekster wel in de nabijheid van het plangebied kunnen broeden, bijvoorbeeld op het terrein ten noorden van het plangebied waar nog enige opgaande begroeiing aanwezig is.

Effectbeoordeling
Het plangebied vormt een, als gevolg van aanwezigheid van de vos inmiddels suboptimaal, geschikt leef- en broedgebied voor enkele grondbroedende vogels zonder jaarrond beschermd nest. Wanneer de aanlegwerkzaamheden worden uitgevoerd in het broedseizoen worden bij het vergraven van grond mogelijk nesten vernietigd of beschadigd. Daarnaast kunnen broedende vogels in het plangebied en de directe omgeving daarvan worden verstoord. Wanneer broedende vogels daardoor voortijdig het nest verlaten, geldt dit eveneens als het opzettelijk vernietigen of beschadigen van nesten en eieren van vogels. Dit is een overtreding van artikel 11.37 1a, 1b en 1d van het Bal. Aanvullende maatregelen zijn noodzakelijk.

Het plangebied vormt geen essentieel biotoop voor broedvogels, in de directe omgeving is voldoende uitwijkmogelijkheid. Ruimtebeslag in de gebruiksfase is beperkt en na inrichting kan het plangebied vrijwel dezelfde ecologische functie vervullen als voorheen. Permanent negatieve effecten worden uitgesloten.

Vervolgstappen
Negatieve effecten op broedvogels moeten voorkomen worden. Dat kan door bepaalde werkzaamheden en activiteiten in tijd en ruimte daarop afgestemd te plannen of specifieke mitigerende maatregelen te treffen. De noodzakelijke maatregelen zijn toegelicht in paragraaf 6.1.

5.1.5 Vissen

Voorkomen
De werkzaamheden worden op land uitgevoerd. Permanent watervoerende elementen ontbreken binnen het plangebied. Op basis van het ontbreken van oppervlaktewateren (zoals plassen, vijvers, etc.) kan het voorkomen van beschermde vissen worden uitgesloten.

Effectbeoordeling
In het plangebied (land-deel) komen geen wettelijk beschermde vissen voor. Negatieve effecten en een overtreding van de Ow worden op voorhand uitgesloten.

5.1.6 Amfibieën

Voorkomen
Er zijn in het noordoostelijk deel van het plangebied in de NDFF en in de Natuurwijzer waarnemingen bekend van de rugstreeppad (*Epidalea calamita*). De soort is waargenomen bij een daar aanwezig waterbassin en komt verspreid over het terrein van het havenbedrijf op meerdere locaties voor[9]. Het voorkomen van de rugstreeppad in het plangebied is daarmee aannemelijk. Voor de rugstreeppad is in en nabij het plangebied geschikt leefgebied aanwezig. Het waterbassin vormt potentieel geschikt voortplantingsbiotoop. In de directe omgeving zijn geschikte overwinteringsplaatsen zoals open zandige locaties en elementen waar amfibieën onder kunnen schuilen aanwezig. De met dicht gras begroeide delen van het plangebied zijn niet geschikt als leefgebied van de soort. De rugstreeppad is echter in staat, indien er geschikte omstandigheden ontstaan, snel een gebied te koloniseren.

Effectbeoordeling
De beoogde aanlegwerkzaamheden kunnen leiden tot het tijdelijk beschadigen en/of vernietigen van verblijfplaatsen en het verwonden en/of doden van individuen van de rugstreeppad. Mogelijk gaat als gevolg van de nieuwe ruimtelijke inrichting ook permanent geschikt leefgebied verloren. Hetgeen leidt tot overtreding van artikel 11.46 1a, 1b en 1d van de Ow het Bal. Aanvullende maatregelen zijn noodzakelijk.

Vervolgstappen
Om aan te sluiten op de gebiedsontheffing van het havenbedrijf, dienen de werkzaamheden te worden uitgevoerd volgens de werkprotocollen zoals vastgelegd in het Managementplan van het havenbedrijf. Indien aan alle eisen van het managementplan kan worden voldaan is het aanvragen van een omgevingsvergunning niet noodzakelijk. De noodzakelijke maatregelen zijn toegelicht in paragraaf 6.1.

5.1.7 Reptielen

Voorkomen
In de ruime omgeving van het plangebied zijn in de NDFF-waarnemingen bekend van de beschermde zandhagedis (*Lacerta agilis*). De zandhagedis is sterk gebonden aan duin- en heidegebieden. De waarnemingen van de soort zijn dan ook gedaan in het duingebied van Hoek van Holland en het duingebied bij Oostvoorne. Voor de zandhagedis geschikt biotoop, zoals open zandige locaties is aanwezig binnen het plangebied. Echter, verbinding met bestaande populaties waarvan onder anderen aan de overzijde van de Nieuwe Waterweg ontbreekt, waardoor aanwezigheid van de soort redelijkerwijs kan worden uitgesloten.

Effectbeoordeling
In het plangebied komen geen wettelijk beschermde reptielen voor. Negatieve effecten en een overtreding van de Ow worden op voorhand uitgesloten.

[9] *Bureau Stadsnatuur, juli 2021.Managementplan beschermde soorten Havenbedrijf Rotterdam 2021. In opdracht van Port of Rotterdam.*

5.1.8 Ongewervelde soorten

Voorkomen
Er zijn in het plangebied in de NDFF en in de Natuurwijzer geen waarnemingen bekend van beschermde ongewervelde diersoorten. Voor de meeste soorten geldt dat het voorkomen op basis van de aanwezige biotopen (voor vrijwel al de zwaarder beschermde soorten ongeschikt) en de algemene verspreidingsgegevens uitgesloten is. Individuen van de grote vos (dagvlinder) (*Nymphalis polychloros*) kunnen incidenteel wel aangetroffen worden. Dit is een zeer mobiele soort. Voor de grote vos geschikte waardplanten als iep, zoete kers, populier en wilgensoorten ontbreken echter in het plangebied. Vaste voortplantingsplaatsen of rustplaatsen van de soort worden daarom op voorhand uitgesloten.

Effectbeoordeling
Het plangebied en de directe omgeving daarvan voorziet op grond van de geraadpleegde verspreidingsgegevens en de aanwezige habitats niet in essentieel leefgebied of verblijfsmogelijkheden van krachtens de Ow beschermde ongewervelden. Negatieve tijdelijke en/of permanente effecten en een overtreding van de Ow ten aanzien van ongewervelden kunnen op voorhand uitgesloten worden.

5.1.9 Samenvatting voorkomende beschermde soortgroepen (land-deel)

Op basis van de uitkomsten van het onderzoek, is het voorkomen van de in het onderstaande overzicht opgenomen soorten te verwachten of niet uitgesloten (Tabel 5-1). Het gaat om: glad biggenkruid, algemeen voorkomende beschermde zoogdieren (konijn en vos), vleermuizen, broedvogels en de rugstreeppad. Er is beoordeeld of en zo ja op welke wijze de projectuitvoering kan leiden tot negatieve effecten op deze soorten. Ten aanzien van vleermuizen zijn negatieve effecten op voorhand uitgesloten. Voor de overige soorten/soortgroepen geldt dat niet.

Glad biggenkruid en de rugstreeppad vallen onder het Managementplan beschermde soorten van het havenbedrijf. Om te kunnen voldoen aan gebiedsontheffing van het havenbedrijf, dient gewerkt te worden conform de bijbehorende werkprotocollen. Onderdeel hiervan is dat voorafgaand aan de werkzaamheden het plangebied nader onderzocht wordt op het voorkomen van leefgebiedsfuncties van glad biggenkruid en de rugstreeppad. Vanuit de bevindingen van dit onderzoek kunnen noodzakelijke vervolgstappen worden genomen, zoals mogelijk het inrichten van compenserend leefgebied. Indien aan alle eisen uit de werkprotocollen van het managementplan kan worden voldaan is het aanvragen van een omgevingsvergunning niet noodzakelijk.

Voor algemeen voorkomende beschermde zoogdieren en broedvogels geldt dat ze niet vallen onder het Managementplan beschermde soorten, maar dat overtreding van de Ow dient te worden voorkomen door het nemen van voorzorgsmaatregelen. Deze voorzorgsmaatregelen dienen samen met de maatregelen uit het Managementplan ten aanzien van glad biggenkruid en de rugstreeppad op genomen te worden in een project specifiek ecologisch werkprotocol. De werkzaamheden kunnen pas worden uitgevoerd na goedkeuring van het havenbedrijf en dienen plaats te vinden onder begeleiding van een erkend ecoloog.

Tabel 5-1. Overzicht van de te verwachten beschermde soorten (land).

Soortgroep	Aanwezig	Effectbeoordeling – negatieve effecten?	Vervolgstappen
Vaatplanten	Glad biggenkruid.	Ja, wanneer standplaatsen vergraven worden, dit is een overtreding van de verbodsbepalingen.	Er dient gewerkt te worden conform de werkprotocollen uit het “Managementplan beschermde soorten Havenbedrijf Rotterdam”. Het aanvragen van een projectspecifieke omgevingsvergunning is niet noodzakelijk.
Grondgebonden zoogdieren	Algemeen voorkomende beschermde soorten als: konijn en vos.	Ja, verstoring van leefgebied tijdens de uitvoering van de	Negatieve effecten moeten zoveel als mogelijk voorkomen dan wel beperkt worden. De te nemen maatregelen om effecten zo veel als mogelijk te beperken

		werkzaamheden, doden en/of verwonden.	dan wel uit te sluiten dienen uitgewerkt te worden in een ecologisch werkprotocol.
Vleermuizen	Verschillende soorten waaronder gewone en ruige dwergvleermuis, laatvlieger en watervleermuis.	Nee, er worden geen negatieve effecten op vleermuizen verwacht. Er is geen sprake van een overtreding van de verbodsbepaling en het uitvoeren van nader onderzoek naar het voorkomen is niet aan de orde.	Geen verdere vervolgstappen.
Algemene broedvogels	Soorten als: kleine mantelmeeuw zilvermeeuw, visdief, kauw, houtduif en ekster.	Ja, aanwezige broedende vogels kunnen door de werkzaamheden verstoord worden, indien gewerkt wordt tijdens het broedseizoen is ecologische begeleiding vereist.	Negatieve effecten moeten voorkomen worden. De te nemen maatregelen dienen uitgewerkt te worden in een ecologisch werkprotocol.
Amfibieën	Rugstreeppad.	Ja, de rugstreeppad kan het plangebied koloniseren. Indien de juiste omstandigheden voor het voorkomen van de rugstreeppad ontstaan gedurende de werkzaamheden moeten mitigerende maatregelen genomen worden.	Er dient gewerkt te worden conform de werkprotocollen uit het “Managementplan beschermde soorten Havenbedrijf Rotterdam”. Het aanvragen van een projectspecifieke omgevingsvergunning is niet noodzakelijk.

5.2 Voorkomende soorten en effectbeoordeling (zee)

5.2.1 Vissen

In het plangebied komen volgens verspreidingsgegevens de beschermde vissen houting en steur voor (Sportvisserij Nederland, 2023; Winter et al., 2014). Andere beschermde vissen zoals de grote modderkruiper en kwabaal zijn zoetwatervissen en komen niet voor op zee.

Voorkomen – Houting
De houting (*Coregonus oxyrinchus*) verdween in de 20e eeuw uit onze rivieren en kustwateren. Door herintroductie van de soort tussen 1999 en 2006 worden er inmiddels weer incidenteel houtingen in rivieren en de Waddenzee gevangen. Door gebrek aan open verbindingen met de Noordzee groeit in Nederland een groot deel van de houtingen op in het IJsselmeer en blijven daar ook als volwassen dieren (Winter et al., 2014).

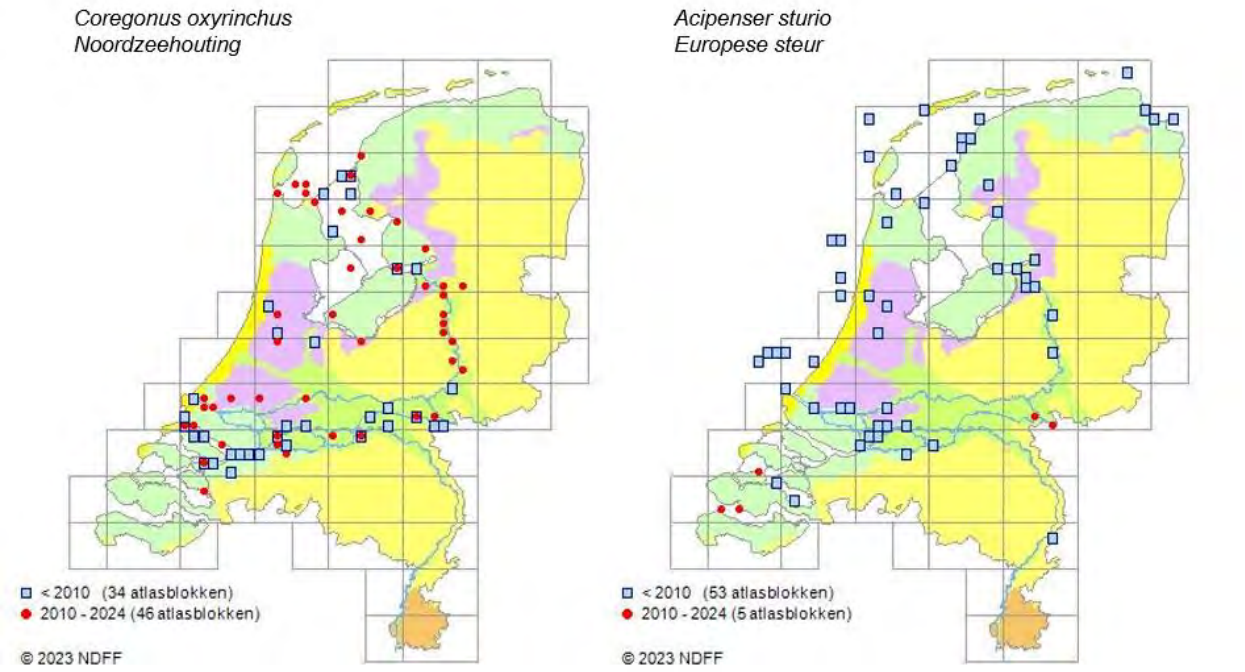
Rond november trekt de Noordzeehouting de rivieren op om zich voort te planten. Er wordt gepaaid boven kiezel- of zandbodems met een matige stroming. De eitjes komen aan het begin van het voorjaar uit. De jonge Noordzeehouting laten zich in de loop van de zomer afzakken richting riviermondingen en de kustzone. Juveniele Noordzeehoutingen voeden zich vooral met zoöplankton. Grotere Noordzeehoutingen eten daarnaast ook insectenlarven, scheldieren, kreeftachtigen en kleine vissen (RAVON, n.d.-b).

Geschikt voortplantingsbiotoop is verder stroomopwaarts van de rivieren te vinden en ontbreekt binnen het plangebied. Volwassen individuen kunnen incidenteel passerend of foeragerend voorkomen in het plangebied (Figuur 5-1). Ook kunnen oudere juvenielen langskomen onderweg naar de Noordzee.

Voorkomen – Steur
In onderzoek van Daan (2000) is geconcludeerd dat de Atlantische steur (*Acipenser sturio*) is verdwenen in de Noordzee. Afgelopen jaren zijn in diverse Europese rivieren steuren uitgezet. Specifiek in Nederland zijn in 2012, 47 individuen uitgezet in de Nieuwe Maas en de Rijn ter hoogte van Kekerdom en in 2015 nog eens 53 individuen in de Rijn nabij de Duitse grens. In juni 2023 zijn er ook in de Biesbosch 29 jonge steuren uitgezet. Al deze dieren zijn naar zee getrokken. Er zijn daarna enkele meldingen bekend van vangsten van steuren in de Delta (Sportvisserij Nederland, 2023).

Voor de voortplanting trekt de steur in het voorjaar de rivieren op waarbij vele honderden kilometers kunnen worden afgelegd. De paai geschied in diepe snelstromende delen op een bodem bestaande uit grof grind en stenen. Jonge steuren zakken de rivier af als ze een aantal jaar oud zijn om op te groeien in het estuarium waarna ze uitzwerven over de kustwateren. Hier voeden ze zich met kreeftachtigen, wormen, schelpdieren en vissen die ze opsporen met behulp van de bekdraden (RAVON, n.d.-a).

Geschikt voortplantingsbiotoop is verder stroomopwaarts van de rivieren te vinden en ontbreekt binnen het plangebied. De soort is ook pas recent weer geïntroduceerd, waardoor de kans dat de steur passerend of foeragerend voorkomt in het plangebied verwaarloosbaar klein is. Negatieve effecten op de soort worden daarom op voorhand uitgesloten.



Figuur 5-1. Verspreidingskaarten van de noordzeehouting (Coregonus oxyrinchus) en Europese steur (Acipenser sturio). Blauwe blokken zijn waarnemingen voor 2010. De rode stippen zijn waarnemingen tussen 2010-2023. Bron: www.verspreidingsatlas.nl.

Effectbeoordeling

De beoogde activiteiten in de aanlegfase (boren, heien, baggeren, trenchen en pijpen leggen) vinden plaats in een drukbevaren gebied. In totaal worden er in de aanlegfase ruim 2.000 extra scheepvaartbewegingen verwacht ten behoeve van de eerdergenoemde activiteiten. In de gebruiksfase vinden ook scheepvaartbewegingen plaats vanuit de havens van Den Helder, Rotterdam en Amsterdam naar de platforms voor onderhoud. Jaarlijks worden er 325 scheepvaartbewegingen verwacht in de gebruiksfase.

Vissen zijn zeer mobiel en hebben genoeg uitwijkmogelijkheden om het onderwatergeluid te vermijden, mocht dit als te verstorend worden ervaren. Door alle vaardrukte is er al een verhoogd achtergrondgeluid en zodoende al een hoge mate van verstoring aanwezig, waardoor de extra scheepvaartbewegingen van het Aramis initiatief in zowel de aanleg- als de gebruiksfase minimaal zullen bijdragen aan extra verstoring van vissen in het plangebied (zie Passende Beoordeling, RHDHV, 2023b).

Voor impulsgeluiden, zoals afkomstig van het heien in de aanlegfase, is de situatie anders omdat dit niet tot het reguliere achtergrondgeluid behoort en bovendien tot acute schade bij vissen kan leiden. Vissen met een zwemblaas kunnen gevoelig zijn voor dit type geluidsverstoring. De aanwezigheid van een zwemblaas nabij of verbonden met het binnenoor zorgt ervoor dat deze vissen gevoeliger zijn voor geluid, doordat variaties in waterdruk worden omgezet in waterbeweging (trillingen). Op deze manier bereikt in totaal meer waterbeweging het binnenoor, en kan daar schade aanrichten. De Temporary Threshold Shift (TTS)-waarde voor deze vissen zou kunnen liggen rond de 186 dB SELcum (Popper and Hawkins (2019). Dit toont aan dat de drempel voor vissoorten die gevoelig zijn voor onderwatergeluid hoger ligt dan voor bijvoorbeeld zeezoogdieren. Uit meerdere studies blijkt dan ook dat vissen na blootstelling aan impulsgeluid geen, of weinig schade oplopen (Debusschere et al., 2014; van der Knaap et al., 2021, 2022). Daarnaast zijn vissen zeer mobiel waardoor ze voor de meeste werkzaamheden relatief eenvoudig kunnen uitwijken. Mede door de standaardvoorzieningen die worden getroffen bij aanvang van de heiactiviteiten, zoals soft starts, is doding of verwonding van vissen door impulsgeluiden uitgesloten.

Door het baggeren, trenchen, het storten van steen bij kruisingen van infrastructuur, en de lozing van boorgruis vindt daarnaast beschadiging van bodemhabitats, vertroebeling van de waterkolom en

sedimentatie plaats. Het leefgebied van de houting kan hierdoor tijdelijk aangetast worden door oppervlakteverlies en vertroebeling van de waterkolom. Omdat de meeste werkzaamheden slechts op één plaats tegelijk plaatsvinden, de effecten zich beperken tot naar verwachting hooguit een paar 1000 m^2 betreft de verstoring op ieder moment slechts een zeer klein oppervlak in vergelijking met omringende vergelijkbare habitats. Door de tijdelijke aard van de activiteiten en doordat er voldoende uitwijkmogelijkheden zijn in de directe omgeving, zijn negatieve effecten op de houting uitgesloten. Bovendien zijn de effecten van met name sedimentatie het meest relevant voor juvenielen, eitjes en larven en dat deel van de levenscyclus wordt stroomopwaarts in rivieren doorgebracht. Dit betekent dat de vissen tijdens de meest kwetsbare levensfasen niet aanwezig zullen zijn in of nabij het plangebied.

Het voornemen leidt niet tot overtreding van de Ow. Het aanvragen van een omgevingsvergunning voor de houting of de steur is niet aan de orde.

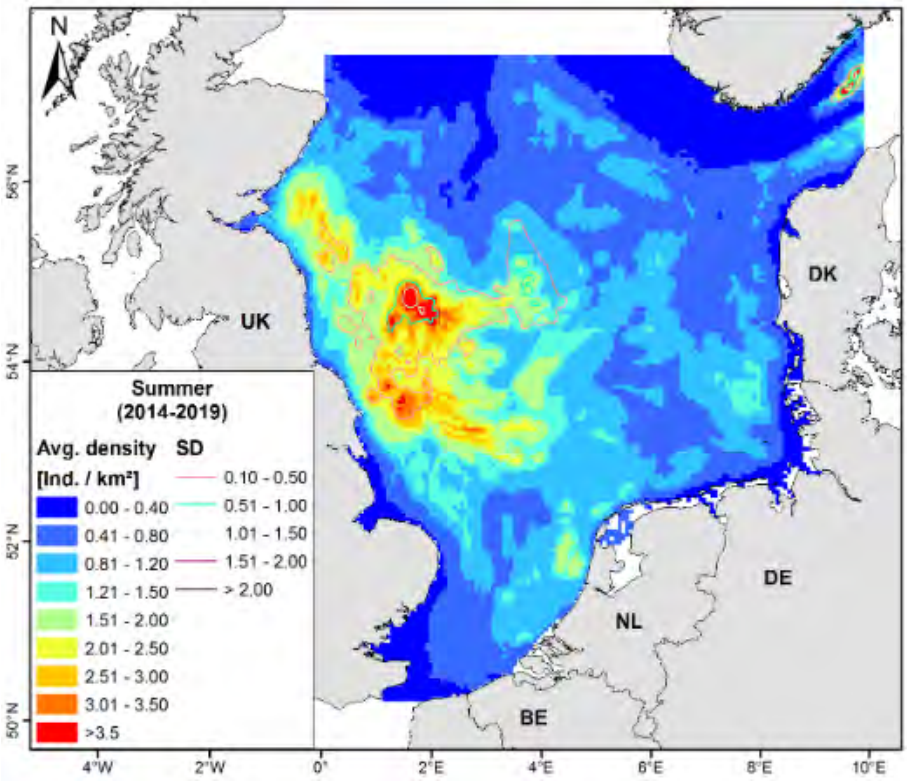
5.2.2 Zeezoogdieren

Het plangebied overlapt met de verspreiding van de beschermde zeezoogdieren bruinvis (*Phocoena phocoena*) en de gewone en grijze zeehond (*Phoca vitulina* en *Halichoerus grypus*).

Bruinvis
Voorkomen
Bruinvissen komen veel voor langs de kust, maar hebben ook een voorkeur voor relatief ondiepere wateren van het NCP (Figuur 5-2) (Redeker & van Doorn, 2019). Jonge bruinvissen worden tussen mei en juli voornamelijk in beschut, ondiep water geboren, een enkele keer op open zee (Geelhoed & van Polanen Petel, 2011a).

Jonge bruinvissen eten vooral grondels. Volwassen bruinvissen eten bij voorkeur vette vis als haring, zandspiering en makreel en anders kabeljauwachtigen, zoals wijting (Leopold, 2015). Voor zowel het zoeken naar voedsel, als ook voor navigatie en communicatie onderling gebruiken de dieren echolocatie. De soort gebruikt korte klikklanken met een hoge frequentie en een smalle bandbreedte (Møhl & Andersen, 1973).

De bruinvis is doorgaans het gehele jaar aanwezig in de Noordzee, maar migreert in de loop van de zomer voornamelijk naar het noorden (Soldaat & Poot, 2019). De zomerperiode (juni-augustus) is tevens ook de voortplantingsperiode van de bruinvis (Ecomare, 2023). Voor zover bekend zijn voortplantingsplaatsen van bruinvissen gelegen in het centrale en Duitse deel van de Noordzee (BfN, 2017; Ministerie van Economische Zaken, 2014). Hieruit wordt afgeleid dat geschikte voortplantingsplaatsen voor bruinvissen op het NCP ontbreken. Het tijdelijk beschadigen of vernielen van vaste voortplantingsplaatsen van de bruinvis is daarmee op voorhand uitgesloten (Bal artikel 11.46 1d van de Ow). Echter, kan wel worden aangenomen dat bruinvissen passerend of foeragerend in het plangebied voorkomen.



Figuur 5-2. Verwachte bruinvis dichtheden in de Noordzee in de zomer (Gillis et al., 2020).

Effectbeoordeling

Oppervlakteverlies. Ter plekke van de heilocaties, de putten en het leidingtracé zal de zeebodem vergraven worden en tijdelijk of permanent ongeschikt zijn als leefgebied voor bodembewonende soorten die als prooi voor bruinvissen kunnen dienen. In de aanlegfase betreft dit voornamelijk het tijdelijke effect voor de aanleg van de leidingen. Voor de aanleg van de nearshore zeeleiding wordt met behulp van een trencher een gleuf gegraven van maximaal twee m diep, zes m breed aan de bovenkant van de gleuf en twee m breed aan de onderkant van de gleuf. Het gaat om de eerste 70 kilometer vanaf de kruising met de Maasgeul waar de zeeleiding wordt ingegraven in de zeebodem, met een dekking van circa één meter. Na de aanlegfase zal de zeebodem ter plekke van de leidingen en overige tijdelijk aangetaste waterbodem zich weer herstellen. Het gaat daardoor om een tijdelijk oppervlakteverlies.

De aanleg van de zeeleiding *op* de zeebodem betreft een permanent oppervlakteverlies. Het permanente effect betreft ter plekke van de constructies circa tien ha op de zeebodem (Passende Beoordeling, RHDHV, 2023b). Sommige soorten zullen al vrijwel meteen weer gebruik maken van het verstoorde gebied, herstel van met name langzaam groeiende sessiele soorten kan jaren duren. Voor de bruinvis is het vooral van belang dat prooidieren al snel na de aanlegfase weer gebruik kunnen maken van het verstoorde gebied, omdat het mobiele vissoorten betreft. Voor de bruinvis zal het verstoorde gebied dus waarschijnlijk al na enkele dagen of weken weer op een vergelijkbare manier als vóór de ingreep bruikbaar zijn als foerageergebied. Significant negatieve effecten van oppervlakteverlies op de bruinvis zijn uitgesloten.

Vertroebeling. Bij het baggeren en trenchen kan vertroebeling optreden. Zeezoogdieren maken over het algemeen vaker gebruik van troebele wateren met name om te foerageren en veel soorten hebben goedontwikkelde sonarsystemen die hun functioneren in een troebele omgeving mogelijk maakt (Au et al., 2000). Troebel water komt onder natuurlijke omstandigheden ook voor op het NCP met name door wind en stromingen. De bruinvis is beperkt gevoelig voor vertroebeling (Tamis et al., 2011) en de troebele wolk zal enkel lokaal aanwezig zijn, waardoor effecten van vertroebeling op de bruinvis zijn uit te sluiten.

Sedimentatie. De werkzaamheden zorgen voor sedimenten in de waterkolom die vervolgens op de bodem neerslaan en daar een sedimentlaagje vormen. Door de aanleg van de nearshore zeeleiding (tot 70 km vanaf de doorkruising van de Maasgeul) treedt sedimentatie op met een maximale toename in sedimentdikte van 0,20 mm aan weerszijden van de leiding (zie Detailrapport zeebodem, RHDHV, 2023a). Ook bij de lozing van boorgruis kan sedimentatie optreden. Op basis van een modelstudie van de lozing van boorgruis van 12 putten bij platform N05-A (Royal HaskoningDHV, 2020) is een inschatting gemaakt van de verspreiding van het boorgruis op de boorlocatie van de nieuwe putten van het Aramis initiatief. Uit de modelstudie van N05-A bleek dat het meeste sediment van het boorgruis direct zou vallen onder het boorplatform op de zeebodem door de grove korrelgrootte, waarbij een laag van maximaal 23 cm per boring zou ontstaan. Het fijnere boorgruis zou door de eb- en vloedbeweging over een groter gebied worden verspreid. Binnen een straal van 90 m rondom de boorlocatie zou de extra sedimentatie per boring groter zijn dan 1,5 cm in een *worst case*-situatie. Dit sediment zou, afhankelijk van het aantal zware stormen, maanden tot jaren na de boorwerkzaamheden nog aanwezig zijn nabij de platformlocatie. Buiten een straal van 105 m rond het platform zou geen tot een verwaarloosbaar kleine hoeveelheid extra sedimentatie zichtbaar zijn.

Er zal geen sprake zijn van bedekking van prooien van de bruinvis (o.a. juvenielen en larven van de zandspiering en haring) door verhoogde sedimentatie. Bij extreme omstandigheden (bijvoorbeeld storm) is de zandspiering bovendien in staat om zich te verplaatsen of in te graven. Het is daarom aannemelijk dat die soort bij een toename van een aantal centimeter sediment in de directe omgeving van de boorlocatie geen direct effect ondervinden vanwege zijn mobiliteit en aanpassingsvermogen (Tulp et al., 2016). Directe en indirecte significant negatieve effecten van sedimentatie op de bruinvis zijn uit te sluiten.

Licht. De activiteiten ten behoeve van de aanleg van de aanlegsteigers, de offshore activiteiten (heien, boren, zeeleiding en verbindingsleidingen leggen) en de inzet van schepen voor het onderhoud aan de platforms leiden tot een toename in lichtuitstraling en scheepvaart- en helikopterbewegingen. Doordat verlichting op schepen beperkt blijft tot de vereiste navigatieverlichting, wordt ervan uitgegaan dat de toename in lichtuitstraling - en dan met name lichtuitstraling onderwater - zeer beperkt tot nauwelijks toeneemt. Significant negatieve effecten van licht op de bruinvis zijn uit te sluiten.

Beweging en optiek. In het geval van verstoring door aanwezigheid (optische verstoring) is vaak moeilijk onderscheid te maken tussen de verstoring die optreedt door het visueel waarnemen van onder andere schepen, of dat eventueel vluchtgedrag te wijden is aan geluid dat met de scheepvaartbewegingen gepaard gaat. Voor diersoorten die zich boven het wateroppervlak bevinden, zoals watervogels, treedt vaak in eerste instantie optische verstoring op. Hierdoor vermijden deze soorten mogelijk het plangebied voordat geluidsverstoring kan optreden. Omdat geluid verder propageert in water dan in lucht en de bruinvis zich voornamelijk in de waterkolom begeeft, is het voor de bruinvis aannemelijker dat deze in eerste instantie het plangebied verlaten door geluidsverstoring dan door optische verstoring van schepen. Er wordt daarmee niet verwacht dat bruinvissen hinder ondervinden van een toename in scheepvaart- en helikopterbewegingen (RHDHV, 2023b). Effecten van geluid worden hieronder beoordeeld.

Geluid. De beoogde activiteiten in de aanlegfase (boren, heien, baggeren, trenchen en pijpleidingen leggen) leiden tot een verhoogd geluidsniveau binnen het plangebied. Bruinvissen zijn gevoelig voor geluidsverstoringen vanaf 140 dB (Heinis et al., 2019). Op basis van de geluidsverstoringscontouren is voor werkzaamheden waar impulsgeluid bij vrijkomt, waaronder het heien van de conductorpijpen, het centrale eindpunt en de platformverankeringspalen, vastgesteld dat deze overlapt met het leefgebied van de bruinvis (Passende Beoordeling, RHDHV, 2023b).

Omdat zeezoogdieren zoals bruinvissen mobiel zijn en zich verplaatsen binnen én buiten diverse Natura 2000-gebieden, zijn effecten van onderwatergeluid op de gehele populatie in de Noordzee beoordeeld (zie Passende Beoordeling, RHDHV, 2023b). Voor Nederland wordt in het Kader Ecologie en Cumulatie (KEC) 4.0 een maximaal ecologisch toelaatbare reductie van 5% van de Nederlandse populatie bruinvissen gehanteerd, die momenteel wordt geschat op 62.771 individuen op het NCP (Heinis et al., 2022). Op basis van de Interim Population Consequences of Disturbance Model (iPCOD) formule is berekend dat voor de verschillende activiteiten van het Aramis initiatief een range van 10.665 – 18.016 bruinvisverstoringsdagen oplevert, wat resulteert in een populatiereductie van 4,5 – 8,4 bruinvissen (Tabel 5-2). In de berekening wordt uitgegaan van de worst case situatie dat activiteiten met effecten op onderwatergeluid vlak na elkaar

plaatsvinden, waardoor mogelijk tussentijds herstel van de populatie niet wordt verwacht. De populatiereductie die door alle activiteiten met impulsgeluid van het Aramis initiatief tijdens de aanlegfase in de Noordzee plaatsvinden komt neer op maximaal 0,007 tot 0,013% en valt daarmee binnen de maximaal toelaatbare reductie (5%). Voor een gedetailleerde beschrijving van de berekeningen wordt verwezen naar de Passende Beoordeling (RHDHV, 2023b).

Tabel 5-2. Aantal bruinvisverstoringsdagen per activiteit en de totale populatiereductie van alle activiteiten met impulsgeluid opgeteld, berekend uit aantal verstoorde bruinvissen per dag maal het aantal verstoringsdagen en de iPCOD formule.

Activiteit		Aantal dagen voor activiteit	Aantal verstorings-dagen	Verstoord oppervlak in km²	Gemiddelde dichtheid per km² o.b.v. locatie activiteit	Verstoorde dieren per dag	Aantal bruinvis-verstorings-dagen	Populatie-reductie (aantal dieren)
Heien aanlegsteigers fase 1	-	50	51	9	0,81	7,29	372	0,1
Heien aanlegsteigers fase 2	-	50	51	9	0,81	7,29	372	0,1
Heien verankeringspalen nieuwe platforms	Per platform	3	4	610	1,20 – 2,0	732 – 1.220	2.926 – 4.880	1,2 – 2,2
	Totaal [1]	6	8	610	1,20 – 2,0	732 – 1.220	5.853– 9.760	2,7 – 4,9
Heien conductorpijpen nieuwe putten	Per put	0,5	1,5	94	1,20 – 2,0	114 – 188	171 - 376	0,04 - 0,1
	Totaal [2]	7	10	94	1,20 – 2,0	114 – 188	1.140 - 2.632	0,4 - 1,1
Heien centrale eindpunt	-	3	4	610	1,20 – 2,0	732 – 1.220	2.928 – 4.880	1,2 – 2,2
Totaal	-	-	-	-	-	-	10.665 – 18.016	4,5 – 8,4

[1]: In totaal 2 nieuwe platforms; (1) L10-zuid en (2) K14-FA.
[2]: Platform K14-FA; 4-6 nieuwe injectieputten. Platform L10-zuid; 4-6 nieuwe injectieputten. Platform L4-A; 2 nieuwe injectieputten (L4-A3 en L4-A4). Worst-case; 14 nieuwe injectieputten.

Er is geen sprake van permanente gehoorschade (PTS) als gevolg van de werkzaamheden. Verstoring door onderwatergeluid kan echter niet worden uitgesloten, omdat bruinvissen het plangebied voor een langere periode mogelijk zullen mijden door de toename in geluid. Zo is bepaald dat bruinvissen bij het heien van het centrale eindpunt het plangebied kunnen mijden tot op 14 km van de heilocatie (Tabel 5-3). Daarnaast wordt bij het heien van de verankeringspalen voor de platforms en het centrale eindpunt de geluidsnorm (SELss 164 dB re 1µPa2s op 750 m van de heilocatie), zoals gehanteerd in de kavelbesluiten voor het offshore windpark IJmuiden, overschreden met 7 dB (RHDHV, 2023b).

Tabel 5-3. Overzicht berekende effecten PTS en mijding zeezoogdieren en vissen.*

Geluidbron	Diersoort	Drempel PTS SEL in dB re 1 µPa2s	Veilige afstand (m) voor PTS bij verblijf van 3 uur	Drempel mijding SPL in dB re 1 µPa bij verhoogd achtergrondgeluid	Mijding op afstand in m mits verhoogd achtergrondgeluid
Pijpleggen	Bruinvis	173	<10	130	<10
	Zeehond	201	<10	130	2.300
	Vissen	207	<10	150	n.v.t.
Aanleg verbindingsleiding(en) voor de spurlines	Bruinvis	173	<10	130	<10
	Zeehond	201	<10	130	2.300
	Vissen	207	<10	150	n.v.t.
Baggeren	Bruinvis	173	<10	130	<10
	Zeehond	201	<10	130	2.300
Heavy lift schip	Bruinvis	173	<10	130	<10
	Zeehond	201	<10	130	2.300
Injectieputten boren	Bruinvis	173	<100	130	10.000
	Zeehond	201	<100	130	10.000
Machinegeluid (gerelateerd aan werkzaamheden platform)	Bruinvis	173	<100	130	10.000
	Zeehond	201	<100	130	10.000
	Vissen	207	<100	150	n.v.t.
Aanlegsteigers heien	Bruinvis	155	3.000	-	3.300 (Verstoringsoppervlak in haven: 9 km^2)
	Zeehond	185	1.350	-	3.300 (Verstoringsoppervlak in haven: 9 km^2)
Verankeringspalen nieuwe platforms	Bruinvis	-	-	-	13.934
	Zeehond	-	-	-	8.574
Conductorpijpen nieuwe putten	Bruinvis	-	-	-	5.500
	Zeehond	-	-	-	4.100
Heien centrale eindpunt	Bruinvis	-	-	-	13.938
	Zeehond	-	-	-	8.577

**Voor het bepalen en beoordelen van eventuele effecten van heiwerk op zeezoogdieren in de Noordzee sluiten we aan bij het Kader Ecologie en Cumulatie (KEC). In de tbael betreft dat de drie laatstgenoemde geluidbronnen. De bijbehorende gepresenteerde mijdingsafstand is gebaseerd op een geluiddosis (SELSS) en niet op een geluiddrukniveau (SPL), zoals wordt gebruikt voor geluidbronnen die continu van karakter zijn. Verder is PTS in de berekeningen rond KEC niet relevant. Om deze redenen bevat de tabel niet voor alle geluidbronnen gegevens over het aspect PTS en mijding uitgedrukt in SPL.*

De effecten zoals hierboven beschreven hebben alleen betrekking op impulsgeluid. Het verstoorde oppervlak is in werkelijkheid groter, doordat bij veel werkzaamheden zoals het baggeren en leggen van de pijpleiding, het boren of aanpassen van de putten en de benodigde schepen om de platforms aan te leggen continu onderwatergeluid vrijkomt. Ook in de gebruiksfase worden extra schepen ingezet voor onderhoud aan de platforms (circa 325 extra scheepvaartbewegingen).

Kijkende naar de werkzaamheden die rond de platforms in de Noordzee plaatsvinden in de aanlegfase, worden er circa één tot twee jaar achter elkaar, intensief werkzaamheden uitgevoerd. Het is aannemelijk dat bruinvissen het verstoorde gebied voor langere tijd zullen mijden. Dit kan effect hebben op individuele bruinvissen en kan daarnaast de staat van instandhouding op populatieniveau negatief beïnvloeden, omdat:

- Er sprake is van een langere periode waarin verstoring plaatsvindt (één tot twee jaar in de aanlegfase en aansluitend in de gebruiksfase) waardoor een deel van het leefgebied een verminderde foerageerfunctie heeft.
- Activiteiten waar geluid bij vrijkomt mogelijk opeenvolgend of tegelijkertijd plaatsvinden. Doordat de activiteiten op verschillende locaties vlakbij elkaar plaatsvinden, kan dit negatieve invloed hebben op de uitwijkmogelijkheden van bruinvissen.

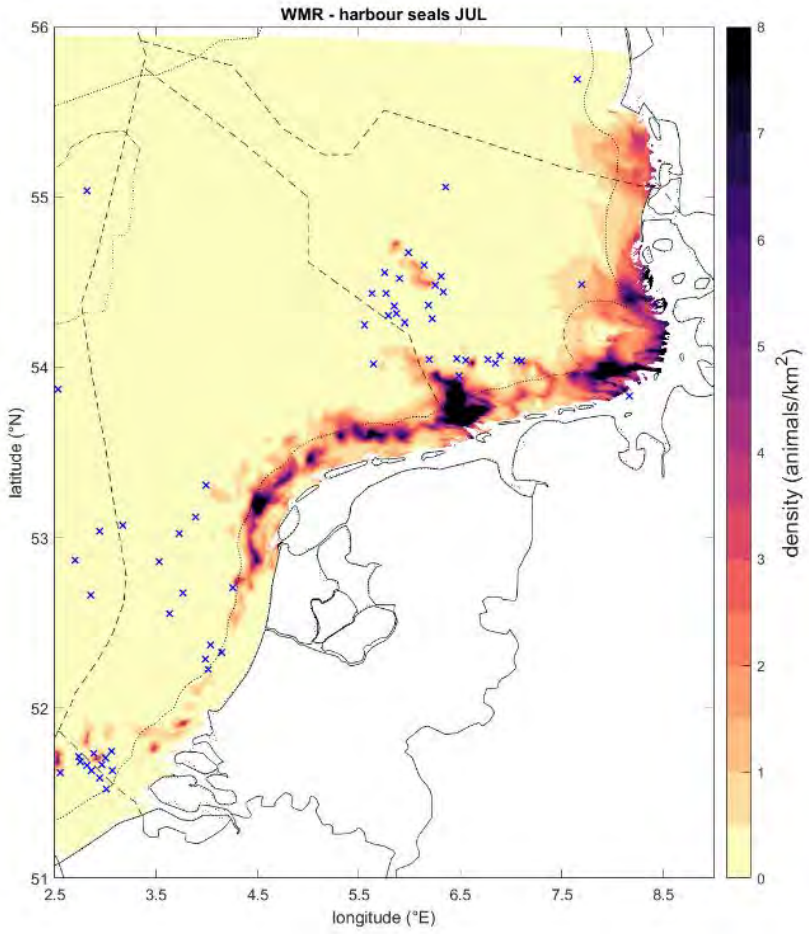
Verstoring van de bruinvis is niet uit te sluiten voor de heiwerkzaamheden (aanlegfase), de inzet van schepen (aanleg- en gebruiksfase) en het gebruik van een Acoustic Deterrent Device (ADD) (aanlegfase). Dit is een overtreding van artikel 11.46 1b van het Bal.

Door het nemen van standaardvoorzieningen zoals een soft start zullen individuen van bruinvissen in het gebied minimaal tot 500 meter van de geluidsbron worden verjaagd. Hierdoor wordt voorkomen dat bruinvissen (gehoor)schade oplopen (Temporary Threshold Shift (TTS) en Permanent Threshold Shift (PTS)). De soft start is onderdeel van het heien en dient ervoor om veel directere negatieve effecten op de soort te voorkomen. De aanvang van een soft start dient niet geïnterpreteerd te worden als opzettelijk verstoring en is daarmee geen overtreding van Bal artikel 11.46 1b van de Ow.

Vervolgstappen
Het feit dat op meerdere locaties in de Noordzee zal worden gewerkt en verspreid over een langere periode met verschillende vormen van verstoring en diverse verstoringsoppervlakten, wijzen uit dat significant negatieve effecten voor de bruinvispopulatie in de Noordzee niet kunnen worden uitgesloten. Voor het verstoren van de bruinvis door de werkzaamheden dient een omgevingsvergunning aangevraagd te worden. Aanvullende mitigatie is nodig om significant negatieve effecten op populatieniveau te kunnen uitsluiten (zie Hoofdstuk 6).

Gewone en grijze zeehond
Voorkomen – Gewone zeehond
De gewone zeehond leeft voornamelijk in getijdengebieden waar plekken aanwezig zijn die bij eb droogvallen (Figuur 5-3). Deze plekken zijn vooral te vinden langs zandige kusten en rotskusten, maar ook op met wier bedekte riffen, kiezelsteenstranden, zandplaten en stenen. Ze hebben een sterke voorkeur voor rustige plekken, zonder menselijke aanwezigheid. Tijdens hoog water zwemmen gewone zeehonden naar andere (diepere) delen om te foerageren. Hierdoor kunnen ze ook in het plangebied op open zee voorkomen, hetzij minder frequent dan in de kustzone. Een enkele keer komt een gewone zeehond (tijdelijk) voor bij riviermondingen of zelfs in (zoete) binnenwateren (Zoogdiervereniging, n.d.). Individuen van de gewone zeehond kunnen het plangebied passeren.

Het is bekend dat gewone zeehonden rusten en mogelijk ook jongen krijgen op de strandjes (bij o.a. Edison Baai) in de buurt van de Maasvlakte (Bijlage 1; Hoekstein et al., 2022). Ook de zandplaat Noorderhaaks die vlakbij de haven van Den Helder is gelegen, wordt veel door zeehonden gebruikt om te rusten, pups te zogen en te verharen.



Figuur 5-3. Gemiddelde populatiedistributie van de gewone zeehond op het Nederlands Continentaal Plat in juli op basis van Aarts (2021). Verkregen uit Heinis et al. (2022).

Voorkomen – Grijze zeehond

De grijze zeehond komt voor langs de oostelijke en westelijke kusten van de Atlantische oceaan. De grijze zeehond foerageert op zee, vooral op platvissen. Grijze zeehonden krijgen hun jongen in de periode november tot en met februari op droogblijvende platen of stranden. De pups van grijze zeehond kunnen in tegenstelling tot de pups van gewone zeehond niet direct zwemmen na hun geboorte. De grijze zeehond verhaart in de periode maart-april. Ook in deze periode zijn ze gebonden aan permanent droogliggende platen, stranden en duinen.

Een deel van het plangebied op open zee kan door zeehonden worden gebruikt om te foerageren. Grijze zeehonden kunnen tot ver uit de kust zoeken naar voedsel (Ministerie van Economische Zaken, 2014b). Daarnaast kunnen individuen van de gewone zeehond mogelijk passerend voorkomen in het plangebied. Het is bekend dat gewone zeehonden rusten en mogelijk ook jongen krijgen op de strandjes (bij o.a. Edison Baai) rondom de Tweede Maasvlakte (Bijlage 1; Hoekstein et al., 2022). Ook de zandplaat Noorderhaaks die vlakbij de haven van Den Helder is gelegen, wordt veel door zeehonden gebruikt om te rusten, pups te zogen en te verharen.

Effectbeoordeling

Oppervlakteverlies. Ter plekke van de heilocaties, de putten en het leidingtracé zal de zeebodem vergraven worden en tijdelijk of permanent ongeschikt zijn als leefgebied voor bodembewonende soorten die als prooi voor zeehonden kunnen dienen. In de aanlegfase betreft dit voornamelijk het tijdelijke effect voor de aanleg van de leidingen. Voor de aanleg van de nearshore zeeleiding wordt met behulp van een trencher een gleuf gegraven van maximaal twee m diep, zes m breed aan de bovenkant van de gleuf en twee m breed aan de onderkant van de gleuf. Het gaat om de eerste 70 kilometer vanaf de kruising met de Maasgeul waar de

zeeleiding wordt ingegraven in de zeebodem, met een dekking van circa één meter. Na de aanlegfase zal de zeebodem ter plekke van de leidingen en overige tijdelijk aangetaste waterbodem zich weer herstellen. Het gaat om een tijdelijk oppervlakteverlies.

De aanleg van de zeeleiding *op* de zeebodem betreft een permanent oppervlakteverlies. Het permanente effect betreft ter plekke van de constructies circa tien ha op de zeebodem (RHDHV, 2023b). Sommige soorten zullen al vrijwel meteen weer gebruik maken van het verstoorde gebied, herstel van met name langzaam groeiende sessiele soorten kan jaren duren. Voor de zeehond is het vooral van belang dat prooidieren al snel na de aanlegfase weer gebruik kunnen maken van het verstoorde gebied, omdat het mobiele vissoorten betreft. Voor de zeehond zal het verstoorde gebied dus waarschijnlijk al na enkele dagen of weken weer op een vergelijkbare manier als voor de ingreep bruikbaar zijn als foerageergebied. Significant negatieve effecten van oppervlakteverlies zijn uit te sluiten.

Licht. De activiteiten ten behoeve van de aanleg van de aanlegsteigers, de offshore activiteiten (heien, boren, zeeleiding en verbindingsleidingen leggen) en de inzet van schepen voor het onderhoud aan de platforms leiden tot een toename in lichtuitstraling en scheepvaart- en helikopterbewegingen. Lichtverstoring is met name relevant voor zeehonden die zich boven het water bevinden op ligplaatsen. In de Voordelta zijn verschillende ligplaatsen van volwassen zeehonden aanwezig. Zeehonden zijn gevoelig voor verstoring op hun ligplaatsen en in hun foerageergebied. Verstoring leidt in eerste instantie tot een verhoogde alertheid. Langdurige verstoring kan leiden tot een verandering van het gebruik van het leefgebied, of tot het verlaten van het gebied (Reijnders et al., 2000). Over specifieke effecten van licht op rustende zeehonden is weinig bekend. Wel is bekend dat zeehonden over het algemeen erg gevoelig zijn voor (kunstmatige) verlichting. Gelet op de aanwezigheid van een aantal zeehonden op de strandjes van het noordelijke deel van de Voordelta en de hoge lichtemissie op de Maasvlakte, kan er vanuit worden gegaan dat bij de in het gebied aanwezige zeehonden gewenning is opgetreden ten aanzien van de aanwezigheid van kunstlicht. De extra lichtuitstraling door de inzet van constructieschepen in de Voordelta is minimaal in vergelijking met de achtergrondverlichting en bovendien tijdelijk, waardoor verstorende effecten op rustende zeehonden in de buurt van de Maasvlakte kunnen worden uitgesloten.

Rustende of zogende zeehonden op Noorderhaaks kunnen mogelijk verstoord raken door lichtuitstraling van uitvarende schepen die de haven van Den Helder uitvaren en de Noordzeekustzone doorkruisen. Vanuit het havengebied van Den Helder zullen ten behoeve van het Aramis initiatief maximaal 2.064 extra scheepvaartbewegingen plaatsvinden in de aanlegfase in één-twee jaar (maximale toename van 128% t.o.v. huidige scheepvaart Den Helder). De toename in scheepvaart kan leiden tot verstoring van rustende of zogende zeehonden op Noorderhaaks. In een studie van Bouma et al. (2010) bleek echter dat de 41 onderzochte passages van baggerschepen langs Noorderhaaks niet leidden tot gedragsveranderingen van rustende zeehonden. De afstanden tussen de ligplaatsen van de zeehonden en de schepen die werden onderzocht lagen tussen de 600 en 1.200 m, wat vergelijkbaar is met de afstanden tussen de schepen van het Aramis initiatief en de ligplaatsen van de zeehonden op Noorderhaaks. Het wordt daarom niet verwacht dat de zeehonden op Noorderhaaks hun ligplaatsen zullen verlaten als gevolg van de toename in scheepvaartverkeer. Bovendien vinden er in het gebied tussen Den Helder en Texel veel menselijke activiteiten plaats, waardoor de zeehonden waarschijnlijk door gewenning minder gevoelig zijn voor verstoring dan in andere gebieden waar geen of in beperkte mate menselijke activiteiten plaatsvinden. Zeehonden op Noorderhaaks zullen geen hinder ondervinden van lichtuitstraling als gevolg van dit project.

Beweging en optiek. Zeehonden zijn ook gevoelig voor verstoring door beweging van objecten en personen. De aanwezigheid van de zeehonden in de buurt van de drukbevaren routes zijn een indicatie van gewenning waarbij zeehonden ook bij verstoring de rustplekken bij de Tweede Maasvlakte blijven benutten. Door de spreiding van de extra scheepvaartbewegingen over een lange periode en de minimale toename van scheepvaartbewegingen (maximaal 80 in de aanlegfase) ten opzichte van het huidige drukbevaren verkeersbeeld in de haven van Rotterdam kunnen effecten door bewegingen van voorbijgaande schepen worden uitgesloten. Er zal ook geen sprake van optische verstoring van rustende, zogende en foeragerende zeehonden op of nabij Noorderhaaks in de kustzone. Zeehonden zijn door gewenning hoogstwaarschijnlijk minder gevoelig voor verstoring door schepen (zie *Effecten van licht*). Zeehonden zullen geen hinder ondervinden van een toename in scheepvaart- en helikopterbewegingen als gevolg van dit project.

Vertroebeling. Bij het baggeren en trenchen kan vertroebeling optreden. Zeezoogdieren vestigen zich over het algemeen vaker in troebele wateren en veel soorten gebruiken goedontwikkelde sonarsystemen om de omgeving te verkennen (Au et al., 2000). De studie van McConnell et al. (1999) toonde aan dat er geen verschil in foerageergedrag bestond tussen één blinde en verschillende niet-blinde grijze zeehonden in de Noordzee. Deze resultaten wijzen erop dat zicht niet essentieel is voor overleving van zeehonden of de mogelijkheid tot foerageren. Het is dus niet te verwachten dat vertroebeling van het water de zeehonden beïnvloedt in het vangen van hun prooi; ook blinde dieren kunnen zich doorgaans goed in het wild redden (Brasseur, 2007). Indirecte effecten van vertroebeling op zeezoogdieren zijn complex om te definiëren. In de literatuur wordt benoemd dat baggeren over het algemeen resulteert in verminderde biomassa, soortenrijkdom en soortendiversiteit van prooien, afhankelijk van de omgeving en het tijdsverloop van de activiteit. Zeezoogdieren zijn echter in staat om te compenseren voor kleinschalige veranderingen in de aanwezigheid van prooien. Dit doen ze door (tijdelijk) over te gaan op andere prooisoorten, zich te verplaatsen naar alternatieve foerageergebieden of de foerageertijd te verlengen (Todd et al., 2015). Significant negatieve effecten van vertroebeling op de zeehond zijn uitgesloten.

Sedimentatie. De werkzaamheden zorgen voor sedimenten in de waterkolom die vervolgens op de bodem neerslaan en daar een sedimentlaagje vormen. Door de aanleg van de nearshore zeeleiding (tot 70 km vanaf de doorkruising van de Maasgeul) treedt sedimentatie op met een maximale sedimentatie waarde van 0,20 mm aan weerszijden van de leiding (zie Detailrapport zeebodem, RHDHV, 2023a). Ook bij de lozing van boorgruis kan sedimentatie optreden. Op basis van een modelstudie van de lozing van boorgruis van twaalf putten bij platform N05-A (Royal HaskoningDHV, 2020) is een inschatting gemaakt van de verspreiding van het boorgruis op de boorlocatie van de nieuwe putten van het Aramis initiatief. Uit de modelstudie van N05-A bleek dat het meeste sediment van het boorgruis direct zou vallen onder het boorplatform op de zeebodem door de grove korrelgrootte, waarbij een laag van maximaal 23 cm per boring zou ontstaan. Bij de twaalf boringen zou de extra sedimentatie binnen een straal van 105 m rond het platform groter dan 1,5 cm zijn. Daarbuiten zou geen tot een verwaarloosbaar kleine hoeveelheid extra sedimentatie zichtbaar.

De grijze en gewone zeehond eten met name vis, zoals zandspiering en haring. Haring is een mobiele pelagische soort die zich eenvoudig kan verplaatsen bij verstoring. De zandspiering is een rondvis die zowel pelagisch als nabij de bodem voorkomt. De soort paait op zandige bodems, maar ook op fijn grind (tussen 0.35-1.3 mm). Het paaien gebeurt bij voorkeur langs de randen van grote zandbanken en op toppen van kleine zandbanken, met een stroomsnelheid van ongeveer één m/s. De eieren worden in de bodem gelegd (Wright et al., 2000). Paai- en opgroeigebieden kunnen schade ondervinden van bodemberoering en/of sedimentatie. Bij extreme omstandigheden (bijvoorbeeld storm) is de zandspiering echter in staat om zich te verplaatsen of in te graven; de soort zal dus bij een toename van een aantal millimeters sediment geen direct effect ondervinden vanwege zijn mobiliteit (Tulp et al., 2016). Zeezoogdieren zijn bovendien in staat om te compenseren voor kleinschalige veranderingen in de aanwezigheid van prooien. Dit doen ze door (tijdelijk) over te gaan op andere prooisoorten, zich te verplaatsen naar alternatieve foerageergebieden of de foerageertijd te verlengen (Todd et al., 2015). Significant negatieve effecten door sedimentatie zijn uit te sluiten.

Geluid. De beoogde activiteiten (boren, heien, baggeren, trenchen en pijpleidingen leggen) leiden tot een verhoogd geluidsniveau binnen het plangebied. Impulsgeluid kan mogelijk fysieke of fysiologische effecten veroorzaken, bestaande uit tijdelijke- of permanente gehoordrempelverschuiving en in het ergste geval verwondingen. Hoe dichter zeezoogdieren zich bevinden bij de geluidsbron, hoe groter de verstoring zal zijn, waarbij permanente gehoorschade (PTS) het meest ingrijpende effect is, daarna tijdelijke gehoordrempelverschuiving (TTS) en vermijding en gedragsverandering. Fysieke schade zoals PTS en TTS worden niet verwacht door de inzet van een soft start procedure bij het heien die in het standaard werkprotocol wordt opgenomen.

De verstoringsoppervlakten voor zeehonden variëren per activiteit tussen de 54 en 314 km² (zie voor meer details de Passende Beoordeling, RHDHV, 2023b). De percentages van verstoorde zeehonden in Tabel 5-4 geven een indicatie weer van de verstoring, maar zijn niet goed bij elkaar op te tellen. In de praktijk zijn de dichtheden op open zee lager en is het aannemelijk dat individuen meermaals worden verstoord door dezelfde of verschillende activiteiten. Ervan uitgaande dat activiteiten kort na elkaar uitgevoerd gaan worden, zullen zeehonden het gebied voor een langere periode mijden. Aangezien de werkzaamheden één

tot twee jaar zullen duren, kan de mijdingsperiode ook oplopen tot een vergelijkbare periode. Dit is het worst-case scenario. Het is namelijk ook mogelijk dat ook hier gewenning optreedt en de effecten veel beperkter zullen uitvallen.

Tabel 5-4. Percentages verstoorde gewone en grijze zeehonden ten gevolge van de voorgenomen activiteiten.

Activiteit		Gewone zeehonden		Grijze zeehonden	
		Totale Nederlandse populatie	Verstoorde dieren (%)	Totale Nederlandse populatie	Verstoorde dieren (%)
Injectieputten boren	Per put	9.245	1,96	8.038	1,70
	Totaal [1]	9.245	27,38	8.038	23,78
Heien verankeringspalen nieuwe platforms	Per verankeringspaal	9.245	1,43	8.038	1,24
	Totaal [2]	9.245	11,46	8.038	9,95
Heien conductorpijpen nieuwe putten	Per put	9.245	0,34	8.038	0,29
	Totaal [1]	9.245	4,71	8.038	4,09
Heien centrale eindpunt	-	9.245	1,43	8.038	1,24

[1]: Platform K14-FA; 4-6 nieuwe injectieputten. Platform L10-zuid; 4-6 nieuwe injectieputten. Platform L4-A; 2 nieuwe injectieputten (L4-A3 en L4-A4). Worst-case; 12-14 nieuwe injectieputten.
[2]: In totaal 2 nieuwe platforms; (1) L10-zuid en (2) K14-FA.

Het plangebied op open zee kan door zeehonden gebruikt worden om te foerageren. Grijze zeehonden kunnen tot ver uit de kust zoeken naar voedsel (Ministerie van Economische Zaken, 2014a). Het foerageergebied neemt door de verstoring daarom mogelijk af. Er zijn anderzijds voldoende uitwijkmogelijkheden voor gewone en grijze zeehonden om te foerageren. Daarbij zijn de nabijgelegen gebieden Noordzeekustzone en de Waddenzee belangrijkere gebieden voor de gewone zeehond en grijze zeehond dan de open zee (Aarts, 2021; Aarts et al., 2016, Figuur 5-3), anders dan voor bruinvissen. Door de activiteiten wordt er daarom geen essentieel foerageergebied van de grijze of gewone zeehond aangetast op zee.

Op basis van een geluidscontour van de voorgenomen hei-activiteiten is vastgesteld dat er gedurende de uitvoering geen overlap is met de rustplaatsen van zeehonden in de Voordelta of andere gebieden op de Noordzee. Wel kunnen zeehonden die rusten, pups zogen of foerageren in de kustzone mogelijk verstoord raken door het geluid van de schepen die worden ingezet voor het Aramis initiatief. Een deel van de schepen van het Aramis initiatief zal via de scheepvaartroute de Noordzeekustzone doorkruisen (maximaal 2.064 extra schepen, toename van maximaal 128% t.o.v. huidige verkeersbeeld scheepvaart), waardoor een direct effect van geluid kan optreden. De zandplaat Noorderhaaks wordt veel door zeehonden gebruikt om te rusten, pups te zogen en te verharen. Daarbij is het belangrijk dat ze in de buurt van de plaat kunnen foerageren. De wateren nabij Noorderhaaks zijn essentieel foerageergebied.

Alhoewel het gaat om een drukke scheepvaartroute waar de schepen van het Aramis initiatief doorheen zullen varen, is de mogelijke toename in onderwatergeluid heel groot. Dit betekent dat extra geluidsverstoring kan optreden en de periode dat ze kunnen foerageren nabij Noorderhaaks wordt verkleind. Essentieel foerageergebied gaat hiermee tijdelijk verloren. Daarbij zal de toename in onderwatergeluid door de inzet van schepen in de aanlegfase voor een langere periode van één-twee jaar aanwezig zijn, wat betekent dat de zeehonden voor een langere periode worden verstoord. Ook in de gebruiksfase worden extra schepen ingezet, waardoor de werkelijke periode waarin geluidsverstoring optreedt langer is dan één-twee jaar.

Verstoring van de rust- en voortplantingsplaats van de gewone en grijze zeehond op en nabij Noorderhaaks is niet uit te sluiten. Dit is een overtreding van artikel 11.54 1b van het Bal.

Vervolgstappen
Voor het verstoren van de rust- en voortplantingsplaats van de gewone en grijze zeehond door de inzet van extra schepen dient een omgevingsvergunning aangevraagd te worden. Aanvullende mitigatie is nodig om significant negatieve effecten op populatieniveau te kunnen uitsluiten (zie Hoofdstuk 6).

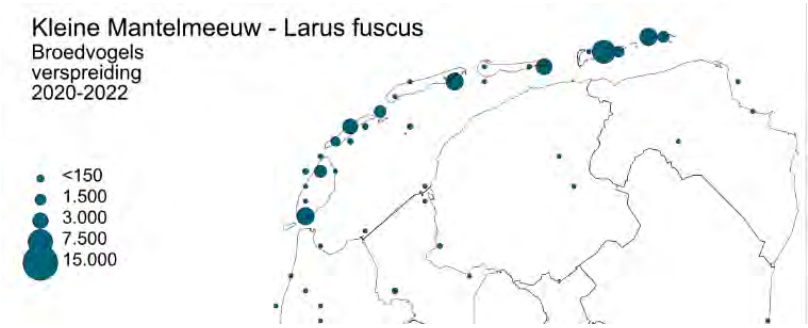
5.2.3 Vogels

Voorkomen
Vogels kunnen op verschillende manieren gebruikmaken van het plangebied: als broedlocatie, plek om te foerageren of om te rusten.

Voor algemeen voorkomende vogels als de drieteenmeeuw (*Rissa tridactyla*) geldt bijvoorbeeld dat ze op installaties of constructies kunnen broeden (Camphuysen & Leopold, 2007; Christensen-Dalsgaard et al., 2019). Drieteenmeeuwen nestelen al vanaf het jaar 2000 op enkele olieplatforms in de Zuidelijke Noordzee (Camphuysen & De Vreeze, 2005). Het broedseizoen valt voor de drieteenmeeuw doorgaans tussen midden-mei en augustus. Uit de voorbereidende milieusurvey van Fugro blijkt dat in de periode van 11 juli 2022 t/m 24 januari 2023 in totaal 388 drieteenmeeuwen zijn waargenomen op het Aramis traject (doorkruising Maasgeul, tracé zeeleiding, putten, platforms) op 249 verschillende telmomenten (Figuur 5-7). Drieteenmeeuwen zijn voornamelijk waargenomen ter hoogte van het tracé van de nearshore zeeleiding. Meer noordelijk – ter hoogte van de (beoogde) locatie van de bestaande en nieuw-te-realiseren platforms – zijn drieteenmeeuwen in kleinere aantallen waargenomen (maximaal zeven per telmoment). Drieteenmeeuwen kunnen broedend voorkomen op het bestaande platform L4-A.

In de periode van 11 juli 2022 t/m 24 januari 2023 is de zeekoet (*Uria aalge*) in totaal 560 keer waargenomen in het plangebied en de daarvan in de buurt gelegen gebieden (Fugro, 2023). In de nabijheid is een vaste rustplaats aanwezig van de zeekoet, waar de vogels ronddobberen op het water (Friese Front). Kenmerkend voor de zeekoet is het gebruik van het Friese Front door ruiende mannetjes met hun jongen in de nazomer. De afstand tot de kust, en daarmee de relatieve rust, in combinatie met het hoge voedselaanbod maakt het Friese Front een aantrekkelijk rust- en foerageergebied voor de zeekoet. De zeekoet kan voorkomen in het plangebied en omliggende gebieden op zee.

De kleine mantelmeeuw (*Larus fuscus*) broedt in alle landen rondom de Noordzee. De kleine mantelmeeuw is een koloniebroeder. De grootste kolonies in Nederland bevinden zich in het Deltagebied en de Waddeneilanden. Op ieder Waddeneiland wordt gebroed, zo ook op de zuidelijke punt van Texel, in de buurt van het plangebied (Sovon, n.d.-a) (Figuur 5-4). De nesten kunnen zich in verschillende habitats bevinden zoals open duin, schorren/kwelders, industriegebieden, opspuitterreinen en eilandjes in afgesloten zeearmen (Ministerie van LNV, 2008b). De kleine mantelmeeuw foerageert op zee op vis, en richt zich voornamelijk op visafval achter boten. Het is bekend dat ze foerageren tot op vele tientallen kilometers afstand van de broedkolonie, en zelfs afstanden tot 200 km zijn ook bekend (Ministerie van LNV, 2008b). Tussen maart en mei trekken de kleine mantelmeeuwen richting de Nederlandse broedgebieden, de broedtijd start rond eind april. (Vogelbescherming, n.d.-b). De kleine mantelmeeuw is een zomergast op de Noordzee, tijdens de winter is deze soort minimaal aanwezig. In augustus komt de kleine mantelmeeuw voor op bijna het hele NCP, met uitzondering van het meest noordelijke gebied (Fijn et al., 2022). De broedvogel kleine mantelmeeuw kan foeragerend voorkomen in het plangebied op zee. Ook broedt de kleine mantelmeeuw in de kustzone waar in de buurt schepen uitvaren vanuit de haven van Den Helder.



Figuur 5-4. Verspreiding van de kleine mantelmeeuw als broedvogel op de Waddeneilanden in 2020-2020 (www.sovon.nl).

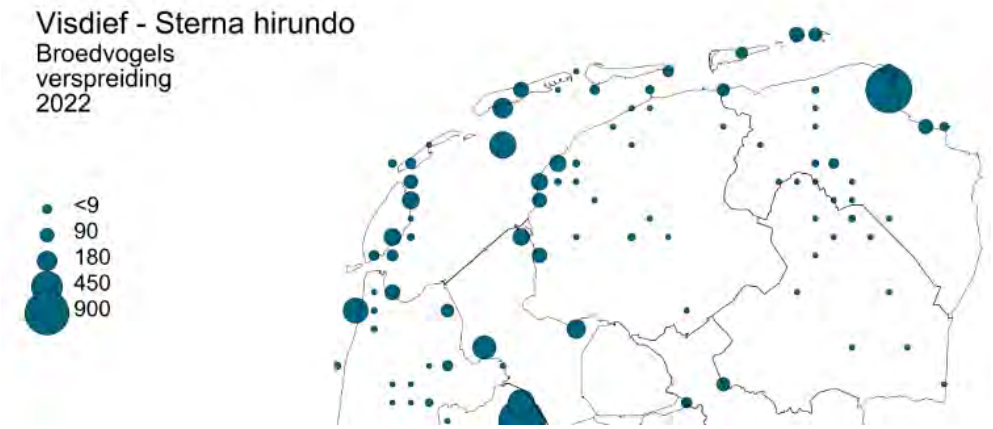
De grote stern (*Thalasseus sandvicensis*) is eveneens een koloniebroeder in alle landen rondom de Noordzee. De omvang van de kolonies is groot, er komen slechts een klein aantal van deze kolonies voor in Nederland. De broedkolonies bevinden zich voornamelijk in het Deltagebied en op de Waddeneilanden. In het Waddengebied wordt voornamelijk gebroed op Texel, een grote kolonie bevindt zich op de zuidelijke punt (Figuur 5-5) (Fijn et al., 2021). De broedkolonies bevinden zich voornamelijk op kale of schaarsbegroeide eilanden. Vaak bevat het broedgebied randbegroeiing, dit gebruiken de kuikens als schuilplaats. De broed start rond eind april en begin mei. Er wordt gefoerageerd in de kustzone van de Noordzee en in geulen in de Waddenzee. De grote stern voedt zich voornamelijk met vis, bij voorkeur op een afstand tussen 15 – 40 km van de nestplaats (Ministerie van LNV, 2008a). Er wordt echter ook op ruime afstand van de broedkolonie vis gevangen; soms ver op zee (Vogelbescherming, n.d.-c). In het rapport van Fijn et al. (2022) wordt gerapporteerd dat bij monitoringsvluchten tot ruim 100 km uit de kust trekkende grote sterns werden waargenomen op het NCP, maar daarbuiten vrijwel niet meer. De broedvogel grote stern kan foeragerend voorkomen in het plangebied op zee. Ook broedt de grote stern in de kustzone waar in de buurt schepen uitvaren vanuit de haven van Den Helder.



Figuur 5-5. Verspreiding van de broedvogel grote stern in het Waddengebied in 2022 (www.sovon.nl).

De visdief (*Sterna hirundo*) is ook een koloniebroeder. Het broedhabitat omvat rustige, schaars begroeide plekken nabij visrijke wateren langs de kust. Ook langs de binnenwateren wordt door de visdief gebroed. Bij voorkeur wordt op plaatsen gebroed die niet toegankelijk zijn voor grondpredatoren (Vogelbescherming, n.d.-a). Er bevinden zich verschillende broedkolonies op de Waddeneilanden, zo ook op Texel nabij het plangebied (Sovon, n.d.-b) (Figuur 5-6). De visdief eet kleine vissen, deze worden meestal gevangen op 5-10 km afstand van de kolonie. Soms zoekt de visdief zijn prooi op meer dan 30 km van de broedplaats (Ministerie van LNV, 2008c). De visdief broedt in Nederland meestal vanaf mei tot begin juni. Vanaf begin juli vertrekken groepen visdief richting het zuiden, ze volgen hierbij graag de kustroute (Vogelbescherming, n.d.-a). De visdief is het talrijkst in de kustzone, maar is ook aanwezig op andere delen van het NCP. De visdief trekt in augustus weg van de Noordzee. Er werden grote getallen visdief waargenomen ten noordwesten van de Waddeneilanden. De afstand tot de kust was hierbij meer dan 100 km (Fijn et al.,

2022). De broedvogel visdief kan foeragerend voorkomen in het plangebied op zee. Ook broedt de visdief in de kustzone waar in de buurt schepen uitvaren vanuit de haven van Den Helder.



Figuur 5-6. Verspreiding van de broedvogels visdief in het Waddengebied in 2022 (www.sovon.nl).

Effectbeoordeling

Licht en optische verstoring. De schepen die worden ingezet bij de aanleg van de nearshore zeeleiding en de aanleg van het tunnelwerk (microtunneling of direct piping) stralen licht uit. Ook het uitvaren van schepen vanuit de haven van Den Helder kan effect hebben op de broedvogels kleine mantelmeeuw, grote stern en visdief. Verstoring door licht en beweging kan leiden tot gedragsverandering van vogels. Lichtuitstraling en beweging treden meestal gelijktijdig op en zodoende kunnen deze doorgaans als één verstoringsbron worden beschouwd. Om deze reden worden de effecten van licht en beweging door de inzet van schepen als één verstoringsbron beoordeeld voor vogels.

Fliessbach et al. (2019) deden onderzoek naar de response van 26 zeevogels in de Duitse Noordzee en Baltische Zee op verstoring door schepen. Op basis van de indicatoren ‘soorten schuwheid’, ‘energiekosten voor vluchten’, ‘potentieel voor uitwijken’ werd als onderdeel van het onderzoek een Disturbance Vulnerability Index (Verstoringsgevoeligheidsindex; DVI) berekend. Een score dichtbij 0 betekent dat de vogel niet gevoelig is voor verstoring door schepen, terwijl een score van 100 een grote gevoeligheid weergeeft. De drieteenmeeuw (DVI-score: 9.3), kleine mantelmeeuw (DVI-score: 6.7), visdief (DVI-score: 3.9), grote stern (DVI-score: 6.7) en zeekoet (DVI-score: 19.5) zijn niet erg gevoelig voor verstoring door scheepvaart. Er is geen sprake van een effect op de overleving of voortplanting van deze vogelsoorten als gevolg van de projectgerelateerde scheepvaart.

De drieteenmeeuw kan daarnaast worden verstoord door beweging en licht als gevolg van de werkzaamheden aan platform L4-A. Er is weinig informatie beschikbaar over de mate waarin een drieteenmeeuw die op een platform broedt verstoring ervaart. Het is wel bekend dat de drieteenmeeuwen op platforms waarschijnlijk nestlocaties kiezen met minder verstoring door mensen (Thompson, 2021). In relatie tot recreatie wordt de verstoringsgevoeligheid van de drieteenmeeuw beschreven als klasse ‘middelgroot’ met een geschatte vluchtafstand van 250 m. Na verstoring is de drieteenmeeuw redelijk snel terug op zijn oorspronkelijke verblijfplaats (Krijgsveld et al., 2022). Omdat de drieteenmeeuw die broedt op een platform gewend is aan lichtuitstraling en beweging op platforms en de soort redelijk snel terugkeert na verstoring, zijn significant negatieve effecten van licht en beweging op de drieteenmeeuw uit te sluiten.

Vertroebeling en sedimentatie. Vertroebeling en sedimentatie kan ontstaan door de lozing van boorgruis en bagger- en trenchactiviteiten.

Uit onderzoek naar Texelse kleine mantelmeeuwen bleek dat het dieet van de kleine mantelmeeuw een sterke binding had met commerciële visserij, natuurlijke prooidieren op afstand van vissersschepen werden vermoedelijk vooral binnen de 20 meter dieptelijn opgepikt van het wateroppervlak (Camphuysen et al., 2008). Omdat de kleine mantelmeeuw voornamelijk vis en zwemkrabben oppikt van het wateroppervlak, zal vertroebeling en sedimentatie in de waterkolom geen grote rol spelen in het foerageersucces. Significant

negatieve indirecte en directe effecten van sedimentatie en vertroebeling op de kleine mantelmeeuw zijn uitgesloten.

Duikende vogels zoals de grote stern, visdief en zeekoet daarentegen kunnen duiken tot dieptes waar vertroebeling voorkomt. Wanneer deze soorten duiken in water waar de troebele pluim aanwezig is, kan dit leiden tot een verminderd vangsucces. Uit een studie van grote sterns die foerageren in de broedtijd nabij de kolonie van De Petten op Texel bleek dat bij de optimale zichtdiepte van ongeveer 1,75 meter de kans op vangen van prooivis ongeveer 60% is. Wanneer het zicht vermindert naar 0,4 meter is deze kans ongeveer 30% (Baptist & Leopold, 2007). In de Westerschelde bleek uit onderzoek dat de visdief een significant hoger vis- en foerageersucces heeft in water met een doorzicht van meer dan 180 cm (Brenninkmeijer et al., 2002). Zicht is hiermee een belangrijk zintuig voor de grote stern en visdief in het vangen van prooien. Door vertroebeling kan het foerageersucces van de broedvogels afnemen.

Zeekoeten eten vooral rondvis, maar ook incidenteel platvis, inktvis, borstelwormen en kleine kreeftachtigen, die ze duikend vangen (Ministerie van LNV, 2008d). Daardoor kan de zeekoet ook een negatief effect ervaren door vertroebeling en sedimentatie. Het verstoringsoppervlak door de lozing van boorgruis bij de putten van platforms L4-A en L10-zuid is echter dermate beperkt in oppervlakte (in een straal van 150 m om de put, 70.685 m^2 verstoringsoppervlak per put) dat er genoeg areaal overblijft voor de duikende vogels om te foerageren. Dit betekent dat minder dan 0,1% van het NCP tijdelijk wordt beïnvloed als gevolg van sedimentatie. De verstoring door vertroebeling is per locatie bovendien van korte duur. Significant negatieve indirecte en directe effecten van sedimentatie en vertroebeling op de broedvogels zijn uitgesloten.

Geluid. Tijdens de verschillende fases van de voorgenomen activiteit wordt geluid geproduceerd door de inzet van schepen en helikopters, het heien van conductors en het boren van putten.

Helikopters zorgen van alle soorten vliegverkeer voor de grootste mate van verstoring van vogels, dit heeft te maken met de grote hoeveelheid lawaai die ze maken, en omdat ze relatief laag vliegen en relatief langzaam vliegen (Krijgsveld et al., 2008). Recentelijk werd de akoestische ecologie van de zeekoet onderzocht, hierbij is gevonden dat de frequenties van het gehoor en de vocalisatie van de zeekoet overlappen met veel antropogene geluidsbronnen, wat aangeeft dat de soort gevoelig is voor verstoring door een scala aan geluidstypen (Smith et al., 2023). Deze overlap omvat, in verschillende mate; geluidsbronnen in de lucht zoals verkeerslawaai, menselijke spraak en vliegtuigen die overvliegen.

Hoe snel de geluid producerende verstoringsbron zich verplaatst en de voorspelbaarheid van de route is van invloed op de mate van verstoring. Omdat bijvoorbeeld een vliegtuig het gebied sneller weer verlaten heeft, reageren vogels weliswaar eerder op een vliegtuig dan op een schip, maar is de verstoring in het algemeen van kortere duur (Krijgsveld et al., 2008). Wanneer het geluid een bepaalde mate van voorspelbaarheid heeft en de vogels het niet als een bedreiging ervaren, dan is het te verwachten dat er gewenning optreedt. Zolang helikopters en schepen vooral gebruik maken van vaste vlieg- en vaarroutes, worden er daarom geen significant negatieve effecten van helikopter- en scheepvaartgeluid op vogels verwacht.

Het heien van de conductors van de putten, het boren van de putten en het heien van de verankeringspalen van de platforms leidt tot impulsief onderwatergeluid. De zeekoet is in de ruiperiode (juli-augustus) gevoelig voor dit type verstoring, omdat de soort dan niet kan vliegen en minder mobiel is. Met name de toename in impulsief onderwatergeluid door heiwerkzaamheden kan verstorende effecten hebben op deze duikende soort (Anderson Hansen et al., 2020). Het rust- en foerageergebied van de zeekoet is echter groot genoeg voor de zeekoet om te zwemmen naar alternatief gebied (oppervlakte Friese Front; circa 2.880 km^2). Bovendien is bekend van de zeekoet dat hij platforms vermijdt, wat betekent dat er geen grote groepen zeekoeten in de buurt van de platforms aanwezig zullen zijn. De enkele zeekoeten die wel voorkomen binnen de verstoringscontouren van de heiwerkzaamheden, kunnen tijdig wegzwemmen naar alternatief gebied dankzij de inzet van een soft start bij de heiwerkzaamheden. De jongen van de zeekoet zijn eveneens in staat om weg te zwemmen van de verstoringsbron. Ook de broedvogels kleine mantelmeeuw, visdief en grote stern kunnen tijdens foerageertrips op open zee uitwijken naar alternatief foerageergebied bij verstoring door hei- en boorwerkzaamheden. De overleving en voortplanting van de zeekoet, kleine

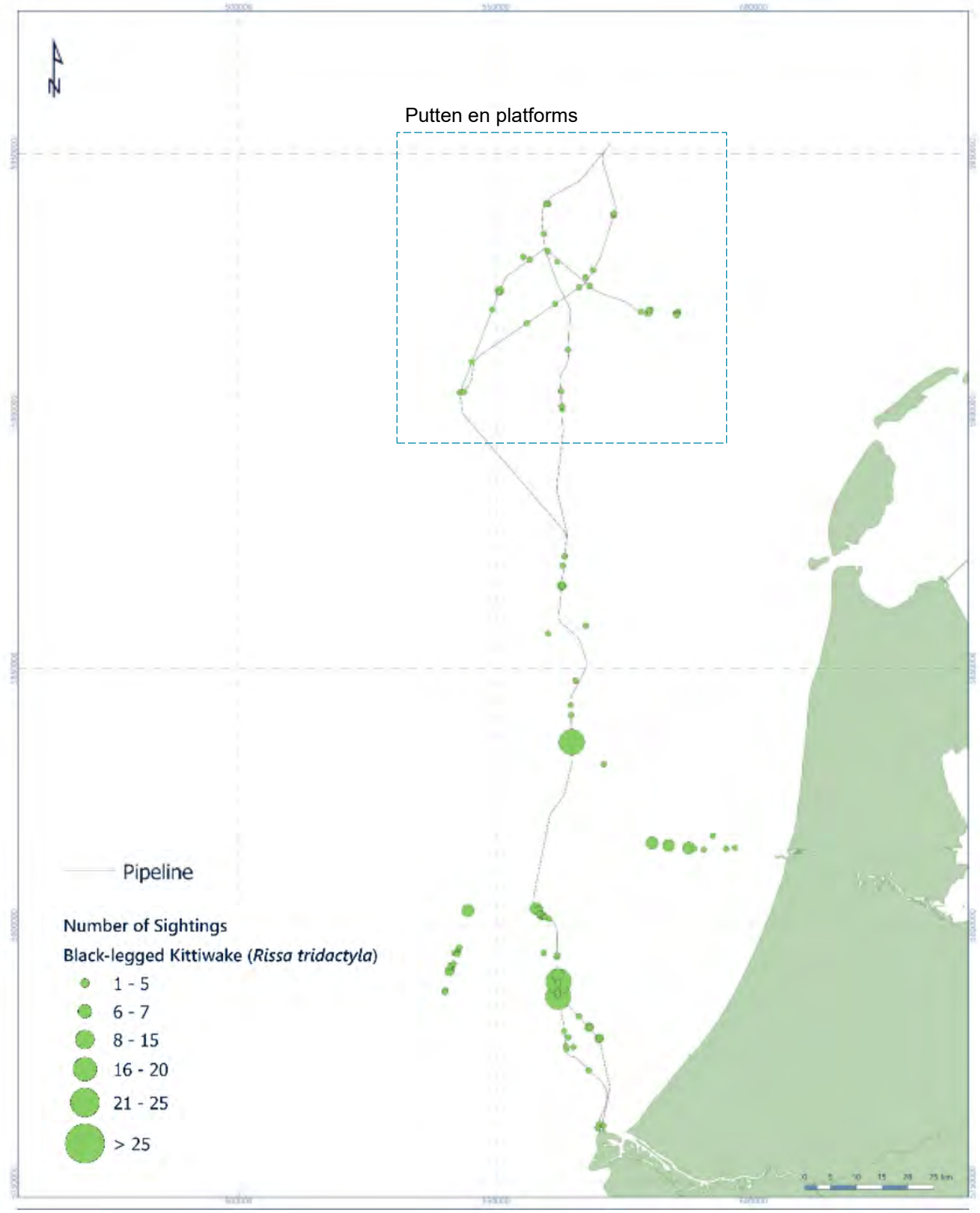
mantelmeeuw, visdief en grote stern komen niet in gevaar door de hei- en boorwerkzaamheden. Er is geen sprake van overtreding van de verbodsbepalingen.

Platform L4-A zal daarnaast worden aangepast zodat het platform en bijbehorende putten geschikt zijn voor CO_2-opslag. Bij de werkzaamheden aan het platform L4-A komt machinegeluid vrij. Wanneer werkzaamheden bij het bestaande platform L4-A worden uitgevoerd in het broedseizoen worden mogelijk nesten van de drieteenmeeuw vernietigd of beschadigd die op het platform aanwezig zijn. Wanneer broedende vogels daardoor voortijdig het nest verlaten, geldt dit als het opzettelijk vernietigen of beschadigen van nesten en eieren van vogels.

Dit is een overtreding van Bal artikel 11.37 1a, 1b en 1d van de Ow. Door het nemen van voorzorgsmaatregelen kan voorkomen worden dat negatieve effecten op vogels optreden.

Vervolgstappen

Negatieve effecten op de broedvogel drieteenmeeuw moeten voorkomen worden gedurende de broedperiode (tussen midden-mei en augustus). De te nemen maatregelen dienen uitgewerkt te worden in een op het werk toegespitst ecologisch werkprotocol. Een voorzet voor de noodzakelijke voorzorgsmaatregelen is beschreven in Hoofdstuk 6.



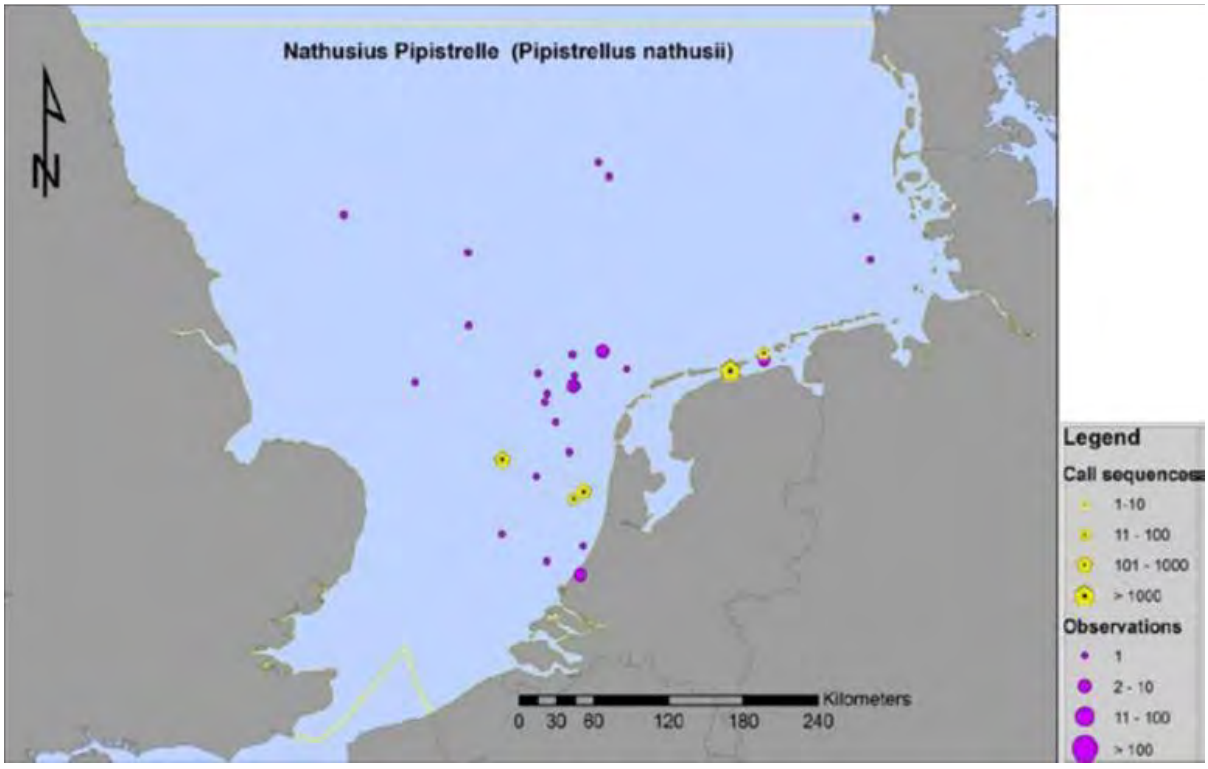
Figuur 5-7. Verspreiding van de drieteenmeeuw in het plangebied (Fugro, 2023).

5.2.4 Vleermuizen

Voorkomen
In de kuststreek komen diverse vleermuissoorten voor, waaronder ruige en gewone dwergvleermuis (*Pipistrellus nathusii en Pipistrellus pipistrellus*), rosse vleermuis (*Nyctalus noctula*), watervleermuis (*Myotis daubentonii*) en meervleermuis (*Myotis dasycneme*) (Figuur 5-8). Vleermuizen hebben hun verblijfplaatsen op land en foerageren daar ook (Lagerveld et al., 2022). De voornaamste dagelijkse vliegbewegingen (los van migratie) vinden dan ook plaats boven land. Hierdoor worden verblijfplaatsen in het plangebied (zee-deel) op voorhand uitgesloten.

Van grofweg maart tot en met november maken vleermuizen vanuit hun verblijfplaatsen foerageertochten. In de winterperiode gaan ze in winterslaap en foerageren ze nagenoeg niet. De maximale foerageerafstand vanaf de kust boven zee van de watervleermuis, rosse vleermuis en meervleermuis ligt doorgaans onder de tien km (RVO, 2014b, 2014a), alhoewel voor rosse vleermuis ook uitschieters tot 18 km zijn waargenomen (Lagerveld & Mostert, 2023). Het voorkomen van vleermuizen binnen het plangebied (op 35 km uit de kust) tijdens foerageertochten vanaf vaste verblijfplekken op land is daarom eveneens uitgesloten.

De migrerende rosse vleermuis en ruige dwergvleermuis trekken in de herfst naar plaatsen met een zacht zeeklimaat (Rydell et al., 2010). Van met name de ruige dwergvleermuis is bekend dat individuen van deze soort in het voor- en najaar van Noord-Holland over de Noordzee naar Groot-Brittannië trekt (Boshamer & Bekker, 2008; Fleming et al., 2003). De najaarstrek lijkt volgens Lagerveld et al. (2019) iets sterker te zijn dan de voorjaarstrek. Het is onduidelijk of de vleermuizen alleen 's nachts trekken of dat zij ook bij daglicht over de Noordzee migreren. In Lagerveld, Wilkes, et al. (2023) is geobserveerd dat trekkende vleermuizen de overtocht vaak niet in één nacht kunnen maken en de dag spenderen op offshore structuren. Er bestaan momenteel nog veel kennisleemtes over de populatiegrootte, het gedrag en de migratie van vleermuizen over de Noordzee. Deze staan gepland om in het meerjarenprogramma van WOZEP 2024-2030 ingevuld te worden. Op basis van de huidige literatuur is het onduidelijk in hoeverre ruige dwergvleermuizen en rosse vleermuizen vaste trekroutes volgen.



Figuur 5-8. De verspreiding van de ruige dwergvleermuis (Pipistrellus nathusii) (Rijkswaterstaat, 2015).

Effectbeoordeling

Het plaatsen van de nieuwe platforms L10-zuid en K14-FA en de inzet van extra schepen zullen leiden tot een toename in lichtuitstraling. Vleermuizen migreren en foerageren meestal in de nacht (Lagerveld, Geelhoed, et al., 2023) en zijn gevoelig voor lichtuitstraling (Voigt et al., 2017, 2018). Van migrerende vleermuizen, zoals van de van de genera *Pipistrellus, Nyctalus* and *Eptesicus,* is bekend dat zij worden aangetrokken door offshore structuren (e.g., platforms en windturbines) vanwege het hoge aantal insecten dat wordt aangetrokken tot het licht (Ahlén et al., 2009; Lagerveld, Geelhoed, et al., 2023). Of dit echter al honderden constructies met verlichting ook van toepassing is op migrerende vleermuizen die bij deze structuren verwacht kunnen worden is onbekend. De nieuwe inrichting kan daardoor potentieel leiden tot verstoring van vliegbeweging. Er zijn echter al honderden constructies met verlichting op de Noordzee (platforms, boeien, windturbines, schepen, etc.) en van een effect daarvan op migratie is vooralsnog geen aanwijzing. De extra platforms en schepen kunnen worden beschouwd als een kleine toename in lichtverstoring ten opzichte van de achtergrondverstoring. Het is daarmee onwaarschijnlijk dat de nieuwe structuren tot een relevante aantrekking van vleermuizen zal leiden en daardoor hinder zou kunnen veroorzaken.

Het voornemen leidt niet tot het opzettelijk verstoren van rosse vleermuizen en ruige dwergvleermuizen. Er is geen sprake van overtreding van de verbodsbepalingen van de Ow.

5.2.5. Samenvatting voorkomende beschermde soortgroepen (zee-deel)

Op basis van de uitkomsten van het onderzoek, is het voorkomen van de in het onderstaande overzicht opgenomen soorten te verwachten of niet uitgesloten (Tabel 5-5). Uit de beschrijving van het voorkomen van beschermde soorten blijkt dat in het plangebied en in de nabijheid van het plangebied de volgende soortgroepen voorkomen of voor kunnen komen: beschermde zeezoogdieren, vleermuizen, broedvogels en vissen. Er is beoordeeld of en zo ja op welke wijze de projectuitvoering kan leiden tot negatieve effecten.

Tabel 5-5. Overzicht van de te verwachten beschermde soorten (zee).

Soortgroep	Aanwezig	Effectbeoordeling – negatieve effecten?	Vervolgstappen
Zeezoogdieren	Bruinvis.	Heiwerkzaamheden en het daarbij gebruik van ADDs leidt tot een overtreding van de verbodsbepaling (artikel 11.46 1b).	Voor de bruinvis dient een Omgevingsvergunning te worden aangevraagd op basis van artikel 11.46 1b van het Bal. Voor de gewone zeehond en grijze zeehond dient een Omgevingsvergunning te worden aangevraagd op basis van artikel 11.54 1b van het Bal. In de aanvraag van de omgevingsvergunning dient een activiteitenplan te worden opgesteld met daarin aanvullende mitigatie.
	Gewone zeehond, grijze zeehond.	De toename in scheepsactiviteit door het Aramis initiatief nabij essentieel foerageergebied Noorderhaaks voor zeehonden leidt tot een overtreding van de verbodsbepaling (artikel 11.54 1b).	
Vissen	Houting en steur.	Er worden geen verbodsbepalingen overtreden. Een omgevingsvergunning in het kader van de Ow is niet nodig.	Geen verdere vervolgstappen.

Vogels	Broedvogelsoorten op zee (drieteenmeeuw, grote stern, visdief en kleine mantelmeeuw).	Er worden geen verbodsbepalingen overtreden. Een omgevingsvergunning in het kader van de Ow is niet nodig.	Geen verdere vervolgstappen, mits er tijdens het broedseizoen niet aan een platform wordt gewerkt waar drieteenmeeuwen broeden.
Vleermuizen	Rosse vleermuis en ruige dwergvleermuis.	Er worden geen verbodsbepalingen overtreden. Een omgevingsvergunning in het kader van de Ow is niet nodig.	Geen verdere vervolgstappen.

6. Voorzorgsmaatregelen en mitigerende maatregelen

Onderstaande zijn de voorzorgs- en mitigerende maatregelen voor de voorkomende soorten uitgewerkt.

6.1 Land-deel

Op basis van de uitkomsten van het onderzoek, is het voorkomen van de volgende beschermde soorten te verwachten: glad biggenkruid, algemeen voorkomende beschermde zoogdieren (konijn en vos), vleermuizen, broedvogels en de rugstreeppad. Ten aanzien van vleermuizen zijn negatieve effecten op voorhand uitgesloten. Voor de overige soorten/soortgroepen geldt dat niet.

Glad biggenkruid en de rugstreeppad vallen onder het Managementplan beschermde soorten van het havenbedrijf. Om te kunnen voldoen aan gebiedsontheffing van het havenbedrijf, dient gewerkt te worden conform de bijbehorende werkprotocollen. Indien aan alle eisen uit de werkprotocollen van het managementplan kan worden voldaan is het aanvragen van een omgevingsvergunning niet noodzakelijk.

Voor algemeen voorkomende beschermde zoogdieren en broedvogels geldt dat ze niet vallen onder het Managementplan beschermde soorten, maar dat overtreding van de Ow dient te worden voorkomen door het nemen van voorzorgsmaatregelen. Onderstaande zijn de noodzakelijke maatregelen toegelicht.

Deze voorzorgsmaatregelen dienen samen met de maatregelen uit het Managementplan ten aanzien van glad biggenkruid en de rugstreeppad opgenomen te worden in een project specifiek ecologisch werkprotocol. De werkzaamheden kunnen pas worden uitgevoerd na goedkeuring van het havenbedrijf en dienen plaats te vinden onder begeleiding van een erkend ecoloog.

Vaatplanten
De werkzaamheden kunnen mogelijk leiden tot vernietiging van aanwezige standplaatsen van beschermde vaatplanten, specifiek gaat het om glad biggenkruid. Dit is een overtreding van de verbodsbepalingen van de Ow. Om aan te sluiten op de gebiedsontheffing van het havenbedrijf, dienen de werkzaamheden te worden uitgevoerd volgens de werkprotocollen zoals vastgelegd in het Managementplan van het havenbedrijf. De bijbehorende noodzakelijke maatregelen zijn:

- Groeiplaatsen worden buiten de werkzaamheden gehouden en zo min mogelijk betreden.
- Rond de periferie van de groeiplaats moet bij graafwerkzaamheden een beschermingszone met een straal van tenminste 5 meter worden ingesteld waar niet wordt gewerkt. Deze maatregel is voor de duidelijkheid niet van toepassing bij het uitvoeren van het reguliere periodieke maaibeheer buiten de kwetsbare periode.
- Men dient ervoor te zorgen dat de groeiplaats voldoende zonlicht kan blijven ontvangen. Toenemende beschaduwing door het planten van bomen of door andere oorzaken moet worden tegengegaan.
- Onder begeleiding van een deskundige – wanneer werkzaamheden plaatsvinden binnen de groeiplaatsen van de beschermde soort.
- Aanwezige groeiplaatsen worden aangegeven op kaartmateriaal welke te allen tijde op de werklocatie aanwezig dient te zijn.
- Bij gebruik van zwaar materieel moeten rijplaten worden gebruikt om te voorkomen dat de bovenste zode kapot wordt gereden en een voedselrijke en voor veel beschermde (en overige) soorten ongeschikte bodem achterblijft.
- Indien een (deel van een) terrein met glad biggenkruid zal verdwijnen, zal een deskundig ecoloog beoordelen of een toplaag met glad biggenkruid moet worden verplaatst naar een nieuwe plek in de nabije omgeving. Het is afhankelijk van de omgeving, of deze maatregel nodig is, of niet. Een deskundig ecoloog moet dit beoordelen en de details zoals dikte van de af te graven toplaag bepalen.
- In depot zetten van een toplaag met glad biggenkruid mag ten hoogste 3 maanden duren, maar bij voorkeur korter. Een deskundig ecoloog zal hierbij betrokken moeten zijn om randvoorwaarden te bepalen.
- Een ecoloog beoordeelt jaarlijks of de hoeveelheid te verdwijnen leefgebied van glad biggenkruid niet in strijd komt met de lokale gunstige staat van instandhouding. Wanneer via de Havenscan

wordt gesignaleerd dat de lokale gunstige staat van instandhouding van glad biggenkruid in het geding komt, kan niet meer van de gebiedsontheffing gebruik gemaakt worden voor wat betreft ruimtelijke ontwikkeling.
- Na voltooiing van het werk wordt er niet met gras ingezaaid.
- HbR zal de omliggende openbare ruimte waar HbR het beheer over voert, dusdanig inrichten en beheren, dat ruim voldoende areaal een gunstig milieu heeft voor glad biggenkruid[10].

Om te kunnen voldoen aan gebiedsontheffing van het havenbedrijf, dient voorafgaand aan de werkzaamheden het plangebied nader onderzocht te worden op het voorkomen van groeiplaatsen van glad biggenkruid. Het is noodzakelijk om dit in het juiste seizoen te doen, wanneer deze bloeien. Glad biggenkruid bloeit van juni tot oktober en is dan goed te onderscheiden van verwante soorten die ook in het gebied voor kunnen komen. Vanuit de bevindingen van dit aanvullende onderzoek kunnen noodzakelijke vervolgstappen worden genomen, zoals mogelijk het inrichten van compenserende groeilocaties om de gunstige staat van instandhouding van de soort te kunnen borgen. Als aan alle eisen van het managementplan kan worden voldaan is het aanvragen van een omgevingsvergunning niet noodzakelijk.

Grondgebonden (land)zoogdieren
Het voorkomen van de nationaal beschermde soorten konijn en vos is niet uitgesloten. Door de werkzaamheden kunnen negatieve effecten optreden, welke leiden tot een overtreding van de verbodsbepalingen. De minister van LNV heeft konijn en vos vrijgesteld van ontheffingsplicht bij ruimtelijke ingrepen (AMvB RN art 3.31), waardoor het aanvragen van een omgevingsvergunning ten aanzien van deze soorten niet noodzakelijk is. Er dient echter wel rekening gehouden te worden met de zorgplicht. Negatieve effecten dienen daarom alsnog (zoveel mogelijk) voorkomen te worden. Dit kan middels het nemen van de algemene maatregelen geadviseerd in het kader van de zorgplicht. In dit geval houdt dit op hoofdlijnen in:

- Het werken in één richting, waardoor aanwezige dieren de kans krijgen de werkzaamheden te ontvluchten. Geef deze dieren daarvoor ook de tijd en ruimte.
- Indien door het werk holen (verblijfplaatsen) worden aangetast en/of vernietigd mag dit alleen plaatsvinden onder ecologische begeleiding en buiten de kwetsbare voortplantingsperiode (globaal van januari tot juli).

Broedvogels
Indien de werkzaamheden op land worden uitgevoerd in het broedseizoen van vogels, bestaat een kans op verstoring van binnen de invloedsfeer aanwezige in gebruik zijnde nesten. Dit is een overtreding van de verbodsbepalingen. Het is niet mogelijk om hiervoor een omgevingsvergunning te verkrijgen. Het heeft daarom de voorkeur de grondverplaatsing op land zo mogelijk buiten het broedseizoen uit te voeren. Het broedseizoen valt voor de meeste soorten tussen half maart en half augustus. Ook daarbuiten is het mogelijk dat broedende vogels worden aangetroffen. Indien de werkzaamheden wel in het broedseizoen worden uitgevoerd, moeten de volgende maatregelen in acht genomen worden:

- De werkzaamheden voorafgaand aan het broedseizoen te beginnen en, voor zover mogelijk, min of meer continue door te laten gaan gedurende het broedseizoen. Hierdoor blijft er steeds sprake van verstoring waardoor verstoringsgevoelige soorten zich niet zullen vestigen. Het grote voordeel van deze methode is, dat de verstoringsafstand “automatisch” bepaald wordt. Vogels zullen uit eigen beweging een nestplaats kiezen buiten hun specifieke verstoringsafstand. Nadeel is dat de continue activiteiten (zowel in tijd als in ruimte) lastig te realiseren is en deze maatregel geen 100% garantie geeft dat zich toch geen vogels vestigen.
- De werkzaamheden ecologisch te laten begeleiden zodat gewerkt wordt buiten de verstoringsafstand van aanwezige broedgevallen. In dit geval wordt door een ter zake kundige in de gaten gehouden waar vogels broeden en wel of juist niet gewerkt kan worden. Nadeel van deze methode is dat als zich een broedgeval voordoet, de planning en werkzaamheden aangepast moeten worden.

[10] *Bureau Stadsnatuur, juli 2021.Managementplan beschermde soorten Havenbedrijf Rotterdam 2021. In opdracht van Port of Rotterdam. Pagina 32.*

- Voorafgaand aan de werkzaamheden dient een erkend ecoloog het plangebied te inspecteren op broedgevallen. Bij afwezigheid van broedende vogels, kan het werkgebied worden vrijgegeven. Tijdens het broedseizoen geldt een dergelijke vrijgave maar voor een paar dagen. Indien er geen gebruik van gemaakt wordt dient daarna opnieuw geïnspecteerd te worden.

Amfibieën

De beoogde aanlegwerkzaamheden kunnen leiden tot het tijdelijk beschadigen en/of vernietigen van verblijfplaatsen en het verwonden en/of doden van individuen van de rugstreeppad. Mogelijk gaat als gevolg van de nieuwe ruimtelijke inrichting ook permanent geschikt leefgebied verloren. Dit is een overtreding van de verbodsbepalingen van de Ow. Om aan te sluiten op de gebiedsontheffing van het havenbedrijf, dienen de werkzaamheden te worden uitgevoerd volgens de werkprotocollen zoals vastgelegd in het Managementplan van het havenbedrijf. De bijbehorende noodzakelijke maatregelen zijn:

- Onder begeleiding van een ecologisch deskundige dient voorafgaand aan werkzaamheden het projectgebied ontoegankelijk gemaakt te worden voor rugstreeppadden door het plaatsen van paddenschermen en het dempen van potentiële voortplantingswateren nadat door een ter zake kundige is vastgesteld dat deze op dat moment niet in gebruik zijn.
- Paddenschermen bestaan in principe uit staand worteldoek van 50 centimeter hoog dat vijftien centimeter wordt ingegraven en wordt verankerd aan paaltjes.
- De voorzieningen die getroffen zijn om het gebied ontoegankelijk te maken moeten zodanig beheerd worden dat ze hun functie te allen tijde kunnen vervullen. Omgewaaide of omvergereden paddenschermen dienen zo spoedig mogelijk te worden hersteld.
- Na hevige regenval ontstane plassen, volgelopen wielsporen of greppels, dienen zo snel mogelijk weer te worden gecontroleerd op activiteit (aanwezigheid van eisnoeren en larven, imago's) van de soort en daarna te worden gedempt.
- Voor de rugstreeppad is vervangend leefgebied gerealiseerd op de Maasvlakte (hierna betiteld als 'mitigatielocaties'), bestaande uit zes in elkaars nabijheid gelegen clusters van drie voortplantingspoelen en landhabitat bestaand uit zandige greppels, zandhopen en stenen.
- Wanneer geen geschikte landhabitat in de buurt (op minder dan twee kilometer afstand) aanwezig is en/of het risico op herkolonisatie van het werkterrein groot is, moeten dieren verplaatst worden naar één van de voor de soort ingerichte mitigatielocaties op de Maasvlakte.
- Wanneer ook voortplantingswater verdwijnt moet voorafgaand aan het grondwerk tijdig nieuw, al dan niet tijdelijk, door te soort te gebruiken water zo dicht mogelijk bij het te verdwijnen water gegraven worden. Pas wanneer (bijvoorbeeld om bodemtechnische redenen) geen geschikt voortplantingswater kan worden gerealiseerd en/of het risico op herkolonisatie van het werkterrein daardoor groot is, mogen dieren verplaatst worden naar één van de voor de soort ingerichte mitigatielocaties op de Maasvlakte.
- Als werkzaamheden niet uitgesteld kunnen worden tot buiten de voortplantingsperiode, dan moet er voordat de werkzaamheden aanvangen gezocht worden naar eisnoeren en larven en imago's. Bij het aantreffen hiervan moeten deze, indien mogelijk, verplaatst worden naar geschikt gebied in de directe omgeving waar geen werkzaamheden voorzien zijn en, wanneer dit ontbreekt of het risico op herkolonisatie van het werkterrein te groot is (in geval van imago's), naar een van de mitigatielocaties op de Maasvlakte.
- De aangelegde alternatieve leefgebieden en verbindingszones voor de rugstreeppad dienen zodanig onderhouden te worden dat de functie van voortplantingswater, dan wel dagrust- of winterrustplaats, behouden blijft. Hiertoe dient het bestaande beheerplan, dat door Dienst Regelingen is goedgekeurd, als geldende richtlijn.
- Gezien het mobiele karakter van rugstreeppadden dient ook zorgvuldig te worden omgesprongen met potentiële voortplantingswateren. Potentiële voortplantingswateren worden bij werkzaamheden mogelijk als gevolg van onwetendheid vernield. Dergelijke potentiële voortplantingswateren dienen door een deskundige op het gebied van amfibieën in kaart te worden gebracht, voor zover die informatie nog niet uit de jaarlijkse monitoring die in opdracht van HbR wordt uitgevoerd kan worden afgeleid[11].

[11] *Bureau Stadsnatuur, juli 2021.Managementplan beschermde soorten Havenbedrijf Rotterdam 2021. In opdracht van Port of Rotterdam. Pagina 48.*

Om te kunnen voldoen aan gebiedsontheffing van het havenbedrijf, dient voorafgaand aan de werkzaamheden het plangebied nader onderzocht te worden op het voorkomen van leefgebiedsfuncties van de rugstreeppad. Het is noodzakelijk om dit in het juiste seizoen te doen wanneer deze dieren actief zijn. Rugstreeppadden kunnen grofweg in de periode april tot en met begin augustus onderzocht worden. Vanuit de bevindingen van dit aanvullende onderzoek kunnen noodzakelijke vervolgstappen worden genomen, zoals mogelijk het inrichten van compenserend leefgebied om de gunstige staat van instandhouding van de soort te kunnen borgen. Indien aan alle eisen van het managementplan kan worden voldaan is het aanvragen van een omgevingsvergunning niet noodzakelijk.

6.2 Zee-deel

In de omgeving van het plangebied komen mogelijk beschermde vissen, zeezoogdieren, vogels en vleermuizen voor. Het voornemen kan leiden tot negatieve effecten op zeezoogdieren, vogels en vleermuizen op zee. Het overtreden van verbodsbepalingen uit de Ow ten aanzien van deze soortgroepen moet voorkomen worden door het nemen van maatregelen. Indien dit niet mogelijk is, dient een omgevingsvergunning te worden aangevraagd. Onderstaande is dit nader toegelicht.

Vissen

Voorzorgsmaatregelen
Om de verstoring van vissen uit voorzorg te voorkomen dienen de volgende voorzorgsmaatregelen te worden uitgevoerd:

- Bij alle hei-activiteiten wordt een ADD (Acoustic Deterrent Device) in combinatie met een soft start toegepast. Voor het heien van conductors met de drill en drive methode zal dit ook worden toegepast. Een ADD is een apparaat dat in het water wordt gehangen en specifieke, onschadelijke geluidsignalen produceert met een afschrikkende werking op vissen. Op deze manier wordt eventueel in het directe plangebied aanwezige vissen de gelegenheid gegeven het plangebied te verlaten. Er wordt gebruik gemaakt van één of meer ADD's met een bereik van minimaal 500 m gedurende een half uur voor en tijdens het heien,
- De soft start dient minimaal 30 minuten lang te duren en te beginnen met vijf minuten op circa 20% van de slagenergie, aansluitend kan de slagenergie geleidelijk naar 90% worden opgehoogd. Na 30 minuten zijn eventueel aanwezige vissen ver genoeg weggezwommen om geen gehoorschade op te lopen.

Zeezoogdieren

Voorzorgsmaatregelen
Om directe verstoringseffecten op zeezoogdieren zoveel mogelijk te beperken dienen de volgende voorzorgsmaatregelen te worden uitgevoerd:

- Bij alle hei-activiteiten wordt een ADD (Acoustic Deterrent Device) in combinatie met een soft start toegepast. Voor het heien van conductors met de drill en drive methode zal dit ook worden toegepast. Een ADD is een apparaat dat in het water wordt gehangen en specifieke, onschadelijke geluidsignalen produceert met een afschrikkende werking op zeezoogdieren. Op deze manier wordt eventueel in het directe plangebied aanwezige zeezoogdieren de gelegenheid gegeven het plangebied te verlaten. Er wordt gebruik gemaakt van één of meer ADD's met een bereik van minimaal 500 m gedurende een half uur voor en tijdens het heien;
- De soft start dient minimaal 30 minuten lang te duren en te beginnen met vijf minuten op circa 20% van de slagenergie, aansluitend kan de slagenergie geleidelijk naar 90% worden opgehoogd. Na 30 minuten zijn eventueel aanwezige zeezoogdieren ver genoeg weggezwommen om geen gehoorschade op te lopen;
- Om effecten van geluid door (hei)werkzaamheden te mitigeren wordt er gebruik gemaakt van een Marine Mammal Observer (MMO) en Passive Acoustic Monitoring (PAM). Wanneer het donker is, of de weersomstandigheden een visuele monitoring ineffectief maken, zal er alleen akoestisch gemonitord worden (PAM), hiermee worden clicks van bruinvissen tot 500 m opgevangen.

Mitigerende maatregelen
Voor het verstoren van het leefgebied van de bruinvis en de gewone en grijze zeehond dient een omgevingsvergunning aangevraagd te worden. Daarnaast is aanvullende mitigatie nodig om significant negatieve effecten op populatieniveau te kunnen uitsluiten:

- Bij de hei-werkzaamheden dienen geluidsbeperkende maatregelen genomen te worden (bijvoorbeeld door gebruik te maken van een HSD Systeem/bubbelscherm) of een werkwijze waarbij relatief weinig onderwatergeluid zal optreden om effecten op de populatie bruinvissen te voorkomen (het geluidsniveau moet onder de 164 dB liggen op 750 meter afstand);
- Er dient zoveel mogelijk gebruik gemaakt te worden van stille schepen om continu onderwatergeluid te minimaliseren.

Vogels

Indien de werkzaamheden op zee worden uitgevoerd in het broedseizoen van vogels, bestaat een kans op verstoring van binnen de invloedsfeer aanwezige in gebruik zijnde nesten op het bestaande platform L4-A. Het is een overtreding van de verbodsbepalingen om rustende en broedende vogels te verstoren. Het is niet mogelijk om hiervoor een omgevingsvergunning te verkrijgen, waardoor het voorkomen van negatieve effecten gedurende de aanlegfase noodzakelijk is. Dit kan door:

- De werkzaamheden bij platform L4-A buiten het broedseizoen van de drieteenmeeuw uit te voeren. Het broedseizoen van de drieteenmeeuw duurt van midden-mei t/m augustus.

Indien dit niet mogelijk is, dienen de volgende maatregelen te worden uitgevoerd;

- De werkzaamheden voorafgaand aan het broedseizoen te laten beginnen en in een, voor zover mogelijk, constante intensiteit te laten doorgaan gedurende het broedseizoen. Het grote voordeel van deze methode is, dat de verstoringsafstand “automatisch” bepaald wordt. Vogels zullen uit eigen beweging een nestplaats kiezen buiten hun specifieke verstoringsafstand. Nadeel is dat de constante intensiteit (zowel in tijd als in ruimte) lastig te realiseren is.

- De werkzaamheden uit te voeren in het broedseizoen onder ecologische begeleiding. Er moet in dit geval gecontroleerd worden door een gecertificeerd persoon of er geen broedende drieteenmeeuwen voorkomen op of onder het platform. Voorafgaand aan de werkzaamheden dient een erkend ecoloog het plangebied te inspecteren op broedgevallen. Bij afwezigheid van broedende vogels, kan het werkgebied worden vrijgegeven. Vanuit praktische overwegingen kan deze inspectie ook via een videoverbinding uitgevoerd worden waarbij de ecoloog niet op de locatie aanwezig is, maar wel aanstuurt waar gefilmd moet worden.

Vleermuizen

Voorzorgsmaatregelen
Om verstoring van vleermuizen uit voorzorg te voorkomen dienen de volgende voorzorgsmaatregelen te worden uitgevoerd:

- Werkzaamheden zoveel als mogelijk bij daglicht uitvoeren[12]. Met name tijdens de voor vleermuizen belangrijk periode (voorjaarstrek, najaarstrek en dicht bij land ook in de zomer).
- De verlichting zoveel mogelijk beperken in aantal, intensiteit en draaiuren door bijvoorbeeld gebruik te maken van bewegingssensors en tijdklokken en afschermen van lichtbundels.
- De verlichting op het platform en de schepen wordt gericht op de activiteit om lichtuitstraling naar de omgeving te voorkomen.
- Voor transportbewegingen van en naar het platform dient waar mogelijk gebruik gemaakt te worden van bestaande scheepvaartroutes en zoveel mogelijk bij daglicht (tenminste in de actieve periode van de vleermuizen).

[12] *Offshore werkzaamheden vinden in veel gevallen 24/7 plaatst. De inzet van bepaalde machines (o.a. boormachines) vraagt om continue activiteit. Deze maatregel geldt dan ook voornamelijk voor activiteiten op land.*

6.3 Overige maatregelen uitvoering - zorgplicht

Voor iedere plant- en diersoort geldt de zorgplicht, los van een vrijstelling of omgevingsvergunning. Schade aan dier- of plantensoorten moet te allen tijde worden voorkomen zover redelijkerwijs mogelijk is. Voor de uitvoeringsfase is aantal algemene voorzorgsmaatregelen beschreven op basis waarvan verstoring en doding van soorten veelal wordt voorkomen:

- De werkzaamheden worden zover mogelijk overdag, tussen zonsopgang en zonsondergang uitgevoerd[13]. Veel algemene en beschermde diersoorten zijn vooral actief gedurende de vroege ochtend, late avond en nacht.
- Indien 's nachts gewerkt wordt, wordt verlichting toegepast die enkel gericht is op de bouwlocatie.
- De werkzaamheden worden bij voorkeur buiten de kwetsbare periode uitgevoerd. De kwetsbare periode betreft hoofdzakelijk de voortplantingsperiode. Voor een aantal diergroepen/soorten betreft dit ook de winter(rust)periode wanneer dieren minder actief zijn met vergrote kans op doding.
- De aannemer maakt enkel gebruik van de ruimte die noodzakelijk is voor het uitvoeren van de werkzaamheden en ontziet daarbij plaatsen met begroeiing en/of beplanting zoveel mogelijk. Zo wordt onnodige verstoring van dieren en planten voorkomen.

Deze maatregelen worden locatie-specifiek uitgewerkt in een Ecologisch werkprotocol dat voorafgaand aan de werkzaamheden wordt opgesteld en waarvan alle relevante betrokkenen kennisgenomen moeten hebben en dat nagevolgd dient te worden.

[13] *Offshore werkzaamheden vinden in veel gevallen 24/7 plaatst. De inzet van bepaalde machines (o.a. boormachines) vraagt om continue activiteit. Deze maatregel geldt dan ook voornamelijk voor activiteiten op land.*

7. Samenvatting bevindingen en toetsing wet- en regelgeving voor soortenbescherming

7.1 Landdeel

Binnen het plangebied kunnen verschillende beschermde soorten voorkomen. Het gaat om: glad biggenkruid, algemeen voorkomende zoogdieren, broedvogels en de rugstreeppad. Voor de meeste van deze soorten geldt dat een overtreding van de Ow voorkomen kan worden door het nemen van voorzorgsmaatregelen zoals beschreven in hoofdstuk 6. Voor glad biggenkruid en de rugstreeppad geldt dat niet. Als gevolg van de werkzaamheden kunnen tijdelijk standplaatsen van glad biggenkruid worden geschaad. Mogelijk gaan als gevolg van de nieuwe ruimtelijke inrichting ook permanent groeilocaties verloren. De beoogde aanlegwerkzaamheden kunnen daarnaast leiden tot het tijdelijk beschadigen en/of vernietigen van verblijfplaatsen en het verwonden en/of doden van individuen van de rugstreeppad.

Om aan te sluiten op de gebiedsontheffing van het havenbedrijf, dienen de werkzaamheden te worden uitgevoerd volgens de werkprotocollen zoals vastgelegd in het Managementplan van het havenbedrijf.

De voorzorgsmaatregelen dienen samen met de maatregelen uit het Managementplan ten aanzien van glad biggenkruid en de rugstreeppad opgenomen te worden in een project specifiek ecologisch werkprotocol. De werkzaamheden kunnen pas worden uitgevoerd na goedkeuring van het havenbedrijf en dienen plaats te vinden onder begeleiding van een erkend ecoloog.

7.2 Zeedeel

Binnen het plangebied op zee kunnen verschillende beschermde soorten voorkomen. Het gaat om: vissen (houting en steur), zeezoogdieren (bruinvis, gewone zeehond en grijze zeehond), broedvogels en migrerende vleermuizen (rosse vleermuis en ruige dwergvleermuis).

Voor de vissoorten geldt dat een overtreding van de Ow op voorhand kan worden uitgesloten, omdat het plangebied niet overlapt met essentieel leefgebied van de houting en steur.

Voor zeezoogdieren is geconcludeerd dat de effecten van onderwatergeluid leiden tot een overtreding van de verbodsbepalingen. Voor de bruinvis betreft dit opzettelijke verstoring door de effecten als gevolg van heiwerkzaamheden en het daarbij gebruik van ADDs. Dit is een overtreding van artikel 11.46 1b van het Bal. In het geval van de gewone zeehond en grijze zeehond betreft dit de verstoring die optreedt door de toename in scheepvaartbewegingen nabij het essentieel foerageergebied Noorderhaaks. Dit is een overtreding van artikel 11.54 1b van het Bal.

Voor broedvogels (i.e., drieteenmeeuwen) geldt dat er mogelijk verstoring optreedt bij rustende of broedende vogels tijdens werkzaamheden op het platform L4-A. Dit type overtreding is niet vergunbaar onder de Ow. Door het nemen van maatregelen, zoals voorgesteld in paragraaf 6.2, wordt een dergelijke overtreding van de Ow voorkomen.

Voor migrerende vleermuissoorten (rosse vleermuis en ruige dwergvleermuis) is geconcludeerd dat nieuwe constructies en daarbij horende lichtverstoring geen relevante effecten teweegbrengen die migratie verhinderen. Het is daarnaast momenteel ook niet bekend of migrerende vleermuizen vaste trekroutes gebruiken. De conclusie luidt dat er voldoende uitwijkmogelijkheden bestaan voor vleermuizen tijdens de overtocht. Het voornemen leidt niet tot het opzettelijk verstoren van de rosse vleermuis en ruige dwergvleermuis. Overtreding van de Ow is daarmee uitgesloten.

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Bijlage 1. Verslagen veldbezoeken

Veldbezoek 17 januari 2023

Uitvoeringsomstandigheden

Locatie	Maasvlakte
Uitgevoerd door:	Royal HaskoningDHV
Datum:	17 januari 2023
Tijd:	14.00-16.00 uur
Temperatuur	4ºC
Bewolking	onbewolkt
Wind	0-1 Bft
Luchtvochtigheid	onbekend

Doel van het onderzoek, onderzoeksmethode

Eerste veldonderzoek om te kijken of en welke dieren aanwezig zijn in het gebied. De hieronder beschreven soorten zijn gebaseerd op waarnemingen die ter plekke zijn gedaan en dit veldverslag kan daarmee niet als volledige inventarisatie worden gezien. Mogelijk zijn in andere seizoenen (of op andere momenten van de dag) andere soorten waarneembaar.

Bij Havenmonding Rotterdam Maasvlakte geparkeerd. Via het pad aan de onderkant van de dijk naar de windmolens gelopen. Daar de dijk opgegaan en via de bovenkant van de dijk teruggelopen. Vervolgens via het strand naar het open veld in het midden gelopen. Daar via rechts naar achter met een bocht naar links gelopen (zie blauwe lijn foto).

Kenschets van het terrein

Industriegebied met gras stroken. Er loopt een 80-weg, waar veel vrachtwagens op rijden. De waterkant is afgeschermd met grote rotsen waar zeehonden niet op kunnen. Op het strand waren auto/quad sporen. In het veld in het midden was een plek waar een soort struikengroei was. Verder was de vegetatie laag.





Waarnemingen

Veel graaf en holsporen van konijnen. Het rode vlak was een grote konijnenburcht, maar zit ook op het veld (ook rood omkaderd, TER INDICATIE).

Daarnaast veel konijnen waargenomen links van het rode vlak en in veld onder het rode vlak. In het veld onder het rode vlak zijn ook predator sporen (botten) en poep van een vos waargenomen. Er is dus ook een vos aanwezig in het gebied.

Geen zeehonden waargenomen. De waterkant is afgeschermd met grote rotsen dus het is niet waarschijnlijk dat ze daarop gaan liggen. Op het strand lagen er ook geen zeehonden. Daar waren wel auto/quad sporen, dus er is ook verstoring. Mensen laten hun hond uit op de dijk.

Veel aalscholvers en meeuwen waargenomen. Ook een aantal eksters en een raaf. Geen broedlocaties waargenomen.





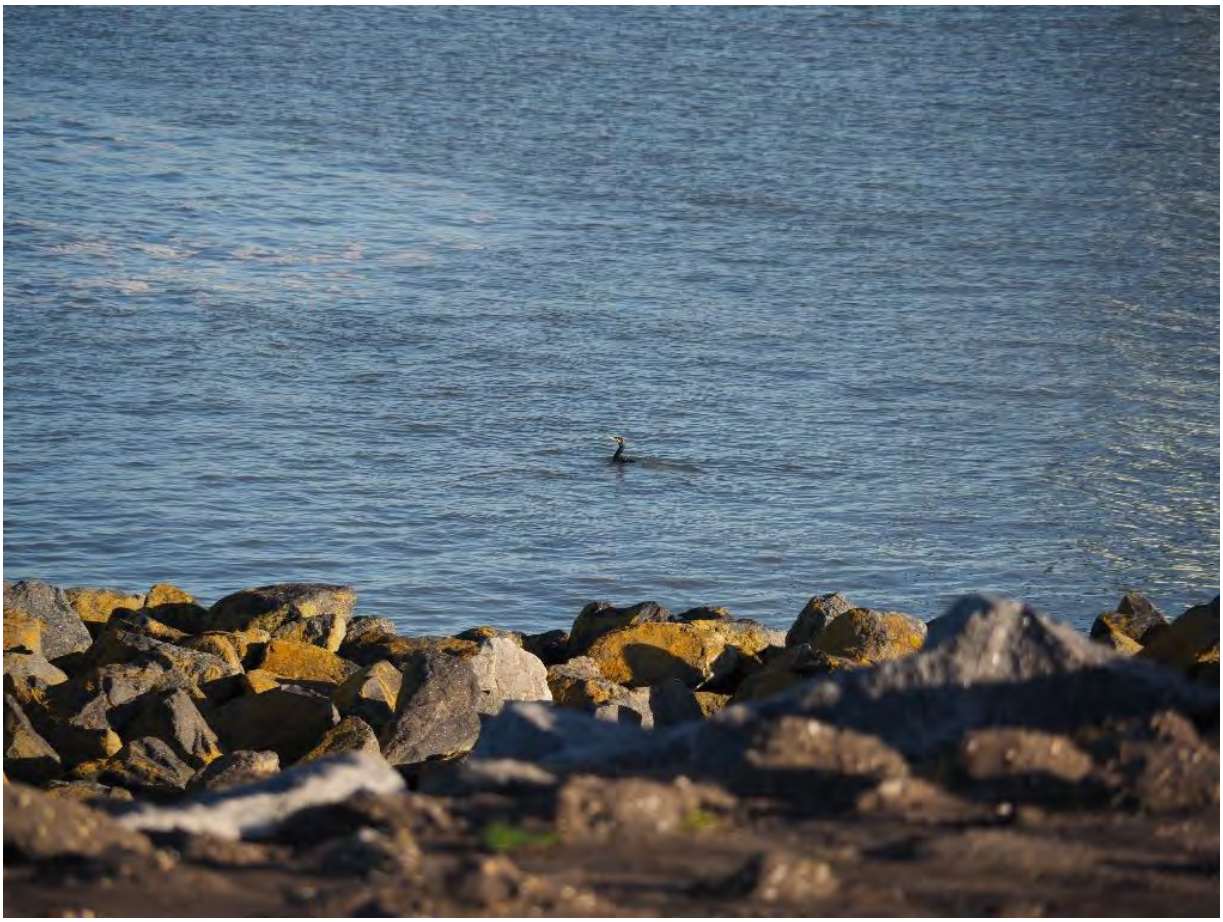












Veldbezoek 16 februari 2023

Uitvoeringsomstandigheden

Locatie:	Maasvlakte
Uitgevoerd door:	Royal HaskoningDHV
Datum:	16 februari 2023
Tijd:	15.00-16.00 uur
Temperatuur	9ºC
Bewolking	bewolk en na een tijdje motregen
Wind	4-5 Bft op de jetty locatie
Luchtvochtigheid	onbekend

Doel van het onderzoek, onderzoeksmethode

Aanvullend (tweede) veldonderzoek om te kijken/welke dieren kunnen aanwezig zijn in het gebied MOT & GATE terrein en rond Beereiland. De hieronder beschreven soorten zijn gebaseerd op waarnemingen die ter plekke zijn gedaan en dit veldverslag kan daarmee niet als volledige inventarisatie worden gezien. Mogelijk zijn in andere seizoenen (of op andere momenten van de dag) andere soorten waarneembaar.

Vanuit GATE is met een medewerker (Daniel) over het terrein gereden en gewandeld. Hij kon meer vertellen over wat medewerkers dagelijks allemaal zien. We zijn begonnen bij het GATE gebouw. Vervolgens met uitzicht op het Beer eiland naar het zuiden gereden (zie blauwe lijn in een Google Maps screenshot hieronder). Vervolgens is er gekeken bij de uitlaatstroom waar de aanlegsteigers komen (zie blauwe dikke lijn bij drie witte opslag tankers).



Kenschets van het terrein

De Maasvlakteweg is een 80 km weg met aan de zeekant een begroeide berm met bomen en struiken. Aan de MOT kant is er een klein dijkje waarachter de opslagvaten staan. Bij het GATE terrein is er aan de waterkant een stuk strand. De waterkant gaat erna over in grote stenen, waar zeehonden niet op kunnen. Op het zuidelijkste punt is een afgesloten stuk gras met laag struikengroei. Op het terrein zijn meerdere grasgebieden met veel lage vegetatie. Bij de GATE opslagvaten is de waterkant afgeschermd met rotsen. Daar zijn ook grasgebieden aanwezig.

Waarnemingen

Bij het opkomen van het terrein stond al een: “pas op overstekende vossen” - bord. Geen vossen gezien, Daniel vertelde dat er wel veel zitten (hier is ook beeldmateriaal van beschikbaar). De holen van de vossen zouden langs de Maasvlakteweg zitten. Ook een buizerd waargenomen boven het gebied.

Naast het GATE gebouw zijn zowel zeehonden in het water waargenomen als rustend op het strand. Tijdens het veldbezoek waren er tussen de zes en negen zeehonden visueel zichtbaar, waarvan twee of drie grijze zeehonden en zes tot zeven gewone zeehonden. Daniel kon ons vertellen dat er soms 30 tot 40 zeehonden kunnen zitten. Bij de zeehonden op het strand en op het GATE terrein zijn ook scholeksters en meeuwen waargenomen (grote of kleine mantelmeeuw of grijze meeuw).

De zichtbare kant van het Beereiland was beschermd met grote stenen, waar zeehonden niet op kunnen rusten.

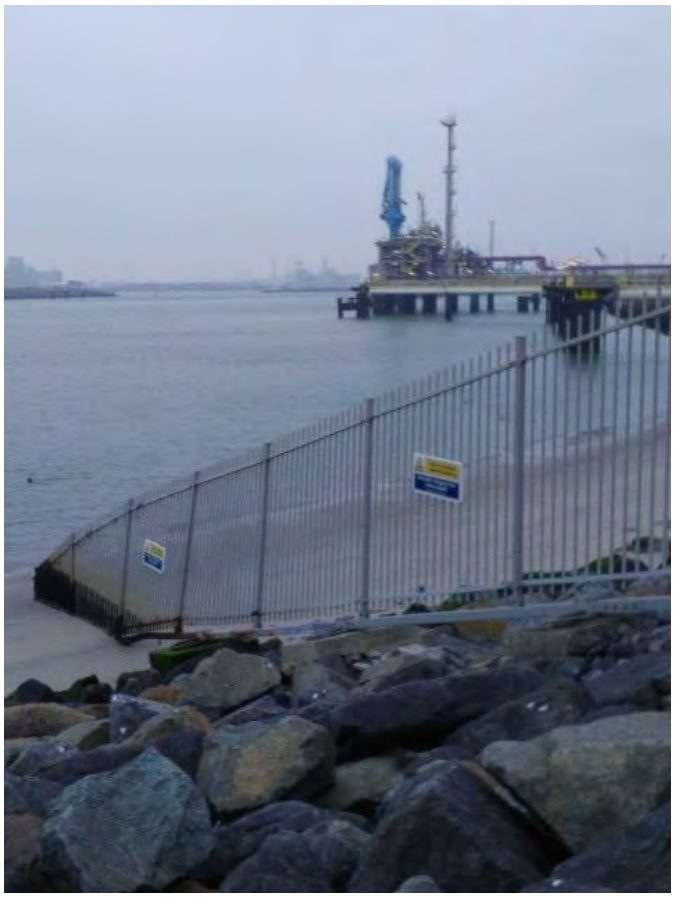
Op het zuidelijke uiteinde was een open graslandschap waar konijnen liepen. Daarnaast vertelde Daniel dat er veel vogels broeden in dat gebied. Nu waren deze niet te zien.

Bij de GATE opslagvaten langs de koelwateruitstroom waren ook konijnen. Daarnaast lagen er veel lege schelpen en krabben resten wat aangeeft dat vogels (meeuwen) daar foerageren. Er waren meeuwen en scholeksters te zien. De waterkant was beschermd met grote stenen.

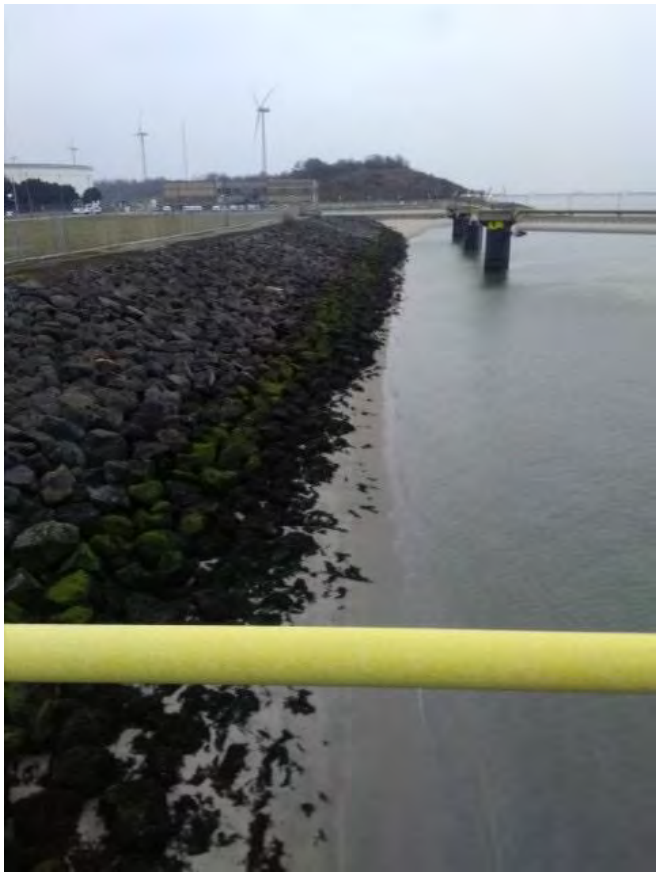
Daniel kon ons vertellen dat er erg veel konijnen, hazen en vossen op het gehele GATE en MOT terrein zitten. Eerst was er ook een hert, maar die zit nu op het Beereiland volgens Daniel. Vooral in de zomer zijn er veel zeehonden aanwezig en (broed)vogels. De vossen, konijnen en hazen krijgen ook jongen in het gebied. Buizerds en wellicht andere roofvogels komen ook voor in het gebied.














Let op!!
overstekende
vossen

Royal HaskoningDHV

Bijlage 2. Scheepvaart- en helikopterbewegingen

	Type schip/ helikopter	Activiteit	Aantal schepen/ helikopters	Aantal bewegingen	Duur activiteit (in dagen)
Direct piping	Baggerschip	Baggerwerkzaamheden bij in en bij de Maasgeul.	1	2	41,29
	Pijplegschip	Intrekken van zeeleiding door direct pipe casing.	1	2	0,37
	Support vessel	Schoonmaken, intern inspecteren en testen van de leiding.	1	2	5,58
Totaal	-	-	3	6	47
Microtunneling	Baggerschip	Baggerwerkzaamheden bij in en bij de Maasgeul.	1	2	5,99
	Pijplegschip	Intrekken van zeeleiding door microtunnel.	1	2	1,15
	Support vessel	Schoonmaken, intern inspecteren en testen van de leiding.	1	2	6,84
Totaal	-	-	3	6	14
Aanleg zeeleiding	Support vessel	Controleren van de route door de aannemer vóór aanvang van alle constructie activiteiten.	1	2	3,41
	Baggerschip	Zeebed correcties om de pijpleg route te verbeteren.	1	2	14,49

	Pijplegschip	Intrekken van offshore zeeleiding.	1	2	7
	Pijplegschip	Doorleggen van zeeleiding naar het eindpunt.	1	2	50,69
	Pipe carrier	Bevoorrading pijplegschip.	3	6	50,69
	Support vessel	Kruising met bestaande infrastructuur.	1	2	11,97
	Transport barge + sleepboot	Speciaal transport voor toekomstige aansluitingen.	2	2	3
	Support vessel	Volgschip voor veilige aanleg zeeleiding.	1	2	50,17
	Support vessel	Schoonmaken, intern inspecteren en testen van de leiding.	2	4	32,3
	Support vessel	Stenen storten.	1	2	13,27
	Trencher	Begraven van de zeeleiding.	1	2	71,72
	Survey schip	Laatste inspectie.	1	2	3,41
Totaal	-	-	15	30	312
Werkzaamheden platform K14-FA (Shell)	Work to work vessel	Varen van en naar het platform.	1	80	N.A.
	Diving support vessel	Varen van en naar het platform / Werkzaamheden bij het platform.	1	2	10
	Supply support vessel	Varen van en naar het platform.	1	10	N.A.
	Standby/survey vessel	Varen van en naar het platform / Werkzaamheden bij het platform.	1	2	25
	Heavy lifting vessel	Varen van en naar het platform / Werkzaamheden bij het platform.	1	2	17
	Transport barge + Tug	Varen van en naar het platform / Werkzaamheden bij het platform.	1	19	12
	Pipelaying vessel	Varen van en naar het platform / Werkzaamheden bij het platform.	1	2	8

	Trenching + rockdump vessel	Varen van en naar het platform / Werkzaamheden bij het platform.	1	2	7
	Helikopter	Beweging van en naar het platform.	1	50	N.A.
Totaal	-	-	9	169	N.A.
Werkzaamheden putten K14-FA (Shell)	Mobilisatie/ Demobilisatie	Varen van en naar het platform.	1	12	N.A.
	Drilling supply vessel	Varen van en naar het platform.	1	229	N.A.
	Standby vessel	Varen van en naar het platform / Werkzaamheden bij het platform.	1	2	400
	Drilling with Jackup	Werkzaamheden bij het platform.	1	2	400
Totaal	-	-	4	245	400
Werkzaamheden platform L10-zuid (Neptune)	Work to work vessel	Varen van en naar het platform.	1	4	N.A.
	Diving support vessel	Varen van en naar het platform / Werkzaamheden bij het platform.	1	2	8
	Heavy lifting vessel	Varen van en naar het platform / Werkzaamheden bij het platform.	1	2	9
	Pipelaying vessel	Varen van en naar het platform / Werkzaamheden bij het platform.	1	2	7
Totaal	-	-	4	10	N.A.
Werkzaamheden putten L10-zuid (Neptune)	Mobilisatie/ Demobilisatie	Varen van en naar het platform.	1	2	N.A.
	Drilling supply vessel	Varen van en naar het platform.	1	276	N.A.
	Standby vessel	Varen van en naar het platform / Werkzaamheden bij het platform.	1	2	420
	Drilling with Jackup	Werkzaamheden bij het platform.	1	2	420
	Helikopter	Beweging van en naar het platform.	1	300	N.A.
Totaal	-	-	5	582	420
Werkzaamheden platform L4-A (Total Energies)	Heavy lifting vessel	Varen van en naar het platform / Werkzaamheden bij het platform.	1	2	N.A.
	Supply vessel	Varen van en naar het platform / Werkzaamheden bij het platform.	1	114	N.A.
	Standby vessel	Varen van en naar het platform.	1	2	132
	Diving support vessel	Varen van en naar het platform.	1	2	14
	Work to work vessel (crew change)	Varen van en naar het platform.	1	60	N.A.

	Pipelaying vessel	Varen van en naar het platform / Werkzaamheden bij het platform.	1	2	15
	Support vessel	Varen van en naar het platform / Werkzaamheden bij het platform.	1	2	7
	Rockdump vessel	Varen van en naar het platform / Werkzaamheden bij het platform.	1	2	1
	DSV (metrology centrale eindpunt + L4-A)	Varen van en naar het platform / Werkzaamheden bij het platform.	1	2	14
	Helikopter	Beweging van en naar het platform.	1	76	N.A.
Totaal	-	-	9	264	132
Werkzaamheden putten L4-A (Total Energies)	Mobilisatie/ Demobilisatie	Varen van en naar het platform.	1	2	N.A.
	Drilling supply vessel	Varen van en naar het platform.	1	816	N.A.
	Drilling with Jackup	Werkzaamheden bij het platform.	1	2	408
	Helikopter	Beweging van en naar het platform.	1	234	N.A.
Totaal	-	-	4	1.054	408
Gebruiksfase – Total Energies	Walk to walk vessel	Varen van en naar het platform / Werkzaamheden bij het platform.	1	144 (per jaar)	-
	Standby vessel	Varen van en naar het platform / Werkzaamheden bij het platform.	1	2 (per jaar)	-
	Mobilisatie/ Demobilisatie	Varen van en naar het platform.	1	5 (per jaar)	-
	Supply vessel	Varen van en naar het platform / Werkzaamheden bij het platform.	1	3 (per jaar)	-
	WS barge	Varen van en naar het platform / Werkzaamheden bij het platform.	1	4 (per jaar)	-
Totaal	-	-	5	158 (per jaar)	-
Gebruiksfase - Neptune	Walk to walk vessel	Varen van en naar het platform / Werkzaamheden bij het platform.	1	48 (per jaar)	-
	Standby vessel	Varen van en naar het platform / Werkzaamheden bij het platform.	1	2 (per jaar)	-
	Mobilisatie/ Demobilisatie	Varen van en naar het platform.	1	5 (per jaar)	-
	Supply vessel	Varen van en naar het platform / Werkzaamheden bij het platform.	1	3 (per jaar)	-
	WS barge	Varen van en naar het platform / Werkzaamheden bij het platform.	1	4 (per jaar)	-
Totaal	-	-	5	62 (per jaar)	-

Gebruiksfase - Shell	Walk to walk vessel	Varen van en naar het platform / Werkzaamheden bij het platform.	1	91 (per jaar)	-
	Standby vessel	Varen van en naar het platform / Werkzaamheden bij het platform.	1	2 (per jaar)	-
	Mobilisatie/ Demobilisatie	Varen van en naar het platform.	1	5 (per jaar)	-
	Supply vessel	Varen van en naar het platform / Werkzaamheden bij het platform.	1	3 (per jaar)	-
	WS barge	Varen van en naar het platform / Werkzaamheden bij het platform.	1	4 (per jaar)	-
Totaal	-	-	5	105 (per jaar)	-

Natuurtoets, Gebiedsbescherming Aramis

MER Aramis CO2-transportinfrastructuur

Klant: Aramis CCS

Referentie: ARM-PFE-B10-ENV-EIA-2004

Status: Definitief/02

Datum: 28 mei 2024

9B ARAMIS	CCS-ARAMIS Project Environment Impact Assessment – Baseline report
	Document No. ARM-PFE-B10-ENV-EIA-2004 Document title Nature report areas (preliminary / appropriate assessment) Revision Final 5.0

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Projectnummer: ARM-PFE-B10-ENV-EIA-2004

Classificatie
Projectgerelateerd

Behoudens andersluidende afspraken met de Opdrachtgever, mag niets uit dit document worden verveelvoudigd of openbaar gemaakt of worden gebruikt voor een ander doel dan waarvoor het document is vervaardigd. HaskoningDHV Nederland B.V. aanvaardt geen enkele verantwoordelijkheid of aansprakelijkheid voor dit document, anders dan jegens de Opdrachtgever.

Let op: dit document bevat mogelijk persoonsgegevens van medewerkers van HaskoningDHV Nederland B.V.. Voordat publicatie plaatsvindt (of anderszins openbaarmaking), dient dit document te worden geanonimiseerd of dient toestemming te worden verkregen om dit document met persoonsgegevens te publiceren. Dit hoeft niet als wet- of regelgeving anonimiseren niet toestaat.

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1 Inleiding

1.1 Aanleiding

Noodzaak CCS als klimaatmaatregel
In Nederland vindt ca. 180 megaton CO_2 per jaar uitstoot plaats. In het Klimaatakkoord is uitgewerkt hoe de reductie van CO_2-emissies in Nederland in de komende jaren gerealiseerd wordt. Voor de industrie is daarbij aangegeven dat de overstap gemaakt moet worden naar CO_2-arme brandstoffen en dat de bedrijfsprocessen zodanig worden aangepast dat hierbij minimale hoeveelheden CO_2 vrijkomen. Het aanpassen van bedrijfsprocessen zal voor sommige industrieën een dermate ingrijpende zijn, dat ontwikkeling van nieuwe technieken essentieel is. Het ontwikkelen en testen van de nieuwe CO_2-arme technieken en het ombouwen van de installaties zal voor sommige bedrijfstakken een langdurige inspanning vergen. Om een voortgaande uitstoot van CO_2 te voorkomen in deze periode, is in het Klimaatakkoord aangegeven dat het afvangen van CO_2 uit deze bedrijfsprocessen en het ondergronds opslaan onder de zeebodem, een effectieve maatregel is. Dit mechanisme wordt aangeduid als CCS[1].

Het Aramis initiatief
Op initiatief van het Shell, TotalEnergies, Gasunie en EBN wordt vanuit het Rotterdamse havengebied de Aramis CO_2-infrastructuur ontwikkeld. De Aramis CO_2-infrastructuur is een 'open-access-netwerk' wat inhoudt dat er in de toekomst nieuwe partijen kunnen aansluiten voor de levering van CO_2 aan de infrastructuur en voor afname en opslag in de diepe ondergrond. De infrastructuur wordt stapsgewijs uitgebreid bij verdere belangstelling voor gebruik. Als gevolg hiervan wordt de stapsgewijze ontwikkeling beschreven. Hiervoor worden drie fasen aangehouden:

- Startfase, waarbij de infrastructuur circa 5 Mton per jaar transporteert;
- De eerste uitbreidingsfase, waarbij de transportcapaciteit is uitgebreid tot 14 Mton per jaar;
- De eindsituatie, waarbij de infrastructuur met 22 Mton per jaar maximaal wordt benut.

Procedures
Voor de realisatie van de Aramis CO_2-infrastructuur zijn meerdere vergunningen nodig. Bij een deel van de vergunningen geldt een m.e.r.-plicht, wat inhoudt dat een milieueffectrapportage (MER) opgesteld moet worden ter onderbouwing van de vergunningsaanvragen. Voor de aanleg van de Aramis CO_2-infrastructuur zal het huidige bestemmingsplan gewijzigd moeten worden. Onder de Omgevingswet wordt dit geregeld via een Projectbesluit in een Omgevingsplan. Hiervoor is een besluit over de planologische inpassing nodig en dient het Voorkeursalternatief vastgesteld te worden. Dit is alleen mogelijk indien uit de Passende Beoordeling de zekerheid is verkregen dat het plan/ het project de natuurlijke kenmerken van de omliggende Natura 2000-gebieden niet zal aantasten. Om deze onderzoeksvraag te beantwoorden is onderhavige Passende beoordeling opgesteld.

1.2 Doel van het rapport

Omdat niet op voorhand kan worden uitgesloten dat het projectvoornemen significante gevolgen heeft voor beschermde gebieden, moet een Passende Beoordeling worden gemaakt. Uit een verkennende analyse om te bepalen of de activiteit vergunningsplichtig is, blijkt dat de voorgenomen activiteit mogelijk kan leiden tot negatieve effecten op de instandhoudingsdoelstellingen van de aangrenzende en nabijgelegen Natura 2000-gebieden. Dit geldt zowel voor Natura 2000-gebieden op zee als op land.

In de Passende Beoordeling wordt ingegaan op de gevolgen voor Natura 2000-gebieden. Indien negatieve effecten worden verwacht, wordt aangegeven of en met welke maatregelen effecten kunnen worden voorkomen of kunnen worden gemitigeerd en of het aanvragen van een vergunning noodzakelijk is.

[1] *CCS staat voor Carbon Capture and Storage, de afvang, transport en geologische opslag van CO_2.*

Dit rapport geeft een overzicht van de afwegingen voor de effecten op zee. Als onderliggend rapport is de afweging voor Natura 2000-gebieden op land opgenomen, waar de effecten van stikstofdepositie relevant zijn. De conclusies van zowel de effecten op land als op zee zijn samengevat in dit rapport.
De Passende Beoordeling geeft antwoord op de vragen:

Welke storingsfactoren kunnen optreden?

- Op welke Natura 2000-gebieden kan een storingsfactor invloed hebben?
- Komen verstoringsgevoelige habitattypen, habitatsoorten, broedvogels of niet-broedvogels voor binnen deze Natura 2000-gebieden?
- Wat zijn de instandhoudingsdoelstellingen voor deze soorten of habitattypen in deze Natura 2000-gebieden?
- Heeft de storingsfactor een significant negatief effect op de soorten en habitattypen?
- Is er sprake van significante aantasting van de natuurlijke kenmerken van het Natura 2000-gebied (gelet op de doelstellingen en de staat van instandhouding)?
- Welke maatregelen kunnen genomen worden om effecten te voorkomen dan wel te verminderen?
- Moet voor het projectvoornemen een vergunning in het kader van de gebiedsbescherming worden aangevraagd?

Cumulatie
Soms is één type effect nog niet schadelijk voor de natuur, maar in combinatie met andere effecten wel. Dit kunnen effecten van dezelfde activiteit of van andere activiteiten zijn. Met deze opeenstapeling (cumulatie) van effecten moet bij het bepalen van significantie rekening worden gehouden.

De Passende beoordeling geeft daarom ook antwoord op de volgende vraag:
- Zijn er andere activiteiten die gevolgen hebben voor de soorten en habitats? Het gaat om de optelsom (cumulatie) van de gevolgen van andere initiatieven op een Natura 2000-gebied.

1.3 Leeswijzer

In hoofdstuk 2 is het projectvoornemen kort toegelicht, ook is de projectomgeving beschreven. Vervolgens is in hoofdstuk 3 het wettelijke kader opgenomen. In Hoofdstuk 4 is per storingsfactor afgewogen of deze relevant is in het kader van voorliggend voornemen.

In de volgende hoofdstukken worden de effecten op het zeedeel uitgewerkt. Voor het landdeel is er een separate rapportage opgesteld. De Passende Beoordeling voor Natura 2000-gebieden op land, ten gevolge van stikstofdepositie, is opgenomen in bijlage 7.

In hoofdstuk 5 is voor de relevante Natura 2000-gebieden op zee bekeken welke van de aangewezen habitattypen of soorten verstoringsgevoelig zijn voor de optredende storingsfactoren. Daarbij is beoordeeld of sprake kan zijn van (significante) aantasting van de natuurlijke kenmerken van de Natura 2000-gebieden (gelet op de doelstellingen en de staat van instandhouding). In hoofdstuk 6 is de Passende Beoordeling voor de Natura 2000-gebieden op zee. Hoofdstuk 7 beschrijft de cumulatie en in hoofdstuk 8 zijn de leemtes in kennis beschreven en hoe hier mee is omgegaan in de Passende Beoordeling.

In hoofdstuk 9 is de conclusie van de Passende Beoordeling opgenomen. Naast de conclusies ten aanzien van het zeedeel zijn hier ook de conclusies voor het landdeel, zoals opgenomen in de Passende beoordeling voor Natura 2000-gebieden op land (bijlage 7) opgenomen.

Hoofdstuk 10 geeft een overzicht van de gebruikte literatuur.

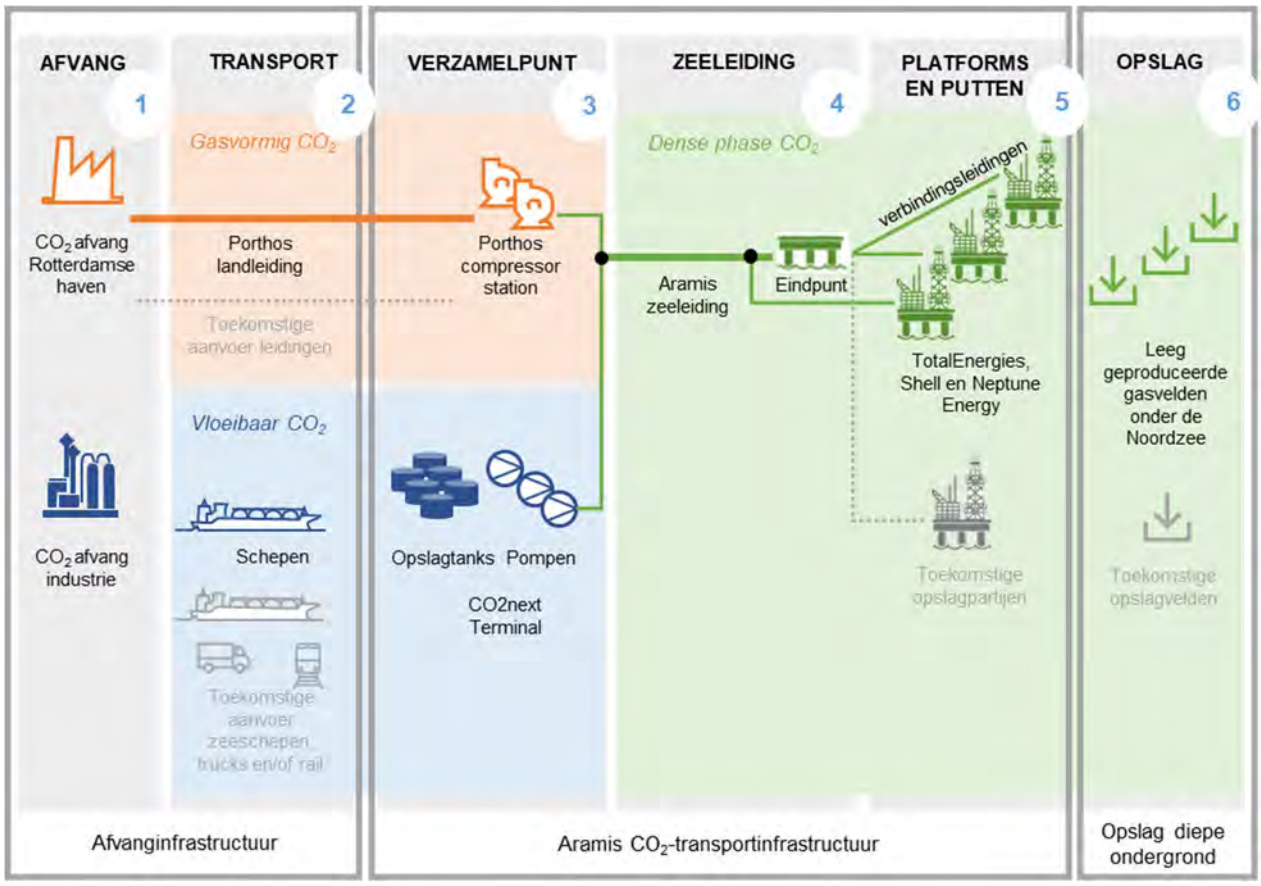
2 Plangebied en afbakening Aramis initiatief

2.1 De voorgenomen activiteit

Het Aramis initiatief is een open CO_2-transportinfrastructuur, waarmee afgevangen CO_2 kan worden vervoerd en opgeslagen in de diepe ondergrond van de Noordzee. Het Aramis initiatief maakt daarmee een nieuwe CCS-keten mogelijk. CCS is een afkorting van het Engelse Carbon Capture and Storage. CCS betekent het afvangen van CO2 dat vrijkomt bij industriële processen en het transport en de opslag van CO2 in leeg geproduceerde gasvelden in de diepe ondergrond. Het Aramis initiatief is een onderdeel van een nieuwe integrale CCS-keten. Figuur 2-1 geeft een overzicht van de integrale CCS-keten, met daarin de componenten van het Aramis initiatief.

Zoals blijkt uit figuur 2-1 sluit Aramis aan op de CCS Porthos infrastructuur. Porthos is een CO_2-transport- en opslagproject in het havengebied van Rotterdam. In dat project wordt afgevangen CO_2 van verschillende industriële bedrijven in het Rotterdamse havengebied met een landleiding naar een compressorstation op de Maasvlakte en vervolgens met een zeeleiding naar het platform P18-A op de Noordzee gebracht. Vanaf het platform wordt de CO_2 in een leeg geproduceerd gasveld opgeslagen. Er is nog capaciteit beschikbaar op de Porthos landleiding die voor het Aramis initiatief kan worden gebruikt.

Afbakening Natuurtoets
De Natuurtoets heeft betrekking op de onderdelen van de Aramis transportinfrastructuur en de opslaginfrastructuur. De onderdelen afvang en transport naar het verzamelpunt zijn geen onderdeel van de Natuurtoets, conform de afbakening in het MER van Aramis. De effecten van het verzamelpunt, de zeeleiding en de platforms met putten zijn uitgewerkt in deze Natuurtoets.



Figuur 2-1. Overzicht van de integrale CCS-keten met daarin de componenten van het Aramis initiatief, namelijk transport per schip, terminal CO2next, compressorstation Porthos, zeeleiding en platforms.

Leveranciers zorgen zelf voor eigen procedures
De CO_2 wordt afgevangen bij de industrie. Voor het Aramis initiatief zijn nog geen leveranciers definitief bekend, maar er zijn welgegadigden met mogelijke interesse. Aramis vormt een flexibele transportinfrastructuur, uitbreidbaar in de toekomst. Voor de startsituatie en voor de nadere uitbreidingen zijn de leveranciers nog niet vastgelegd, zodat de effecten hiervan niet getoetst kunnen worden, maar in separate procedures door de industrie zelf moeten worden uitgewerkt.

Afvang
De industrie zorgt zelf voor de afvang van CO_2 en compressie tot juiste druk voor Aramis. De industrie zorgt ook voor het transport naar hetzij een binnenvaarthaven voor transport per schip of een verbinding met de Porthos landleiding.

Transport naar het verzamelpunt
De afgevangen CO_2 wordt met transportschepen of met de Porthos landleiding aangevoerd naar het Aramis verzamelpunt op de Maasvlakte. Doordat de leveranciers nog niet zijn vastgelegd, kunnen de effecten hiervan niet getoetst worden. Deze worden in separate procedures door de industrie zelf uitgewerkt.

2.1.1 Verzamelpunt

Terminal
De transportschepen komen aan bij de terminal van CO2next op de Maasvlakte. In de toekomst kunnen hier mogelijk ook trucks of rail CO_2 aanleveren. Onderdeel van de terminal zijn aanlegsteigers voor de schepen, een aantal opslagtanks voor het bufferen van CO_2, lage- en hogedrukpompen om de CO_2 op de juiste druk te brengen voor transport met de zeeleiding en tussenliggende leidingen. De leiding van de terminal richting de zeeleiding komt te liggen in de leidingstraat.

Voor de aanvoer van CO_2 per schip worden langs het Yangtzekanaal nieuwe steigers aangelegd. De fundering van de steigers wordt geheid in de bodem.

Compressorstation
De Porthos landleiding komt uit bij het Porthos compressorstation. Het station wordt uitgebreid met compressoren voor het Aramis initiatief. De CO_2 uit de Porthos landleiding wordt gesplitst in een stroom voor de Porthos compressor en een stroom voor de Aramis compressor. Bij de compressors wordt de CO_2 op de juiste druk gebracht voor de zeeleiding.

Mengpunt
De Aramis CO_2 stroom wordt na de compressor bij het mengpunt gemengd met de stroom van de terminal.

2.1.2 Zeeleiding

De gemengde stroom CO_2 van de compressor en de terminal wordt met de zeeleiding naar de platforms getransporteerd. De zeeleiding loopt voor een deel over land, kruist onder de zeewering en de Maasgeul door en loopt over de zeebodem naar een eindpunt op zee. Het eindpunt vormt een distributiepunt (eindpunt), waar vandaan verbindingsleiding(en) voor de spurlines naar verschillende platforms mogelijk zijn. Er zijn in het leidingtracé ook meerdere connectiepunten, waar aansluiting richting een platform mogelijk is.

Er zijn twee alternatieven voor de kruising van de zeewering en Maasgeul:

Microtunnel is de voorgenomen activiteit. Er wordt vanaf de Maasvlakte een tunnel met diameter van circa 3 meter aangelegd onder zowel de zeewering als de Maasgeul. De totale lengte bedraagt circa 2 kilometer. De tunnel komt circa 40 meter onder de bodem van de Maasgeul te liggen, 10 meter dieper dan de vaargeul (30 meter onder NAP). Er vindt beperkt baggerwerk plaats nadat de tunnel voorbij de Maasgeul komt

Direct pipe is het alternatief. Er wordt een kortere boring uitgevoerd onder de zeewering en daarna komt er door de Maasgeul een gebaggerde sleuf. De direct pipe methode wordt gebruikt om een stalen mantelbuis met een diameter van circa 48 inch (circa 122 cm) te installeren, waar de zeeleiding later doorheen wordt getrokken. De boring komt achter de zeewering, maar vóór de Maasgeul weer aan het oppervlak van de zeebodem. Vervolgens wordt met behulp van een gebaggerde sleuf de Maasgeul gekruist. De boring onder de zeewering heeft een lengte van circa 650 m. De gebaggerde sleuf in de Maasgeul moet zo diep zijn dat de bovenkant van de leiding op meer dan 40 m onder NAP komt te liggen. De lengte van de sleuf is circa 1.700 m. Echter, voor de aanleg wordt een bredere stook gebaggerd, 10 meter diep met een hellingshoek van 45 graden. Voor de bepaling van het totale oppervlak van het baggerwerk wordt uitgegaan van een breedte van de verstoorde strook van 20 meter (10 meter aan beide kanten van de leiding). De oppervlakte van het baggerwerk komt op 3,4 ha.

Voor de aanleg van de zeeleiding zijn schepen nodig voor de aanvoer van de leidingsegmenten en voor het aanbrengen van de leidingsegmenten voor het leggen van de zeeleiding op de zeebodem.

2.1.3 Platforms en putten

Bestaande en nieuwe platforms van TotalEnergies, Shell en Neptune Energy worden aangesloten op het eindpunt of connectiepunten van de zeeleiding. In de toekomst kunnen ook andere opslagpartners op de zeeleiding aansluiten. Vanaf platforms wordt de CO_2 in leeg geproduceerde gasvelden onder de zeebodem geïnjecteerd en daar permanent opgeslagen.

TotalEnergies zal het platform L4-A aanpassen en geschikt maken voor CO_2-opslag, waarbij bestaande putten worden aangepast. Shell en Neptune Energy zullen een nieuw platform plaatsen en nieuwe putten boren. Voor alle partijen geldt dat bestaande, niet gebruikte putten, worden afgesloten.

De nieuwe platforms worden verankerd in de bodem door palen in de grond te heien. Daarnaast worden er conductors in de bodem geheid ter ondersteuning van nieuwe injectieputten.

2.1.4 Fasering en uitbreidingsmogelijkheden

De CCS-keten wordt stapsgewijs uitgebreid. In het MER zijn drie fases onderscheiden: startsituatie, eerste uitbreidingssituatie en eindsituatie. De capaciteit per fase is gegeven in Tabel 2-1Tabel 2-1. Capaciteit per fase.. Tabel 2-2 geeft de fasering van de ketenonderdelen.

Tabel 2-1. Capaciteit per fase.

Fase	Capaciteit (Mton CO_2 per jaar)	Toelichting
Startsituatie	5	Deze capaciteit is gebaseerd op de huidige vraag van CO_2-leveranciers naar opslagcapaciteit
Eerste uitbreidingssituatie	14	Deze waarde is gebaseerd op een verwachte groei van de vraag naar CO_2-transportcapaciteit binnen enkele jaren na de startsituatie
Eindsituatie	22	Deze waarde is gebaseerd op een verwachte maximale vraag naar CO_2-transportcapaciteit voor opslag van CO_2 in leeggeproduceerde gasvelden op zee

Tabel 2-2. Fasering uitbreiding CCS-keten.

Fase	Ketenonderdelen Aramis initiatief	Overige onderdelen CCS-keten	Ingebruikname
Startsituatie	Terminal, compressorstation, zeeleiding en platforms TotalEnergies, Shell	Afvang, transport Porthos-landleiding, transport per schip, opslag in diepe ondergrond	2028
Eerste uitbreidingssituatie	Uitbreiding terminal, platforms waar onder Neptune Energy	Aanvullende afvang en transport naar verzamelpunt, uitbreiding opslaglocaties in diepe ondergrond	2028-2032
Eindsituatie	Uitbreiding terminal en platforms op zee tot maximale capaciteit zeeleiding	Uitbreiding afvang en transport en aanvullende opslag in de diepe ondergrond en uitbreiding CO2Next	Na 2028

De aanleg van de eerste twee fasen vindt gelijktijdig plaats. Hiervoor worden nu vergunningaanvragen voorbereid. Het MER beschrijft en toetst de effecten van deze eerste twee fasen. In het deelrapport Technische Beschrijving zijn de aanleg en het gebruik van deze fasen expliciet beschreven. Voor de eindsituatie zullen te zijner tijd waar nodig vergunningen worden aangevraagd met aanvullend milieuonderzoek. De eindsituatie is globaal beschreven.

Toekomstige initiatieven, na de eerste uitbreidingssituatie, behoren niet tot dit onderzoek. De opzet van de CO_2-transportinfrastructuur is wel zodanig flexibel en ruim, dat er voldoende ruimte is voor toekomstige uitbreiding, tot een maximale capaciteit van 22 Mton CO_2 per jaar. Toekomstige ontwikkelingen zijn onder andere:

- Aanvullend transport naar het verzamelpunt met extra landleidingen, schepen of via spoor- en weg;
- Verdere uitbreiding van de terminal;
- Nieuwe platforms en/of opslagvelden.

Om toekomstige uitbreidingen mogelijk te maken is de zeeleiding gedimensioneerd op de maximale uiteindelijke capaciteit. Overige onderdelen zijn of uit te breiden (terminal en compressorstation) of aan te koppelen (toevoerleidingen op land en verbindingsleidingen naar nieuwe platforms/opslagvelden). Om de terminal en het compressorstation in de toekomst uit te kunnen bereiden, wordt nu extra ruimte gereserveerd. Voor het aankoppelen van leidingen op land en op zee zijn verbindingspunten voorzien.

Voor een gedetailleerde en volledige omschrijving van alle onderdelen wordt verwezen naar het MER-deelrapport Technische beschrijving.

2.2 Locatie

De projectomgeving, welke beschouwd wordt ten behoeve van deze Passende Beoordeling bestaat uit twee gebieden:

- Het **landdeel**, bestaande uit het Rotterdamse havengebied, en Maasvlakte;
- Het **zeedeel**, bestaande uit de Noordzee, het passeren van de Voordelta en de Maasgeul, Noordzeekustzone, Klaverbank, Bruine Bank en Friese Front.

Landdeel

De Aramis transportleiding op de Maasvlakte is gepland in de leidingstrook van Leidingenbureau Rotterdam en wordt beheerd door het Havenbedrijf Rotterdam (HbR). De Maasvlakte is onderdeel van het Rotterdamse havengebied. Het gebied is ontwikkeld door zand vanuit zee aan te brengen tot een hoogte van ongeveer 5 meter +NAP. Aan de noordwestzijde van de Maasvlakte bevindt zich hierboven een harde zeewering ter bescherming van golfslag.

Het leidingwerk van de terminal naar het Porthos compressor station is bovengronds voorzien over het MOT terrein. De CO2next terminal is gepland aan de oostzijde van de MOT.

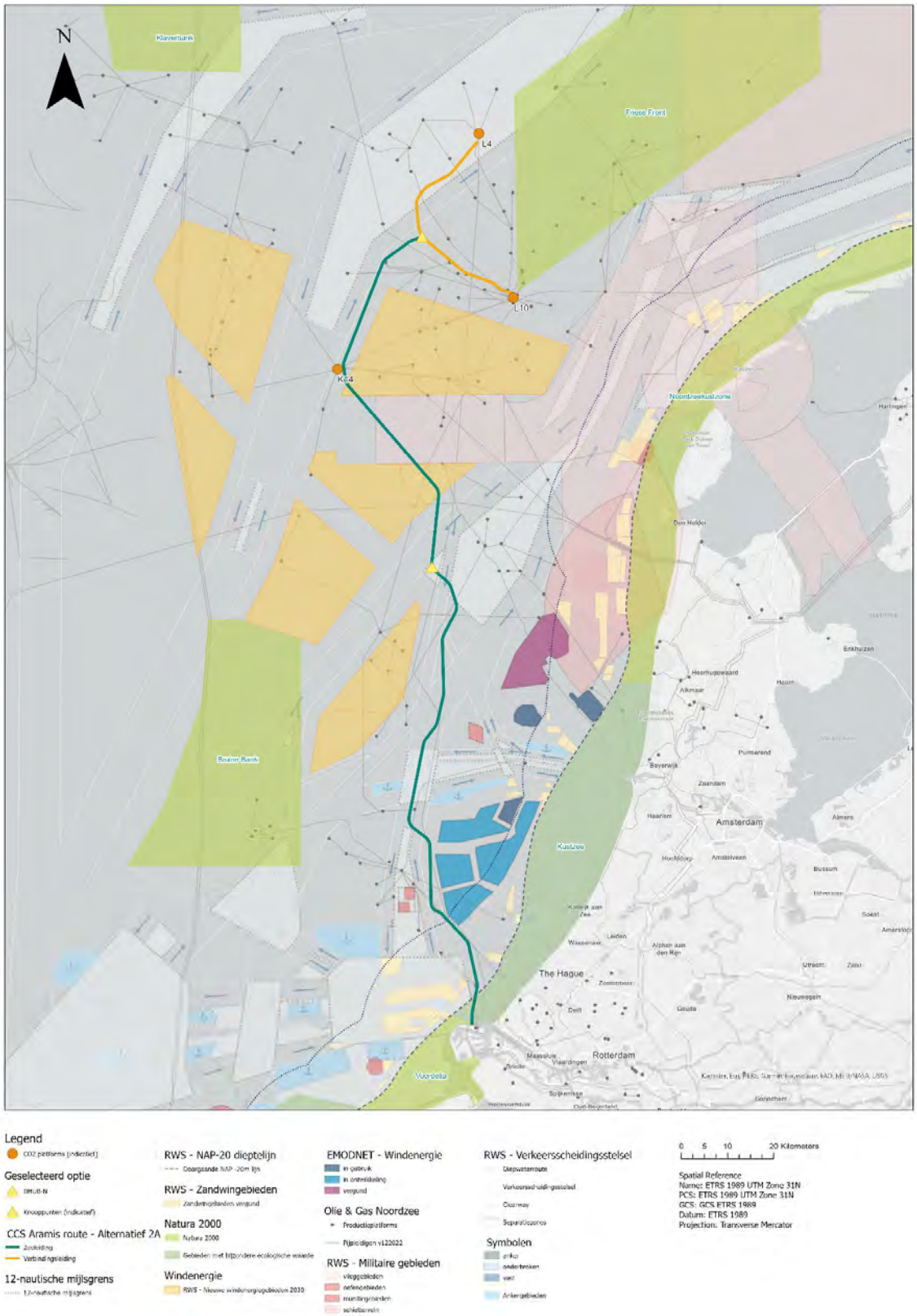
Zeedeel
Het gemeentelijke bestemmingsplan van de gemeente Rotterdam is geldig tot 1 kilometer vanaf de kust, zodat het leidingtracé onder de Maasgeul in het bestemmingsplan moet worden opgenomen. De 12 mijls-zone (zeemijlen[2]) geeft de territoriale grens van Nederland aan. Voorbij deze zone bevindt zich de exclusieve economische zone (EEZ), een gebied dat zich tot 200 zeemijl (370,4 km) buiten de kust uitstrekt.

De transportroute van CO_2 schepen gaat via binnenlands water en/of kustwateren. Echter zijn deze waterlichamen van het Rijk en niet van de provincie. De zeeleiding bevindt zich deels binnen de territoriale wateren en het grootste gedeelte in de EEZ. De platforms bevinden zich binnen de EEZ. De EEZ wordt ook aangeduid als het Nederlands Continentaal Plat (NCP).

Direct ten noorden van de Maasvlakte bevindt zich de vaargeul naar de Rotterdamse haven. Deze wordt aangeduid als de Maasgeul (gelegen in de Maasmond) en is circa 30 meter diep. De diepte over het geplande traject van de zeeleiding is maximaal 31 m.

De zeeleiding bevindt zich op de Noordzee en zodoende dient Aramis rekening te houden met de andere functies op de Noordzee. Dit gedeelte van de Noordzee wordt druk bevaren. Daarnaast is er visserij en militaire oefenruimte. Er komen in toenemende mate windmolens te staan. De afstand van de pijpleiding en platforms ten opzichte van de Natura 2000-gebieden is weergegeven in Figuur 2-2 en Tabel 2-3.

[2] *Een zeemijl komt overeen met 1,852 kilometer.*



Figuur 2-2. Overzicht van Aramis initiatief met aanwezige Natura 2000-gebieden.

Tabel 2-3. Overzicht afstanden van de platforms en zeeleiding/verbindingsleidingen tot de Natura 2000-gebieden.

Type infrastructuur	Afstand tot Natura 2000-gebieden in km				
	Voordelta	Bruine Bank	Noordzeekust-zone	Friese Front	Klaverbank
Platform L4-A	192	116	69	7,8	53
Platform L10-R	156	87	41	1,6	77
Platform K14-FA	143	58	70	43	68
Eindpunt	170	91	65	20	53
Zeeleiding	0	23	37	2,1	40

2.3 Overzicht activiteiten

In Tabel 2-4 zijn de werkzaamheden samengevat uit de technische beschrijving die worden meegenomen in de Voortoets en Passende Beoordeling.

2.3.1 Scheepvaart aanvoer vanaf de leveranciers

Binnen het MER van Aramis is een afbakening gemaakt waarbij alleen generiek is gekeken naar mogelijke effecten bij de afvanginstallaties, compressie van CO_2 voor transport en transport naar het verzamelpunt op de Maasvlakte.

Het CO_2 wordt aangevoerd middels de buisleiding van Porthos in het Rotterdamse havengebied of middels schepen vanaf de locatie van de leverancier. De leveranciers zijn nog niet bekend en daarmee is de route voor scheepvaart ok niet bekend. In het kader van dit onderzoek kan zodoende geen effectbepaling worden uitgevoerd. Wel kan worden aangenomen dat als de CO_2 transportschepen gebruik maken van de bestaande scheepvaartroute de effecten klein zijn en op voorhand uit te sluiten.

Als de CO_2 transportschepen buiten de bestaande scheepvaartroutes varen moet er rekening worden met de volgende mogelijke storingsfactoren:

- Verstoring door trillingen en geluid
- Verstoring door licht
- Verstoring door beweging/optiek
- Verstoring door luchtwerveling, betreding, golfslag
- Verstoring door stikstofemissie

2.3.2 Zeeleiding en verbindingsleidingen leggen

Scheepvaartroutes van constructieschepen en ondersteunende schepen
Constructieschepen (pijplegschip, baggerschip, trencher) varen uit vanaf de Rotterdamse haven. Het baggerschip vaart mogelijk vanuit Antwerpen. Deze constructieschepen varen op weg naar en op de weg terug van de constructielocatie zoveel mogelijk volgens de bestaande scheepvaartroutes. Om de constructielocatie te bereiken, zullen de schepen echter op enig moment van de route moeten afwijken. Ondersteunende schepen (crew change, survey, pipe carriers, andere support vessels) kunnen uit zowel de Rotterdamse haven, als Amsterdamse haven of Den Helder uitvaren, afhankelijk van de locatie waar de zeeleiding wordt aangelegd. De ondersteunende schepen houden zoveel mogelijk bestaande scheepvaartroutes aan, maar zullen op enig moment moeten afwijken om de constructieschepen te bereiken.

2.3.3 Nieuwe platforms en putten

Nieuwe platforms worden geschikt voor CO_2-injectie onder normaal onbemande operatie. Het eindpunt (DHUB) is geschikt voor aansluiten, in gebruik nemen en inspecteren van verbindingsleidingen naar de opslagpartijen. Er wordt een volledig nieuwe constructie gerealiseerd: onderstructuur die op de zeebodem wordt gezet, bovenstructuur met alle injectie-installaties en nieuwe putten. De werkzaamheden bestaan uit:

- Installeren van de onderstructuur van het platform (jacket).
- Heien van de fundering, nl de verankeringspalen van het platform.
- Installeren van de bovenstructuur van het platform (topside). De topside wordt zo compleet mogelijk aangevoerd met daarop de manifold, injectieleiding en metering skid, de risers, voorzieningen voor de duurzame energievoorziening, leidingen, monitoringsapparatuur, drukaflaatvoorzieningen en entreepunten waar personeel van onderhouds- en inspectieschepen op het platform kan komen.
- Constructiewerkzaamheden om de jacket en topside met elkaar te verbinden (o.a. poten en riser) en de verbindingsleiding aan de riser aan te sluiten.

Bovenstaande punten zijn ook van toepassing voor de installatie van het eindpunt, het enige verschil is dat de topside geen injectiefaciliteiten heeft.

Voor de injectieplatforms worden daarna de volgende werkzaamheden verricht:

- Heien van conductors: dat zijn de bovenste doorvoerbuizen voor de putten.
- Boren van de putten, plaatsen spuitkruis en verbinden met topside leidingwerk.

Daarnaast zijn er werkzaamheden om een bestaand platform aan te passen (zie verder Tabel 2-4). Puttesten en dus ook affakkelen zijn niet noodzakelijk.

2.3.4 Aanleg van steigers voor de terminal

Langs de oever van het Yangtzekanaal komen steigers voor lossen en laden van CO_2-schepen. In de aanlegfase wordt met een heihamer de fundering van de aanlegsteigers gerealiseerd.

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Tabel 2-4. Overzicht van de te beoordelen activiteiten van het Aramis initiatief.

Activiteit		Verstoringsfactoren	Natura 2000-gebied	Technische aandachtspunten van belang bij de toetsing
Zeedeel				
Pijpleiding leggen	Baggeren zeeleiding inclusief twee alternatieven: Microtunnel en Direct Piping [1]	Vertroebeling, oppervlakteverlies, beweging/optiek, verandering dynamiek substraat, onderwatergeluid	Voordelta	▪ Diameter zeeleiding is circa 80 cm. ▪ Het volume grondverzet als gevolg van de baggerwerkzaamheden wordt grotendeels gebruikt om de gebaggerde sleuf weer dicht te maken (voor microtunneling: 1.967 m^3, voor direct piping: 706.756 m^3) een deel wordt afgevoerd naar een stortplaats op zee (voor microtunneling: 53 m^3, voor direct piping: 996 m^3).
	Aftoppen zandgolven met sleephopperzuiger	Vertroebeling, verandering dynamiek substraat, onderwatergeluid/trillingen	Voordelta, mogelijk Bruine Bank	▪ 6 weken vóór de installatie van de zeeleiding worden de zandgolven afgetopt. ▪ Opties zijn ter plaatse storten, elders storten of nuttig gebruiken als suppletie- of ophoogzand.
	Leggen zee- en verbindingsleidingen	Vertroebeling, oppervlakteverlies, beweging/optiek, verandering dynamiek substraat, onderwatergeluid/trillingen	Voordelta, Bruine Bank, Friese Front	**Verbindingsleidingen** ▪ Ieder platform wordt met een verbindingsleiding (spurline) verbonden aan de zeeleiding, via het noordelijke distributieplatform of één van de connectiepunten van de zeeleiding. ▪ K14-FA; Er komt een 800 m lange 16" (circa 40 cm diameter) verbindingsleiding naar het connectiepunt. ▪ L4-A: Er komt een 24 km lange 20" (circa 50 cm diameter) verbindingsleiding naar het noordelijke distributieplatform van de zeeleiding. ▪ L10-R: Er komt een 24 km lange 20" (circa 50 cm diameter) verbindingsleiding naar het noordelijke distributieplatform van de zeeleiding. ▪ Verbindingsleiding wordt (gedeeltelijk) ingegraven en, bij kruisingen met andere leidingen, gedeeltelijk afgedekt met stortsteen. **Zeeleiding** ▪ Het tracé van de zeeleiding loopt vanuit de doorkruising met de Maasgeul in noordelijke richting naar het eindpunt dat zich ongeveer op 230 kilometer afstand in noordelijke richting op de Noordzee bevindt. ▪ Gemiddelde aanleg 1 km per dag. ▪ De leiding wordt opgebouwd uit leidingsegmenten met een lengte van ongeveer 12 meter. De leidingsegmenten worden met bevoorradingsschepen vanuit het depot aan wal naar het

Activiteit		Verstoringsfactoren	Natura 2000-gebied	Technische aandachtspunten van belang bij de toetsing
				pijpenlegschip aangevoerd en op zee op het pijpenlegschip overgeladen. Op het pijpenlegschip wordt steeds een nieuw segment aan de opgebouwde leiding gelast.
	Ingraven of begraven zee- en/of verbindingsleidingen	Vertroebeling, oppervlakteverlies, beweging/optiek, verandering dynamiek substraat, onderwatergeluid/trillingen	Voordelta, Bruine Bank, Friese Front	▪ 70 kilometer vanaf de kruising met de Maasgeul wordt de zeeleiding ingegraven in de zeebodem, met dekking van circa 1 meter. ▪ Voor kruisingen van shipping lanes en zandgolven wordt mogelijk eerst een sleuf gebaggerd voor een verdiepte aanleg, als de benodigde ingraafdiepte te groot is voor een ingraafmachine (trencher).
	Rock dump kruisingen	Vertroebeling, oppervlakteverlies, beweging/optiek, verandering dynamiek substraat, onderwatergeluid	Voordelta, Bruine Bank, Friese Front	▪ Naar verwachting gaat dit om circa 45 kruisingen van gemiddeld 500 meter lengte waar stenen worden gestort bij bestaande leidingen/ kabels. De verwachting is dat na het storten van het steen geen verdere stortingen nodig zijn gedurende de levensduur van het Aramis initiatief.
Scheepvaart en helikoptervluchten	Schepen, langer op één locatie, baggerschip, pijplegschip, bevoorradingsschepen, trenchschip, begeleidingsschepen, helikopters	Onderwatergeluid/trillingen, verstoring door licht, verstoring door beweging/optiek	Voordelta, Friese Front, Noordzeekustzone, Klaverbank, Bruine Bank	Bijlage 6: Scheepvaart- en helikopterbewegingen.
Aanpassing bestaande putten/platform L4-A	Nieuwe putten boren bij de sloten van L4-A3 en L4-A4	Onderwatergeluid/trillingen, verstoring door licht, verstoring door beweging/optiek	Friese Front, Klaverbank	▪ 100 dagen per put.
	Aanpassen platform L4-A	Onderwatergeluid/trillingen, verstoring door licht, verstoring door beweging/optiek	Friese Front, Klaverbank	▪ Verwijderen van compressie- en accommodatiemodules met een heavy lift vaartuig ▪ Aanbrengen van de riser (beschermd met staalconstructie) langs een van de staanders van het platform ▪ Plaatsen productiemanifold, injectie- en meteringskid ▪ Plaatsen van voorzieningen voor de duurzame energievoorziening (e.g. zonnepanelen, windturbines)

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Activiteit		Verstoringsfactoren	Natura 2000-gebied	Technische aandachtspunten van belang bij de toetsing
				▪ Aanbrengen van entree punten waar personeel vanaf onderhouds- en inspectieschepen (Walk-to-Work (W2W) vessels) op het platform kan komen ▪ Aanpassen en waar nodig vervangen van de leidingen op het platform.
Plaatsen nieuwe platforms en putten nabij K14-FA en bij L10-R	Plaatsen platforms K14-FA en L10-R (inclusief heiwerkzaamheden verankeringspalen)	Oppervlakteverlies, versnippering leefgebied, onderwatergeluid/trillingen, verstoring door licht, verstoring door beweging/optiek	Friese Front, Klaverbank	▪ Plaatsen nieuw platform duurt totaal 7 dagen. ▪ 4 verankeringspalen; diameter 1 - 1.7 m; diepte 35 - 60 m. ▪ Heien verankeringspalen duurt circa 2-3 dagen.
	Heien conductors voor putten	Onderwatergeluid/trillingen, verstoring door licht, verstoring door beweging/optiek	Friese Front, Klaverbank	▪ K14-FA; 40-80 m diepte, 4 of 6 conductors, 3 dagen per 4-6 conductors, diameter is 0,76 m. ▪ L10-R; 40-80 m diepte, maximal 6 conductors, 3 dagen per 4-6 conductors, diameter is 0,76 m; ▪ L4-A; 2 conductors. ▪ Het heien van een conductor duurt circa 6 uur (hei energie bedraagt circa 90 kJ).
	Boren putten	Onderwatergeluid/trillingen, verstoring door licht, verstoring door beweging/optiek	Friese Front, Klaverbank	▪ K14-FA; 400 dagen boorwerkzaamheden vanaf een zelfheffend booreiland, 4 nieuwe injectieputten Shell, 2500 m diepte bovenste deel put. ▪ L10-R; 80 dagen per put, maximaal 6 nieuwe putten. ▪ L4-A; 2 nieuwe putten en 2 sidetracks.
Centrale eindpunt	Heiwerkzaamheden centrale eindpunt	Onderwatergeluid/trillingen, verstoring door licht, verstoring door beweging/optiek	Friese Front, Klaverbank	▪ Diameter 2 m, lengte 45 m. ▪ 4 of 6 verankeringspalen. ▪ 3 dagen per 4-6 verankeringspalen.
Lozingen	Lozing van boorvloeistof en boorgruis	Verontreiniging, vertroebeling, verandering dynamiek	Friese Front	▪ K14-FA: De restanten van de boorvloeistof en het boorgruis worden volgens de gangbare praktijk op zee geloosd bij de desbetreffende put. Het gaat om circa 10.371 ton waterbasisboorgruis, en 7.909 ton waterbasis boorvloeistof (in totaal voor alle putten). Er wordt ongeveer 6.500 ton schoon regen- en spoelwater van de dekken en 250 ton sanitair afval (septic tank) op zee geloosd (in totaal). ▪ L10-R: De lozing van schoon regen- en spoelwater bedraagt 6.500 ton en voor het sanitaire afval 250 ton (in totaal). Water wordt tot beneden de wettelijk vastgestelde concentraties ontdaan van

Activiteit		Verstoringsfactoren	Natura 2000-gebied	Technische aandachtspunten van belang bij de toetsing
				koolwaterstoffen en vervolgens geloosd. Geloosd water voldoet aan de emissie eisen van H9 van de mijnbouwregeling (30 ppm olie in water). Bij de werkzaamheden aan platform L10-R worden nieuwe putten geboord, waarbij Water Based Mud (WBM)-houdende boorvloeistof wordt gebruikt. Het gaat om circa 1.700 tot 2.000 ton waterbasisboorgruis en 1.700 tot 3.500 ton waterbasis boorvloeistof per put (maximaal 6 putten). De boorvloeistof en het boorgruis worden volgens de gangbare praktijk op zee geloosd. ▪ L4-A: het gaat in totaal om 2.000 ton waterbasisboorgruis en 1.900 ton waterbasis boorvloeistof. ▪ Het onderste deel van de putten wordt geboord met boorvloeistof op lage toxiciteit oliebasis (LTOBM, Low toxicity oil based mud). Deze boorvloeistof en boorgruis worden afgevoerd naar land.
Landdeel				
Terminal	Aanleg aanlegsteigers (jetties) en vaarbewegingen in de aanlegfase	Onderwatergeluid/trillingen, oppervlakteverlies		▪ Het heien van fundering bij de aanlegsteigers geeft onderwatergeluid. Dit vindt plaats binnen het Yangtzekanaal en staat niet in direct contact met de Noordzee. Vaarbewegingen in de aanlegfase, onderdeel van verkeer in de Maasgeul en in het Yangtzekanaal.
Leidingtracé	Aanleg onshore leiding	Oppervlakteverlies		▪ Het leidingwerk van de terminal naar het Porthos compressor station is bovengronds voorzien over het MOT terrein. De CO2next terminal is gepland aan de oostzijde van de MOT. ▪ Vanaf het compressorstation wordt de leiding in de bestaande leidingstrook ondergronds geplaatst naast andere leidingen, waaronder de Porthos-zeeleiding. Hiervoor moet de leidingstrook bij de expansieloops en over de hele lengte langs de Aziëweg worden verbreed.
Compressorstation	Aanpassingen aan het compressorstation	Oppervlakteverlies		▪ Gasvormig CO2 wordt aangeleverd via de Porthos landleiding aan het compressorstation. ▪ Tijdens de bouwfase van het Porthos compressorstation zal er een verbrede fundering worden aangelegd voor de toekomstige plaatsing van de compressoren voor Aramis, Het compressorstation wordt uitgebreid met drie extra compressoren voor Aramis.

[1] In dit rapport wordt gesproken over de microtunnel. Maar mogelijk wordt in plaats van de microtunnel boortechniek (over delen van de tunnel) gebruik gemaakt van een iets ander boortechniek, de segmented tunnel boortechniek of een hybride vorm. Daar waar dat tot verschillen in milieueffecten leidt, is dat aangegeven in de MER.

2.4 Standaard maatregelen

Voor het project worden uitvoeringsmethodieken gebruikt waarmee de effecten op de omgeving en fauna zo veel mogelijk worden beperkt. De volgende standaardvoorzieningen voor de onderwerpen lichthinder, schadelijke stoffen en onderwatergeluid worden genomen als onderdeel van de activiteit:

Lichthinder en aanwezigheid

- De verlichting op het platform en schepen wordt zo veel mogelijk afgeschermd. De verlichting zal zodanig uitgevoerd worden dat onnodige lichtuitstraling naar buiten toe zoveel mogelijk wordt vermeden. Denk hierbij aan naar beneden gerichte uitstraling en schone lichtbronnen, ter beperking van strooilicht[3]. Daarmee is de verlichting beperkt tot wat noodzakelijk is, dat wil zeggen volgens eisen van de Mijnbouwwet en regelgeving veiligheid.
- Voor transportbewegingen van en naar het platform zal er zoveel mogelijk gebruik worden gemaakt van bestaande scheepvaartroutes, waarbij doorkruising met Natura 2000-gebieden zoveel mogelijk wordt vermeden.

Schadelijke stoffen/afvalstoffen

- Afvalwater wordt tot beneden de wettelijk vastgelegde concentraties ontdaan van koolwaterstoffen en vervolgens geloosd. Geloosd water voldoet aan de emissie-eisen van hoofdstuk 9 van de Mijnbouwregeling (< 30 ppm olie in water).
- Boorgruis met nog aanhangende LTOBM[4]-boorspoeling wordt naar land afgevoerd en daar verwerkt in een speciale installatie. De olie wordt zoveel mogelijk teruggewonnen voor hergebruik. Gereinigd boorgruis wordt gestort op IBC-stortplaatsen (isoleren, beheersen, controleren).
- Reststoffen en afval worden in containers verzameld en gescheiden afgevoerd.

Onderwatergeluid

- Bij het heien van de conductors, platforms en de aanlegsteigers wordt een ADD (Acoustic Deterrent Device) in combinatie met een soft start toegepast. Voor het heien van de conductors met de drill en drive methode zal dit ook worden toegepast. Een ADD is een apparaat dat in het water wordt gehangen en specifieke, onschadelijke geluidsignalen produceert met een afschrikkende werking op zeezoogdieren. Op deze manier wordt eventueel in het directe plangebied aanwezige zeezoogdieren de gelegenheid gegeven het gebied te verlaten. Er wordt gebruik gemaakt van een of meer ADD's met een bereik van minimaal 500 m gedurende een half uur voor en tijdens het heien. De gebruikte frequentie en het geluidsniveau waarop de ADD wordt toegepast is afhankelijk van het type of model.
- De soft start dient minimaal 30 minuten lang te duren en te beginnen met vijf minuten op circa 20% van de slagenergie, aansluitend kan de slagenergie geleidelijk naar 90% worden opgehoogd. Na 30 minuten zijn eventueel aanwezige zeezoogdieren ver genoeg weggezwommen om geen gehoorschade op te lopen (zie ook tekstkader hieronder).
- Om effecten van geluid door werkzaamheden zoveel mogelijk te voorkomen wordt er gebruik gemaakt van een Marine Mammal Observer (MMO) en Passive Acoustic Monitoring (PAM). Wanneer het donker is, of de weersomstandigheden een visuele monitoring ineffectief maken, zal er alleen akoestisch gemonitord worden (PAM), hiermee worden clicks van bruinvissen tot 500 m opgevangen. Het protocol dat wordt uitgevoerd indien zeezoogdieren zich binnen de effectzone bevinden staat in het tekstkader hieronder uitgewerkt.
- Bij windstilte geldt dat het verstoorde oppervlak ongeveer tweemaal zo groot is als bij gemiddelde wind van 6,5 m/s (Heinis, 2018). Om die reden voert Aramis standaard geen hei-werkzaamheden uit als het windstil is (windkracht 0 Beaufort of 0-0,2 m/s).

[3] *Kwantificering van de lichtuitstraling is niet mogelijk omdat dit afhangt van een groot aantal factoren, waaronder de weersomstandigheden. Bij helder zicht zal het boorplatform 's nachts op afstand zichtbaar zijn. Bij mist of storm is het boorplatform slechts op relatief korte afstand zichtbaar*
[4] *low toxicity oil based mud*

MMO en PAM
Een zone van 500 meter rondom het boorplatform of de airguns zal, als het licht en de weersomstandigheden het toelaten, zowel op zicht door Marine Mammal Observers (MMO) als op geluid door middel van Passive Acoustic Monitoring (PAM) worden gemonitord op de aanwezigheid van zeezoogdieren. Wanneer het donker is, of de weersomstandigheden een visuele monitoring ineffectief maken, zal er alleen akoestisch gemonitord worden (PAM), hiermee worden clicks van bruinvissen tot 500 m opgevangen. Het MMO/PAM-team zal, voor er een geluidsbron wordt opgestart, minimaal 30 minuten lang observeren of er geen zeezoogdieren binnen de 500 meter zone zijn. Wanneer een zeezoogdier zich binnen de 500 meter zone bevindt, dan zal er gewacht worden met het opstarten van de heihamer tot deze zich buiten de zone bevindt en daar minimaal 20 minuten buiten blijft. Door het toepassen van een ADD, soft start, MMO-ers en PAM kan worden uitgesloten dat er zich zeezoogdieren binnen 500 meter van de geluidsbron bevinden (heien). Op deze manier kan voorkomen worden dat PTS optreedt en dat TTS zoveel mogelijk wordt geminimaliseerd doordat de zeezoogdieren het gebied verlaten.

3 Natura 2000 en Passende beoordeling

3.1 Natura 2000

Natura 2000 is een van de belangrijkste beschermingsregimes voor natuur in Europa en Nederland. Natura 2000 is een Europees netwerk van natuurgebieden. Dit netwerk dient de biodiversiteit te bevorderen door geïsoleerd liggende gebieden met elkaar te verbinden zodat planten en dieren tussen gebieden kunnen migreren. Nederland kent meer dan 160 Natura 2000-gebieden die zijn aangewezen onder de Vogelrichtlijn en/of onder de Habitatrichtlijn. Bij het bepalen van effecten op Natura 2000-gebieden is significantie een belangrijk begrip.

3.2 Wettelijk kader

Onderstaand wordt eerst ingegaan op het wettelijk kader vanuit de Wet natuurbescherming (Wnb), en daarna op de veranderingen in de Omgevingswet.

3.2.1 Wet natuurbescherming (Wnb)

De Wet natuurbescherming (Wnb), hoofdstuk 2, regelt met name de bescherming van gebieden die in het kader van de Vogelrichtlijn en/of Habitatrichtlijn beschermd moeten worden. Deze vallen samen onder Natura 2000 en zijn Europees beschermd. De Wnb regelt de aanwijzing en bescherming van Natura 2000-gebieden, beschermde natuurmonumenten en gebieden die de Minister van EZK aanwijst ter uitvoering van verdragen of andere internationale verplichtingen. De Natura 2000-gebieden vormen de Ecologische Hoofdstructuur van Europa en omvatten de Vogel- en Habitatrichtlijngebieden en veelal aangrenzende aaneengesloten EHS-gebieden. Per 1 januari 2024 is het beschermingskader van de Wnb opgenomen in de Omgevingswet (zie paragraaf 3.3.1).

De begrenzing van de Natura 2000-gebieden en de instandhoudingsdoelstellingen zijn vastgelegd in de aanwijzingsbesluiten voor de betreffende gebieden en in het Wijzigingsbesluit Habitatrichtlijngebieden vanwege aanwezige waarden (Ministerie LNV, 2022). De instandhoudingsdoelstellingen beschrijven voor de (in ontwerp) aangewezen habitattypen, habitatrichtlijnsoorten en vogelrichtlijnsoorten in het gebied of een bepaalde ontwikkeling ervan gewenst is, of dat het behoud ervan op het aanwezige niveau moet worden nagestreefd. Op grond van de wet moet worden bepaald welke effecten een activiteit heeft op de instandhoudingsdoelstellingen van een Natura 2000-gebied. In de wet is het uitgangspunt dat projecten en andere handelingen die de kwaliteit van habitats kunnen verslechteren of die een significant verstorend effect kunnen hebben op Natura 2000-gebieden, gelet op de instandhoudingsdoelstelling, niet mogen plaatsvinden zonder vergunning. De instandhoudingsdoelstellingen zoals bedoeld in artikel 2.1, lid 4 van de Wnb beschrijven de doelen voor de instandhouding van leefgebieden, natuurlijke habitats en populaties. Deze moeten in een 'gunstige staat van instandhouding' gebracht of gehouden worden. In het aanwijzingsbesluit staat per habitattype of soort aangegeven of behoud of verbetering en/of uitbreiding het doel is voor het betreffende gebied

Bij de besluitvorming rond plannen die gevolgen kunnen hebben voor Natura 2000-gebieden is het beschermingskader van toepassing dat de Wnb geeft aan deze gebieden. Artikelen 2.7 en 2.8 bevatten de procedures die moeten worden gevoerd bij besluitvorming over deze plannen.

Artikel 2.7

1. Een bestuursorgaan stelt een plan dat niet direct verband houdt met of nodig is voor het beheer van een Natura 2000-gebied, en dat afzonderlijk of in combinatie met andere plannen of projecten significante gevolgen kan hebben voor een Natura 2000-gebied, uitsluitend vast indien is voldaan aan artikel 2.8, met uitzondering van het negende lid.
2. Het is verboden, zonder vergunning van Gedeputeerde Staten, projecten te realiseren of andere handelingen te verrichten die gelet op de instandhoudingsdoelstellingen voor een Natura 2000-gebied de kwaliteit van de natuurlijke habitattypen of de leefgebieden van soorten in dat gebied kunnen verslechteren of een significant verstorend effect kunnen hebben op de soorten waarvoor dat gebied is aangewezen.

3. Gedeputeerde staten verlenen een vergunning als bedoeld in het tweede lid uitsluitend indien is voldaan aan artikel 2.8.
4. Het verbod, bedoeld in het tweede lid, is niet van toepassing op projecten ten aanzien waarvan bij of krachtens enige wettelijke bepaling een besluit is vereist, indien bij of krachtens die wet is bepaald dat dat besluit uitsluitend wordt vastgesteld indien is voldaan aan artikel 2.8.

Artikel 2.8

1. Voor een plan als bedoeld in artikel 2.7, eerste lid, of een project als bedoeld in artikel 2.7, derde lid, maakt het bestuursorgaan, onderscheidenlijk de aanvrager van de vergunning, een Passende beoordeling van de gevolgen voor het Natura 2000-gebied, rekening houdend met de instandhoudingsdoelstellingen voor dat gebied.

3.2.2 Omgevingswet (Ow)

Natuurtoestemming onder de Omgevingswet

Het voorgaande kader uit de Wnb – dat een implementatie van de Habitatrichtlijn vormt – komt met enige aanpassingen terug in de Omgevingswet, die per 1 januari 2024 in werking is getreden.

Op grond van artikel 5.1, eerste lid, aanhef en onder e, van de Omgevingswet is het verboden zonder omgevingsvergunning een Natura 2000-activiteit te verrichten. Blijkens Bijlage A bij de Omgevingswet worden activiteiten inhoudende het realiseren van een project dat niet direct verband houdt met of nodig is voor het beheer van een Natura 2000-gebied, maar afzonderlijk of in combinatie met andere plannen of projecten significante gevolgen kan hebben voor een Natura 2000-gebied, aangemerkt als Natura 2000-activiteit.

Een vergunningaanvraag voor een Natura 2000-activiteit wordt op grond van artikel 5.18 en artikel 5.29 van de Omgevingswet beoordeeld op grond van de regels gesteld in afdeling 8.6 van het Besluit kwaliteit leefomgeving ("Bkl"). Een project dat significante gevolgen kan hebben voor een Natura 2000-gebied kan slechts een omgevingsvergunning in de zin van artikel 5.1, eerste lid, aanhef en onder e, van de Omgevingswet verkrijgen voor zover uit de passende beoordeling in de zin van artikel 16.53c, eerste lid, van de Omgevingswet de zekerheid is verkregen dat het project de natuurlijke kenmerken van het gebied niet zal aantasten.

De systeemherziening onder de Omgevingswet laat het instrument van de voortoets onverlet: indien op basis van objectieve gegevens op voorhand is uit te sluiten dat het project significante gevolgen voor een Natura 2000-gebied heeft, geldt nog altijd dat géén sprake is van een vergunningplicht. Om het projectbesluit vast te stellen, is in dat geval evenmin een passende beoordeling noodzakelijk.

3.2.3 Passende beoordeling

In de Passende beoordeling worden het projecteffect beoordeeld, in cumulatie met overige vergunde projecten en/of handelingen, die gevolgen hebben voor dezelfde instandhoudingsdoelstellingen van het Natura 2000-gebied waar het project effect op heeft. Dit betekent dat er een Passende Beoordeling opgesteld dient te worden en dat het bestuursorgaan de vergunning alleen af mag geven als de zekerheid is verkregen dat de natuurlijke kenmerken van een Natura 2000 gebied niet aangetast worden. Mochten er significante gevolgen zijn dan dient een ADC[5]-toetsing doorlopen te worden en kan vergunning alleen verleend worden als aan alle voorwaarden wordt voldaan (geen alternatieve oplossingen, dwingende reden van groot openbaar belang en compensatie). De voorwaarden staan vermeld in art 2.8, lid 4 t/m 8.

Significantie bij beoordeling van gevolgen voor Natura 2000-gebieden

De Natura 2000-gebieden zijn aangewezen in het kader van de Europese Vogel- en Habitatrichtlijnen. Voor de meest bedreigde soorten en habitattypen is bepaald welke gebieden minimaal noodzakelijk zijn voor hun voortbestaan. Per soort of habitat zijn behoud- of verbeterdoelen vastgesteld, de zogenaamde instandhoudingsdoelstellingen. Er is sprake van significante gevolgen als het plan of project het behalen van de

[5] *Een ADC-toets geeft antwoord op de volgende vragen: 1. Zijn er Alternatieve oplossingen met minder gevolgen voor het gebied? 2. Zijn er Dwingende redenen van groot openbaar belang waarom het moet doorgaan? 3. Als er geen alternatieven zijn, maar wel dwingende redenen van groot openbaar belang, dan moet er Compensatie plaatsvinden.*

instandhoudingsdoelstellingen bemoeilijkt. Deze doelstellingen zijn vastgelegd in de aanwijzingsbesluiten voor de Natura 2000-gebieden.

Er is sprake van significante gevolgen als de natuurlijke kenmerken van het Natura 2000-gebied worden aangetast in het licht van de bijbehorende instandhoudingsdoelstellingen. Wanneer de instandhoudingsdoelstellingen door menselijk handelen of een project (mogelijk) niet gehaald worden, is mogelijk sprake van significant negatieve gevolgen.

Aantasting van instandhoudingsdoelstellingen kan door direct verlies aan areaal of aan populatieomvang alsook via afname in kwaliteit. Een afname in oppervlak die kleiner is dan het minimum areaal voor een habitat (meestal 100 m^2) wordt niet als significant beschouwd. Maar een afname als gevolg van het project waardoor het oppervlak, omvang leefgebied en/of populatieomvang vervolgens onder het instandhoudingsdoel komt, wordt wel als significant negatief beschouwd.

Bij afname in kwaliteit staat de vraag centraal of er sprake is van afname van het habitat ingenomen oppervlakte door verslechtering en/of de specifieke structuur en functies afnemen die voor de instandhouding van het habitat op lange termijn noodzakelijk zijn en/of het voorkomen van de typische soorten een dalende trend vertoont in vergelijking met de begintoestand. Deze evaluatie geschiedt in het licht van de bijdrage van het gebied tot de coherentie van het netwerk (Leidraad significantie, 2009; Factsheet significantie, 2010). Bij de beoordeling van verslechtering spelen factoren als kwaliteit, abiotische randvoorwaarden en overige kenmerken van functies en structuren een rol. Hierbij speelt de veerkracht van het gebied een rol, waarbij het effect kan worden opgevangen in de natuurlijke fluctuaties. Deze effectbeoordeling vergt maatwerk. Zijn er wel significant negatieve effecten, dan is een vergunning in principe nog mogelijk als voldaan wordt aan de ADC-criteria.

Verderop in deze rapportage wordt onderzocht of mogelijk sprake is van significante aantasting van de natuurlijke kenmerken van omliggende Natura 2000-gebieden (gelet op de doelstellingen en de staat van instandhouding).

De Passende Beoordeling brengt de gevolgen voor de instandhoudingsdoelstellingen van de geselecteerde gebieden langs twee wegen in beeld:

1. Effecten in de aanlegfase. Hierbij wordt ingegaan op de directe dosis-effect-relaties tussen verstoringsfactoren en instandhoudingsdoelstellingen. Bijvoorbeeld: verstoring door geluid tijdens de uitvoering vermindert de geschiktheid van het plangebied als foerageer- rust- en ruigebied voor kwalificerende watervogels. Naast verstoring is ook gekeken naar verslechtering: in hoeverre zorgt de aanleg voor een verslechtering van de kwaliteit van het leefgebied?
2. Effecten na realisatie. Hierbij wordt ingegaan op de veranderingen die in het ecosysteem worden verwacht na aanleg en tijdens de gebruiksfase van de transportleiding en platforms en de doorwerking daarvan op instandhoudingsdoelstellingen.

Externe werking

Het uitgangspunt is dat toetsing noodzakelijk is wanneer negatieve effecten als gevolg van deze maatregelen of plannen mogelijk zijn. Dit betreft tevens met betrekking tot zogenaamde ‘externe werking’ van negatieve effecten door projecten of plannen buiten Natura 2000-gebieden op de instandhoudingsdoelstellingen. Hierbij speelt het voorzorgsbeginsel een belangrijke rol. Dit voorzorgsbeginsel houdt in dat voordat aan een plan of project toestemming wordt verleend, op basis van de beste wetenschappelijke kennis ter zake, alle aspecten daarvan die op zichzelf of in combinatie met andere plannen of projecten de instandhoudingsdoelstellingen van een beschermd gebied in gevaar kunnen brengen, moeten worden onderzocht. Dit betekent dat ook moet worden bekeken of ontwikkelingen *buiten* een Natura 2000-gebied negatieve effecten kunnen hebben op de voor het betreffende gebied vastgestelde instandhoudingsdoelstellingen. Alle Natura 2000-gebieden die mogelijk beïnvloed worden door een ingreep in de beoordeling van deze effecten moeten worden beschouwd.

Vergunningverlening

Het is niet toegestaan om projecten te realiseren of andere handelingen te verrichten die gelet op de instandhoudingsdoelstellingen voor een Natura 2000-gebied de kwaliteit van de natuurlijke habitats of de habitats van soorten in dat gebied kunnen verslechteren of een significant verstorend effect kunnen hebben

op de soorten waarvoor dat gebied is aangewezen (Wnb, Art. 2.7, lid 2). Voor een dergelijk project maakt de aanvrager van de vergunning een Passende Beoordeling van de gevolgen voor het Natura 2000-gebied, rekening houdend met de instandhoudingsdoelstellingen voor dat gebied (Wnb Art. 2.8, lid 2). Het Bevoegde Gezag kan voor het project uitsluitend een vergunning verlenen, indien uit de Passende Beoordeling de zekerheid is verkregen dat het project de natuurlijke kenmerken van het gebied niet zal aantasten (Art. 2.8, lid 3).

Het Noordzee Akkoord
In het Noordzeeakkoord[6] zijn afspraken vastgelegd over het gebruik van de Noordzee tussen Rijk en diverse belangenorganisaties zoals voor de energie, visserij, milieu en natuur. De uitdaging is om een gezonde en duurzame Noordzee te waarborgen waarbinnen plek is voor beschermde natuurwaarden, een duurzame visserij en voldoende ruimte voor windparken op zee en CCS om te voldoen aan het klimaatbeleid.

Daarom wordt in het akkoord de gaswinning op de Noordzee nadrukkelijker ingepast binnen de doelstellingen van het klimaatbeleid en aan meer ecologische randvoorwaarden gebonden. Het Planbureau voor de Leefomgeving (PBL) is gevraagd te onderzoeken of de afspraken uit het Noordzeeakkoord worden nagekomen.

3.2.4 Aanvullende beoordeling

Deze Natuurtoets bevat een Voortoets en een Passende Beoordeling. In aanvulling op de formele beoordeling is in paragraaf 6.8 een zogenaamde Aanvullende beoordeling opgenomen waarin waar mogelijk een beschrijving is opgenomen van mogelijke effecten ten gevolge van een aantal wijzigingen in het beleid en toekomstige activiteiten:
- Mogelijke beïnvloeding toekomstige Natura 2000-gebieden. Dit betreft nabij het Aramis initiatief vooral de Hollandse kust als Vogelrichtlijngebied.
- Toekomstig bodembeschermingsgebied in de Voordelta, aangewezen als compensatiegebied voor de aanleg van de Maasvlakte.
- Locatie voor experiment herstel platte oester in westelijk deel van het Friese Front.
- Toekomstig seismisch onderzoek voor kennisopbouw bij Aramis initiatief. Dit is onderdeel van het monitoringsprogramma bij de platforms, maar geen onderdeel van dit project.

3.3 Aanwezige Natura 2000-gebieden

In de omgeving van het landdeel bevinden zich enkele Natura 2000-gebieden:
- Voordelta (voor de kust van de Maasvlakte);
- Voornes Duin (aan de zuidkant van het zuidelijke tracé bij Oostvoorne);
- Spanjaards Duin (dit nieuwe natuurgebied is aangelegd als natuurcompensatie voor de tweede Maasvlakte en maakt deel uit van Natura 2000-gebied Solleveld en Kapittelduinen);
- Solleveld- en Kapittelduinen;
- Oude Maas, welke nabij met meest oostelijke deel van het tracé op land is gelegen.

De Natura 2000-gebieden op land worden nader beschreven in Bijlage 7.

In de omgeving van het plangebied bevinden zich enkele Natura 2000-gebieden:
- Voordelta;
- Friese Front;
- Noordzeekustzone;
- Klaverbank;
- Bruine Bank.

[6] *https://open.overheid.nl/documenten/ronl-99d46f4b-1d45-49cd-a979-2ce8bf737e22/pdf*

De werkzaamheden voor de zeeleiding worden voor een deel binnen de begrenzing van en direct nabij het Natura 2000-gebied Voordelta uitgevoerd. Werkzaamheden met betrekking tot de platforms worden nabij het Natura 2000-gebied Friese Front uitgevoerd.

In de volgende paragrafen is een beschrijving van de relevante Natura 2000 gebieden op zee opgenomen. Informatie over de Natura 2000 gebieden is afkomstig uit de Aanwijzingsbesluiten (geraadpleegd via https://www.natura2000.nl/gebieden/noordzee-nederlandse-exclusieve-economische-zone), tenzij anders aangegeven.

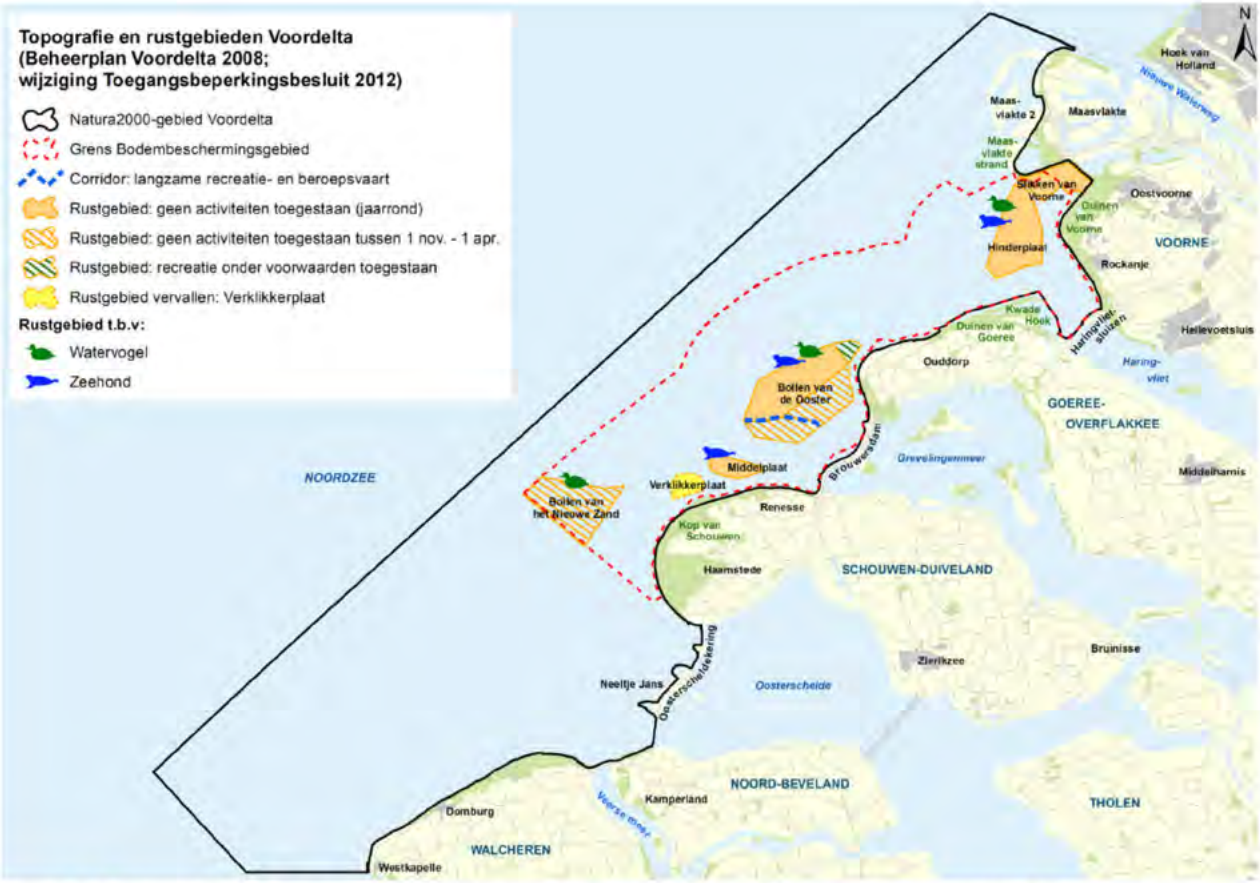
3.3.1 Natura 2000-gebied Voordelta

Het Natura 2000-gebied Voordelta omhelst het ondiepe zeegedeelte van de Zuid-Hollandse en Zeeuwse Kust. Kenmerkend aan het gebied is het gevarieerde en dynamisch milieu van kustwateren, intergetijdengebied en stranden. De Voordelta heeft een oppervlakte van 835 km^2.

De Voordelta bestaat voornamelijk uit het habitattype ‘permanent met zeewater overstroomde zandbanken’ (H1110) dat maximaal 20 meter diep ligt.

De Voordelta is aangewezen vanwege het voorkomen van 10 habitattypen, 7 habitatrichtlijnsoorten (waarvan 4 vissoorten en 3 zeezoogdiersoorten) en 30 niet-broedvogelsoorten. Een aantal vogels, zeezoogdieren en vissen hebben een verspreiding die tot in het plangebied kan reiken. De instandhoudingsdoelstellingen per soort zijn te vinden in Bijlage 1. Voor deze soorten is de staat van instandhouding en verspreiding verder uitgewerkt in Hoofdstuk 5 van dit rapport.

Naast de instandhoudingsdoelstellingen zijn er ook aanvullende beschermde gebieden aangewezen in de Voordelta. De rustgebieden zijn weergeven in Figuur 3-1 Per rustgebied zijn de specifieke beschermingsmaatregelen samengevat in Tabel 3-1. Het plangebieden de vaarroute ligt buiten deze rustgebieden. De effecten van onderwatergeluid kunnen mogelijk wel reiken tot in de rustgebieden.



Figuur 3-1. Overzicht van de verschillende rustplekken in de Voordelta (Kaart verkregen uit Evaluatie Natura 2000-beheerplan Voordelta 2008-2014).

Tabel 3-1. Overzicht maatregelen rond de rustgebieden en de desbetreffende soorten.

Rustgebied	Periode	Soorten
Slikken van Voorne	Jaarrond gesloten	Steltlopers Eenden
Hinderplaat	Jaarrond gesloten, beperkte recreatie en visserij toegestaan van 1 sept t/m 1 mei	Gewone zeehond Grote stern Visdief
Bollen van de Ooster	Jaar gesloten, van 1 nov t/m 1 april is een groter gebied (2740 ha t.o.v. 1550 ha in zomer) gesloten	Gewone zeehond Zwarte zee-eend Grote stern Grijze zeehond
Middelplaat	Jaar gesloten, van 1 nov t/m 1 april is een groter gebied gesloten	Gewone zeehond Roodkeelduiker
Bollen van de Nieuwe Zand	Tussen 1 nov tot 1 mei volledig gesloten voor alle activiteiten. Tussen 1 mei en 1 nov is gebied open voor sommige activiteiten	Zwarte zee-eend

Door erosie- en sedimentatieprocessen treden verschuivingen op in de omvang van de intergetijden-gebieden van de Voordelta. Daarbij heeft o.a. de "zandhonger" van de Oosterschelde, maar ook de uit-breiding van de arealen door aanslibbing in de Kwade Hoek effect op de Voordelta (Westplaat). De water-kwaliteit wordt beïnvloed door met name de uitstroming van Rijn en Maas via de Haringvlietsluizen. Mede

door deze aanvoer van voedingsstoffen kent de Voordelta een hoge voedselrijkdom. In de randen van het gebied bij Voorne en Goeree liggen een aantal schorren en meer slikkige platen. Verder horen ook de stranden van de Zeeuwse en Zuid-Hollandse eilanden, waar plaatselijk duinvorming optreedt, tot het gebied.

Het gebied wordt gekenmerkt door de aanwezigheid van een gevarieerd en dynamisch milieu van kust-wateren (zout), intergetijdengebied en stranden, dat een relatief beschutte overgangszone vormt tussen (voormalige) estuaria en volle zee. Na de afsluiting van de Deltawerken is dit kustgedeelte sterk aan veranderingen onderhevig geweest, waarbij een uitgebreid stelsel van droogvallende en diepere zand-banken is ontstaan met daartussen diepere geulen.

3.3.2 Natura 2000-gebied Friese Front

Het Friese Front is een zeegebied ten noorden van de Waddeneilanden op een afstand van ongeveer 60 km uit de kust. Het gebied heeft een oppervlak vergelijkbaar met de Nederlandse Waddenzee (2.880 km²) en vormt een overgangszone tussen de ondiepe zuidelijke en de diepe centrale Noordzee. In deze overgangszone komen verschillende watermassa's samen, wat een front veroorzaakt met een verhoogde biologische productie en een verhoogde biodiversiteit van het bodemleven. Het Friese Front is hierdoor een belangrijk foerageergebied voor vogels en is uitsluitend Vogelrichtlijngebied.

Het gebied is alleen voor de zeekoet (*Uria aalge*) aangewezen, omdat de soort er in de zomer en de herfst in internationaal belangrijke aantallen (meer dan 15.620 individuen) voorkomt (van Bemmelen et al., 2013). Na de broedperiode in het voorjaar zwemmen de ruiende vaders met hun jongen, die nog niet kunnen vliegen, naar het Friese Front om de jongen groot te brengen (foerageer- en rustgebied) en om te ruien. Dit vindt vooral plaats gedurende de rmaanden juli-oktober. In deze kwetsbare periode is het Friese Front voor hen onmisbaar. Zeekoeten zijn voornamelijk van juli tot oktober te vinden op het Friese Front met piek-aantallen in september-oktober (Ministerie van Economische Zaken, 2014a). De instandhoudingsdoelstelling voor de zeekoet is behoud van omvang en kwaliteit van het leefgebied en behoud van de populatie. De zeekoet heeft een gunstige staat van instandhouding (Tabel 3-2).

Tabel 3-2. Instandhoudingsdoelstellingen Natura 2000-gebied Friese Front (Ministerie LNV 2021).

Instandhoudingsdoelstellingen		SVI Landelijk	Doelst. Opp.vl.	Doelst. Kwal.	Doelst. Pop.
A199	Zeekoet	+	=	=	

Het Friese Front heeft een waterdiepte van tussen de 30 en 40 meter. Het Friese Front is onderdeel van een lang front wat de overgang tussen ondiepe zandgronden van de Zuidelijke Noordzee en de diepere slibbodems van de Centrale Oestergronden markeert. De menging van verschillende waterlagen zorgt voor transport van water bij de bodem wat voedingsstoffen naar de oppervlakte verplaatst. In de zomer kan dit voor een hogere primaire productie zorgen.

Het Friese Front wordt gekenmerkt door een relatief hoog aandeel van langlevende soorten, soorten met planktonische larven, en een iets minder dan gemiddeld aandeel van soorten met pelagische eieren en/of larven (van Denderen, 2015). De verhoogde secundaire productie heeft zijn weerslag op de hele voedselketen, dus ook voor vis en vogels die aan het oppervlak foerageren (Lindeboom et al., 2015).

3.3.3 Natura 2000-gebied Noordzeekustzone

Het Natura 2000-gebied Noordzeekustzone is ca. 1.500 km² groot en loopt van Bergen aan zee tot Rottumeroog. De Noordzeekustzone loopt vanaf de enkele tientallen meters diepe zee geleidelijk op naar het strand. De begrenzing van het Natura 2000-gebied volgt aan de vastelandskust de laagwaterlijn, op de Waddeneilanden de voet van het duin, en ligt aan de zeezijde op drie zeemijl (ongeveer 5,5 kilometer) voor de kust, op een diepte van ongeveer 20 meter. Kenmerkend voor de Noordzeekustzone is dat het een dynamisch gebied is dat een zeldzame biotoop creëert waar veel pionierssoorten goed gedijen. Hierdoor is het gebied een belangrijke kraamkamer voor mariene vissoorten, herbergt het grote hoeveelheden schelpdieren en vormt het een belangrijk foerageergebied voor vogels. De instandhoudingdoelstellingen

voor de Noordzeekustzone bestaat uit 7 habitattypen, 7 habitatrichtlijnsoorten (1 vaatplant, 3 vissoorten en 3 zeezoogdiersoorten), 3 soorten broedvogels en 18 soorten niet-broedvogels. De instandhoudingsdoelstellingen per soort zijn te vinden in Bijlage 2.

3.3.4 Natura 2000-gebied Klaverbank

De Klaverbank is gelegen in het noordwestelijke deel van de Nederlandse Noordzee. Het zeegebied Klaverbank is zo'n 1.235 km² groot en ligt op circa 160 km ten noordwesten van Den Helder. Het gebied ligt deels in het Engelse en deels in het Nederlandse deel van de Noordzee. Het bodemoppervlak bestaat uit (grof) grind en grotere stenen in afwisseling met grof zand en schelpenmateriaal. De aanwezigheid van de grove sedimenttypen biedt een specifieke leefomgeving voor onder andere aan substraat gebonden organismen. In het gebied kan het licht doordringen tot een diepte van wel 40 meter, wat de begroeiing met kalkroodwieren mogelijk maakt. De structuur van het habitattype wordt gevormd door de aangroei van organismen die met het substraat zijn verbonden en door kalkroodwieren die het losse sediment aan elkaar kunnen vastleggen.

De Klaverbank vormt een leefgebied van de bruinvis (*Phocoena phocoena*), grijze zeehond (*Halichoerus grypus*) en gewone zeehond (*Phoca vitulina*). Vooral daar leven in de zomer veel bruinvissen. Ook de dwergvinvis (*Balaenoptera acutorostrata*) en witsnuitdolfijn (*Lagenorhynchus albirostris*) komen hier regelmatig voor. De Klaverbank is aangewezen vanwege het voorkomen van Habitattype H1170 Riffen, bruinvis, gewone zeehond en grijze zeehond. De instandhoudingsdoelstellingen per soort zijn te vinden in Bijlage 3.

De Klaverbank heeft een grote diversiteit in bodemsamenstelling, die bestaat uit grof grind en stenen samen met zandbodems en een slibrijke geul. De Klaverbank heeft diepe gedeeltes, tot 70 meter, met een gemiddelde waterdiepte van 43 meter. Doordat de Klaverbank vrij diep is wordt de bodem bijna nooit beïnvloed door stroming of stormen. Hierdoor is het water helder en kan er licht doordringen tot op de bodem. Door de aanwezige grindlaag en stenen is er een hoge biodiversiteit met soorten uit verschillende levensfases.

3.3.5 Natura 2000-gebied Bruine Bank

Het Natura 2000-gebied de Bruine Bank is 1.365 km² groot en gelegen in het westelijk deel van de Nederlandse Noordzee tegen de grens van het Verenigd Koninkrijk aan. De Bruine Bank is een zandige verhoging gelegen in de diepe zee. Het hoogste punt van de Bruine Bank ligt op 16 meter beneden zeeniveau. De algehele diepte varieert tussen de -16 en -50 meter. Daarnaast komen zandduinen voor die wel tot 20 meter hoog kunnen worden vanaf de zeebodem. Hierdoor komen verschillende vissoorten zoals zandspiering, haring en sprot voor, welke dienen als een belangrijke voedselbron voor verschillende vogels en zeezoogdieren.

De Bruine Bank is uitsluitend aangewezen als vogelrichtlijngebied voor de jan-van-gent (*Morus bassanus*) grote jager (*Stercorarius skua*), dwergmeeuw (*Hydrocoloeus minutus*), grote mantelmeeuw (*Larus marinus*), zeekoet (*Uria aalge*) en alk (*Alca torda*). Met name tijdens de herfst en wintermaanden zijn deze soorten in grote getalen te vinden op de Bruine Bank (Fijn & de Jong, 2019). Dit gebied dient dan ook als belangrijk foerageergebied. De instandhoudingsdoelstellingen per soort zijn te vinden in Bijlage 4.

De Bruine Bank wordt gekarakteriseerd door een hoge bank die wordt omgeven door een diepere zeebodem. De bodem bestaat vooral uit grof zand en met een slibgehalte van 2% of minder. Er zijn in de Bruine Bank veel fossiele botten van grote landzoogdieren uit de laatste ijstijd te vinden.

4 Scoping relevante effecten

In het voorliggende hoofdstuk is beschreven of storingsfactoren kunnen optreden (scoping). De effecten-indicator zoals aangereikt door het Ministerie van Economische Zaken en Klimaat geeft een negentiental mogelijke storingsfactoren waarmee in ieder geval rekening moet worden gehouden ten aanzien van in Natura 2000-gebieden beschermde waarden.

4.1 Storingsfactoren

Onderstaand is per storingsfactor afgewogen of deze relevant is in het kader van voorliggend voornemen. De storingsfactoren zijn geclusterd per 'type' invloed. Hierbij is de volgende clustering aangehouden:

- Storingsfactoren die onder het type 'ruimtelijke invloeden' vallen zijn oppervlakteverlies en versnippering van leefgebied.
- Storingsfactoren die onder het type 'chemische invloeden' vallen zijn verzuring, vermesting, verzoeting, verzilting en verontreiniging.
- Storingsfactoren die onder het type 'fysische invloeden' vallen zijn verdroging, vernatting, verandering stroomsnelheid, verandering overstromingsfrequentie, verandering dynamiek substraat en vertroebeling.
- Storingsfactoren die onder het type 'mechanische invloeden' vallen zijn verstoring door geluid, door licht, door trilling, door beweging/optiek of door luchtwerveling, betreding, golfslag.
- Storingsfactoren die onder het type 'menselijke invloeden' vallen zijn verandering die bewust door de mens zijn uitgevoerd, bijvoorbeeld door herintroductie of uitzetting van soorten, introductie exoten.

Hieronder zijn de storingsfactoren kort toegelicht, waarbij beschreven wordt of en zo ja voor welke Natura 2000-gebieden de verstoringsfactor invloed kan hebben. Daarbij is aangegeven of de storingsfactor kan optreden tijdens het uitvoeren van de werkzaamheden op het landdeel (hierna: 'onshore'), het uitvoeren van de werkzaamheden in het zeedeel ('offshore') of bij beide tracédelen.

Effecten scheepvaart

Op dit moment is nog niet bekend waar het CO_2 wordt opgevangen en waarvandaan het getransporteerd moet worden. Doordat de route nog niet bekend is, is niet bekend welke Natura 2000-gebieden de route doorkruist. Hierdoor is het niet mogelijk om voor de effecten van scheepvaart in de gebruiksfase een beoordeling te schrijven. In dit tekstvak worden de mogelijke effecten van scheepvaart kort beschreven.

Als de CO_2 transportschepen gebruik maken van de bestaande scheepvaartroute zijn de effecten klein en op voorhand uit te sluiten, omdat ze wegvallen in het heersende verkeersbeeld.

Als de CO_2 transportschepen buiten de bestaande scheepvaartroutes varen moet er getoetst worden of het mogelijk effect heeft op Natura 2000 waarden. Scheepvaart kan de volgende storingsfactoren veroorzaken voor het zeedeel:

- Verstoring door trillingen en geluid
- Verstoring door licht
- Verstoring door beweging/optiek
- Verstoring door luchtwerveling, betreding, golfslag
- Verstoring door stikstofemissies

Per Natura 2000-gebied moet door de emitters gekeken worden of deze storingsfactoren significant negatieve effect hebben op beschermde waarden. De effecten bij het laden van de schepen vallen toe aan de havenactiviteiten van de emitter.

4.2 Ruimtelijke invloeden

Deze storingsfactor kan alleen optreden bij activiteiten die binnen de begrenzing van de beschermde gebieden plaatsvindt, of wanneer het gebied binnen de invloedsfeer is gelegen. Bepaald moet worden of er sprake kan zijn van een afname van het beschikbare oppervlak van het leefgebied van aangewezen habitattypen en soorten. Verlies van oppervlak leidt in sommige gevallen ook tot versnippering van leefgebied. Hierbij is dan sprake van het uiteenvallen van het leefgebied van soorten, waardoor de duurzame instandhouding van populaties onder druk komt te staan.

Op welke Natura 2000-gebieden kan de storingsfactor invloed hebben?
Het leggen van de zeeleiding vindt voor een deel plaats binnen de begrenzing van het Natura 2000-gebied Voordelta. Hierdoor kan zowel sprake zijn van tijdelijke (tijdens de aanlegfase) en permanente effecten. Het betreft effecten vanuit de offshore projectuitvoering.

Er zijn geen andere Natura 2000-gebieden waarbinnen het plaatsen van de zeeleiding, platforms of een andere infrastructuur plaatsvinden. Voor de andere Natura 2000-gebieden wordt uitgesloten dat de storingsfactor van toepassing is.

4.3 Chemische invloeden

Verzuring en vermesting worden veroorzaakt door stikstofdepositie. Tijdens de aanleg van Aramis wordt stikstof uitgestoten door onder meer aggregaten, pompen en rijdend en varend materieel. Een deel van de stikstof kan op de daarvoor gevoelige habitattypen in Natura 2000-gebieden terechtkomen. Het effect is groter op de meest dichtbijgelegen gebieden. Een deel van de habitattypen waarvoor deze gebieden zijn aangewezen zijn stikstofgevoelig en vaak wordt de daarvoor geldende kritische depositiewaarde voor stikstof (KDW) al jaren overschreden. De storingsfactor treedt op tijdens de aanleg van Aramis, vanuit zowel de rijbewegingen die nodig zijn om het tracé op het land te realiseren, als de vaarbewegingen, helikoptervluchten, (nood)generatoren en andere werktuigen die nodig zijn om het tracé op de zeebodem aan te leggen. Gedurende de aanleg- en gebruiksfase van het project is sprake van stikstof uitstoot.

Verzoeting treedt meestal op ten gevolge van vernatting of, zoals in het Deltagebied, door het afsluiten van zeearmen. In (voormalig) brakke of zoute wateren leidt verzoeting tot vermesting. Verzilting betreft de ophoping van oplosbare zouten (kalium, natrium, magnesium, calcium) in bodems en wateren. Verzilting van bodems treedt vaak op ten gevolge van verdroging. Het optreden van de storingsfactoren verzoeting of verzilting is vanwege de aard van de werkzaamheden niet aan de orde.

Er is sprake van verontreiniging als er verhoogde concentraties van stoffen in een gebied voorkomen, welke stoffen onder natuurlijke omstandigheden niet of in zeer lage concentraties aanwezig zijn. Bij verontreiniging is sprake van een zeer brede groep van ecosysteem/gebiedsvreemde stoffen: organische verbindingen, zware metalen, schadelijke stoffen die ontstaan door verbranding of productieprocessen, straling (radioactief en niet radioactief), geneesmiddelen, endocrien werkende stoffen etc. Deze stoffen werken in op de bodem, grondwater en de lucht. Vrijwel alle soorten en habitattypen reageren op verontreiniging. De ecologische effecten uiten zich in het verdwijnen van soorten en/of het beïnvloeden van gevoelige ecologische processen. In het algemeen kan gesteld worden dat aquatische habitattypen en soorten gevoeliger zijn dan terrestrische systemen. Ook geldt dat soorten in de top van de voedselpiramide, als gevolg van accumulatie, van verontreinigingen gevoeliger zijn.
Er is sprake van lozing van boorgruis- en vloeistof bij het boren van de putten en van afvalwater vanaf de platforms. Voor relevante soorten en habitattypen wordt onderzocht of er negatieve effecten optreden.

Op welke Natura 2000-gebieden kan de storingsfactor invloed hebben?
De aanleg van Aramis vindt, met uitzondering van Natura 2000-gebied Voordelta, plaats buiten de begrenzing van Natura 2000-gebieden. Als gevolg van externe werking kunnen de voorgenomen activiteiten echter leiden tot extra stikstofdepositie voor Natura 2000-gebieden op land. De storingsfactor treedt op in zowel de aanlegfase als gebruiksfase, voor zowel de werkzaamheden op land als op zee. Daarnaast kan er sprake zijn van verontreiniging door lozingen op zee door externe werking op de genoemde Natura 2000-gebieden op zee.

4.4 Fysische invloeden

Verdroging uit zich in lagere grondwaterstanden. Voor het project is het voor de aanleg mogelijk nodig om delen (tijdelijk) te bemalen. Om inzicht te krijgen in de te verwachten invloed-gebieden van de bemalingen per kruising/veldstrekking is een bureauonderzoek uitgevoerd (Geohydrologisch rapport, RHDHV, 2023). De effecten zijn alleen van toepassing nabij de bemalingslocaties op land.

Het is echter uitgesloten dat de storingsfactor als gevolg van het project optreedt op voor verdroging gevoelige aangewezen habitattypen van omliggende Natura 2000-gebieden. Hiervoor is de afstand te groot (zie Tabel 2-3).

Dit geldt ook voor vernatting, er worden geen werkzaamheden uitgevoerd die leiden tot toenemende kwel, of aanpassing van het watersysteem. De werkzaamheden worden daarnaast niet uitgevoerd in de rivier, waardoor het optreden van een verandering van stroomsnelheid niet aan de orde is en de overstromingsfrequentie niet wijzigt.

Bij een verandering van de dynamiek van het substraat treedt een verandering op in de bodemdichtheid of bodemsamenstelling van terrestrische of aquatische systemen, bijvoorbeeld door aanslibbing of verstuiving. Verandering van dynamiek van het substraat kan leiden tot verandering van de abiotische randvoorwaarden wat mogelijk effecten kan hebben voor de aanwezige levensgemeenschappen. Dynamiek van het substraat is bijvoorbeeld van belang voor droge pioniervegetaties in de duinen en stuifzanden, of voor mosselbanken in de Waddenzee.

Vertroebeling kan ontstaan door het opwervelen van sediment als gevolg van mechanische ingrepen zoals graven, baggeren of lozingen. Door de vertroebeling van de waterkolom ontstaat tijdelijk een lokale troebele pluim (suspensie van sediment in de waterkolom). Grotere vissen, zeezoogdieren en vogels die jagen op zicht kunnen het gebied tijdelijk mijden. Sessiele bodemdieren die het water filtreren kunnen door een hoge mate van vertroebeling inactief worden en in conditie achteruitgaan. Dit kan mogelijk effect hebben op de rest van de voedselketen.

Op welke Natura 2000-gebieden kan de storingsfactor invloed hebben?
Een deel van de werkzaamheden vindt plaats binnen de Natura 2000-gebieden Voordelta (leggen van de zeeleiding). Vanwege de aard van de werkzaamheden is het optreden van storingsfactoren van het type fysische invloed mogelijk, er kan vertroebeling optreden en verandering van dynamiek van het substraat. Er kan sprake zijn van externe werking op de genoemde Natura 2000-gebieden op zee. Er wordt geen invloed van het project door verdroging, vernatting, of het teweegbrengen van een verandering in stroomsnelheden, overstromingsdynamiek verwacht.

4.5 Mechanische invloeden

Met verstoring door geluid wordt verstoring door onnatuurlijke geluidsbronnen bedoeld; permanent zoals geluid van wegverkeer dan wel tijdelijk zoals geluidsbelasting bij evenementen. Geluid is een hoorbare trilling, gekenmerkt door geluidsdruk en frequentie. Logischerwijs zijn alleen diersoorten gevoelig voor direct effecten van geluid. Geluid is een belangrijke factor in de verstoring van fauna. De verstoring door geluid is afhankelijk van het achtergrondgeluid en de duur, frequentie en sterkte van de geluidsbron. Geluidsbelasting kan leiden tot stress en/of vluchtgedrag van individuen. Dit kan vervolgens weer leiden tot het verlaten van het leefgebied of bijvoorbeeld een afname van het reproductieproces. In bepaalde gevallen kan ook gewenning optreden, in het bijzonder bij continu geluid. Door de uitvoering van de werkzaamheden treedt geluidsemissie op, zowel voor werkzaamheden onshore als offshore.

Kunstmatige verlichting van de nachtelijke omgeving kan tot verstoring van het normale gedrag van soorten leiden. Naar mogelijke effecten is nog vrij weinig onderzoek gedaan. De projectlocatie onshore ligt op het terrein van de Rotterdamse Haven. Dit is het grootste haven- en industriecomplex van Europa. Er is veel bedrijvigheid. Het terrein wordt tijdens de nachtelijke uren verlicht ten behoeve van de veiligheid bij het uitvoeren van de werkzaamheden. Voor het uitvoeren van het projectvoornemen kan het nodig zijn om delen te verlichten. Voor de werkzaamheden op land geldt dat er in principe voor de aanleg van de leidingen

niet ’s nachts wordt gewerkt en na afloop van de werkzaamheden wordt geen aanvullende verlichting toegepast. Voor de werkzaamheden op zee is het optreden van lichtverstoring niet op voorhand uitgesloten.

Optische verstoring betreft verstoring door de aanwezigheid en/of beweging van mensen dan wel voorwerpen die niet thuishoren in het natuurlijke systeem en treedt vaak samen op met verstoring door geluid, trilling en licht veroorzaakt door werkzaamheden (in geval van voertuigen, schepen). Optische verstoring leidt vooral tot vluchtgedrag van dieren. De soort reageert bijvoorbeeld op beweging omdat een potentiële vijand wordt verwacht. Andersom kan optische verstoring juist ook het uitzicht van soorten beperken waardoor zij potentiële vijanden niet zien naderen. De daadwerkelijke effecten zijn zeer soort-specifiek en hangen van de schuwheid van de soort en de mate waarin gewenning optreedt. Voor de aanleg van de leiding op land, wordt niet verwacht dat dit leidt tot het verstoren van voor Natura 2000-gebieden aangewezen habitatsoorten of (niet-)broedvogels. Voor de werkzaamheden op zee kan de storingsfactor wel tot verstoring leiden.

Verstoring door betreding, golfslag, luchtwervelingen etc. die optreden ten gevolge van menselijke activiteiten kan leiden tot een verandering van het habitattype en/of verstoring of het doden van fauna-individuen. Het effect is zeer afhankelijk van de kwetsbaarheid (gevoeligheid) van het habitattype. Waterrecreatie en scheepvaart leiden tot golfslag, hetgeen effect kan hebben op de oeverbegroeiing en waterfauna. Luchtwervelingen van bijvoorbeeld windmolens kunnen leiden tot sterfte van vleermuizen. De werkzaamheden vinden plaats in een reeds verstoord gebied, waar in geruime mate sprake is van golfslag (vanwege de zeevaart). Het is uitgesloten dat aanvullende verstoring door betreding of golfslag, als gevolg van het projectvoornemen optreden. Er kan wel sprake zijn van optische verstoring door aanwezigheid van schepen. Dit kan effect hebben op de instandhoudingsdoelstellingen van de Natura 2000-gebieden waar de CO_2 schepen doorheen varen. Omdat de vaarroute nog niet bekend is, kunnen gerichte effecten op de instandhoudingsdoelstellingen in dit stadium nog niet worden beoordeeld. Daarnaast kan er sprake zijn van verstoring door luchtwerveling indien stoom wordt afgeblazen bij het decompressiestation op het eindpunt.

Op welke Natura 2000-gebieden kan de storingsfactor invloed hebben?
De optredende storingsfactoren geluid, trilling, licht en optische verstoring (beweging), kunnen als gevolg van het uitvoeren van het plaatsen van de aanlegsteigers, het leggen van de pijpleiding en het plaatsen van de platforms niet worden uitgesloten. Er kan een (extern) effect optreden op de Natura 2000-gebieden Voordelta, Friese Front, Klaverbank, Bruine Bank en Noordzeekustzone (zie detailrapport Onderwatergeluid, RHDHV, 2023).

4.6 Menselijke invloeden

Bij menselijke invloeden is er sprake van bewust ingrijpen in de natuur door herintroductie van soorten, introductie van exoten, uitzetten van vis, inzaaien van genetisch gemodificeerde organismen etc. waardoor de storingsfactor (bewuste) verandering in soortensamenstelling kan optreden.

De storende factor verandering in populatiedynamiek treedt op indien er een direct effect is van een activiteit op de populatie-opbouw en/of populatiegrootte. Er wordt hier vooral gedoeld op de situatie wanneer sprake van sterfte van individuen door wegverkeer, windmolens, of door jacht of visserij. Het planvoornemen voorziet niet in een (bewuste) verandering in soortensamenstelling of andere veranderingen in de populatiedynamiek (en zeker niet in sterfte van individuen).

Op welke Natura 2000-gebieden kan de storingsfactor invloed hebben?
De storingsfactor verandering in populatiedynamiek en (bewuste) verandering in soortensamenstelling treden als gevolg van het projectvoornemen niet op.

4.7 Samenvatting

De storingsfactoren zijn geclusterd per ‘type’ invloed, hierbij is in het overzicht aangegeven of de storings-factor voor het zeedeel dan wel voor het landdeel van invloed kan zijn (Tabel 4-1).

Tabel 4-1. Overzicht van effecten van storingsfactoren op offshore of onshore Natura 2000-gebieden. Een o betekent geen effect en een x betekent mogelijk effect en wordt verder onderzocht in het benoemde hoofdstuk.

Type Invloed	Storingsfactor	Landdeel	Zeedeel
Ruimtelijke invloeden	• Oppervlakteverlies	o	X
	• Versnippering leefgebied	o	X
Chemische invloeden	• Verzuring	X	o
	• Vermesting	X	o
	• Verzoeting	o	o
	• Verzilting	o	o
	• Verontreiniging	o	X
Fysische invloeden	• Verdroging	o	o
	• Vernatting	o	o
	• Verandering dynamiek substraat	o	X
	• Vertroebeling	o	X
Mechanische invloeden	• Verstoring door trillingen en geluid	o	X
	• Verstoring door licht	o	X
	• Verstoring door beweging/optiek	o	X
	• Verstoring door luchtwerveling, betreding, golfslag	o	o
Menselijke invloeden	• Verandering populatiedynamiek	o	o
	• Bewuste ingreep soortensamenstelling	o	o

Verzuring en vermesting - Stikstofdepositie in bijlagerapport

Uit Tabel 4-1Tabel 4-1 blijkt dat voor het landdeel alleen effecten op Natura 2000-gebieden ten gevolge van stikstofdepositie worden verwacht. Dit aspect is uitgewerkt in een separaat onderzoek, waarvan de bevindingen in bijlage 7 zijn opgenomen.

Uitwerking zeedeel in volgende hoofdstukken

De volgende hoofdstukken hebben betrekking op de storingsfactoren voor de Natura 2000-gebieden op zee. Hoofdstuk 5 beschrijft de Voortoets, hoofdstuk 6 beschrijft de Passende Beoordeling, hoofdstuk 7 de cumulatietoets en hoofdstuk 8 de leemten in kennis.

Gezamenlijke conclusies

De conclusies in hoofdstuk 9 hebben betrekking op de Natura 2000-gebieden van zowel het landdeel als het zeedeel.

5 Voortoets - zeedeel

In dit hoofdstuk wordt de voortoets beschreven voor de gebieden op zee. Hierin is het voorkomen van habitattypen en soorten met een instandhoudingsdoelstelling in de gebieden beschreven en is een inschatting gemaakt of significante negatieve effecten op voorhand kunnen worden uitgesloten. Indien deze niet kunnen worden uitgesloten is het aspect verder uitgewerkt in hoofdstuk 6, de passende beoordeling. De voortoets voor gebieden op land is separaat uitgevoerd en gerapporteerd in bijlage 7. Informatie over de Natura 2000 gebieden is afkomstig uit de Aanwijzingsbesluiten (geraadpleegd via https://www.natura2000.nl/gebieden/noordzee-nederlandse-exclusieve-economische-zone), tenzij anders aangegeven.

5.1 Noordzee

De Noordzee op zichzelf is niet aangewezen als Natura 2000-gebied. Omdat een groot deel van de activiteiten in de Noordzee en buiten Natura 2000-gebied plaatsvindt worden hier de meest relevante en kwetsbare soorten beschreven die niet beschreven worden in de volgende paragrafen. Het gaat daarbij met name om bodemdieren en vissen. Daarbij kan onderscheid gemaakt worden tussen bodemdieren die zeldzaam zijn of in heel specifieke delen van de Noordzee voorkomen, soorten die een belangrijke rol vervullen (rifvormende soorten) en vissen die belangrijk zijn als voedsel voor vogels en zeezoogdieren (zandspiering).

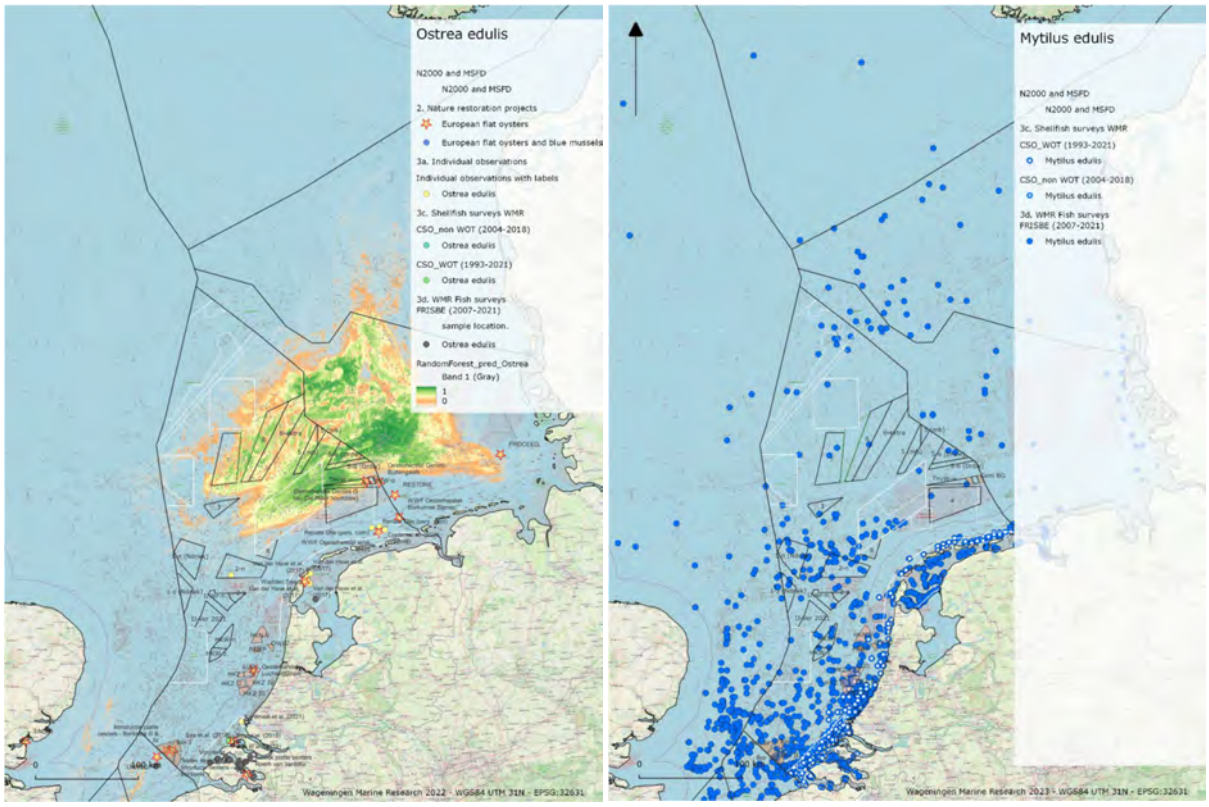
5.1.1 Bodemdieren en zandgolven

Een studie van Cheng et al. (2021) naar de distributie van faunasoorten op zandgolven in het Nederlandse deel van de Noordzee liet zien dat zandgolven unieke soorten herbergen, die niet op andere delen van de zeebodem voorkomen. In totaal waren er op de steile delen van de zandgolven 53 verschillende taxa aanwezig, waarvan 13 specifiek voor dat type habitat. Met name verschillen in hydronamische condities verklaren de specifieke opbouw van de macrofaunagemeenschap op zandgolven. Stabiliteit van de zandbodem blijkt een belangrijke factor voor soortenrijkdom; benthische soorten kunnen over het algemeen beter overleven op locaties waar de stabiliteit van de bodem hoger is. De soortenrijkdom bleek in de studie van Cheng et al. (2021) het hoogste te zijn op de steile delen en de diepere troggen van zandgolven. Door de aanvoer van hogere chlorofyl-a en organische stof concentraties is er hier meer voedsel beschikbaar, wat mogelijk verklaart waarom de soortenrijkdom hoger is bij troggen en steile delen van zandgolven dan bij de minder steile delen van de zandgolven.

5.1.2 Rifvormende soorten

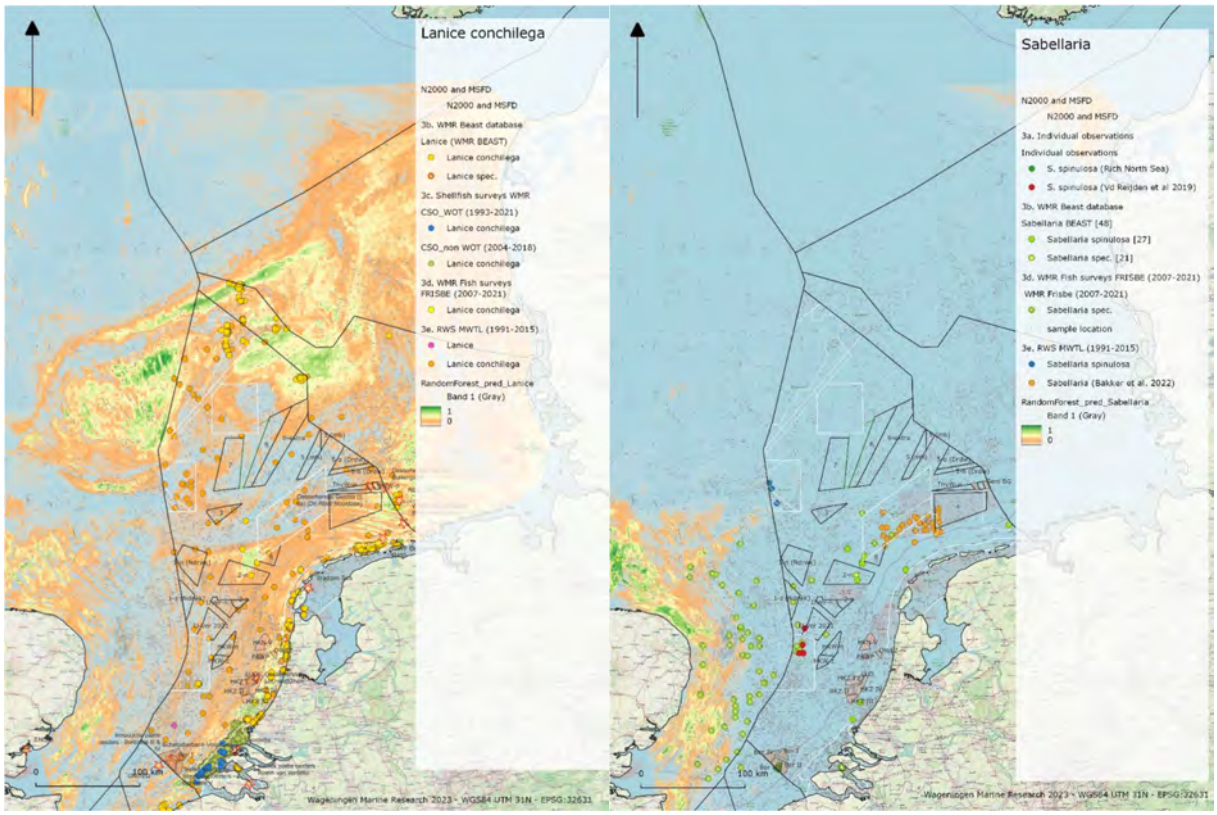
Rifvormende soorten vormen biogene riffen die habitats vormen die qua structuur en soortensamenstelling verschillen van de open zeebodem, waardoor de algehele biodiversiteit en mogelijk ook de productiviteit van het Noordzee-ecosysteem toenemen (Sas et al., 2023)[7]. In de Kaderrichtlijn Mariene Strategie geldt als doel herstel van rifvormende soorten.

[7] https://edepot.wur.nl/633785



Figuur 5-1. Links: Platte oester (Ostrea edulis) voorspelde habitatkwaliteit (Herman en van Rees, 2022) en observaties. De meeste observaties zijn op hard substraat (Bos et al., 2023 in prep.). Rechts: Mossel (Mytilus edulis) observaties (Bos et al., 2023 in prep.). Beide figuren staan in Sas et al. (2023).

De activiteit vindt plaats in gebieden die geschikt zijn voor platte oesters (in de buurt van het Friese Front) en waar mossels voorkomen (Figuur 5-1). Alhoewel deze soorten niet expliciet zijn beschermd onder de Habitatrichtlijn en de activiteit plaatsvindt buiten Natura 2000-gebied worden de effecten op deze soorten wel beoordeeld in de Passende beoordeling omdat ze een specifiek habitat creëren en deels (mossel) fungeren als voedselbron voor beschermde soorten.



Figuur 5-2. Links: Schelpkokerworm (Lanice conchilega) voorspelde habitatkwaliteit (Herman en van Rees, 2022) en observaties (Bos et al., 2023 in prep.). Rechts: Gestekelde zandkokerworm (Sabellaria spinulosa) voorspelde habitatkwaliteit (Herman en van Rees, 2022) en observaties. De meeste observaties zijn op hard substraat (Bos et al., 2023 in prep.). Beide figuren staan in Sas et al. (2023).

Op de Bruine Bank zijn de troggen bijvoorbeeld een belangrijk habitat voor de zandkokerworm (*Sabellaria spinulosa),* waar diverse biogene zandkokerworm riffen zijn opgebouwd uit duizenden individuelen zandbuisjes. Deze riffen staan erom bekend dat ze lokaal de biodiversiteit kunnen vergroten, en bescherming en substraat kunnen bieden voor andere soorten (Pearce et al., 2014).

De activiteit vindt plaats in gebieden waar de schelpkokerworm voorkomt en kan voorkomen en waar de zandkokerworm voorkomt (nabij het Friese Front) (Figuur 5-2). Alhoewel deze soorten niet expliciet zijn beschermd onder de Habitatrichtlijn en de activiteit grotendeels plaatsvindt buiten Natura 2000-gebied worden de effecten op deze soorten wel beoordeeld in de Passende beoordeling omdat ze een specifiek habitat creëren. Bovendien zijn *Sabellaria* riffen opgenomen op de OSPAR-lijst en verdienen bescherming in het kader van deze conventie.

5.1.3 Zandspiering

Zandspiering is een kleine algemene vissoort die een sleutelrol speelt in het voedselweb van de Noordzee[8]. De soort is van groot belang voor zeevogels, het broedsucces is direct afhankelijk van zandspiering. Zandspiering is niet alleen voor veel zeevogels een hele belangrijke prooi, maar ook voor zeezoogdieren in de Noordzee, zoals bruinvissen, dwergvinvissen en de gewone en grijze zeehond[9].

Door de afwezigheid van een commercieel belang is er in Nederland nooit veel onderzoek naar zandspiering gedaan. Er zijn op dit moment (nog) geen verspreidingskaarten beschikbaar van deze soort. Er wordt vanuit gegaan dat de zandspiering overal in de Noordzee kan voorkomen en dus ook in het gebied waar activiteiten plaatsvinden.

[8] https://blauweroute.nl/projecten/habitatmodellen-voor-verspreiding-van-zandspiering/
[9] https://www.nioz.nl/en/news/zandspiering-onbekend-maakt-onbemind

5.2 Natura 2000-gebied Voordelta

De Voordelta omhelst het ondiepe zeegedeelte van de Zeeuwse en Zuid-Hollandse Delta (natura2000.nl). Het gebied is zowel aangewezen als Habitatrichtlijngebied als Vogelrichtlijngebied voor 10 habitattypen, 7 habitatsoorten en 30 niet-broedvogelsoorten (Doelstelling Voordelta, 2020).

5.2.1 Habitattypen

De Voordelta is aangewezen voor 10 habitattypen (Tabel 5-1). De habitattypen kunnen effecten ondervinden van oppervlakteverlies, versnippering leefgebied, verontreiniging en vertroebeling door direct piping of microtunneling.

Tabel 5-1. Aangewezen habitattypen en bijbehorende doelstelling van het Natura 2000-gebied Voordelta.

Habitattype	Habitatsubtype	Status doel	Doelstelling oppervlakte*	Doelstelling kwaliteit*	Relatieve bijdrage**
H1320 - Slijkgrasvelden		Definitief	=	=	C
H2110 - Embryonale duinen		Definitief	=	=	B1
H2120 - Witte duinen		Definitief	=	=	C
H1110A - Permanent overstroomde zandbanken	Getijdengebied	Definitief	=	=	C
H1140A - Slik- en zandplaten	Getijdengebied	Definitief	=	=	C
H1310A - Zilte pionierbegroeiingen	Zeekraal	Definitief	=	=	C
H1310B - Zilte pionierbegroeiingen	Zeevetmuur	Definitief	=	=	C
H1330A - Schorren en zilte graslanden	Buitendijks	Definitief	=	=	C
H1110B - Permanent overstroomde zandbanken	Noordzee-kustzone	Definitief	=	=	B2
H1140B - Slik- en zandplaten	Noordzee-kustzone	Definitief	=	=	A1

** Instandhoudingsdoelstelling: = behoud. ** Betekenis van het gebied naar oppervlakte van het habitattype: oppervlakte in het onderhavige gebied uitgedrukt als percentage van de landelijke oppervlakte: A4: > 75%; A3: 50-75%; A2: 30-50%; A1: 15-30%; B2: 6-15%; B1: 2-6%; C: < 2%.*

De habitattypen (Tabel 5-1) zijn onder te verdelen in de 'terrestrische' habitats en 'mariene' habitats. De op land gelegen habitattypen zijn embryonale duinen (H2110), witte duinen (H2120), zilte pionierbegroeiingen (H1310A en H1310B) en schorren en zilte graslanden (H1330A). Embryonale en witte duinen zijn te vinden ten zuiden van de Maasvlakte, ter hoogte van Noordzeeboulevard en Loswalweg. Hier zijn ook zilte pionierbegroeiingen (subtype A) gelegen. Deze habitattypen zijn niet nabij de uitvoeringslocatie van de voorgenomen werkzaamheden voor het project gelegen maar kunnen wel effect ondervinden van stikstofdepositie.

De watergebonden habitattypen zijn slijkgrasvelden (H1320), permanent overstroomde zandbanken (H1110A en H1110B) en slik- en zandplaten (H1140A en H1140B). Slijkgrasvelden zijn te vinden ten zuiden van de Maasvlakte, ook ter hoogte van de Noordzeeboulevard en de Loswalweg. Slik- en zandplaten zijn op meerdere locaties in het Natura 2000-gebied gelegen, maar bevinden zich eveneens op ruime afstand van de projectlocatie (> 5 kilometer afstand hemelsbreed). Deze habitattypen zijn niet nabij de uitvoerings-locatie van de voorgenomen werkzaamheden voor het project gelegen, waardoor effecten kunnen worden uitgesloten.

Subtype H1110B betreft de permanent met zeewater van geringe diepte overstroomde zandbanken van de Noordzeekust, inclusief de buitendelta's in de Noordzeekustzone, de Voordelta, de Westerschelde en de zeegaten van de Waddenzee. Door de dynamische omstandigheden (hogere stroomsnelheden en sterkere golfwerking vanuit de Noordzee) is de bodem hier meestal grofzandiger dan bij subtype H1110A. Het habitattype permanent overstroomde zandbanken subtype H1110A[10] komt in het geheel niet voor binnen de begrenzing van het Natura 2000-gebied, het subtype H1110B is wel dominant aanwezig. de kwaliteit van het habitattype wordt onder andere bepaald door de aanwezigheid van de zogenaamde typische soorten, zoals een aantal verschillende soorten borstelwormen (bijvoorbeeld schelpkokerworm en zandkokerworm), kreeftachtigen (bijvoorbeeld gewone zwemkrab en bulldozerkreeftje), stekelhuidigen (bijvoorbeeld hartegel en gewone slangster), vissen (waaronder haring, schol en tong) en weekdieren (onder andere nonnetje en zaagje).

De instandhoudingsdoelstelling van habitattype H1110B is behoud van de huidige oppervlakte en kwaliteit. Dit habitattype kan voorkomen in het plangebied, en significant negatieve effecten kunnen niet op voorhand worden uitgesloten. De effecten van de activiteit op dit habitattype worden in hoofdstuk 6 nader onderzocht.

5.2.2 Habitatrichtlijnsoorten

Natura 2000-gebied Voordelta is aangewezen voor vier vissoorten en drie zeezoogdieren. De vissen en zeezoogdieren kunnen effecten ondervinden van verstoring door trillingen en geluid, licht, beweging en optiek, verontreiniging en vertroebeling door de benodigde activiteiten voor het aanleggen van de zeeleiding.

Vissen en vislarven
De zeeprik (*Petromyzon marinus)*, rivierprik (*Lampetra fluviatilis*), elf (*Alosa alosa*) en fint (*Alosa fallax*) zijn aangewezen met een instandhoudingsdoelstelling in het Natura 2000-gebied de Voordelta. De (volwassen dieren van de) elft, fint, zeeprik en rivierprik leven in zout water, maar zij planten zich voort in zoet rivierwater. Als gevolg van barrières in de trekroutes (stuwen, dammen), overbevissing en slechte waterkwaliteit (de laatste twee vooral in het verleden) zijn trekvissen sinds de jaren '50 en '60 van de vorige eeuw sterk in aantal afgenomen. De zeeprik en rivierprik wordt incidenteel waargenomen in de (monding van) grote rivieren. De fint wordt nog steeds aangetroffen in Nederlandse kustwateren (hetzij in lage dichtheden), er zijn vrij recentelijk jonge individuen aangetroffen die kunnen duiden op voortplanting. Van de elft zijn in de afgelopen decennia slechts enkele waarnemingen gedaan in de Nederlandse kustwateren.
De instandhoudingsdoelstellingen zijn voor alle vissoorten uitbreiding van de huidige populatie en behoud van de omvang en de kwaliteit van het leefgebied.

Zeeprik (H1095)
De landelijke staat van instandhouding van de zeeprik (*Petromyzon marinus*) is zeer ongunstig. De zeeprik is zeer zeldzaam op open zee en iets minder zeldzaam langs de kust (Winter et al., 2014; Emmerik, 2016; Figuur 5-3: links). De Voordelta vormt onderdeel van het foerageer- en leefgebied van volwassen zeeprikken. Volwassen exemplaren leven parasitair in zee, en leven vooral op grotere vissen, maar ook bruinvissen en andere walvisachtigen (Ministerie van Economische Zaken, 2008a).

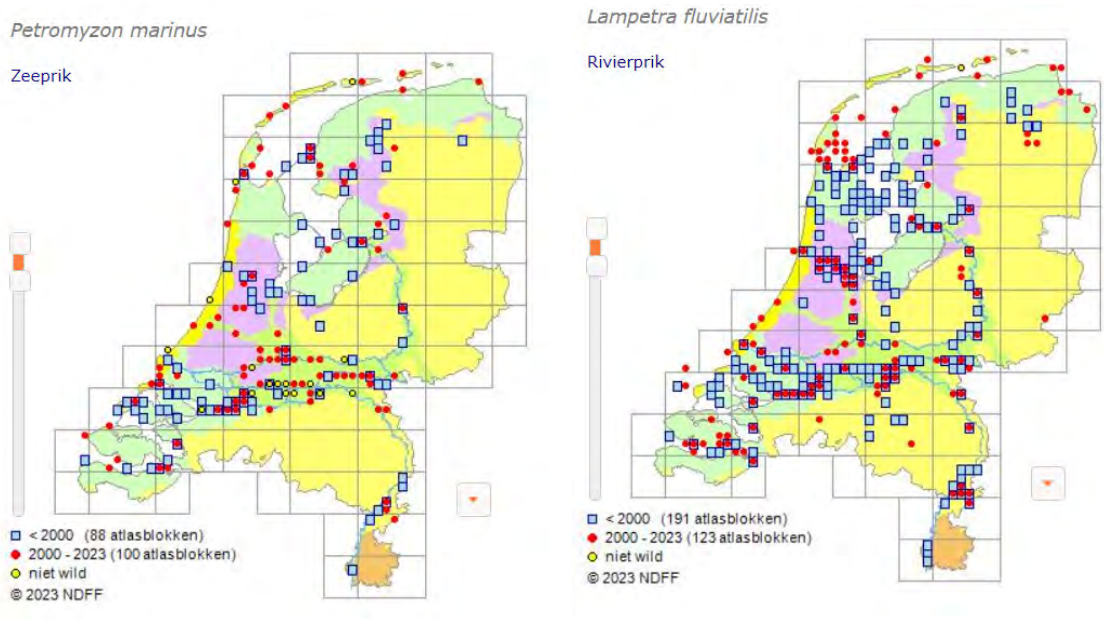
Omdat niet uitgesloten kan worden dat de soort in het gebied kan worden aangetroffen en significant negatieve effecten op voorhand niet kunnen worden uitgesloten wordt deze soort meegenomen in de effectbeoordeling.

Rivierprik (H1099)
De landelijke staat van instandhouding van de rivierprik (*Lampetra fluviatilis*) is matig ongunstig. De rivierprik is zeer zeldzaam op open zee, maar langs de kust en vooral in brak water wordt de soort vaker aangetroffen (Winter et al., 2014; Emmerik, 2016; Figuur 5-3: rechts). De Voordelta maakt onderdeel uit van het foerageer- en leefgebied van de rivierprik. De paaiplaatsen van prikken liggen bovenstrooms in de rivier. Jonge rivierprikken filteren algen en organisch materiaal. Volwassen exemplaren kunnen zowel parasitair

[10] *Volgens het Profielendocument komt het subtype 1110A voornamelijk voor in de Waddenzee en in geringe mate in de voormalige mond van het Haringvliet. Subtype -A betreft zowel relatief vlakliggende gebieden als geulen in getijdengebieden.*

leven in zee of als roofvis jagen op kleine vissoorten zoals haring en kabeljauwachtigen (Ministerie van Economische Zaken, 2008b)

Omdat niet uitgesloten kan worden dat de soort in het gebied kan worden aangetroffen en significant negatieve effecten op voorhand niet kunnen worden uitgesloten wordt deze soort meegenomen in de effectbeoordeling.



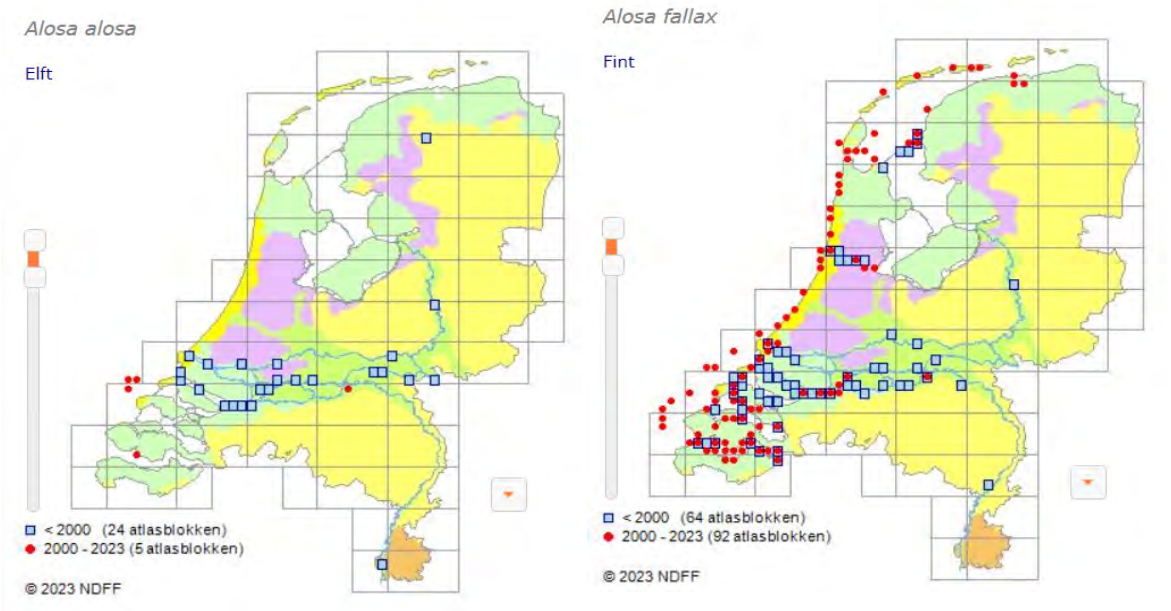
Figuur 5-3. Verspreidingskaarten van de zeeprik (links) en rivierprik (rechts). Blauwe blokken zijn waarnemingen voor 2000, en de rode bollen zijn waarnemingen tussen 2000-2023. Verkregen van www.verspreidingsatlas.nl.

Fint (1103)
De landelijke staat van instandhouding van de fint (*Alosa fallax*) is zeer ongunstig. De fint wordt vaker aangetroffen in zee dan de andere beschermde vissen, maar van een stabiele populatie is geen sprake (Winter et al., 2014; Emmerik, 2016). De Voordelta is onderdeel van het foerageer- en leefgebied van deze soort. De fint trekt tot het gebied waar het getij nog merkbaar is. Met name langs de kust en in de Waddenzee worden soms grote hoeveelheden juveniele exemplaren waargenomen, vermoedelijk afkomstig uit het buitenland. Volwassen exemplaren op open zee zijn zeldzamer (Patberg et al., 2005). In de Delta is de soort weer toegenomen, dankzij de verbeterde waterkwaliteit, er vindt ook weer voortplanting plaats in het zoetwatergetijdegebied in België (Breine et al., 2017). In de Westerschelde en het Benedenrivierengebied zijn jonge finten waargenomen (Ministerie van Economische Zaken, 2008c).

Omdat niet uitgesloten kan worden dat de soort in het gebied kan worden aangetroffen (Figuur 5-4: rechts) en significant negatieve effecten op voorhand niet kunnen worden uitgesloten, wordt deze soort meegenomen in de effectbeoordeling.

Elft (1102)
De landelijke staat van instandhouding van de elft (*Alosa alosa*) is zeer ongunstig. Elften trekken in de paaitijd (mei-juni) de rivier op. Bovenstrooms worden elften geboren en zakken geleidelijk met de rivier mee naar zoetwatergetijdegebied, waar ze opgroeien. Na 1-2 jaar trekken de jonge vissen naar zee. Door effectieve visserij, verstuwing van de grote rivieren en grindwinning zijn de paaiplaatsen van de elft verdwenen (Patberg et al., 2005). Paaigebieden liggen buiten Nederlands grondgebied. Het is nog mogelijk dat er een kleine paaipopulatie aanwezig is in de Rijn in Duitsland, waardoor ons land nog steeds een opgroei- en doortrekfunctie heeft (Patberg et al., 2005). Volwassen elften worden maar zelden waargenomen in Nederland.

Omdat niet uitgesloten kan worden dat de soort in het gebied kan worden aangetroffen (Figuur 5-4: links) en significant negatieve effecten op voorhand niet kunnen worden uitgesloten wordt deze soort meegenomen in de effectbeoordeling.



Figuur 5-4. Verspreidingskaarten van de elft (links) en fint (rechts). Blauwe blokken zijn waarnemingen voor 2000, en de rode bollen zijn waarnemingen tussen 2000-2023. Verkregen van www.verspreidingsatlas.nl.

Zeezoogdieren

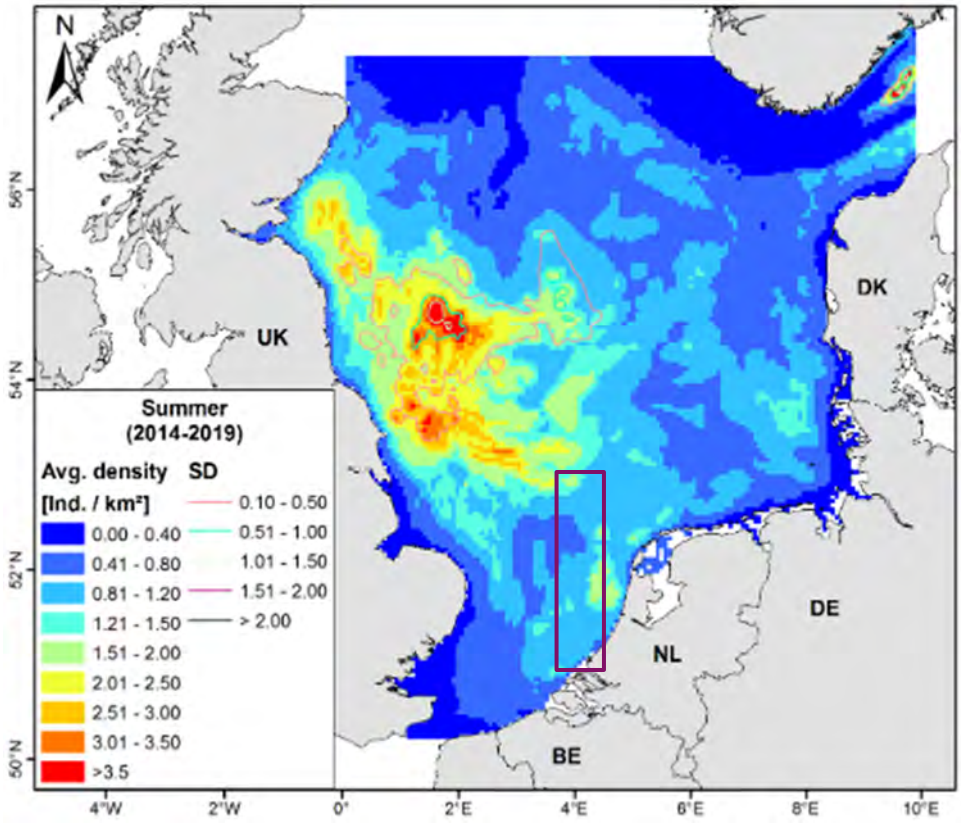
Bruinvis (H1351)
De bruinvis (*Phocoena phocoena*) heeft een landelijke staat van instandhouding die gunstig is. De instandhoudingsdoelstelling van de bruinvis is behoud van zijn populatie en omvang leefgebied. Voor kwaliteit van het leefgebied is een toename de instandhoudingsdoelstelling.

Algemene informatie
Bruinvissen zijn veelal voorkomend langs de kust, maar hebben ook een voorkeur voor relatief ondiepere wateren van het NCP (Redeker & van Doorn, 2019). Bruinvissen hebben een hoge energiebehoefte. Ze kunnen in hun vetlaag niet veel reserves opslaan, waardoor ze genoodzaakt zijn om vrijwel continu voedsel te zoeken, 24 uur per dag. Per dag eet een bruinvis ongeveer 10% van zijn lichaamsgewicht. Jonge bruinvissen eten vooral grondels. Volwassen bruinvissen eten bij voorkeur vette vis als haring, zandspiering en makreel en anders kabeljauwachtigen, zoals wijting (Leopold, 2015). Jonge bruinvissen worden tussen mei en juli voornamelijk in beschut, ondiep water geboren, een enkele keer op open zee (Geelhoed & van Polanen Petel, 2011a). Voor zowel het zoeken naar voedsel, als ook navigatie en communicatie onderling gebruiken de dieren echolocatie. De soort gebruikt korte klikklanken met een hoge frequentie en een smalle bandbreedte (Møhl & Andersen, 1973).

Omvang en verspreiding
In de eerste helft van de vorige eeuw kwam de bruinvis algemeen voor langs de Nederlandse kust. Daarna werd deze soort een zeldzame en onregelmatige verschijning. De laatste decennia wordt de bruinvis steeds zuidelijker waargenomen en is inmiddels weer redelijk algemeen langs de Nederlandse kust. De soort kent geen lange migratie naar andere gebieden en is het gehele jaar aanwezig. De populatie bruinvissen op het Nederlands Continentaal Plat (NCP) wordt geschat op 62.771 dieren (Gilles et al., 2020). Het NCP herbergt tenminste minimaal 14% (juli) tot maximaal tenminste 48% (maart) van de totale Noordzeepopulatie bruinvissen (Geelhoed et al., 2014b; Geelhoed & van Polanen Petel, 2011b). Het aantal bruinvissen op het NCP vertoont dus veel seizoensvariatie, maar ook veel ruimtelijke variatie.

Op basis van tellingen tussen 2005-2013, heeft Gilles et al. (2016) een dichtheidsmodel ontwikkeld voor bruinvissen in de Noordzee. Voor de zomerperiode is dit dichtheidsmodel later geüpdatet met gegevens van 2013-2019 en gepubliceerd onder (Gilles et al., 2020). De meest recente resultaten op basis van dit model worden gebruikt als input voor de bruinvis dichtheid in het plangebied (Figuur 5-5. Verwachte bruinvis dichtheden in de Noordzee in de zomer (Gillis et al., 2020). Het plangebied is indicatief aangegeven met de rode rechthoek.). De verwachte dichtheden in de Voordelta liggen in de zomer op 0,81 – 1,20 bruinvissen per km^2 (Gilles et al., 2020). Er is van deze kaart uitgegaan, omdat bij het samenstellen ervan naast de resultaten van (vliegtuig)tellingen ook rekening is gehouden met de variabelen die bepalend zijn voor de habitatgeschiktheid. De kaart geeft daarom een betrouwbaardere schatting van het gemiddelde voorkomen van bruinvissen.

Omdat deze soort regelmatig in het plangebied wordt waargenomen en significant negatieve effecten op voorhand niet kunnen worden uitgesloten wordt deze soort meegenomen in de effectbeoordeling.



Figuur 5-5. Verwachte bruinvis dichtheden in de Noordzee in de zomer (Gillis et al., 2020). Het plangebied is indicatief aangegeven met de rode rechthoek.

Gewone zeehond (H1365)

De gewone zeehond (*Phoca vitulina*) heeft een instandhoudingsdoelstelling in het Natura 2000-gebied Voordelta. De landelijke staat van instandhouding is gunstig, de doelstellingen zijn behoud van omvang leefgebied en toename van kwaliteit leefgebied voor toename van de populatie.

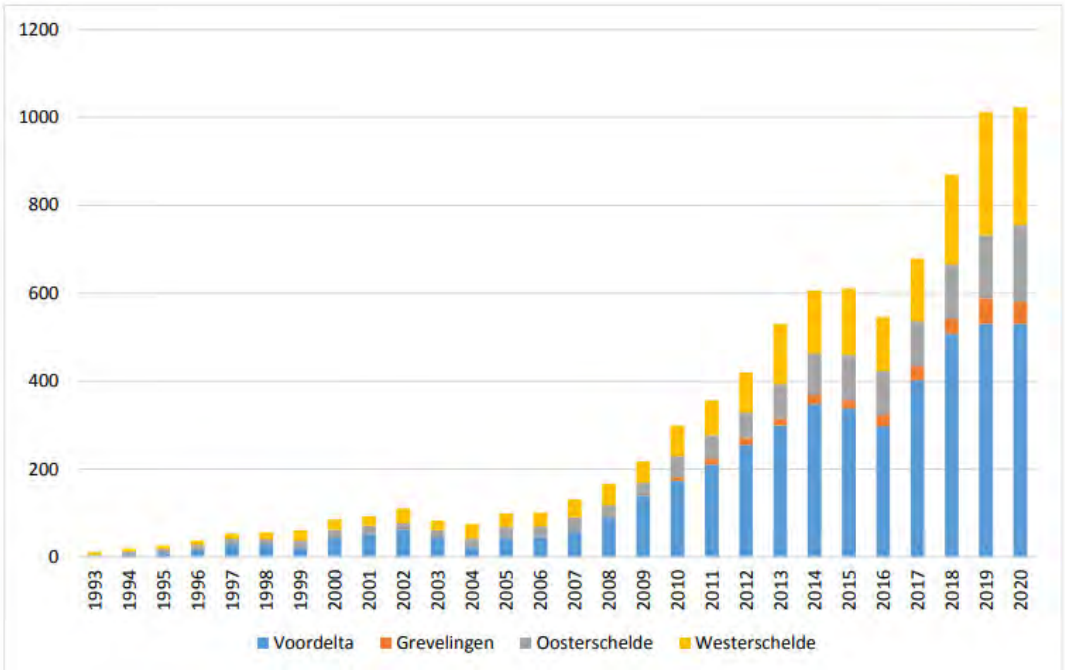
Algemene informatie

De gewone zeehond komt voor langs de kusten van de gematigde klimaatzones op het Noordelijk Halfrond. De gewone zeehond foerageert vooral op aan-de-bodem-gebonden vis, zoals platvis. Gewone zeehonden komen regelmatig op de kant om er te rusten, bij het zogen en tijdens de verharing worden de ligplaatsen frequenter bezocht. Ligplaatsen worden het hele jaar door gebruikt. Tijdens de voortplanting (in Nederland november-januari) en de daaropvolgende verharingsperiode (maart-april) worden ze intensiever bezocht. De pups kunnen vrijwel direct na hun geboorte zwemmen.

Omvang en verspreiding

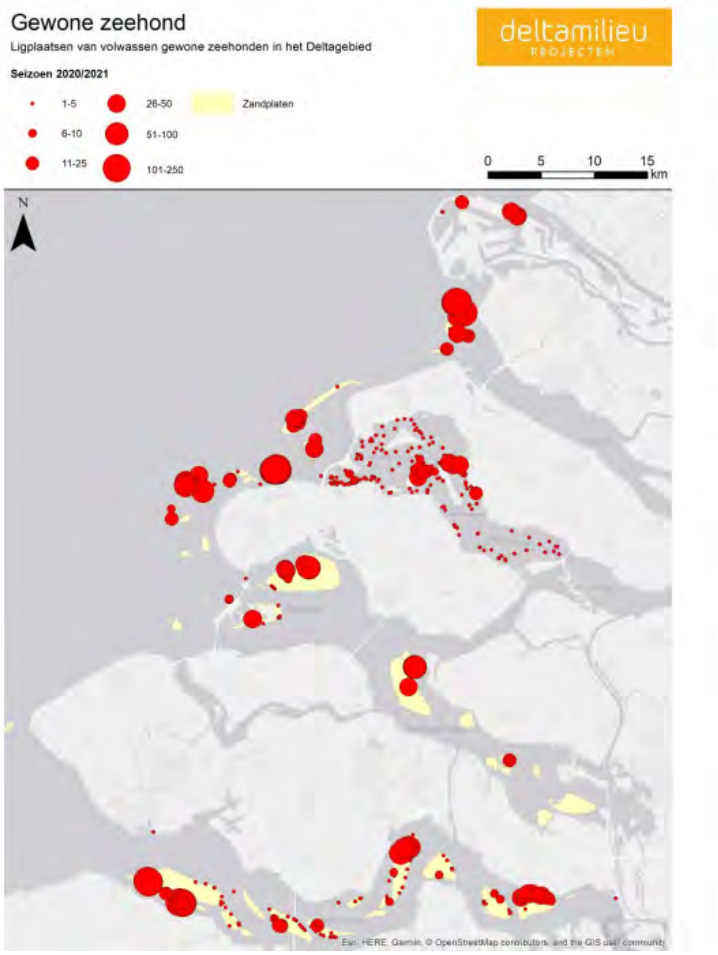
De Noordzee omvat een metapopulatie (een groep gescheiden populaties) gewone zeehonden, bestaande uit een aantal deelpopulaties waarvan de meeste dieren in de Waddenzee van Nederland tot Denemarken voorkomen. Geregeld vindt uitwisseling van zeehonden plaats tussen de deelpopulaties in Nederland, maar ook met Engeland, Duitsland en Denemarken. In augustus 2021 zijn ruim 26.000 dieren geteld op zandplaten, waarvan 8.245 in het Nederlandse deel (volwassen zeehonden) (Galatius et al., 2021).

In Nederland is daarnaast een kleine deelpopulatie in de Deltawateren aanwezig. In de Delta zijn in seizoen 2020/2021 gemiddeld van ongeveer 1.000 gewone zeehonden waargenomen, waarvan 52% in de Voordelta (Figuur 5-6; Hoekstein et al., 2022). De gewone zeehond worden regelmatig rondom de Maasvlakte/Maasgeul en vooral op het zeehonden beereiland waargenomen. Daarnaast worden ze ook in het Yangtzekanaal waargenomen. Ondanks de aanwezige scheepsvaart(bewegingen) en geluiden van het havenbedrijf, maken zij wel gebruik van mogelijke zon- en ligplaatsen.



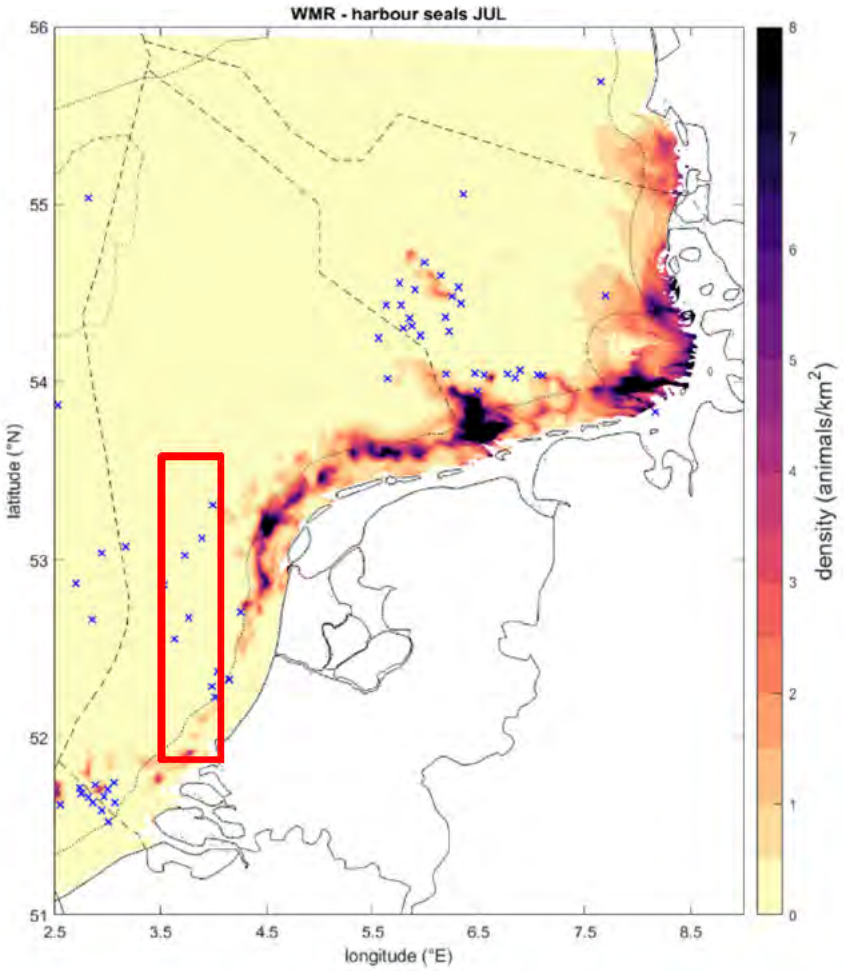
Figuur 5-6. Trend van seizoensgemiddelde van de gewone zeehond in het Deltagebied in de seizoenen 1993/1994 tot en met 2020/2021 (Afbeelding verkregen uit Hoekstein et al., 2022).

De Voordelta gebruiken ze om (bij eb) op droogvallende zandplaten te rusten en daarnaast foerageren ze hier ook (Figuur 5-7). Op open zee is de concentratie van zeehonden laag. In de zomerperiode worden de jongen ook geworpen op de droogvallende platen. De zoogperiode van de gewone zeehond is van mei tot september. Dat de drooggevallen platen in de zomerperiode niet verstoord worden is belangrijk voor de kwaliteit van het leefgebied van de gewone zeehond. Daarom gelden in deze tijd (vanaf 1 mei t/m 1 sept) strengere regels voor de rustgebieden die specifiek voor de gewone zeehond zijn aangewezen.



Figuur 5-7. De ligplaatsen van volwassen gewone zeehonden, gebaseerd op alle tellingen in het seizoen 2020/2021 (Hoekstein et al., 2022).

Op basis van telemetrie data (i.e. het zenderen van zeehonden) uit Aarts et al. (2016) is in combinatie met een recent ontwikkeld habitatmodel (Aarts, 2021) is een schatting gemaakt van de gemiddelde dichtheid van de gewone zeehond op het NCP in de maand juli (Figuur 5-8). Tijdens deze periode is de gewone zeehond voornamelijk te vinden langs de Noordzeekustzone. De soort is vrijwel niet aanwezig op open zee of nabij het plangebied (indicatief aangegeven met het rode vierkant). Dit is in de winterperiode echter niet het geval. Tijdens de winterperiode maken gewone zeehonden minder gebruik van rustplaatsen zoals stranden en zandbanken en verspreiden zich verder over de Noordzee (Aarts et al., 2013).



Figuur 5-8. Gemiddelde populatiedistributie van de gewone zeehond op het Nederlands Continentaal Plat in juli op basis van Aarts (2021). Verkregen uit Heinis et al. (2022). Het plangebied is indicatief aangegeven met de rode rechthoek.

Omdat deze soort regelmatig in het plangebied wordt waargenomen en significant negatieve effecten op voorhand niet kunnen worden uitgesloten wordt deze soort meegenomen in de effectbeoordeling.

Grijze zeehond (H1364)

De grijze zeehond (*Halichoerus grypusis*) is aangewezen met een instandhoudingsdoelstelling in het Natura 2000-gebied Voordelta. De landelijke staat van instandhouding is gunstig, de doelstellingen zijn behoud van omvang en behoud van kwaliteit leefgebied voor behoud populatie.

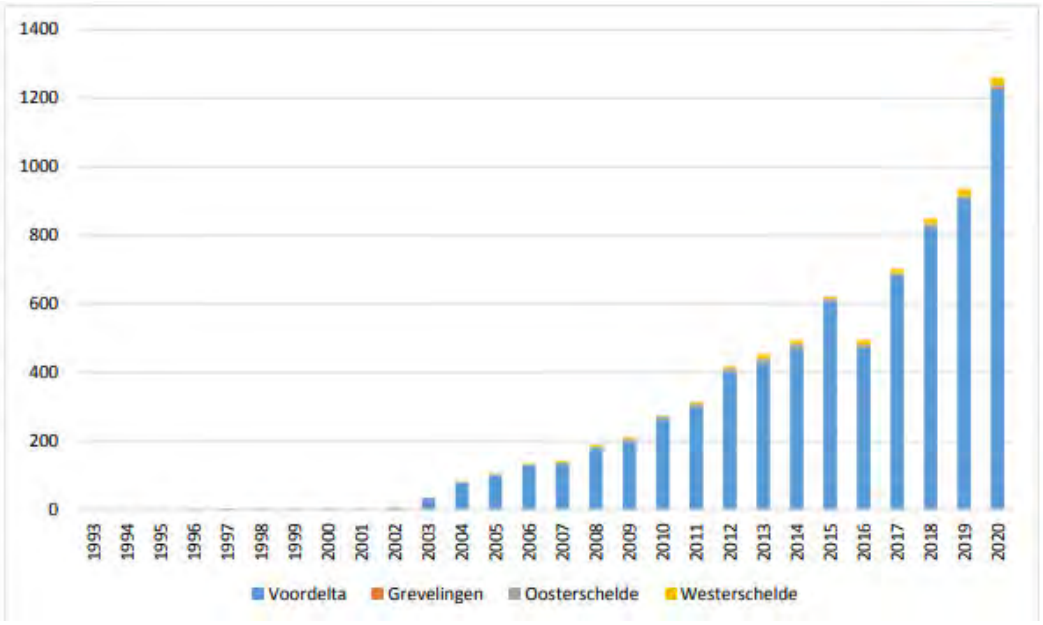
Algemene informatie

De grijze zeehond komt voor langs de oostelijke en westelijke kusten van de Atlantische oceaan. De grijze zeehond foerageert op zee, vooral op platvissen. Grijze zeehonden krijgen hun jongen in de periode november tot en met februari op droogblijvende platen of stranden. De pups van grijze zeehond kunnen in tegenstelling tot de pups van gewone zeehond niet direct zwemmen na hun geboorte. De grijze zeehond verhaart in de periode maart-april. Ook in deze periode zijn ze gebonden aan permanent droogliggende platen, stranden en duinen.

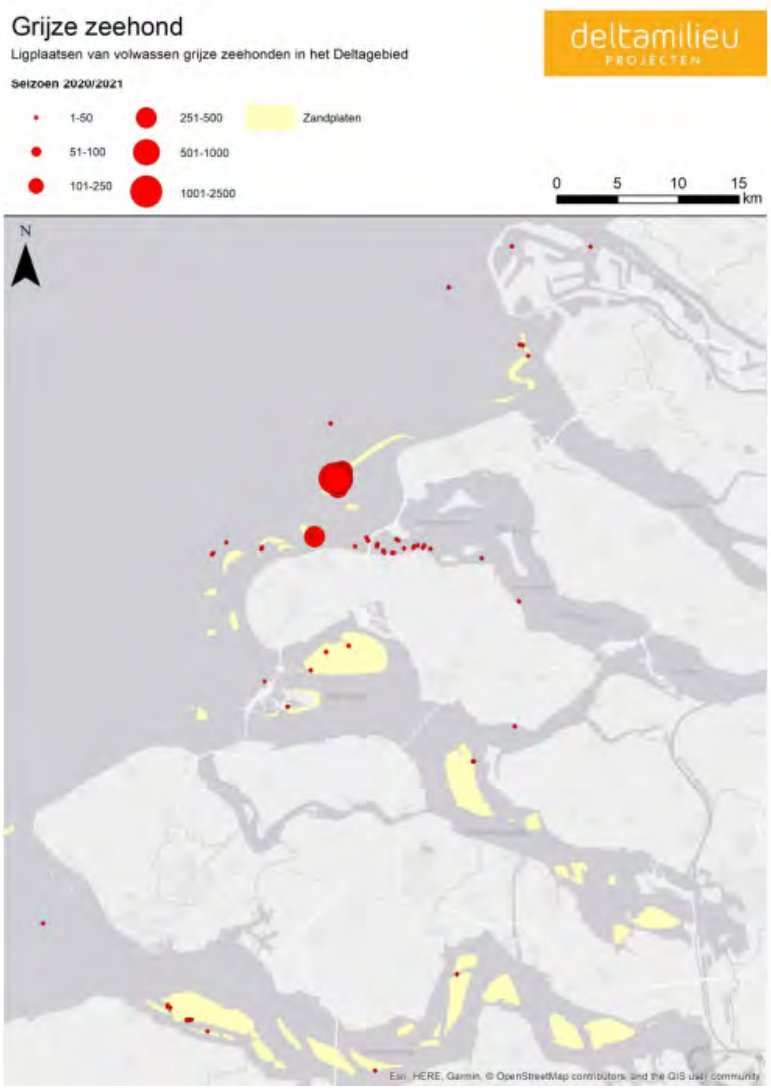
Omvang en verspreiding

In het vroege voorjaar van 2021 zijn in er 6.788 grijze zeehonden in de Nederlandse Waddenzee geteld (S. M. J. M. Brasseur et al., 2021). In de Delta zijn er ongeveer 1250 grijze zeehonden geteld in het seizoen 2020/2021 (Figuur 5-9; Hoekstein et al., 2022). Waarvan de meeste geteld zijn in de Voordelta. De meeste grijze zeehonden worden in het voorjaar geteld in het Deltagebied. De grijze zeehonden gebruiken ook

rustplekken in de Voordelta (Figuur 5-10). Vooral op de Bollen van de Ooster liggen veel grote groepen grijze zeehonden. De grijze zeehond heeft zijn zoogperiode van december tot en met februari. Net als de gewone zeehond wordt de grijze zeehond regelmatig rondom de Maasvlakte waargenomen, waarbij zij zelfs zonnen in de drukke Nijlhaven. Ondanks de aanwezige scheepsvaart(bewegingen) en geluiden van het havenbedrijf, maken zij wel gebruik van mogelijke zon- en ligplaatsen.



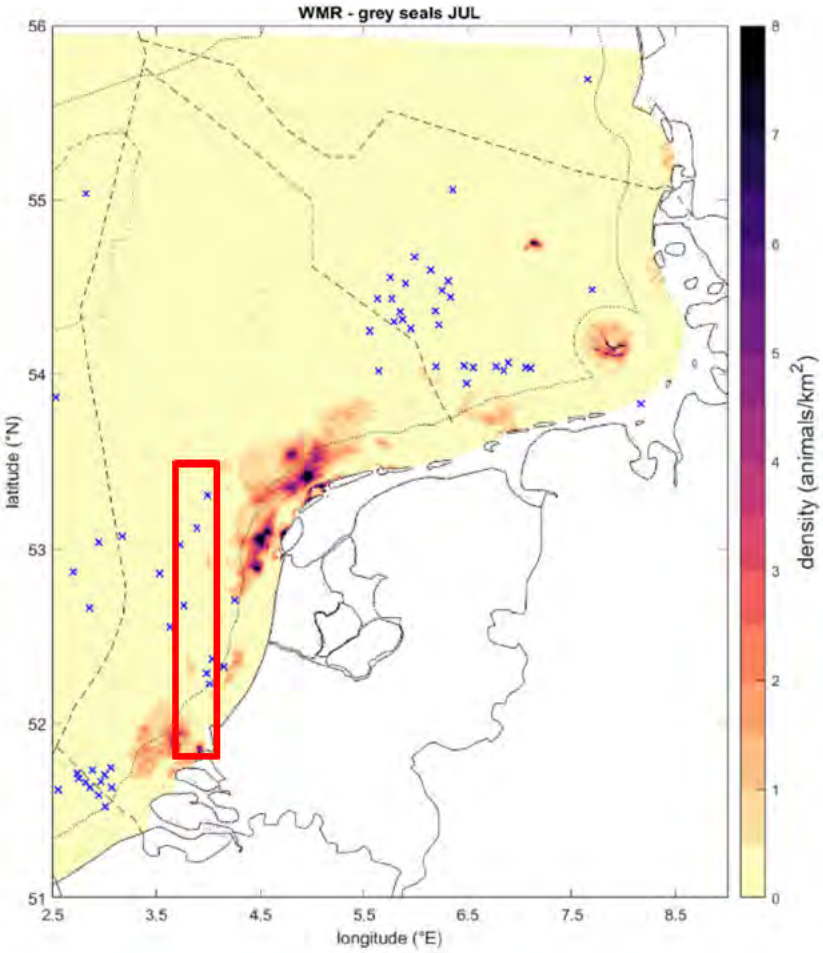
Figuur 5-9. Trend van het seizoensgemiddelde van de grijze zeehond in het Deltagebied tussen de seizoenen 1993/1994 en 2020/2021 (Afbeelding verkregen uit (Hoekstein et al., 2022)).



Figuur 5-10. Ligplaatsen van volwassen grijze zeehonden, gebaseerd op alle tellingen in seizoen 2020/2021 (Hoekstein et al., 2022).

Op basis van telemetrie data van de grijze zeehond uit (Aarts et al., 2016) is in combinatie met een recent habitatmodel (Aarts, 2021) een schatting gemaakt van de gemiddelde dichtheid van grijze zeehonden op het NCP in juli. Van de grijze zeehond is bekend dat deze over het algemeen een grote voorkeur heeft voor gebieden die dicht bij hun rustplaatsen (‘haul-out-sites’) gelegen zijn (Aarts, 2021). Daarmee is de gemiddelde dichtheid voor de grijze zeehond ook hoger in de kustgebieden (Figuur 5-11). Er zijn echter wel individuen geobserveerd die ver op open zee foerageren (Aarts, 2021).

Omdat deze soort regelmatig in het plangebied wordt waargenomen en significant negatieve effecten op voorhand niet kunnen worden uitgesloten wordt deze soort meegenomen in de effectbeoordeling.



Figuur 5-11. Gemiddelde populatiedistributie van de grijze zeehond op het Nederlands Continentaal Plat in juli op basis van Aarts (2021). Verkregen uit Heinis et al. (2022). Het plangebied is indicatief aangegeven met de rode rechthoek.

5.2.3 Vogelrichtlijnsoorten

In Natura 2000-gebied Voordelta zijn een groot aantal vogelsoorten aangewezen met een instandhoudingsdoelstelling. Het merendeel van deze soorten is kustgebonden en heeft een verspreiding die niet tot in het plangebied reikt. Hieronder zijn soorten vogels geclusterd op basis van hun gedrag en eetpatroon en is per cluster aangegeven waar deze vogels voorkomen op het NCP en specifiek in het plangebied.

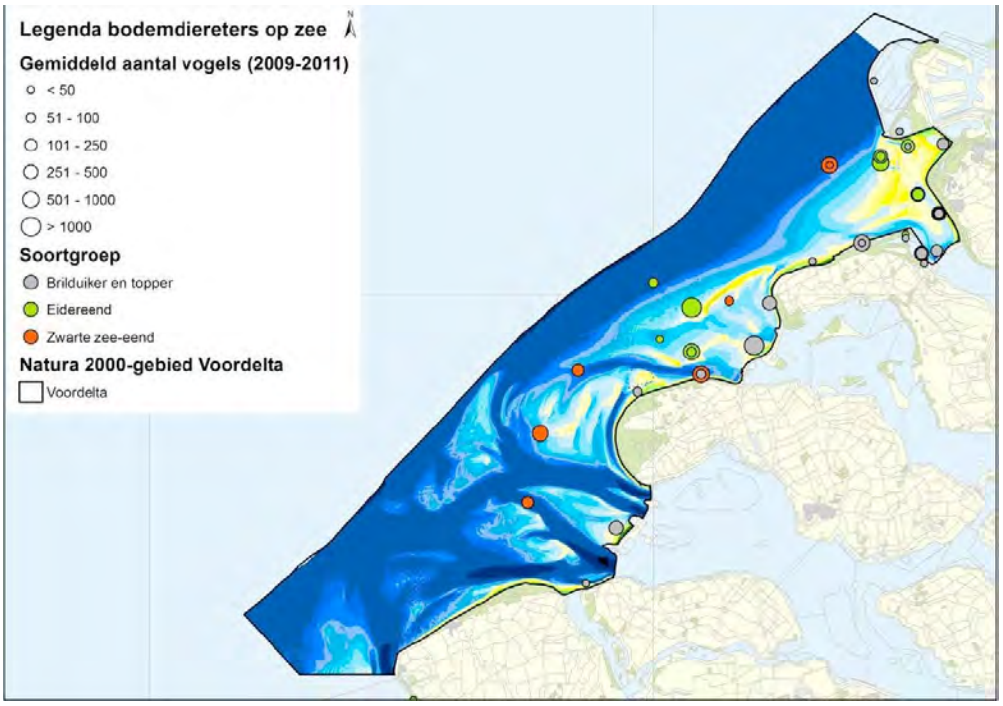
De broedvogels en niet-broedvogels kunnen effecten ondervinden van verstoring door trillingen en geluid, licht, beweging en optiek, verontreiniging en vertroebeling door het aanleggen van het verzamelpunt en het aanleggen van de zeeleiding.

Broedvogels
Er zijn geen broedvogels aangewezen in de Voordelta. Wel kunnen er broedvogels van kolonies in de zuidwestelijke Delta foerageren in de Voordelta.

Niet-broedvogels

Schelpdieretende vogels
In de Voordelta komen schelpdieretende zee-eenden, zoals eider (*Somateria mollissima*), topper (*Aythya marila*), brilduiker (*Bucephala clangula*) en zwarte zee-eend (*Melanitta nigra*) in de wintermaanden verspreid langs de kustzone voor (Figuur 5-12). De hoogste dichtheden worden gezien binnen de 20 meter dieptelijn

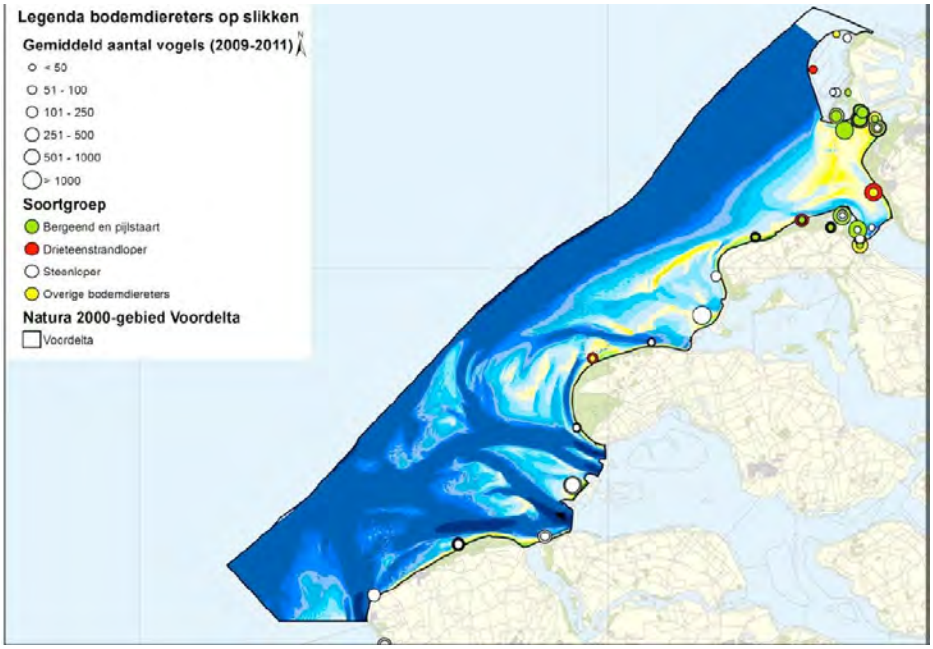
(voor de Hollandse Kust en de Zuidwestelijke Delta, nl. omgeving Brouwersdam). De schelpdieretende vogels eten vooral, mosselen, kokkels, Amerikaanse zwaardschede (*Ensis directus*), witte dunschaal (*Abra alba*) en halfgeknotte strandschelp (*Spisula subtruncata*). Het aantal *Spisula* banken in de Nederlandse wateren is sinds begin van het millennium sterk afgenomen waardoor ook de zwarte zee-eend, die op *Spisula* foerageert, niet meer in grote aantallen wordt aangetroffen. In 2017 is er een flinke toename van het *Spisula* bestand geconstateerd. De zwarte zee-eend foerageert naast *Spisula* op de Amerikaanse zwaardschede (*Ensis*) en tere dunschaal (*Abra alba*). De eider en topper foerageren vooral op kokkels en mossels. In de Voordelta is vooral veel *Ensis* aanwezig, in tegenstelling tot de andere soorten (Ministerie van Economische Zaken, 2016a).



Figuur 5-12. Verspreiding van de schelpdier etende vogels op zee (Bron Beheerplan Voordelta, Rijkswaterstaat 2016).

Er wordt verwacht dat deze soorten voor kunnen komen in het plangebied, waardoor significante effecten niet met zekerheid zijn uit te sluiten en de soorten daarom verder worden besproken (Ministerie van Economische Zaken, 2016a).

Bodemdiereters (op de slikken)
Onder de categorie bodemdiereters op de slikken vallen steltlopers en twee soorten eenden. De steltlopers en eenden komen vooral voor op en rond de Slikken van Voorne en verder verspreid over het gebied (Figuur 5-13). Het is vooral belangrijk dat er voldoende aanbod van rustige foerageergebieden in combinatie met voedselbeschikbaarheid aanwezig is (Ministerie van Economische Zaken, 2016a). De rustplek Slikken van Voorne is daarom ook aangewezen als rustgebied voor steltlopers en eenden. Het gebied is jaarrond gesloten, met uitzondering van recreatie tot de rustgebied grens en sommige vormen van visserij (Ministerie van Economische Zaken, 2016a).

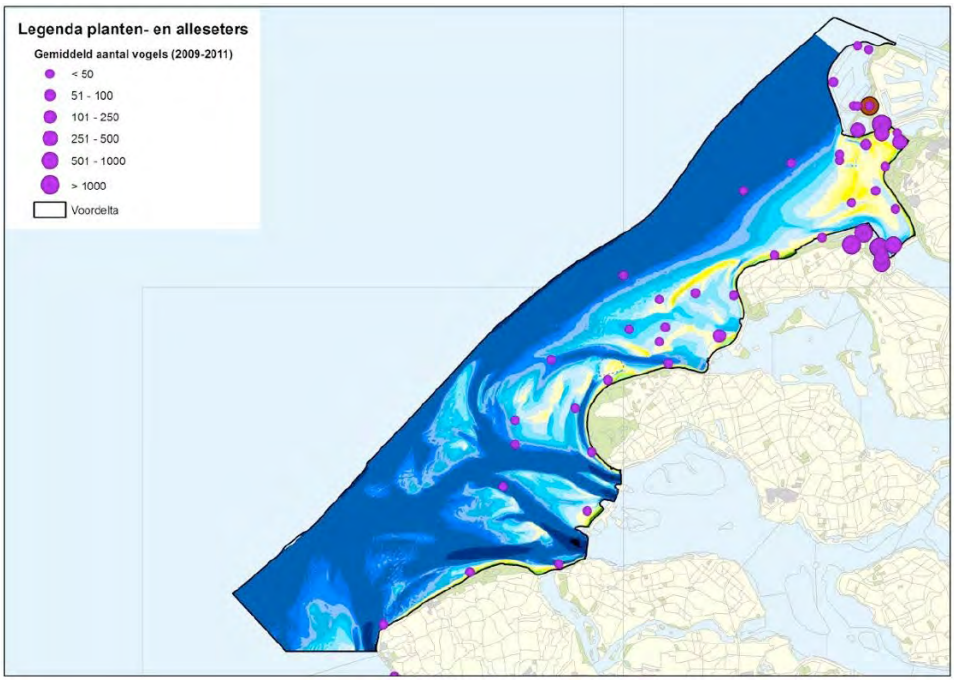


Figuur 5-13. Verspreiding van de Bodemdiereters op de slikken (Bron Beheerplan Voordelta).

Aangezien deze soorten bovenwater foerageren zullen deze soorten geen hinder ondervinden van de activiteiten die onder water plaatsvinden. Er kan echter wel sprake zijn van optische verstoring door de aanwezigheid van schepen die tijdens de aanlegfase aanwezig kunnen zijn in het gebied. Significante effecten kunnen niet met zekerheid worden uitgesloten en de soorten worden daarom verder besproken.

Planteters en alleseters

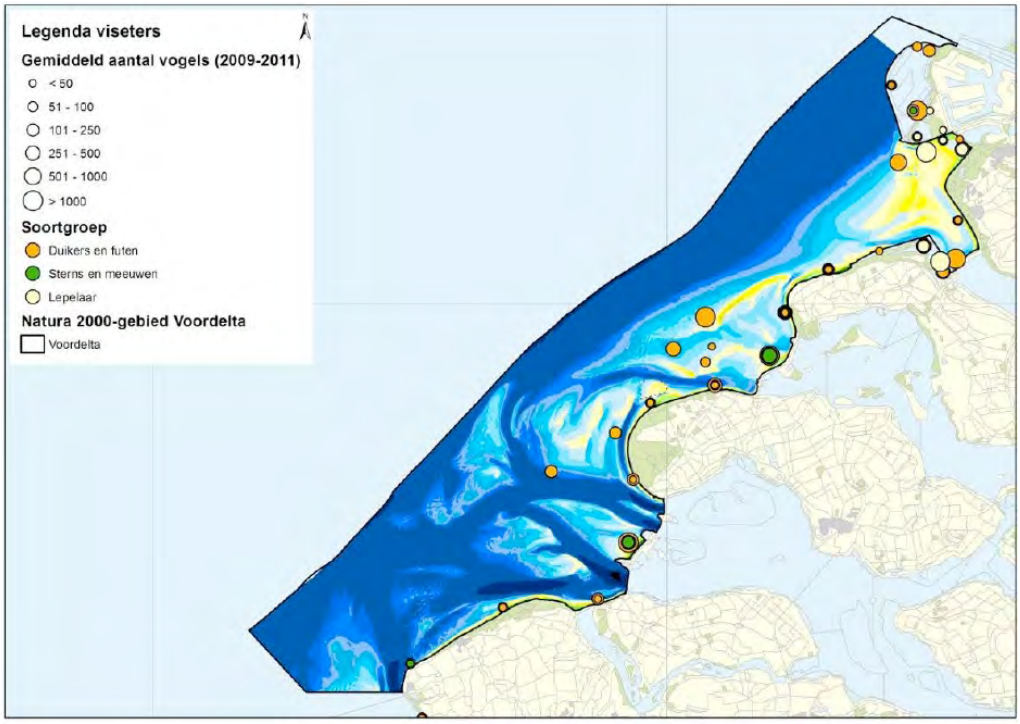
Er zijn ook een aantal planteters aanwezig in de Voordelta. Hieronder vallen de grauwe gans (*Anser anser*), smient (*Mareca penelope*), wintertaling (*Anas crecca*), slobeend (*Spatula clypeata*) en krakeend (*Mareca strepera*). Voor deze groep vogels is ook het rustgebied Slikken van Voorne aangewezen als rustgebied. In Figuur 5-14 is ook te zien dat ze daar het meest voorkomen (Ministerie van Economische Zaken, 2016a). Deze soorten foerageren langs de kust buiten het plangebied van de activiteit. Effecten op planteters en alleseters zijn op voorhand uitgesloten.



Figuur 5-14. Verspreiding van de planten – en alles eters (Rijkswaterstaat 2016).

Visetende vogels

Onder de categorie viseters vallen de aalscholver (*Phalacrocorax carbo*), dwergmeeuw, fuut (*Podiceps cristatus*), grote stern (*Thalasseus sandvicensis*), kuifduiker (*Podiceps auritus*), lepelaar (*Platalea leucorodia*), middelste zaagbek (*Mergus serrator*), roodkeelduiker (*Gavia stellata*) en visdief (*Sterna hirundo*) (Figuur 5-15). De roodkeelduiker is van september tot april op de Noordzee aanwezig. Deze soort wordt voornamelijk in kleine groepjes van 10 tot 20 vogels gesignaleerd en heeft in de Nederlandse wateren een overwegend kustgebonden verspreiding (Poot et al. 2011). De soort is zeer schuw en ontwijkt menselijke activiteit. De fuut overwintert in de Noordzee en foerageert vooral langs de kust. De aalscholver foerageert ook meestal rond de kust. De aalscholver is wel een opportunistische soort die visresten opeet en platforms van windmolens op zee gebruikt als foerageerlocatie (Camphuysen & Webb, 1999; Leopold et al., 2011 & 2013). De dwergmeeuw en grote stern foerageren verder op zee, voor de grote stern wel tot 30 km (van der Hut et al., 2007). Het rustgebied de Middelplaat (Figuur 3-1) is aangewezen als rustgebied voor de roodkeelduiker, het gebied is jaarrond gesloten, wel is er recreatie tot en met de rustgrens mogelijk. In de winter (1 nov t/m 1 april), als de roodkeelduiker een winterrustgebied nodig heeft, is er een uitgebreider gebied aangewezen. Het rustgebied de Hinderplaat (Figuur 3-1) is een rustgebied voor zowel de grote stern als de visdief. Het gebied is jaarrond gesloten, maar buiten de foerageerperiode (1 mei t/m 1 sept) is er een beperkte vorm van recreatie en visserij mogelijk. De grote stern heeft ook de Bollen van de Ooster (Figuur 3-1) aangewezen gekregen als rustgebied. In de winterperiode (1 nov t/m 1 april) is er een groter rustgebied aangewezen (Ministerie van Economische Zaken, 2016a). Het is een gesloten gebied met uitzondering van beperkte vorm van recreatie en doorvaart.



Figuur 5-15. Verspreiding van de viseters (Rijkswaterstaat 2016).

Er wordt verwacht dat deze soorten kunnen voorkomen in het plangebied, waardoor significante effecten niet met zekerheid zijn uit te sluiten, de effecten op deze soorten worden daarom verder besproken (Ministerie van Economische Zaken, 2016a).

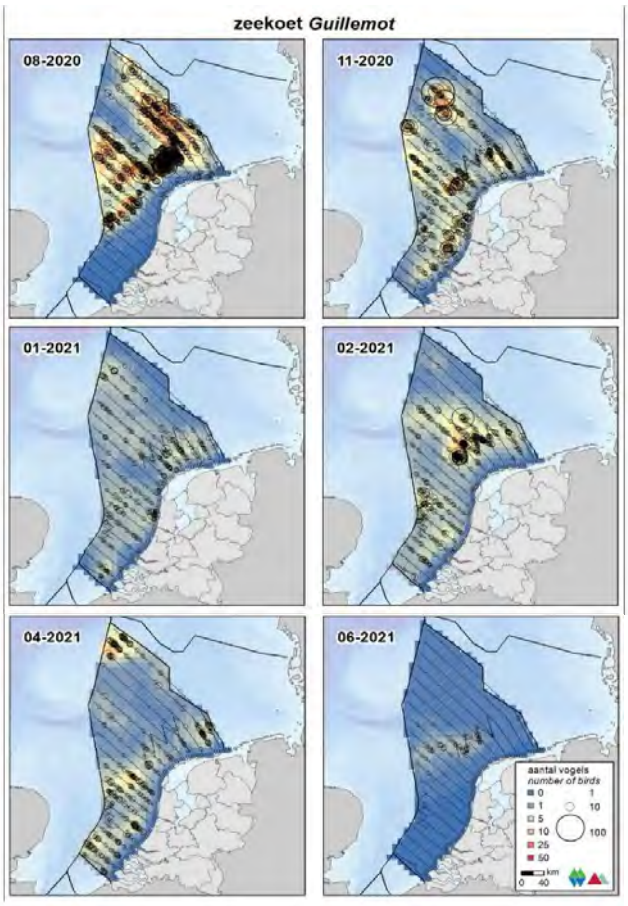
5.3 Natura 2000-gebied Friese Front

Het Friese Front is aangewezen als Vogelrichtlijngebied voor de zeekoet (A199).

5.3.1 Vogelrichtlijnsoorten

Zeekoet (A199)
De zeekoet (*Uria aalge*) heeft een landelijke staat van instandhouding die gunstig is. De instandhoudingsdoelstellingen zijn behoud van oppervlakte en kwaliteit leefgebied. De zeekoet kan effecten ondervinden van oppervlakteverlies, versnippering van het leefgebied, verstoring door trillingen en geluid, licht, beweging en optiek, verontreiniging en vertroebeling door het aanleggen van de platforms en verbindingsleiding(en) voor de spurlines.

Zeekoeten zijn visetende vogels die niet in Nederland broeden, maar algemeen het gehele jaar op het NCP voorkomen. De zeekoeten op het NCP zijn voornamelijk afkomstig van de Britse kolonie. Na de broedperiode in het voorjaar zwemmen de ruiende vaders met hun jongen, die nog niet kunnen vliegen, naar het Friese Front om de jongen groot te brengen (foerageer- en rustgebied) en om te ruien. Dit vindt vooral plaats gedurende de zomermaanden juli-oktober. In deze kwetsbare periode is het Friese Front voor hen onmisbaar. Zeekoeten zijn voornamelijk van juli tot oktober te vinden op het Friese Front met piek-aantallen in september-oktober (Ministerie van Economische Zaken, 2014a). Vanaf november verplaatst de zeekoet zich vanaf de centrale Noordzee meer naar de Zuidelijke Noordzee, Doggersbank en kustzones (Fijn et al., 2020). Vanaf februari is de zeekoet verspreid over de gehele Nederlandse Noordzee (Figuur 5-16). De zeekoet is de meest talrijke vogelsoort op de Nederlandse Noordzee buiten de kustzone, met de grootste aantallen geschat in augustus (tussen de 420.100 – 912.400 exemplaren (Fijn et al., 2022). Dit is een verschil met de tellingen van 2019-2020, toen zijn de grootste aantallen geschat in februari (tussen de 182.100-387.900 exemplaren) (Fijn et al., 2020).



Figuur 5-16. Verspreiding van zeekoeten tijdens de zes monitoringvluchten in 2020-2021 op het totale NCP (Fijn et al., 2022).

Er wordt verwacht dat de zeekoet voorkomt in het plangebied. Significante effecten zijn op voorhand niet met zekerheid zijn uit te sluiten en de effecten worden nader beoordeeld.

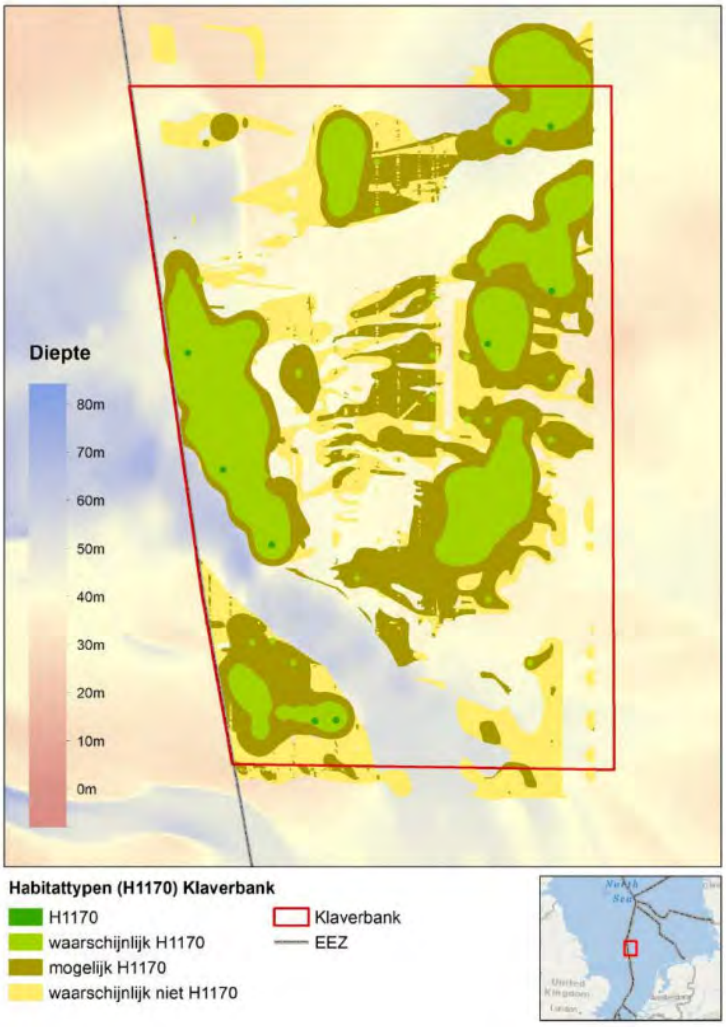
5.4 Natura 2000-gebied Klaverbank

De Klaverbank is uitsluitend aangewezen als Habitatrichtlijngebied voor het habitattype H1170 Riffen op open zee en de habitatrichtlijnsoorten bruinvis (H1351), grijze zeehond (H1364) en gewone zeehond (H1365).

5.4.1 Habitattypen

De Klaverbank is aangewezen voor één habitattype; H1170 Riffen op open zee. Dit habitattype kan effecten ondervinden van oppervlakteverlies, versnippering leefgebied, verontreiniging en vertroebeling door het aanleggen van de zeeleiding.

Habitattype H1170
Het habitattype H1170 Riffen op open zee heeft een landelijke staat van instandhouding die matig ongunstig is. De instandhoudingsdoelstelling is behoud van oppervlakte en verbeteren van de kwaliteit.



Figuur 5-17. Habitattype kaart H1170 Klaverbank (Bron afbeelding: Didderen et al., (2019).

Het habitattype H1170 Riffen op open zee wordt gekenmerkt door hard substraat, zoals stenen of schelpenbanken) die boven de bodem komen. De begrenzing van H1170 op de Klaverbank is bepaald door substraatgrootte (meer dan 64 mm) en de aanwezigheid van aan de ondergrond vastzittende organismen die van dat harde substraat afhankelijk zijn. Op de Klaverbank is 2 km^2 zeker habitattype H1170, 257 km^2 waarschijnlijk habitattype H1170, 363 km^2 mogelijk habitattype H1170 en 268 km^2 geen habitattype H1170 (Figuur 5-17).

Habitattype H1170 bevindt zich buiten het plangebied en negatieve effecten van de activiteit op het habitattype kunnen worden uitgesloten. Het habitattype zal niet meegenomen worden in de Passende Beoordeling.

5.4.2 Habitatrichtlijnsoorten

In Natura 2000-gebied Klaverbank zijn drie zeezoogdieren aangewezen met een instandhoudingsdoelstelling. De zeezoogdieren kunnen effecten ondervinden van verstoring door trillingen en geluid, licht, beweging en optiek, verontreiniging en vertroebeling door het aanleggen van de zeeleiding en het plaatsen van de platforms met verbindingsleiding(en) voor de spurlines.

Bruinvis (H1351)
De bruinvis heeft een gunstige staat van instandhouding. De instandhoudingsdoelstellingen zijn behoud van oppervlakte en kwaliteit leefgebied en behoud populatie.

De bruinvis is besproken in paragraaf 5.2.2 Voordelta. De dichtheid van deze soort op het NCP is weergegeven in Figuur 5-5. Verwachte bruinvis dichtheden in de Noordzee in de zomer (Gillis et al., 2020). Het plangebied is indicatief aangegeven met de rode rechthoek.. De bruinvis wordt regelmatig in het plangebied waargenomen en daarom wordt deze soort meegenomen in de effectbeoordeling.

Gewone zeehond (H1365)
De gewone zeehond heeft een gunstig staat van instandhouding. De instandhoudingsdoelstellingen zijn behoud van oppervlakte en kwaliteit leefgebied en behoud populatie.

De gewone zeehond is besproken in paragraaf 5.2.2 Voordelta. De dichtheid van de gewone zeehond op het NCP is weergegeven in Figuur 5-8. De gewone zeehond kan mogelijk in het plangebied voorkomen en daarom wordt deze soort meegenomen in de effectbeoordeling.

Grijze zeehond (H1364)
De grijze zeehond heeft een gunstige staat van instandhouding. De instandhoudingsdoelstellingen zijn behoud van oppervlakte en kwaliteit leefgebied en populatiebehoud.

De grijze zeehond is besproken in paragraaf 5.2.2 Voordelta. De dichtheid van de grijze zeehond op het NCP is weergegeven in Figuur 5-11. De grijze zeehond kan mogelijk in het plangebied voorkomen en daarom wordt deze soort meegenomen in de effectbeoordeling.

5.5 Natura 2000-gebied Bruine Bank

De Bruine Bank is aangewezen als Vogelrichtlijngebied voor de vogels jan-van-gent (A016), grote jager (A175), dwergmeeuw (A177), grote mantelmeeuw (A187), zeekoet (A199) en alk (A200).

5.5.1 Vogelrichtlijnsoorten

De niet-broedvogels kunnen effecten ondervinden van verstoring door trillingen en geluid, licht, beweging en optiek, verontreiniging en vertroebeling door het aanleggen van het verzamelpunt en het aanleggen van de zeeleiding.

Jan-van-gent (A016)
De jan-van-gent heeft een landelijke gunstige staat van instandhouding. De Bruine Bank is aangewezen als foerageergebied. De instandhoudingsdoelstellingen zijn behoud van omvang en kwaliteit leefgebied en populatiebehoud.

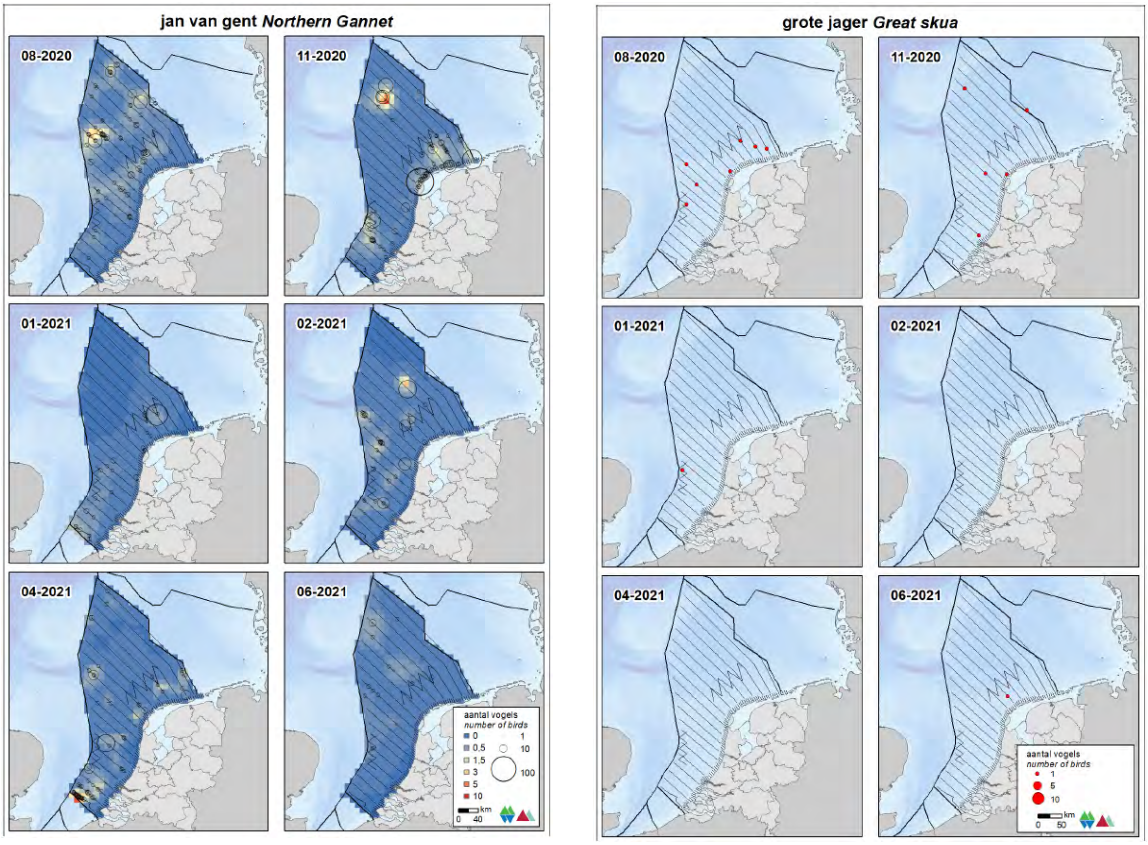
De jan-van-gent (*Morus bassanus*) is de grootste in Nederland voorkomende zeevogel. Deze soort broedt niet in Nederland. De grootste kolonie jan-van-genten is te vinden langs de kust van Schotland (Bass Rock) en een kleinere kolonie langs de oostkust van Engeland (Bempton Cliffs) (Hamer et al., 2001), echter met de vogelgriep uitbraak in juni 2022 is de populatie in omvang afgenomen. Op het NCP komt de soort in lage dichtheden zeer verspreid voor (Fijn et al., 2022, Figuur 5-18). Hier en daar kunnen hogere concentraties van de jan-van-gent geobserveerd worden. Dit gebeurt meestal rond vissersboten. In juni wordt de soort meer langs de kust waargenomen. Vanwege de grote verspreiding kan niet uitgesloten worden dat de soort van het plangebied gebruik maakt.

Er wordt verwacht dat de jan-van-gent kan voorkomen in het plangebied, waardoor significant negatieve effecten niet op voorhand zijn uit te sluiten en de effecten nader worden beoordeeld.

Grote jager (A175)
De grote jager heeft een landelijke gunstige staat van instandhouding. De Bruine Bank is aangewezen als foerageergebied. De instandhoudingsdoelstellingen zijn behoud van omvang en kwaliteit leefgebied en populatiebehoud.

De grote jager (*Stercorarius skua*) is de grootste soort die behoort tot de roofmeeuwen. De grote jager is een opportunistische soort die zich voornamelijk voedt met witvis (Votier et al., 2003). Vaak worden deze ook gestolen van andere zeevogels zoals jan-van-genten, alken en papegaaiduikers. Langs de Nederlandse kust is de grote jager voornamelijk te vinden van juli tot februari. De soort broedt voornamelijk in losse kolonies waar zo min mogelijke menselijke verstoring optreedt. Deze broedkolonies bevinden zich vooral in IJsland, Noorwegen, Faeröer eilanden en Schotse eilanden (Fijn et al., 2022), echter met de vogelgriep uitbraak in juni 2022 is de populatie in omvang afgenomen. Vanwege de verspreiding is het mogelijk dat de grote jager (in lage aantallen) voorkomt in het plangebied (Figuur 5-18).

Er wordt verwacht dat de grote jager voor kan komen in het plangebied, waardoor significante effecten niet met zekerheid zijn uit te sluiten en effecten op de soort worden nader beoordeeld.



Figuur 5-18. Verspreiding van de jan-van-gent (links) en grote jager (rechts) tijdens zes monitoringsvluchten in 2020-2021 op het totale NCP (Fijn et al., 2022).

Dwergmeeuw (A177)

De dwergmeeuw heeft een landelijke gunstige staat van instandhouding. De Bruine Bank is aangewezen als foerageergebied. De instandhoudingsdoelstellingen zijn behoud van omvang en kwaliteit leefgebied en populatiebehoud.

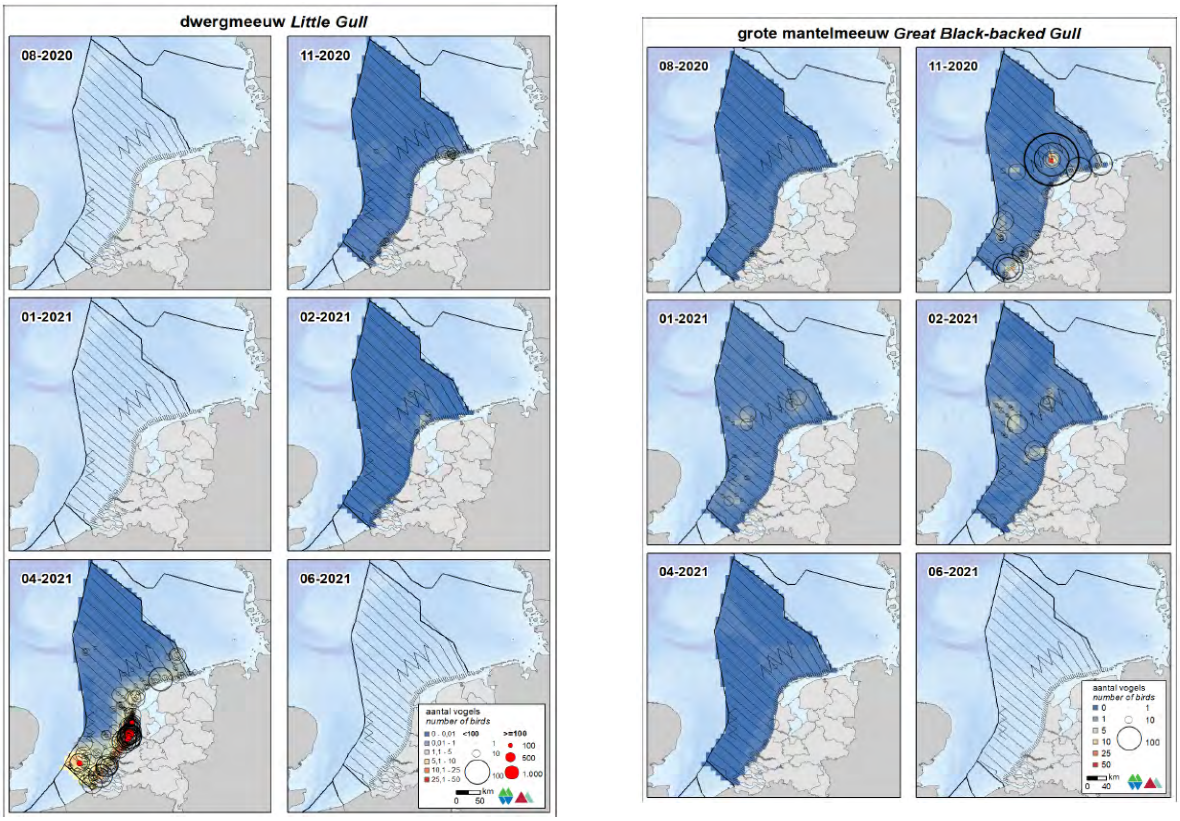
De dwergmeeuw (*Larus minutus*) is een broedvogel in de meren van Noord-Scandinavië, Baltische staten, Wit-Rusland en de Oekraïne. De Noordzee is een belangrijk doortrek en overwinteringsgebied voor de soort. De dwergmeeuw komt voor op het gehele NCP en de kustzones (Fijn et al., 2022; Figuur 5-19). Het grootste aantal dwergmeeuwen op de Noordzee wordt in augustus en februari waargenomen. In de kustzone is de soort te vinden in november en februari. Het voedsel van de dwergmeeuw bestaat voornamelijk uit insecten, die van het wateroppervlak of tijdens de vlucht worden opgepikt. Op zee foerageert de dwergmeeuw vermoedelijk op kreeftachtigen. Vanwege de verspreiding van de dwergmeeuw is het mogelijk dat deze soort in het plangebied voorkomt.

Er wordt verwacht dat de dwergmeeuw voor kan komen in het plangebied, waardoor significante effecten niet met zekerheid zijn uit te sluiten en effecten op de soort worden nader beoordeeld.

Grote Mantelmeeuw (A187)
De grote mantelmeeuw heeft een landelijke heeft een gunstige staat van instandhouding. De Bruine Bank is aangewezen als foerageergebied. De instandhoudingsdoelstellingen zijn behoud van omvang en kwaliteit leefgebied en populatiebehoud.

De grote mantelmeeuw (*Larus marinus*) is een vogelsoort uit de familie van meeuwen. De soort broedt langs de kusten van Groot-Brittannië, Ierland, IJsland en Scandinavië. (Fijn et al., 2022). De Noordzee is voor de grote mantelmeeuw voornamelijk een doortrekgebied. De hoogste aantallen grote mantelmeeuwen zijn waargenomen in november; 52.900 (Fijn et al., 2022). Verder komt de soort verspreid voor op het NCP.

Er wordt verwacht dat de grote mantelmeeuw voor kan komen in het plangebied (Figuur 5-18), waardoor significante effecten niet met zekerheid zijn uit te sluiten en effecten op de soort worden nader beoordeeld.



Figuur 5-19. Verspreiding van de dwergmeeuw (links) en grote mantelmeeuw (rechts) tijdens zes monitoringsvluchten in 2020-2021 op het totale NCP (Fijn et al., 2022).

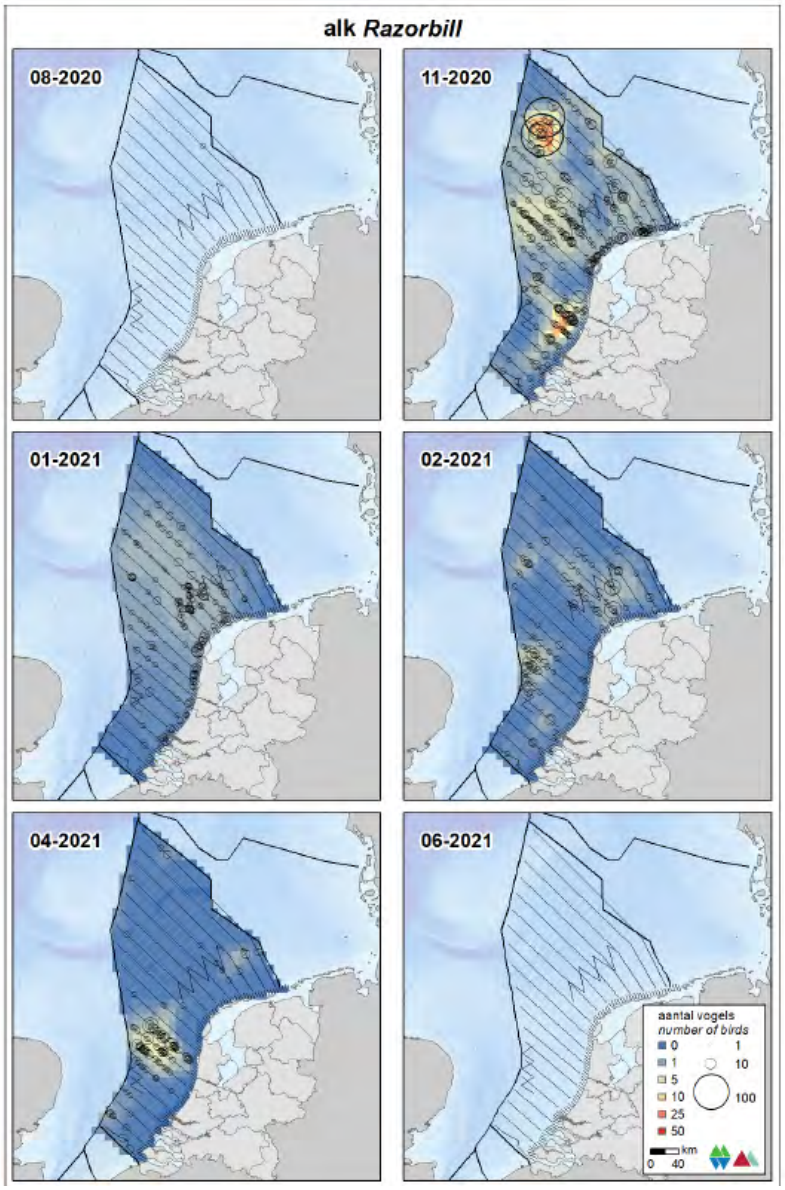
Zeekoet (A199)
De zeekoet heeft een landelijke heeft een gunstige staat van instandhouding. De Bruine Bank is aangewezen als foerageergebied. De instandhoudingsdoelstellingen zijn behoud van omvang en kwaliteit leefgebied en behoud populatie.

De zeekoet is besproken in paragraaf 5.3 Friese Front. De dichtheid van de zeekoet in Nederland is weergegeven op Figuur 5-16. De zeekoet kan worden waargenomen in het plangebied en wordt daarom meegenomen in de effectbeoordeling.

Alk (A200)
De alk heeft een gunstige staat van instandhouding. De Bruine Bank is aangewezen als foerageergebied. De instandhoudingsdoelstellingen zijn behoud van omvang en kwaliteit leefgebied en populatiebehoud.

In Nederland kunnen twee ondersoorten van de alk voorkomen. De noordelijke ondersoort (*Alca t. torda*) broedt vooral in Amerika, Noorwegen en Groenland. De zuidelijkere ondersoort (*A. t. islandica*) broedt vooral in IJsland, Helgoland, de Britse eilanden en het noordwesten van Frankrijk (Rijkswaterstaat, 2015a). In november is de alk aanwezig op de Zuidelijke Noordzee, in de Noordzeekustzone en op de Doggersbank (Figuur 5-20). De grootste aantallen worden in deze maand dan ook waargenomen op het NCP en geschat op ongeveer 208.500 (147.000-295.800) exemplaren (Fijn et al., 2022). In april is de soort ook waar te nemen rond de Bruine Bank. Vanaf juni tot en met september is de alk bijna niet aanwezig op het NCP (Camphuysen & Leopold, 1994; Fijn et al., 2020). Het is aannemelijk dat alken in het plangebied voorkomen.

Er wordt verwacht dat de alk voor kan komen in het plangebied, waardoor significante effecten niet met zekerheid zijn uit te sluiten en effecten op de soort worden nader beoordeeld.



Figuur 5-20. Verspreiding van de alk tijdens zes monitoringsvluchten in 2020-2021 op het totale NCP (Fijn et al., 2021).

5.6 Natura 2000-gebied Noordzeekustzone

De Noordzeekustzone is een dynamisch gebied met hoge stroomsnelheden, sterke temperatuur verschillen en sterke schommelingen in zoutgehalte. Door de zeestromingen en golfwerking wordt er voortdurend sediment afgezet en verplaatst. In de Noordzeekustzone is het normaal dat geulen, zandbanken en platen, strandafslag, strandaangroei, duinafslag, duinaangroei en wandelen duinen voorkomen. Op de bodem van zo'n dynamisch gebied komen vooral pionier soorten voor als weekdieren (schelpdieren) en borstelwormen.

De Noordzeekustzone is aangewezen als Vogelrichtlijngebied en Habitatrichtlijngebied voor 7 habitattypen, 7 habitatrichtlijnsoorten (1 vaatplant, 3 vissoorten en 3 zeezoogdiersoorten), 3 soorten broedvogels en 18 soorten niet-broedvogels.

5.6.1 Habitattypen

De Noordzeekustzone is aangewezen voor 7 habitattypen (Tabel 5-2Tabel 5-2. Habitattypen en bijbehorende doelstelling van het Natura 2000-gebied Noordzeekustzone.). De habitattypen kunnen effecten ondervinden van oppervlakteverlies, versnippering leefgebied, verontreiniging en vertroebeling door het aanleggen van de zeeleiding en het plaatsen van de platforms met verbindingsleiding(en) voor de spurlines.

Tabel 5-2. Habitattypen en bijbehorende doelstelling van het Natura 2000-gebied Noordzeekustzone.

Habitattype	Habitatsubtype	Status doel	Doelstelling oppervlakte*	Doelstelling kwaliteit*	Relatieve bijdrage**
H1110B – Permanent overstroomde zandbanken	Noordzeekustzone	Definitief	=	>	A1
H1140B – Slik- en zandplaten	Noordzeekustzone	Definitief	=	=	A3
H1310A – Zilte pionierbegroeiingen	Zeekraal	Definitief	=	=	B1
H1310B – Zilte pionierbegroeiingen	Zeevetmuur	Definitief	=	=	A1
H1330A – Schorren en zilte graslanden	Buitendijks	Definitief	=	=	C
H2110 – Embryonale duinen		Definitief	=	=	A2
H2190B – Vochtige duinvalleien	Kalkrijk	Definitief	=	=	B1

** Instandhoudingsdoelstelling: = behoud. ** Betekenis van het gebied naar oppervlakte van het habitattype: oppervlakte in het onderhavige gebied uitgedrukt als percentage van de landelijke oppervlakte: A4: > 75%; A3: 50-75%; A2: 30-50%; A1: 15-30%; B2: 6-15%; B1: 2-6%; C: < 2%.*

De habitattypen van de Noordzeekustzone liggen op geruime afstand van het plangebied (minimaal 37 km). Effecten van de activiteit op de habitattypen is op voorhand uitgesloten.

5.6.2 Habitatrichtlijnsoorten

In Natura 2000-gebied Noordzeekustzone zijn drie vissen, drie zeezoogdieren en een orchidee aangewezen met een instandhoudingsdoelstelling. De vissen en zeezoogdieren kunnen effecten ondervinden van verstoring door trillingen en geluid, licht, beweging en optiek, verontreiniging en vertroebeling door het aanleggen van de zeeleiding en het plaatsen van de platforms met verbindingsleiding(en) voor de spurlines.

Vissen
Zeeprik (H1095)
De zeeprik heeft een zeer ongunstige staat van instandhouding. De instandhoudingsdoelstellingen zijn behoud van oppervlakte en kwaliteit leefgebied en een toename van de populatie.

De zeeprik is besproken in paragraaf 5.2 Voordelta. De dichtheid van de zeeprik in Nederland is weergegeven in Figuur 5-3 (links). De zeeprik kan worden waargenomen in het plangebied en wordt daarom meegenomen in de effectbeoordeling.

Rivierprik (H1099)
De rivierprik heeft een matig ongunstige staat van instandhouding. De instandhoudingsdoelstellingen zijn behoud van oppervlakte en kwaliteit leefgebied en een toename van de populatie.
De rivierprik is besproken in paragraaf 5.2 Voordelta. De dichtheid van de rivierprik in Nederland is weergegeven in Figuur 5-3 (rechts). De rivierprik kan worden waargenomen in het plangebied en wordt daarom meegenomen in de effectbeoordeling.

Fint (H1103)
De fint heeft een zeer ongunstige staat van instandhouding. De instandhoudingsdoelstellingen zijn behoud van oppervlakte en kwaliteit leefgebied en een toename van de populatie.
De fint is besproken in paragraaf 5.2 Voordelta. De dichtheid van de fint in Nederland is weergegeven in Figuur 5-4 (rechts). De fint kan worden waargenomen in het plangebied en wordt daarom meegenomen in de effectbeoordeling.

Zeezoogdieren

Bruinvis (H1351)
De bruinvis heeft een gunstig staat van instandhouding. De instandhoudingsdoelstellingen zijn behoud van oppervlakte, toename kwaliteit leefgebied en behoud populatie.
De bruinvis is besproken in paragraaf 5.2 Voordelta. De dichtheid van de bruinvis op het NCP is weergegeven in Figuur 5-5. Verwachte bruinvis dichtheden in de Noordzee in de zomer (Gillis et al., 2020). Het plangebied is indicatief aangegeven met de rode rechthoek.. De bruinvis wordt regelmatig in het plangebied waargenomen en daarom wordt deze soort meegenomen in de effectbeoordeling.

Gewone zeehond (H1365)
De gewone zeehond heeft een gunstig staat van instandhouding. De instandhoudingsdoelstellingen zijn behoud van oppervlakte en kwaliteit leefgebied en behoud populatie.

De gewone zeehond is besproken in paragraaf 5.2 Voordelta. De dichtheid van de bruinvis op de NCP is weergegeven in Figuur 5-8. De gewone zeehond kan mogelijk in het plangebied voorkomen en daarom wordt deze soort meegenomen in de effectbeoordeling.

Grijze zeehond (H1364)
De grijze zeehond heeft een gunstig staat van instandhouding. De instandhoudingsdoelstellingen zijn behoud van oppervlakte en kwaliteit leefgebied en behoud populatie.

De grijze zeehond is besproken in paragraaf 5.2 Voordelta. De dichtheid van de bruinvis op het NCP is weergegeven in Figuur 5-11. De grijze zeehond kan mogelijk in het plangebied voorkomen en daarom wordt deze soort meegenomen in de effectbeoordeling.

Orchideeën

Groenknolorchis (H1903)
De groenknolorchis (*Liparis loeselii*) heeft een gunstig staat van instandhouding. De instandhoudingsdoelstellingen zijn behoud van oppervlakte en kwaliteit leefgebied en populatiebehoud.

De groenknolorchis is een orchidee met een tros van vier tot acht niet-opvallende bloemen. De groenknolorchis komt niet op zee voor. Daarmee kunnen effecten op de groenknolorchis voor de beoordeling van het zeedeel worden uitgesloten en zal deze soort niet verder besproken worden.

5.6.3 Vogelrichtlijnsoorten

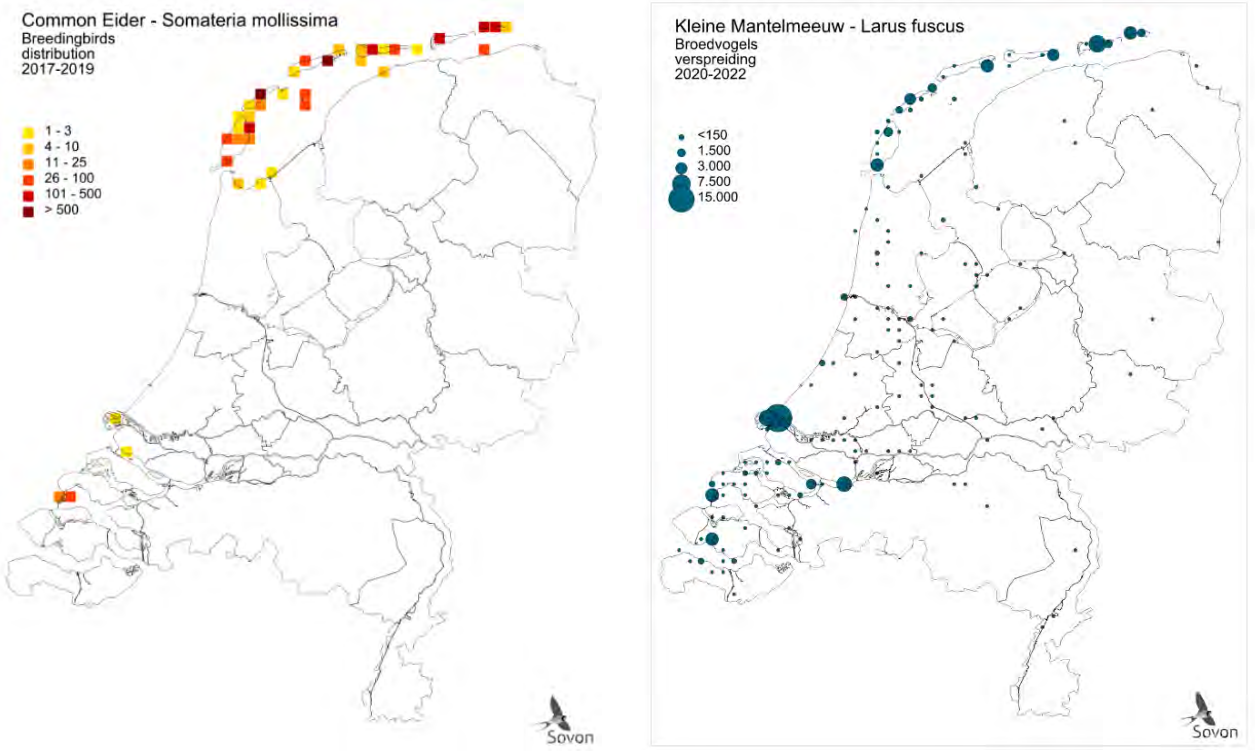
Het Natura 2000-gebied Noordzeekustzone is voor een groot aantal vogelsoorten aangewezen. Het merendeel van deze soorten is kustgebonden. Hieronder zijn soorten vogels geclusterd op basis van hun gedrag en eetpatroon en is per cluster aangegeven waar deze vogels voorkomen op het NCP en of ze in het plangebied kunnen voorkomen.

Broedvogels in de kustzone kunnen effecten ondervinden van verstoring door geluid en trilling, licht en beweging en optiek als gevolg van de inzet van extra schepen en helikopters vanuit Den Helder. (Niet-)broedvogels die verder uit de kustzone foerageren kunnen ook effecten ondervinden van verstoring door geluid en trilling, licht, beweging en optiek, verontreiniging en vertroebeling door het aanleggen van de zeeleiding en het plaatsen van de putten, platforms en verbindingsleiding(en) voor de spurlines op open zee.

Broedvogels
Noordzeekustzone
Het Natura 2000-gebied Noordzeekustzone is aangewezen voor de bontbekplevier (*Charadrius hiaticula*), strandplevier (*Charadrius alexandrinus*) en dwergstern (*Sternula albifrons*). De bontbekplevier en strandplevier hebben een ongunstige staat van instandhouding. De dwergstern heeft een gunstige staat van instandhouding. De instandhoudingsdoelstellingen voor de bontbekplevier zijn behoud van oppervlakte en kwaliteit leefgebied. De instandhoudingsdoelstellingen van de strandplevier en dwergstern zijn toename van oppervlakte en toename leefgebied. Alle drie de vogels foerageren in de buurt van de kolonie/broedlocaties. De dwergstern binnen 5 km van de kolonie/broedlocatie, en de bontbekplevier en strandplevier binnen 3 km (Van der Hut et al., 2007). Op basis van recente verspreidingsgegevens (afgelopen 5 jaar) kunnen bontbekplevier en dwergstern worden verwacht op Noorderhaaks, de Hors en de Prins Hendrik Zanddijk (Latour et al., 2021). Er zijn geen recente waarnemingen van strandplevier, maar gezien het aanwezige biotoop kan de aanwezigheid van deze soort niet worden uitgesloten. Gezien de afstand van het plangebied en de scheepvaart tot de broedlocaties van deze soorten kunnen mogelijke effecten op broedvogels op voorhand worden uitgesloten.

Waddengebied
Vanwege de nabijheid van het Natura 2000-gebied Waddenzee is er ook aandacht besteed aan de broedvogels die in dit gebied voorkomen en waarvan het voorkomen van de soorten mogelijk overlapt met de activiteiten in het plangebied. Het gaat om de volgende broedvogels: eider, kleine mantelmeeuw, grote stern en visdief. Van andere broedvogels zoals de kluut, noordse stern, kiekendief en de strand- en zilverplevier is het voorkomen van de broedvogel in het plangebied uitgesloten.

De eider *(Somateria mollissima)* is jaarrond aanwezig in de Waddenzee en broedt hier ook. De eider komt onder andere voor als broedvogel op de Hors. In de periode 2017-2019 zijn er op de Hors tussen de 26-100 broedparen waargenomen (Figuur 5-21) (Sovon, n.d.-a). De instandhoudingsdoelstellingen van de eider zijn behoud van oppervlakte en kwaliteit leefgebied. De staat van instandhouding van de eider als broedvogel in Nederland is gunstig. Eiders nestelen vaak in een kleine kuil in de grond of in de beschutting van stenen, graspollen of struiken van 50-150 cm hoogte, voornamelijk duindoorn en kruipwilg. Ze broeden dus verder van de waterlijn af, waardoor verstoring van extra voorbijgaande schepen op nesten of broedende eiders is uit te sluiten. Ook foerageert de eider in het broedseizoen op grotere afstand (tot 15 km) en met name op open water in de Waddenzee (Van der Hut et al., 2007), wat betekent dat de soort kan uitwijken naar een groot alternatief foerageergebied bij verstoring. Mogelijke effecten op de broedvogel eider kunnen op voorhand worden uitgesloten.



Figuur 5-21 Verspreiding van de eidereend in Nederland tussen 2017-2019 (links) en de verspreiding van de kleine mantelmeeuw tussen 2020-2022 (rechts). (bron: https://stats.sovon.nl/).

De kleine mantelmeeuw (*Larus fuscus*) is een vogelsoort uit de familie van de meeuwen (*Laridae*). Deze soort is op de Noordzee een echte zomergast en is in de maanden juni en augustus buiten de kustzone op bijna het hele NCP te vinden, met uitzondering van de uiterst noordelijke delen (Fijn et al., 2022). In de winterperiode is de soort vrijwel afwezig. De kleine mantelmeeuw heeft voor omvang en kwaliteit leefgebied een behoudsdoelstelling. De staat van instandhouding is gunstig. De grootste kolonies van de kleine mantelmeeuw bevinden zich in het Deltagebied en op de Waddeneilanden. De kleine mantelmeeuw broedt onder andere op de Hors. In de periode 2020-2022 zijn op de Hors circa 3.000 broedparen waargenomen (Figuur 5-21) (Sovon, n.d.-c). De broedbiotoop van de kleine mantelmeeuw beperkt zich vrijwel geheel tot kustlocaties. De nestplaats is gelegen in open duingebieden en op schorren/kwelders, industriegebieden, opspuitterreinen en eilandjes in afgesloten zeearmen. Vanwege de broedgebieden op de Hors kunnen effecten op de broedvogel niet op voorhand worden uitgesloten en worden verder beoordeeld.

De grote stern (*Thalasseus sandvicensis*) komt in alle landen rondom de Noordzee voor als broedvogel in kolonies aan de kust. De kolonies grote stern in Nederland bevinden zich in het Deltagebied en op de Waddeneilanden. De Hors vormt een belangrijk broedgebied voor de grote stern. In 2022 zijn er op de Hors 3.200 broedparen waargenomen (Sovon, n.d.-b). De broedplaatsen worden bezet in het zomerhalfjaar, in het najaar trekken de vogels langs de kust naar West-Afrika om te overwinteren. Begin maart komen de eerste vogels weer terug in Nederland. De grote stern heeft voor omvang en kwaliteit leefgebied een behoudsdoelstelling. De staat van instandhouding is zeer ongunstig voor de grote stern als broedvogel. De vogelgriep heeft in 2022 gezorgd voor massale sterfte onder grote sterns. Het zal nog vele jaren duren om weer op het peil te komen van vóór 2022. Grote sterns brengen gemiddeld maar één jong in de twee jaar groot, wat ze extra kwetsbaar maakt. Door het belang van het broedgebied op de Hors en de kwetsbaarheid van de broedvogel, kunnen effecten van extra scheepvaart niet op voorhand worden uitgesloten en worden verder beoordeeld.

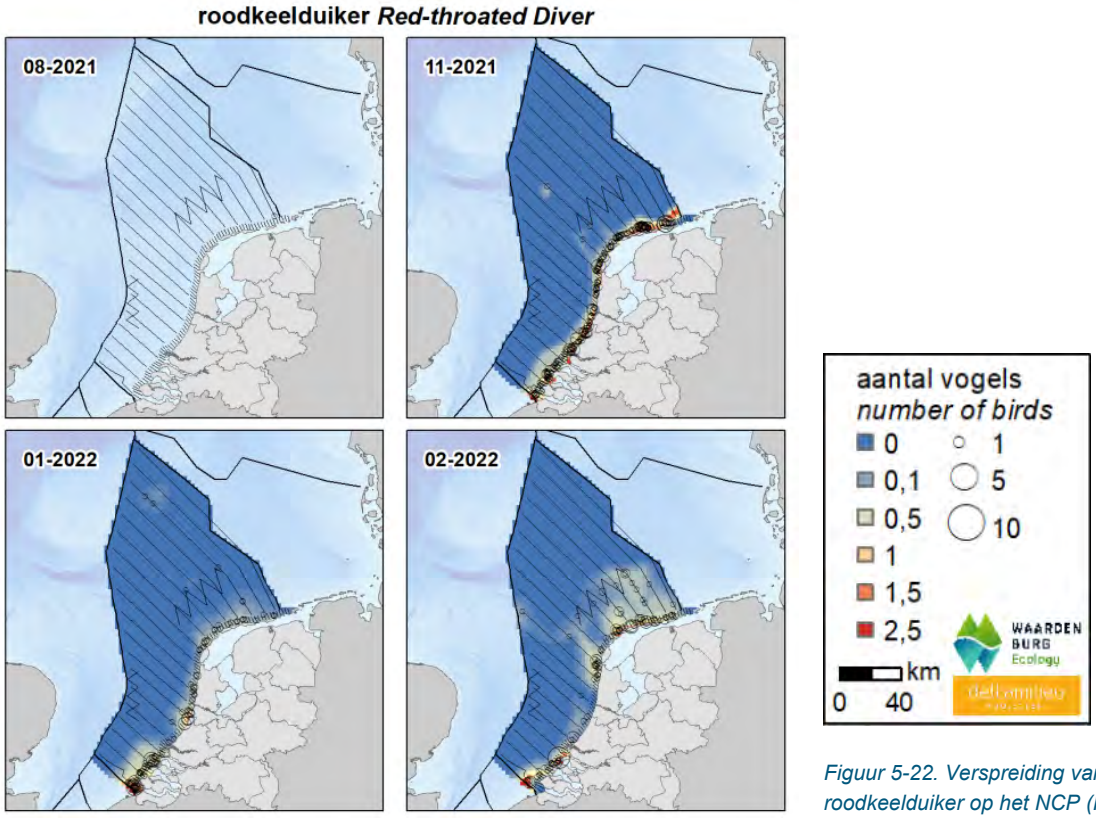
De visdief (*Sterna hirundo*) is een vogel uit de familie van de meeuwen (Laridae). De soort heeft voor omvang en kwaliteit leefgebied een behoudsdoelstelling. De staat van instandhouding is zeer ongunstig

voor de visdief als broedvogel. De visdief is in de Noordzee een doortrekker en zomergast. In Nederland broeden circa 15.000–16.200 broedparen in de Delta, Waddenzee en het IJsselmeer (Fijn et al., 2022). Ook op de Hors komen broedparen van de visdief voor (Sovon, n.d.-e). De visdief voedt zich bij voorkeur met kleine vissen, die hij meestal duikend bemachtigd langs de kustzone. De soort kan daardoor foeragerend voorkomen in het plangebied. Mogelijke effecten op de visdief kunnen niet op voorhand worden uitgesloten en worden verder beoordeeld.

Niet-broedvogels

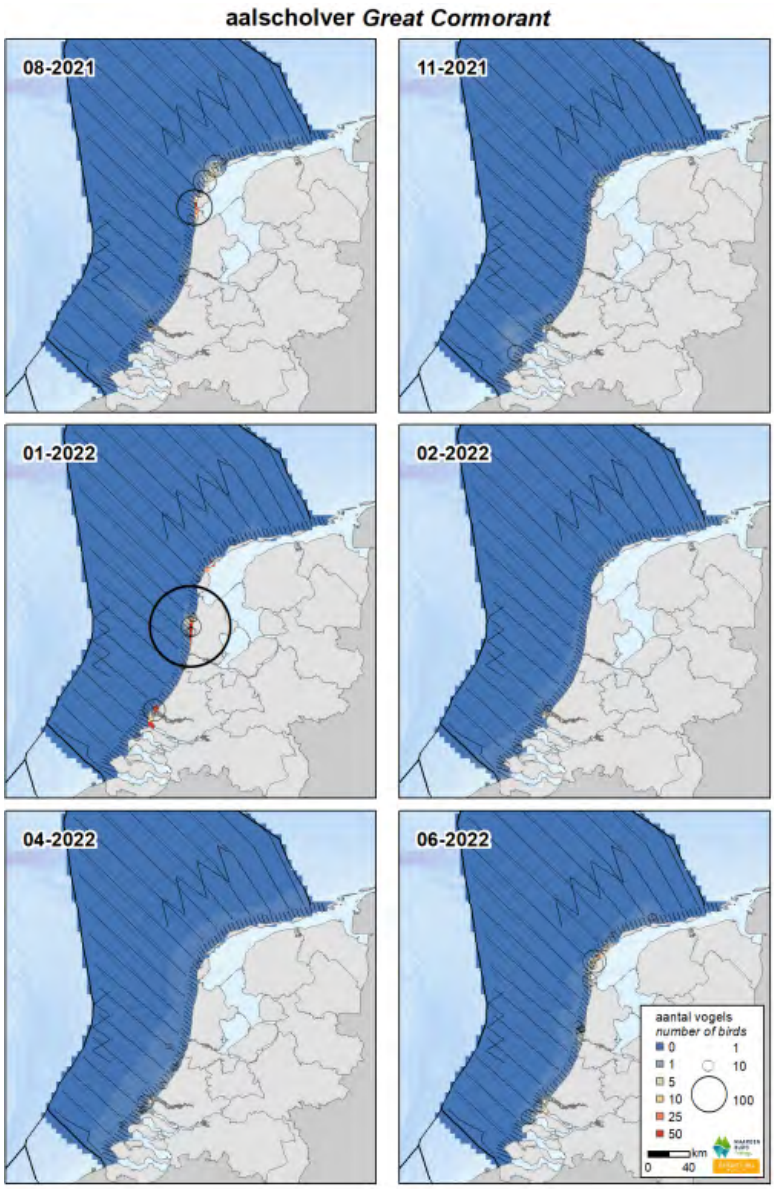
Duikende viseters
In de Noordzeekustzone komen de duikende viseters roodkeelduiker (*Gavia stellata*), parelduiker (*Gavia arctica*) en aalscholver (*Phalacrocorax carbo*) buiten het broedseizoen voor. De parelduiker komt heel sporadisch voor in het plangebied en wordt niet verder beoordeeld. De aalscholver heeft voor omvang en kwaliteit leefgebied een behoudsdoelstelling. De instandhoudingsdoelstellingen voor de roodkeelduiker is gericht op behoud van de populatie, omvang en kwaliteit van het leefgebied.

De roodkeelduiker is van september tot april op de Noordzee aanwezig. Deze soort wordt voornamelijk in kleine groepjes van 10 tot 20 vogels gesignaleerd en heeft in de Nederlandse wateren een overwegend kustgebonden verspreiding (Poot et al., 2011), de roodkeelduiker komt vooral langs de kustzone voor en minder op open zee (Ministerie van Infrastructuur en Milieu, 2016). Vanwege de verspreiding van de roodkeelduiker is het mogelijk dat deze soort in lage aantallen in het plangebied voorkomt (Figuur 5-22).



Figuur 5-22. Verspreiding van de roodkeelduiker op het NCP (Fijn et al., 2022).

De grootste aantallen aalscholvers worden in de periode van mei tot en met oktober waargenomen. De soort kan aanwezig zijn in het plangebied (Figuur 5-23). Mogelijke effecten op de aalscholver en roodkeelduiker zijn niet op voorhand uit te sluiten en worden verder beoordeeld.

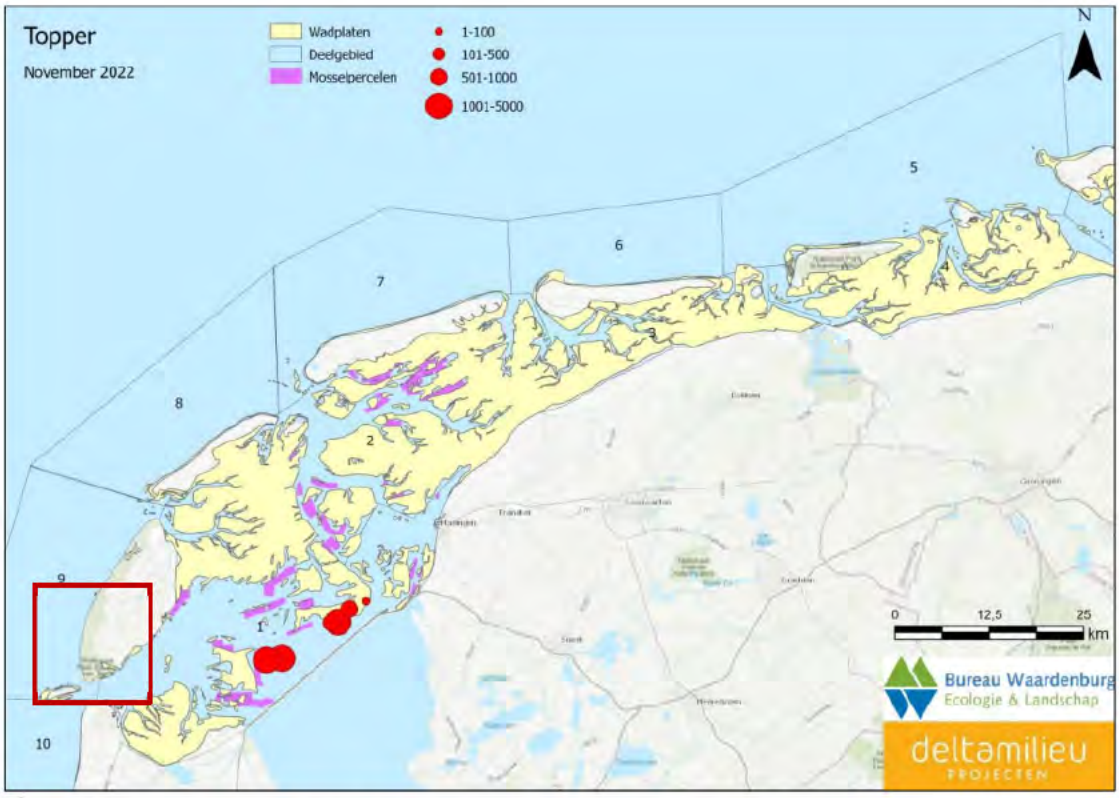


Figuur 5-23. Verspreiding van de aalscholver op het NCP (Fijn et al., 2022).

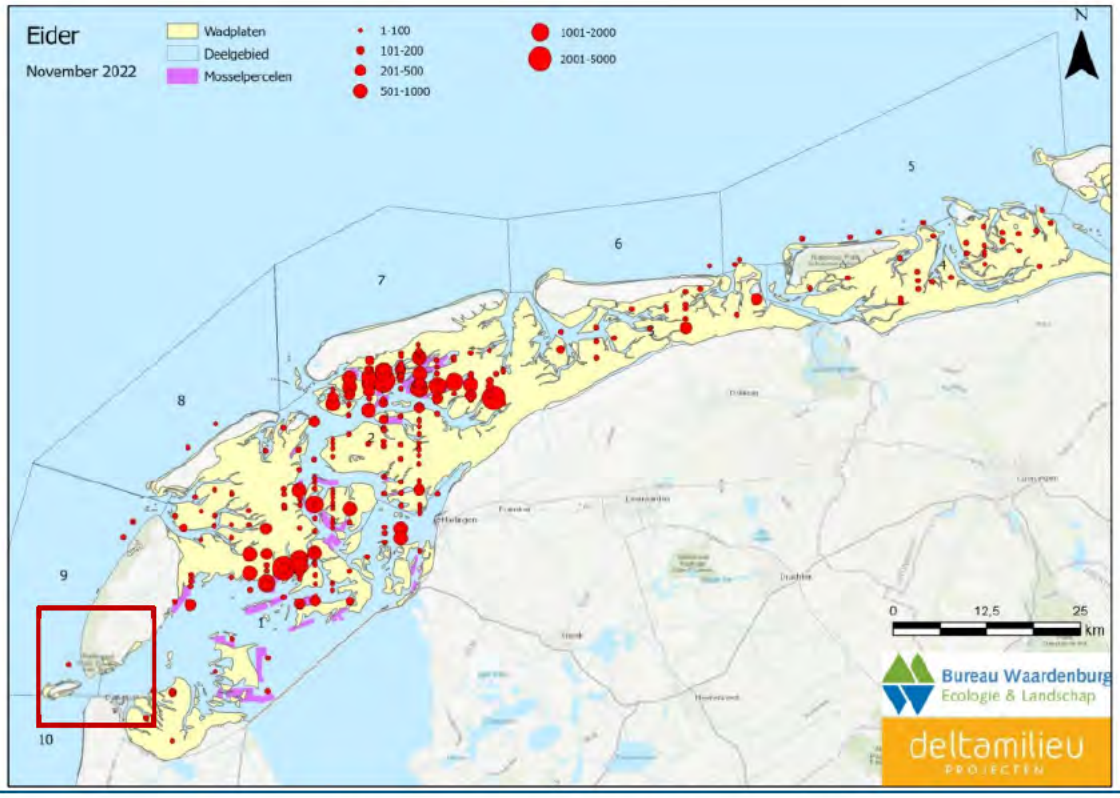
Duikeenden

In de Noordzeekustzone komen schelpdieretende duikeenden, eider, topper en zwarte zee-eend in de wintermaanden verspreid langs de kustzone voor (Figuur 5-24, Figuur 5-25, Figuur 5-26). De eider en de topper komen met name voor in de Waddenzee en veel minder in de Noordzeekustzone. De hoogste dichtheden van zwarte zee-eenden worden gezien binnen de 20 meter dieptelijn (voor de Hollandse Kust en de Zuidwestelijke Delta, namelijk omgeving Brouwersdam). De zwarte zee-eenden eten vooral Amerikaanse zwaardschede (*Ensis directus*) en halfgeknotte strandschelp (*Spisula subtruncata*). Het aantal *Spisula* banken in de Nederlandse wateren is sinds begin van het millennium sterk afgenomen waardoor ook de zwarte zee-eend, die op *Spisula* foerageert, niet meer in grote aantallen wordt aangetroffen. In 2017 is er een flinke toename van het *Spisula* bestand geconstateerd.

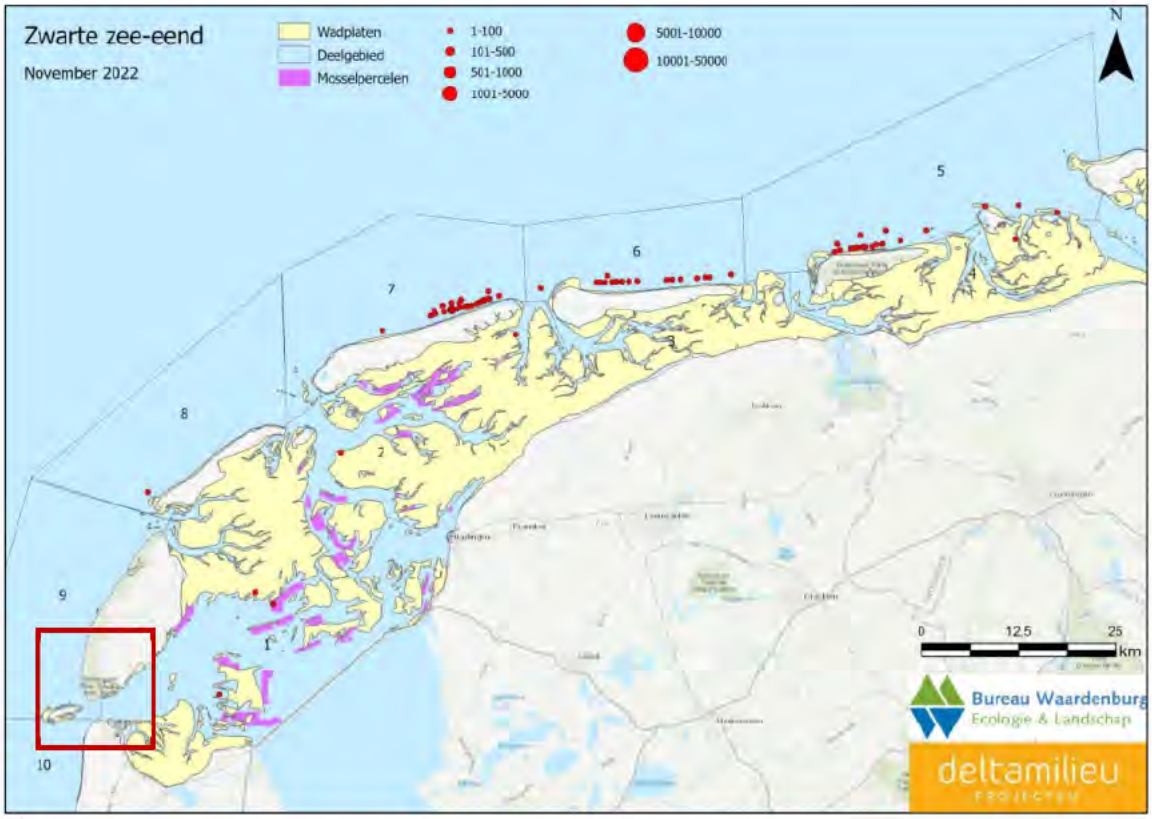
Van alle drie de soorten wordt nauwelijks verwacht dat ze in het plangebied aanwezig zijn (Sluijter et al., 2023), waardoor significante effecten met zekerheid zijn uit te sluiten en de soorten niet verder worden beoordeeld.



Figuur 5-24. Verspreiding van de topper tijdens de novembertelling in 2022 (Sluijter et al., 2023).



Figuur 5-25. Verspreiding van de eider tijdens de novembertelling in 2022 (Sluijter et al., 2023).



Figuur 5-26. Verspreiding van de zwarte zee-eend tijdens de novembertelling in 2022 (Sluijter et al., 2023).

Steltlopers

In de Noordzeekustzone komt een grote groep steltlopers voor: scholekster (*Haematopus ostralegus*), kluut (*Recurvirostra avosetta*), zilverplevier (*Pluvialis squatarola*), kanoet (*Calidris canutus*), drieteenstrandloper (*Calidris alba*), bonte strandloper (*Calidris alpina*), steenloper (*Arenaria interpres*), bontbekplevier (*Charadrius hiaticula*), rosse grutto (*Limosa lapponica*) en wulp (*Numenius arquata*). Deze steltlopers zijn te vinden op de stranden, de platen, de kwelders en de duinen van de Noordzeekustzone. Ze gebruiken deze plekken vooral als slaap- en hoogwatervluchtplaats en in mindere mate als foerageergebied. Steltlopers komen vooral langs de kust voor en niet op open zee.

Van de niet-broedvogels wordt nauwelijks verwacht dat ze in het plangebied aanwezig zijn, waardoor significante effecten met zekerheid zijn uit te sluiten en de soorten niet verder worden beoordeeld.

Overig: bergeend en dwergmeeuw

Er zijn twee soorten in de Noordzeekustzone die niet vallen onder de eerdergenoemde groepen; de bergeend (*Tadorna tadorna*) en dwergmeeuw (*Hydrocoloeus minutus*). De bergeend is het gehele jaar door aanwezig in de Noordzeekustzone met piekaantallen in het najaar en begin winter. De bergeend foerageert in slibvlakten en in ondiep water. De dwergmeeuw is een doortrekker en gebruikt de Noordzeekustzone als foerageergebied en foerageert ook op open zee.

De bergeend wordt niet verwacht in het plangebied aanwezig te zijn, waardoor significante effecten met zekerheid zijn uit te sluiten en de soort niet verder beoordeeld wordt. Van de dwergmeeuw is het mogelijk dat hij in het plangebied kan voorkomen (in de kustzone en op open zee), hierdoor zijn significante effecten niet met zekerheid uit te sluiten, effecten worden nader beoordeeld.

5.7 Samenvatting relevante soorten voor toetsing

Gezien de informatie uit de bovenstaande paragrafen kan geconcludeerd worden dat de soorten weergegeven in Tabel 5-3Tabel 5-3 relevant zijn voor de toetsing in de Passende Beoordeling.

Tabel 5-3. Samenvatting van relevante soorten voor de effectbeoordeling.

Natura 2000-gebied	Relevante habitattypen/ soorten	Storingsfactor	Activiteit
Voordelta	Habitattype H1110B	• Oppervlakteverlies • Versnippering leefgebied • Verontreiniging • Vertroebeling • Verandering dynamiek substraat	• Het verzamelpunt (terminal en compressor) • De zeeleiding
	Rivierprik	• Verstoring door trillingen en geluid • Verstoring door licht • Verstoring door beweging/optiek • Verontreiniging • Vertroebeling • Verandering dynamiek substraat	
	Zeeprik		
	Fint		
	Elft		
	Bruinvis		
	Grijze zeehond		
	Gewone zeehond		
	Eider	• Verstoring door trillingen en geluid • Verstoring door licht • Verstoring door beweging/optiek • Verontreiniging • Vertroebeling • Verandering dynamiek substraat	
	Topper		
	Brilduiker		
	Zwarte zee-eend		
	Aalscholver		
	Dwergmeeuw		
	Fuut		
	Grote stern		
	Kuifduiker		
	Lepelaar		
	Middelste zaagbek		
	Roodkeelduiker		
	Visdief		
Friese Front	Zeekoet	• Oppervlakteverlies • Versnippering leefgebied • Verstoring door trillingen en geluid • Verstoring door licht • Verstoring door beweging/optiek • Verstoring door luchtwerveling • Verontreiniging • Vertroebeling • Verandering dynamiek substraat	• De zeeleiding • De platforms met verbindingsleiding(en) voor de spurlines

Natura 2000-gebied	Relevante habitattypen/ soorten	Storingsfactor	Activiteit
Klaverbank	Bruinvis Grijze zeehond Gewone zeehond	• Verstoring door trillingen en geluid	• De zeeleiding • De platforms met verbindingsleiding(en) voor de spurlines
Bruine Bank	Zeekoet Jan-van-gent Grote jager Dwergmeeuw Grote mantelmeeuw Alk	• Verstoring door trillingen en geluid • Verstoring door licht • Verstoring door beweging/optiek • Verontreiniging • Vertroebeling • Verandering dynamiek substraat	• De zeeleiding
Noordzeekust-zone	Fint Rivierprik Zeeprik Bruinvis Gewone zeehond Grijze zeehond	• Verstoring door trillingen en geluid • Verstoring door licht • Verstoring door beweging/optiek • Verontreiniging • Vertroebeling • Verandering dynamiek substraat	• De zeeleiding • De platforms met verbindingsleiding(en) voor de spurlines en putten
	Grote stern *(Instandhoudings-doelstelling in de Waddenzee)* Aalscholver Dwergmeeuw	• Verstoring door trillingen en geluid • Verstoring door licht • Verstoring door beweging/optiek • Verontreiniging • Vertroebeling • Verandering dynamiek substraat	• De zeeleiding • De platforms met verbindingsleiding(en) voor de spurlines en putten • Scheepvaart- en helikopterbewegingen
	Visdief *(Instandhoudingsdoelstelling in de Waddenzee)* Roodkeelduiker Kleine mantelmeeuw *(Instandhou-dingsdoelstelling in de Waddenzee)*	• Verstoring door trillingen en geluid • Verstoring door licht • Verstoring door beweging/optiek	• Scheepvaart- en helikopterbewegingen

6 Passende Beoordeling – zeedeel

Onderstaand wordt de Passende beoordeling beschreven voor de gebieden op zee. De paragrafen 6.1 tot en met 6.6 gaan over de aanlegfase, paragraaf 6.7 beschrijft de effecten tijdens de gebruiksfase.

6.1 Noordzee

In deze paragraaf worden effecten beoordeeld van activiteiten die plaatsvinden buiten de Natura 2000-gebieden. Door middel van externe werking en indirecte effecten kunnen deze effecten alsnog een effect hebben op Natura 2000-gebieden. Deze paragraaf geeft een overzicht van de effecten. Waar relevant wordt het externe effect nader beoordeeld in de betreffende Natura 2000-gebieden.

6.1.1 Effecten van oppervlakteverlies

Voor de aanleg van de direct pipe zal er worden gebaggerd. Voor het aanleggen van de nearshore zeeleiding wordt met behulp van een trencher een gleuf gegraven. Het gaat om de eerste 70 kilometer vanaf de kruising met de Maasgeul waar de zeeleiding wordt ingegraven in de zeebodem, met een dekking van circa 1 meter. De offshore zeeleiding wordt op de zeebodem geplaatst, behalve als dat om veiligheids- of stabiliteitsredenen niet mogelijk is. In dat geval wordt de zeeleiding ingegraven of met steenstort bedekt. Bij de aanleg van direct pipe en de nearshore zeeleiding zal er tijdelijk verlies van oppervlakte zijn; de zeebodem kan zich na het ingraven van de zeeleiding (trenchen) en het baggeren (t.b.v. direct piping/ microtunneling) herstellen. De aanleg van de offshore zeeleiding resulteert in permanent oppervlakteverlies door de plaatsing van de zeeleiding op de zeebodem. Voor het alternatief microtunnel is er geen sprake van oppervlakteverlies.

Aanleg microtunnel/direct pipe
Bij de direct pipe resulteert het baggerwerk ten behoeve van de aanleg van de direct pipe in een tijdelijk verlies van maximaal 3,4 ha. De baggerwerkzaamheden duren voor het alternatief 47 dagen.

Aanleg nearshore zeeleiding
De nearshore zeeleiding bestaat uit de eerste 70 km (KP70) van de zeeleiding vanaf de doorkruising van de Maasgeul. Dit deel wordt ingegraven in de zeebodem. Voor het baggeren van de gleuf wordt met behulp van een trencher een gleuf gebaggerd van maximaal 2 meter diep, 6 meter breed aan de bovenkant van de gleuf en 2 meter breed aan de onderkant van de gleuf. Voor de activiteiten wordt een sleephopperzuiger ingezet voor circa 15 dagen om de zeebodem te egaliseren (Bijlage 6). Het begraven van de zeeleiding met behulp van een trencher duurt circa 72 dagen (Bijlage 6). In totaal resulteert het ingraven van de nearshore zeeleiding in een tijdelijk verlies van maximaal 42 ha (70 km x 6 m).

Aanleg offshore zeeleiding
De offshore zeeleiding wordt aangelegd op de zeebodem vanaf KP70 tot de inlaat van het eindpunt. De lengte van de offshore zeeleiding is circa 129 km en de diameter circa 80 cm. De aanleg van de zeeleiding resulteert daarmee in een permanent oppervlakteverlies (gedurende de tijd dat de leiding aanwezig is) van circa 10 ha (129 km x 80 cm).

Aanleg verbindingsleidingen
Bij de aanleg van de verbindingsleidingen van de centrale hub naar de platforms gaat in totaal 2,43 ha aan zeebodem verloren (800 m x 40 cm + 24 km x 50 cm + 24 km x 50 cm).

Platforms en eindpunt
Voor het aanpassen van platform L4-A geldt dat het verwijderen van compressie- en accommodatiemodules plaatsvindt met behulp van een jack-up of kraanschip (heavy lift vessel). De keuze voor het inzetten van een jack-up of heavy lift schip is afhankelijk van het gewicht en de grootte van de te verwijderen platform delen. Uitgaande dat er een onderstructuur (jacket) wordt geplaatst, betekent dit een tijdelijk oppervlakteverlies van 32 m^2 (2 onderstructuren x 4 poten x 4 m^2) (Tabel 6-1). Voor de realisatie van de twee nieuwe platforms K14-FA en L10-R wordt ook een jack-up barge of een kraanschip ingezet om de onderstructuur van het platform te installeren. Hierbij gaat tijdelijk een oppervlakte verloren van 32 m^2 (2 onderstructuren x 4 poten x 4 m^2). De verankeringspalen van de platforms hebben per paal een oppervlakte

van circa 4 m^2. In totaal resulteert het plaatsen van de verkankeringspalen in een semipermanent oppervlakteverlies van 32 m^2 (2 nieuwe platforms x 4 palen x 4 m^2) gedurende de periode dat het platform aanwezig is.

De jacket van het centrale eindpunt wordt aan de zeebodem verankerd. Hiervoor worden stalen buispalen gebruikt met een diameter van circa 2 meter. In totaal resulteert dit in een semipermanent oppervlakteverlies van 16 m^2 (1 eindpunt x 4 palen x 4 m^2). Door de inzet van de jack-up gaat een tijdelijk oppervlakte verloren van 16 m^2 (1 eindpunt x 4 poten x 4 m^2).

Alle hier genoemde arealen betreft een ordegrootte van het ruimtebeslag. Dit kan in de praktische uitwerking nog kan wijzigen als de definitieve cijfers komen. Hier wordt in de beoordeling rekening mee gehouden door uit te gaan van 2x het oppervlak.

Tabel 6-1. Tijdelijk en semipermanent oppervlakteverlies als gevolg van de voorgenomen activiteiten. Alle hier genoemde arealen betreft een ordegrootte van het ruimtebeslag. Dit kan in de praktische uitwerking nog kan wijzigen als de definitieve cijfers komen.

Activiteit	Tijdelijk oppervlakteverlies door jack-up barge (m^2)	Semi-permanent oppervlakteverlies door verankeringspalen (m^2)
Aanpassen platforms L4-A	32	-
Aanleg nieuwe platforms K14-FA en L10-R	32	32
Aanleg eindpunt	16	16
Totaal	80	48

Totaal oppervlakteverlies

In totaal is er maximaal sprake van 3,4 ha (direct pipe) + 42 ha + 0,02 ha + 10 ha + 2,43 ha (*totaal: 57,8 ha*) oppervlakteverlies in de Noordzee. Dat is 0,0009 % van het gehele NCP. Een deel hiervan is tijdelijk (nearshore leiding, plaatsing jack-up) en een deel hiervan is semipermanent (verankeringspalen platforms, verankeringspalen eindpunt, offshore zeeleiding).

Effectbeoordeling

Op de Noordzee is oppervlakteverlies met name relevant voor bodemdieren en vissen. Daarbij kan onderscheid gemaakt worden tussen bodemdieren die een belangrijke rol vervullen (rifvormende soorten), zeldzaam zijn of in heel specifieke delen van de Noordzee voorkomen en bodemdieren die belangrijk zijn als voedsel voor vogels en zeezoogdieren (schelpenbanken, zandspiering, e.d.). Uit paragraaf 5.1 blijkt dat de activiteit plaatsvindt in gebieden waar rifvormende soorten en zandspiering voor (kunnen) komen.

De platte oester is waargenomen op harde structuren (windparken) en er bevindt zich potentieel habitat in het noordelijke deel van de Noordzee. Dit overlapt niet of nauwelijks met de voorgenomen activiteit, waardoor wezenlijke effecten kunnen worden uitgesloten. De voorgenomen activiteit overlapt wel met het voorkomen van mosselen. In de Waddenzee komen mosselen op de bodem voor in banken, in de Noordzee komen ze echter voor op harde substraten hoger in de waterkolom, zoals monopiles, platforms en boeien en op de bodem op scheepswrakken en erosiebescherming van windturbines. Daardoor is er geen sprake van oppervlakteverlies van mossel habitat en kunnen wezenlijke effecten worden uitgesloten.

De schelpkokerworm komt relatief algemeen voor in de Noordzee en dus ook in het gebied waar de voorgenomen activiteit plaatsvindt. Het oppervlak dat verloren gaat is voor deze soort verwaarloosbaar klein, waardoor wezenlijke effecten kunnen worden uitgesloten. De zandkokerworm is veel zeldzamer op de Noordzee en komt alleen in bepaalde delen voor. De activiteiten voor Aramis worden uitgevoerd in gebieden waar (mogelijk) zandkokerwormen voorkomen. Daardoor kunnen wezenlijke effecten niet worden uitgesloten.

Over de zandspiering is relatief weinig bekend. De soort graaft zich in de zandbodem in maar kan zich ook in de waterkolom verplaatsen. Het is de verwachting dat deze soort de werkzaamheden kan vermijden, waardoor geen significante effecten zullen optreden.

Conclusie
Wezenlijke effecten van oppervlakteverlies op platte oesters, mosselen en schelpkokerwormen kunnen worden uitgesloten. Wezenlijke effecten op zandkokerwormen kunnen niet worden uitgesloten.

6.1.2 Effecten van verontreiniging

Bij het boren van de putten bij de platforms wordt Water Based Mud (WBM)-houdende boorvloeistof gebruikt. Dit is een gebiedsvreemde stof, wat bestaat uit zoet of zout water als basis vloeistof met bariet (BaSO4) of ilmeniet ($FeTiO_3$) als wegingsmiddel. Klei of organische polymeren worden toegevoegd om een homogene vloeistof te creëren. Andere chemicaliën (e.g. kalium formaat en verschillende glycolen) zorgen voor een optimale viscositeit en stabiliteit (Neff, 2005). De boorvloeistof en het boorgruis worden volgens de gangbare praktijk op zee geloosd. Het onderste deel van de putten wordt geboord met boorvloeistof op oliebasis. Deze boorvloeistof wordt afgevoerd naar land.

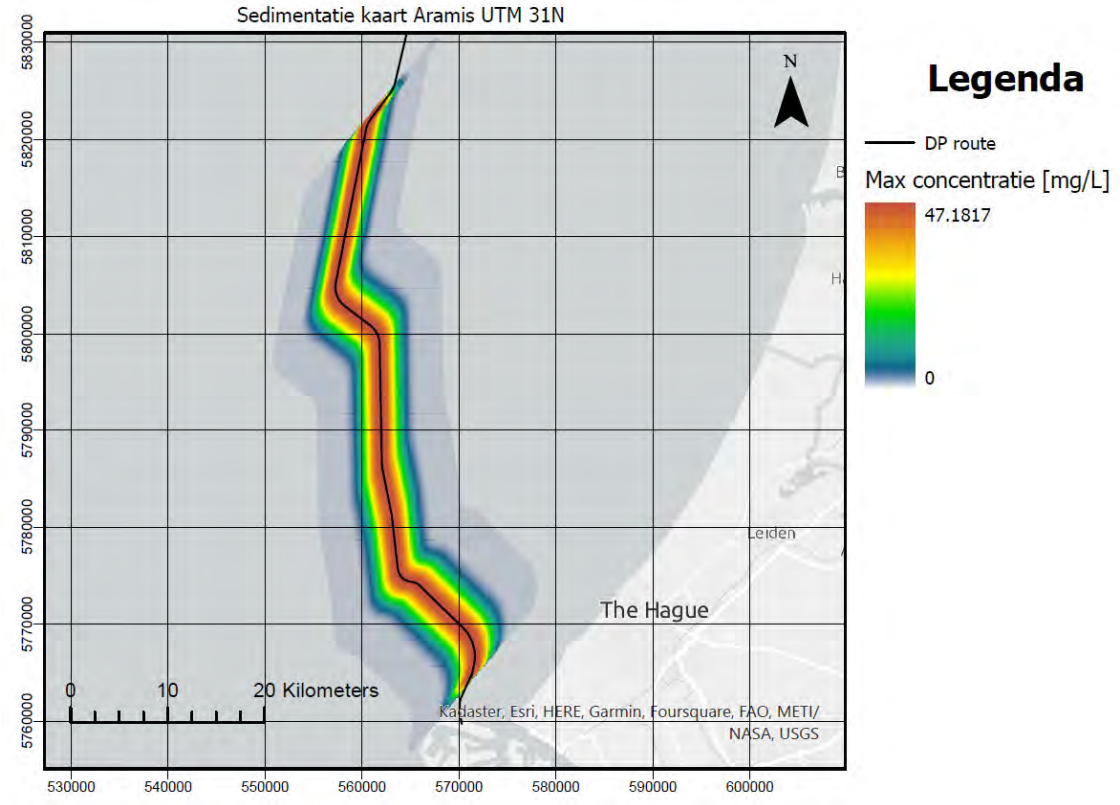
Een studie van Daan & Mulder (1993) toonde verder aan dat er 2 maanden na de lozing van WBM boorgruis (met een gewicht van circa 1.600 ton) in de buurt van platforms L3-3 en L6-3 in het Friese Front geen effecten op de benthische levensgemeenschappen optraden. Ook uit de survey die in 1992 bij L3-3 plaatsvond, één jaar na de lozing van het boorgruis, bleken er geen effecten op de benthische levensgemeenschappen, zelfs niet op een afstand van maar 25 m van het voormalige lozingspunt (Daan & Mulder, 1993a). Andere studies benoemen ook de lage acute toxiciteit van WBM, net zoals de afwezigheid van aantoonbare effecten van WBM-houdende boorvloeistof op de benthische levensgemeenschappen van sedimentrijke systemen (Park et al., 2001; Renaud et al., 2008). Mogelijke effecten van sedimentatie, als gevolg van de lozing van de boorvloeistof en het boorgruis, worden beoordeeld in de paragrafen ‘Effecten van vertroebeling/verandering dynamiek’.

Conclusie
De te lozen WBM-houdende boorvloeistof en boorgruis vormen geen risico op verontreiniging van bodemdieren. Significante effecten door verontreiniging kunnen worden uitgesloten.

6.1.3 Effecten van vertroebeling

Effecten van vertroebeling kunnen op zee ontstaan door het ingraven van de nearshore zeeleiding met een trench schip en het aftoppen van zandgolven op de Noordzeebodem.

<u>Aanleg van de zeeleiding</u>
Voor de aanleg van de nearshore zeeleiding wordt met behulp van een trencher een gleuf gegraven van maximaal 2 meter diep, 6 meter breed aan de bovenkant van de gleuf en 2 meter breed aan de onderkant van de gleuf. Het gaat om de eerste 70 kilometer vanaf de kruising met de Maasgeul waar de zeeleiding wordt ingegraven in de zeebodem, met een dekking van circa 1 meter. Door het ingraven van de nearshore zeeleiding kan sediment opwervelen, waardoor de troebelheid in de waterkolom toeneemt tot een maximale zwevende stof concentratie van 47,2 mg/L in de waterkolom (Figuur 6-1). De maximum concentratie treedt op langs de nearshore zeeleiding. Dit komt voornamelijk door het fijnere sediment; de grovere deeltjes slaan snel neer op de bodem. De concentraties verder van de zeeleiding zijn een stuk lager. Bovendien liggen de zwevend stof concentraties binnen de bandbreedte van de achtergrondconcentratie in de Noordzee (3-100 mg/L) (Suijlen & Duin, 2002).

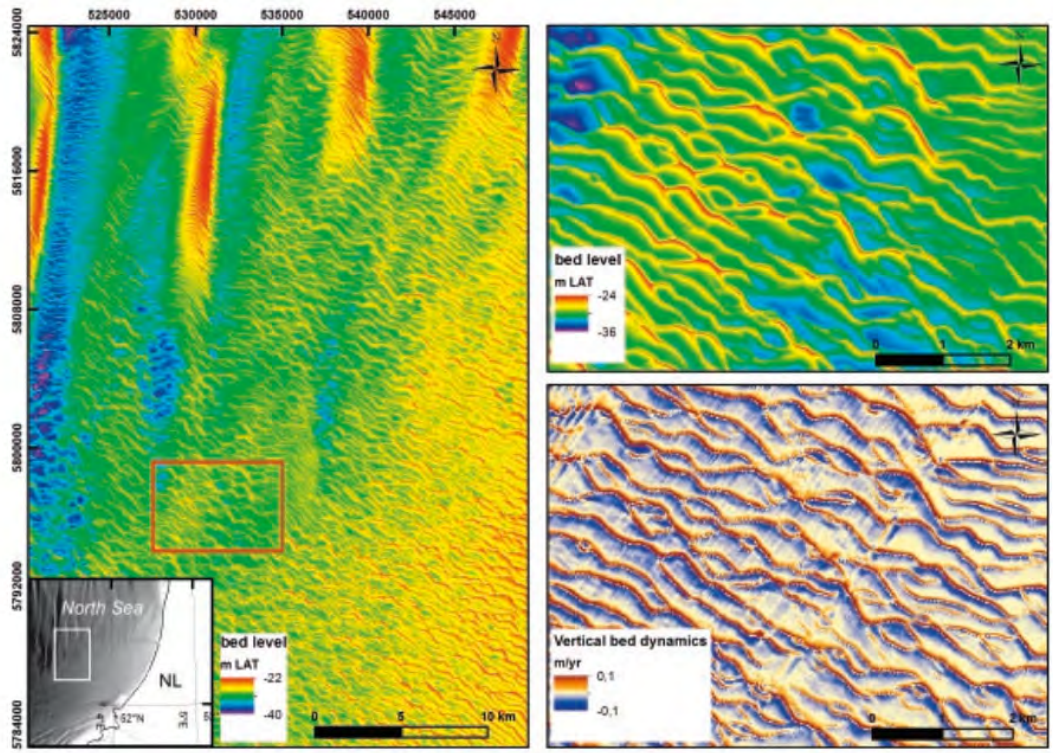


Figuur 6-1. Maximum opgetreden concentraties langs het tracé van de zeeleiding.

Bij de aanleg van de zeeleiding is er sprake van een toename van de troebelheid van maximaal 47 mg/L. Deze toename in troebelheid valt binnen de natuurlijke bandbreedte en is tijdelijk, waardoor geen significante afname van bodemdieren en vissen wordt verwacht.

Aftoppen van zandgolven

De beoogde locatie voor de zeeleiding doorkruist ook een aantal zandgolven op de Noordzeebodem (Figuur 6-2). Zandgolven ontstaan in los zand op de bodem van ondiepe zeeën. Door de getijstroming wordt dit losse zand verplaatst en ontstaan golfpatronen. Deze patronen verstoren de getijstroming, waardoor nog meer zand de helling op wordt gestuwd. Zandgolven kunnen kilometerslang en tientallen meters hoog zijn, met een afstand tussen de zandgolven van circa 5-10 km (Knaapen, 2009). Vóór het ingraven van de zeeleiding zal op sommige locaties de zeebodem worden geëgaliseerd met behulp van een sleephopperzuiger. Een deel van het gebaggerde materiaal zal terug worden gestort op de locatie waar wordt gebaggerd, wat tot vertroebeling kan leiden. Het overige materiaal wordt gestort op vergunde stortplaatsen van Rijkswaterstaat. Het zogenoemde ‘aftoppen van zandgolven’ kan mogelijk effect hebben op het ecosysteem door vertroebeling. Het aftoppen vindt plaats in een zandige omgeving, waardoor de sedimentpluim zeer tijdelijk van aard is doordat het zand snel weer neerslaat. Wezenlijke effecten op bodemdieren, vissen en zeezoogdieren zijn niet aan de orde.



Figuur 6-2. Verticale bodemdynamiek in het centrale deel van het Nederlands Continentaal Plat. Afbeelding B en C zijn een ingezoomde versie van het rode vlak in afbeelding A (van Dijk, 2016).

Boren van putten – lozen van boorvloeistof

Bij het boren van putten komen boorgruis en boorvloeistof vrij. De boorvloeistof en het boorgruis op waterbasis worden volgens de gangbare praktijk op zee geloosd. Het onderste deel van de putten wordt geboord met boorvloeistof op oliebasis. Deze boorvloeistof wordt afgevoerd naar land. Voor vertroebeling is met name het lozen van boorvloeistof relevant. Wat betreft de lozingen op zee gaat het om circa 7.909 ton waterbasis boorvloeistof dat wordt geloosd bij de putten van platform K14-FA. Bij de putten van platform L10-R wordt circa 21.000 ton waterbasis boorvloeistof geloosd. Bij platform L4-A gaat het om circa 1.900 ton waterbasis boorvloeistof.

Uit een modelstudie van de lozing van boorvloeistof van 12 putten bij platform N05-A (Royal HaskoningDHV, 2020) blijkt dat bij één boring de maximale toename in slibconcentratie ten opzichte van een achtergrondconcentratie van 5-20 mg/l bij het boorplatform circa 12 mg/l is op een afstand van 5 km van het boorplatform. Het slib in de waterkolom verplaatst zich na de lozing en slaat uiteindelijk neer op de bodem. Berekend is dat de toename in de slibconcentratie na afloop van een boring 0 mg/l bedraagt in de omgeving van het boorplatform. De verwachting is dat na de boring van de putten bij de Aramis platforms de zwevende stof concentratie in de waterkolom weer relatief snel terugkeert naar de achtergrondconcentratie.

Tweekleppigen zijn, vanwege hun aanpassingsmechanismen, in het algemeen vrij tolerant voor vertroebeling. Toch kunnen ze een effect ondervinden door blootstelling aan vertroebeling. Effecten zijn onder andere vermindering van voedselactiviteit en respiratie en verhoging van de pseudofaecesproductie en energieverbruik (Wilber & Clarke, 2001). Dichter bij de zeebodem is de slibconcentratie hoger. Volgens Rozemeijer en Graafland (2007) beginnen de eerste effecten op larven van tweekleppigen bij 400 mg/l chronische belasting. Voor adulte tweekleppigen is dat bij 2000 mg/l chronische belasting. Rozemeijer & Graafland (2007) adviseren om een veilige norm van 150 mg/l aan te houden. Die wordt slechts af en toe overschreden onder stormcondities, als een natuurlijk aspect. Een randvoorwaarde voor een gezonde oesterbank is een laag (<90 mg/l) zwevend stofgehalte (Smaal et al., 2017; Kamermans et al., 2018). Kortdurende vertroebeling en verhoging van sedimentatie zal naar verwachting geen groot effect hebben op een platte oesterbank en de bijbehorende soorten (Perry & Tyler-Walters, 2016). Er zijn geen

aanwijzingen dat de zandkokerworm gevoelig is voor een toename van de vertroebeling, in tegenstelling tot sedimentatie en vernietiging (OSPAR, 2013).

Effecten van een toename van vertroebeling op de zandspiering zijn niet bekend. De soort leeft een deel van de tijd ingegraven in de bodem, waardoor verwacht kan worden dat ze weinig last hebben van vertroebeling.

Bij een maximale verhoging van 12 mg/l per boring en de achtergrondconcentratie van 20 mg/l ontstaat een concentratie van 32 mg/l, wat ruim onder de maximale concentratie van 150 mg/l voor bodemdieren. Bij het Aramis project is er sprake van 12 – 14 boringen in totaal. Wanneer de putten achter elkaar worden geboord is er sprake van een lange periode met lozingen en dus een toename van 12 mg/L. Wanneer meerdere putten tegelijk worden geboord is er mogelijk sprake van een grotere toename. Hoe groot die toename zal zijn is niet bekend en op welke manier de pluim zich zal verplaatsen is ook niet bekend. Aangezien de platte oester relatief gevoelig is voor een hoge vertroebeling (optimum <90 mg/L) kan niet worden uitgesloten dat er effecten optreden in de omgeving van de platforms waar mogelijk of potentieel oesterbanken kunnen voorkomen (Friese Front). Wanneer de cumulatieve toename van vertroebeling niet hoger wordt dan 150 mg/L zijn effecten op andere soorten niet te verwachten.

Conclusie
Effecten als gevolg van vertroebeling door de baggerwerkzaamheden en het aftoppen van zandgolven vinden plaats in een zandige omgeving en zijn van tijdelijke aard en lokaal, waardoor wezenlijke negatieve effecten van vertroebeling op relevante soorten kunnen worden uitgesloten. Met betrekking tot het lozen van boorvloeistof kunnen negatieve effecten op de platte oester niet helemaal worden uitgesloten.

6.1.4 Effecten van verandering dynamiek

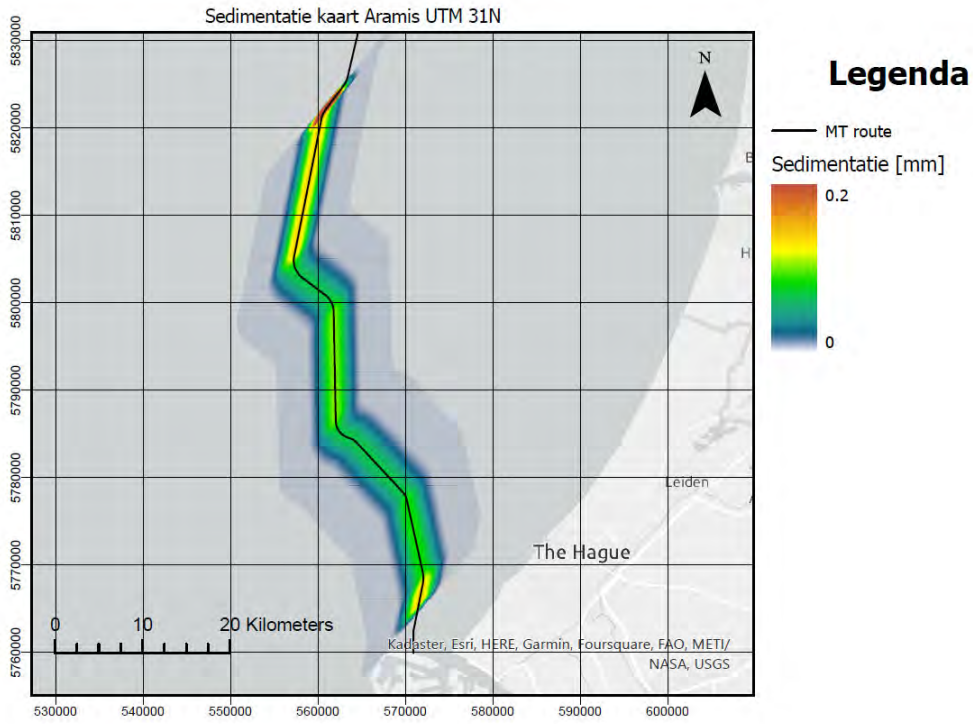
Voor de aanleg van de zeeleiding zal (deels) worden gebaggerd. Het zand afkomstig van baggeren wordt op locatie gestort en zal sedimenteren op de zeebodem, waardoor het bodemleven wordt bedekt. De meeste benthische soorten komen voor in de bovenste 10 cm van de zeebodem en zijn gebaat bij een connectie met het water, onder andere voor de uitwisseling van zuurstof en afvalstoffen en het verkrijgen van voedsel (Miller et al., 2002). Wanneer er sprake is van bedekking door sedimentatie zorgt dit voor een extra laag sediment op de zeebodem, wat de connectie met de oppervlakte kan verhinderen. Afhankelijk van de dikte van de sedimentatie-laag zal dit effect hebben op de verschillende benthische soorten. Is de laag te dik dan kan dit leiden tot sterfte van het bodemleven (Rozemeijer & Smith, 2017).

Het Detailrapport Zeebodem beschrijft de morfologie bij de kruising van de Maasgeul en de verschillende leidingtracés (RHDHV, 2023b).

<u>Aanleg zeeleiding</u>

Alternatief 1: Microtunnel
Figuur 6-3 toont het ruimtelijk beeld voor sedimentatie van het fijne sediment bij het alternatief van de zeeleiding met microtunneling. Het aandeel fijn sediment is laag (9,5%) en de hoeveelheid sediment die in suspensie is gebracht is klein ten opzichte van het gebied waarover dit is verspreid. De maximum sedimentatie waardes blijven daarom ook laag (0,20 mm). Waar het trench schip in dezelfde richting baggert als de stroomrichting, vindt de meeste sedimentatie plaats (maximaal 0,20 mm). Uit Figuur 6-3 blijkt dat sedimentatie vooral plaatsvindt bij de doorkruising van de Maasgeul en het noordelijke deel van de aan te leggen nearshore zeeleiding (gelegen op 5-70 km van de Tweede Maasvlakte). De activiteiten voor microtunneling nemen circa 14 dagen in beslag. De aanleg van de gehele zeeleiding 312 dagen.

Figuur 6-3 toont slechts het fijne sediment en niet het grotere aandeel zand dat binnen tien meter van de zeeleiding neerslaat.

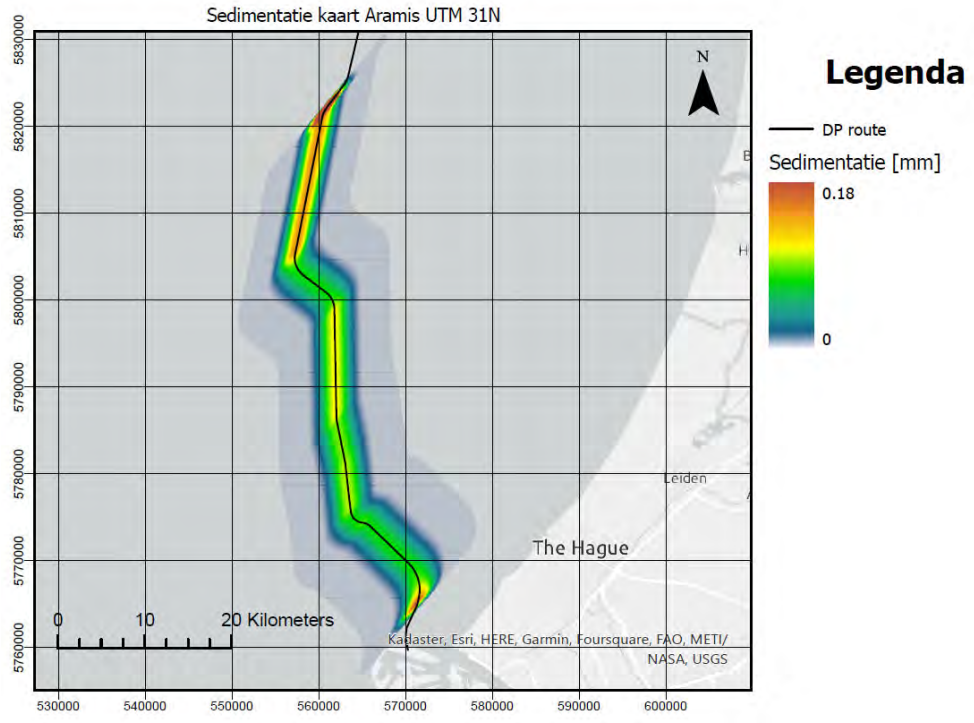


Figuur 6-3. Kaart van de sedimentatie waardes voor het alternatief met Microtunneling (MT) route.

Alternatief 2: Direct piping

Figuur 6-4 toont het ruimtelijk beeld voor sedimentatie van het fijne sediment bij de aanleg van de zeeleiding alternatief directpiping. Het aandeel fijn sediment is laag (9,5%) en de hoeveelheid sediment die in suspensie is gebracht is klein ten opzichte van het gebied waarover dit is verspreid. De maximum sedimentatie waardes blijven daarom ook laag (0,18 mm). Sedimentatie waardes zijn vergelijkbaar met het alternatief microtunneling.

Waar het trench schip in dezelfde richting baggert als de stroomrichting, vindt de meeste sedimentatie plaats (maximaal 0,18 mm). Uit Figuur 6-4 blijkt dat sedimentaties waardes het hoogst zijn bij de doorkruising van de Maasgeul en het noordelijke deel van de aan te leggen nearshore zeeleiding (gelegen op 5-70 km van de Tweede Maasvlakte). In vergelijking met het alternatief microtunneling vindt er bij het alternatief direct piping meer sedimentatie plaats op deze locaties langs het tracé. De verhoogde sedimentatie waardes bij de doorkruising van de Maasgeul kunnen worden verklaard doordat er wordt gebaggerd. De activiteiten voor direct piping nemen circa 47 dagen in beslag. De aanleg van de gehele zeeleiding 312 dagen.



Figuur 6-4. Kaart van de sedimentatie waardes voor de Direct piping (DP) route.

Uit de studie naar vertroebeling en bodemberoering (RHDHV, Achtergrondrapportage morfologie, 2023) komt naar voren dat sedimentatie als gevolg van de doorkruising van de Maasgeul minimaal is (maximaal 0,20 mm). In Rozemeijer & Smith (2017) wordt een overzicht gegeven van de sedimentdiktes waarbij bodemdieren sterven. Dit verschilt per soort, de ene soort is gevoeliger voor bedekking dan de andere. Er wordt een range van 1,5 – 15 cm genoemd, waarbij wordt aangegeven dat de meeste tweekleppige schelpdieren een sedimentlaag van 10 cm kunnen overleven. Bedekking met sediment van 0,20 mm heeft geen effect op bodemdieren.

Afweging alternatieven
Sedimentatie door direct piping is iets hoger dan voor microtunneling door de baggerwerkzaamheden, daarnaast is de uitvoeringsduur bij direct piping langer.

Conclusie
Effecten van sedimentatie door de microtunnel en direct pipe op bodemdieren in de Noordzee zijn verwaarloosbaar. Microtunneling vormt het voorkeursalternatief. Vanuit ecologisch perspectief zou dit alternatief ook de voorkeur hebben door de beperktere impact van de maatregel ten opzichte van direct piping wat betreft het volume vrijkomend baggermateriaal en de duur van de werkzaamheden.

<u>Boren van putten – lozen van boorgruis</u>
Een toename in sedimentatie van de zeebodem kan ontstaan door het sedimenteren van zwevende stof als gevolg van de lozing van boorgruis bij de platforms. Wat betreft de lozingen op zee gaat het om circa 10.371 ton waterbasisboorgruis dat wordt geloosd bij de putten van platform K14-FA. Bij de putten van platform L10-R wordt circa 12.000 ton waterbasisboorgruis geloosd. Bij platform L4A gaat het om 1.900 ton waterbasisboorgruis.

Uit van een modelstudie van de lozing van boorgruis van 12 putten bij platform N05-A (Royal HaskoningDHV, 2020) bleek dat het meeste sediment van het boorgruis direct zou vallen onder het boorplatform op de zeebodem door de grove korrelgrootte, waarbij een laag van maximaal 23 cm per boring zou ontstaan. Het fijnere boorgruis zou door de eb- en vloedbeweging over een groter gebied worden verspreid. Binnen een straal van 90 m rondom de boorlocatie zou de extra sedimentatie per boring groter

zijn dan 1,5 cm in een worst case-situatie. Dit sediment zou, afhankelijk van het aantal zware stormen, maanden tot jaren na de boorwerkzaamheden nog aanwezig zijn nabij de platformlocatie. Bij twaalf boringen zou de extra sedimentatie binnen een straal van 105 m rond het platform groter dan 1,5 cm zijn. Daarbuiten zou geen tot een verwaarloosbaar kleine hoeveelheid extra sedimentatie zichtbaar zijn. Bij het Aramis initiatief zijn de lozingen verspreid over 3 platforms, wat betekent dat het totale oppervlak dat wordt beïnvloed groter is (afhankelijk van de timing van de verschillende boringen) en dat de dikte van de laag waarschijnlijk kleiner is.

In Rozemeijer & Smith (2017) wordt een overzicht gegeven van de sedimentdiktes waarbij bodemdieren sterven. Dit verschilt per soort, de ene soort is gevoeliger voor bedekking dan de andere. Er wordt een range van 1,5 – 15 cm genoemd, waarbij wordt aangegeven dat de meeste tweekleppige schelpdieren een sedimentlaag van 10 cm kunnen overleven. Het is niet de verachting dat een groot oppervlak zal worden bedekt met meer dan 1,5 cm sediment, waardoor effecten op de meeste soorten kunnen worden uitgesloten. In OSPAR (2013) is aangegeven dat zandkokerwormen gevoelig zijn voor bedekking met sediment, hier is echter geen dikte van de laag genoemd. Effecten op deze soort kunnen daarom niet worden uitgesloten.

Conclusie
Effecten van sedimentatie op bodemdieren in het algemeen kunnen worden uitgesloten, wezenlijke negatieve effecten op zandkokerwormen kunnen niet worden uitgesloten.

6.1.5 Effecten van onderwatergeluid

Continu geluid
Voor de aanleg van de (nearshore) zeeleiding en verbindingsleidingen en de aanleg van de microtunnel/ direct pipe worden bagger-, pijpleg- en trenchschepen ingezet. Voor de aanleg van de platformen wordt er een heavy lift vessel gebruikt en de putten worden geboord. Daarnaast zal er sprake zijn van machinegeluid. Bij al deze activiteiten komt continu onderwatergeluid vrij. Zeezoogdieren als bruinvissen en zeehonden zijn gevoelig voor het onderwatergeluid dat bij deze activiteiten vrijkomt. Zij foerageren en communiceren voor een belangrijk deel door middel van geluid. Door het geluid dat bij de activiteiten vrijkomt, kan verstoring van het foerageren en communiceren optreden (bv. masking). *Masking* kan leiden tot gedragsverandering en vindt plaats wanneer een hard geluid een zachter geluid overstemt of wanneer achtergrondgeluid dezelfde frequentie heeft als geluidssignalen van zeezoogdieren. *Masking* is vooral een probleem als onderwatergeluid een soortgelijke frequentie heeft als de van biologisch belangrijke signalen, zoals bij onderlinge communicatie of benodigd bij foerageren.

Impulsgeluid
Daarnaast is er bij een aantal activiteiten sprake van impulsgeluid door de heiwerkzaamheden van de conductorpijpen en de verankeringspalen van de platforms. Impulsgeluid kan mogelijk fysieke of fysiologische effecten veroorzaken, bestaande uit tijdelijke- of permanente gehoordrempelverschuiving en in het ergste geval verwondingen. Hoe dichter zeezoogdieren zich bevinden bij de geluidsbron, hoe groter de verstoring zal zijn, waarbij permanente gehoorschade (PTS) het meest ingrijpende effect is, daarna tijdelijke gehoordrempelverschuiving (TTS) en vermijding en gedragsverandering.

Geluidsberekeningen
De te verwachten geluidsniveaus voor de activiteiten die binnen het Aramis initiatief plaatsvinden zijn bepaald in Detailrapport Onderwatergeluid (RHDHV, 2023a). Grotendeels is hierin gebruik gemaakt van berekeningen van TNO en internationaal geaccepteerde drempelwaarden van NOAA. Er is rekening gehouden met de waterdiepte en de uitbreiding en de frequentie van geluid. De overige omgevingsparameters, zoals bodem en wateroppervlak waar geluid wordt verstrooid en geabsorbeerd, zijn niet in de berekeningen betrokken omdat hiervoor geen gevalideerde rekenprogrammatuur beschikbaar is. De rekenresultaten, bijvoorbeeld in de vorm van afstanden, zijn daarmee indicatief van karakter. De drempels 'PTS SEL' betreffen ongewogen waarden, in de veilige afstand en de veilige verblijfstijd is bij bruinvissen en zeehonden een (M-)weging toegepast. Uit Tabel 6-2 blijkt dat de afstand waarop er mogelijk sprake is van PTS heel klein is (veilige afstand) voor pijpleggen en baggeren. Bruinvissen en zeehonden zullen niet zo dicht bij het schip komen dat er sprake kan zijn van PTS. Voor het heien van de aanlegsteigers is deze afstand groter. Bij het heien in de haven, verlaat weinig geluid de haven vanwege het besloten karakter. De genoemde afstand is dus theoretisch en komt niet overeen met de werkelijkheid. Daarnaast

zal er gebruik gemaakt wordt van een soft start, waardoor bruinvissen op tijd de haven verlaten. Er is daardoor geen sprake van PTS. Geluidseffecten van de booractiviteiten ten behoeve van de aanleg van de microtunnel/ direct pipe zijn niet beoordeeld; er zal geen contact zijn tussen de boormachines en het water waardoor effecten van onderwatergeluid kunnen worden uitgesloten.

Voor het bepalen en beoordelen van eventuele effecten van heiwerk op zeezoogdieren in de Noordzee sluiten we aan bij het Kader Ecologie en Cumulatie (KEC). In Tabel 6-2 betreft dat de drie laatstgenoemde geluidbronnen. De bijbehorende gepresenteerde mijdingsafstand is gebaseerd op een geluiddosis (SEL_{SS}) en niet op een geluiddrukniveau (SPL), zoals wordt gebruikt voor geluidbronnen die continu van karakter zijn. Verder is PTS in de berekeningen rond KEC niet relevant. Om deze redenen bevat Tabel 6-2 niet voor alle geluidbronnen gegevens over het aspect PTS en mijding uitgedrukt in SPL.

Tabel 6-2. Overzicht berekende effecten PTS en mijding zeezoogdieren en vissen.

Geluidbron	Diersoort	Drempel PTS SEL in dB re 1 µPa2s	Veilige afstand (m) voor PTS bij verblijf van 3 uur	Drempel mijding SPL in dB re 1 µPa bij verhoogd achtergrondgeluid	Mijding op afstand in m mits verhoogd achtergrondgeluid
Pijpleggen	Bruinvis	173	<10	130	<10
	Zeehond	201	<10	130	2.300
	Vissen	207	<10	150	n.v.t.
Aanleg verbindingsleiding(en) voor de spurlines	Bruinvis	173	<10	130	<10
	Zeehond	201	<10	130	2.300
	Vissen	207	<10	150	n.v.t.
Baggeren	Bruinvis	173	<10	130	<10
	Zeehond	201	<10	130	2.300
Heavy lift schip	Bruinvis	173	<10	130	<10
	Zeehond	201	<10	130	2.300
Injectieputten boren	Bruinvis	173	<100	130	10.000
	Zeehond	201	<100	130	10.000
Machinegeluid (gerelateerd aan werkzaamheden platform)	Bruinvis	173	<100	130	10.000
	Zeehond	201	<100	130	10.000
	Vissen	207	<100	150	n.v.t.
Aanlegsteigers heien	Bruinvis	155	3.000	-	3.300 (Verstoringsoppervlak in haven: 9 km²)
	Zeehond	185	1.350	-	3.300 (Verstoringsoppervlak in haven: 9 km²)
Verankeringspalen nieuwe platforms	Bruinvis	-	-	-	13.934
	Zeehond	-	-	-	8.574
Conductorpijpen nieuwe putten	Bruinvis	-	-	-	5.500
	Zeehond	-	-	-	4.100
Heien centrale eindpunt	Bruinvis	-	-	-	13.938
	Zeehond	-	-	-	8.577

Er is geen sprake van gehoorschade (PTS) maar er is wel sprake van verstoring door het onderwatergeluid doordat zeezoogdieren wegzwemmen van het geluid. In Tabel 6-2 zijn de afstanden opgenomen waarop bruinvissen en zeehonden de geluidsbron mijden. De verstoringsafstand voor zeehond bij het pijpleggen en baggeren is hoog ten opzichte van de afstand voor de bruinvis. Dit komt doordat er frequentieweging is toegepast in de berekeningen. Zeehonden zijn gevoeliger voor lage frequenties dan bruinvissen en bij schepen is er met name sprake van lage frequenties.

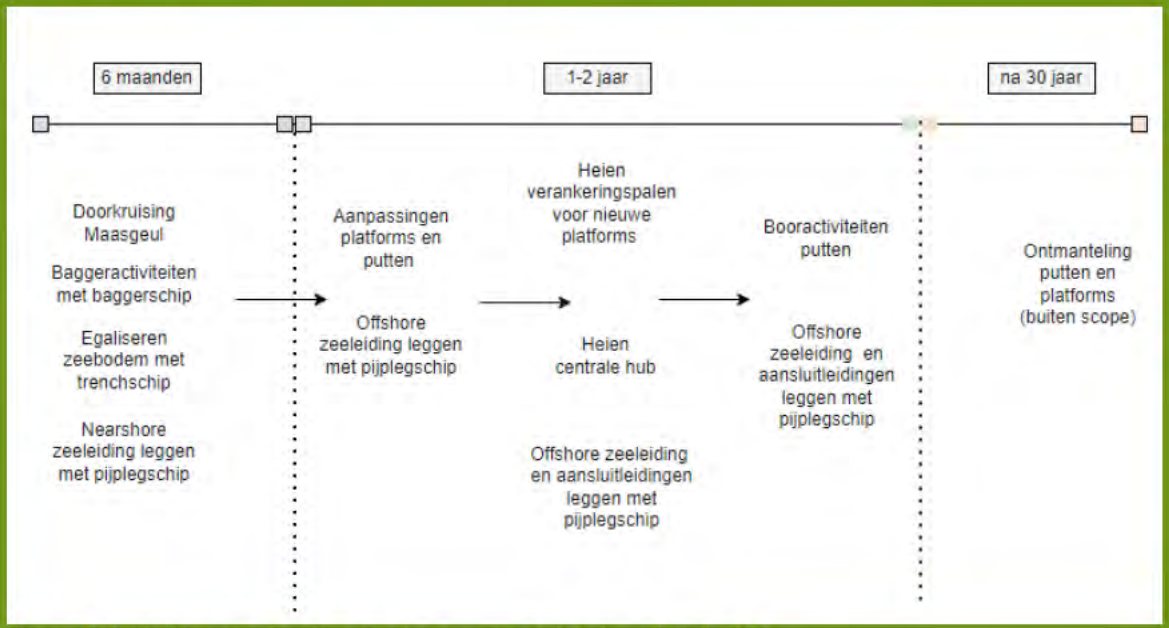
Om de effecten van de activiteiten te beoordelen, dient ook rekening gehouden te worden met welke activiteiten tegelijkertijd, of vlak na elkaar plaatsvinden. Uit Kader 2 blijkt dat voornamelijk de boor- en heiactiviteiten en de activiteiten ten behoeve van de aanleg van de offshore zeeleiding mogelijk na elkaar wordt uitgevoerd. Boren en heien kunnen worden gezien als de twee geluidsbronnen die het meeste bijdragen aan de toename in onderwatergeluid. Als deze activiteiten tegelijk of kort na elkaar plaatsvinden kan dit resulteren in een grotere verstoring.

Kader 2. Tijdlijn voorgenomen activiteiten

Voor het bepalen van mogelijke effecten van onderwatergeluid dient te worden bepaald welke activiteiten tegelijkertijd, vlak na elkaar of enige jaren later worden uitgevoerd. De logistieke planning voor de uitvoering van de voorgenomen activiteiten is echter nog niet bekend. Wel kan worden aangenomen dat er een bepaalde volgorde van activiteiten zal plaatsvinden, zoals weergegeven in Figuur A. In de eerste fase vinden activiteiten plaats ten behoeve van de aanleg van de nearshore zeeleiding en de doorkruising van de Maasgeul (microtunneling of direct piping). Vóór de aanleg van de nearshore zeeleiding wordt de bodem met een baggerschip waar nodig geëgaliseerd. Tezamen nemen deze activiteiten maximaal een half jaar in beslag.

De tweede fase bestaat uit de aanleg van de offshore zeeleiding en de boor- en hei activiteiten voor de putten en de platforms. Het heien van de conductors van de putten vindt altijd plaats na het heien van de palen van het platform. In theorie zou het heien van de conductors van de putten tegelijkertijd met het heien van de palen van een platform op een andere locatie kunnen plaatsvinden. Die kans is echter extreem klein. De kans dat heien van verankeringspalen voor de nieuwe platforms/centrale hub tegelijkertijd plaatsvindt is ook verwaarloosbaar. Eventueel vindt het heien van de drie platforms met een tussentijd van een week plaats (1 installatie schip installeert drie platforms in 1 campagne).

De putten worden mogelijk met één en hetzelfde boorschip geboord, wat betekent dat in dat geval de booractiviteiten kort na elkaar zullen plaatsvinden. Na circa 30 jaar wordt de ontmanteling van de platforms en putten in gang gezet. Deze activiteit is echter geen onderdeel van de effectbeoordeling.

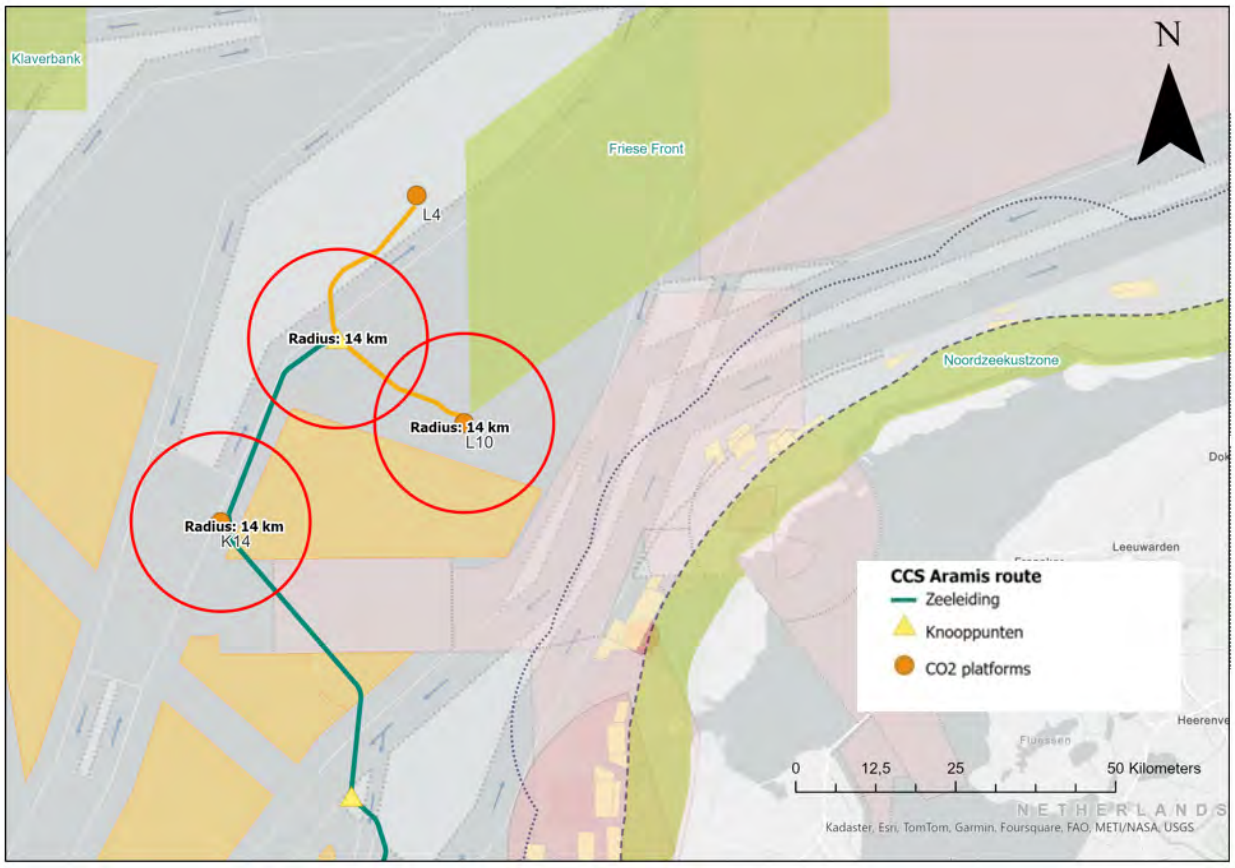


Figuur A. Indicatie van volgorde van voorgenomen activiteiten Aramis CCS.

De activiteiten met de hoogste geluidsverstoring zijn een combinatie van continu onderwatergeluid en impulsgeluid. Dit maakt de beoordeling complex omdat de verschillende vormen van geluidsverspreiding

anders beoordeeld worden en er alleen een kwantitatieve beoordelingsmethodiek voor impulsgeluid beschikbaar is. Voor de bruinvis, gewone zeehond en grijze zeehond wordt in de volgende paragrafen nader ingegaan op de beoordeling.

Figuur 6-5 geeft een overzicht van de vermijdingscontouren voor bruinvissen bij het heien van de verankeringspalen van het platform.



Figuur 6-5. Maximale vermijdingscontouren (radius; 14 km gebaseerd op de 140 dB contour (worst case situatie)) voor de bruinvis bij het plaatsen van de verankeringspalen van de platforms en de afstanden tussen de vermijdingscontouren bij het gelijktijdig plaatsvinden van heiactiviteiten.

Effectbeoordeling bruinvis

Omdat zeezoogdieren zoals bruinvissen mobiel zijn en zich verplaatsen binnen én buiten diverse Natura 2000-gebieden, worden effecten van onderwatergeluid op de gehele populatie in de Noordzee beoordeeld. Daarnaast zal in de volgende paragrafen in worden gegaan op het effect op de instandhoudingsdoelstellingen van specifieke Natura 2000-gebieden.

Het aantal mogelijk verstoorde bruinvissen wordt berekend door het verstoringsoppervlak te vermenigvuldigen met de lokale bruinvisdichtheid. Op basis van de locaties waar de activiteiten plaatsvinden, is een lokale bruinvisdichtheid per km^2 bepaald Tabel 6-3). Dichtheden zijn nader toegelicht in Paragraaf 5.4.2 van deze beoordeling. Door deze dichtheden te vermenigvuldigen met het berekende verstoringsoppervlak, volgen schattingen van het aantal mogelijk verstoorde bruinvissen per dag dat de activiteiten worden uitgevoerd.

Om te kunnen bepalen hoe groot het effect is van verstoring op de populatie in de Nederlandse Noordzee wordt het aantal bruinvisverstoringsdagen berekend. Het totale aantal bruinvisverstoringsdagen (Heinis et al., 2022) wordt berekend door het aantal verstoorde dieren (Tabel 6-3) per dag te vermenigvuldigen met het aantal verstoringsdagen. Daarnaast duurt het ongeveer één dag voordat bruinvissen weer terugkeren

na het stoppen van het heien (TNO, 2015). Op basis hiervan wordt er in totaal uitgegaan van de verstoringsdagen te zien in Tabel 6-3.

Volgens het KEC (Heinis et al., 2022) kan een schatting van een maximale populatiereductie, die met een 95% zekerheid niet zal worden overschreden, worden bepaald met behulp van de volgende benaderingsformule:

$$Populatiereductie = 1{,}06\ x\ 10^{-4}\ x\ bvvd^{1{,}17}$$

De populatiereductie is daarbij uitgedrukt in het aantal individuen en $bvvd$ staat voor het aantal bruinvisverstoringsdagen. In het KEC wordt ook een kanttekening geplaatst bij het berekenen van de populatiereductie, aangezien berekeningen met het Interim Population Consequences of Disturbance (iPCoD) model (Harwood et al., 2014) een grote onzekerheid met zich meebrengen (zie tekstkader hieronder). Toch is hier een berekening uitgevoerd op basis van de verstoringscontouren voor het heien, om een beeld te geven van de mogelijke effecten. Bovenstaande formule is alleen toe te passen op impulsgeluid, de effecten van continu geluid op de populatie kan niet met de iPCoD formule worden berekend.

Kritische noot bij de rekenmethodiek voor populatie-effecten (pers. comm. Heinis, 2022)

Tijdens het berekenen van de effecten op de populatie bleek dat de formule niet direct geschikt is om toe te passen op activiteiten anders dan het plaatsen van windturbines (monopiles). De heiwerkzaamheden voor dit project worden in minder dan een dag uitgevoerd, maar ook bij een lagere hei-energie in vergelijking tot de plaatsing van monopiles. Dit inzicht leidde tot de conclusie dat het effect op de populatie, zoals het nu wordt berekend, mogelijk niet representatief is voor het Aramis initiatief. Daarnaast is de gebruikte formule gebaseerd op aannames met betrekking tot een stabiele populatie en moet voor correct gebruik van het model een kwetsbare subpopulatie worden gedefinieerd, waarvan de gegevens nog niet beschikbaar zijn (Heinis et al., 2022, bijlage F). Op het moment van schrijven is er nog geen maatwerkaanpak ontwikkeld om de populatiereductie te beoordelen. Deze aanpak zal worden geadviseerd in het proces van verdere vergunningaanvraag.

De populatiereductie kan niet worden toegeschreven aan directe mortaliteit ten gevolge van het onderwatergeluid van de werkzaamheden. De benaderingsformule is afgeleid uit resultaten van berekeningen met het Interim Population Consequences of Disturbance (iPCoD) model (Harwood et al., 2014), waarin de populatiereductie indirect volgt uit de invloed van langdurige geluidsverstoring op 'vital rates' van de bruinvissen, met name de kans op reproductie en de overlevingskans van jonge dieren. Daarbij gaat het om de verstoring die optreedt als gevolg van de werkzaamheden.

Op basis van de iPCOD formule is berekend dat voor de verschillende activiteiten van het Aramis initiatief een range van 10.665-18.016 bruinvisverstoringsdagen oplevert, wat resulteert in een populatiereductie van 4,5-8,4 bruinvissen (Tabel 6-3). In Kader 2 wordt de tijdlijn van de verschillende activiteiten die plaatsvinden weergegeven. In de berekening wordt uitgegaan van de worst case situatie dat activiteiten met effecten op onderwatergeluid vlak na elkaar plaatsvinden, waardoor mogelijk tussentijds herstel van de populatie niet wordt verwacht.

Volgens ASCOBANS dient het door menselijke handelen veroorzaakte aantal sterfgevallen onder de 1,7% van de gehele Noordzeepopulatie te blijven (Ministerie van Economische Zaken, 2014b). Voor Nederland wordt in het KEC 4.0 een maximaal ecologisch toelaatbare reductie van 5% van de Nederlandse populatie gehanteerd, die momenteel wordt geschat op 62.771 individuen op het Nederlands Continental Plat (NCP) (Heinis et al., 2022). De populatiereductie die door alle activiteiten met impulsgeluid van het Aramis initiatief tijdens de aanlegfase in de Noordzee plaatsvinden komt neer op maximaal 0,007 tot 0,013% en valt daarmee binnen de maximaal toelaatbare reductie. Dit geldt ook als er in cumulatie met wind op zee wordt gekeken, dan is er sprake van 3,4% + 0,007/0,013%.

Tabel 6-3. Aantal bruinvisverstoringsdagen per activiteit en de totale populatiereductie van alle activiteiten met impulsgeluid opgeteld, berekend uit aantal verstoorde bruinvissen per dag maal het aantal verstoringsdagen en de iPCOD formule.

Activiteit		Aantal dagen voor activiteit	Aantal verstorings-dagen	Verstoord oppervlak in km²	Gemiddelde dichtheid per km² o.b.v. locatie activiteit	Verstoorde dieren per dag	Aantal bruinvis-verstorings-dagen	Populatie-reductie (aantal dieren)
Heien aanlegsteigers fase 1	-	50	51	9	0,81	7,29	372	0,1
Heien aanlegsteigers fase 2	-	50	51	9	0,81	7,29	372	0,1
Heien verankeringspalen nieuwe platforms	Per platform	3	4	610	1,20 – 2,0	732 – 1.220	2.926 – 4.880	1,2 – 2,2
	Totaal [2]	6	8	610	1,20 – 2,0	732 – 1.220	5.853– 9.760	2,7 – 4,9
Heien conductorpijpen nieuwe putten	Per put	0,5	1,5	94	1,20 – 2,0	114 – 188	171 - 376	0,04 - 0,1
	Totaal [1]	7	10	94	1,20 – 2,0	114 – 188	1.140 - 2.632	0,4 - 1,1
Heien centrale eindpunt	-	3	4	610	1,20 – 2,0	732 – 1.220	2.928 – 4.880	1,2 – 2,2
Totaal	-	-	-	-	-	-	10.665 – 18.016	4,5 – 8,4

[1]: Platform K14-FA; 4-6 nieuwe injectieputten. Platform L10-R; maximaal 6 nieuwe injectieputten. Platform L4-A; 2 nieuwe injectieputten (L4-A3 en L4-A4). Worst-case; 14 nieuwe injectieputten.
[2]: In totaal 2 nieuwe platforms; (1) L10-R en (2) K14-FA.

Op basis van de populatiereductieformule, kan worden gesteld dat de wettelijke norm niet wordt overschreden en er bij uitvoering van het Aramis initiatief binnen de maximale populatiereductie richtlijnen wordt gebleven. In de Kavelbesluiten voor het offshore windpark IJmuiden Ver wordt een geluidsnorm gehanteerd van SELss 164 dB re 1µPa2s op 750 m van de heilocatie. Voor het heien van de verankeringspalen voor de platforms en het centrale eindpunt wordt deze norm overschreden met 7 dB, bij het heien van de conductors ligt het geluidsniveau precies op de norm. Het geluidsniveau van het heien van de aanlegsteigers ligt onder de genoemde norm.

Daarnaast is er geen rekening gehouden met activiteiten waarbij continu onderwatergeluid wordt verspreid, waarbij ook verstoring optreedt. Kijkende naar de werkzaamheden die rond de platforms in de Noordzee plaatsvinden, worden er circa 1 tot 2 jaar achter elkaar met een paar weken tussen de activiteiten in, intensief werkzaamheden uitgevoerd. Het is aannemelijk dat zeezoogdieren het verstoorde gebied voor langere tijd zullen mijden. Om een beeld te krijgen van de verstoring, is in Tabel 6-4 een overzicht gegeven van de verstoringsoppervlakten van zowel continu geluid als impulsgeluid op basis van de verstoringscontour van de bruinvis. Omdat de verstoring deels vanaf het platform plaatsvindt en zich concentreert op vier locaties met overlap tussen continue geluidsverstoring en impulsgeluidsverstoring, kan het totaal aantal verstoorde dieren niet berekend worden. Daarnaast zullen de werkzaamheden van het pijplegschip, het baggerschip en overige schepen een tracé door de Noordzee doorlopen wat verplaatsende verstoring oplevert.

Het feit dat op meerdere locaties in de Noordzee en verspreid over een periode van 1 tot 2 jaar met verschillende vormen van verstoring en diverse verstoringsoppervlakten wijzen uit op dat significant negatieve effecten voor de bruinvispopulatie in de Noordzee niet kunnen worden uitgesloten.

Tabel 6-4. Verstoringsoppervlakten van continu en impulsgeluid voor de bruinvis.

Activiteit	Verstoringsoppervlak voor bruinvissen in km^2
Pijpleggen	0,000314 (o.b.v. stilliggend schip)
Baggeren	0,000314 (o.b.v. stilliggend schip)
Aanpassingen platforms	314 (per platform)
Injectieputten boren	314 (per put)
Verankeringspalen nieuwe platforms	610 (per verankeringspaal)
Conductorpijpen nieuwe putten	94 (per conductorpijp)
Heien centrale eindpunt	610
Ontmanteling putten	314 (per platform)
Heavy lift schip	0,04 (o.b.v. varend schip)

Effectbeoordeling gewone zeehond en grijze zeehond

Voor het beoordelen van de effecten van onderwatergeluid op zeehonden geldt ook dat een kwantitatieve beoordeling van het aantal verstoorde dieren van alle activiteiten tezamen lastig is te maken. Er worden in totaal 12-14 putten achter elkaar geboord waaraan vooraf ook 12-14 conductorpijpen geheid worden. Daarnaast worden er op twee verschillende locaties dicht bij elkaar geheid voor de conductorpijpen ten behoeve van de nieuwe platforms, en drie injectieputten geboord. Om een beeld te krijgen van de verstoring, is in Tabel 6-5 een overzicht gegeven van de verstoringsoppervlakten van zowel continu geluid als impulsgeluid op basis van de verstoringscontour van de zeehond. De verstoring vindt deels plaats vanaf het platform en concentreert zich op vier locaties met overlap tussen continue geluidsverstoring en impulsgeluidsverstoring. Daarnaast zullen de werkzaamheden van het pijplegschip, het baggerschip en overige schepen een tracé door de Noordzee doorlopen wat verplaatsende verstoring oplevert. Daardoor is het lastig om het aantal verstoorde dieren goed te bepalen, er is wel een poging gedaan om een beeld te geven. Daarin is dus niet het gehele tracé meegenomen, ook is het aspect tijd niet meegenomen.
Tabel 6-6Tabel 6-5 geeft de percentages verstoorde dieren weer ten opzichte van de Nederlandse populatie gewone en grijze zeehonden voor de activiteiten waarvan het totale oppervlak bekend is door het aantal verankeringspalen en conductoren e.d. bij elkaar op te tellen.

De percentages geven een indicatie weer van de verstoring, maar zijn niet goed bij elkaar op te tellen. In de praktijk zijn de dichtheden op open zee lager en is het aannemelijk dat individuen meermaals worden verstoord door dezelfde of verschillende activiteiten. Ervan uitgaande dat activiteiten kort na elkaar met een aantal weken ertussen uitgevoerd gaan worden, zullen zeehonden het gebied voor een langere periode mijden. Aangezien de werkzaamheden 1 tot 2 jaar zullen duren, kan de mijdingsperiode ook oplopen tot een vergelijkbare periode.

Het gebied op open zee kan door zeehonden gebruikt worden om te foerageren. Grijze zeehonden kunnen tot ver uit de kust zoeken naar voedsel (Ministerie van Economische Zaken, 2014a). Het foerageergebied neemt door de verstoring daarom mogelijk af. Er zijn anderzijds voldoende uitwijkmogelijkheden voor gewone en grijze zeehonden om te foerageren. De nabijgelegen gebieden Noordzeekustzone en de Waddenzee zijn belangrijkere gebieden voor de gewone zeehond en grijze zeehond dan de open zee (zie Figuur 5-8 en Figuur 5-11), anders dan voor bruinvissen.

Tabel 6-5. Verstoringsoppervlak per activiteit voor de gewone en grijze zeehond.

Activiteit	Verstoringsoppervlak (km^2)	Dichtheid zeehonden (ind./ km^2)	Verstoorde dieren
Pijpleggen	17	0,5	8
Aanleg verbindingsleiding(en) voor de spurlines	17	0,5	8
Baggeren	17	0,5	8
Aanpassingen platforms (per platform)	314	0,5	157
Injectieputten boren (per put)	314	0,5	157
Plaatsen jacket en top side met heavy lift schip	131	0,5	65
Heien verankeringspalen nieuwe platforms (per verankeringspaal)	231	0,5	115
Heien conductorpijpen nieuwe putten (per put)	54	0,5	27
Heien centrale eindpunt	231	0,5	115

Tabel 6-6. Percentages verstoorde gewone en grijze zeehonden ten gevolge van de voorgenomen activiteiten.

Activiteit		Gewone zeehonden		Grijze zeehonden	
		Totale Nederlandse populatie	Verstoorde dieren (%)	Totale Nederlandse populatie	Verstoorde dieren (%)
Injectieputten boren	Per put	9.245	1,96	8.038	1,70
	Totaal [1]	9.245	27,38	8.038	23,78
Heien verankeringspalen nieuwe platforms	Per verankeringspaal	9.245	1,43	8.038	1,24
	Totaal [2]	9.245	11,46	8.038	9,95
Heien conductorpijpen nieuwe putten	Per put	9.245	0,34	8.038	0,29
	Totaal [1]	9.245	4,71	8.038	4,09
Heien centrale eindpunt	-	9.245	1,43	8.038	1,24

[1]: Platform K14-FA; 4-6 nieuwe injectieputten. Platform L10-R; maximaal 6 nieuwe injectieputten. Platform L4-A; 2 nieuwe injectieputten (L4-A3 en L4-A4). Worst-case; 12-14 nieuwe injectieputten.
[2]: In totaal 2 nieuwe platforms; (1) L10-R en (2) K14-FA.

Het gebied waar de activiteiten plaatsvinden is van minder groot belang voor de zeehonden dan de kustzone en het waddengebied (Aarts, 2021; Aarts et al., 2016), waardoor significant negatieve effecten op de Noordzeepopulatie zijn uit te sluiten. In de volgende paragrafen wordt per Natura 2000-gebied een beoordeling van de effecten gedaan. De verstoringspercentages hierboven genoemd zijn indicatief en zijn naar verwachting een overschatting omdat de dieren het gebied waarschijnlijk zullen mijden.

6.1.6 Conclusie Noordzee

Voor de Noordzee kan het volgende geconcludeerd worden:

- Wezenlijke effecten op platte oester, mossel en schelpkokerworm door oppervlakteverlies kunnen worden uitgesloten.
- Wezenlijke effecten op zandkokerwormen door oppervlakteverlies kunnen niet worden uitgesloten;

- Wezenlijke effecten op de platte oester door vertroebeling kunnen niet worden uitgesloten, op andere soorten kunnen effecten worden uitgesloten;
- Wezenlijke effecten zandkokerwormriffen door verandering dynamiek kunnen niet worden uitgesloten, effecten op andere soorten kunnen worden uitgesloten;
- Significante effecten door onderwatergeluid op bruinvissen kunnen niet worden uitgesloten;
- Significante effecten door onderwatergeluid op zeehonden kunnen worden uitgesloten.

6.1.7 Mitigerende maatregelen Noordzee

Ondanks het feit dat de zandkokerworm en platte oester als soort niet wettelijk beschermd zijn via de gebiedsbescherming van de Ow (maar wel onder OSPAR), en dus niet vallen onder het toetsingskader van deze passende beoordeling, wordt aangeraden om de volgende maatregelen uit te voeren om negatieve effecten te voorkomen:

- Bij de aanleg van de zeeleiding en het lozen van boorgruis worden zandkokerwormriffen zoveel mogelijk vermeden. Bij de detaillering van het leidingtracé wordt vastgesteld of deze voorkomen en hoe deze vermeden kunnen worden;
- Vertroebeling > 90 mg/L in het Friese Front wordt voorkomen om effecten op de platte oester te tegen te gaan.

Bruinvissen komen in de Noordzee en specifiek in meerdere Natura 2000-gebieden voor. Hierbij geldt dat er in de Natura 2000-gebieden geen significante directe effecten optreden, maar indirecte effecten door onderwatergeluid op bruinvissen kunnen niet worden uitgesloten (indirecte effecten op de gehele Noordzeepopulatie door activiteiten buiten Natura 2000-gebieden). Daarom dienen de volgende maatregelen te worden genomen:

- Bij de hei-werkzaamheden dienen geluidsbeperkende maatregelen genomen te worden (bijvoorbeeld door gebruik te maken van een HSD Systeem/bubbelscherm) of een werkwijze waarbij relatief weinig onderwatergeluid zal optreden om effecten op de populatie bruinvissen te voorkomen (het geluidsniveau moet onder de 164 dB liggen op 750 meter afstand);
- Er dient zoveel mogelijk gebruik gemaakt te worden van stille schepen om continu onderwatergeluid te minimaliseren.

6.2 Natura 2000-gebied Voordelta

De habitattypen, habitatrichtlijnsoorten en vogelrichtlijnsoorten waarvoor het Natura 2000-gebied Voordelta is aangewezen kunnen effecten ondervinden van de activiteiten rond het verzamelpunt (terminal en compressor) en de aanleg van de microtunnel/ direct pipe. De microtunnel/ direct pipe gaat door het noordoostelijke punt van de Voordelta. Hieronder wordt voor de relevante habitattypen en soorten beoordeeld of ze significante negatieve effecten ondervinden van bovengenoemde activiteiten.

6.2.1 Habitattype

Het Natura 2000-gebied Voordelta is aangewezen voor het habitattype H1110B Permanent overstroomde zandbanken, subtype Noordzeekustzone. De instandhoudingsdoelstellingen voor het habitattypen zijn behoud van oppervlakte en behoud van kwaliteit. De landelijke staat van instandhouding van habitattype H1110B is zeer ongunstig.

In de Voortoets is beoordeeld dat het habitattype H1110B mogelijk effect ondervindt van de activiteiten bij de aanleg van de microtunnel/ direct pipe. Door deze activiteiten kunnen de volgende effecten optreden: oppervlakteverlies, versnippering leefgebied, verontreiniging, vertroebeling en verandering dynamiek. De effecten van deze vier storingsfactoren worden hieronder nader beoordeeld, uit Tabel 6-7. De gevoeligheid voor verstoring door oppervlakteverlies, versnippering, verontreiniging en verandering van de dynamiek van substraat voor habitattype H1110B (Effectenindicator Ministerie LNV).blijkt dat het habitattype gevoelig is voor alle vier de verstoringsfactoren.

Tabel 6-7. De gevoeligheid voor verstoring door oppervlakteverlies, versnippering, verontreiniging en verandering van de dynamiek van substraat voor habitattype H1110B (Effectenindicator Ministerie LNV).

Habitattype	Gevoeligheid			
	Oppervlakteverlies	*Versnippering*	*Verontreiniging*	*Verandering dynamiek substraat/vertroebeling*
H1110B Permanent overstroomde zandbanken	Gevoelig	Gevoelig	Gevoelig	Gevoelig

Schaal - Gevoeligheid voor verstoring (Effectenindicator Ministerie LNV)

Niet gevoelig	Gevoelig	Zeer gevoelig

Effecten van oppervlakteverlies

Voor Natura 2000-gebied Voordelta zijn de effecten van oppervlakteverlies beoordeeld voor de eerste sectie; de doorkruising van de Maasgeul. De werkzaamheden voor de aanleg van de voorkeursvariant 'microtunneling' duren in totaal 14 dagen. De 3 meter brede microtunnel wordt aangelegd op een diepte van 20 m, over een lengte van circa 2 km. Door de ligging op diepte leidt dit niet tot oppervlakteverlies in de Voordelta.

Door de baggerwerkzaamheden bij het direct pipe alternatief is er sprake van een tijdelijk verlies van oppervlakte van circa 3,4 ha. In totaal resulteert direct pipe dus in een verlies van 3,4 ha, wat in verhouding minder dan 0,01 % is van de gehele oppervlakte van de Voordelta (80.000 ha) en dus ook van habitattype H1110 (aangezien dit bijna vlakdekkend is in de Voordelta). Het ruimtebeslag voor doorkruising van de Maasgeul zal plaatsvinden in de uiterste noordoosthoek binnen de begrenzing van het Natura 2000-gebied (Figuur 6-6). De werkzaamheden nemen in totaal 47 dagen in beslag (inclusief baggerwerkzaamheden in de Voordelta).

Tabel 6-8. Alternatieven voor de doorkruising van de zeewering en de Maasgeul en het bijbehorende volume baggermateriaal dat vrijkomt door de activiteit.

Type uitwerking voor de doorkruising van de zeewering en de Maasgeul	Lengte van het baggerwerk (m)	Volume vrijkomend baggermateriaal (m^3)	Oppervlakteverlies door aanleg (ha)
Microtunnel (voorkeursvariant)	101	2.019	0,1
Direct piping (alternatieve variant)	1.920	707.752	3,4

De Voordelta is een dynamisch gebied dat voortdurend aan verandering onderhevig is. Er vindt vaker verstoring van de bodem plaats door baggerwerkzaamheden. De benthos samenstelling bestaat uit kortlevende en snel voortplantende soorten (Craeymeersch et al., 2019). Het effect op de bodemdierengemeenschap is afhankelijk van de intensiteit, frequentie en de schaal van de bodemberoerende activiteiten. In de literatuurreview van Rippen et al., (2020) wordt geconcludeerd dat in een dynamisch gebied de herstelperiode van de benthosgemeenschap kort kan zijn (<1 jaar), maar dit kan oplopen afhankelijk van de mate van beroering. Voor kabels en leidingen wordt gesteld dat de impact op de bodemdierengemeenschap klein is, wat betekent dat de bodemsoorten zich binnen enkele maanden (wormsoorten) tot een jaar (schelpdieren) kunnen herstellen (Rippen et al., 2020). Wanneer de gleuf wordt dichtgemaakt met hetzelfde soort sediment kan de natuur zich herstellen. Het oppervlakteverlies is klein en er is sprake van een korte hersteltijd, waardoor de effecten als klein worden beoordeeld.

Conclusie H11010B
Significant negatieve effecten van oppervlakteverlies van habitattype H1110B als gevolg van de voorgenomen activiteiten in de Voordelta zijn uitgesloten.

Effecten van versnippering
De Maasgeul zal worden doorkruist door middel van de microtunnel/ direct pipe van de voorkeursvariant microtunneling of de alternatieve variant direct piping. De leiding loopt door de uiterste hoek van het Natura 2000-gebied (). De afstand die wordt afgelegd door de Voordelta is beperkt (maximaal 200 meter). Voor microtunneling en direct piping geldt dat de microtunnel/direct pipe wordt aangelegd onder de zeebodem. Er is hierdoor geen sprake van permanente versnippering van leefgebied.



Figuur 6-6. Kruising van zeeleiding door het noordelijke deel van Natura 2000-gebied de Voordelta in de rode rechthoek.

De doorkruising van het habitattype H1110B vindt alleen plaats in het noordelijke deel van de Voordelta en is zeer minimaal (maximaal 200 meter). De microtunnel/direct pipe wordt bovendien onder de zeebodem aangelegd, waardoor er geen sprake is van permanente versnippering van leefgebied. Er is wel sprake van tijdelijke versnippering bij het alternatief direct piping. Na aanleg van de microtunnel/direct pipe kunnen soorten zich weer vestigen en vindt herstel plaats. Bodemsoorten kunnen zich binnen enkele maanden (wormsoorten) tot een jaar (schelpdieren) herstellen (zie effecten van oppervlakteverlies; Rippen et al., 2020).

Conclusie H11010B
Significante effecten van versnippering op het habitattype H1110B kunnen worden uitgesloten.

Effecten van verontreiniging
Verontreiniging kan ontstaan wanneer verhoogde concentraties schadelijke stoffen in zee terechtkomen. Habitattype H1110B is gevoelig voor verontreiniging (Tabel 6-7).

Bij de werkzaamheden worden delen van de leiding onder bestaande watergangen aangelegd. Tijdens het boren wordt de tunnelboormachine voorzien van boorvloeistoffen zoals bentoniet, terwijl aan de boorkop slurry wordt afgevoerd. De slurry wordt gescheiden; water en bentoniet worden hergebruikt in het boorproces. De grond wordt met vrachtwagens naar een stortplaats gebracht. Vanwege het feit dat de boorvloeistof en het boorgruis worden afgevoerd naar land, is er geen sprake van verontreiniging in de Voordelta.

Conclusie H11010B
De boorvloeistof en boorgruis worden afgevoerd naar land en vormen daardoor geen risico op verontreiniging van de typische soorten van habitattype H1110B. Significante effecten door verontreiniging kunnen worden uitgesloten.

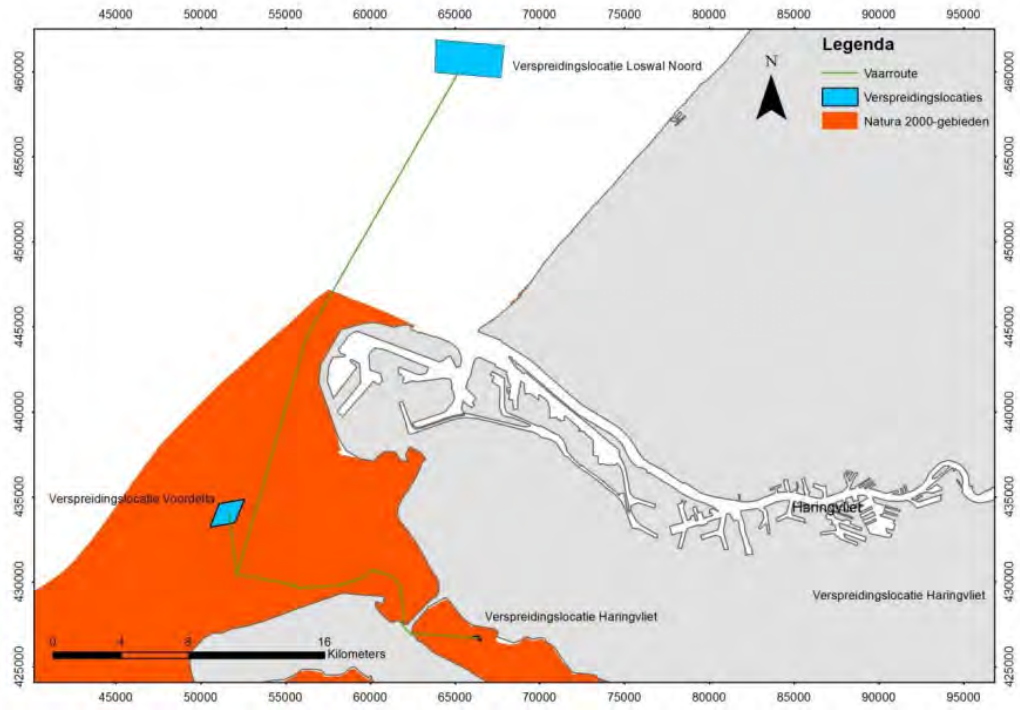
Effecten van vertroebeling
Afhankelijk van de keuze voor direct piping of microtunneling bedraagt het vrijkomende volume baggermateriaal respectievelijk 707.752 m^3 en 2.019 m^3 (Tabel 6-8). Het gaat hier enkel om het volume baggermateriaal dat vrijkomt en wordt neergelegd in de Voordelta als gevolg van de werkzaamheden aan de microtunnel/direct pipe, en niet om het sediment dat vrijkomt bij de aanleg van de onshore en offshore zeeleiding (zie daarvoor paragraaf 6.1.2).

De baggeractiviteiten ten behoeve van de doorkruising van de Maasgeul kunnen leiden tot opwerveling van sediment van de zeebodem, waardoor de troebelheid in de waterkolom toeneemt. Habitattype H1110B is gevoelig voor vertroebeling (Tabel 6-6).

Vertroebeling in de Voordelta
In de modelstudie *Vertroebeling en bodemberoering Aramis* is geanalyseerd welke concentraties sediment in suspensie komen en hoeveel sedimentatie plaatsvindt als gevolg van de aanleg van de nearshore zeeleiding (Royal HaskoningDHV, Notitie vertroebeling en bodemberoering Aramis, 2023). De vertroebeling en sedimentatie die optreedt door de baggerwerkzaamheden voor direct piping/microtunneling zijn niet in kaart gebracht. Om toch inzicht te krijgen in de mogelijk effecten van vertroebeling op de natuurwaarden van de Voordelta is daarom kennis genomen van een modelstudie van vertroebeling als gevolg van baggerwerkzaamheden in het Slijkgat in de Voordelta (Arcadis, 2014). Jaarlijks wordt er zand en slib gebaggerd uit de vaargeul bij de Drempel bij de Hinderplaat, de Drempel bij de Kwade Hoek en de Drempel bij de Pampus, en vervolgens weer verspreid op een verspreidingslocatie in de Voordelta (Figuur 6-7). Gemiddeld gaat het om een baggervolume van 100.000 – 300.000 m^3 op jaarbasis dat weer wordt verspreid op de verspreidingslocaties. In een piekjaar ligt het baggervolume tussen de 600.000 en 900.000 m^3. Voor Aramis geldt dat bij direct piping circa 700.000 m^3 aan baggervolume vrijkomt ten behoeve van de aanleg van de microtunnel/direct pipe.

Uit de modelstudie blijkt dat de toename van slibconcentratie in de waterkolom in het gebied van de baggerlocatie Pampus en op de verspreidingslocatie als gevolg van de baggerwerkzaamheden bij de Drempel van de Pampus maximaal 0,8 mg/l is en op de verspreidingslocatie maximaal 3,4 mg/l. Ook blijkt dat na het stoppen van de baggerwerkzaamheden de concentratie binnen een dag naar respectievelijk 0,25

mg/l en 0,75 mg/l daalt. Alleen lokaal treedt er een verhoogde slibconcentratie van maximaal 6 mg/l op (baggerpluim na twee weken).



Figuur 6-7. Overzicht van de verspreidingslocaties en vaarroutes ten opzichte van Natura-2000 gebied de Voordelta (Arcadis, 2014).

Effecten op typische soorten in de Voordelta

Het effect van vertroebeling op de typische soorten van Habitattype H1110B is afhankelijk van de intensiteit, frequentie en de schaal van de bodemberoerende activiteiten, alsmede de gevoeligheid van deze typische soorten voor vertroebeling. De kwaliteit van het habitattype H1110B wordt onder andere bepaald door de aanwezigheid van soorten zoals een aantal verschillende soorten borstelwormen (bijvoorbeeld schelpkokerworm en zandkokerworm), kreeftachtigen (bijvoorbeeld gewone zwemkrab en bulldozer-kreeftje), stekelhuidigen (bijvoorbeeld hartegel en gewone slangster), vissen (waaronder haring, schol en tong) en weekdieren (onder andere nonnetje en zaagje).

Voor bepaalde vissen, zoals zichtjagers, geldt dat een verhoogde sedimentconcentratie een negatief effect kan hebben op de soort. Voor andere vissoorten kan een verhoogde sedimentconcentratie een positief effect hebben, omdat ze bijvoorbeeld minder zichtbaar zijn als prooi (Wenger et al., 2017). Uit de literatuurstudie van Wenger et al. (2017), waarin naar de effecten van een toename in sedimentconcentratie op een groot aantal vissoorten (van zoet tot zout) is gekeken, blijkt dat sommige vissoorten geen reactie vertonen bij een sediment concentratie van 28.000 mg/l en dat bij andere soorten de dood intreedt bij 25 mg/l. Dit is sterk afhankelijk van de natuurlijke habitat van de soort. Aangezien de achtergrondconcentratie in de Voordelta al vrij hoog is (20-100 mg/l) is de kans groot dat de soorten die daar voorkomen een concentratie van meer dan 20 mg/l goed kunnen verdragen. Voor een soort als de Amerikaanse elft (een trekvis) wordt een concentratie van 100 mg/l als tolerantiegrens benoemd (Kjelland et al., 2015). Op basis daarvan wordt aangenomen dat een toename van 6 mg/l (*worst-case*) geen negatief effect heeft op de typische vissoorten in de Voordelta.

Filtervoeders, zoals kokerwormen, zijn mogelijk gevoeliger voor vertroebeling. Bij verhoogde zwevende stof concentraties kan het filteren van het water voor voedsel lastiger worden, waardoor de kokerwormen in conditie achteruitgaan. De studie van Dubois et al. (2009) toonde aan dat de filtersnelheid (*clearance rate* in L/uur) van zandkokerwormen sterk afnam (van ca. 3 naar 1,5 L/uur) bij een verhoging van zwevende stof concentratie van 6,5 tot 153,8 mg/l. Mogelijk hebben kokerwormen bij hogere zwevende stof concentraties moeite om de gefiltreerde deeltjes volledig te sorteren en om pseudofeces te produceren. Als gevolg neemt

de filtersnelheid af. De filteractiviteit bleef echter onveranderd bij hoge zwevende stof concentraties van circa 100 mg/l; het aantal actief filterende zandkokerwormen bleef stabiel bij toenemende zwevende stof concentraties in de waterkolom. Zandkokerwormen in de Voordelta kunnen hoogstens tijdelijk worden gehinderd door de troebele pluim, maar dit leidt niet tot afname van de soort.

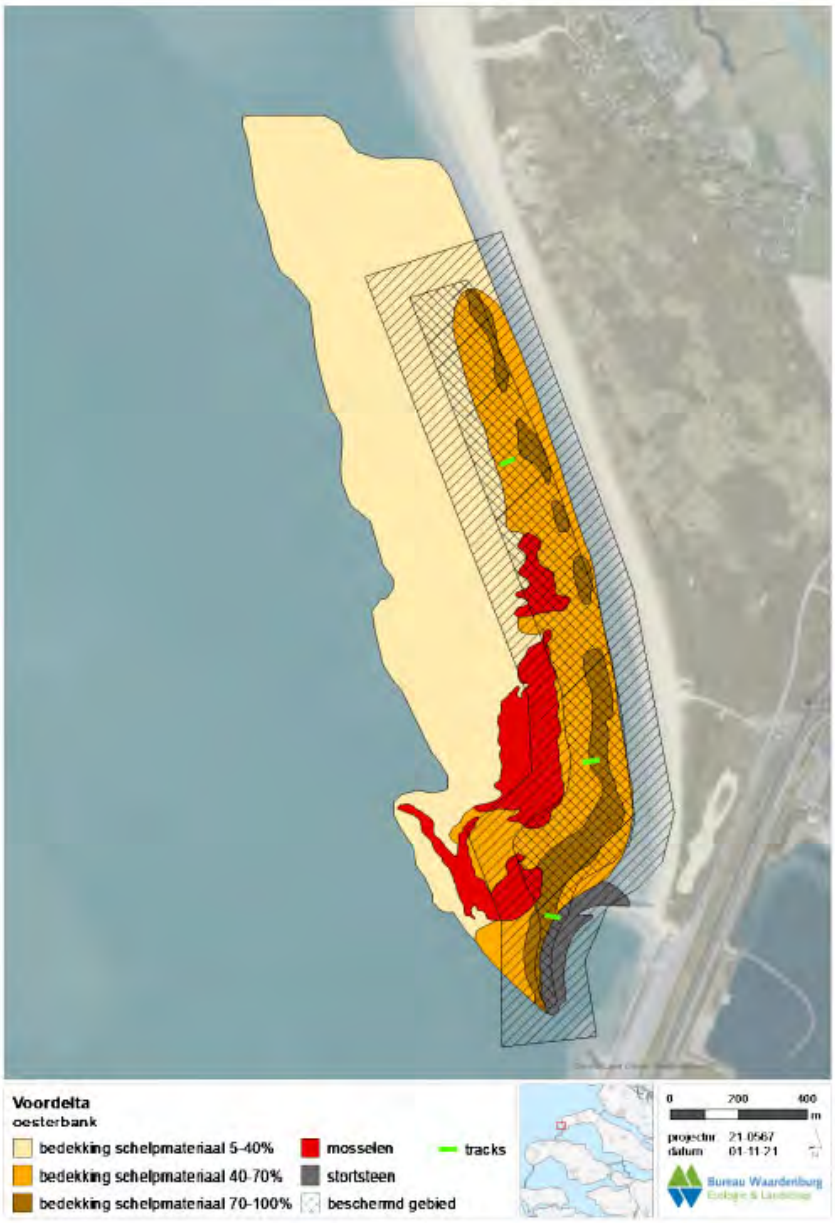
Effecten op de oesterbank in de Voordelta

In het noordelijke deel van de Voordelta bevindt zich een habitat dat mogelijk gevoelig is voor vertroebeling; een oesterbank waar de Japanse oester, platte oester en mosselen voorkomen (Figuur 6-8). Vanwege het ecologische belang van dit habitat voor de Voordelta worden mogelijke effecten van vertroebeling nog specifiek besproken voor deze oesterbank. Het oppervlakte oesterbank met een hoge bedekking van schelpen en oesters (70-100%) beslaat 9,6 hectare en met een gemiddelde bedekking (40-70%) van 30,3 hectaren. Daarnaast is er 14,1 hectaren mosselbank aanwezig (Kamermans, Didderen, et al., 2022).

Tweekleppigen zoals oesters zijn, vanwege hun aanpassingsmechanismen, in het algemeen vrij tolerant voor vertroebeling. Toch kunnen ze een effect ondervinden door blootstelling aan vertroebeling. Effecten zijn onder andere vermindering van voedselactiviteit en respiratie en verhoging van de pseudofaecesproductie en energieverbruik (Wilber & Clarke, 2001).

Dichter bij de zeebodem is de slibconcentratie hoger. Volgens Rozemeijer & Graafland (2007) beginnen de eerste effecten op larven van tweekleppigen bij 400 mg/l chronische belasting. Voor adulte tweekleppigen is dat bij 2000 mg/l chronische belasting. Rozemeijer & Graafland (2007) adviseren om een veilige norm van 150 mg/l aan te houden. Die wordt slechts af en toe overschreden onder stormcondities, als een natuurlijk aspect.

Een randvoorwaarde voor een gezonde oesterbank is een zwevend stofgehalte van <90 mg/l (Kamermans et al., 2018; Smaal et al., 2017). Een kortdurende toename in vertroebeling zal naar verwachting geen groot effect hebben op een platte oesterbank en de bijbehorende soorten (Perry & Tyler-Walters, 2016).



Figuur 6-8. Oesterbank in de Voordelta met bedekking van schelpmateriaal (Japanse oester, platte oester en mosselen) (Kamermans, Didderen, et al., 2022).

Bij een maximale toename in zwevende stof concentratie van 6 mg/l (*worst-case*) en een achtergrondconcentratie van 100 mg/l in de Voordelta (Suijlen & Duin, 2002) ontstaat een concentratie van 106 mg/l op de locatie van de voorgenomen activiteit (Figuur 6-1). De afstand tussen de locatie van de voorgenomen activiteit en de oesterbank is bovendien ca. 35 kilometer, waardoor kan worden aangenomen dat de troebele wolk verder zal verdunnen door stroming en menging en de zwevende stof concentraties ter hoogte van de oesterbank verder zullen zijn afgenomen en niet hoger zal zijn dan 90 mg/l.

Conclusie H11010B
Significante effecten van vertroebeling van habitattype H1110B als gevolg van de aanleg van de direct pipe in de Voordelta zijn uitgesloten.

Effecten van verandering dynamiek
Voor de aanleg van de direct pipe zal worden gebaggerd. Het zand afkomstig van baggeren wordt op locatie gestort en zal sedimenteren op de zeebodem, waardoor het bodemleven wordt bedekt. De meeste benthische soorten komen voor in de bovenste 10 cm van de zeebodem en zijn gebaat bij een connectie met het water, onder andere voor de uitwisseling van zuurstof en afvalstoffen en het verkrijgen van voedsel (Miller et al., 2002). Wanneer er sprake is van bedekking door sedimentatie zorgt dit voor een extra laag sediment op de zeebodem, wat de connectie met de oppervlakte kan verhinderen. Afhankelijk van de dikte van de sedimentatie-laag zal dit effect hebben op de verschillende benthische soorten. Is de laag te dik dan kan dit leiden tot sterfte van het bodemleven (Rozemeijer & Smith, 2017).

Verandering dynamiek in de Voordelta
In de modelstudie *Vertroebeling en bodemberoering Aramis* is geanalyseerd welke concentraties sediment in suspensie komen en hoeveel sedimentatie plaatsvindt als gevolg van de aanleg van de nearshore zeeleiding (Royal HaskoningDHV, Notitie vertroebeling en bodemberoering Aramis, 2023). De vertroebeling en sedimentatie die optreedt door de baggerwerkzaamheden voor direct piping/ microtunneling zijn niet in kaart gebracht. Om toch inzicht te krijgen in de mogelijk effecten van vertroebeling op de oesterbank is daarom kennis genomen van een modelstudie van sedimentatie als gevolg van baggerwerkzaamheden in het Slijkgat in de Voordelta (Arcadis, 2014). Jaarlijks wordt er zand en slib gebaggerd uit de vaargeul bij de Drempel bij de Hinderplaat, de Drempel bij de Kwade Hoek en de Drempel bij de Pampus, en vervolgens weer verspreid op een verspreidingslocatie in de Voordelta (Figuur 6-7). Gemiddeld gaat het om een baggervolume van 100.000 – 300.000 m^3 op jaarbasis dat weer wordt verspreid op de verspreidingslocaties. In een piekjaar ligt het baggervolume tussen de 600.000 en 900.000 m^3. Voor Aramis geldt dat bij direct piping circa 700.000 m^3 aan baggervolume vrijkomt ten behoeve van de aanleg van de microtunnel/ direct pipe.

Uit de modelstudie blijkt dat de kleine verhoging van de concentraties slib kan leiden tot een zeer beperkte extra sedimentatie, in de grootte van orde van mm/jaar op de plekken waar de condities van nature al leiden tot de sedimentatie van slib.

Effecten op de typische soorten in de Voordelta
Op basis van de AMBI sedimentation index[11] kan worden verondersteld dat van de typische soorten van de Voordelta - zoals beschreven in de paragraaf hiervoor – de gewone slangster (*Ophiura ophiura*), schelpkokerworm (*Lanice conchilega*) en de gewone zwemkrab niet gevoelig zijn voor een toename in sedimentatie (Tabel 6-9). Het bulldozerkreeftje (*Urothoe poseidonis*), het zaagje (*Donax vittatus*), de hartegel/ zeeklit (*Echinocardium cordatum*) en het nonnetje (*Limecola balthica)* zijn geclassificeerd als soorten die gevoeliger zijn voor sedimentatie en die bij grote fluctuaties in sedimentatie niet eenvoudig herstellen (Gittenberger & Van Loon, 2011). Sedimentatie is echter pas dodelijk bij bedelving van >60 cm, >30 cm of >10 cm voor respectievelijk het nonnetje, de hartegel en het zaagje (Bijkerk, 1988; Rozemeijer & Smith, 2017). Voor het bulldozerkreeftje is de relatie tussen sedimentdikte en het percentage overlevende dieren niet bekend. Over het algemeen geldt echter dat kreeftjes de capaciteit hebben om bij sedimentatie op tijd weg te zwemmen of anders zichzelf uit te graven. Kreeftachtigen kunnen een toename in ventilatie regelen of opgelost zuurstof in het sediment gebruiken. Bij de meeste kreeftachtigen zal sedimentatie tot 15 cm weinig effect hebben (Rozemeijer & Smith, 2017). Omdat de toename in sedimentdikte is in de ordergrootte van enkele millimeters op de locatie van de voorgenomen activiteit, en dit is ruim onder de fatale sedimentdikte.

De zandkokerworm is niet beoordeeld in de AMBI sedimentation index (Gittenberger & Van Loon, 2011). Wel is bekend dat de zandkokerworm vaak voorkomt in dynamische gebieden waar (enige) sedimentatie optreedt (Jackson & Hiscock, 2008). Het laatste is ook essentieel voor de zandkokerworm voor de vorming van de kokers en voor voedselinname. In verschillende studies is aangetoond dat dat zandkokerwormriffen in de buurt van zandwinningsgebieden onaangetast bleven (Pearce et al., 2007, 2011). Significant negatieve effecten op de zandkokerworm kunnen worden uitgesloten.

[11] *De marine biotic index (AMBI) Sedimentation is een indicator die de gevoeligheid van soorten beoordeeld voor sedimentatie door bedelving van zand of modder.*

Tong en schol foerageren met name op benthische invertebraten zoals borstelwormen, schelpdieren en kleine kreeftjes, die (deels) schuilhouden in en op de zeebodem. De sedimentdikte is medebepalend voor het foerageergedrag van de bodemvissen. Ende et al. (2018) toonde bijvoorbeeld aan dat bij een sedimentdikte van 2-5 cm de voedselinname van tong hoger was dan bij een sedimentdikte van 20 cm. Door de dikkere sliblaag (bij een sedimentdikte van 20 cm) konden prooisoorten zich dieper ingraven, waardoor het foerageersucces afnam. De toename in sedimentatie is echter in de ordergrootte van enkele millimeters, waardoor veranderingen in prooi-predatorrelaties niet te verwachten zijn.

Tabel 6-9 Beoordeling van typische soorten in de Voordelta aan de hand van de AMBI sedimentation index (Gittenberger & Van Loon, 2011).

Klassen AMBI sedimentation	Definitie	Typische soorten Voordelta
Klasse I	Soort is heel erg gevoelig voor sedimentatie. In helder water is de soort aanwezig in hoge dichtheid.	-
Klasse II	Soort is gevoelig voor hoge sedimentatie, maar leeft bij voorkeur in gebieden waar enige sedimentatie optreedt. Van grotere fluctuaties in sedimentatie herstellen ze niet eenvoudig.	Bulldozerkreeftje (*Urothoe poseidonis*), zaagje (*Donax vittatus*), hartegel/ zeeklit (*Echinocardium cordatum*), nonnetje (*Limecola balthica)*
Klasse III	Soort is niet gevoelig voor hoge sedimentatie, maar herstelt niet eenvoudig van grotere fluctuatie in sedimentatie.	Gewone zwemkrab (*Liocarcinus holsatus*)
Klasse IV	Soort is niet gevoelig voor hoge sedimentatie. De populatie herstelt relatief snel en kan baat hebben bij sedimentatie. Populatiegroei vindt plaats na fluctuaties in sedimentatie.	Gewone slangster (*Ophiura ophiura*), schelpkokerworm (*Lanice conchilega*)
Klasse V	Soorten die zeer veel baat hebben bij hoge sedimentatie en fluctuaties in sedimentatie.	-

Effecten op de oesterbank in de Voordelta

In Rozemeijer & Smith (2017) wordt een overzicht gegeven van de sedimentdiktes waarbij bodemdieren sterven. Dit verschilt per soort, de ene soort is gevoeliger voor bedekking dan de andere. Er wordt een range van 1,5 – 15 cm genoemd, waarbij wordt aangegeven dat de meeste tweekleppige schelpdieren een sedimentlaag van 10 cm kunnen overleven. De toename in sedimentatie van enkele millimeters valt ruim onder de genoemde sedimentdiktes (1,5 -15 cm) waarbij sterfte kan optreden en daardoor is er geen sprake van negatieve effecten op de oesters.

Conclusie H11010B

Significant negatieve effect van verandering dynamiek op habitattype H1110B kunnen worden uitgesloten.

6.2.2 Vissen

Het Natura 2000-gebied Voordelta is aangewezen voor de vissen rivierprik, zeeprik, fint en elft. De instandhoudingsdoelstellingen voor deze vissen zijn uitbreiding populatie en behoud van omvang en kwaliteit leefgebied. De staat van instandhouding van de zeeprik, fint en elft is zeer ongunstig. De landelijke staat van instandhouding van de rivierprik is matig ongunstig.

Door de activiteiten kunnen de vissen effect ondervinden van trillingen en geluid, licht, beweging en optiek, verontreiniging, vertroebeling en verandering dynamiek. De effecten van deze storingsfactoren worden hieronder nader beoordeeld, in Tabel 6-10 is de gevoeligheid van vissen voor deze verstoringsfactoren weergegeven.

Tabel 6-10. De gevoeligheid voor verstoring door geluid en trillingen, licht en beweging en optiek voor vissen (Effectenindicator Ministerie LNV).

Vissoort	Gevoeligheid			
	Onderwatergeluid & trilling	*Licht*	*Beweging en optiek*	*Verontreiniging*
Elft	Gevoelig	Niet beoordeeld	Niet beoordeeld	Zeer gevoelig
Zeeprik	Gevoelig	Niet beoordeeld	Niet beoordeeld	Zeer gevoelig
Rivierprik	Gevoelig	Niet beoordeeld	Niet beoordeeld	Zeer gevoelig
Fint	Gevoelig	Niet beoordeeld	Niet beoordeeld	Zeer gevoelig

Schaal - Gevoeligheid voor verstoring (Effectenindicator Ministerie LNV)

Niet gevoelig	Gevoelig	Zeer gevoelig

Effecten van trillingen en geluid

De Voordelta is aangewezen voor de habitatrichtlijnsoorten rivierprik, zeeprik, elft en fint. De zeeprik, de rivierprik en de fint zijn anadrome soorten, wat betekent dat volwassen vissen vanuit zee de rivieren optrekken om daar te paaien. Een belangrijk deel van het leven wordt echter op zee doorgebracht, waarbij de kustzone van groot belang is. Deze soorten hebben een zwemblaas.

Vissen hebben geen extern gehoororgaan. Geluid, in de vorm van drukverschillen onder water, kan door vissen op verschillende manieren worden waargenomen (Thomsen et al., 2006). Er wordt onderscheid gemaakt in gehoorspecialisten, waartoe soorten behoren met een relatief lage gehoordrempel en hoge gevoeligheid voor geluid, en gehoorgeneralisten: soorten die geen zwemblaas hebben of waarbij speciale structuren voor een efficiënte geluidsoverdracht ontbreken. De meeste bodemvissen, zoals platvissen en grondels, zijn gehoorgeneralisten terwijl de meeste vissen die hoger in de waterkolom leven gehoorspecialisten zijn.

Het (impuls)geluid dat bij heien van de aanlegsteigers wordt geproduceerd kan door sommige vissoorten worden waargenomen en tot gedragseffecten leiden. Fysieke of fysiologische effecten omvatten in theorie tijdelijke of permanente schade aan de zwemblaas, bloedvaten of het gehoorapparaat. Visseneieren kunnen bij hoge geluidniveaus ook effecten van onderwatergeluid ondervinden. (Van Damme et al., 2011). In Popper et al. (2014) wordt aangegeven dat het risico op schade of sterfte door heien op volwassen vissen optreedt bij een geluidsniveau van meer dan SELss 174 dB re 1 µPa2s en dat er een effect optreedt op larven van vissen bij een geluidsniveau van meer dan SELss 187 dB re 1 µPa2s. Deze waarden worden door een Zweeds onderzoeksinstituut voorgesteld als toekomstige drempelwaarden voor heien (Popper & Hawkins, 2019). Een recenter onderzoek in de Belgische Noordzee van der Knaap et al. (2022) richtte zich op effecten van heien op gedrag van de Atlantische kabeljauw. Tijdens de heiactiviteit bereikte de SPL maximaal 199, 196, en 188 dB bij 400, 500 en 1.700 meter afstand ten opzichte van de geluidsbron. De gemeten SELss) waarden waren gemiddeld 176, 175 en 168 dB (re1 µPa2s). De kabeljauwen bleven tijdens het heien in de nabije omgeving en vertoonden geen verhoogde bewegingsactiviteit van de geluidsbron af. Kleine veranderingen in beweging waren te zien in dat de vissen zich dichter bij het vestiging substraat bevonden (van der Knaap et al., 2022). Dit onderzoek suggereert dat deze vissoort met zwemblaas (en dus gevoeliger zijn voor geluid) geen grote veranderingen in gedrag vertonen. Er zijn geen specifieke studies bekend naar het effect van onderwatergeluid op trekvissen, behalve dat ze in staat zijn om relatief hoge frequenties te horen (Gregory et al., 2007).

Conclusie vissen

Vissen zijn zeer mobiel en hebben genoeg uitwijkmogelijkheden om het onderwatergeluid te vermijden, mocht dit als te verstorend worden ervaren. Het tot nu toe gepubliceerde onderzoek laat zien dat vissen weinig tot geen directe negatieve effecten ondervinden van impulsgeluid dat bij het heien zal vrijkomen. De instandhoudingsdoelstelling behoud van omvang en behoud van kwaliteit leefgebied voor uitbreiding van de populatie voor de genoemde trekvissoorten komt niet door de voorgenomen activiteiten in gevaar en significant negatieve effecten kunnen worden uitgesloten.

Effecten van licht
De pijpleg- en baggerschepen die worden ingezet bij de aanleg van de microtunnel/direct pipe stralen licht uit. Verstoring door licht kan effect hebben op bepaalde vissoorten en leiden tot verstoring van gedrag. Sommige soorten worden door verlichting aangetrokken, terwijl andere soorten nauwelijks reactie lijken te vertonen. Omdat het een continu proces is, is het schip ook 's nachts verlicht om het werk goed uit te kunnen voeren en de veiligheid van de bemanning te waarborgen. De verlichting is zodanig uitgevoerd dat onnodige lichtuitstraling wordt vermeden.

Pelagische vissen, zoals elft, zeeprik, rivierprik en fint , bevinden zich 's nachts hoger en meer verspreid in de waterkolom terwijl ze overdag meer in scholen samenkomen en ze zich laag in de waterkolom bevinden (e.g. Acolas et al., 2004). Mogelijk kan er dus een effect van verlichting zijn in de nacht. Finten zijn echter naast zichtjagers ook filterfeeders (plankton) (Aprahamian et al., 2003; De Laak 2009), waardoor ze niet geheel afhankelijk van zicht om te jagen. Rivierprik en zeeprik jagen zowel op zicht als 'geur'; zij kunnen prooidieren lokaliseren door het volgen van chemische sporen van de prooi (Maitland & Hatton-Ellis, 2003). Rivierprik en zeeprik zijn daarom waarschijnlijk minder gevoelig voor lichtverstoring in de waterkolom.

In de epipelagische zone (tot 200 m diepte) is er bovendien veel licht aanwezig waardoor lenzen van vissen die hier leven vaak lenspigmenten bevatten (Lisney & Collin, 2007). De pigmenten verminderen de spectrale bandbreedte en de intensiteit van het licht waardoor er 80% minder licht beschikbaar is voor het netvlies. Men vermoedt dat ze onder andere belangrijk zijn voor het beschermen van het netvlies. Sommige vissoorten kunnen ook de grootte en vorm van hun pupil sterk veranderen (Hart et al., 2006). Het kunnen bewegen van de pupil is nuttig om de hoeveelheid licht die het oog binnenkomt te kunnen reguleren (Van Gompel, 2016). Vissoorten die in de bovenste delen van de waterkolom voorkomen zijn dus vaak aangepast aan een lichte omgeving, waardoor lichtinval wordt gereguleerd.

Het extra licht van de werkzaamheden zal naar verwachting geen verstoring opleveren. Bovendien worden er standaard maatregelen getroffen om uitstraling van licht zoveel mogelijk te vermijden (Paragraaf 2.4).

Conclusie vissen
Significante negatieve effecten als gevolg van lichtverstoring op trekvissoorten kunnen worden uitgesloten.

Effecten van beweging en optiek
De pijpleg- en baggerschepen die worden ingezet bij de aanleg van de microtunnel/direct pipe zijn (in fases) in beweging. Verstoring door beweging en optiek kan effect hebben op soorten en leiden tot een verandering in gedrag.

Er is weinig bekend over de effecten van beweging en optiek op vissen. Trekvissen zijn echter mobiele soorten waardoor ze zich eenvoudig kunnen verplaatsen bij verstoring. Verstoring door beweging en optiek vindt daarnaast voornamelijk in het bovenste deel van de waterkolom plaats, waardoor vissen voldoende mogelijkheid hebben om uit te wijken.

Conclusie vissen
Significant negatieve effecten van beweging en optiek op de instandhoudingsdoelstellingen van de vissen zijn uit te sluiten.

Effecten van verontreiniging
De elft, zeeprik, rivierprik en fint zijn erg gevoelig voor verontreiniging. Bij de werkzaamheden worden delen van de leiding onder bestaande watergangen aangelegd. Tijdens het boren wordt de tunnelboormachine voorzien van boorvloeistoffen zoals bentoniet, terwijl aan de boorkop slurry wordt afgevoerd. De slurry wordt gescheiden; water en bentoniet worden hergebruikt in het boorproces. De grond wordt met vrachtwagens naar een stortplaats gebracht. Vanwege het feit dat de boorvloeistof en het boorgruis worden afgevoerd naar land, is er geen sprake van verontreiniging.

Conclusie vissen
De boorvloeistof en boorgruis voor het boren van de microtunnel/direct pipe worden afgevoerd naar land en vormen daardoor geen risico op verontreiniging van vissen. Significante effecten door verontreiniging kunnen worden uitgesloten.

Effecten van vertroebeling
Vertroebeling van de waterkolom wordt veroorzaakt door het opwervelen van sediment tijdens het baggeren. Een troebele pluim zorgt voor verminderd zicht, wat kan leiden tot verminderde voedselinname door vissen. Vooral visetende soorten die zich voeden met grotere prooien en over grotere afstanden prooien kunnen waarnemen, worden beperkt in hun foerageermogelijkheden als gevolg van vertroebeling (De Robertis et al., 2003; Hecht, 1992; Utne-Palm, 2002). De fint is een voorbeeld van een typische zichtjager. Verhoogde concentraties zwevend stof in de waterkolom kunnen daarnaast de kieuwen van vissen beschadigen, wat wederom resulteert in verminderde voedselinname en uiteindelijk verminderde of vertraagde groei (Au et al., 2004; Lake & Hinch, 1999; Wong et al., 2013).

Baggeren in voortplantingsgebieden of in de nabijheid van voortplantingssubstraat kan daarom effect hebben op het voorplantingssucces van vissen, en daardoor op de populatiestructuur- en groei (Todd et al., 2015). De elft, fint, zeeprik en rivierprik planten zich voort in zoet rivierwater en niet in zout water. Dit betekent dat de vissen tijdens de meest kwetsbare levensfasen niet aanwezig zullen zijn in of nabij het plangebied.

In paragraaf 6.2.1 is beschreven dat er sprake is van een maximale toename van 6 mg/L en dat de achtergrondconcentratie in de Voordelta al relatief hoog is waardoor er geen sprake is van negatieve effecten.

Conclusie vissen
Effecten als gevolg van vertroebeling door de baggerwerkzaamheden zijn tijdelijk, lokaal en minimaal, waardoor significant negatieve effecten van vertroebeling op trekvissen kunnen worden uitgesloten.

Effecten van verandering dynamiek
Door het baggeren ontstaat er een troebele pluim in de waterkolom. Wanneer de zwevende stofdeeltjes sedimenteren is er ook sprake van sedimentatie. De effecten van sedimentatie zijn het meest relevant voor juvenielen, eitjes en larven. Bedelving door sediment leidt tot verstikking van deze kwetsbare levensfasen en tot het verlaat uitkomen van viseitjes (Berry et al., 2011). De elft, fint, zeeprik en rivierprik planten zich echter voort in zoet rivierwater en niet in zout water. Dit betekent dat de vissen tijdens de meest kwetsbare levensfasen niet aanwezig zullen zijn in of nabij het plangebied.

Conclusie vissen
Significant negatieve effecten van verandering dynamiek als gevolg van de baggerwerkzaamheden kunnen worden uitgesloten.

6.2.3 Zeezoogdieren

Het Natura 2000-gebied Voordelta is aangewezen voor de zeezoogdieren bruinvis, grijze zeehond en gewone zeehond. De instandhoudingsdoelstellingen voor de bruinvis zijn behoud populatie en omvang leefgebied en verbetering kwaliteit leefgebied. De instandhoudingsdoelstellingen voor de grijze zeehond zijn behoud populatie, omvang leefgebied en kwaliteit leefgebied. De instandhoudingsdoelstellingen voor de gewone zeehond zijn uitbreiding populatie, behoud omvang leefgebied en verbetering kwaliteit leefgebied. De landelijke staat van instandhouding van de bruinvis, grijze en gewone zeehond is gunstig.

Door de activiteiten kunnen de zeezoogdieren effect ondervinden van trillingen en geluid, licht, beweging en optiek, verontreiniging, vertroebeling en verandering dynamiek. De effecten van deze storingsfactoren worden hieronder nader beoordeeld, in Tabel 6-11 is de gevoeligheid per verstoringsfactor weergegeven (de gevoeligheid voor vertroebeling en verandering dynamiek is onbekend).

Tabel 6-11. De gevoeligheid voor verstoring door geluid en trillingen, licht en beweging en optiek voor zeezoogdieren (Effectenindicator Ministerie LNV).

Zeezoogdier	Gevoeligheid			
	Onderwatergeluid & trilling	*Licht*	*Beweging en optiek*	*Verontreiniging*
Bruinvis	Zeer gevoelig	Zeer gevoelig	Niet beoordeeld	Zeer gevoelig
Grijze zeehond	Zeer gevoelig	Zeer gevoelig	Zeer gevoelig	Zeer gevoelig
Gewone zeehond	Zeer gevoelig	Zeer gevoelig	Zeer gevoelig	Zeer gevoelig

Schaal – Gevoeligheid voor verstoring (Effectenindicator Ministerie LNV)

Niet gevoelig	Gevoelig	Zeer gevoelig

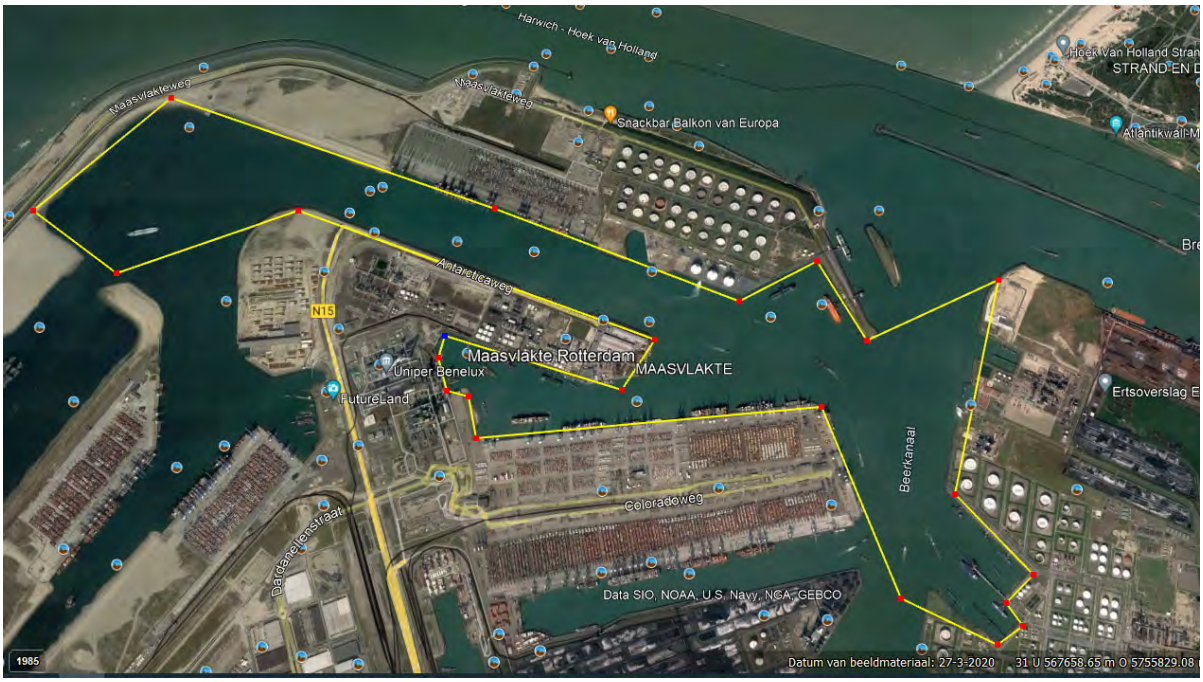
Effecten door trillingen en geluid

De effecten van onderwatergeluid op zeezoogdieren is gedetailleerd beschreven in paragraaf 6.1.5. Hier wordt nader ingegaan op de specifieke effecten op deze soortgroep in de Voordelta.

Bruinvis

De gemiddelde dichtheid in de Voordelta is 0,81 bruinvissen per km^2. Dit aantal is gebaseerd op een worst-case benadering, mogelijk zijn de daadwerkelijke aantallen in de haven lager doordat er diverse activiteiten plaatsvinden waarvoor de bruinvis gevoelig is en dit gebied waarschijnlijk zal vermijden. Dichtheden zijn nader toegelicht in paragraaf 5.1.2 van deze beoordeling. Door deze dichtheden te vermenigvuldigen met het berekende verstoringsoppervlak, volgen schattingen van het aantal mogelijk verstoorde bruinvissen per dag dat de activiteiten worden uitgevoerd, wat uiteindelijk wordt door vertaald in het effect op de Noordzeepopulatie door het totaal aantal bruinvisverstoringsdagen te berekenen en de populatiereductie (paragraaf 6.1.5). Het effect op populatieniveau resulteert in een range van 10.665 – 18.016 bruinvisverstoringsdagen en een populatiereductie (Noordzeepopulatie) van maximaal 8 bruinvissen.

Bij het heien van de aanlegsteigers in de haven, verlaat weinig geluid de haven vanwege het besloten karakter. De genoemde afstand in Tabel 6-2 is dus theoretisch en komt niet overeen met de werkelijkheid. Op basis van de oppervlakte van het havengebied is een realistische schatting gemaakt van de mijdingsoppervlakte (9 km^2), rekening houdend met de geometrie en reflectie van het onderwatergeluid op de oevers (zie Figuur 6-9). Dat betekent dat er alleen een verwaarloosbare geluidstoename optreedt in het Natura 2000-gebied Voordelta door het heien van de aanlegsteigers. Er is ook geen sprake van een overschrijding van de geluidsnorm van SELss 164 dB re 1µPa2s op 750 m van de heilocatie. Daarnaast zal er gebruik worden gemaakt van een soft start en ADD, waardoor bruinvissen op tijd de haven verlaten. Er is daardoor geen sprake van PTS.



Figuur 6-9. Omtrek oppervlakte Havengebied op basis waarvan een realistische schatting is gemaakt van de mijdingsoppervlakte van 9 km^2, rekening houdend met de geometrie en reflectie van het onderwatergeluid op de oevers.

Voor het continu onderwatergeluid vrijkomt door de baggerwerkzaamheden en het pijpleggen, wordt uitgegaan van respectievelijk 51 en 42 verstoringsdagen van de bruinvis in de Voordelta. Hierdoor neemt de omvang en kwaliteit van het leefgebied van de bruinvis tijdelijk af. Er is momenteel nog geen methodiek om effecten van continu onderwatergeluid op de populatie te berekenen. Omdat het geluid van de schepen binnen de gehoorfrequentie van de bruinvis valt, kan er sprake zijn van verstoring in de vorm van masking, wat de mogelijke communicatie tussen bruinvissen tijdelijk negatief kan beïnvloeden. Daarnaast is het aannemelijk dat bruinvissen het verstoorde gebied zullen mijden, maar omdat de baggerwerkzaamheden en het pijleggen in slechts een klein deel van de Voordelta plaatsvinden en de hoeveelheid aan vaarbewegingen beperkt is (in totaal 6), want het schip beweegt zich langzaam voort, zijn er voldoende uitwijkmogelijkheden zodat de bruinvis zich kan verplaatsen naar een gebied wat niet wordt verstoord.

Conclusie bruinvis
Fysieke gehoorschade zoals PTS en TTS worden niet verwacht omdat de dieren op tijd kunnen wegzwemmen door het inzetten van een soft start bij het heien. Het is echter niet te voorkomen dat bruinvissen tijdelijk verstoord worden. Omdat de baggerwerkzaamheden en het pijpleggen in slechts een klein deel van de Voordelta plaatsvinden en de hoeveelheid aan vaarbewegingen beperkt is en het heien van de aanlegsteigers in de haven nauwelijks een toename van geluid in het Natura 2000-gebied veroorzaakt, is er geen sprake van **directe** significant negatieve effecten op de instandhoudingsdoelstellingen.

Zoals in paragraaf 6.1.5 is geconcludeerd kunnen significante effecten op de Nederlandse Noordzeepopulatie niet worden uitgesloten door het geheel aan activiteiten voor Aramis. De Voordelta populatie maakt onderdeel uit van deze populatie, waardoor **indirecte** significante effecten op de bruinvis in de Voordelta niet kunnen worden uitgesloten.

<u>Gewone en grijze zeehond</u>
De dichtheid van de gewone en grijze zeehond in het plangebied is maximaal 1 zeehond/km^2 (Figuur 5-8). Op basis van de mijdingsafstanden uit Tabel 6-2 zijn vermijdingscontouren berekend voor de activiteiten waarbij impulsgeluid vrijkomt in de Voordelta (Tabel 6-12 en Tabel 6-13). De Voordelta kent een deelpopulatie gewone zeehonden die geschat wordt op 520 individuen. De totale populatie in Nederland

wordt geschat op 9.245 individuen. De grijze zeehondenpopulatie in de Voordelta wordt geschat op 1.200 individuen en de totale populatie in Nederland wordt geschat op 8.038 individuen (Hoekstein et al., 2022). Om idee te krijgen van de ernst van het aantal verstoorde zeehonden per dag, is het aantal verstoorde zeehonden afgezet tegen de totale populatie Nederlandse zeehonden en tegen het aantal zeehonden in de Voordelta. De aantallen verstoorde zeehonden zijn laag ten opzichte van de Voordelta populatie en de Noordzeepopulatie.

Tabel 6-12. Verstoringsoppervlak i.r.t. verstoorde gewone zeehonden.

Activiteit	Verstoringsoppervlak	Aantal verstoorde dieren per dag (dichtheid van 1 dieren/km²)	Populatie verstoord t.o.v. deelpopulatie in de Voordelta	Populatie verstoord t.o.v. de totale populatie in Nederland
Aanlegsteigers fase 1	9 km²	9 dieren	1,73%	0,097%
Aanlegsteigers fase 2	9 km²	9 dieren	1,73%	0,097%

Tabel 6-13. Verstoringsoppervlak i.r.t. verstoorde grijze zeehonden.

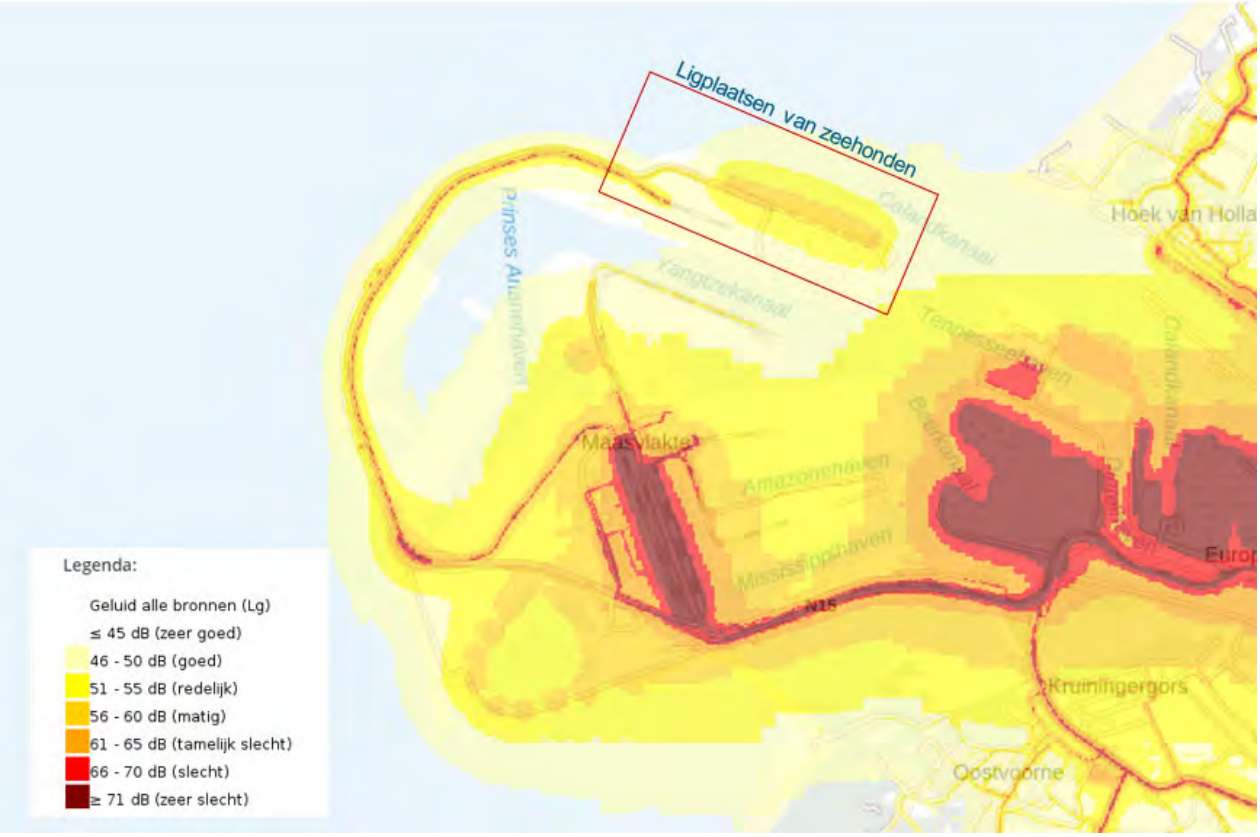
Activiteit	Verstoringsoppervlak	Aantal verstoorde dieren per dag (dichtheid van 1 dieren/km²)	Populatie verstoord t.o.v. deelpopulatie in de Voordelta	Populatie verstoord t.o.v. de totale populatie in Nederland
Aanlegsteigers fase 1	9 km²	9 dieren	0,75%	0,11%
Aanlegsteigers fase 2	9 km²	9 dieren	0,75%	0,11%

Het plangebied bevindt zich in een drukbevaren gebied, namelijk de Maasgeul. Naast dat er veel vaarverkeer is, wat een verhoogd achtergrondgeluid oplevert, wordt er ook 6-8 keer per jaar gebaggerd om de Maasgeul te onderhouden en 1 keer per jaar in de Voordelta. Van verhoogd continue onderwatergeluid is dus al sprake. Voor het Aramis project wordt er 51 en 42 dagen gevaren met een bagger- en pijplegschip wat resulteert in additionele verstoring in het gebied.

De zandplaten in het Natura 2000-gebied Voordelta zijn voor belang voor beide zeehondensoorten. De zandplaten worden gebruikt om uit te rusten na het foerageren, maar ook tijdens de voortplanting en verharingsperiode, zie Paragraaf 5.2.2. Tijdens de zoogperiode (1 mei t/m 1 september) gelden er strengere regels voor de rustgebieden. De officiële rustgebieden van de gewone en grijze zeehond worden niet verstoord tijdens de activiteiten. Wel is tijdens een veldbezoek (De Reus en Maas, 2023) geconstateerd dat zeehonden ook rusten bij het strand van het MOT terrein en mogelijke verstoring zullen ondervinden.

Een studie over effecten van een Trailer Suction Hopper Dredging vessels (TSHD) op de gewone zeehond toont aan dat het geluid geproduceerd door dit type schepen waarneembaar is voor de gewone zeehond in de bandbreedte 35 Hz tot 40 kHz (Nedwell et al., 2004). Er treden tijdelijke effecten zoals vermijding en verstoring op, maar er zijn geen significante negatieve effecten voor zeehonden. Verwacht wordt dat de zeehonden die rusten op het strand bij het MOT terrein daarom ook geen hinder zullen ondervinden van de schepen die langsvaren. Aan de noordzijde van de Maasvlakte waar de extra schepen langs zullen varen, is bovendien al veel scheepvaart aanwezig en daarmee ook een verhoogd achtergrondgeluid (zie Figuur 6-10). De extra scheepvaartbewegingen van het Aramis initiatief worden daarnaast verspreid over een langere periode en de toename van scheepvaartbewegingen (maximaal 80) ten opzichte van het huidige drukbevaren verkeersbeeld in de haven van Rotterdam is minimaal te noemen (30.000 passerende zeeschepen per jaar[12]). De toename in geluid door de inzet van extra schepen zullen verwaarloosbare en tijdelijke effecten opleveren op de zeehond.

[12] https://www.portofrotterdam.com/nl/eropuit/schepen-spotten.



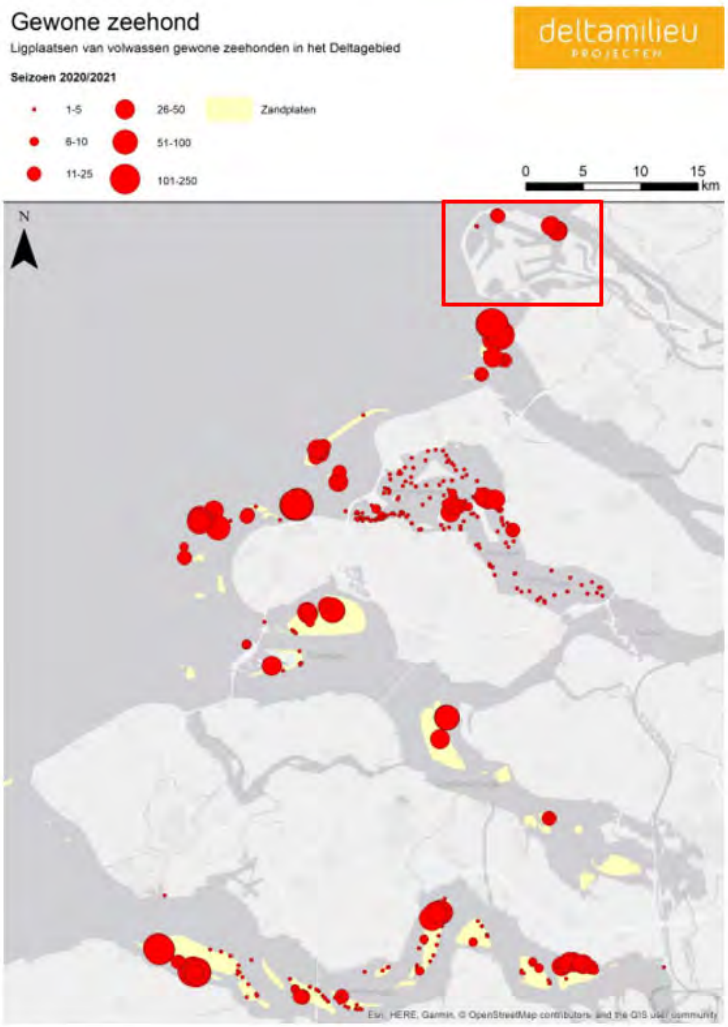
Figuur 6-10. Geluidemissie ter hoogte van het plangebied op land (Atlas Natuurlijk Kapitaal).

Conclusie gewone en grijze zeehond
Fysieke schade zoals PTS en TTS worden niet verwacht door het gedrag van de grijze of gewone zeehond door de soft start procedure bij het heien die in het standaard werkprotocol wordt opgenomen. Geluid van de heiwerkzaamheden reikt niet tot het Natura 2000-gebied of de ligplaatsen.

Directe significante negatieve effecten op de instandhoudingsdoelstellingen van grijze zeehonden en gewone zeehonden kunnen daarom uitgesloten worden. Van activiteiten die buiten de Voordelta plaatsvinden kunnen **indirecte** significante negatieve effecten worden uitgesloten, zie paragraaf 6.1.5.

Effecten door licht
De schepen die worden ingezet bij de aanleg van de microtunnel/ direct pipe stralen licht uit. Verstoring door licht kan effect hebben op bepaalde soorten en leiden tot verstoring van gedrag. Omdat het een continu proces is, is het schip ook ’s nachts verlicht om het werk goed uit te kunnen voeren en de veiligheid van de bemanning te waarborgen. De verlichting is zodanig uitgevoerd dat onnodige lichtuitstraling wordt vermeden.

Indirect kan lichtuitstraling effect hebben op de voedselinname van zeezoogdieren. Kunstmatige lichtuitstraling kan leiden tot een hoger vangstsucces voor zeehonden, omdat de prooi onderwater beter zichtbaar wordt (Becker et al., 2013; Yurk & Trites, 2000). Lichtverstoring is echter met name relevant voor zeehonden die zich boven het water bevinden op ligplaatsen. In de Voordelta zijn verschillende ligplaatsen van volwassen zeehonden aanwezig (Figuur 6-11). Zeehonden zijn gevoelig voor verstoring op hun ligplaatsen en in hun foerageergebied. Verstoring leidt in eerste instantie tot een verhoogde alertheid. Langdurige verstoring kan leiden tot een verandering van het gebruik van het leefgebied, of tot het verlaten van het gebied (Reijnders et al., 2000). Over specifieke effecten van licht op rustende zeehonden is weinig bekend. Wel is bekend dat bruinvissen en zeehonden over het algemeen erg gevoelig zijn voor (kunstmatige) verlichting (zie Tabel 6-11).



Figuur 6-11. De ligplaatsen van volwassen gewone zeehonden, gebaseerd op alle tellingen in het seizoen 2020/2021. In het rode kader staat het plangebied weergegeven (Hoekstein et al., 2022).

Lichtuitstraling van voorbijgaande schepen

De schepen die worden ingezet voor het Aramis initiatief kunnen leiden tot verhoogde lichtuitstraling. Er zullen voor respectievelijk de aanleg van de microtunnel/direct pipe, de aanleg van de zeeleiding, de werkzaamheden aan de platforms en de werkzaamheden aan de putten in totaal 6, 30, 457 en 1.651 extra scheepvaartbewegingen plaatsvinden (Bijlage 6). De constructieschepen (pijplegschip, heavy lift schip, baggerschip, trencher) varen uit vanaf de Rotterdamse haven. Alle scheepvaartbewegingen van constructieschepen zijn dus relevant voor de effectbeoordeling van de Voordelta.

Ondersteunende schepen (crew change, survey, pipe carriers, andere support vessels) kunnen uit zowel de Rotterdamse haven, als de Amsterdamse haven of Den Helder uitvaren, afhankelijk van de locatie waar de zeeleiding wordt aangelegd. Het is nog niet bekend hoeveel van deze ondersteunende schepen uitvaren vanuit de haven van Rotterdam en daarmee door of langs het plangebied varen. Echter, ervan uitgaande dat schepen zo efficiënt mogelijk worden ingezet, wordt de aanname gedaan dat de extra ondersteunende schepen die worden ingezet ten behoeve van de werkzaamheden aan de putten en platforms zullen uitvaren vanuit de haven van Amsterdam of Den Helder. De toename in scheepvaartbewegingen vanuit de haven van Rotterdam is daarmee maximaal 80 voor het Aramis initiatief; 56 extra scheepvaartbewegingen door constructieschepen en 24 extra scheepvaartbewegingen door ondersteunende schepen (Tabel 6-14). De schepen voor de aanleg van de microtunnel/direct pipe worden ingezet voor een periode van maximaal 47 dagen (voor direct piping variant) en de schepen voor de aanleg van de zeeleiding maximaal 312 dagen

(Bijlage 6). Door de spreiding van de extra scheepvaartbewegingen over een lange periode en de minimale toename van scheepvaartbewegingen (maximaal 80) ten opzichte van het huidige drukbevaren verkeersbeeld in de haven van Rotterdam (Figuur 6-13; 30.000 passages van zeeschepen per jaar[13]), kunnen effecten door lichtuitstraling van voorbijgaande schepen worden uitgesloten.

Tabel 6-14. Totaal aantal extra scheepvaartbewegingen ten behoeve van de activiteiten van het Aramis initiatief.

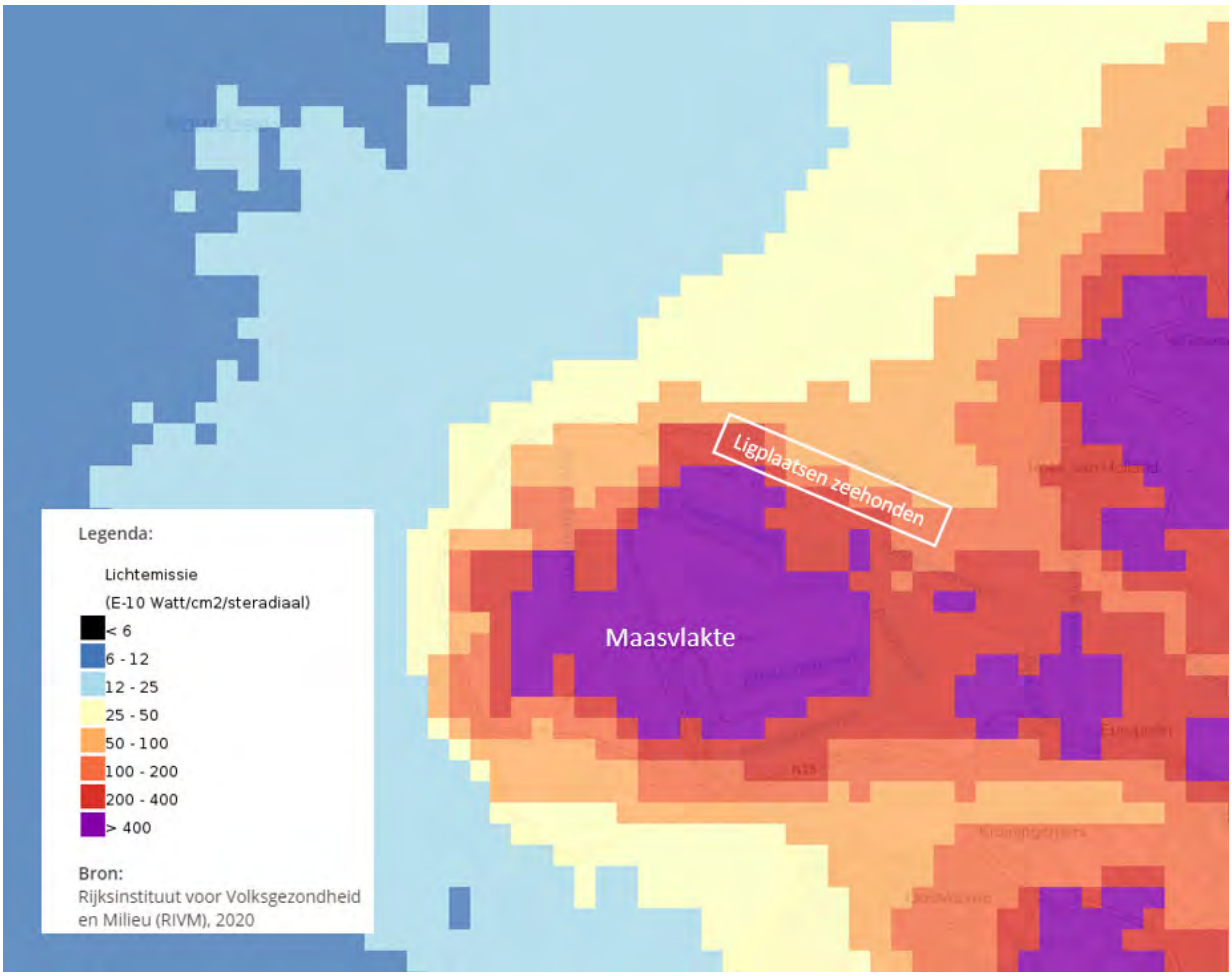
Activiteiten	Totaal aantal extra scheepvaart- bewegingen	Scheepvaartbewegingen Constructieschepen	Scheepvaartbewegingen Ondersteunende schepen
Aanleg tunnelwerk	6	4	2
Aanleg zeeleiding	30	8	22
Werkzaamheden platforms	457	18	439
Werkzaamheden putten	1.651	26	1.625
Totaal	2.144	**56**	2.088

Lichtuitstraling van constructieschepen

Voor de aanleg van de microtunnel/direct pipe worden er in totaal twee schepen ingezet waarvan één baggerschip en één pijplegschip. Deze schepen varen beide twee keer op en neer gedurende de werkzaamheden. In totaal worden het bagger- en pijplegschip maximaal 47 dagen (voor direct piping variant) ingezet voor de werkzaamheden ten behoeve van de aanleg van de microtunnel/direct pipe. Tijdens de aanleg van de microtunnel (een 24 uur constructieproces) zal er verlichting zijn bij de verticale schacht (tunnel ingang) tijdens het donkere gedeelte van de dag. Ook tijdens de aanleg van de verticale schacht is er verlichting nodig in de herfst, winter en lente vanwege variërende tijden van zons- op en ondergang. Het is niet bekend hoeveel extra lichtuitstraling er kan worden verwacht door de inzet van de schepen gedurende de aanleg van de microtunnel/direct pipe.

Gelet op de aanwezigheid van een relatief groot aantal zeehonden op de zandbanken van het noordelijke deel van de Voordelta (rode kader;) alsmede de hoge lichtemissie op de Tweede Maasvlakte (Figuur 6-12), kan ervan uit worden gegaan dat bij de in het gebied aanwezige zeehonden gewenning is opgetreden ten aanzien van de aanwezigheid van licht. De extra lichtuitstraling door de inzet van constructieschepen in de Voordelta is minimaal en tijdelijk, waardoor significante effecten op rustende zeehonden kunnen worden uitgesloten.

[13] https://www.portofrotterdam.com/nl/eropuit/schepen-spotten.



Figuur 6-12. Lichtemissie ter hoogte van het plangebied op land (Atlas Natuurlijk Kapitaal).

Conclusie zeezoogdieren
Significante effecten op de zeezoogdieren door de toename van licht kunnen worden uitgesloten.

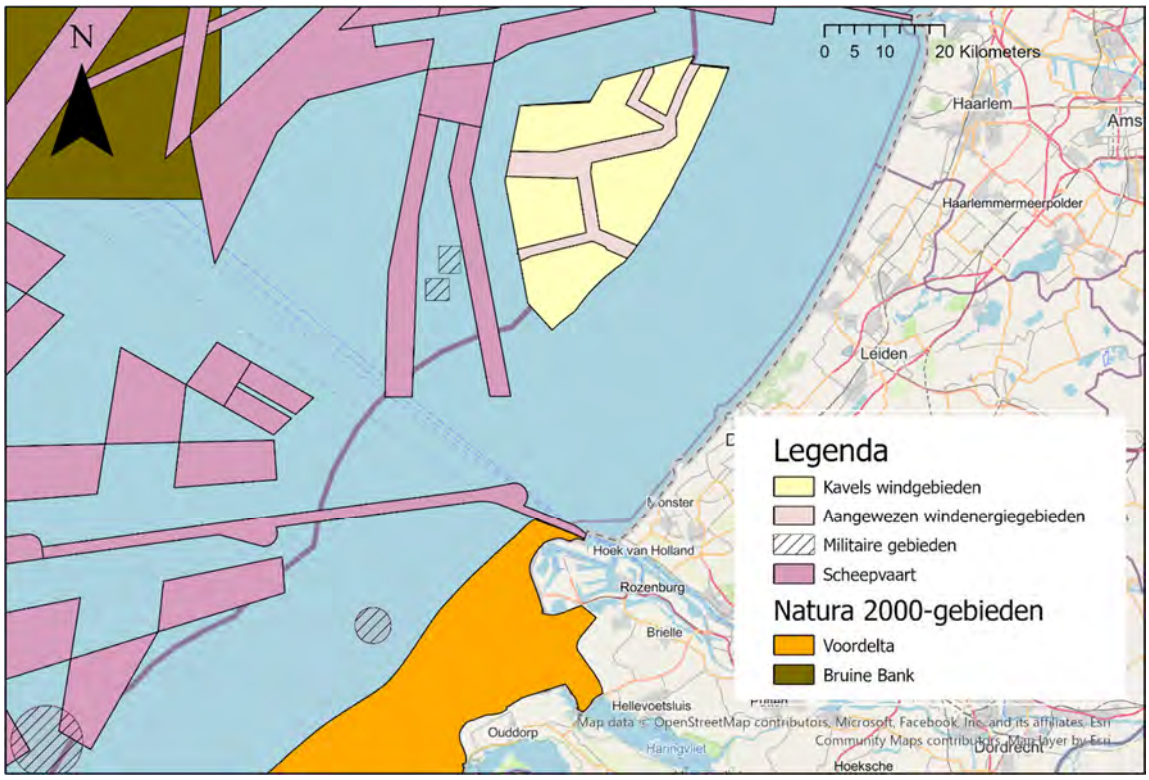
Effecten door beweging en optiek
De pijpleg- en baggerschepen die worden ingezet bij de aanleg van de microtunnel/ direct pipe zijn (in fases) in beweging. Verstoring door beweging en optiek kan effect hebben op soorten en leiden tot een verandering in gedrag. Bruinvissen en zeehonden zijn erg gevoelig voor optische verstoring (Tabel 6-11).

Effecten van beweging en optiek zijn met name relevant voor zeehonden die zich boven het water bevinden; op bijvoorbeeld de ligplaatsen in de Voordelta en de Tweede Maasvlakte. Een studie van Jansen et al. (2010) liet zien dat het risico op optische verstoring van de gewone zeehond toenam als schepen in een straal van 500 m van de ligplaatsen naderden; bij een afstand van 100 m of minder verplaatsten rustende zeehonden zich 25 keer sneller naar het water dan bij afwezigheid van schepen.

De afstand tussen de scheepvaartroute door de Maasgeul (Figuur 6-13) en de rustplaatsen van de zeehonden in het noorden van de Voordelta (Figuur 6-11) is kleiner dan de eerdergenoemde afstand van 100-500 m waarbinnen zeehonden reageren op beweging van schepen. De aanwezigheid van de zeehonden in de buurt van deze relatief drukbevaren route zouden echter een indicatie kunnen zijn dat zeehonden ook bij verstoring de rustplekken kunnen benutten.

Door de spreiding van de extra scheepvaartbewegingen over een lange periode en de minimale toename van scheepvaartbewegingen (maximaal 80) ten opzichte van het huidige drukbevaren verkeersbeeld in de

haven van Rotterdam (Figuur 6-13; 30.000 passerende zeeschepen per jaar[14]), kunnen effecten door bewegingen van voorbijgaande schepen worden uitgesloten (zie ook Paragraaf 6.2.3 *Effecten door licht*).



Figuur 6-13. Scheepvaartroute nabij Natura 2000-gebied Voordelta.

Conclusie zeezoogdieren
Significante effecten door beweging en optiek op zeezoogdieren kunnen worden uitgesloten.

Effecten van verontreiniging
Bruinvissen en zeehonden zijn erg gevoelig voor verontreiniging (Tabel 6-11). Bij de werkzaamheden worden delen van de leiding onder bestaande watergangen aangelegd. Tijdens het boren wordt de tunnelboormachine voorzien van boorvloeistoffen zoals bentoniet, terwijl aan de boorkop slurry wordt afgevoerd. De slurry wordt gescheiden; water en bentoniet worden hergebruikt in het boorproces. De grond wordt met vrachtwagens naar een stortplaats gebracht. Vanwege het feit dat de boorvloeistof en het boorgruis worden afgevoerd naar land, is er geen sprake van verontreiniging in de Voordelta.

Conclusie zeezoogdieren
De boorvloeistof en boorgruis worden afgevoerd naar land en vormen daardoor geen risico op verontreiniging van zeezoogdieren. Significante effecten door verontreiniging kunnen worden uitgesloten.

Effecten van vertroebeling
De baggeractiviteiten voor de aanleg van de zeeleiding en de doorkruising van de Maasgeul kunnen resulteren in opwerveling van sediment van de zeebodem, waardoor de troebelheid in de waterkolom toeneemt. Voor het aanleggen van de zeeleiding wordt in de Voordelta met behulp van een trencher een gleuf gebaggerd van maximaal 2 meter diep, 6 meter breed aan de bovenkant van de gleuf en 2 meter breed aan de onderkant van de gleuf. Hierdoor ontstaat er tijdelijk een lokale troebele pluim.

Zeezoogdieren vestigen zich over het algemeen vaker in troebele wateren en veel soorten gebruiken goedontwikkelde sonarsystemen om de omgeving te verkennen (Au et al., 2000). De studie van McConnell et al. (1999) toonde aan dat er geen verschil in foerageergedrag bestond tussen één blinde en verschillende

[14] https://www.portofrotterdam.com/nl/eropuit/schepen-spotten.

niet-blinde grijze zeehonden in de Noordzee. Deze resultaten wijzen erop dat zicht niet essentieel is voor overleving van zeehonden of de mogelijkheid tot foerageren. Het is dus niet te verwachten dat vertroebeling van het water de zeehonden beïnvloedt in het vangen van hun prooi; ook blinde dieren kunnen zich doorgaans goed in het wild redden (Brasseur, 2007).

Indirecte effecten van vertroebeling op zeezoogdieren zijn complex om te definiëren. In de literatuur wordt benoemd dat baggeren over het algemeen resulteert in verminderde biomassa, soortenrijkdom en soortendiversiteit, afhankelijk van de omgeving en het tijdsverloop van de activiteit. Zeezoogdieren zijn echter in staat om te compenseren voor kleinschalige veranderingen in de aanwezigheid van prooien. Dit doen ze door (tijdelijk) over te gaan op andere prooisoorten, zich te verplaatsen naar alternatieve foerageergebieden of de foerageertijd te verlengen (Todd et al., 2015).

Conclusie zeezoogdieren
Door het gedrag van zeezoogdieren is het niet de verwachting dat verstoring optreedt door vertroebeling. Significant negatieve effecten als gevolg van vertroebeling op zeezoogdieren kunnen worden uitgesloten.

Effecten van verandering dynamiek
Het baggeren en verspreiden van het slib zorgt voor een beperkte verhoging van de concentraties slib. De kleine verhoging van de concentraties slib kan leiden tot een beperkte toename in sedimentatie, in de grootte van orde van mm/jaar op de plekken waar de condities van nature al leiden tot de sedimentatie van slib. Indirecte effecten van sedimentatie kunnen leiden tot een verminderd foerageersucces voor zeezoogdieren door bedekking van voedsel.

De bruinvis, grijze en gewone zeehond eten met name vis, zoals zandspiering en haring. Haring is een mobiele pelagische soort die zich eenvoudig kan verplaatsen bij verstoring. De zandspiering is een rondvis die zowel pelagisch als nabij de bodem voorkomt. De soort paait op zandige bodems, maar ook op fijn grind (tussen 0.35-1.3 mm). Het paaien gebeurt bij voorkeur langs de randen van grote zandbanken en op toppen van kleine zandbanken, met een stroomsnelheid van ongeveer 1 m/s. De eieren worden in de bodem gelegd (Wright et al., 2000). Paai- en opgroeigebieden kunnen schade ondervinden van bodemberoering en/of sedimentatie. Bij extreme omstandigheden (bijvoorbeeld storm) is de zandspiering echter in staat om zich te verplaatsen of in te graven; de soort zal dus bij een toename van een aantal millimeters sediment geen direct effect ondervinden vanwege zijn mobiliteit (Tulp et al., 2016).

Zeezoogdieren zijn bovendien in staat om te compenseren voor kleinschalige veranderingen in de aanwezigheid van prooien. Dit doen ze door (tijdelijk) over te gaan op andere prooisoorten, zich te verplaatsen naar alternatieve foerageergebieden of de foerageertijd te verlengen (Todd et al., 2015).

Conclusie zeezoogdieren
Significant negatieve effecten als gevolg van verandering dynamiek op zeezoogdieren kunnen worden uitgesloten.

6.2.4 Niet-broedvogels

Het Natura 2000-gebied Voordelta is aangewezen voor een groot aantal niet-broedvogels. Uit paragraaf 5.2.3 blijkt dat de volgende soorten relevant zijn voor de effectbeoordeling: eider, topper, brilduiker, zwarte zee-eend, aalscholver, dwergmeeuw, fuut, grote stern, kuifduiker, lepelaar, middelste zaagbek, roodkeelduiker en visdief. De instandhoudingsdoelstellingen voor deze vogelsoorten zijn weergegeven in Tabel 6-15.

Tabel 6-15. Overzicht doelstellingen van aangewezen niet-broedvogels Voordelta. =: behoud,

Vogelsoort	Omvang leefgebied	Kwaliteit leefgebied	SvI [1]
Eider	=	=	--
Topper	=	=	+
Brilduiker	=	=	--

Vogelsoort	Omvang leefgebied	Kwaliteit leefgebied	SvI [1]
Zwarte zee-eend	=	=	--
Aalscholver	=	=	+
Dwergmeeuw	=	=	+
Fuut	=	=	+
Grote stern	=	=	+
Kuifduiker	=	=	+
Lepelaar	=	=	+
Middelste zaagbek	=	=	-
Roodkeelduiker	=	=	+
Visdief	=	=	+

[1] SvI: Staat van Instandhouding (landelijk).

Door de activiteiten in de Voordelta kunnen de vogels effect ondervinden van trillingen en geluid, licht, beweging en optiek, verontreiniging, vertroebeling en verandering dynamiek. De effecten van deze storingsfactoren worden hieronder nader beoordeeld, in Tabel 6-16 is de gevoeligheid voor de verschillende verstoringsfactoren weergegeven.

Tabel 6-16. De gevoeligheid voor verstoring door geluid en trillingen, licht en beweging en optiek en verontreiniging voor de niet-broedvogelsoorten (Effectenindicator Ministerie LNV).

Niet-broedvogelsoort	Gevoeligheid voor trillingen en geluid	Gevoeligheid voor licht	Gevoeligheid voor beweging en optiek	Gevoeligheid voor verontreiniging
Eider	Niet gevoelig	Gevoelig	Gevoelig	Gevoelig
Topper	Niet gevoelig	Gevoelig	Gevoelig	Gevoelig
Brilduiker	Niet gevoelig	Gevoelig	Niet gevoelig	Gevoelig
Zwarte zee-eend	Niet gevoelig	Gevoelig	Gevoelig	Gevoelig
Aalscholver	Niet gevoelig	Gevoelig	Gevoelig	Gevoelig
Dwergmeeuw	Niet gevoelig	Gevoelig	Gevoelig[1]	Gevoelig
Fuut	Niet gevoelig	Gevoelig	Gevoelig	Gevoelig
Grote stern	Niet gevoelig	Gevoelig	Zeer gevoelig	Gevoelig
Kuifduiker	Niet gevoelig	Gevoelig	Niet gevoelig	Gevoelig
Lepelaar	Gevoelig	Gevoelig	Niet gevoelig	Gevoelig
Middelste zaagbek	Niet gevoelig	Gevoelig	Niet gevoelig	Gevoelig
Roodkeelduiker	Niet gevoelig	Gevoelig	Gevoelig	Gevoelig
Visdief	Niet gevoelig	Gevoelig	Zeer gevoelig	Gevoelig

[1] (Krijgsveld et al., 2022).

Schaal – Gevoeligheid voor verstoring (Effectenindicator Ministerie LNV).

Niet gevoelig	Gevoelig	Zeer gevoelig

Effecten door trillingen en geluid
Door de aanleg van de microtunnel/direct pipe in de Voordelta is er sprake van een toename in geluid als gevolg van de inzet van extra schepen en het heien van de aanlegsteigers. De niet-broedvogelsoorten waarvoor de Voordelta is aangewezen zijn, met uitzondering van de lepelaar, niet gevoelig voor geluid en trilling (Tabel 6-16Tabel 6-16).

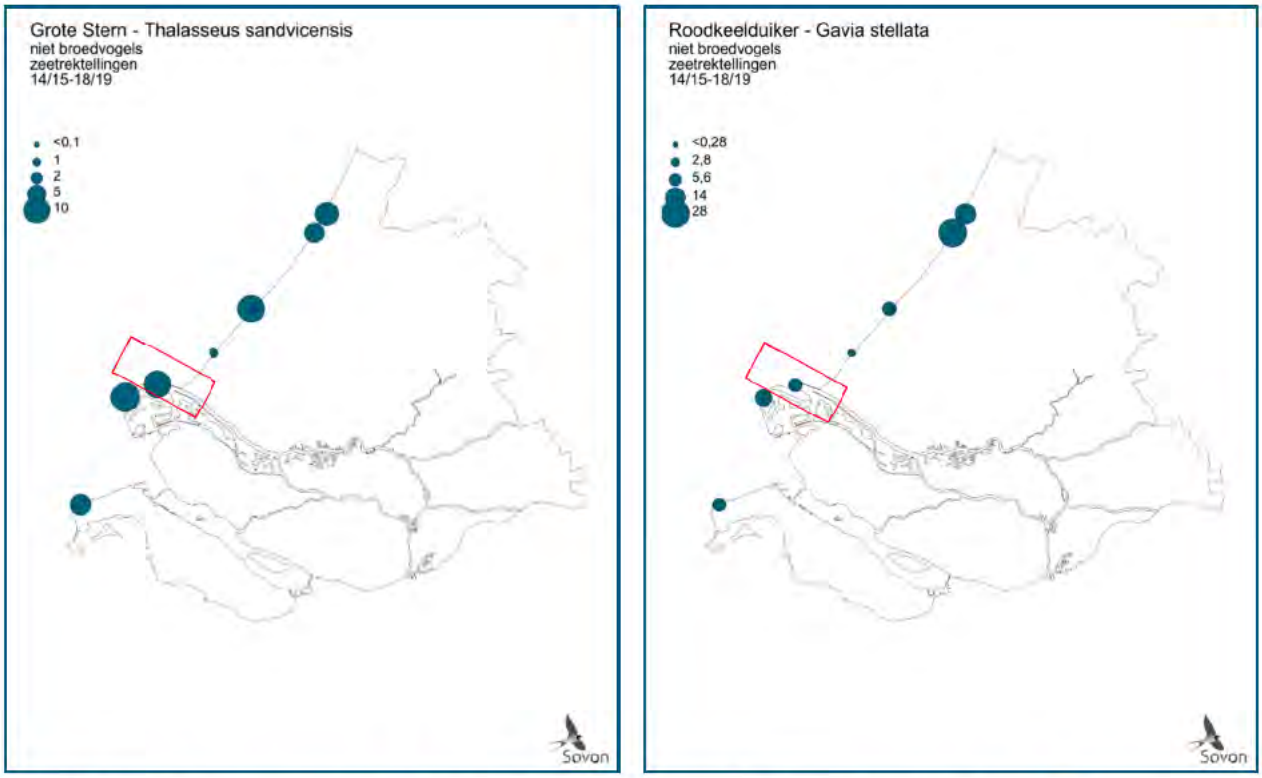
De Voordelta is een belangrijk foerageergebied en slaapplaats voor de lepelaar. Vooral in de nazomer zijn de slikken van de Westplaat van belang, waarbij uitwisseling bestaat met de Kwade Hoek, waar de aantallen vaak nog hoger zijn (Arcadis, Royal HaskoningDHV, Sweco, 2022). De lepelaar komt niet voor in het plangebied, waardoor negatieve effecten van geluid en trilling op de lepelaar zijn uit te sluiten.

Conclusie niet-broedvogels
Significante effecten op niet-broedvogels als gevolg van trillingen en geluid kunnen worden uitgesloten.

Effecten door licht
De schepen die worden ingezet bij de aanleg van de nearshore zeeleiding en de aanleg van de microtunnel/ direct pipestralen licht uit. Uitstraling van licht kan effect hebben op bepaalde vogels en leiden tot verstoring van gedrag. Alle vogelsoorten waarvoor de Voordelta is aangewezen zijn gevoelig voor licht (Tabel 6-16). Van de niet-broedvogels waarvoor de Voordelta is aangewezen komen alleen de grote stern en de roodkeelduiker voor in het plangebied (Sovon, (n.d.); Figuur 6-14).

Grote sterns zijn voornamelijk aanwezig van maart tot en met half november. In de wintermaanden kunnen tot enkele tientallen exemplaren in het Deltagebied verblijven. De broedvogels arriveren vanaf eind maart in de kolonies, die ze uiterlijk half augustus weer verlaten. In april en mei vindt tevens doortrek plaats. De wegtrek, deels in familieverband speelt zich voornamelijk tussen eind juli en eind september af. Uit de voorbereidende milieusurvey van Fugro blijkt dat in de periode van 11 juli 2022 t/m 24 januari 2023 in totaal zes sternen zijn waargenomen op het Aramis traject (doorkruising Maasgeul, tracé zeeleiding, putten, platforms) op drie verschillende telmomenten (Fugro, 2023). Op de Tweede Maasvlakte zijn in de telseizoenen 2014/2015 – 2018/2019 (juli-juni) gemiddeld 20 grote sterns per uur geteld (Sovon, n.d.).

Roodkeelduikers zijn voornamelijk langs de Noordzeekust te zien en bijna alleen in de periode oktober-mei, met name hartje winter. De meeste vogels worden langsvliegend waargenomen, soms vele honderden of meer per dag. Veel van zulke bewegingen zijn lokale verplaatsingen, veroorzaakt door verstoring (scheepvaart) of verdrifting (waterstromen). Incidenteel houden zich groepen van vele tientallen op bij voedselrijke plekken. Uit de voorbereidende milieusurvey van Fugro blijkt dat in de periode van 11 juli 2022 t/m 24 januari 2023 in totaal 410 duikers zijn waargenomen op het Aramis traject (doorkruising Maasgeul, tracé zeeleiding, putten, platforms) op 59 verschillende telmomenten (Fugro, 2023). Op de Tweede Maasvlakte zijn in de telseizoenen 2014/2015 – 2018/2019 (juli-juni) gemiddeld 9 roodkeelduikers per uur geteld (Sovon, n.d.).



Figuur 6-14. Systematische waarnemingen van niet-broedvogels in de provincie Zuid-Holland (seizoen juli t/m juni). Weergegeven is het uurgemiddelde per telpost. Bron: Sovon, (n.d.).

Lichtuitstraling van voorbijgaande schepen

De toename in scheepvaartbewegingen vanuit de haven van Rotterdam is maximaal 80 voor het Aramis initiatief; 56 extra scheepvaartbewegingen door constructieschepen en 24 extra scheepvaartbewegingen door ondersteunende schepen (Paragraaf 6.2.3 Effecten door licht). Door de spreiding van de extra scheepvaartbewegingen over een lange periode en de minimale toename van scheepvaartbewegingen (maximaal 80) ten opzichte van het huidige aantal zeeschepen dat jaarlijks de haven van Rotterdam passeert (30.000 per jaar; 84 per dag[15]), kunnen effecten door lichtuitstraling van voorbijgaande schepen worden uitgesloten.

Lichtuitstraling van constructieschepen

Voor de aanleg van de microtunnel/direct pipe worden er in totaal twee schepen ingezet waarvan één baggerschip en één pijplegschip. Deze schepen varen beide twee keer op en neer gedurende de werkzaamheden. In totaal worden het bagger- en pijplegschip maximaal 47 dagen (voor direct piping variant) ingezet voor de werkzaamheden ten behoeve van de aanleg van de microtunnel/direct pipe. Tijdens de aanleg van de microtunnel (een 24 uur constructieproces) zal er verlichting zijn bij de verticale schacht (tunnel ingang) tijdens het donkere gedeelte van de dag. Ook tijdens de aanleg van de verticale schacht is er verlichting nodig in de herfst, winter en lente vanwege variërende tijden van zons- op en ondergang. Het is niet bekend hoeveel extra lichtuitstraling er kan worden verwacht door de inzet van de schepen gedurende de aanleg van de microtunnel/direct pipe.

Gelet op de hoge lichtemissie op de Tweede Maasvlakte (Figuur 6-12) kan worden verondersteld dat de toename in lichtuitstraling door de inzet van twee extra constructieschepen in de Voordelta minimaal zal zijn, waardoor effecten op niet-broedvogels kunnen worden uitgesloten.

Conclusie niet-broedvogels

Significante effecten door de aanwezigheid van licht op niet-broedvogels kunnen worden uitgesloten.

[15] https://www.portofrotterdam.com/nl/eropuit/schepen-spotten.

Effecten door beweging en optiek
De pijpleg-, bagger- en trenchschepen die worden ingezet bij de aanleg van de nearshore zeeleiding en de aanleg van de microtunnel/direct pipe zijn (in fases) in beweging. Vogels kunnen last ondervinden door bewegingen en aanwezigheid van schepen en daardoor worden verstoord. Vooral in de ruiperiode kunnen vogels daar veel last van ondervinden, omdat vogels dan minder mobiel zijn en niet snel weg kunnen vliegen bij verstoring. Vooral de grote stern en visdief zijn zeer gevoelig voor optische verstoring (Tabel 6-16).

Voor de aanleg van de microtunnel/ direct pipe worden er in totaal twee schepen ingezet waarvan één baggerschip en één pijplegschip. Deze schepen varen beide twee keer op en neer gedurende de werkzaamheden. In totaal worden het bagger- en pijplegschip maximaal 47 dagen (voor direct piping variant) ingezet voor de werkzaamheden ten behoeve van de aanleg van de microtunnel/direct pipe. De schepen voor de aanleg van de zeeleiding varen uit vanaf de haven van Rotterdam verspreid over een periode van ongeveer 312 dagen (Bijlage 6).

Door de spreiding van de extra scheepvaartbewegingen over een langere periode en de minimale toename van scheepvaartbewegingen (maximaal 80) ten opzichte van het huidige drukbevaren verkeersbeeld in de haven van Rotterdam (30.000 passerende zeeschepen per jaar[16]), kunnen effecten door bewegingen van voorbijgaande schepen worden uitgesloten.

Conclusie niet-broedvogels
Significante effecten van beweging en optiek op de instandhoudingsdoelstellingen van de niet-broedvogels kunnen worden uitgesloten.

Effecten van verontreiniging
Bij de werkzaamheden worden delen van de leiding onder bestaande watergangen aangelegd. Tijdens het boren wordt de tunnelboormachine voorzien van boorvloeistoffen zoals bentoniet, terwijl aan de boorkop slurry wordt afgevoerd. De slurry wordt gescheiden; water en bentoniet worden hergebruikt in het boorproces. De grond wordt met vrachtwagens naar een stortplaats gebracht. Vanwege het feit dat de boorvloeistof en het boorgruis worden afgevoerd naar land, is er geen sprake van verontreiniging in de Voordelta.

Conclusie zeezoogdieren
De boorvloeistof en boorgruis worden afgevoerd naar land en vormen daardoor geen risico op verontreiniging van niet-broedvogels. Significante effecten door verontreiniging kunnen worden uitgesloten.

Effecten van vertroebeling
De baggeractiviteiten ten behoeve van de doorkruising van de Maasgeul kunnen leiden tot opwerveling van sediment van de zeebodem, waardoor de troebelheid in de waterkolom toeneemt. De voor het Natura 2000-gebied aangewezen niet-broedvogelsoorten zijn in de meeste gevallen beperkt gevoelig voor vertroebeling, van andere soorten is het onbekend (Tabel 6-17Tabel 6-17).

Tabel 6-17. De gevoeligheid voor verstoring door vertroebeling en verandering van de dynamiek van substraat alsmede de terugkeertijd na verstoring voor de niet-broedvogelsoorten (Tamis et al., 2011).

Niet-broedvogelsoort	Gevoeligheid voor vertroebeling	Gevoeligheid voor verandering dynamiek substraat	Specifiek te vermijden verstoring/ verbeterpunt
Eider	Beperkt	Aanzienlijk	Beschikbaarheid schelpdieren en rust in foerageergebied
Topper	Beperkt	Aanzienlijk	Beschikbaarheid schelpdieren en rust in foerageergebied
Brilduiker	Niet beoordeeld	Niet beoordeeld	Niet beoordeeld

[16] https://www.portofrotterdam.com/nl/eropuit/schepen-spotten.

Niet-broedvogelsoort	Gevoeligheid voor vertroebeling	Gevoeligheid voor verandering dynamiek substraat	Specifiek te vermijden verstoring/ verbeterpunt
Zwarte zee-eend	Beperkt	Aanzienlijk	Beschikbaarheid schelpdieren en rust in foerageergebied
Aalscholver	Beperkt	Marginaal	Geen
Dwergmeeuw	Beperkt	Marginaal	Geen
Fuut	Niet beoordeeld	Niet beoordeeld	Niet beoordeeld
Grote stern	Niet beoordeeld	Niet beoordeeld	Niet beoordeeld
Kuifduiker	Niet beoordeeld	Niet beoordeeld	Niet beoordeeld
Lepelaar	Niet beoordeeld	Niet beoordeeld	Niet beoordeeld
Middelste zaagbek	Niet beoordeeld	Niet beoordeeld	Niet beoordeeld
Roodkeelduiker	Beperkt	Marginaal	Rust in foerageergebied
Visdief	Niet beoordeeld	Niet beoordeeld	Niet beoordeeld

Schaal – Gevoeligheid voor verstoring door vertroebeling (Tamis et al., 2011).

Marginaal	Beperkt	Aanzienlijk	Groot

De brilduiker, aalscholver, kuifduiker, roodkeelduiker, fuut, grote stern, middelste zaagbek en visdief zijn duikende soorten en kunnen duiken tot dieptes waar vertroebeling ontstaat. Wanneer deze soorten duiken in water waar de troebele pluim aanwezig is, kan dit leiden tot een verminderd vangsucces. Een beetje vertroebeling leidt echter niet tot effecten aangezien duikende vogels vaker in vertroebeld water duiken (Zamon et al., 2014). De verstoring reikt tot enkele honderden meters naast de baggerlocatie waardoor de Voordelta voor het overgrote deel onverstoord blijft. Het verstoringsoppervlak door baggeren is dermate beperkt dat er genoeg areaal overblijft voor de brilduiker, aalscholver, kuifduiker, roodkeelduiker, fuut, grote stern, middelste zaagbek en visdief om te foerageren.

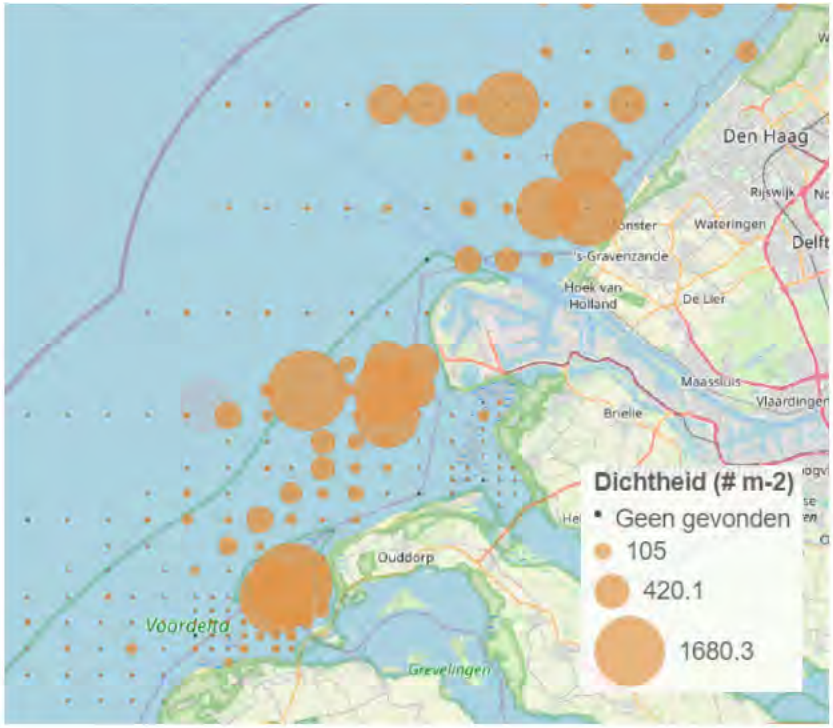
De lepelaar foerageert in ondiep en helder water (10-30 cm), wat betekent dat de soort geen effect zal ondervinden van vertroebeling in open en dieper water. De dwergmeeuw zoekt voedsel terwijl hij boven het wateroppervlak vliegt waarna hij al vliegend prooien pakt van het wateroppervlak. De soort foerageert dus niet op waterdiepten waar vertroebeling plaatsvindt en zal geen effect van vertroebeling ondervinden.

Conclusie niet-broedvogels

Significante effecten van vertroebeling op niet-broedvogelsoorten kunnen worden uitgesloten.

Effecten van verandering dynamiek

Eidereenden, toppereenden en zwarte zee-eenden zoeken voornamelijk voedsel (benthos) in de onderwaterbodem. Schelpdieren zijn een belangrijke voedselbron. In Figuur 6-15 zijn de locaties weergegeven waar schelpdieren voorkomen in en nabij de Tweede Maasvlakte en Natura 2000-gebied de Voordelta. In het noorden van de Voordelta en ten noorden van de Tweede Maasvlakte zijn relatief grote dichtheden schelpdieren aanwezig; waaronder de *Spisula substruncata*, *Chamelea striatula*, *Lutraria lutraria*, *Donnax vittatus* (WUR Schelpdiermonitor 2023). Daarbij is met name Spisula een belangrijke voedselbron. Veranderingen in substraat in de Voordelta – bijvoorbeeld door bedelving van schelpdierbanken – kunnen indirect een effect hebben de voedselbeschikbaarheid van schelpdieren voor eenden. In Paragraaf 6.2.1 werd echter al beschreven dat effecten van sedimentatie op schelpdierbanken in de Voordelta zijn uitgesloten.



Figuur 6-15. Dichtheid van het totaal aantal schelpdieren in de Nederlandse kustzone (aantal schelpdieren / m²) (WUR schelpdiermonitor 2023). In de figuur is indicatief met de blauwe lijn weergegeven wat vanuit het oogpunt van behoud van schelpdierbanken de meest geschikte locatie zou zijn voor de aanleg van de zeeleiding.

Conclusie niet-broedvogels

Significante effecten van verandering van dynamiek op niet-broedvogels kunnen worden uitgesloten.

6.2.5 Conclusie Voordelta

Voor de Voordelta kan het volgende geconcludeerd worden:

- Significante effecten op habitattype H1110B kunnen worden uitgesloten;
- Significante effecten op trekvissen kunnen worden uitgesloten;
- Significante effecten op zeezoogdieren door geluid en trillingen kunnen niet worden uitgesloten, hierbij gaat het om indirecte effecten op de bruinvis;
- Significante effecten op niet-broedvogels kunnen worden uitgesloten.

6.2.6 Mitigerende maatregelen Voordelta

De volgende mitigerende maatregelen dienen naast de standaard maatregelen uitgevoerd te worden om significante effecten te voorkomen:

- In de Voordelta treden geen significante directe effecten op voor de bruinvis, maar indirecte effecten door onderwatergeluid op bruinvissen kunnen niet worden uitgesloten (indirecte effecten op de gehele Noordzeepopulatie). Daarom dienen mitigerende maatregelen te worden genomen bij de heiwerkzaamheden en scheepvaart. Deze zijn opgenomen in paragraaf 6.1.7.
- Voor het heien van de aanlegsteigers in de haven is geen mitigatie nodig omdat het geluid binnen de haven blijft. Van de standaardmaatregelen zijn alleen soft start en ADD noodzakelijk, een MMO is hier niet nodig.

6.3 Natura 2000-gebied Friese Front

Het Friese Front is aangewezen als Vogelrichtlijngebied voor de zeekoet (A199). De zeekoet kan effect ondervinden van de activiteiten voor de aanleg van de zeeleiding en de platforms met verbindingsleiding(en) voor de spurlines. Het platform L10-R komt op ongeveer 1,6 km afstand van het Friese Front te liggen. In deze paragraaf wordt beoordeeld of er sprake is van significante negatieve effecten door de voorgenomen activiteiten.

6.3.1 Niet-broedvogels: zeekoet

De instandhoudingsdoelstellingen voor de zeekoet zijn behoud van de populatie en behoud van omvang en kwaliteit leefgebied. De landelijke staat van instandhouding van de zeekoet is gunstig.

Kenmerkend voor de zeekoet is het gebruik van het Friese Front door ruiende mannetjes met hun jongen in de nazomer. De afstand tot de kust, en daarmee de relatieve rust, in combinatie met het hoge voedselaanbod maakt het Friese Front een aantrekkelijk rust- en foerageergebied voor de zeekoet in deze kwetsbare fase van de levenscyclus. De zeekoet jaagt vooral op de grote scholen sprot die door de volop aanwezige bodemfauna worden aangetrokken. Omdat de zeekoet in staat is om diepten van meer dan 100 m te bereiken, kunnen ze de hele waterkolom van het Friese Front afzoeken (Leopold, 1991). In de ruiperiode kunnen de jongen en ruiende volwassen mannetjes zich minder snel naar andere locaties verplaatsen doordat ze (tijdelijk) niet in staat zijn om te vliegen.

Uit de voorbereidende milieusurvey van Fugro blijkt dat in de survey periode van 11 juli 2022 t/m 24 januari 2023 in totaal 560 zeekoeten zijn waargenomen op het Aramis traject (doorkruising Maasgeul, tracé zeeleiding, putten, platforms) op 249 verschillende telmomenten (Fugro, 2023).

Door de activiteiten in het Friese Front kan de zeekoet effect ondervinden van oppervlakteverlies, trillingen en geluid, licht, beweging en optiek, verontreiniging, vertroebeling en verandering dynamiek substraat. In Tabel 6-18 is de gevoeligheid van de zeekoet voor deze storingsfactoren opgenomen. Daaruit blijkt dat de zeekoet alleen gevoelig is voor onderwatergeluid en trillingen, verontreiniging en beweging en optiek. De effecten hiervan worden hieronder beoordeeld.

Tabel 6-18. De gevoeligheid voor storingsfactoren voor de niet-broedvogel zeekoet (Tamis et al., 2011).

Storingsfactor	Gevoeligheid
Oppervlakteverlies	Beperkt
Bovenwatergeluid & trilling	Marginaal
Onderwatergeluid & trilling	Aanzienlijk[1]
Licht	Marginaal
Beweging en optiek	Aanzienlijk
Verontreiniging	Groot[2]
Vertroebeling	Beperkt
Verandering dynamiek substraat	Marginaal

[1] Smith et al. (2023)
[2] RHDHV (2019)

Schaal – Gevoeligheid voor verstoring (Tamis et al., 2011)

Marginaal	Beperkt	Aanzienlijk	Groot

Effecten door trillingen en geluid

Onderwatergeluid
Voor de aanleg van de offshore zeeleiding en de installatie van de nieuwe platforms en putten worden verschillende schepen en helikopters ingezet (Bijlage 6). Vogels kunnen hinder ondervinden van het geluid dat hierbij vrijkomt. Ook bij het heien van de verankeringspalen voor de nieuwe platforms en het boren van de nieuwe putten - waarbij ook conductors moeten worden geheid - is er sprake van onderwatergeluid. Zeekoeten jagen onderwater, waarbij ze tot grote diepte duiken en last kunnen hebben van harde onderwatergeluiden (Camphuysen & Leopold, 1994).

Heiwerkzaamheden
De werkzaamheden voor de nieuwe platforms nemen per platform maximaal 3 dagen in beslag voor het heien van de 4 verankeringspalen. Daarnaast zijn er 3 dagen nodig voor het heien van 4-6 conductorpijpen. Het impulsgeluid heeft voornamelijk een lage frequentie van 10 Hz tot 10 kHz, hoewel ook hogere frequenties voorkomen. Het heien van een conductor duurt gemiddeld 8 tot 12 uur bij een frequentie van maximaal vijftig slagen per minuut. De hamer die voor het heien van de verankeringspalen wordt gebruikt heeft een maximale slagkracht van 1000 kJ en de hamer die voor de conductor wordt gebruikt heeft een maximale slagkracht van 90 kJ.

Zeekoeten kunnen hinder ondervinden van onderwatergeluid, aangezien ze jagen onder water (tot 180 - 230 m diepte) (Anderson Hansen et al., 2020; Camphuysen & Leopold, 1994; Didderen et al., 2019). Zo volgde uit de studie van Anderson Hansen et al. (2020) dat zeekoeten reageren op onderwatergeluid en daarom potentieel kwetsbaar zijn voor verhoogd onderwatergeluid. In het experiment werden twee zeekoeten (één mannetje en één vrouwtje) blootgesteld aan verschillende geluidsniveaus (110, 120, 130 en 137 dB re 1 µPa). Bij hogere geluidsniveaus reageerde zowel de vrouwelijke als mannelijke zeekoet sterker dan bij lagere geluidsniveaus en het controle experiment. In de studie van Smith et al. (2023) werd verder aangetoond dat de zeekoet gevoeliger is voor geluidsverstoring dan niet-duikende alkensoorten. De onderzochte zeekoeten waren gevoelig voor gemiddelde geluidsfrequenties tussen de 1 en 3,5 kHz (min-max; 0,5-6,0 kHz) met een laagste gemiddelde gehoordrempel van 30 dB bij 2 kHz. De zeekoet is dus gevoelig voor geluidsfrequenties die overlappen met geluidsfrequenties afkomstig van heiwerkzaamheden. Voor bruinvissen is de geluidscontour van 140 dB in beeld gebracht (zie Figuur 6-5), dit komt dicht in de buurt van de hiervoor genoemde 137 dB. In die figuur is te zien dat deze geluidscontouren deels overlappen met het Friese Front, waardoor er sprake is van een direct effect.

Vooral in de ruiperiode van de zeekoet (juli-oktober) is de zeekoet gevoelig voor verstoring door geluid, omdat de zeekoet in die periode niet in staat om zich te verplaatsen naar alternatief foerageer- of rustgebied. Als activiteiten plaatsvinden in de ruiperiode van de zeekoet, kunnen significant negatieve effecten door geluid en trilling door heiwerkzaamheden niet worden uitgesloten.

Boren van de putten en machinegeluid
Het boren van de putten duurt ongeveer 100 dagen per put. In totaal worden bij platform L10-R 4 tot 6 nieuwe putten geboord, wat betekent dat de boringen van de putten bij platform L10-R in totaal 400-600 dagen in beslag nemen. Wanneer we de vermijdingsafstand van bruinvissen aanhouden (voor de zeekoet is deze niet bekend), welke 10 km is, is er sprake van overlap van deze activiteiten met het Friese Front. Aangezien zeekoeten niet of minder gevoelig zijn voor laagfrequent geluid (Hildebrand, 2009; Smith et al., 2023) kunnen significante effecten worden uitgesloten.

Scheepvaart en helikoptervluchten
Er zullen voor de werkzaamheden aan de platforms en putten van L10-R en L4-A in totaal 1.300 extra scheepvaartbewegingen plaatsvinden (Tabel 6-19Tabel 6-19). Schepen veroorzaken een continu geluid dat voornamelijk door de schroef en de machinekamer geproduceerd wordt. De mate van geluid hangt af van de snelheid, of er gemanoeuvreerd wordt of niet en van de belading.

Geluid van scheepvaart is vaak laagfrequent (maximaal 100 Hz voor een groot cargo schip), terwijl zeekoeten juist gevoelig zijn voor hoger frequent geluid (bijvoorbeeld ontploffingen van explosieven, onderwater sonar en heien van conductoren) (Hildebrand, 2009; Smith et al., 2023). In het gebied is ook veel vergelijkbaar geluid aanwezig afkomstig van scheepvaart. Het Friese Front wordt in het huidige

verkeersbeeld doorsneden door een aantal scheepvaartverbindingen die relatief intensief worden bevaren (12 schepen/10 km^2/uur), waarbij het met name gaat om koopvaardijschepen. De scheepvaartroutes beslaan ongeveer 23% van het oppervlak van het Friese Front. Iets meer dan de helft van het totaal aantal schepen dat op het Friese Front aanwezig is maakt gebruik van de scheepvaartroutes (Van Mastrigt et al., 2019).

Boven het Friese Front is ook een helikopterroute voor verkeer van en naar de olie- en gasplatforms. Het Friese Front valt deels samen met een defensie-oefengebied voor de luchtmacht en de marine. In dit gebied worden vrijwel dagelijks vlieg- en schietoefeningen gehouden met (laagvliegende) F16's en marineschepen (Van Mastrigt et al., 2019; AIS Netherlands). Het gedeelte helikoptergeluid dat vanuit de lucht doordringt tot in het water is zeer beperkt. Bij loodrechte inval reflecteert meer dan 99,9% van het geluid aan het wateroppervlak en blijft dus in de lucht. Laagvliegen is alleen van toepassing bij de landing en bij het opstijgen, en beslaat daarom alleen het gebied rondom platforms L10-R en L4-A.

Uit de beoordeling Wet natuurbescherming bij het MER militaire luchthaven de Kooy (waarin ook burgerluchtvaart met helikopters is meegenomen) blijkt dat effecten van helikoptervluchten op vogels in omliggende Natura 2000-gebieden (Noordzeekustzone, Waddenzee) kunnen worden uitgesloten (Zweers & Den Held, 2017). In de toetsing van luchthaven de Kooy wordt er van 27.000 vliegbewegingen per jaar door groot verkeer (helikopters en vast vleugelvliegtuigen) uitgegaan. Tijdens de aanlegfase van het Aramis initiatief is er gedurende een periode van 1-2 jaar sprake van maximaal 300 en 310 extra helikopterbewegingen voor de werkzaamheden aan respectievelijk platforms L10-R en L4-A. Vanwege het feit dat er al dagelijks wordt gevlogen met F16's nabij het plangebied, wordt niet verwacht dat een toename van één helikopter per dag/twee dagen leidt tot verstoring van de zeekoet. Significant negatieve effecten van helikopter- en scheepvaartgeluid op de zeekoet zijn uitgesloten.

Tabel 6-19. Scheepvaart- en helikopterbewegingen ten behoeve van de activiteiten bij platforms en putten van L10-R en L4-A.

Activiteiten	Schepen/ helikopters	Aantal schepen/ helikopters	Aantal bewegingen	Duur activiteit (in dagen)
Werkzaamheden platform L10-R	Schepen	4	10	24
Werkzaamheden putten L10-R	Schepen	4	282	840
	Helikopters	1	300	N.A.
Werkzaamheden platform L4-A	Schepen	8	188	183
	Helikopters	1	76	N.A.
Werkzaamheden putten L4-A	Schepen	3	820	408
	Helikopters	1	234	N.A.
Totaal	-	22	Schepen: 1.300 Helikopters: 610	-

Conclusie zeekoet
De zeekoet is in de ruiperiode (juli-oktober) gevoelig voor onderwatergeluid als gevolg van heiwerkzaamheden. Significante effecten op de instandhoudingsdoelstellingen van de zeekoet door geluid en trillingen kunnen hierdoor niet worden uitgesloten.

Effecten door beweging en optiek
De schepen die worden ingezet bij de aanleg van de zeeleiding en de installatie van de nieuwe platforms en putten zijn (in fases) in beweging. Garthe & Hüppop (2004) deden onderzoek naar het vlucht- en vermijdgedrag van verschillende zeevogels bij verstoring door scheepvaart- en helikopterverkeer. In totaal kregen 26 vogelsoorten een score toebedeeld - op basis van extensief onderzoek vanaf boten op zee - tussen de 0 (nauwelijks vlucht- en vermijdgedrag waarneembaar/ zeer korte vluchtafstand) en 5 (sterk waarneembaar vlucht- en vermijdgedrag/ grote vluchtafstand). Vooral duikende soorten zoals de parelduiker (score 4), de roodkeelduiker (score 4) en de zwarte zee-eend (score 5) blijken (zeer) gevoelig

voor verstoring door schepen en helikopters. De zeekoet is daarentegen matig gevoelig voor verstoring door schepen en helikopters (score 3).

Van zeekoeten is verder bekend dat deze vaak vroegtijdig hun zwemrichting aanpassen om obstakels zoals platforms en schepen op geruime afstand te passeren (Tamis et al., 2011). Van de 929 waargenomen zeekoeten in de studie van Garthe & Hüppop (2004) vertoonde slechts 37% van de vogels vermijd- of vluchtgedrag in de nabijheid van een naderend schip, waarvan 17% wegvloog en 20% onder water dook. Van de duikende soorten, zoals de parelduiker en roodkeelduiker, vluchtten minstens 94% van de waargenomen vogels. De ruiende mannetjes en jongen van de zeekoet kunnen – door hun beperkte mobiliteit - scheepvaart echter minder makkelijk vermijden waardoor stress ontstaat (Didderen, Rebolledo, et al., 2019). Gebieden met veel scheepvaart zijn daarom mogelijk minder aantrekkelijk voor zeekoeten, vooral tijdens de ruiperiode van de zeekoet (juli – augustus).

In en nabijheid het plangebied zijn drukbevaren scheepvaartroutes aanwezig. Het Friese Front wordt in het huidige verkeersbeeld doorsneden door een aantal scheepvaartverbindingen die relatief intensief worden bevaren, waarbij het met name gaat om koopvaardijschepen. In totaal varen er 27 schepen (of meer) per 1000 km^2 (Hermans et al., 2020). De scheepvaartroutes beslaan ongeveer 23% van het oppervlak van het Friese Front. Iets meer dan de helft van het totaal aantal schepen dat op het Friese Front aanwezig is maakt gebruik van de scheepvaartroutes. Vissersschepen varen daarnaast ook verspreid door het Friese Front, met hogere dichtheden in de periode juni – augustus (Van Mastrigt et al., 2019).

Er zullen voor de werkzaamheden aan het platform L10-R en de putten bij platform L10-R in totaal 292 extra scheepvaartbewegingen plaatsvinden (Tabel 6-19Tabel 6-19). In totaal neemt het aantal helikoptervluchten (retour) toe met 300 door de inzet van schepen voor de werkzaamheden aan de putten van platform L10-R. De werkzaamheden aan het platform L10-R en de putten van L10-R vinden op 1,6 km afstand van het Friese Front plaats. Ook wordt er zoveel mogelijk gebruikt gemaakt van bestaande routes (Kader 2). De extra scheepvaart- en helikopterbewegingen zullen niet leiden tot een oppervlakteverlies van foerageer- of rustgebied voor de zeekoet.

Conclusie zeekoet
Significant negatieve effecten op de instandhoudingsdoelstelling van de zeekoet door beweging en optiek kunnen worden uitgesloten.

Verontreiniging
Bij het boren van de putten tijdens de aanlegfase wordt Water Based Mud (WBM)-houdende boorvloeistof gebruikt. Dit is een gebiedsvreemde stof, wat bestaat uit zoet of zout water als basis vloeistof met bariet ($BaSO4$) of ilmeniet ($FeTiO_3$) als wegingsmiddel. Klei of organische polymeren worden toegevoegd om een homogene vloeistof te creëren. Andere chemicaliën (e.g. kalium formaat en verschillende glycolen) zorgen voor een optimale viscositeit en stabiliteit (Neff, 2005). De boorvloeistof en het boorgruis worden volgens de gangbare praktijk op zee geloosd. Het onderste deel van de putten wordt geboord met boorvloeistof op oliebasis. Deze boorvloeistof wordt afgevoerd naar land.

Een studie van Daan & Mulder (1993) toonde verder aan dat er 2 maanden na de lozing van WBM boorgruis (met een gewicht van circa 1.600 ton) in de buurt van platforms L3-3 en L6-3 in het Friese Front geen effecten op de benthische levensgemeenschappen optraden. Ook uit de survey die in 1992 bij L3-3 plaatsvond, één jaar na de lozing van het boorgruis, bleken er geen effecten op de benthische levensgemeenschappen, zelfs niet op een afstand van maar 25 m van het voormalige lozingspunt (Daan & Mulder, 1993a). Andere studies benoemen ook de lage acute toxiciteit van WBM, net zoals de afwezigheid van aantoonbare effecten van WBM-houdende boorvloeistof op de benthische levensgemeenschappen van sedimentrijke systemen (Park et al., 2001; Renaud et al., 2008). Er zijn geen studies bekend van de effecten van WBM op vissen en vogels, aangezien er geen effect is op de benthische gemeenschap kan worden aangenomen dat er ook geen effecten zijn op de zeekoet.

Tijdens de gebruiksfase wordt er productiewater geloosd vanaf de platforms. Het lozen van productiewater zorgt voor een lokale verontreiniging van het zeewater. Productiewater is het water dat omhoogkomt uit het gasveld samen met het aardgas. Het vrijgekomen productiewater wordt na behandeling geloosd. Het debiet varieert per platform van enkele kubieke meters water per uur bij een klein platform tot tientallen kubieke

meters per uur voor een groot platform. Het productiewater is licht verontreinigd met alifaten (olie), aromaten (voornamelijk benzeen), zware metalen en natuurlijke radionucliden. In hoofdstuk 9 van de Mijnbouwregeling is vastgesteld dat een lozing pas mag plaatsvinden wanneer de concentratie stoffen voldoet aan de wettelijke eisen. Voor gedispergeerde olie geldt bijvoorbeeld een norm van 30 mg/L.
Bij een overschrijding van de wettelijke normen worden maatregelen getroffen. Het productiewater verdunt al een factor 30-100 in de eerste 10-100 meter vanaf het lozingspunt (IAOGP, 2005). De olieconcentraties van de lozingen zijn door de stroming op de Noordzee binnen enkele honderden meters maximaal verdund tot de achtergrondconcentratie. Om die reden wordt alleen het effect van de platforms in en op de rand van het gebied verwacht. Van externe werking als gevolg van platforms buiten het gebied is geen sprake (RHDHV, 2019).

Conclusie zeekoet
Significant negatieve effecten op de instandhoudingsdoelstelling van de zeekoet door verontreiniging kunnen worden uitgesloten.

6.3.2 Conclusie Friese Front

Voor het Friese Front kan het volgende geconcludeerd worden:
- Significante effecten in juli-oktober op de zeekoet door onderwatergeluid en trillingen door heiwerkzaamheden kunnen niet worden uitgesloten;
- Significante effecten op de zeekoet door andere verstoringsfactoren kunnen worden uitgesloten.

6.3.3 Mitigerende maatregelen Friese Front

De volgende mitigerende maatregelen dienen naast de standaard maatregelen uitgevoerd te worden om significante effecten te voorkomen:
- Er wordt bij heiwerkzaamheden in de periode juli-oktober nabij het Friese Front (L4-A en L10-R) gebruik gemaakt van bijvoorbeeld een HSD Systeem/bubbelscherm bij het heien om het onderwatergeluid zodanig te minimaliseren dat de 140 dB geluidscontour geen overlap heeft met het Friese Front. Ook kan gebruik worden gemaakt van nieuwe methoden, waarmee een veel lagere geluidsbelasting optreedt indien de geluidscontour (140 dB) dan niet tot het Friese Front reikt;
- Indien bovenstaande niet mogelijk is, worden tijdens de gevoelige periode van zeekoet (juli – oktober) geen heiwerkzaamheden uitgevoerd ten behoeve van de aanleg van de platforms en putten L4-A en L10-R.

6.4 Natura 2000-gebied Klaverbank

De habitatrichtlijnsoorten waarvoor het Natura 2000-gebied Klaverbank is aangewezen kunnen effecten ondervinden van de activiteiten de zeeleiding en de platforms met verbindingsleiding(en) voor de spurlines. De zeeleiding bevindt zich op ongeveer 40 km van de Klaverbank en het dichtstbijzijnde platform en de verbindingsleiding(en) voor de spurlines op ongeveer 53 km. Hieronder wordt voor de relevante soorten beoordeeld of ze significante negatieve effecten ondervinden van bovengenoemde activiteiten.

6.4.1 Zeezoogdieren

Het Natura 2000-gebied Klaverbank is aangewezen voor de zeezoogdieren bruinvis, grijze zeehond en gewone zeehond. De instandhoudingsdoelstellingen voor alle drie de zeezoogdieren zijn behoud populatie en behoud omvang en kwaliteit leefgebied. De landelijke staat van instandhouding van de bruinvis, grijze en gewone zeehond is gunstig.

Door de activiteiten kunnen de zeezoogdieren een (indirect) effect ondervinden van geluid en trillingen. Er is geen sprake van (indirecte) effecten door verstoring door licht, beweging en optiek, verontreiniging, vertroebeling en verandering dynamiek vanwege de mate van het effect en de grote afstand tot de Klaverbank. De drie zeezoogdiersoorten zijn allemaal zeer gevoelig voor geluid en trillingen (onderwatergeluid).

Effecten door trillingen en geluid
Bij het heien van de verankeringspalen voor de nieuwe platforms en de conductors voor de nieuwe putten en het boren van de nieuwe putten is er sprake van impuls onderwatergeluid wat verstoring oplevert voor zeezoogdieren. Voor de aanleg van de offshore zeeleiding, de installatie van de nieuwe platforms en putten, en de ontmanteling van de putten worden verschillende schepen ingezet (Bijlage 6). Zeezoogdieren kunnen hinder ondervinden van het continue geluid dat hierbij vrijkomt.

In de Klaverbank zelf worden geen activiteiten uitgevoerd. De minimale afstand van de Klaverbank tot aan de locatie (K10) waar heiactiviteiten plaats zullen vinden is 76,6 kilometer. De minimale afstand van de Klaverbank ten opzichte van het meest nabije platform waar sprake is van verstoring door continu geluid door scheepvaart en boorwerkzaamheden is 53 kilometer (L4A). De mijdingsafstand van zeezoogdieren bij werkzaamheden zoals machinegeluid dat vrijkomt van het platform en het boren van injectieputten kan oplopen tot 100 kilometer wanneer er geen sprake is van verhoogd achtergrondgeluid (zie Tabel 6-1). Gezien er vrijwel in de gehele Noordzee sprake is van verhoogd achtergrondgeluid (de Jong et al., 2021), kan worden uitgegaan van een mijdingsafstand van 10 kilometer. Hiermee kan worden gesteld dat in de Klaverbank geen directe effecten van onderwatergeluid zullen optreden. Wel kunnen er indirecte effecten optreden aangezien de bruinvis een mobiele soort is en van de gehele Noordzee gebruik maakt. Een effect op de Noordzeepopulatie kan een effect hebben op de instandhoudingsdoelstelling van de zeezoogdieren in de Klaverbank.

<u>Bruinvis</u>
De gemiddelde dichtheid bruinvissen per km^2 bij de activiteiten die doorwerking kunnen hebben op de instandhoudingsdoelstellingen in de Klaverbank is een range tussen 1,20 en 2,0. Dichtheden zijn nader toegelicht in paragraaf 5.1.2 van deze beoordeling. Door deze dichtheden te vermenigvuldigen met het berekende verstoringsoppervlak door activiteiten met impulsgeluid (heien), volgen schattingen van het aantal mogelijk verstoorde bruinvissen per dag dat de activiteiten worden uitgevoerd, wat uiteindelijk wordt door vertaald in het effect op de populatie door het totaal aantal bruinvisverstoringsdagen te berekenen en de populatiereductie (Tabel 6-2 en paragraaf 6.1.5). Het effect op populatieniveau resulteert in een range van 10.665 – 18.016 bruinvisverstoringsdagen en een populatiereductie (Noordzeepopulatie) van maximaal 7 bruinvissen. Daarnaast is er sprake van een overschrijding van de geluidsnorm door het heien van de verankeringspalen (zie paragraaf 6.1.5).

Er is momenteel nog geen methodiek om effecten van continu onderwatergeluid op de populatie bruinvissen te berekenen. Omdat het geluid van de schepen binnen de gehoorfrequentie van de bruinvis valt, kan er sprake zijn van verstoring in de vorm van masking, wat de mogelijke communicatie tussen bruinvissen tijdelijk negatief kan beïnvloeden. Dit kan effect hebben op populatieniveau, wat in theorie dus ook effect

kan hebben op de instandhoudingsdoelstellingen van de bruinvis in de Klaverbank. Er is echter nog te weinig onderzoek bekend over de effecten van continu geluid op het gedrag van bruinvissen en hoe dit effect heeft op populatieniveau om een kwantitatieve beoordeling te doen. Het is aannemelijk dat bruinvissen het verstoorde gebied voor langere tijd zullen mijden. Hiermee zal de kwaliteit en de omvang van het leefgebied van de bruinvis afnemen.

Conclusie bruinvis
Fysieke schade zoals PTS en TTS worden niet verwacht door het gebruik van soft start waardoor de bruinvissen het gebied verlaten voordat er schade optreedt. De populatiereductie van 7 bruinvissen kan vertaald worden naar een afname van 0,007 tot 0,013% ten opzichte van de Nederlandse populatie bruinvissen, wat betekent dat er wordt voldaan aan de maximale ecologisch toelaatbare reductie van 5%. Echter is hier geen rekening gehouden met activiteiten waarbij sprake is van continu onderwatergeluid, waarbij ook verstoring optreedt. Kijkende naar de werkzaamheden die rond de platformen in de Noordzee plaatsvinden, worden er circa 1 tot 2 jaar achter elkaar met een paar weken tussen de activiteiten in intensief werkzaamheden uitgevoerd. Het is aannemelijk dat bruinvissen het verstoorde gebied voor langere tijd zullen mijden. Een groot gebied zal hierdoor niet geschikt zijn als leefgebied van de bruinvis. In het geval van de Klaverbank is er geen sprake van een **direct** effect (het onderwatergeluid reikt niet in het gebied), maar wel van een **indirect** effect, aangezien bruinvissen gebruikmaken van de gehele Noordzee en een effect op de Noordzeepopulatie een effect heeft op de instandhoudingsdoelstelling van de bruinvis in de Klaverbank. Indirecte significante effecten op bruinvissen kunnen niet worden uitgesloten.

Gewone en grijze zeehond
Fysieke schade zoals PTS en TTS worden niet verwacht. De dichtheid van de gewone en grijze zeehond in het plangebied is maximaal 0,50 zeehonden per km^2. In paragraaf 6.1.5 zijn de effecten van onderwatergeluid op zeehonden in de Noordzee beoordeeld (Tabel 6-2, Tabel 6-5, Tabel 6-6, Paragraaf 6.1.5). De verstoringsoppervlakten variëren per activiteit tussen de 54 en 314 km^2.

De in paragraaf 6.1.5 genoemde percentages geven een indicatie weer van de verstoring, maar zijn niet goed bij elkaar op te tellen omdat dit een overschatting zal zijn. In de praktijk zijn de dichtheden op open zee lager en is het aannemelijk dat individuen meermaals worden verstoord door dezelfde of verschillende activiteiten. Ervan uitgaande dat activiteiten kort na elkaar met een aantal weken ertussen uitgevoerd gaan worden, zullen zeehonden het gebied voor een langere periode mijden. Aangezien de werkzaamheden 1 tot 2 jaar zullen duren, kan de mijdingsperiode ook oplopen tot een vergelijkbare periode.

Zowel ten zuiden als in de zuidelijkste punt van de Klaverbank bevindt zich een bestaande scheepvaartroute. De aanwezigheid van veel vaarverkeer levert in het huidige verkeersbeeld al een verhoogd achtergrondgeluid op.

Het gebied op open zee kan door zeehonden gebruikt worden om te foerageren. Grijze zeehonden kunnen tot ver uit de kust zoeken naar voedsel (Ministerie van Economische Zaken, 2014a). Het foerageergebied neemt door de verstoring daarom mogelijk af. Er zijn anderzijds voldoende uitwijkmogelijkheden voor gewone en grijze zeehonden om te foerageren. De nabijgelegen gebieden Noordzeekustzone en de Waddenzee zijn belangrijkere gebieden voor de gewone zeehond en grijze zeehond dan de open zee (anders dan voor bruinvissen).

Conclusie grijze en gewone zeehond
Het belang van het gebied waar de activiteiten plaatsvinden is van minder groot belang voor de zeehonden dan de kustzone en het waddengebied, waardoor significant negatieve effecten zijn uit te sluiten.

6.4.2 Conclusie Klaverbank

Voor de Klaverbank kan het volgende geconcludeerd worden:
- Significante effecten op de bruinvis door geluid en trillingen kunnen niet worden uitgesloten, hierbij gaat het om indirecte effecten op de Noordzee populatie;
- Significante effecten op de bruinvis door andere verstoringsfactoren kunnen worden uitgesloten;
- Significante effecten op zeehonden kunnen worden uitgesloten.

6.4.3 Mitigerende maatregelen Klaverbank

De volgende mitigerende maatregelen dienen naast de standaard maatregelen uitgevoerd te worden om significante effecten te voorkomen:

- In de Klaverbank treden geen significante directe effecten op voor de bruinvis, maar indirecte effecten door onderwatergeluid op bruinvissen kunnen niet worden uitgesloten (indirecte effecten op de gehele Noordzee populatie). Daarom dienen mitigerende maatregelen te worden genomen bij de heiwerkzaamheden en scheepvaart. Deze zijn opgenomen in paragraaf 6.1.7.

6.5 Natura 2000-gebied Bruine Bank

De voor het Natura 2000-gebied Bruine Bank aangewezen vogelrichtlijnsoorten kunnen effecten ondervinden van het aanleggen van de zeeleiding. De zeeleiding bevindt zich op ongeveer 23 km van de Bruine Bank. Daarmee vinden er geen directe activiteiten plaats in de Bruine Bank, maar er kan sprake zijn van externe werking in dit Natura 2000-gebied. Hieronder wordt voor de relevante soorten beoordeeld of ze significante negatieve effecten ondervinden door het aanleggen van de zeeleiding.

6.5.1 Niet-broedvogels

Het Natura 2000-gebied Bruine Bank is aangewezen voor de vogelrichtlijnsoorten zeekoet, jan-van-gent, grote jager, dwergmeeuw, grote mantelmeeuw en alk. De instandhoudingsdoelstellingen voor alle zes de vogelsoorten is behoud populatie en behoud omvang en kwaliteit leefgebied. De staat van instandhouding van de zeekoet, jan-van-gent, grote jager, dwergmeeuw, grote mantelmeeuw en alk is gunstig.

Uit de voorbereidende milieusurvey van Fugro blijkt dat in de periode van 11 juli 2022 t/m 24 januari 2023 de zeekoet, jan-van-gent, dwergmeeuw, grote mantelmeeuw en alk regelmatig zijn waargenomen op het Aramis traject (doorkruising Maasgeul, tracé zeeleiding, putten, platforms) (Tabel 6-20). De grote jager is één keer waargenomen (Fugro, 2023).

Tabel 6-20. Aantal waargenomen niet-broedvogelsoorten op het Aramis traject in de periode juli 2022 t/m januari 2023 (Fugro, 2023).

Soort	Aantal waarnemingen op het Aramis traject	Aantal individuen op het Aramis traject
Zeekoet	249	560
Jan-van-gent	429	607
Grote jager	1	1
Dwergmeeuw	7	26
Grote mantelmeeuw	188	258
Alk	205	498

Door de activiteiten in de Bruine Bank kunnen de vogelsoorten effect ondervinden van trillingen en geluid, licht, beweging en optiek, verontreiniging, vertroebeling en verandering dynamiek. De effecten van deze storingsfactoren worden hieronder nader beoordeeld (zie voor een samenvattend overzicht Tabel 6-21Tabel 6-21).

Tabel 6-21. De gevoeligheid voor verstoring door bovenwatergeluid en trillingen, licht en beweging en optiek voor de niet-broedvogelsoorten (Tamis et al., 2011 en Effectenindicator Ministerie LNV).

Niet-broedvogelsoort	Gevoeligheid			
	Geluid & trilling	*Licht*	*Beweging en optiek*	*Verontreiniging*
Zeekoet	Bovenwater: marginaal Onderwater: aanzienlijk[2]	Marginaal	Aanzienlijk	Beperkt
Jan-van-gent	Niet beoordeeld	Niet beoordeeld	Niet beoordeeld	Niet beoordeeld
Grote jager	Marginaal	Marginaal	Marginaal	Beperkt
Dwergmeeuw	Niet gevoelig	Gevoelig	Gevoelig[1]	Gevoelig
Grote mantelmeeuw	Marginaal	Marginaal	Marginaal	Beperkt
Alk	Niet beoordeeld	Niet beoordeeld	Niet beoordeeld	Niet beoordeeld

[1] (Krijgsveld et al., 2022).
[2] (Smith et al., 2023).

Schaal - Gevoeligheid voor verstoring (Tamis et al., 2011)

Marginaal	Beperkt	Aanzienlijk	Groot

Schaal - Gevoeligheid voor verstoring (Effectenindicator Ministerie LNV)

Niet gevoelig	Gevoelig	Zeer gevoelig

Effecten door trillingen en geluid
Voor de aanleg van de zeeleiding worden verschillende schepen ingezet (Bijlage 6). Vogels kunnen hinder ondervinden van het geluid dat hierbij vrijkomt. Ook bij het heien van de verankeringspalen voor de nieuwe platforms en het boren van de nieuwe putten is er sprake van onderwatergeluid. Het heien van de verankeringspalen en het boren van de putten leidt over het algemeen tot de grootste geluidsverstoring, met name de zeekoet is hier gevoelig voor. De hei- en boorwerkzaamheden vinden echter op minstens 58 km van de Bruine Bank, waardoor effecten van geluid en trilling zijn uit te sluiten.

De extra schepen die worden ingezet voor het Aramis initiatief volgen zoveel mogelijk bestaande scheepvaartroutes. In totaal zullen maximaal 80 extra schepen uitvaren vanuit de haven van Rotterdam, waarvan 30 schepen mogelijk de scheepvaartroute langs of door de Bruine Bank volgen voor de aanleg van de zeeleiding. Deze toename in scheepvaartverkeer is minimaal te noemen en verspreidt zich over een langere periode van ongeveer 300 dagen. De schepen die uitvaren vanuit de haven van Amsterdam of Den Helder komen niet in de buurt van de Bruine Bank. Er is geen sprake van effecten door geluid en trilling op niet-broedvogels in de Bruine Bank.

Conclusie niet-broedvogels
Significante effecten op de instandhoudingsdoelstellingen van de niet-broedvogels door geluid en trilling kunnen worden uitgesloten.

Effecten door licht
De schepen die worden ingezet bij de aanleg van de zeeleiding putten stralen licht uit. Uitstraling van licht kan effect hebben op bepaalde en leiden tot verstoring van gedrag. Sommige soorten worden door verlichting aangetrokken, terwijl andere soorten nauwelijks reactie lijken te vertonen. De dwergmeeuw is bijvoorbeeld een soort die gevoelig is voor licht (Tabel 6-21). De zeekoet, jan-van-gent, grote jager, grote mantelmeeuw en alk zijn niet erg gevoelig voor verstoring door licht (Tabel 6-21) (Tamis et al., 2011). De extra schepen die worden ingezet voor het Aramis initiatief volgen zoveel mogelijk bestaande scheepvaartroutes.

In totaal zullen maximaal 80 extra schepen uitvaren vanuit de haven van Rotterdam, waarvan 30 schepen mogelijk de scheepvaartroute langs of door de Bruine Bank volgen voor de aanleg van de zeeleiding. De schepen die uitvaren vanuit de haven van Amsterdam of Den Helder komen niet in de buurt van de Bruine Bank. De toename in scheepvaartverkeer is minimaal en tijdelijk, waardoor effecten van lichtuitstraling van schepen zijn uit te sluiten.

Conclusie niet-broedvogels
Significante effecten op de instandhoudingsdoelstellingen van de dwergmeeuw en andere niet-broedvogels door aanwezigheid van licht kunnen worden uitgesloten.

Effecten door beweging en optiek
De schepen die worden ingezet bij de aanleg van de zeeleiding zijn (in fases) in beweging. Vogels kunnen last ondervinden door bewegingen en aanwezigheid van schepen en daardoor worden verstoord. Vooral in de ruiperiode kunnen vogels gevoelig zijn voor optische verstoring.

De extra schepen die worden ingezet voor het Aramis initiatief volgen zoveel mogelijk bestaande scheepvaartroutes. In totaal zullen maximaal 80 extra schepen uitvaren vanuit de haven van Rotterdam, waarvan 30 schepen mogelijk de scheepvaartroute langs of door de Bruine Bank volgen voor de aanleg van de zeeleiding (Tabel 6-24). Deze toename in scheepvaartverkeer is minimaal te noemen en verspreidt zich over een periode van ongeveer 300 dagen. De schepen die uitvaren vanuit de haven van Amsterdam

of Den Helder komen niet in de buurt van de Bruine Bank. Er is geen sprake van effecten door beweging en optiek op niet-broedvogels in de Bruine Bank.

Conclusie niet-broedvogels
Significante effecten op de instandhoudingsdoelstellingen van de niet-broedvogels door beweging en optiek kunnen worden uitgesloten.

Effecten van verontreiniging
De vogelsoorten kunnen effecten van verontreiniging ondervinden door de lozing van boorgruis en boorvloeistof, regen- en spoelwater en sanitair afval. De meeste niet-broedvogelsoorten zijn beperkt gevoelig voor verontreiniging, de dwergmeeuw is gevoelig (Tabel 6-21). Effecten kunnen optreden via de voedselketen, de dwergmeeuw eet met name vis.

De lozing van schoon regen- en spoelwater bedraagt 6.500 ton en voor het sanitaire afval 250 ton. Hierbij wordt ervanuit gegaan dat er wordt voldaan aan de lozingsnormen uit de Mijnbouwwet, daarmee kunnen effecten van verontreiniging door de lozing van sanitair afval en regen- en spoelwater worden uitgesloten.

Bij de werkzaamheden worden delen van de leiding onder bestaande watergangen aangelegd. Dit vindt plaats door middel van boringen, waarbij Water Based Mud (WBM)-houdende boorvloeistof wordt gebruikt. Dit is een gebiedsvreemde stof, wat bestaat uit zoet of zout water als basis vloeistof met bariet ($BaSO_4$) of ilmeniet ($FeTiO_3$) als wegingsmiddel. Klei of organische polymeren worden toegevoegd om een homogene vloeistof te creëren. Andere chemicaliën (e.g. kalium formaat en verschillende glycolen) zorgen voor een optimale viscositeit en stabiliteit (Neff, 2005). De boorvloeistof en het boorgruis worden volgens de gangbare praktijk op zee geloosd. Het onderste deel van de putten wordt geboord met boorvloeistof op oliebasis. Deze boorvloeistof wordt afgevoerd naar land.

Er is onderzocht wat de potentiële schadelijkheid is van de toegepaste stoffen bij het gebruik van boorgruis- en spoeling voor de boringen (Paragraaf 6.3.1; Hurley & Ellis, 2004). Uit de literatuurstudie van Hurley & Ellis (2004) blijkt dat geen één van de onderzochte stoffen of een functionele groep van stoffen wordt aangemerkt als problematisch of als (onacceptabel) risico.

Een studie van Daan & Mulder (1993) toonde verder aan dat er 2 maanden na de lozing van WBM boorgruis (met een gewicht van circa 1.600 ton) in de buurt van platforms L3-3 en L6-3 in het Friese Front geen effecten op de benthische levensgemeenschappen optraden. Ook uit de survey die in 1992 bij L3-3 plaatsvond, één jaar na de lozing van het boorgruis, bleken er geen effecten op de benthische levensgemeenschappen, zelfs niet op een afstand van maar 25 m van het voormalige lozingspunt (Daan & Mulder, 1993a). Andere studies benoemen ook de lage acute toxiciteit van WBM, net zoals de afwezigheid van aantoonbare effecten van WBM-houdende boorvloeistof op de benthische levensgemeenschappen van sedimentrijke systemen (Park et al., 2001; Renaud et al., 2008). Mogelijke effecten van sedimentatie, als gevolg van de lozing van de boorvloeistof en het boorgruis, worden beoordeeld in de paragrafen ‘Effecten van vertroebeling en verandering dynamiek’. Als er geen effecten zijn op de benthische gemeenschap is de kans klein dat er een effect optreedt op vissen. Dwergmeeuwen ondervinden geen effecten van verontreiniging omdat er geen sprake van verontreiniging van hun voedsel.

Conclusie niet-broedvogels
De te lozen WBM-houdende boorvloeistof en boorgruis vormen geen risico op verontreiniging van de niet-broedvogels. Significante effecten door verontreiniging kunnen worden uitgesloten.

Effecten van vertroebeling
Vertroebeling van de waterkolom wordt veroorzaakt door het opwervelen van sediment tijdens het storten van steen bij kruisingen van infrastructuur en door de baggeractiviteiten ten behoeve van de aanleg van de zeeleiding.

De zeeleiding die wordt aangelegd bestaat uit twee secties; een nearshore gedeelte dat wordt begraven in de zeebodem tot KP70 en een offshore gedeelte dat op de zeebodem wordt gelegd tot KP198.4. De beoordeling van het ingraven van de zeeleiding tot KP70 is relevant voor de Voordelta en de Noordzeekustzone door de afstand van deze Natura 2000-gebieden tot de locatie waar de zeeleiding wordt

ingegraven. De vertroebelingspluim van de baggeractiviteiten nabij dit deel van het tracé reikt daarnaast tot maximaal drie kilometer aan weerszijden van het tracé (zie Figuur 6-3 en Figuur 6-4). De activiteiten ten behoeve van de aanleg van de zeeleiding vinden plaats op minstens 35 km van de Bruine Bank. Er is geen sprake van effecten door vertroebeling op niet-broedvogels in of nabij de Bruine Bank.

Effecten van vertroebeling kunnen ook optreden door de aanleg van de tweede sectie van de zeeleiding (het gelegde deel van de zeeleiding). Het gelegde deel van de zeeleiding bevat meerdere kruisingen met bestaande infrastructuur op de zeebodem. Naar verwachting gaat dit om 25 kruisingen van gemiddeld 500 meter (9,7% van de lengte van de tweede sectie van de zeeleiding). Deze kruisingen worden gerealiseerd door het storten van steen (*rock dump*) ter hoogte van de kruising van infrastructuur. Er kan lokaal vertroebeling optreden bij deze kruisingen. De zeebodem bestaat echter voor ongeveer 80% uit matig grof zand en voor maar 7% uit fijn zand en silt. De grovere zanddeeltjes hebben een valsnelheid tussen de 27 en 60 mm/s en slaan binnen een minuut neer op de bodem tot een maximale afstand van tien meter van de zeeleiding. Vertroebeling door het storten van steen zal dus slechts tijdelijk optreden. De activiteiten ten behoeve van het kruisen van infrastructuur vinden plaats op minstens 35 km van de Bruine Bank. Er is geen sprake van effecten door vertroebeling op niet-broedvogels in of nabij de Bruine Bank.

Conclusie niet-broedvogels
Significante effecten op de instandhoudingsdoelstellingen van de niet-broedvogels door vertroebeling kunnen worden uitgesloten.

Effecten van verandering dynamiek
Het baggeren van het slib zorgt voor een beperkte verhoging van de concentraties slib. Als het slib sedimenteert is er sprake van een beperkte toename in sedimentatie van maximaal 0.2 mm direct naast het tracé (Royal HaskoningDHV, Notitie vertroebeling en bodemberoering Aramis, 2023). Indirecte effecten van sedimentatie kunnen leiden tot een verminderd foerageersucces voor niet-broedvogels door bedekking van voedsel. De activiteiten ten behoeve van de aanleg van de zeeleiding vinden echter plaats op minstens 35 km van de Bruine Bank. Er is geen sprake van effecten door verandering van dynamiek op niet-broedvogels in of nabij de Bruine Bank.

Conclusie niet-broedvogels
Significante effecten op de instandhoudingsdoelstellingen van de niet-broedvogels door verandering van dynamiek kunnen worden uitgesloten.

6.5.2 Conclusie Bruine Bank

Significante effecten op de instandhoudingsdoelstellingen van niet-broedvogels worden uitgesloten.

6.6 Natura 2000-gebied Noordzeekustzone

De voor het Natura 2000-gebied Noordzeekustzone aangewezen habitattypen, habitatrichtlijnsoorten en vogelrichtlijnsoorten kunnen effecten ondervinden van de activiteiten bij de zeeleiding en de platforms met verbindingsleiding(en) voor de spurlines. De zeeleiding bevindt zich op ongeveer 37 km van de Noordzeekustzone en het dichtstbijzijnde platform en verbindingsleiding(en) voor de spurlines op ongeveer 41 km (L10-R). Er kan echter sprake zijn van externe werking op dit Natura 2000-gebied of van indirecte effecten. Hieronder wordt voor de relevante soorten beoordeeld of ze significant negatieve effecten ondervinden van bovengenoemde activiteiten.

6.6.1 Vissen

Het Natura 2000-gebied Noordzeekustzone is aangewezen voor de vissen rivierprik, zeeprik en fint. De instandhoudingsdoelstellingen voor deze vissen zijn uitbreiding populatie en behoud van omvang en kwaliteit leefgebied. De staat van instandhouding van de zeeprik, fint en elft is zeer ongunstig. De staat van instandhouding van de rivierprik is matig ongunstig.

Door de activiteiten kunnen de vissen effect ondervinden van trillingen en geluid, licht, beweging en optiek, verontreiniging, vertroebeling en verandering dynamiek. De effecten van deze storingsfactoren worden hieronder nader beoordeeld (zie voor een samenvattend overzicht Tabel 6-22Tabel 6-22).

Tabel 6-22. De gevoeligheid voor verstoring door geluid en trillingen, licht en beweging en optiek voor vissen (Effectenindicator Ministerie LNV).

Vissoort	Gevoeligheid			
	Onderwatergeluid & trilling	*Licht*	*Beweging en optiek*	*Verontreiniging*
Zeeprik	Gevoelig	Niet beoordeeld	Niet beoordeeld	Zeer gevoelig
Rivierprik	Gevoelig	Niet beoordeeld	Niet beoordeeld	Zeer gevoelig
Fint	Gevoelig	Niet beoordeeld	Niet beoordeeld	Zeer gevoelig

Schaal - Gevoeligheid voor verstoring (Effectenindicator Ministerie LNV)

Niet gevoelig	Gevoelig	Zeer gevoelig

Effecten door trillingen en geluid

Voor de aanleg van de zeeleiding en de installatie van de nieuwe platforms en putten worden verschillende schepen en helikopters ingezet (Bijlage 6). Vissen kunnen hinder ondervinden van het geluid dat hierbij vrijkomt. Ook bij het heien van de conductorpalen voor de nieuwe platforms en het boren van de nieuwe putten is er sprake van onderwatergeluid.

De zeeprik, de rivierprik en de fint zijn anadrome soorten, wat betekent dat volwassen vissen vanuit zee de rivieren optrekken om daar te paaien. Een belangrijk deel van het leven wordt echter op zee doorgebracht, waarbij de kustzone van groot belang is. Deze soorten hebben een zwemblaas.

Vissen hebben geen extern gehoororgaan. Geluid, in de vorm van drukverschillen onder water, kan door vissen op verschillende manieren worden waargenomen (Thomsen et al., 2006). Er wordt onderscheid gemaakt in gehoorspecialisten, waartoe soorten behoren met een relatief lage gehoordrempel en hoge gevoeligheid voor geluid, en gehoorgeneralisten: soorten die geen zwemblaas hebben of waarbij speciale structuren voor een efficiënte geluidsoverdracht ontbreken. De meeste bodemvissen, zoals platvissen en grondels, zijn gehoorgeneralisten terwijl de meeste vissen die hoger in de waterkolom leven gehoorspecialisten zijn.

In de Noordzeekustzone kunnen vissen mogelijk verstoord worden door onderwatergeluid van schepen.

Vissen zijn echter zeer mobiel en hebben genoeg uitwijkmogelijkheden om het onderwatergeluid te vermijden, mocht dit als te verstorend worden ervaren. Het tot nu toe gepubliceerde onderzoek laat zien dat vissen weinig tot geen directe negatieve effecten ondervinden van onderwatergeluid.

Conclusie vissen
De instandhoudingsdoelstelling behoud van omvang en behoud van kwaliteit leefgebied voor uitbreiding van de populatie voor de genoemde trekvissoorten komt niet door de voorgenomen activiteiten in gevaar en significant negatieve effecten kunnen worden uitgesloten.

Effecten door licht
De schepen die worden ingezet bij de aanleg van de zeeleiding en de installatie van de platforms en putten stralen licht uit. Verstoring door licht kan effect hebben op bepaalde vissoorten en leiden tot verstoring van gedrag. Sommige soorten worden door verlichting aangetrokken, terwijl andere soorten nauwelijks reactie lijken te vertonen. Omdat het een continu proces is, is het schip ook ’s nachts verlicht om het werk goed uit te kunnen voeren en de veiligheid van de bemanning te waarborgen. De verlichting is zodanig uitgevoerd dat onnodige lichtuitstraling wordt vermeden.

Pelagische vissen, zoals elft, zeeprik, rivierprik en fint , bevinden zich ’s nachts hoger en meer verspreid in de waterkolom terwijl ze overdag meer in scholen samenkomen en ze zich laag in de waterkolom bevinden (e.g. Acolas et al., 2004). Mogelijk kan er dus een effect van verlichting zijn in de nacht. Finten zijn echter naast zichtjagers ook filterfeeders (plankton) (Aprahamian et al., 2003; De Laak 2009), waardoor ze niet geheel afhankelijk van zicht om te jagen. Rivierprik en zeeprik jagen zowel op zicht als ‘geur’; zij kunnen prooidieren lokaliseren door het volgen van chemische sporen van de prooi (Maitland & Hatton-Ellis, 2003). Rivierprik en zeeprik zijn daarom waarschijnlijk minder gevoelig voor lichtverstoring in de waterkolom.

In de epipelagische zone (tot 200 m diepte) is er bovendien veel licht aanwezig waardoor lenzen van vissen die hier leven vaak lenspigmenten bevatten (Lisney & Collin, 2007). De pigmenten verminderen de spectrale bandbreedte en de intensiteit van het licht waardoor er 80% minder licht beschikbaar is voor het netvlies. Men vermoedt dat ze onder andere belangrijk zijn voor het beschermen van het netvlies. Sommige vissoorten kunnen ook de grootte en vorm van hun pupil sterk veranderen (Hart et al., 2006). Het kunnen bewegen van de pupil is nuttig om de hoeveelheid licht die het oog binnenkomt te kunnen reguleren (Van Gompel, 2016). Vissoorten die in de bovenste delen van de waterkolom voorkomen zijn dus vaak aangepast aan een lichte omgeving, waardoor lichtinval wordt gereguleerd.

De extra lichtuitstraling zal naar verwachting geen verstoring opleveren. Bovendien worden er standaard maatregelen getroffen om uitstraling van licht zoveel mogelijk te vermijden (Paragraaf 2.4).

Conclusie vissen
Significante effecten op de instandhoudingsdoelstellingen van vissen door aanwezigheid van licht kunnen worden uitgesloten.

Effecten door beweging en optiek
De schepen die worden ingezet bij de aanleg van de zeeleiding en de installatie van de nieuwe platforms en putten zijn (in fases) in beweging. Er is weinig bekend over de effecten van beweging en optiek op vissen. Trekvissen zijn echter mobiele soorten waardoor ze zich eenvoudig kunnen verplaatsen bij verstoring. Verstoring door beweging en optiek vindt daarnaast voornamelijk in het bovenste deel van de waterkolom plaats, waardoor vissen voldoende mogelijkheid hebben om uit te wijken.

Conclusie vissen
Significante effecten op de instandhoudingsdoelstellingen van vissen door beweging en optiek kunnen worden uitgesloten.

Effecten van verontreiniging
De elft, zeeprik, rivierprik en fint zijn erg gevoelig voor verontreiniging (Tabel 6-22). Er vinden in de (nabijheid) van de Noordzeekustzone geen lozingen plaats waardoor er geen sprake is van negatieve effecten.

Conclusie vissen
Significante effecten door verontreiniging op beschermde vissen kunnen worden uitgesloten.

Effecten van vertroebeling
De activiteiten ten behoeve van de aanleg van de zeeleiding en het lozen van de boorgruis vinden plaats op minstens 35 km van de Noordzeekustzone. Er is daardoor geen sprake van effecten door vertroebeling op vissen in of nabij de Noordzeekustzone.

Conclusie vissen
Significante effecten van vertroebeling op de instandhoudingsdoelstellingen van vissen kunnen worden uitgesloten.

Effecten van verandering dynamiek
De activiteiten ten behoeve van de aanleg van de zeeleiding en het lozen van de boorgruis vinden plaats op minstens 35 km van de Noordzeekustzone. Er is daardoor geen sprake van effecten door verandering van dynamiek op vissen in of nabij de Noordzeekustzone.

Conclusie vissen
Significante effecten van verandering van dynamiek op de instandhoudingsdoelstellingen van vissen kunnen worden uitgesloten.

6.6.2 Zeezoogdieren

Het Natura 2000-gebied Noordzeekustzone is aangewezen voor de zeezoogdieren bruinvis, grijze zeehond en gewone zeehond. De instandhoudingsdoelstellingen voor de bruinvis zijn behoud populatie en omvang leefgebied en verbetering kwaliteit leefgebied. De instandhoudingsdoelstellingen voor de grijze zeehond en gewone zeehond zijn behoud populatie, omvang leefgebied en kwaliteit leefgebied. De staat van instandhouding van de bruinvis, grijze en gewone zeehond is gunstig.

Door de activiteiten kunnen de zeezoogdieren effect ondervinden van trillingen en geluid, licht, beweging en optiek, verontreiniging, vertroebeling en verandering dynamiek. De effecten van deze storingsfactoren worden hieronder nader beoordeeld (zie voor een samenvattend overzicht Tabel 6-23).

Tabel 6-23. De gevoeligheid voor verstoring door geluid en trillingen, licht en beweging en optiek voor zeezoogdieren (Effectenindicator Ministerie LNV).

Zeezoogdiersoort	Gevoeligheid			
	Onderwatergeluid & trilling	*Licht*	*Beweging en optiek*	*Verontreiniging*
Bruinvis	Zeer gevoelig	Zeer gevoelig	Niet beoordeeld	Zeer gevoelig
Grijze zeehond	Zeer gevoelig	Zeer gevoelig	Zeer gevoelig	Zeer gevoelig
Gewone zeehond	Zeer gevoelig	Zeer gevoelig	Zeer gevoelig	Zeer gevoelig

Schaal - Gevoeligheid voor verstoring (Effectenindicator Ministerie LNV)

Niet gevoelig	Gevoelig	Zeer gevoelig

Effecten door trillingen en geluid
Voor de aanleg van de zeeleiding en de installatie van de nieuwe platforms en putten worden verschillende schepen en helikopters ingezet (Bijlage 6). Zeezoogdieren kunnen hinder ondervinden van het geluid dat hierbij vrijkomt. Ook bij het heien van de verankeringspalen voor de nieuwe platforms en de conductors en het boren van de nieuwe putten is er sprake van onderwatergeluid.

De te verwachten geluidsniveaus zijn bepaald in het Detailrapport Onderwatergeluid (RHDHV, 2023a). In paragraaf 6.1.5 staat een overzicht van de berekende geluidsniveaus voor het leggen van de pijp, baggeren,

heavy lift schip, boren van putten, machinegeluid, heien van verankeringspalen nieuwe platforms, conductorpijpen en het centrale eindpunt.

In de Noordzeekustzone zelf worden geen activiteiten uitgevoerd. De minimale afstand van de Noordzeekustzone tot aan de locatie (L10) waar heiactiviteiten plaats zullen vinden is 41,1 kilometer.

De minimale afstand van de Noordzeekustzone ten opzichte van het meest nabije platform waar sprake is van verstoring door continu geluid door scheepvaart en bagger- en pijplegwerkzaamheden is 36,9 kilometer. De mijdingsafstand van zeezoogdieren bij werkzaamheden zoals machinegeluid dat vrijkomt van het platform en het boren van injectieputten kan oplopen tot 100 kilometer wanneer er geen sprake is van verhoogd achtergrondgeluid (zie Tabel 6-1). Gezien er vrijwel in de gehele Noordzee sprake is van verhoogd achtergrondgeluid (de Jong et al., 2021), kan worden uitgegaan van een mijdingsafstand van 10 kilometer. Deze activiteiten hebben daardoor geen **direct** effect op de Noordzeekustzone, wel kan er sprake zijn van **indirecte** effecten. Schepen die vertrekken van of aankomen in de haven van Den Helder varen door de Noordzeekustzone, hier kan er wel sprake zijn van een direct effect.

Bruinvis

De gemiddelde dichtheid bruinvissen per km^2 bij de activiteiten die doorwerking kunnen hebben op de instandhoudingsdoelstellingen in de Klaverbank is een range tussen 1,20 en 2,0. Dichtheden zijn nader toegelicht in paragraaf 5.1.2 van deze beoordeling. Door deze dichtheden te vermenigvuldigen met het berekende verstoringsoppervlak, volgen schattingen van het aantal mogelijk verstoorde bruinvissen per dag dat de activiteiten met impulsgeluid worden uitgevoerd, wat uiteindelijk wordt door vertaald in het effect op de populatie door het totaal aantal bruinvisverstoringsdagen te berekenen en de populatiereductie (zie Tabel 6-3 en paragraaf 6.1.5). Het effect op populatieniveau resulteert in een range van 10.665 – 18.016 bruinvisverstoringsdagen en een populatiereductie (Noordzeepopulatie) van maximaal 7 bruinvissen. Daarnaast is er sprake van een overschrijding van de geluidsnorm door het heien van de verankeringspalen (zie paragraaf 6.1.5).

Er is momenteel nog geen methodiek om effecten van continu onderwatergeluid op de populatie bruinvissen te berekenen. Omdat het geluid van de schepen binnen de gehoorfrequentie van de bruinvis valt, kan er sprake zijn van verstoring in de vorm van masking, wat de mogelijke communicatie tussen bruinvissen tijdelijk negatief kan beïnvloeden. Dit kan effect hebben op populatieniveau, wat in theorie dus ook effect kan hebben op de instandhoudingsdoelstellingen van de bruinvis in de Noordzeekustzone. Er is echter nog te weinig onderzoek bekend over de effecten van continu geluid op het gedrag van bruinvissen en hoe dit effect heeft op populatieniveau om een kwantitatieve beoordeling te doen. Het is aannemelijk dat bruinvissen het verstoorde gebied voor langere tijd zullen mijden.

Anders dan in de andere Natura 2000-gebieden is er in de Noordzeekustzone wel sprake van een activiteit in het gebied. De scheepvaartbewegingen van en naar de haven van Den Helder nemen mogelijk sterk toe (maximaal 128% (zie Tabel 6-24). Een klein deel van de scheepvaartroute gaat door de Noordzeekustzone, waardoor een direct effect kan optreden. Alhoewel het hier gaat om een drukke scheepvaartroute is de mogelijke toename heel groot waardoor extra geluidsverstoring kan optreden.

Conclusie bruinvis

Fysieke schade zoals PTS en TTS worden niet verwacht door het gebruik van soft start waardoor de bruinvissen het gebied verlaten voordat er schade optreedt. De populatiereductie van 7 bruinvissen kan vertaald worden naar een afname van 0,007 tot 0,013% ten opzichte van de Nederlandse Noordzeepopulatie bruinvissen, wat betekent dat er wordt voldaan aan de maximale ecologisch toelaatbare reductie van 5%. Echter is hier geen rekening gehouden met activiteiten waarbij sprake is van continu onderwatergeluid, waarbij ook verstoring optreedt. Kijkende naar de werkzaamheden die rond de platformen in de Noordzee plaatsvinden, worden er circa 1 tot 2 jaar achter elkaar met een paar weken tussen de activiteiten in intensief werkzaamheden uitgevoerd. Het is aannemelijk dat bruinvissen het verstoorde gebied voor langere tijd zullen mijden. Een groot gebied zal hierdoor niet geschikt zijn als leefgebied van de bruinvis. In het geval van de Noordzeekustzone is er sprake van een **direct** effect (het onderwatergeluid door schepen vindt plaats in het gebied) en van een **indirect** effect, aangezien bruinvissen gebruikmaken van de gehele Noordzee en een effect op de Noordzeepopulatie een effect heeft op de

instandhoudingsdoelstelling van de bruinvis in de Noordzeekustzone. Directe en indirecte significante effecten op bruinvissen kunnen niet worden uitgesloten.

Gewone en grijze zeehond
Fysieke schade zoals PTS en TTS worden niet verwacht. De dichtheid van de gewone en grijze zeehond in het plangebied is maximaal 0,50 zeehonden per km^2. Eerder in dit hoofdstuk zijn de effecten van onderwatergeluid op zeehonden in de Noordzee beoordeeld (Tabel 6-2, Tabel 6-5, Tabel 6-6, Paragraaf 6.1.5). De verstoringsoppervlakten variëren per activiteit tussen de 54 en 314 km².

De percentages geven een indicatie weer van de verstoring, maar zijn niet goed bij elkaar op te tellen omdat dit een overschatting zal zijn. In de praktijk zijn de dichtheden op open zee lager en is het aannemelijk dat individuen meermaals worden verstoord door dezelfde of verschillende activiteiten. Ervan uitgaande dat activiteiten kort na elkaar met een aantal weken ertussen uitgevoerd gaan worden, zullen zeehonden het gebied voor een langere periode mijden. Aangezien de werkzaamheden 1 tot 2 jaar zullen duren, kan de mijdingsperiode ook oplopen tot een vergelijkbare periode.

Anders dan in de andere Natura 2000-gebieden is er in de Noordzeekustzone wel sprake van een activiteit in het gebied. De scheepvaartbewegingen van en naar de haven van Den Helder nemen mogelijk sterk toe (maximaal 128% (zie Tabel 6-29Tabel 6-24). Een klein deel van de scheepvaartroute gaat door de Noordzeekustzone, waardoor een direct effect kan optreden. De zandplaat Noorderhaaks die vlakbij de haven van Den Helder is gelegen wordt veel door zeehonden gebruikt om te rusten, pups te zogen en te verharen. Daarbij is het belangrijk dat ze in de buurt van de plaat kunnen foerageren. Alhoewel het hier gaat om een drukke scheepvaartroute is de mogelijke toename heel groot waardoor extra geluidsverstoring kan optreden en de periode dat ze kunnen foerageren wordt verkleind.

Conclusie zeehonden
Significante directe effecten van onderwatergeluid door een toename van scheepvaart kunnen niet worden uitgesloten. Er is geen sprake van indirecte significante effecten door de activiteiten buiten de Noordzeekustzone.

Effecten door licht
De schepen die worden ingezet bij de aanleg van de zeeleiding en de installatie van de platforms en putten stralen licht uit. Uitstraling van licht kan effect hebben op bepaalde soorten en leiden tot verstoring van gedrag. Bruinvissen en zeehonden zijn gevoelig voor (kunstmatige) verlichting (Tabel 6-23). De activiteiten ten behoeve van de aanleg van de nieuwe platforms, de aanpassingen aan bestaande platforms en de aanleg van de zeeleiding vinden echter plaats op minstens 35 km van de Noordzeekustzone. Effecten van lichtuitstraling van constructieschepen en platforms op zee kunnen worden uitgesloten.

Een aantal van de ondersteunende schepen zullen uitvaren vanuit de haven van Den Helder, waarbij de Noordzeekustzone wordt doorkruist. De ondersteunende schepen die worden ingezet voor het Aramis initiatief kunnen leiden tot verhoogde lichtuitstraling. Er zullen voor respectievelijk de aanleg van de microtunnel/ direct pipe, de aanleg van de zeeleiding, de werkzaamheden aan de platforms en de werkzaamheden aan de putten in totaal 6, 30, 457 en 1.651 extra scheepvaartbewegingen plaatsvinden (Bijlage 6). De constructieschepen (pijplegschip, heavy lift schip, baggerschip, trencher) varen uit vanaf de Rotterdamse haven. Alle scheepvaartbewegingen van constructieschepen zijn door de afstand tussen de haven en het Natura-2000 gebied Noordzeekustzone niet relevant voor de effectbeoordeling van de Noordzeekustzone.

Ondersteunende schepen (crew change, survey, pipe carriers, andere support vessels) kunnen uit zowel de Rotterdamse haven, als de Amsterdamse haven of Den Helder uitvaren, afhankelijk van de locatie waar de zeeleiding wordt aangelegd. Het is nog niet bekend hoeveel van deze ondersteunende schepen uitvaren vanuit de haven van Rotterdam en daarmee door of langs het plangebied varen. Echter, ervan uitgaande dat schepen zo efficiënt mogelijk worden ingezet, wordt de aanname gedaan dat de extra ondersteunende schepen die worden ingezet ten behoeve van de werkzaamheden aan de putten en platforms zullen uitvaren vanuit de haven van Amsterdam of Den Helder.

Als gevolg van het Aramis initiatief is de toename in scheepvaartbewegingen van ondersteunende schepen vanuit de haven van Den Helder/ Amsterdam maximaal 2.064 (Tabel 6-24). De ondersteunende schepen die worden ingezet voor de werkzaamheden aan de platforms en putten varen uit voor een periode van 1-2 jaar. In de haven van Den Helder vinden jaarlijks gemiddeld 1.600 (periode 2018-2021) bezoeken van zeeschepen (zonder visserij) plaats (Port of Den Helder, n.d.). Door het Aramis initiatief neemt het totaal aantal jaarlijkse zeescheepvaartbewegingen vanuit de haven van Den Helder toe met minimaal 1,3% en maximaal 128% (Tabel 6-25).

Tabel 6-24. Totaal aantal extra scheepvaartbewegingen ten behoeve van de activiteiten van het Aramis initiatief.

Activiteiten	Totaal aantal extra scheepvaart-bewegingen	Scheepvaartbewegingen Constructieschepen	Scheepvaartbewegingen Ondersteunende schepen
Aanleg tunnelwerk	6	4	2
Aanleg zeeleiding	30	8	22
Werkzaamheden platforms	457	18	**439**
Werkzaamheden putten	1.651	26	**1.625**
Totaal	2.144	56	2.088

Tabel 6-25. Percentuele toename van scheepvaart in de havens van Amsterdam en Den Helder als gevolg van het Aramis initiatief.

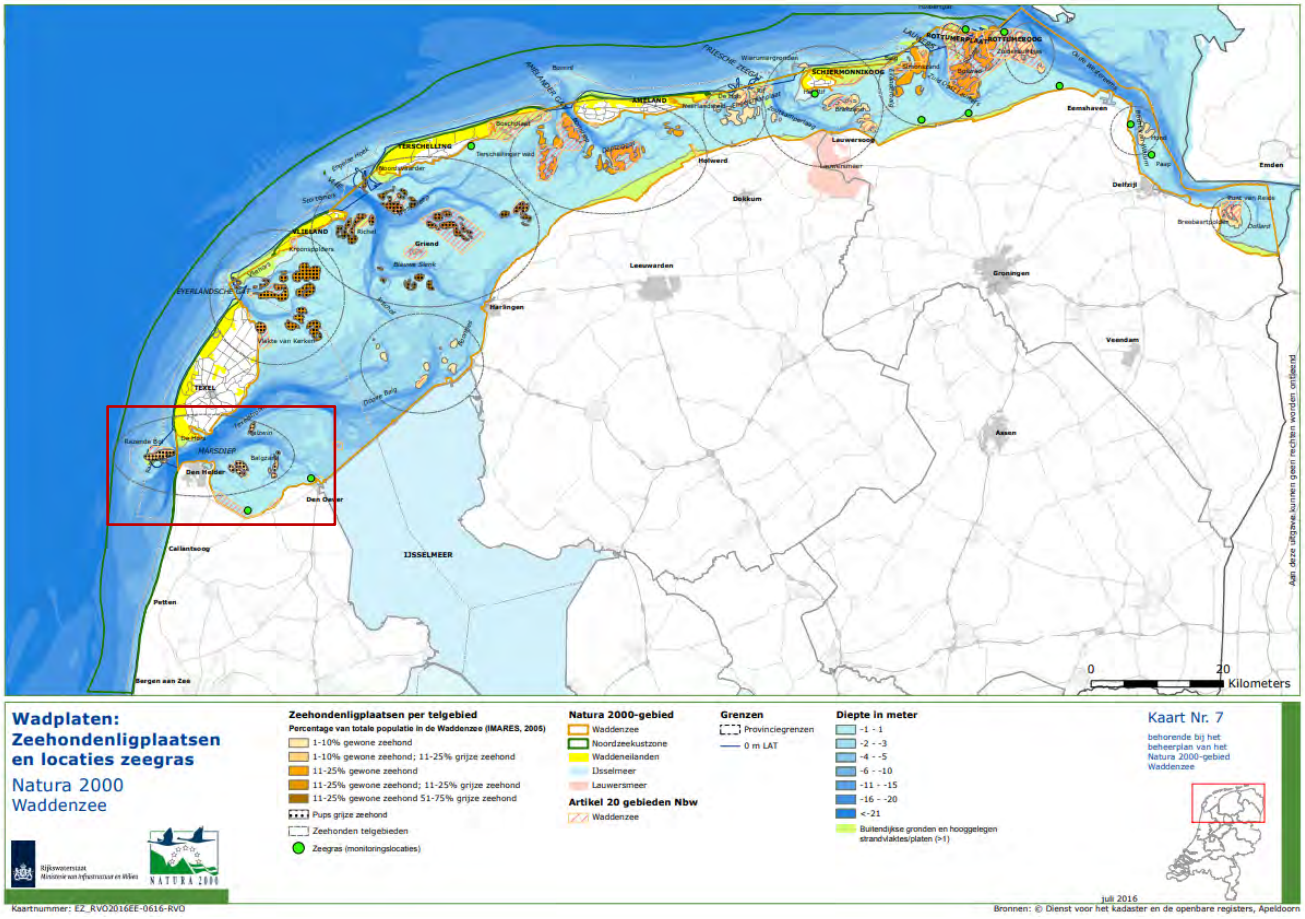
	Haven Amsterdam	Haven Den Helder
Huidig aantal uitvarende schepen per jaar [1]	5.300	1.600
Totale toename in ondersteunende schepen door het Aramis initiatief (worst-case: in 1 jaar)	2.064	2.064
Toename in scheepvaart in de havens door Aramis initiatief (worst-case scenario 1: 99% vaart uit vanaf Amsterdam)	99% van 2.064 = 2.043 schepen (5.300+2.043)/5.300 * 100% = 139% **Toename van 39% per jaar**	1% van 2.064 = 21 schepen (1.600+21)/1.600 * 100% = 101,3% **Toename van 1,3% per jaar**
Toename in scheepvaart door Aramis initiatief (worst-case scenario 2: 99% vaart uit vanaf Den Helder)	1% van 2.064 = 21 schepen (5.300+21)/5.300 * 100% = 100,4% **Toename van 0,4% per jaar**	99% van 2.064 = 2.043 schepen (1.600+2.043)/1.600 * 100% = 228% **Toename van 128% per jaar**
Toename in scheepvaart in de haven (minimaal-maximaal)	0,4-39%	1,3-128%

[1] Bronnen: Port of Den Helder, n.d., CBS Eurostat.

Indirect kan lichtuitstraling van de extra ondersteunende schepen effect hebben op de voedselinname van zeezoogdieren. Kunstmatige lichtuitstraling kan leiden tot een hoger vangstsucces voor zeehonden, omdat de prooi onderwater beter zichtbaar wordt (Becker et al., 2013; Yurk & Trites, 2000). Lichtverstoring is echter met name relevant voor zeehonden die zich boven het water bevinden op ligplaatsen. In de buurt van de haven van Den Helder zijn verschillende ligplaatsen van zeehonden aanwezig, zoals op de Noorderhaaks. Zeehonden zijn gevoelig voor verstoring op hun ligplaatsen en in hun foerageergebied. Verstoring leidt in eerste instantie tot een verhoogde alertheid. Langdurige verstoring kan leiden tot een verandering van het gebruik van het leefgebied, of tot het verlaten van het gebied (Reijnders et al., 2000). Over specifieke effecten van licht op rustende zeehonden is weinig bekend. Wel is bekend dat bruinvissen en zeehonden over het algemeen erg gevoelig zijn voor (kunstmatige) verlichting (zie Tabel 6-23).

Verstoring door geluid en licht, en optische verstoring treedt meestal echter gelijktijdig op en zodoende kunnen deze doorgaans als één verstoringsbron worden beschouwd. Over het algemeen is de reikwijdte van de lichtbelasting minder groot dan die van verstoringen door geluid of visuele verstoringen. Om deze

reden worden de effecten van schepen op zeezoogdieren verder beoordeeld in de paragrafen *Effecten door beweging en optiek, en geluid*.



Figuur 6-16. Zeehonden ligplaatsen in het Natura-2000 gebied Waddenzee (Rijkswaterstaat, 2016).

Effecten door beweging en optiek

De schepen die worden ingezet bij de aanleg van de zeeleiding en de installatie van de nieuwe platforms en putten zijn (in fases) in beweging. Verstoring door beweging en optiek kan effect hebben op soorten en leiden tot een verandering in gedrag.

Met name rustende zeehonden zijn gevoelig voor verstoring door beweging van objecten en personen (Tabel 6-23). Vanuit het havengebied van Den Helder zullen aanzienlijk meer schepen uitvaren ten behoeve van het Aramis initiatief (maximaal 2.064 in 1-2 jaar). De toename in scheepvaart kan leiden tot verstoring van rustende of zogende zeehonden op de Noorderhaaks. In een studie van Bouma et al. (2010) bleek echter dat de 41 onderzochte passages van baggerschepen langs de Noorderhaaks niet leidden tot gedragsveranderingen van rustende zeehonden. De afstanden tussen de ligplaatsen van de zeehonden en de schepen die werden onderzocht lagen tussen de 600 en 1.200 m, wat vergelijkbaar is met de afstanden tussen de schepen van het Aramis initiatief en de ligplaatsen van de zeehonden op de Noorderhaaks.

Het wordt daarom niet verwacht dat de zeehonden op de Noorderhaaks hun ligplaatsen zullen verlaten als gevolg van de extra schepen die worden ingezet voor het Aramis initiatief. Ook vinden er in het gebied tussen Den Helder en Texel veel menselijke activiteiten plaats, waardoor de zeehonden waarschijnlijk door gewenning minder gevoelig zijn voor verstoring dan in andere gebieden waar geen of in beperkte mate menselijke activiteiten plaatsvinden. Significant negatieve effecten van beweging en optiek door de inzet van de schepen (die de Noordzeekustzone doorkruisen) kunnen worden uitgesloten.

De activiteiten ten behoeve van de aanleg van de nieuwe platforms en putten, de aanpassingen aan bestaande platforms en de aanleg van de zeeleiding vinden plaats op minstens 35 km van de Noordzeekustzone. Significant negatieve effecten van beweging en optiek door de inzet van constructieschepen op zee kunnen worden uitgesloten.

Conclusie zeezoogdieren
Significante effecten op de instandhoudingsdoelstellingen van zeezoogdieren door beweging en optiek kunnen worden uitgesloten.

Effecten van verontreiniging
De bruinvis en gewone en grijze zeehond kunnen effecten van verontreiniging ondervinden door de lozing van boorgruis en boorvloeistof, regen- en spoelwater en sanitair afval. Bruinvissen en zeehonden zijn erg gevoelig voor verontreiniging (Tabel 6-23Tabel 6-23).

Er vinden in de (nabijheid) van de Noordzeekustzone geen lozingen plaats waardoor er geen sprake is van negatieve effecten.

Conclusie zeezoogdieren
Significante effecten op de instandhoudingsdoelstellingen van zeezoogdieren door verontreiniging kunnen worden uitgesloten.

Effecten van vertroebeling
Vertroebeling van de waterkolom wordt veroorzaakt door het opwervelen van sediment tijdens het storten van steen bij kruisingen van infrastructuur en door de baggeractiviteiten ten behoeve van de aanleg van de zeeleiding. Vertroebeling van het water leidt niet direct tot een verminderd vangstsucces voor zeezoogdieren, ook blinde dieren kunnen zich doorgaans goed in het wild redden (zie ook Paragraaf 6.2.3). De activiteiten ten behoeve van de aanleg van de zeeleiding vinden plaats op minstens 35 km van de Noordzeekustzone. Er is geen sprake van effecten door vertroebeling op zeezoogdieren in of nabij de Noordzeekustzone.

Conclusie zeezoogdieren
Significante effecten van vertroebeling op de instandhoudingsdoelstellingen van zeezoogdieren kunnen worden uitgesloten.

Effecten van verandering dynamiek
Het baggeren en verspreiden van het slib zorgt voor een beperkte verhoging van de concentraties slib. Als het slib sedimenteert is er sprake van een beperkte toename in sedimentatie (Royal HaskoningDHV, Notitie vertroebeling en bodemberoering Aramis, 2023). Indirecte effecten van sedimentatie kunnen leiden tot een verminderd foerageersucces voor zeezoogdieren door bedekking van voedsel. De activiteiten ten behoeve van de aanleg van de zeeleiding vinden echter plaats op minstens 35 km van de Noordzeekustzone. Er is geen sprake van effecten door verandering van dynamiek op zeezoogdieren in of nabij de Noordzeekustzone.

Conclusie zeezoogdieren
Significante effecten van verandering van dynamiek op de instandhoudingsdoelstellingen van zeezoogdieren kunnen worden uitgesloten.

6.6.3 Vogels

Het Natura 2000-gebied Noordzeekustzone is aangewezen voor een groot aantal niet-broedvogels. De niet-broedvogels aalscholver, roodkeelduiker en dwergmeeuw kunnen voorkomen in het plangebied (zie paragraaf 5.6.3) en worden hier beoordeeld. De instandhoudingsdoelstellingen voor deze niet-broedvogelsoorten zijn behoud omvang en kwaliteit leefgebied. De staat van instandhouding is gunstig voor de dwergmeeuw en de aalscholver en ongunstig voor de roodkeelduiker Tabel 6-26.

Vanwege de beperkte afstand tot het Waddengebied en het mogelijk voorkomen van broedvogels in of nabij het plangebied, worden ook de effecten van het Aramis initiatief op de broedvogels kleine mantelmeeuw,

grote stern en visdief nader beschouwd. Deze soorten hebben geen instandhoudingsdoelstelling in de Noordzeekustzone, maar wel in de Waddenzee. De kleine mantelmeeuw, grote stern en visdief hebben voor omvang en kwaliteit leefgebied een behoudsdoelstelling. De staat van instandhouding is zeer ongunstig voor de visdief en grote stern en gunstig voor de kleine mantelmeeuw.

Tabel 6-26. Overzicht doelstellingen van aangewezen niet-broed- en broedvogels Noordzeekustzone en Waddenzee. =: behoud. Trend: ~ geen trend aantoonbaar, 0 geen significante aantalsverandering, - significante afname (<5% per jaar), + significante toename (<5% per jaar).

Vogelsoort	Omvang leefgebied	Kwaliteit leefgebied	Trend laatste twaalf jaar (Sovon, 2020)	Staat van instandhouding
Niet-broedvogels				
Dwergmeeuw	=	=	~	Gunstig
Roodkeelduiker	=	=	0	Ongunstig
Aalscholver	=	=	0	Gunstig
Broedvogels				
Kleine mantelmeeuw	=	=	-	Gunstig
Grote stern	=	=	+	Zeer ongunstig
Visdief	=	=	-	Zeer ongunstig

Door de extra scheepvaart- en helikopterbewegingen in Den Helder kunnen vogels effect ondervinden van trillingen en geluid, licht en beweging en optiek. Omdat de dwergmeeuw, aalscholver en grote stern mogelijk ook verder op zee voorkomen in het plangebied, worden voor deze soort naast de effecten van scheepvaart eveneens de effecten van de aanleg van de platforms, putten en zeeleiding beoordeeld (Fugro, 2023). Het gaat om effecten door trillingen en geluid, licht, beweging en optiek, verontreiniging, vertroebeling en verandering dynamiek. De effecten van deze storingsfactoren worden hieronder nader beoordeeld (zie voor een samenvattend overzicht Tabel 6-27).

Tabel 6-27. De gevoeligheid voor verstoring door bovenwatergeluid en trillingen, licht en beweging en optiek voor de niet-broed- en broedvogels van Noodzeekustzone en Waddenzee (Effectenindicator Ministerie LNV).

Vogelsoort	Gevoeligheid			
	Geluid & trilling	*Licht*	*Beweging en optiek*	*Verontreiniging*
Niet-broedvogels				
Dwergmeeuw	Niet gevoelig	Gevoelig	Gevoelig [1]	Gevoelig
Roodkeelduiker	Niet gevoelig	Gevoelig	Gevoelig	Gevoelig
Aalscholver	Niet gevoelig	Gevoelig	Gevoelig	Gevoelig
Broedvogels				
Kleine mantelmeeuw	Niet gevoelig	Gevoelig	Niet gevoelig	Gevoelig
Grote stern	Niet gevoelig	Gevoelig	Zeer gevoelig [2]	Gevoelig
Visdief	Niet gevoelig	Gevoelig	Gevoelig	Gevoelig

[1] (Krijgsveld et al. 2022)
[2] Uit Garthe & Hüppop (2004) en Fliessbach et al. (2019) blijkt dat de grote stern niet zo heel gevoelig is voor beweging en optiek

Schaal - Gevoeligheid voor verstoring (Effectenindicator Ministerie LNV)

Niet gevoelig	Gevoelig	Zeer gevoelig

Royal HaskoningDHV

Scheepvaart

Voor de beoordeling van effecten van schepen is met name de scheepvaartroute vanuit de haven van Den Helder relevant, omdat dit de enige locatie is waar de schepen die worden ingezet voor het Aramis initiatief de Noordzeekustzone doorkruisen. Als gevolg van het Aramis initiatief is de toename in scheepvaartbewegingen van ondersteunende schepen vanuit de haven van Den Helder/Amsterdam maximaal 2.064 (439 + 1.625 schepen) (Tabel 6-28). De ondersteunende schepen die worden ingezet voor de werkzaamheden aan de platforms en putten varen uit voor een periode van 1-2 jaar. In de haven van Den Helder vinden jaarlijks gemiddeld 1.600 (periode 2018-2021) bezoeken van zeeschepen (zonder visserij) plaats (Port of Den Helder, n.d.). Door het Aramis initiatief neemt het totaal aantal jaarlijkse zeescheepvaartbewegingen vanuit de haven van Den Helder toe met minimaal 1,3% en maximaal 128% (Tabel 6-29).

Tabel 6-28. Totaal aantal extra scheepvaartbewegingen ten behoeve van de activiteiten van het Aramis initiatief.

Activiteiten	Totaal aantal extra scheepvaart-bewegingen	Scheepvaartbewegingen Constructieschepen	Scheepvaartbewegingen Ondersteunende schepen
Aanleg microtunnel/ direct pipe	6	4	2
Aanleg zeeleiding	30	8	22
Werkzaamheden platforms	457	18	**439**
Werkzaamheden putten	1.651	26	**1.625**
Totaal	2.144	56	2.088

Tabel 6-29. Percentuele toename van scheepvaart in de havens van Amsterdam en Den Helder als gevolg van het Aramis initiatief.

	Haven Amsterdam	Haven Den Helder
Huidig aantal uitvarende schepen per jaar [1]	5.300	1.600
Totale toename in ondersteunende schepen door het Aramis initiatief (worst-case: in 1 jaar)	2.064	2.064
Toename in scheepvaart in de havens door Aramis initiatief (worst-case scenario 1: 99% vaart uit vanaf Amsterdam)	99% van 2.064 = 2.043 schepen (5.300+2.043)/5.300 * 100% = 139% **Toename van 39% per jaar**	1% van 2.064 = 21 schepen (1.600+21)/1.600 * 100% = 101,3% **Toename van 1,3% per jaar**
Toename in scheepvaart door Aramis initiatief (worst-case scenario 2: 99% vaart uit vanaf Den Helder)	1% van 2.064 = 21 schepen (5.300+21)/5.300 * 100% = 100,4% **Toename van 0,4% per jaar**	99% van 2.064 = 2.043 schepen (1.600+2.043)/1.600 * 100% = 228% **Toename van 128% per jaar**
Toename in scheepvaart in de haven (minimaal-maximaal)	0,4-39%	1,3-128%

[1] Bronnen: Port of Den Helder, n.d., CBS Eurostat.

Helikoptervluchten

Den Helder Airport is de belangrijkste basis voor het transport met helikopters van werknemers van en naar offshore olie- en gasexploratie- en exploitatieplatforms op het Nederlandse deel van de Noordzee. Vogels kunnen hinder ervaren van overvliegende helikopters door de toename in bovenwatergeluid. In totaal neemt het aantal helikoptervluchten (retour) toe met 664 (Tabel 6-30).

Tabel 6-30. Totaal aantal extra helikopterbewegingen ten behoeve van de activiteiten van het Aramis initiatief.

Activiteiten	Totaal aantal extra helikopterbewegingen
Werkzaamheden platform K14-FA	50
Werkzaamheden putten K14-FA	2

Activiteiten	Totaal aantal extra helikopterbewegingen
Werkzaamheden platform L10-R	2
Werkzaamheden putten L10-R	300
Werkzaamheden platform L4-A	76
Werkzaamheden putten L4-A	234
Totaal	664

Effecten door trillingen en geluid
Voor de aanleg van de zeeleiding en de installatie van de nieuwe platforms en putten worden verschillende schepen en helikopters ingezet. De vogels zijn niet gevoelig voor effecten van geluid en trillingen, significant negatieve effecten zijn uitgesloten.

Conclusie vogels
Significante effecten van geluid en trilling op de instandhoudingsdoelstellingen van de dwergmeeuw, roodkeelduiker, aalscholver, kleine mantelmeeuw, grote stern en visdief kunnen worden uitgesloten.

Effecten door licht
De schepen die worden ingezet bij de aanleg van de zeeleiding en de installatie van de platforms en putten stralen licht uit. Uitstraling van licht kan ervoor zorgen dat vogels gedesoriënteerd raken en van hun migratie- of foerageerroute afwijken, wat tot verhoogde sterfte kan leiden (Lieske et al., 2019). Door het Aramis initiatief neemt het totaal aantal jaarlijkse zeescheepvaartbewegingen vanuit de haven van Den Helder toe met minimaal 1,3% en maximaal 128% (Tabel 6-29).

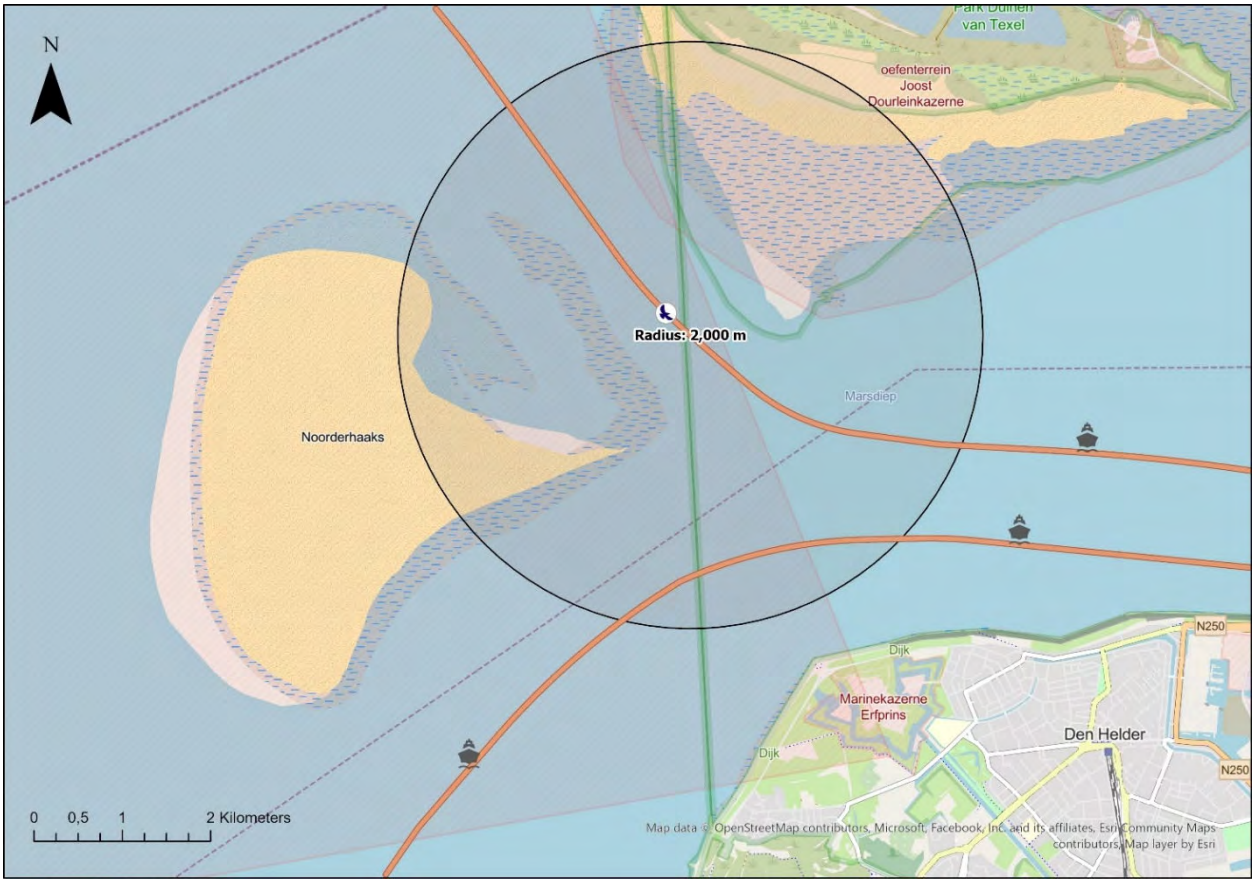
Er is onvoldoende informatie beschikbaar om aan te tonen of een toename in lichtuitstraling wel of niet een significant effect op de populaties heeft (OSPAR, 2015). Verstoring door geluid en licht, en optische verstoring treedt meestal gelijktijdig op en zodoende kunnen deze doorgaans als één verstoringsbron worden beschouwd. Over het algemeen is de reikwijdte van de lichtbelasting minder groot dan die van verstoringen door geluid of visuele verstoringen. Om deze reden worden de effecten van schepen op vogels verder beoordeeld in de paragraaf *Effecten door beweging en optiek.*

Effecten door beweging en optiek
Door het Aramis initiatief neemt het totaal aantal jaarlijkse zeescheepvaartbewegingen vanuit de haven van Den Helder toe met minimaal 1,3% en maximaal 128% (Tabel 6-2). De schepen die worden ingezet bij de aanleg van de zeeleiding en de installatie van de nieuwe platforms en putten zijn (in fases) in beweging. Optische verstoring leidt tot vluchtgedrag van vogels. Vogels reageren bijvoorbeeld op beweging omdat een potentiële vijand wordt verwacht. Daarnaast kan optische verstoring het uitzicht van soorten beperken waardoor zij potentiële vijanden niet zien naderen. Dit betekent dat de vogels hinder kunnen ondervinden door bewegingen en aanwezigheid van schepen.

Garthe & Hüppop (2004) deden onderzoek naar het vlucht- en vermijdgedrag van verschillende zeevogels bij verstoring door scheepvaart- en helikopterverkeer. In totaal kregen 26 vogelsoorten een score toebedeeld - op basis van extensief onderzoek vanaf boten op zee - tussen de 0 (nauwelijks vlucht- en vermijdgedrag waarneembaar/zeer korte vluchtafstand) en 5 (sterk waarneembaar vlucht- en vermijdgedrag/ grote vluchtafstand). Vooral duikende soorten zoals de aalscholver (score 4) en de roodkeelduiker (score 4) blijken zeer gevoelig voor verstoring door schepen en helikopters. Dit beeld is vergelijkbaar met het onderzoek van Fliessbach et al. (2019) naar de response van 26 zeevogels in de Duitse Noordzee en Baltische Zee op verstoring door schepen. Op basis van de indicatoren 'soorten schuwheid', 'energiekosten voor vluchten', 'potentieel voor uitwijken' werd als onderdeel van het onderzoek een Disturbance Vulnerability Index (Verstoringsgevoeligheidsindex; DVI) berekend. Een score dichtbij 0 betekent dat de vogel niet gevoelig is voor verstoring door schepen, terwijl een score van 100 een grote gevoeligheid weergeeft. De aalscholver (DVI 24,2) en roodkeelduiker (DVI 77,8) zijn de twee soorten die – van de vogelsoorten die worden beoordeeld - het meest gevoelig zijn voor optische verstoring door scheepvaart (Tabel 6-31).

Van de roodkeelduiker en aalscholver is verder bekend dat zij bij verstoring over het algemeen ver wegvliegen van de verstoringsbron en traag terugkeren naar hun oorspronkelijk verblijfplaats (Krijgsveld et al., 2022). Als de schepen van het Aramis initiatief op korte afstand komen van rustende of foeragerende vogels, bestaat de kans dat de vogels moeten uitwijken naar alternatief gebied en hierdoor tijdelijk foerageer- of leefgebied verliezen. Vooral de roodkeelduiker kan tot op grote afstand (tot 2.000 m) worden verstoord door bewegende objecten (Tabel 6-31). Het is niet uit te sluiten dat de schepen binnen de verstoringscontouren van de roodkeelduiker zullen varen, aangezien de afstand tussen het schip en de verblijfplaats van de roodkeelduiker dan op elk punt van de scheepvaarroute groter zou moeten zijn dan 2 km (Figuur 6-17). Dit laatste is gezien de dimensies van de vaarroute niet mogelijk. Vogels die in het gebied voorkomen zullen echter in meer of mindere mate zijn gewend aan het geluid, licht en de beweging die voorkomt uit de voorbijgaande schepen, waardoor ze minder gevoelig zullen zijn voor verstoring. Een toename in scheepvaart kan leiden tot enige extra verstoring van de roodkeelduiker, maar dit is niet significant.

De grote stern (score 2), kleine mantelmeeuw (score 2), visdief (score 2) en dwergmeeuw (score 1) zijn minder gevoelig voor verstoring door schepen en helikopters (Garthe & Hüppop, 2004 en Fliessbach et al. (2019)). Significant negatieve effecten van beweging en optiek op deze vogels zijn uit te sluiten.



Figuur 6-17. De verstoringscontouren van de roodkeelduiker (radius 2 km) waarbinnen de vogel gevoelig is voor optische verstoring.

Tabel 6-31. Gevoeligheid van niet-broed- en broedvogels voor verstoring door schepen (Krijgsveld et al., 2022). Gevoeligheidsindex voor scheepvaart: 0 niet gevoelig, 100 heel gevoelig.

Vogelsoort	Verstoringsafstand broedseizoen	Verstoringsafstand buiten broedseizoen	Terugkeertijd na verstoring	Gevoeligheidsindex Fliessbach et al., 2019.
Niet-broedvogels				
Dwergmeeuw	n.v.t.	250 m	Redelijk snel terug op foerageer-plekken; lange terugkeertijd op rustplekken	12.0
Roodkeelduiker	n.v.t.	2.000 m	Traag; vliegen vaak ver weg	77,8
Aalscholver	n.v.t.	250 m	Grote groepen keren traag terug, vliegen vaak ver weg van verstoringslocatie	24,4
Broedvogels				
Kleine mantelmeeuw	250 m	n.v.t.	Redelijk snel terug op foerageerplekken	6.7
Grote stern	500 m	n.v.t.	Snel terug op foerageerplekken en broedkolonies, en lange terugkeertijd op rustplekken	6.7
Visdief	250 m	n.v.t.	Snel in foerageergebied, maar traag bij rustplekken	3.0

Conclusie vogels
Significante effecten op de instandhoudingsdoelstellingen van de dwergmeeuw, roodkeelduiker, aalscholver, kleine mantelmeeuw, grote stern en visdief door beweging en optiek kunnen worden uitgesloten.

Effecten van verontreiniging
Er vinden in de (nabijheid) van de Noordzeekustzone geen lozingen plaats waardoor er geen sprake is van negatieve effecten.

Conclusie vogels
Significante effecten op de instandhoudingsdoelstellingen van vogels door verontreiniging kunnen worden uitgesloten.

Effecten van vertroebeling
Omdat de dwergmeeuw, aalscholver en grote stern mogelijk ook verder op zee voorkomen in het plangebied, kunnen deze vogels effecten ondervinden van vertroebeling als gevolg van de activiteiten verder op zee. Vertroebeling van de waterkolom wordt veroorzaakt door het opwervelen van sediment tijdens het storten van steen bij kruisingen van infrastructuur en door de trenchactiviteiten ten behoeve van de aanleg van de zeeleiding. De troebele pluim die hierdoor ontstaat kan leiden tot verminderd doorzicht op zee. Als gevolg van de aanleg van de zeeleiding kan de troebelheid in de waterkolom lokaal toenemen tot

een maximale zwevende stof concentratie van 47,2 mg/L in de waterkolom (RHDHV, Achtergrondrapportage Vertroebeling en Bodemberoering, 2023).

Een direct effect van vertroebeling kan een verminderd vangstsucces van vogels zijn. De dwergmeeuw zoekt voedsel echter terwijl hij boven het wateroppervlak vliegt waarna hij al vliegend prooien pakt van het wateroppervlak. De soort foerageert dus niet op waterdiepten waar vertroebeling plaatsvindt en zal geen effect van vertroebeling ondervinden. De grote stern en aalscholver zijn soorten die wel op enkele meters diepte duiken voor vis. Door het trenchen van de zeeleiding kan mogelijk het zicht onderwater worden beperkt, waardoor het vangstsucces van deze vogelsoorten kan afnemen. Van de aalscholver is verder bekend dat deze soort alternatieve (minder troebele) foerageergebieden opzoekt als een water troebeler is door bijvoorbeeld windwerking (Van Rijn & Van Eerden, 2003). Het is daarom mogelijk dat er tijdens de aanleg van de zeeleiding lokaal enkele vierkante kilometers aan foerageergebied verloren gaan, en de soort zal uitwijken naar alternatief foerageergebied. De vertroebeling als gevolg van de aanleg van de zeeleiding is echter lokaal (tot 3 km aan weerszijden van de zeeleiding) en van tijdelijke aard, waardoor significant negatieve effecten van vertroebeling zijn uit te sluiten. De vogels hebben voldoende uitwijkmogelijkheden om te foerageren in het plangebied en omliggend gebied.

Indirecte effecten van vertroebeling kunnen optreden als het vangstsucces van de vogels afneemt, doordat vissen hinder ondervinden van de vertroebeling in de waterkolom. De aalscholver eet in zoute wateren voornamelijk platvis (schol). Platvissen komen op de bodem voor, waar van nature vertroebeling optreedt door o.a. golfwerking. Omdat deze soorten dus zijn aangepast aan troebele omstandigheden, zal de lokale en beperkte toename in zwevend stofgehalte geen effect hebben op het voedselaanbod van de aalscholver. De grote stern foerageert op een grote verscheidenheid aan vissoorten, zoals haring, sprot, zandspiering en smelt. Het gaat hier om mobiele vissoorten die in staat zijn om uit te wijken voor een lokale troebele pluim. Significant negatieve indirecte effecten zijn uit te sluiten.

De dwergmeeuw leeft op zee vermoedelijk van kreeftachtigen, die hij van het wateroppervlak oppikt. Kreeftachtigen zijn relatief kortlevende, snelgroeiende en snel reproducerende organismen. Herstel na een verstoring (zoals een storm of mechanisme ingreep) vindt voor deze soorten doorgaans binnen één tot enkele jaren plaats (Kleijberg et al., 2017). Omdat de effecten van vertroebeling lokaal zijn en van tijdelijke aard, en kreeftachtigen relatief snel herstellen, worden indirecte effecten van vertroebeling uitgesloten.

Conclusie vogels
Significante effecten op de instandhoudingsdoelstellingen van de dwergmeeuw, aalscholver en grote stern door vertroebeling kunnen worden uitgesloten.

Effecten van verandering dynamiek
Omdat de dwergmeeuw, aalscholver en grote stern mogelijk ook verder op zee voorkomen in het plangebied, kunnen deze vogels effecten ondervinden van sedimentatie als gevolg van de activiteiten verder op zee. Het baggeren en verspreiden van het slib zorgt voor een beperkte verhoging van de concentraties slib. Als het slib sedimenteert is er sprake van een beperkte toename in sedimentatie. Sedimentatie als gevolg van het trenchen van de zeeleiding is maximaal 0,20 mm tot op 3 km aan weerszijden van de zeeleiding (RHDHV, Achtergrondrapportage Vertroebeling en Bodemberoering, 2023).

Directe effecten van sedimentatie zijn uitgesloten, omdat de dwergmeeuw, aalscholver en grote stern niet foerageren op waterdiepten waar sedimentatie voorkomt. Indirecte effecten van sedimentatie kunnen optreden als het vangstsucces van de vogels afneemt, doordat vissen hinder ondervinden van de sedimentatie op de bodem. De aalscholver eet in zoute wateren voornamelijk platvis (schol). Schol komt overdag voor in dieper water, ingegraven in de bodem. De verwachting is dat de toename in sedimentatie (maximaal 0,20 mm) als gevolg van het trenchen van de zeeleiding geen effect zal hebben op de mogelijkheden voor de schol om zich in te graven. Sedimentatie heeft geen effect op het voedselaanbod van de aalscholver. De aalscholver is bovendien een opportunistische soort, wat betekent dat hij zijn prooikeuze en selectie van visgrootte kan aanpassen aan het lokale voedselaanbod.

De grote stern foerageert op een grote verscheidenheid aan vissoorten, zoals haring, sprot, zandspiering en smelt. Het voedsel van jonge sprot bestaat bijvoorbeeld vooral uit kiezelalgen (diatomeeën). Oudere sprot voedt zich met zoöplankton, met name larven van kreeftachtigen en pelagische viseieren. Doordat

juveniele sprot naast prooien in de waterkolom ook prooien van in of op de bodem eet, kan extra sedimentatie leiden tot verminderde voedselinname van de sprot. Omdat de effecten van sedimentatie naar verwachting echter zeer lokaal zullen zijn en de grote stern op verschillende soorten vis foerageert, zijn indirecte effecten van sedimentatie op de grote stern uit te sluiten.

De dwergmeeuw leeft op zee vermoedelijk van kreeftachtigen, die hij van het wateroppervlak oppikt. Over het algemeen geldt dat kreeftjes de capaciteit hebben om bij sedimentatie op tijd weg te zwemmen of anders zichzelf uit te graven. Kreeftachtigen kunnen een toename in ventilatie regelen of opgelost zuurstof in het sediment gebruiken. Bij de meeste kreeftachtigen zal sedimentatie tot 15 cm weinig effect hebben (Rozemeijer & Smith, 2017).

Conclusie vogels
Significante effecten op de instandhoudingsdoelstellingen van de dwergmeeuw, aalscholver en grote stern door verandering van dynamiek kunnen worden uitgesloten.

6.6.4 Conclusie Noordzeekustzone

Voor de Noordzeekustzone kan het volgende geconcludeerd worden:
- Significante effecten op trekvissen kunnen worden uitgesloten;
- Significante effecten op zeezoogdieren door geluid en trillingen kunnen niet worden uitgesloten, hierbij gaat het om directe en indirecte effecten op de bruinvis (heiwerkzaamheden en scheepvaart) en directe effecten op zeehonden (scheepvaart);
- Significante effecten op niet-broedvogels en broedvogels kunnen worden uitgesloten.

6.6.5 Mitigerende maatregelen Noordzeekustzone

De volgende mitigerende maatregelen dienen naast de standaard maatregelen uitgevoerd te worden om significante effecten te voorkomen:
- In de Noordzeekustzone kunnen directe en indirecte significante effecten door onderwatergeluid op bruinvissen niet worden uitgesloten (indirecte effecten op de gehele Noordzee populatie). Daarom dienen mitigerende maatregelen te worden genomen bij de heiwerkzaamheden en scheepvaart. Deze zijn opgenomen in paragraaf 6.1.7;
- Significante directe effecten van onderwatergeluid door een toename van scheepvaart op zeehonden kunnen niet worden uitgesloten. Daarom dienen mitigerende maatregelen te worden genomen met betrekking tot scheepvaart. Deze zijn opgenomen in paragraaf 6.1.7.
- Schepen dienen op een afstand van 1.500 m afstand te blijven van rustende en zogende zeehonden.

6.7 Gebruiksfase

Tijdens de gebruiksfase is er sprake van de volgende activiteiten op zee:
- Scheepvaartbewegingen van havens naar platforms en weer terug

Effecten door trillingen en geluid
Schepen in de haven en op zee veroorzaken onderwatergeluid tijdens het varen, lossen en aanmeren gedurende de gebruiksfase. De voorziene activiteiten omvatten het lossen van een barge met een volume (cargo tank gross volume 100%) van 6500 m^3, het nestgeluid van een afgemeerde barge en het varen van schepen (uitgaande van een vermogen van 2 MW. Daarnaast kunnen incidenteel inspecties worden uitgevoerd door middel van remotely operated camera's (ROVs) of bodemscans.

In de onderwatergeluidsrapportage (RHDHV, 2023) wordt gesteld dat het varen van de schepen het meeste onderwatergeluid oplevert. Brongeluid van middelgrote barge schepen worden als worst-case aangehouden met een geluidsrange van 250 Hz t/m 1 kHz. De afstanden tot het bereiken van een achtergrondgeluidniveau van 130 dB re 1 µPa en daarmee mijding door zeezoogdieren van de (werk-)locatie komt neer op 300 meter in luide omstandigheden en 150 meter bij minder luide omstandigheden. Een geluiddrukniveau van 150 dB re 1 µPa wordt enkele tientallen meters afstand van de bron bereikt.

Het aantal scheepvaartbewegingen in de gebruiksfase vindt plaats vanuit de havens naar de platforms voor onderhoud. Jaarlijks worden er 325 scheepvaartbewegingen verwacht. Op dit moment is het onduidelijk vanuit welke havens deze bewegingen plaatsvinden. Aangezien het gaat om een klein aantal extra scheepvaartbewegingen per jaar kunnen significante effecten worden uitgesloten.

Effecten door licht
Effecten door licht op schepen zijn kleiner dan tijdens de aanlegfase, aangezien er sprake is van beduidend minder scheepvaartbewegingen. Effecten in de aanlegfase zijn beschreven in voorgaande paragrafen en beoordeeld als niet significant. Significante effecten door licht kunnen voor alle soorten worden uitgesloten.

Effecten door beweging en optiek
Effecten door beweging en optiek door schepen zijn kleiner dan tijdens de aanlegfase, aangezien er sprake is van beduidend minder scheepvaartbewegingen. Effecten in de aanlegfase zijn beschreven in voorgaande paragrafen en beoordeeld als niet significant. Significante effecten door beweging en optiek kunnen voor alle soorten worden uitgesloten.

Conclusie gebruiksfase
- Significante effecten van de activiteiten in de gebruiksfase kunnen worden uitgesloten.

6.8 Aanvullende beoordeling

In deze aanvullende beoordeling is gekeken naar toekomstige ontwikkelingen die mogelijk relevant zijn voor het Aramis initiatief. Deze ontwikkelingen vallen buiten het toetsingskader en geven alleen een doorkijk naar mogelijk effecten. Er kunnen pas eventuele maatregelen geformuleerd worden als er meer informatie beschikbaar is.

6.8.1 Toekomstige Vogelrichtlijngebieden

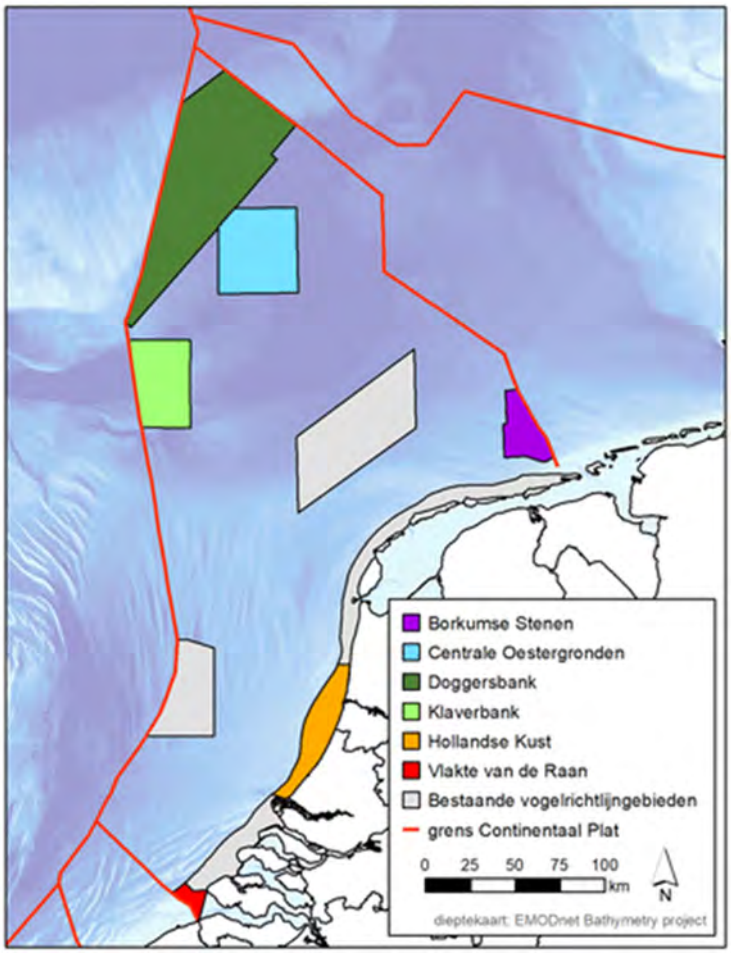
In het Noordzee Akkoord is afgesproken om in het Nederlandse deel van de Noordzee een samenhangend representatief netwerk van beschermde mariene gebieden te realiseren. Er is hiervoor onderzoek gedaan naar een zestal nieuwe gebieden die mogelijk aangewezen worden tot Vogelrichtlijngebied, zie Figuur 6-18. Naar verwachting worden vier van de zes gebieden in 2025 formeel aangewezen als Vogelrichtlijngebied. Er zijn nog geen instandhoudingsdoelstellingen en maatregelen bekend, deze zullen in het volgende beheerplan opgenomen worden dat na 2025 wordt opgesteld.

Hollandse Kust is het meest nabijgelegen gebied en ligt ten noorden van de terminal, de aanlegsteigers en waar de pijpleiding de zeebodem ingaat (microtunneling/ direct piping). In het verrichtte vooronderzoek is aangetoond dat Hollandse Kust een belangrijk gebied is voor diverse meeuwsoorten en de grote stern, mogelijk ook voor de zwarte zee-eend (Fijn, de Jong, et al., 2022).

Kust- en zeevogels kunnen effecten ondervinden van verstoring door trillingen en geluid, licht, beweging en optiek, verontreiniging en vertroebeling door het aanleggen van het verzamelpunt en het aanleggen van de zeeleiding. Deze effecten zijn nader onderzocht voor soorten vogels in Paragraaf 6.2 Natura 2000-gebied Voordelta, waaruit als conclusie is gekomen dat significante effecten zijn uit te sluiten. Aangezien de Hollandse kust verder van de werkzaamheden af ligt, zullen effecten van verstoring door licht, beweging en optiek, verstoring door trillingen en geluid minder merkbaar zijn dan in de Voordelta. Relevante effecten van vertroebeling en verontreiniging die ook indirecte gevolgen kunnen hebben voor de voedselbeschikbaarheid, zijn nader onderzocht en als niet significant beschouwd. Het is de verwachting dat significante effecten kunnen worden uitgesloten voor de Hollandse Kust.

De Doggersbank, Klaverbank en Centrale Oestergronden zijn potentiële gebieden die als Vogelrichtlijngebied worden aangewezen en liggen verder op zee. De Klaverbank is momenteel alleen aangewezen als Habitatrichtlijngebied. Recent onderzoek en tellingen laten zien dat in dit gebied grote aantallen vogels aggregeren waaronder een aantal soorten meeuwen, de zeekoet, alk en jan-van-gent (Fijn, de Jong, et al., 2022). Duikende vogels die gevoelig zijn voor onderwatergeluid zoals de zeekoet kunnen hier mogelijk significante effecten ondervinden, zoals is gesteld in de conclusie bij het Friese Front in

Paragraaf 6.3. De Doggersbank, Klaverbank en Centrale Oestergronden liggen verder af van de werkzaamheden. Omdat er nog geen instandhoudingsdoelstellingen zijn om effecten op soorten te toetsen, kunnen effecten (ondanks het feit dat er voor de zeekoet mitigerende maatregelen worden getroffen) niet op voorhand uitgesloten worden.



Figuur 6-18. Potentiële vogelrichtlijngebieden in de Noordzee (Bron: Waardenburg Ecology).

6.8.2 Toekomstig bodembeschermingsgebied in de Voordelta

In aanvulling op het huidige bodembeschermingsgebied in de Voordelta (Figuur 3-1) is een nieuw bodembeschermingsgebied in voorbereiding, ten noorden van het huidige bodembeschermingsgebied. De verwachting is dat de minister van Natuur en Stikstof het Toegangsbeperkingsbesluit begin volgend jaar neemt.

De exacte begrenzing van het toekomstig bodembeschermingsgebied was ten tijde van het opstellen van dit rapport nog niet bekend. Ook de beperkingen die zullen gelden in het gebied (een verbod op bodemberoerende visserij of een verbod op alle bodemberoerende activiteiten) is nog niet duidelijk. In voorgaande paragrafen zijn de bodemberoerende activiteiten als gevolg van het voornemen in beeld gebracht. Doordat de begrenzing en de voorgenomen beperkingen nog niet bekend zijn, kunnen de gevolgen voor het voornemen nog niet in beeld worden gebracht.

6.8.3 Herstel platte oester in het Friese Front

Als onderdeel van het in 2020 gesloten Noordzeeakkoord is afgesproken dat binnen het Friese Front een gebied van 100 km^2 wordt aangewezen voor oesterherstel. Voorafgaand aan het vaststellen van de exacte

locatie van het oesterherstelgebied, is in 2022 onderzoek gedaan naar de geschiktheid van het sediment in het Friese Front voor het herstel van de platte oester. Het onderzoek toonde aan dat de twee onderzoeksgebieden in het oosten en westen van het Friese Front geschikt zijn voor oesterherstel (Figuur 6-19; A en B). Binnen ieder gebied zijn geen duidelijke gradiënten geobserveerd in aanwezigheid van schelpen, wat gezien wordt als geschikt voor platte oesterherstel, of lage slibgehaltes, wat ook wordt beschouwd als geschikt voor rif ontwikkeling (Kamermans et al., 2022).In het Noordzeeoverleg van 11 mei 2022 hebben de leden overeenstemming bereikt; de onderzoeksgebieden zijn aangewezen als oesterherstelgebieden in het Friese Front. In de twee aangewezen gebieden van ieder 50 km^2 kunnen oesterbanken zich herstellen door het uitsluiten van bodemberoerende visserij (Figuur 6-19).

Door de voorgenomen activiteiten van het Aramis initiatief kunnen mogelijk effecten van vertroebeling, verandering dynamiek en verontreiniging optreden op de oesterherstelgebieden in het Friese Front. Effecten van verontreiniging op bodemdieren zijn reeds uitgesloten in Paragraaf 6.3.1 – *Effecten van verontreiniging.*

Effecten van vertroebeling
Bij de werkzaamheden aan platforms K14-FA, L10-R en L4-A worden nieuwe putten geboord, waarbij Water Based Mud (WBM)-houdende boorvloeistof en boorgruis wordt gebruikt voor de bovenste delen van de put. Daarbij Door de lozing van met name boorvloeistof kan vertroebeling van de waterkolom optreden. Uit een modelstudie van de lozing van boorvloeistof van 12 putten bij platform N05-A (Royal HaskoningDHV, 2020) blijkt dat bij één boring de maximale toename in slibconcentratie ten opzichte van een achtergrondconcentratie van 5-20 mg/l bij het boorplatform circa 12 mg/l is op een afstand van 5 km van het boorplatform.

Effecten op oesters
Tweekleppigen zoals oesters zijn, vanwege hun aanpassingsmechanismen, in het algemeen vrij tolerant voor vertroebeling. Toch kunnen ze een effect ondervinden door blootstelling aan vertroebeling. Effecten zijn onder andere vermindering van voedselactiviteit en respiratie en verhoging van de pseudofaecesproductie en energieverbruik (Wilber & Clarke, 2001).

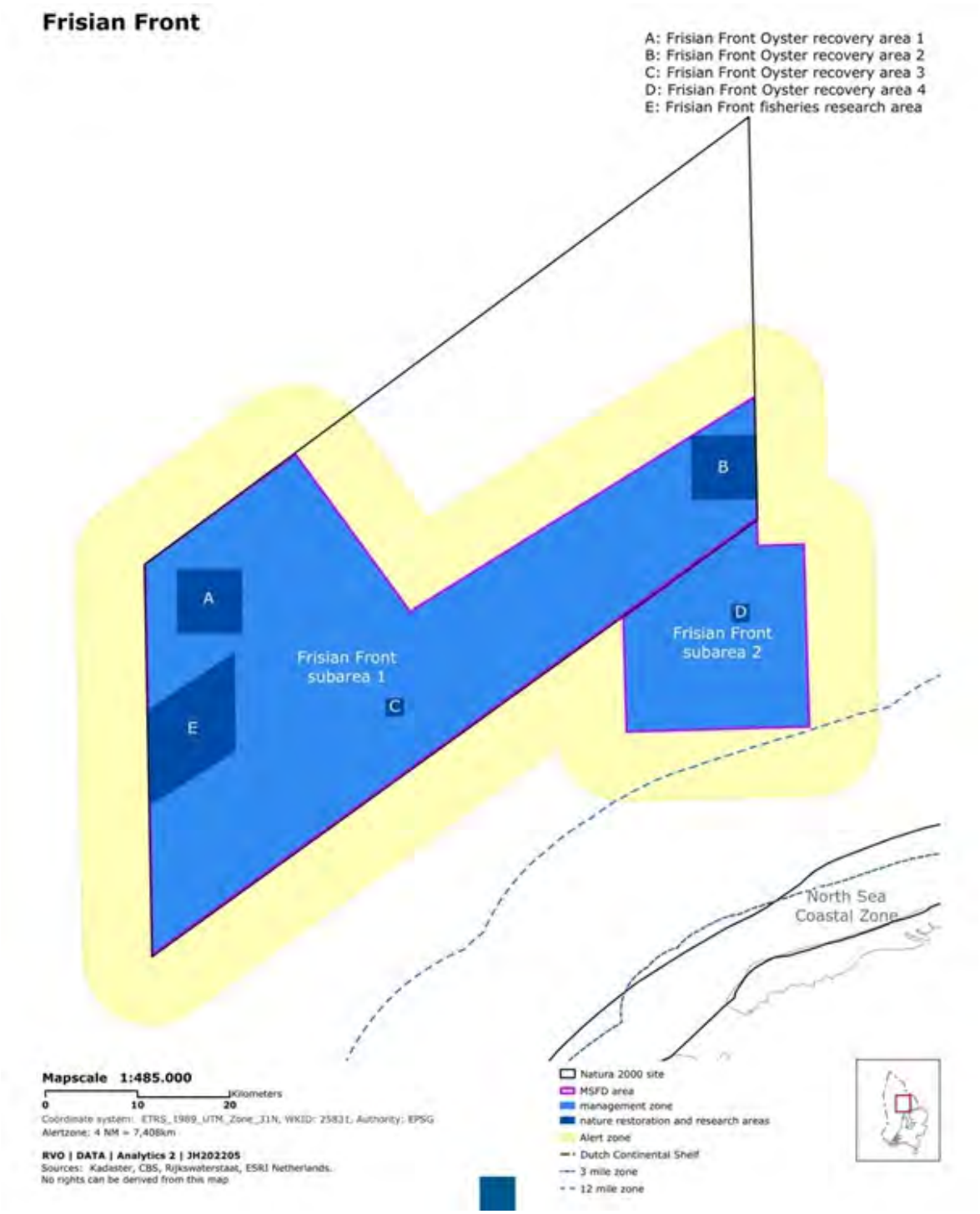
Een randvoorwaarde voor een gezonde oesterbank is een laag (<90 mg/l) zwevend stofgehalte (Smaal et al., 2017; Kamermans et al., 2018). Kortdurende vertroebeling en verhoging van sedimentatie zal naar verwachting geen groot effect hebben op een platte oesterbank en de bijbehorende soorten (Perry & Tyler-Walters, 2016).

Bij een verhoging van 12 mg/l na één boring en een achtergrondconcentratie van 5 - 20 mg/l in het Friese Front (Suijlen & Duin, 2002) ontstaat een concentratie van 32 mg/l. Bij het Aramis project is er sprake van 12 – 14 boringen in totaal, waarbij er 8 – 12 boringen in de omgeving van het Friese Front plaatsvinden. Wanneer de putten achter elkaar worden geboord is er sprake van een lange periode met lozingen en een toename van 12 mg/L. Wanneer meerdere putten tegelijk worden geboord is er mogelijk sprake van een grotere toename, afhankelijk van de stromingen en het weer. Er is geen sprake van een effect als de toename niet leidt tot een vertroebeling van > 90 mg/L in het Friese Front.

Effecten van verandering dynamiek
Op basis van een modelstudie van de lozing van boorgruis van 12 putten bij platform N05-A (Royal HaskoningDHV, 2020) is een inschatting gemaakt van de verspreiding van het boorgruis op de boorlocatie van de nieuwe putten bij platforms L10-R en L4-A (zie ook Paragraaf 6.3.1 – *Effecten van verandering dynamiek*). Uit de modelstudie van N05-A bleek dat bij twaalf boringen de extra sedimentatie binnen een straal van 105 m rond het platform 1,5 cm zou zijn. Daarbuiten zou geen tot een verwaarloosbaar kleine hoeveelheid extra sedimentatie zichtbaar zijn.

Effecten op oesters
In Rozemeijer & Smith (2017) wordt een overzicht gegeven van de sedimentdiktes waarbij bodemdieren sterven. Dit verschilt per soort, de ene soort is gevoeliger voor bedekking dan de andere. Er wordt een range van 1,5 – 15 cm genoemd, waarbij wordt aangegeven dat de meeste tweekleppige schelpdieren een sedimentlaag van 10 cm kunnen overleven. De toename in sedimentatie van 1,5 cm valt in de ondergrens van de genoemde sedimentdiktes (1,5-15 cm) waarbij sterfte kan optreden. De afstand tussen de boorlocaties van platforms K14-FA, L10-R en L4-A en de oesterherstelgebieden is daarnaast vele malen

groter dan 105 m (minimaal 7,8 km), waardoor sedimentatie op de locatie van de oesterherstelgebieden verder dan 1,5 cm zal zijn afgenomen. De sedimentatie valt hiermee onder de range van sedimentdiktes waarbij de overleving van de oesters in gevaar komt. Effecten van sedimentatie op de oesterherstelgebieden in het Friese Front zijn uitgesloten.



Figuur 6-19. Oesterherstelgebieden in het Friese Front. A. en B. Oesterherstelgebieden van elk 50 km², C. en D. Pilotgebieden oesterherstel, E. Onderzoek naar impact van bodemberoering.

6.8.4 Seismisch onderzoek

Naast bovenstaande constructiewerkzaamheden zijn TotalEnergies en Shell van plan om voor aanvang van de injectie een 3D seismische survey uit te voeren en een vergelijkbare survey na het eind van de injectie fase. Deze survey 's zijn standaard operaties in de olie en gas wereld en gaan gepaard met bootbewegingen en onderwatergeluid om door middel van zogenaamde "airguns" een akoestisch (seismisch) signaal op te wekken.

TotalEnergies gaat voor beide opslaglocatie (L4-A) een 3D survey uitvoeren van elk ongeveer 425 km^2. Shell zal ook een 3D survey gaan doen van ongeveer 425 km^2. Neptune Energy is niet van plan om een 3D survey uit te voeren.

Deze 3D seismische survey 's en shallow seismisch onderzoek vallen buiten het MER en deze Passende Beoordeling en zijn onderdeel van de Opslagvergunning. Het kan zijn dat er een vergunning en/of ontheffing aangevraagd moet worden aangezien 3D seismisch survey's effect kunnen hebben op het onderwaterleven en diersoorten die gevoelig kunnen zijn voor onderwatergeluid zoals bruinvissen, zeehonden en duikende vogels. Dit zal in een seperate procedure plaatsvinden.

7 Cumulatie – zeedeel

Om de effecten op de staat van instandhouding goed te kunnen beoordelen is het noodzakelijk om te kijken naar de cumulatieve effecten van andere projecten die in dezelfde periode als het Aramis initiatief worden uitgevoerd. Voor het beoordelen van deze mogelijke cumulatieve effecten wordt gekeken naar de periode vanaf wanneer Aramis op zijn vroegst zal starten met de aanlegfase tot en met de afronding van de eerste uitbreidingsfase in de aanlegfase. De gebruiksfase is lastig te beoordelen op cumulatieve effecten omdat de route van de schepen die CO_2 gaan vervoeren nog niet duidelijk is. In de volgende paragrafen is toegelicht welke projecten worden meegenomen en is vervolgens de cumulatietoets uitgewerkt.

7.1 Hoe is het optreden van cumulatieve effecten onderzocht?

In de Omgevingswet wordt op twee manieren rekening gehouden met cumulatie. Enerzijds op grond van gevolgen voor Natura 2000-gebieden en anderzijds door te toetsen aan een gunstige staat van instandhouding van een soort.

Bij het onderdeel soorten en de toelichting daarop wordt echter niet gesproken over het onderwerp cumulatie. Er worden ook geen eisen gesteld aan wat wel of niet dient te worden meegenomen in de cumulatieve effectbeoordeling. Echter, omdat getoetst moet worden aan de gunstige staat van instandhouding, zal elke activiteit die een negatief effect hierop kan hebben in de beoordeling meegenomen moeten worden, tenzij die al geacht mag worden verwerkt te zijn in de gehanteerde inschatting van de staat van instandhouding (Rijkswaterstaat, 2015a). Bij mobiele soorten die zich over landgrenzen heen bewegen en niet gebonden zijn aan beschermde gebieden zoals zeezoogdieren, grote vissoorten en zeevogels moet de borging van de instandhouding feitelijk op biogeografische populatieniveau plaatsvinden. Om deze reden dient er gekeken te worden naar activiteiten die invloed kunnen hebben op de staat van instandhouding binnen het gehele leefgebied van deze soorten. Voor dit project wordt evenals in het KEC de ‘management unit’ Noordzee als het leefgebied van de bruinvis beschouwd.

De volgende projecten worden meegenomen in de cumulatietoets:
- Projecten waar een vergunning voor is verleend die nog niet zijn uitgevoerd, waarvan uitvoering is gepland in de periode 2026 - 2028;
- Projecten die tussen 2026 – 2028 worden uitgevoerd volgens het Programma Noordzee maar waarvoor nog geen vergunningen zijn verleend (alleen wind op zee);
- Projecten die effecten hebben op beschermde soorten waarvan in het huidige project negatieve effecten op beschermde soorten niet uit zijn te sluiten.

De volgende projecten/activiteiten worden niet meegenomen in de cumulatietoets:
- Onzekere toekomstige gebeurtenissen;
- Projecten die na de eerste uitbreidingsfase (2028) starten;
- Projecten die reeds zijn uitgevoerd, dan wel bestaande activiteiten, waar geen Natuurbeschermingswet (of na 1 januari 2024 Omgevingswet)-vergunning voor benodigd was. Deze projecten maken deel uit van de bestaande situatie en zijn al verwerkt in de staat van instandhouding, of hebben geen of nauwelijks effecten.

De projecten die in deze cumulatietoets worden beschouwd conform puc.overheid.nl en de Wind op Zee routekaart zijn beschreven in de volgende paragrafen. In de cumulatietoets worden alleen negatieve effecten die niet significant zijn meegenomen.

In de cumulatietoets worden alleen de niet-significante effecten meegenomen omdat het doel is om te kijken of niet-significante effecten in cumulatie alsnog significant worden. Significante effecten van onderwatergeluid door heien en scheepvaart op de bruinvis door Aramis kunnen niet worden uitgesloten. Significante effecten van het heien van twee platforms op de zeekoet in het Friese Front kunnen niet worden uitgesloten en hetzelfde geldt voor effecten van scheepvaart op de gewone en grijze zeehond in de Noordzeekustzone. Er zijn mitigerende maatregelen geformuleerd om significante effecten te voorkomen. Deze effecten worden niet meegenomen in de cumulatietoets.

7.1.1 Net op Zee IJmuiden Ver Alpha

Vanaf 1 maart 2024 staan aanlegwerkzaamheden van Net op Zee IJmuiden Ver Alpha gepland. LNV heeft hier een vergunning voor afgegeven in januari 2021. Dit project omvat een aanlegfase waarbij een ondergronds kabelsysteem wordt aangelegd voor het transport van gelijkstroom vanuit het platform op zee (IJmuiden Ver Alpha), bestaande uit vier kabels die naar land lopen. Voor het aanleggen van het kabelsysteem wordt Horizontal Directional Drilling (HDD) uitgevoerd. Voor het plaatsen van het platform zal in een worst-case scenario maximaal 16 dagen geheid worden voor de installatie van een jacket, de aanleg van het platform zal plaatsvinden vanaf 2026. In 2024 vinden mogelijk geofysische survey's plaats en zal de kabelaanleg vervolgens starten (Arcadis, Pondera, 2021a). Mogelijke ecologische effecten kunnen in de aanlegfase optreden op de Natura 2000-gebieden Voordelta, het Veerse Meer en de Bruine Bank. De kabellijn loopt door de Voordelta en de Bruine Bank ligt nabij, ten westen van de kabels (Figuur 7-1).

Ecologische effecten die optreden betreffen: vertroebeling en sedimentatie, verstoring als gevolg van continu en impulsgeluid onderwater, verstoring boven water door geluid, licht en visuele verstoring (van het platform), habitataantasting op zee door mechanische effecten en elektromagnetische straling afkomstig van de kabels.

7.1.2 Net op Zee IJmuiden Ver Bèta en Gamma

Voor de aanleg van Net op Zee Béta wordt in de MER beschreven dat door de parallelligging van het Net op zee IJmuiden Ver Alpha en het Net op zee IJmuiden Ver Beta de effectbeoordeling vergelijkbaar is. Het oppervlak dat verstoord wordt zal in totaal wel kleiner zijn doordat de corridor netto smaller is over een lengte van 79 km (iets meer dan de helft van de lengte van het VKA-tracé), maar verstoring is hetzelfde aangezien twee keer een kabelgeul wordt gegraven. Het tracé Gamma loopt ca. 128 km parallel aan Béta. In de MER worden de volgende opties verkend (Arcadis, Pondera, 2021b, 2022):

- Béta en Gamma tracé worden mogelijk tegelijkertijd met Alfa aangelegd;
- Alfa, Béta en Gamma worden telkens met één jaar ertussen aangelegd;
- Net op Zee Alfa en Béta worden tegelijkertijd aangelegd en één jaar erna Gamma;
- Eerst wordt Alfa aangelegd en één jaar erna Béta en Gamma tegelijkertijd.

Voor de aanleg van Net op Zee IJmuiden Ver Bèta en Gamma zijn nog geen vergunningen afgegeven, maar deze zullen hoogstwaarschijnlijk in de periode 2024 – 2029 aangelegd worden. Ecologische effecten die optreden zijn: vertroebeling en sedimentatie, verstoring als gevolg van continu en impulsgeluid onderwater, verstoring boven water door geluid, licht en visuele verstoring habitataantasting op zee door mechanische effecten en elektromagnetische straling afkomstig van de kabel (Arcadis, Pondera, 2021b).

7.1.3 Net op Zee - Nederwiek 1, 2 en 3

Volgens de tijdlijn gepubliceerd op RVO[17] in diverse informatiepagina's is de realisatie van Net op Zee Nederwiek 1 gepland vanaf 2024 en Nederwiek 2 staat gepland vanaf 2025. Er is nog geen planning van Nederwiek 3 bekend.

Het project Net op Zee Nederwiek 1 bestaat uit de volgende hoofdonderdelen:

- Een platform op zee voor de aansluiting van de windturbines en het omzetten van wisselstroom (afkomstig van de windturbines) naar 525 kV-gelijkstroom;
- Een ondergronds gebundeld kabeltracé op zee en door het Veerse Meer voor het transport van 525 kV-gelijkstroom;
- Een ondergronds gebundeld kabeltracé op land voor het transport van 525 kV-gelijkstroom naar het converterstation;
- Een converterstation op land voor het omzetten van 525kV-gelijkstroom naar 380kV-wisselstroom, dat geschikt is voor het landelijk hoogspanningsnet (Ministerie van LNV, 2023a).

[17] *https://www.rvo.nl/onderwerpen/bureau-energieprojecten/lopende-projecten*

Het project Nederwiek 2 bestaat uit de volgende hoofdonderdelen:
- Een platform op zee voor de aansluiting van de windturbines en het om zetten van wisselstroom (afkomstig van de windturbines) naar 525kV-gelijkstroom;
- Een ondergronds kabeltracé op zee voor het transport van 525kV-gelijkstroom op zee;
- Een ondergronds gebundeld kabeltracé op land voor het transport van 525kV-gelijkstroom naar het converterstation op land (de aanlanding);
- Een converterstation op land voor het om zetten van 525kV-gelijkstroom naar 380kV-wisselstroom;
- Een ondergronds kabeltracé op land voor het transport van 380 kV-wisselstroom van het converterstation naar een nieuw te bouwen 380kV-hoogspanningsstation voor de aansluiting op het landelijke hoogspanningsnet (Ministerie van LNV, 2023b).

Ecologische effecten die optreden zijn: vertroebeling en sedimentatie, verstoring als gevolg van continu en impulsgeluid onderwater, verstoring boven water door geluid, licht en visuele verstoring, habitataantasting op zee door mechanische effecten en elektromagnetische straling afkomstig van de kabel.

Voor Net op Zee Nederwiek 3 is zoals gezegd nog geen planning bekend. Ook de ecologische effecten zijn nog niet in beeld gebracht. Dit voornemen wordt daarom niet meegenomen in de cumulatietoets.

7.1.4 Wind op zee Nederland

In het Programma Noordzee 2022-2027 zijn windenergiegebieden aangewezen waar de komende jaren windparken ontwikkeld worden. De planning conform website van de rijksoverheid (10 juni 2022) voor de ingebruikname van windparken is als volgt[18]:
- Hollandse Kust West kavels VI en VII – 2025 – 2026
- IJmuiden Ver Beta – 2028
- IJmuiden Ver Alpha – 2029
- IJmuiden Ver kavels V en VI – 2029
- Nederwiek kavels I en II – 2030
- Nederwiek kavel III – 2031
- Hollandse Kust West kavel VIII – nader te bepalen
- Ten Noorden van de Waddeneilanden kavel I – 2031
- Doordewind kavels I en II - 2031

Dit betekent dat de aanleg van Hollandse Kust West en IJmuiden Ver Beta relevant zijn. Omdat in het Kader Ecologie Cumulatie (KEC) naar cumulatie van onderwatergeluid is gekeken voor alle windparken is deze als basis gebruikt voor deze verstoringsfactor.

Er is sprake van effecten van onderwatergeluid op zeezoogdieren, vogelslachtoffers door aanvaringen en habitatverlies, verstoring van vogels en zeezoogdieren door licht, beweging en optiek en stikstofdepositie.

[18] https://open.overheid.nl/documenten/ronl-7438902539596226b438ef329f782cf1a8a05aee/pdf



Figuur 7-1. Windenergie op zee inclusief kabelroutes van het net op zee (Windopzee.nl, 2023)

7.1.5 Seismisch onderzoek Shell P&O mijnbouwblokken

Shell wil een 3D seismisch onderzoek (survey) uitvoeren op de Noordzee (in de zogeheten P & O mijnbouwblokken) om te onderzoeken of CO2 opgeslagen kan worden in ondergrondse aquifers. Dit valt onder de noemer Carbon Capture and Storage (CCS). Voor het onderzoek zal in totaal 51 dagen worden gevaren waarvan 25 dagen daadwerkelijk seismisch onderzoek wordt uitgevoerd. Het voorgestelde onderzoeksgebied ligt ten westen van de kust van de provincie Zuid-Holland tussen de Maasvlakte en Zandvoort. Op het dichtstbijzijnde punt bevindt het onderzoeksgebied zich ongeveer 10 km van de Nederlandse kustlijn bij de Maasvlakte. Westwaarts strekt het onderzoek zich uit tot de grens tussen de Exclusieve Economische Zone (EEZ) Nederland en het Verenigd Koningrijk (VK). Het voorgestelde onderzoeksgebied zal een oppervlakte van bijna 1.500 km^2 beslaan. Inclusief de vaarlijnen beslaat het werkgebied bijna 2.300 km^2. Het seismisch onderzoek overlapt met circa 85 km^2 het Natura 2000-gebied Bruine Bank en nadert het Natura 2000-gebied Voordelta tot op een afstand van 6,5 km. Er is een Nbwet vergunning afgegeven die geldig is tot april 2026. Volgens de passende beoordeling wordt het project uitgevoerd in 2024. Dit project overlapt daardoor niet met Aramis CCS, maar doordat er achtereenvolgend vergelijkbare effecten optreden kan er alsnog een cumulatief effect ontstaan. Daarom is het project wel meegenomen in de cumulatietoets.

Effecten die optreden zijn verstoring van zeezoogdieren door onderwatergeluid en verstoring van vogels en zeezoogdieren door licht, beweging en optiek en stikstofdepositie (Royal HaskoningDHV, 2023b).

7.1.6 Exploratieboring P11-B Johan de Liefde

Dana Petroleum Netherlands B.V. opereert sinds 2006 het platform P11-B-De Ruyter, dat is geplaatst in de Nederlandse Exclusieve Economische Zone (EEZ). Dana NL is van plan om vanaf het P11-B-De Ruyter platform een exploratieput te boren naar het Johan de Liefde prospect in het naburige P10b mijnbouwblok. Exploratie prospecten zijn mogelijke gasvoorkomens waarvan nog moet worden aangetoond of winbare hoeveelheden aardgas aanwezig zijn. De boring zal plaatsvinden van de locatie van platform P11-B-De Ruyter. Dit platform ligt in de Nederlandse EEZ in mijnbouwblok P11b. Deze locatie ligt ongeveer 65 km ten noordwesten van Hoek van Holland en 20 km ten oosten van de Nederlands-Britse grenslijn. De locatie lig op een veilige afstand van scheepvaartroutes en kabels en leidingen van derden. Recent is het gebied rond het platform P11-B-De Ruyter aangemerkt als Natura 2000-gebied Bruine Bank, maar het platform zelf is hiervan uitgezonderd (geëxclaveerd). De vergunning is geldig t/m december 2025, maar volgens de passende beoordeling wordt het project uitgevoerd in 2023 – 2024. Dit project overlapt daardoor niet met Aramis CCS, maar doordat er achtereenvolgend vergelijkbare effecten optreden kan er alsnog een cumulatief effect ontstaan. Daarom is het project wel meegenomen in de cumulatietoets.

Effecten die optreden zijn verstoring zeezoogdieren door onderwatergeluid en verstoring van vogels en zeezoogdieren door licht, beweging en optiek en stikstofdepositie (Royal HaskoningDHV, 2023a).

7.1.7 Overzicht projecten cumulatietoets

In tabel 7-1 is een overzicht opgenomen van de projecten die worden meegenomen in de cumulatietoets, met een tijdsplanning en de relevante effecten.

*Tabel 7-1. Overzicht van projecten die worden meegenomen in de cumulatietoets en relevante effecten voor cumulatie. * inschatting vergunningsperiode*

Project	Planning	Relevante effecten
Aramis CCS	2026 – 2028	Vertroebeling, onderwatergeluid, verstoring door licht en beweging/optiek, stikstofdepositie
Net op Zee IJmuiden Ver Alpha	2024 – 2027	Vertroebeling, onderwatergeluid, verstoring door licht en beweging/optiek, stikstofdepositie
Net op Zee IJmuiden Ver Beta en Gamma*	2024 – 2029	Vertroebeling, onderwatergeluid, verstoring door licht en beweging/optiek, stikstofdepositie
Net op Zee Nederwiek 1 en 2	2025 – 2030	Vertroebeling, onderwatergeluid, verstoring door licht en beweging/optiek, stikstofdepositie
Wind op Zee Nederland*	2024 – 2031	Onderwatergeluid, verstoring door licht en beweging/optiek, stikstofdepositie
Seismisch onderzoek Shell	2024 - 2026	Onderwatergeluid, verstoring door licht en beweging/optiek, stikstofdepositie
Exploratieboring P11-B	2023 - 2024	Vertroebeling, onderwatergeluid, verstoring door licht en beweging/optiek, stikstofdepositie

7.2 Effecten van vertroebeling

Aramis CCS
Effecten van vertroebeling kunnen op zee ontstaan door het ingraven van de Aramis nearshore zeeleiding met een trench schip en het aftoppen van zandgolven op de Noordzeebodem. Door het ingraven van de nearshore zeeleiding kan sediment opwervelen, waardoor de troebelheid in de waterkolom toeneemt tot

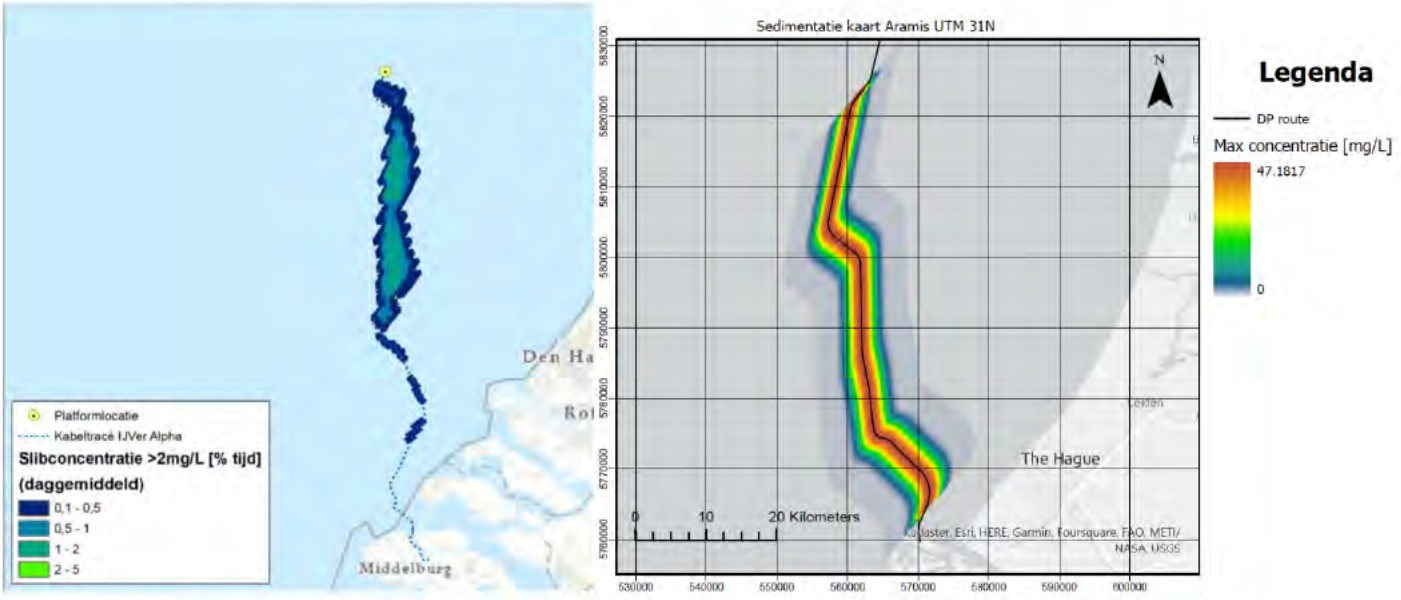
een maximale zwevende stof concentratie van 47,2 mg/L in de waterkolom. Dit valt binnen de bandbreedte van de gemiddelde achtergrondconcentratie (Paragraaf 6.1.3). De maximum concentratie treedt op langs de nearshore zeeleiding. De concentraties verder van de zeeleiding zijn een stuk lager. De vertroebeling is lokaal van aard en tijdelijk waardoor significante effecten zijn uit te sluiten.

Uit een modelstudie van de lozing van boorvloeistof van 12 putten bij platform N05-A (Royal HaskoningDHV, 2020) blijkt dat bij één boring de maximale toename in slibconcentratie ten opzichte van een achtergrondconcentratie van 5-20 mg/l bij het boorplatform circa 12 mg/l is op een afstand van 5 km van het boorplatform. Het slib in de waterkolom verplaatst zich na de lozing en slaat uiteindelijk neer op de bodem. Berekend is dat de toename in de slibconcentratie na afloop van een boring 0 mg/l bedraagt in de omgeving van het boorplatform. Bij het Aramis project is er sprake van 12 – 14 boringen in totaal. Wanneer de putten achter elkaar worden geboord is er sprake van een lange periode met lozingen en dus een toename van 12 mg/L. Wanneer meerdere putten tegelijk worden geboord is er mogelijk sprake van een grotere toename. Hoe groot die toename zal zijn is niet bekend en op welke manier de pluim zich zal verplaatsen is ook niet bekend. Aangezien de platte oester relatief gevoelig is voor een hoge vertroebeling (optimum <90 mg/L) kan niet worden uitgesloten dat er effecten optreden in de omgeving van de platforms waar mogelijk of potentieel oesterbanken kunnen voorkomen (Friese Front). Wanneer de cumulatieve toename van vertroebeling niet hoger wordt dan 150 mg/L zijn effecten op andere soorten niet te verwachten. Er is geen sprake van significante effecten op Natura 2000-gebieden.

Door de baggerwerkzaamheden voor het aanleggen van de direct pipe treedt een kortdurende toename op van 0,8 - 6 mg/L. Er is geen sprake van significante effecten op Natura 2000-gebied de Voordelta.

Net op Zee IJmuiden Ver Alpha

Voor de aanleg van het kabeltracé is vertroebeling in kaart gebracht in een Passende Beoordeling (Arcadis, Pondera, 2021a). Geconcludeerd wordt dat de slibwolk tijdelijk is (134 dagen, Figuur 7-2), waarbij deze niet langer dan enkele dagen op een specifieke locatie boven de 2 mg/L is. De slibpluim beweegt bovendien mee met de werkzaamheden langs het VKA-tracé, hierdoor zal het gebied waar de hoogste slibconcentratieverhogingen optreden (direct langs het VKA-tracé) al minder interessant zijn als foerageergebied voor zichtjagende vogels door andere verstorende effecten (zoals bovenwaterverstoring). Verder van het VKA-tracé af dunt de slibwolk al snel uit. Effecten door vertroebeling zijn tijdelijk van aard en er is ruim voldoende alternatief foerageergebied voor zichtjagende vogels (Arcadis, Pondera, 2021a).



Figuur 7-2 Links: Net op Zee IJmuiden Alpha, rechts: Aramis zeeleiding. Het percentage van de simulatietijd dat de slibconcentratieverhogingen in het gekleurde gebied boven de 2 mg/L uitkomen. De verschillende kleuren geven verschillende percentage categorieën weer, waarvan de hoogste categorie (lichtgroen) maximaal 5% (= 1 week) van de simulatietijd betreft (Arcadis, Pondera, 2021).

Net op Zee IJmuiden Ver Beta en Gamma
De slibconcentratie verhoging aan de bodem van boven de 2 mg/L treedt op bij 4 locaties in de Voordelta, in totaal circa 485 ha bij de (1x4)-kabelconfiguratie en 9.713 hectare voor de (2x2)-kabelconfiguratie. Voor beide kabelconfiguraties blijft de slibconcentratie verhoging aan de bodem onder de 5 mg/L en zal na enkele dagen onder de grens van 2 mg/L zijn. Deze waardes vallen binnen de natuurlijke achtergrondconcentratie van het systeem, en filterfeeders zullen geen effect van ondervinden van deze tijdelijke concentratieverhoging (Arcadis, Pondera, 2021b, 2022).

Net op Zee Nederwiek 1 en 2
De vertroebelingswolk blijft voornamelijk ter plaatse van het tracé en wordt nooit groter dan enkele hectares. De vertroebelingswolk bereikt dan ook niet Natura 2000-gebied de Bruine Bank. In Natura 2000-gebied Voordelta is er enkel aan de bodem en het wateroppervlak vertroebeling bij de aanlanding bij de Veerse Gatdam. De maximale daggemiddelde en dieptegemiddelde slibconcentratieverhoging is niet hoger dan 5 mg/L en zal binnen enkele dagen tot een week onder de 2,0 mg/L komen. De achtergrondconcentratie is jaargemiddeld 20-30 mg/L, wat kan afnemen tot onder de 10 mg/L bij kalm weer en kan toenemen tot 100 mg/L na een storm. Een verhoging van 2 mg/L is circa 2-20% van de jaargemiddelde slibconcentratie langs de Nederlandse kust. Het is niet te verwachten dat vogels, trekvissen of benthische soorten significant negatieve effecten van vertroebeling zullen ondervinden. Ook het effect op primaire productie is gering. Daarmee kunnen ook significant negatieve effecten op de habitattypen H1110B en H1140B worden uitgesloten (Ministerie van LNV, 2023a, 2023b).

Exploratieboring P11-B
Voor de mate van vertroebeling wordt verwezen naar de studie van N05-A zoals ook in Aramis CCS is gebruikt. Het gaat om één boring en dus om een maximale toename van 12 mg/L. Vertroebeling als gevolg van de lozing van boorvloeistof zal niet leiden tot een lokaal langdurig effect op bodemdieren. Ook vissen, zeezoogdieren en zeevogels zullen nauwelijks effecten ondervinden van de lokale vertroebeling. Significante negatieve effecten op soorten als gevolg van vertroebeling kunnen daarom op voorhand uitgesloten worden (Royal HaskoningDHV, 2023a).

Cumulatie
De voorgenomen werkzaamheden voor de zeeleiding van het Aramis initiatief en de kabels voor Net op Zee IJmuiden Ver en Nederwiek komen bij elkaar in de buurt. Er zal waarschijnlijk net geen of gedeeltelijke overlap zijn van beide vertroebelingspluimen mochten deze tegelijkertijd of in enkele dagen na elkaar plaatsvinden (zie Figuur 7-2)Figuur 7-2 Links: Net op Zee IJmuiden Alpha, rechts: Aramis zeeleiding. Het percentage van de simulatietijd dat de slibconcentratieverhogingen in het gekleurde gebied boven de 2 mg/L uitkomen. De verschillende kleuren geven verschillende percentage categorieën weer, waarvan de hoogste categorie (lichtgroen) maximaal 5% (= 1 week) van de simulatietijd betreft (Arcadis, Pondera, 2021).. De exploratieboring P11-B vindt plaats in Natura 2000-gebied Bruine Bank. De toename bij het aanleggen van de kabels wordt geschat op 2-5 mg/L en bij het boren van putten 12 mg/L per put. Er is sprake van een toename van de troebelheid in de Bruine Bank door Net op Zee IJmuiden Ver Alpha en de exploratieboring, er is geen sprake van een toename door Aramis CCS waardoor cumulatie niet relevant is. Daarnaast is er sprake van een toename in de Voordelta door de verschillende Net op Zee projecten (2-5 mg/L per project) en door Aramis CCS (0,8-6 mg/L). Zelfs
wanneer een aantal van deze projecten tegelijk plaatsvinden of kort volgend op elkaar is er sprake van een kleine toename die valt binnen de natuurlijke variatie. Er is in cumulatie geen sprake van een direct effect op Natura 2000-gebieden.

Wanneer meerdere projecten tegelijk een toename in troebelheid veroorzaken kan er een indirect effect ontstaan voor zichtjagende vogels die gebonden zijn aan een bepaalde afstand vanaf hun broedgebied. De grootste toename vindt echter verder plaats op zee waardoor dit niet relevant is. Er is geen sprake van een cumulatief significant effect door vertroebeling.

7.3 Effecten van onderwatergeluid

Aramis CCS
Significante effecten van onderwatergeluid door heien en scheepvaart op de bruinvis kunnen niet worden uitgesloten. Significante effecten van het heien van 2 platforms op de zeekoet in het Friese Front kunnen

niet worden uitgesloten en hetzelfde geldt voor effecten van scheepvaart de gewone en grijze zeehond in de Noordzeekustzone. Er zijn mitigerende maatregelen geformuleerd om significante effecten te voorkomen. Significante effecten worden niet meegenomen in deze cumulatietoets.

Zeehonden
Het gebied op open zee kan door zeehonden gebruikt worden om te foerageren. Zeehonden kunnen tot ver uit de kust zoeken naar voedsel (Ministerie van Economische Zaken, 2014a). Door het heien worden maximaal 115 zeehonden per dag verstoord. Het foerageergebied neemt door de verstoring mogelijk af. Er zijn anderzijds voldoende uitwijkmogelijkheden voor gewone en grijze zeehonden om te foerageren. De nabijgelegen kustzone en de Waddenzee zijn belangrijkere gebieden voor de gewone zeehond en grijze zeehond dan de open zee (Aarts, 2021; Aarts et al., 2016), anders dan voor bruinvissen. Significant negatieve effecten op zeehonden in de Voordelta en de Klaverbank zijn uit te sluiten.

Net op Zee IJmuiden Ver en Nederwiek
Bij de Net op Zee projecten is er sprake van continu onderwatergeluid door scheepvaart en van impulsgeluid door het heien van verankeringspalen van platforms.

Zeehonden
Zeehonden leven, rusten en foerageren voornamelijk in de Waddenzee en in de Zoute Delta. Er komen geen hoge dichtheden zeehonden voor in de omgeving van het platform. De werklocatie is geen veelgebruikt foerageergebied en er is voldoende ruimte op het NCP voor de zeehonden om uit te wijken. De Noordzee wordt verder voornamelijk gebruikt voor migratie. Tussen het platform en de kust is een zone waar de dieren ongehinderd kunnen zwemmen. Er wordt dus geen migratie van noord naar zuid langs de kust geblokkeerd door de heiwerkzaamheden. Ook voor migratie tussen Nederland en het Verenigd Koninkrijk is het heien geen blokkade. Effecten op zeehonden leiden tot een tijdelijke verplaatsing van dieren naar een andere route of foerageergebied, maar er is geen sprake van effecten op populatieniveau. Zodoende zal er geen populatiereductie optreden. Negatieve effecten als gevolg van externe werking op instandhoudingsdoelstellingen voor de grijze- en/of gewone zeehond van omliggende Natura 2000-gebieden, zoals de Voordelta, kunnen daarmee worden uitgesloten (Arcadis, Pondera, 2021a, 2021b, 2022; Ministerie van LNV, 2023a, 2023b).

Wind op Zee

Zeehonden
Uit de resultaten in het KEC 4.0 blijkt dat op basis van de gehanteerde uitgangspunten een versnelde uitrol van wind op zee in de periode 2016 – 2030 geen negatieve effecten op de populaties van gewone en grijze zeehonden zal hebben, zelfs als het totaalaantal dierverstoringsdagen als gevolg van het uitvoeren van geofysisch onderzoek zou verdubbelen. Er worden in deze berekeningen waarschijnlijk geen cumulatieve effecten gevonden, omdat de kans dat een zeehond gedurende meerdere dagen wordt verstoord heel klein is. Dit is een gevolg van het feit dat op de locaties waar windparken zijn voorzien, de dichtheid van zeehonden heel laag is en daarmee de kans dat een zeehond meerdere dagen wordt verstoord ook. Hierbij wordt aangetekend dat er in de berekeningen van is uitgegaan dat de kans dat een individuele zeehond wordt verstoord voor alle individuen uit de populatie gelijk is. Als er worst case van wordt uitgegaan dat een veel kleiner deel van de populatie kan worden verstoord en er sprake is van dieren die steeds naar dezelfde locatie toegaan (grote mate van plaatstrouw), neemt de kans dat een zeehond meerdere malen wordt verstoord toe. Omdat het in een dergelijke situatie om een verwaarloosbaar aandeel van de totale populatie gaat, is het effect op de populatie als geheel nog steeds nihil.

Seismisch onderzoek

Zeehonden
Het seismisch onderzoek leidt alleen tot mogelijke tijdelijke verstoring. Fysieke schade (PTS) is uitgesloten, omdat door het nemen van de standaard maatregelen geen gewone en grijze zeehonden binnen de contouren waarbij permanente gehoordrempelverschuiving optreedt aanwezig zijn. Er is gedurende het gehele onderzoek een maximaal oppervlak van 5.854 km^2 dat zeehonden zullen vermijden. De verstoorde oppervlakte van een worst-case dag ligt tussen de 1.040 en de 3.500 km^2. Voor het gehele seismisch onderzoeksgebied ligt het aantal verstoorde gewone zeehonden op een worst-case dag op maximaal 116

zeehonden. Voor de grijze zeehond ligt het aantal verstoorde dieren op maximaal 140 op een worst-case dag. Het oppervlak leefgebied blijft na de ingreep ongewijzigd. Er is een tijdelijke beperkte afname van het leefgebied van de gewone zeehond. De kwaliteit van het leefgebied neemt eveneens tijdelijk af, vergelijkbaar aan de afname van het oppervlak van het leefgebied. Ook de kwaliteit van het leefgebied is na de ingreep ongewijzigd. De trend van gewone en grijze zeehond is positief. Daarnaast vindt het onderzoek op zee plaats en de populatie zeehonden bevindt zich voornamelijk dichter bij de kust. Er worden geen rustplaatsen van de gewone of grijze zeehond verstoord. Het daadwerkelijke aantal verstoorde dieren zal daarom naar verwachting lager liggen dan de worst-case aantallen. Het is dan ook niet de verwachting dat het seismisch onderzoek invloed heeft op de instandhoudingsdoelstelling. Naar verwachting heeft het onderzoek geen significant effect op de instandhoudingsdoelstelling van behoud oppervlak en behoud kwaliteit voor behoud van de populatie van de gewone zeehond. Er is geen sprake van significant negatieve effecten van het seismisch onderzoek op de instandhoudingsdoelstellingen van de gewone zeehond en de grijze zeehond in het Natura 2000-gebied Voordelta.

Exploratieboring P11-B

Zeehonden

De vermijdingsdrempel voor de zeehond ligt op 145 dB. De SEL05-contour van 145 dB ten gevolge van heien ligt op 4,8 km van de geluidsbron af (Remmers & Rosemeyer, 2018). Er is dus een vermijdingsgebied van 4,8 km rond de bron (73 km^2) voor zeehonden. In het vermijdingsgebied rondom de exploratieboring, komen maximaal 0,5 gewone zeehonden voor per km^2. Hetzelfde geldt voor de grijze zeehond. Voor beide soorten is uitgegaan van de distributiemodellen van Aarts (2021) zoals beschreven in het KEC 4.0 (Heinis et al., 2022). Hierdoor wordt ervan uitgegaan dat er maximaal 37 gewone en grijze zeehonden in het plangebied verstoord kunnen worden. Er worden standaardmaatregelen getroffen om tijdelijke en blijvende gehoorschade te voorkomen. Gezien de lage dichtheden van zeehonden in het plangebied en de geringe duur van de werkzaamheden kunnen significante negatieve effecten op de instandhoudingsdoelstellingen van de grijze en gewone zeehond worden uitgesloten.

Cumulatie

De precieze planning van de werkzaamheden van de genoemde projecten is niet bekend. Het heien van platforms voor de verschillende projecten en windturbines kunnen in principe tegelijkertijd plaatsvinden, dit zal maximaal voor een deel van de projecten het geval zijn. Daarnaast is er sprake van opeenvolgende heiactiviteiten gedurende de jaren dat de projecten worden uitgevoerd. Ook is er sprake van een toename in scheepvaartbewegingen en dus continu onderwatergeluid. Binnen alle projecten wordt gebruik gemaakt van soft start en ADD om gehoorschade te voorkomen. Daarnaast geldt er een geluidsnorm die ervoor zorgt dat het geluidsniveau wordt beperkt. Voor Aramis CCS is als maatregel ook het gebruik van stille schepen opgenomen. Er treden naar verwachting geen cumulatieve effecten op van onderwatergeluid.

7.4 Effecten van verstoring door licht, beweging en optiek

Aramis CCS

Voordelta vogels

De pijpleg-, bagger- en trenchschepen die worden ingezet bij de aanleg van de nearshore zeeleiding en de aanleg van de microtunnel/direct pipe zijn (in fases) in beweging. Vogels kunnen last ondervinden door bewegingen en aanwezigheid van schepen en daardoor worden verstoord. Vooral in de ruiperiode kunnen vogels daar veel last van ondervinden, omdat vogels dan minder mobiel zijn en niet snel weg kunnen vliegen bij verstoring. Vooral de grote stern en visdief zijn zeer gevoelig voor optische verstoring. Voor de aanleg van de microtunnel/direct pipe worden er in totaal twee schepen ingezet waarvan één baggerschip en één pijplegschip. Deze schepen varen beide twee keer op en neer gedurende de werkzaamheden. In totaal worden het bagger- en pijplegschip maximaal 47 dagen (voor direct piping variant) ingezet voor de werkzaamheden ten behoeve van de aanleg van de microtunnel/direct pipe. De schepen voor de aanleg van de zeeleiding varen uit vanaf de haven van Rotterdam verspreid over een periode van ongeveer 312 dagen. Door de spreiding van de extra scheepvaartbewegingen over een langere periode en de minimale toename van scheepvaartbewegingen (maximaal 80) ten opzichte van het huidige drukbevaren verkeersbeeld in de haven van Rotterdam (30.000 passerende zeeschepen per jaar), kunnen effecten door

voorbijgaande schepen worden uitgesloten. Significante effecten van licht, beweging en optiek op de instandhoudingsdoelstellingen van de niet-broedvogels kunnen worden uitgesloten.

Voordelta zeehonden
Effecten van licht, beweging en optiek zijn met name relevant voor zeehonden die zich boven het water bevinden; op bijvoorbeeld de ligplaatsen in de Voordelta en de Tweede Maasvlakte. Een studie van Jansen et al. (2010) liet zien dat het risico op optische verstoring van de gewone zeehond toenam als schepen in een straal van 500 m van de ligplaatsen naderden; bij een afstand van 100 m of minder verplaatsten rustende zeehonden zich 25 keer sneller naar het water dan bij afwezigheid van schepen. De afstand tussen de scheepvaartroute door de Maasgeul en de rustplaatsen van de zeehonden in het noorden van de Voordelta is kleiner dan de eerdergenoemde afstand van 100-500 m waarbinnen zeehonden reageren op beweging van schepen. De aanwezigheid van de zeehonden in de buurt van deze relatief drukbevaren route zouden echter een indicatie kunnen zijn dat zeehonden ook bij verstoring de rustplekken kunnen benutten. Door de spreiding van de extra scheepvaartbewegingen over een langere periode en de minimale toename van scheepvaartbewegingen (maximaal 80) ten opzichte van het huidige drukbevaren verkeersbeeld in de haven van Rotterdam 30.000 passerende zeeschepen per jaar), kunnen effecten door licht en bewegingen van voorbijgaande schepen worden uitgesloten.

Bruine Bank vogels
De schepen die worden ingezet bij de aanleg van de zeeleiding zijn (in fases) in beweging. Vogels kunnen last ondervinden door licht, bewegingen en aanwezigheid van schepen en daardoor worden verstoord. Vooral in de ruiperiode kunnen vogels gevoelig zijn voor optische verstoring. De extra schepen die worden ingezet voor het Aramis initiatief volgen zoveel mogelijk bestaande scheepvaartroutes. In totaal zullen maximaal 80 extra schepen uitvaren vanuit de haven van Rotterdam, waarvan 30 schepen mogelijk de scheepvaartroute langs of door de Bruine Bank volgen voor de aanleg van de zeeleiding. Deze toename in scheepvaartverkeer is minimaal te noemen en verspreidt zich over een periode van ongeveer 300 dagen. De schepen die uitvaren vanuit de haven van Amsterdam of Den Helder komen niet in de buurt van de Bruine Bank. Er is geen sprake van effecten door beweging en optiek op niet-broedvogels in de Bruine Bank. Significante effecten op de instandhoudingsdoelstellingen van de niet-broedvogels door licht, beweging en optiek kunnen worden uitgesloten.

Net op Zee IJmuiden Ver en Nederwiek
Bij de aanleg van de kabels voor IJmuiden Ver en Nederwiek vindt er verstoring plaats in de Voordelta en nabij de Bruine Bank. Verstoring door geluid en licht, en optische verstoring treedt meestal gelijktijdig op en zodoende kunnen deze doorgaans als één verstoringsbron worden beschouwd. Over het algemeen is de reikwijdte van de lichtbelasting echter minder groot dan die van verstoringen door geluid of visuele verstoringen. Voor aspecten rond verlichting wordt tevens ten alle tijden het verlichtingsplan als leidraad gebruikt, deze wordt opgesteld conform de hiervoor geldende wettelijke richtlijnen. Zodoende zijn effecten op fauna gevoelig voor verlichtingsverstoring uitgesloten. Hieronder wordt per Natura 2000-gebied ingegaan op de effecten van geluid, beweging en optiek.

Voordelta vogels
Het grootste deel van de verstoringscontour zal overlappen met reeds verstoord areaal door reguliere scheepsvaart. De tijdelijke aard van de werkzaamheden en het beperkte additioneel verstoorde areaal (ten opzichte van de huidige situatie in het gebied) zorgen ervoor dat de behoudsdoelstellingen voor de omvang en kwaliteit van het leefgebied voor de roodkeelduiker en zwarte zee-eend en hun populaties binnen Natura 2000-gebied Voordelta geen negatieve effecten ondervinden.

Voordelta zeehonden
Binnen de Voordelta bevinden zich ligplaatsen van gewone zeehond en een van de grijze zeehond. Deze ligplaatsen worden in de huidige situatie reeds verstoord door reguliere scheepvaart. Het beperkte aantal schepen dat wordt gebruikt tijdens de werkzaamheden voegt daarmee een relatief verwaarloosbare fractie toe aan de aanwezige scheepvaart intensiteit. Voor dit scheepvaartverkeer gelden dezelfde verstoringsafstanden. De verstoring als gevolg van de werkzaamheden voor de kabels zal het oppervlakte verstoord gebied daarom niet vergroten bij de rustplaatsen van de zeehonden. Mochten hier rustende zeehonden toch verstoord raken, zijn er in de buurt voldoende onverstoorde uitwijkmogelijkheden

beschikbaar. Een negatief effect door bovenwaterverstoring op de instandhoudingsdoelstellingen van de grijze en gewone zeehond in Natura 2000-gebied Voordelta is hiermee uitgesloten.

Bruine Bank vogels
De verstoringscontour van 500 meter voor minder gevoelige vogels (jan-van-gent, dwergmeeuw en grote mantelmeeuw) raakt niet aan de Bruine Bank. Minder gevoelige vogels op de Bruine Bank worden daarom niet verstoord. Grote jagers ruien tijdens hun trek en behouden tijdens de rui hun vliegvermogen. Eventueel verstoorde ruiende grote jagers kunnen zodoende bij verstoring uitwijken naar onverstoord areaal. De optredende verstoring als gevolg van de werkzaamheden is tijdelijk en lokaal, en zodoende is er ruim onverstoord areaal beschikbaar. Door de tijdelijke aard van de effecten en het beperkte areaal is er geen sprake van een negatieve invloed op de gestelde behoudsdoelstellingen voor de kwaliteit en omvang van het leefgebied voor deze soort binnen het Natura 2000-gebied.

Ruiende alken en zeekoeten zijn in de ruiperiode van zomer- naar winterkleed kwetsbaar omdat zij wegens hun beperkte vliegvermogen moeilijk uit kunnen wijken voor verstoringsfactoren. Naast het gegeven dat het additioneel verstoord oppervlak op en in de buurt van de Bruine Bank klein is, is de regulier aanwezige scheepsvaartintensiteit in (maar ook buiten) de standaard vaarwegen op de Bruine Bank en langs het tracé op zee relatief hoog. De werkzaamheden zullen slechts enkele schepen aan deze hoge scheepsvaartintensiteit toevoegen. Zodoende is ook de intensiteit van de verstoring binnen het geringe verstoorde oppervlak relatief laag t.o.v. de regulier aanwezige scheepsvaartintensiteit.

Wind op Zee

In de Kavelbesluiten voor Hollandse Kust West kavels V en VI en IJmuiden Ver Alpha en Beta is een aantal voorwaarden opgenomen met betrekking tot scheepvaartbewegingen:
- De (onderhouds)schepen van de vergunninghouder zullen bij hun vaarbewegingen rekening houden met de maatregelen ten aanzien van scheepvaart die zijn opgenomen in de beheerplannen van de Natura 2000-gebieden Voordelta, Deltawateren, Noordzeekustzone en Waddenzee.
- In de Voordelta zal gedurende de winter een afstand van 1.500 meter aangehouden moeten worden (vanwege de aangewezen rustgebieden zoals opgenomen in het beheerplan Voordelta).
- In de Waddenzee zullen (onderhouds)schepen minimaal 1.500 meter afstand houden tot rust- en zoogplaatsen van zeehonden en minimaal 500 meter afstand houden van vogelconcentraties van topper en eider;
- In de Deltawateren mogen rust- en foerageergebieden voor zeehonden en vogels niet te dicht benaderd worden indien buiten de vaargeul wordt gevaren. Om negatieve effecten op de instandhoudingsdoelstellingen te beperken, dient ervoor te worden gezorgd dat (onderhouds)schepen een minimale afstand van 500 meter ten opzichte van foeragerende vogels en 1.200 meter van op de plaats rustende zeehonden wordt aangehouden;
- In de Noordzeekustzone moeten onderhoudsschepen minimaal 500 meter afstand houden van vogelconcentraties van topper, eidereend en zwarte zee-eend alsmede 1.200 meter van het deel van de zandplaat(platen) waarop zich grijze of gewone zeehonden bevinden.

Seismisch onderzoek

Bruine Bank vogels
Het seismische zoekgebied overlapt een gedeelte met het zuidelijkste deel van de Bruine Bank. Dit betekent dat er mogelijk ook verstoring plaatsvindt van de aangewezen vogelsoorten: jan-van-gent, grote jager, dwergmeeuw, grote mantelmeeuw, zeekoet en alk door de aanwezigheid van het onderzoeksschip en de begeleidende schepen. Er wordt rekening gehouden met dat het onderzoeksschip circa 51 dagen op zee vaart, waarvan 25 dagen actief seismisch onderzoek wordt uitgevoerd. De overige dagen zijn als reserve opgenomen in geval van slechte (weers-)omstandigheden. De Bruine Bank ligt deels in en nabij een drukbevaren scheepvaartroute, waardoor het aannemelijk is dat soorten gewend zijn aan de aanwezigheid van schepen of gevoelige soorten niet aanwezig zijn. In de voorgestelde periode in februari, zijn voor zover bekend geen vogelsoorten in het gebied in de rui, waardoor ze niet weg kunnen vliegen. Ervan uitgaande dat er geen 51 dagen in de Bruine Bank worden gevaren, maar dat de schepen ofwel stilliggen of op een lage snelheid de route vervolgen in de reservedagen, zal de verstoring door de aanwezigheid van drie

schepen beperkt blijven. Er zal ongeveer 65 uur door de Bruine Bank worden gevaren. Daarnaast is als standaard maatregel in het ecologisch werkprotocol opgenomen dat werklampen op de schepen worden voorzien van adequate armaturen om onnodige lichtemissie buiten de schepen te voorkomen. Deze maatregel vermindert de verstoring in de nachtelijke uren en vermindert ook het risico dat vogels gedesoriënteerd raken door sterke lichten en rond het schip blijven cirkelen. Significant negatieve effecten op de instandhoudingsdoelstellingen van de vogelsoorten jan-van-gent, grote jager, dwergmeeuw, grote mantelmeeuw, zeekoet en alk door verstoring van licht en geluid door scheepvaart in de Bruine Bank kunnen worden uitgesloten (Royal HaskoningDHV, 2023b).

Exploratieboring P11-B

Bruine Bank vogels

Omdat het plangebied is gelegen nabij drukbezochte scheepvaartroutes is niet te verwachten dat extra scheepsbewegingen leiden tot een significant verlies aan foerageeroppervlak voor de betreffende vogelsoorten. De te verwachten effecten van helikopterbewegingen zijn lokaal en zijn er genoeg mogelijkheden om uit te wijken op de Bruine Bank. Door de transportbewegingen van schepen en helikopters zal er een kortdurende verstoring plaatsvinden. Het gebied is daarna echter weer beschikbaar en zal naar verwachting geen negatief effect hebben op de instandhoudingsdoelstellingen van vogelsoorten waarvoor het Natura 2000-gebied Bruine Bank is aangewezen. Daarnaast zijn er standaardmaatregelen aanwezig die de onnodige uitstraling van licht door platforms, schepen en het fakkelen zoveel mogelijk beperken en nachtelijke lichtverstoring door het fakkelen te beperken. Significant negatieve effecten op de instandhoudingdoelstellingen van vogelsoorten waarvoor de Bruine Bank is aangewezen kunnen worden uitgesloten (Royal HaskoningDHV, 2023a).

Cumulatie

Door de projecten die in de komende jaren worden uitgevoerd neemt het aantal scheepvaartbewegingen sterk toe. Een deel daarvan vindt gelijktijdig plaats en een ander deel opeenvolgend. Het is lastig te bepalen wat het precieze effect daarvan is, daardoor kunnen significante effecten van de toename van verstoring door licht, beweging en optiek door scheepvaartbewegingen niet worden uitgesloten op zeehonden en vogels.

7.5 Effecten van stikstofdepositie

Effecten van stikstofdepositie zijn apart beschouwd in bijlage 7. Hier is ook cumulatie opgenomen. Hier is geconcludeerd dat het Aramis-project ook in cumulatie géén gevolgen heeft voor het kunnen behalen van de instandhoudingsdoelstellingen als gevolg van stikstofdepositie.

7.6 Mitigerende maatregelen cumulatie

Om significante effecten in cumulatie met andere projecten te voorkomen zijn de volgende mitigerende maatregelen noodzakelijk:

- In de Voordelta zal gedurende de winter een afstand van 1.500 meter aangehouden moeten worden van het deel van de zandplaat(platen) waarop zich grijze of gewone zeehonden bevinden.
- In de Noordzeekustzone moeten schepen minimaal 500 meter afstand houden van vogelconcentraties van topper, eidereend en zwarte zee-eend alsmede 1.500 meter van het deel van de zandplaat(platen) waarop zich grijze of gewone zeehonden bevinden.

8 Leemtes in kennis & toekomstige ontwikkelingen

Dit hoofdstuk geeft inzicht in de onderdelen van het Aramis initiatief waarop meer kennis gewenst is om effecten goed te kunnen beoordelen.

Rekenmethodiek voor populatie-effecten
Tijdens het berekenen van de effecten op de populatie bleek dat de formule niet direct geschikt is om toe te passen op activiteiten anders dan het plaatsen van windturbines (monopiles). De formule gaat ervan uit dat een heidag gelijk staat aan 4 uur heien. De heiwerkzaamheden voor dit project worden soms in minder dan een dag uitgevoerd, maar ook bij een lagere hei-energie in vergelijking tot de plaatsing van monopiles (pers. communicatie Heinis, 2022). Dit inzicht leidde tot de conclusie dat het effect op de populatie, zoals het nu wordt berekend, mogelijk niet representatief is voor de opslagboring. Daarnaast is de gebruikte formule gebaseerd op aannames met betrekking tot een stabiele populatie en moet voor correct gebruik van het model een kwetsbare subpopulatie worden gedefinieerd, waarvan de gegevens nog niet beschikbaar zijn (Heinis et al., 2022, bijlage F). Op het moment van schrijven is er nog geen maatwerkaanpak ontwikkeld om de populatiereductie te beoordelen voor andere werkzaamheden dan het heien van monopiles. Deze aanpak zal worden geadviseerd in het proces van verdere vergunningaanvraag.

Vaarroute van CO_2 schepen
Op het moment dat de vaarroute bekend wordt van de schepen die CO_2 vervoeren naar de terminal, zal beoordeeld moeten worden op welke Natura 2000-gebieden effecten (of externe werking) van toepassing is. Deze gebieden zijn nu niet meegenomen in de beoordeling, omdat de vaarroutes en intensiteit nog niet bekend zijn.

9 Conclusie

9.1 Conclusies landdeel

De aanlegwerkzaamheden ten behoeve van Aramis leiden tot emissie van stikstof (stikstofoxiden en ammoniak) als gevolg van de inzet van (werk)schepen, transportmiddelen en mobiele werktuigen. Hoewel deels met elektrisch aangedreven materieel wordt gewerkt, laat de huidige stand van de techniek het echter nog niet toe de werkzaamheden geheel zonder stikstofemissie plaats te laten vinden.

Deze emissie leidt tot een tijdelijke stikstofdepositiebijdrage op een aantal Natura 2000-gebieden in het kustgebied, te weten Solleveld & Kapittelduinen, Westduinpark & Wapendal, Voornes Duin, Meijendel & Berkheide, Voordelta, Duinen Goeree & Kwade Hoek en Grevelingen. De effecten daarvan zijn in een aparte passende beoordeling ecologisch getoetst (Bijlage 7, Koolstra 2023). Die ecologische beoordeling concludeert dat de tijdelijke depositiebijdrage als gevolg van de aanlegwerkzaamheden van Aramis niet leidt tot een aantasting van de natuurlijke kenmerken van de betrokken Natura 2000-gebieden.

9.2 Conclusies zeedeel

De Passende beoordeling leidt tot het inzicht dat significante effecten niet zijn uit te sluiten. Dit leidt tot de volgende mitigerende maatregelen per gebied, aanvullend op de standaard maatregelen zoals beschreven in paragraaf 2.4.

Noordzee
Significante effecten door onderwatergeluid op bruinvissen kunnen niet worden uitgesloten. Wezenlijke effecten op zandkokerwormen door oppervlakteverlies en sedimentatie kunnen niet worden uitgesloten. Wezenlijke effecten door een toename van vertroebeling op de platte oester kunnen niet worden uitgesloten. Ondanks het feit dat de zandkokerworm en platte oester als soort niet wettelijk beschermd zijn via de gebiedsbescherming van de Ow (maar wel onder OSPAR) wordt aangeraden om de volgende maatregelen uit te voeren om wezenlijke effecten te voorkomen:

- Bij de aanleg van de zeeleiding en lozen van boorgruis worden de zandkokerwormriffen zoveel mogelijk vermeden. Bij de detaillering van het leidingtracé wordt vastgesteld of deze voorkomen en hoe deze vermeden kunnen worden. Deze maatregel valt buiten het toetsingskader in deze passende beoordeling;
- Vertroebeling > 90 mg/L in het Friese Front wordt voorkomen om effecten op de platte oester tegen te gaan. Deze maatregel valt buiten het toetsingskader in deze passende beoordeling;
- Bruinvissen komen in de Noordzee en specifiek in meerdere Natura 2000-gebieden voor. Hierbij geldt dat er in de Natura 2000-gebieden geen significante directe effecten optreden, maar indirecte effecten door onderwatergeluid op bruinvissen kunnen niet worden uitgesloten (indirecte effecten op de gehele Noordzee populatie). Daarom dienen de volgende maatregelen te worden genomen:
    - Bij de hei-werkzaamheden dienen geluidsbeperkende maatregelen genomen te worden (bijvoorbeeld door gebruik te maken van een HSD Systeem/bubbelscherm) of een werkwijze waarbij relatief weinig onderwatergeluid zal optreden om effecten op de populatie bruinvissen te voorkomen (het geluidsniveau moet onder de 164 dB liggen op 750 meter afstand)
    - Er dient zoveel mogelijk gebruik gemaakt te worden van stille schepen om continu onderwatergeluid te minimaliseren.

Voordelta
Significante effecten op zeezoogdieren door geluid en trillingen kunnen niet worden uitgesloten, hierbij gaat het om indirecte effecten op de bruinvis. De volgende mitigerende maatregelen dienen naast de standaard maatregelen uitgevoerd te worden om significante effecten te voorkomen:

- In de Voordelta treden geen significante directe effecten op voor bruinvis, maar indirecte significante effecten door onderwatergeluid op bruinvissen kunnen niet worden uitgesloten (indirecte effecten op de

gehele Noordzee populatie). Daarom dienen mitigerende maatregelen te worden genomen bij de heiwerkzaamheden en scheepvaartbewegingen. Deze zijn opgenomen onder het kopje ‘Noordzee’.

Friese Front
Significante effecten in juli-oktober op de zeekoet door geluid en trillingen door heiwerkzaamheden kunnen niet worden uitgesloten. De volgende mitigerende maatregelen dienen naast de standaard maatregelen uitgevoerd te worden om significante effecten te voorkomen:

- Er wordt bij heiwerkzaamheden nabij het Friese Front (L4-A en L10-R) gebruik gemaakt van bijvoorbeeld een HSD Systeem/bubbelscherm bij het heien om het onderwatergeluid zo te minimaliseren dat de geluidscontour (140 dB) geen overlap heeft met het Friese Front. Ook kan gebruik worden gemaakt van nieuwe methoden, waarmee een veel lagere geluidsbelasting optreedt indien de geluidscontour (140 dB) dan niet tot het Friese Front reikt;
- Indien bovenstaande niet mogelijk is, wordt tijdens de gevoelige periode van zeekoet (juli – oktober) geen heiwerkzaamheden uitgevoerd ten behoeve van de aanleg van de platforms en putten L4-A en L10-R.

Klaverbank
Significante effecten op de bruinvis door geluid en trillingen kunnen niet worden uitgesloten, hierbij gaat het om indirecte effecten op de gehele Noordzee populatie. De volgende mitigerende maatregelen dienen naast de standaard maatregelen uitgevoerd te worden om significante effecten te voorkomen:

- In de Klaverbank treden geen significante directe effecten op voor bruinvis, maar indirecte effecten door onderwatergeluid op bruinvissen kunnen niet worden uitgesloten (indirecte effecten op de gehele Noordzee populatie). Daarom dienen mitigerende maatregelen te worden genomen bij de heiwerkzaamheden en scheepvaartbewegingen. Deze zijn opgenomen onder het kopje ‘Noordzee’.

Bruine Bank
De voor Natura 2000-gebied Bruine Bank aangewezen niet-broedvogels zullen geen significant negatief effect ondervinden van de voorgenomen activiteiten. Significante effecten op de instandhoudingsdoel-stellingen van de niet-broedvogels worden uitgesloten.

Noordzeekustzone
Significante effecten op zeezoogdieren door geluid en trillingen kunnen niet worden uitgesloten, hierbij gaat het om indirecte effecten op de bruinvis en om directe effecten op zeehonden.
De volgende mitigerende maatregelen dienen naast de standaard maatregelen uitgevoerd te worden om significante effecten te voorkomen:

- In de Noordzeekustzone treden geen significante directe effecten op voor bruinvis, maar indirecte effecten door onderwatergeluid op bruinvissen kunnen niet worden uitgesloten (indirecte effecten op de gehele Noordzee populatie). Daarom dienen mitigerende maatregelen te worden genomen bij de heiwerkzaamheden en scheepvaartbewegingen. Deze zijn opgenomen onder het kopje ‘Noordzee’.
- Significante directe effecten van onderwatergeluid door een toename van scheepvaart op zeehonden kunnen niet worden uitgesloten. Daarom dienen mitigerende maatregelen te worden genomen met betrekking tot scheepvaart. Deze zijn opgenomen in paragraaf 6.1.7.
- Schepen dienen op een afstand van 1.500 m afstand te blijven van rustende en zogende zeehonden.

Cumulatie
Cumulatieve effecten van vertroebeling en onderwatergeluid kunnen worden uitgesloten. Cumulatieve effecten van licht, beweging en optiek door scheepvaartbewegingen kunnen niet worden uitgesloten.

Om significante effecten in cumulatie met andere projecten te voorkomen zijn de volgende mitigerende maatregelen noodzakelijk:

- In de Voordelta zal gedurende de winter een afstand van 1.500 meter aangehouden moeten worden van het deel van de zandplaat(platen) waarop zich grijze of gewone zeehonden bevinden.

- In de Noordzeekustzone moeten schepen minimaal 500 meter afstand houden van vogelconcentraties van topper, eidereend en zwarte zee-eend alsmede 1.500 meter van het deel van de zandplaat(platen) waarop zich grijze of gewone zeehonden bevinden.

9.3 Eindconclusie

Het Aramis initiatief leidt tot diversie milieueffecten op land en op zee. Met de in de rapport opgenomen standaard maatregelen en mitigerende maatregelen wordt een negatieve invloed op de natuurlijke kenmerken van Natura 2000-gebieden voorkomen en vormt Aramis geen belemmering voor het behalen van de instandhoudingsdoelstellingen van de betreffende Natura 2000-gebieden. Aramis zal daarnaast ook in cumulatie niet leiden tot een aantasting van de natuurlijke kenmerken van de Natura 2000-gebieden.

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Bijlage

1. Instandhoudingsdoelstellingen Natura 2000-gebied Voordelta

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Tabel B-10-1. Instandhoudingsdoelstellingen aangewezen soorten Voordelta. Landelijke staat van instandhouding (SVI): + is gunstig, - is matig ongunstig, -- is zeer ongunstig. Doelstellingen: = is behoud, > is uitbreiding/verbetering (Ministerie LNV, 2018).

	Landelijke SVI	Doelst. oppervlak	Doelst. kwaliteit	Doelst. populaite
Habitattypen				
H1110A Permanent overstroomde zandbanken		=	=	
H1110B Permanent overstroomde zandbanken		=	=	
H1140A Slik- en zandplaten		=	=	
H1140B Slik- en zandplaten		=	=	
H1310A Zilte pionierbegroeiingen		=	=	
H1310B Zilte pionierbegroeiingen		=	=	
H1320 Slijkgrasvelden		=	=	
H1330A Schorren en zilte graslanden		=	=	
H2110 Embryonale duinen		=	=	
H2120 Witte duinen		=	=	
Habitatsoorten				
H1095 - Zeeprik	--	=	=	>
H1099 - Rivierprik	-	=	=	>
H1102 - Elft	--	=	=	>
H1103 - Fint	--	=	=	>
H1351 - Bruinvis	+	=	>	=
H1364 - Grijze zeehond	+	=	=	=
H1365 - Gewone zeehond	+	=	>	>
Niet-broedvogelsoorten				
A001 - Roodkeelduiker	-	=	=	behoud
A005 - Fuut	-	=	=	280
A007 - Kuifduiker	+	=	=	6
A017 - Aalscholver	+	=	=	480
A034 – Lepelaar	+	=	=	10
A043 – Grauwe Gans	+	=	=	70
A048 - Bergeend	+	=	=	360
A050 – Smient	+	=	=	380
A051 – Krakeend	+	=	=	90
A052 – Wintertaling	-	=	=	210
A054 – Pijlstaart	-	=	=	250
A056 – Slobeend	+	=	=	90

	Landelijke SVI	Doelst. oppervlak	Doelst. kwaliteit	Doelst. populaite
A062 - Toppereend	--	=	=	80
A063 - Eider	--	=	=	2.500
A065 - Zwarte zee-eend	-	=	=	9.700
A067 –Brilduiker	+	=	=	330
A069 – Middelste Zaagbek	+	=	=	120
A130 – Scholekster	--	=	=	2.500
A132 – Kluut	-	=	=	150
A137 – Bontbekplevier	+	=	=	70
A141 – Zilverplevier	+	=	=	210
A144 - Drieteenstrandloper	-	=	=	350
A149 - Bonte strandloper	+	=	=	620
A157 - Rosse grutto	+	=	=	190
A160 - Wulp	+	=	=	980
A162 – Tureluur	-	=	=	460
A169 - Steenloper	--	=	=	70
A177 - Dwergmeeuw	-	=	=	
A191 – Grote stern		=	=	n.v.t.
A193 – Visdief		=	=	n.v.t.

Bijlage

2. Instandhoudingsdoelstellingen Natura 2000-gebied Noordzeekustzone

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Tabel B-2 Instandhoudingsdoelstellingen Natura 2000-gebied Noordzeekustzone. Landelijke staat van instandhouding (SvI): + gunstig, - matig ongunstig, -- zeer ongunstig. Doelstellingen: = behoud, > uitbreiding/verbetering (Ministerie LNV, 2021).

Instandhoudingsdoelstellingen		SVI Landelijk	Doelst. Opp.vl.	Doelst. Kwal.	Doelst. Pop.	Draagkracht aantal vogels
Habitattypen						
H1110B	Permanent overstroomde zandbanken (Noordzee-kustzone)	-	=	>		
H1140B	Slik- en zandplaten (Noordzee-kustzone)	+	=	=		
H1310A	Zilte pionierbegroeiingen (zeekraal)	-	=	=		
H1310B	Zilte pionierbegroeiingen (zeevetmuur)	+	=	=		
H1330A	Schorren en zilte graslanden (buitendijks)	-	=	=		
H2110	Embryonale duinen	+	=	=		
H2190B	Vochtige duinvalleien (kalkrijk)	-	=	=		
Habitatsoorten						
H1095	Zeeprik	-	=	=	>	
H1099	Rivierprik	-	=	=	>	
H1103	Fint	--	=	=	>	
H1351	Bruinvis	+	=	>	=	
H1364	Grijze zeehond	+	=	=	=	
H1365	Gewone zeehond	+	=	=	=	
H1903	Groenknolorchis	--	=	=	=	
Broedvogels						
A137	Bontbekplevier	-	=	=	20	
A138	Strandplevier	--	>	>	30	
A195	Dwergstern	--	>	>	20	
Niet-broedvogels						
A001	Roodkeelduiker	-	=	=		behoud
A002	Parelduiker	?	=	=		behoud
A017	Aalscholver	+	=	=		1900
A048	Bergeend	+	=	=		520
A062	Toppereend	--	=	=		behoud
A063	Eider	--	=	=		26200

Instandhoudingsdoelstellingen		SVI Landelijk	Doelst. Opp.vl.	Doelst. Kwal.	Doelst. Pop.	Draagkracht aantal vogels
A065	Zwarte zee-eend	-	=	=		51900
A130	Scholekster	--	=	=		3300
A132	Kluut	-	=	=		120
A137	Bontbekplevier	+	=	=		510
A141	Zilverplevier	+	=	=		3200
A143	Kanoet	-	=	=		560
A144	Drieteenstrandloper	-	=	=		2000
A149	Bonte strandloper	+	=	=		7400
A157	Rosse grutto	+	=	=		1800
A160	Wulp	+	=	=		640
A169	Steenloper	--	=	=		160
A177	Dwergmeeuw	-	=	=		behoud

Bijlage

3. Instandhoudingsdoelstellingen Natura 2000-gebied Klaverbank

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Instandhoudingsdoelstellingen		SVI Landelijk	Doelst. Opp.vl.	Doelst. Kwal.	Doelst. Pop.
Habitattypen					
H1170	Riffen	–	=	>	
Habitatrichtlijnsoorten					
H1351	Bruinvis	+	=	=	=
H1364	Grijze zeehond	+	=	=	=
H1365	Gewone zeehond	+	=	=	=

Tabel B-3 Instandhoudingsdoelstellingen Natura 2000-gebied Klaverbank. Landelijke staat van instandhouding (SvI): + gunstig, -matig ongunstig, -- zeer ongunstig. Doelstellingen: = behoud, > uitbreiding/verbetering (Ministerie LNV, 2021).

Bijlage

4. Instandhoudingsdoelstellingen Natura 2000-gebied Bruine Bank

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Instandhoudingsdoelstellingen		SVI Landelijk	Doelst. Opp.vl.	Doelst. Kwal.	Doelst. Pop.
Niet-broedvogels					
A016	Jan-van-gent	?	=	=	behoud
A175	Grote jager	?	=	=	behoud
A177	Dwergmeeuw	+	=	=	behoud
A187	Grote mantelmeeuw	+	=	=	behoud
A199	Zeekoet	?	=	=	behoud
A200	Alk	?	=	=	behoud

Tabel B-4 Instandhoudingsdoelstellingen Natura 2000-gebied Bruine Bank. Landelijke staat van instandhouding (SvI): + gunstig, -matig ongunstig, -- zeer ongunstig. Doelstellingen: = behoud, > uitbreiding/verbetering (Ministerie LNV, 2021).

Bijlage

5. Onderwatergeluid

Zie MER-Bijlage 18. Onderwatergeluid - F1

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Bijlage

6. Scheepvaart- en helikopterbewegingen

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	Type schip/ helikopter	Activiteit	Aantal schepen/ helikopters	Aantal bewegingen	Duur activiteit (in dagen)
Direct piping	Baggerschip	Baggerwerkzaamheden bij in en bij de Maasgeul	1	2	41,29
	Pijplegschip	Intrekken van zeeleiding door direct pipe casing	1	2	0,37
	Support vessel	Schoonmaken, intern inspecteren en testen van de leiding	1	2	5,58
Totaal	-	-	3	6	47
Microtunneling	Baggerschip	Baggerwerkzaamheden bij in en bij de Maasgeul	1	2	5,99
	Pijplegschip	Intrekken van zeeleiding door microtunnel	1	2	1,15
	Support vessel	Schoonmaken, intern inspecteren en testen van de leiding	1	2	6,84
Totaal	-	-	3	6	14
Aanleg zeeleiding	Support vessel	Controleren van de route door de aannemer vóór aanvang van alle constructie activiteiten	1	2	3,41

	Type schip/ helikopter	Activiteit	Aantal schepen/ helikopters	Aantal bewegingen	Duur activiteit (in dagen)
	Baggerschip	Zeebed correcties om de pijpleg route te verbeteren	1	2	14,49
	Pijplegschip	Intrekken van offshore zeeleiding	1	2	7
	Pijplegschip	Doorleggen van zeeleiding naar het eindpunt	1	2	50,69
	Pipe carrier	Bevoorrading pijplegschip	3	6	50,69
	Support vessel	Kruising met bestaande infrastructuur	1	2	11,97
	Transport barge + sleepboot	Speciaal transport voor toekomstige aansluitingen	2	2	3
	Support vessel	Volgschip voor veilige aanleg zeeleiding	1	2	50,17
	Support vessel	Schoonmaken, intern inspecteren en testen van de leiding	2	4	32,3
	Support vessel	Stenen storten	1	2	13,27
	Trencher	Begraven van de zeeleiding	1	2	71,72
	Survey schip	Laatste inspectie	1	2	3,41

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	Type schip/ helikopter	Activiteit	Aantal schepen/ helikopters	Aantal bewegingen	Duur activiteit (in dagen)
Totaal	-	-	15	30	312
Werkzaamheden platform K14-FA (Shell)	Work to work vessel	Varen van en naar het platform	1	80	N.A.
	Diving support vessel	Varen van en naar het platform / Werkzaamheden bij het platform	1	2	10
	Supply support vessel	Varen van en naar het platform	1	10	N.A.
	Standby/survey vessel	Varen van en naar het platform / Werkzaamheden bij het platform	1	2	25
	Heavy lifting vessel	Varen van en naar het platform / Werkzaamheden bij het platform	1	2	17
	Transport barge + Tug	Varen van en naar het platform / Werkzaamheden bij het platform	1	19	12
	Pipelaying vessel	Varen van en naar het platform / Werkzaamheden bij het platform	1	2	8
	Trenching + rockdump vessel	Varen van en naar het platform / Werkzaamheden bij het platform	1	2	7
	Helikopter	Beweging van en naar het platform	1	50	N.A.
Totaal	-	-	9	169	N.A.
Werkzaamheden putten K14-FA (Shell)	Mobilisatie/ Demobilisatie	Varen van en naar het platform	1	12	N.A.
	Drilling supply vessel	Varen van en naar het platform	1	229	N.A.
	Standby vessel	Varen van en naar het platform / Werkzaamheden bij het platform	1	2	400
	Drilling with Jackup	Werkzaamheden bij het platform	1	2	400

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	Type schip/ helikopter	Activiteit	Aantal schepen/ helikopters	Aantal bewegingen	Duur activiteit (in dagen)
Totaal	-	-	4	245	400
Werkzaamheden platform L10-R (Neptune)	Work to work vessel	Varen van en naar het platform	1	4	N.A.
	Diving support vessel	Varen van en naar het platform / Werkzaamheden bij het platform	1	2	8
	Heavy lifting vessel	Varen van en naar het platform / Werkzaamheden bij het platform	1	2	9
	Pipelaying vessel	Varen van en naar het platform / Werkzaamheden bij het platform	1	2	7
Totaal	-	-	4	10	N.A.
Werkzaamheden putten L10-R (Neptune)	Mobilisatie/ Demobilisatie	Varen van en naar het platform	1	2	N.A.
	Drilling supply vessel	Varen van en naar het platform	1	276	N.A.
	Standby vessel	Varen van en naar het platform / Werkzaamheden bij het platform	1	2	420
	Drilling with Jackup	Werkzaamheden bij het platform	1	2	420
	Helikopter	Beweging van en naar het platform	1	300	N.A.
Totaal	-	-	5	582	420
Werkzaamheden platform L4-A (Total Energies)	Heavy lifting vessel	Varen van en naar het platform / Werkzaamheden bij het platform	1	2	N.A.
	Supply vessel	Varen van en naar het platform / Werkzaamheden bij het platform	1	114	N.A.
	Standby vessel	Varen van en naar het platform	1	2	132

	Type schip/ helikopter	Activiteit	Aantal schepen/ helikopters	Aantal bewegingen	Duur activiteit (in dagen)
	Diving support vessel	Varen van en naar het platform	1	2	14
	Work to work vessel (crew change)	Varen van en naar het platform	1	60	N.A.
	Pipelaying vessel	Varen van en naar het platform / Werkzaamheden bij het platform	1	2	15
	Support vessel	Varen van en naar het platform / Werkzaamheden bij het platform	1	2	7
	Rockdump vessel	Varen van en naar het platform / Werkzaamheden bij het platform	1	2	1
	DSV (metrology centrale eindpunt + L4-A)	Varen van en naar het platform / Werkzaamheden bij het platform	1	2	14
	Helikopter	Beweging van en naar het platform	1	76	N.A.
Totaal	-	-	9	264	132
Werkzaamheden putten L4-A (Total Energies)	Mobilisatie/ Demobilisatie	Varen van en naar het platform	1	2	N.A.
	Drilling supply vessel	Varen van en naar het platform	1	816	N.A.
	Drilling with Jackup	Werkzaamheden bij het platform	1	2	408
	Helikopter	Beweging van en naar het platform	1	234	N.A.
Totaal	-	-	4	1.054	408
Gebruiksfase – Total Energies	Walk to walk vessel	Varen van en naar het platform / Werkzaamheden bij het platform	1	144 (per jaar)	-
	Standby vessel	Varen van en naar het platform / Werkzaamheden bij het platform	1	2 (per jaar)	-

	Type schip/ helikopter	Activiteit	Aantal schepen/ helikopters	Aantal bewegingen	Duur activiteit (in dagen)
	Mobilisatie/ Demobilisatie	Varen van en naar het platform	1	5 (per jaar)	-
	Supply vessel	Varen van en naar het platform / Werkzaamheden bij het platform	1	3 (per jaar)	-
	WS barge	Varen van en naar het platform / Werkzaamheden bij het platform	1	4 (per jaar)	-
Totaal	-	-	5	158 (per jaar)	-
Gebruiksfase - Neptune	Walk to walk vessel	Varen van en naar het platform / Werkzaamheden bij het platform	1	48 (per jaar)	-
	Standby vessel	Varen van en naar het platform / Werkzaamheden bij het platform	1	2 (per jaar)	-
	Mobilisatie/ Demobilisatie	Varen van en naar het platform	1	5 (per jaar)	-
	Supply vessel	Varen van en naar het platform / Werkzaamheden bij het platform	1	3 (per jaar)	-
	WS barge	Varen van en naar het platform / Werkzaamheden bij het platform	1	4 (per jaar)	-
Totaal	-	-	5	62 (per jaar)	-
Gebruiksfase - Shell	Walk to walk vessel	Varen van en naar het platform / Werkzaamheden bij het platform	1	91 (per jaar)	-
	Standby vessel	Varen van en naar het platform / Werkzaamheden bij het platform	1	2 (per jaar)	-
	Mobilisatie/ Demobilisatie	Varen van en naar het platform	1	5 (per jaar)	-
	Supply vessel	Varen van en naar het platform / Werkzaamheden bij het platform	1	3 (per jaar)	-

	Type schip/ helikopter	Activiteit	Aantal schepen/ helikopters	Aantal bewegingen	Duur activiteit (in dagen)
	WS barge	Varen van en naar het platform / Werkzaamheden bij het platform	1	4 (per jaar)	-
Totaal	-	-	5	105 (per jaar)	-

Bijlage

7. Passende beoordeling Natura 2000-gebieden op land

Zie MER-Bijlage 7. Passende beoordeling Aramis - stikstofdepositie – F2

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Royal HaskoningDHV is een onafhankelijk internationaal advies- en ingenieursbureau. We combineren 140 jaar engineering- en ontwerpexpertise met consultancy, software en technology diensten. We leveren hiermee toegevoegde waarde voor klanten en hebben een positieve impact op mensen en onze leefomgeving. Dat is onze drijfveer: Enhancing Society Together. Daar hoort bij dat we onszelf en anderen voortdurend uitdagen om bij te dragen aan duurzame oplossingen voor lokale en wereldwijde vraagstukken in de gebouwde omgeving en de industrie.

In onze snel veranderende wereld wordt de agenda bepaalt door onder meer klimaatverandering, de digitale transformatie, een veranderende consumentenvraag en hybride werken. Met onze geïntegreerde duurzame oplossingen willen we bijdragen aan het bredere technologische en maatschappelijke plaatje.

Gesteund door de kennis en ervaring van meer dan 6.000 collega's werken we vanuit kantoren in meer dan 20 landen. We ondersteunen klanten om de transitie te maken naar een slimme en duurzame organisatie. We koppelen onze engineering- en ontwerpexpertise aan onze software- en technologische diensten om toegevoegde waarde te leveren voor onze klanten en de lifecycle van hun assets.

We zijn oprecht, handelen integer en transparant in al onze activiteiten, ook onze bedrijfsvoering Ons team is divers en inclusief. De veiligheid en het welzijn van mensen, in ons team en daarbuiten, staat onder alle omstandigheden voorop.

In projecten en initiatieven werken we actief samen met overheden en het bedrijfsleven, partners en stakeholders. We zien een belangrijke rol voor onszelf in innovatieve duurzame ontwikkeling en willen bijdragen aan een betere leefomgeving, nu en in de toekomst.

Ons hoofkantoor is gevestigd in Nederland en we hebben kantoren in Europa, Azie, Afrika, Australie en Amerika.

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RAPPORT

Nautische Veiligheid

MER Aramis CO2 transportinfrastructuur

Klant: Aramis

Referentie: ARM-PFE-B10-ENV-EIA-2007

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Datum: 9 februari 2024

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	Environment Impact Assessment – Baseline report
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1 Inleiding

Voor u ligt het detailrapport over Nautische veiligheid bij het MER voor het Aramis initiatief (kortweg Aramis). Het Aramis initiatief bestaat uit de aanleg en exploitatie van een open CCS-infrastructuur. Hiermee is het mogelijk om bij de industrie afgevangen CO_2 te vervoeren naar leeg geproduceerde gasvelden onder de Noordzee, om het daar permanent op te slaan. Hiermee leveren de Aramis initiatiefnemers een bijdrage aan het behalen van de Nederlandse klimaatdoelstellingen.

Dit detailrapport heeft betrekking op het milieuthema nautische veiligheid. Hierbij zijn de mogelijke risico's vanuit nautisch perspectief beschreven.

Dit detailrapport bevat een gedetailleerde beschrijving en beoordeling van de effecten van alle onderdelen van het Aramis initiatief, en een globale beschrijving en beoordeling van de effecten van onderdelen die niet tot het Aramis initiatief behoren, maar wel tot de CCS-keten.

1.1 Korte introductie van het Aramis initiatief

Integrale Aramis CCS-keten

Om de klimaatdoelstellingen te behalen, is er behoefte aan additionele transportinfrastructuur voor CO_2, waarmee meerdere opslaglocaties op zee worden ontsloten voor verschillende industriële emissiebronnen. Het Aramis initiatief speelt in op die behoefte door een nieuwe integrale en open CCS-keten mogelijk te maken. Het Aramis initiatief vormt een onderdeel van deze CCS-keten en bestaat uit de aanleg en exploitatie van een open CO_2-transportinfrastructuur. Het Aramis initiatief wordt in de rapportage dan ook wel aangeduid als Aramis CO_2-transportinfrastructuur. Samen met de afvanginfrastructuur en opslaginfrastructuur vormt dit de integrale CCS keten met onderstaande samenhangende onderdelen (zie figuur 1-1).

CO_2-afvanginfrastructuur

1 CO_2-afvang bij industrie, en geschikt maken voor transport;

2 CO_2-transport naar het verzamelpunt op de Maasvlakte, middels de Porthos landleiding of per schip;

CO_2-transportinfrastructuur (Aramis initiatief)

3 CO_2-verzamelpunt op de Maasvlakte met een compressorstation en een terminal.

- Het compressorstation ontvangt gasvormig CO_2 dat aangevoerd wordt per landleiding (via de Porthos-landleiding) en brengt het op druk voor het transport per zeeleiding;
- De terminal ontvangt vloeibaar CO_2 aangevoerd per schip. De terminal locatie bevat steigers, opslagtanks voor tijdelijke opslag van CO_2 en hogedrukpompen voor levering aan de zeeleiding. CO_2 uit het compressorstation en vanaf de terminal komen samen in de CO_2-zeeleiding;

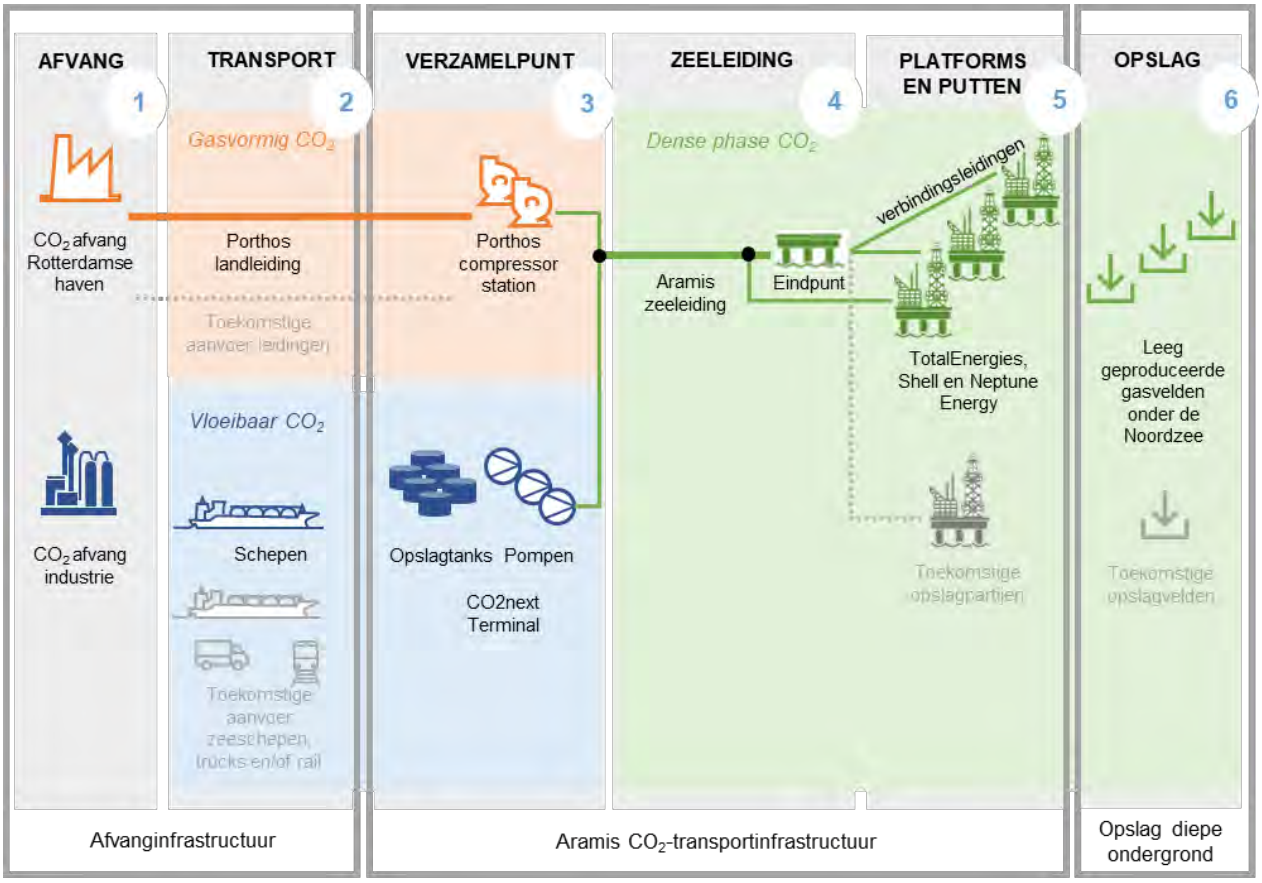
4 CO_2-transport door de centrale CO_2-zeeleiding naar het distributieplatform op de Noordzee. Dit platform is uitgerust met een verdeelstation voor toevoer van CO_2 naar de verschillende platforms. Er zijn tevens connectiepunten in de zeeleing waar vandaan CO_2 aan platforms geleverd kan worden;

5 CO_2-injectie: via verbindingsleidingen komt de CO_2 vanaf de zeeleiding bij injectieplatform. Middels putten bij deze platforms wordt CO_2 geïnjecteerd in leeg geproduceerde gasvelden in de diepe ondergrond van de Noordzee.

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CO_2-opslag diepe ondergrond

6 CO_2-opslag: permanente CO_2 opslag in de diepe ondergrond.



Figuur 1-1: Overzicht van de integrale CCS-keten met daarin de componenten die onderdeel zijn van de voorgenomen activiteit, namelijk: transport per schip, terminal CO2next, uitbreiding compressorstation Porthos, zeeleiding met eindpunt en connectiepunten, aansluitleidingen en platforms

Het Aramis initiatief

Het Aramis initiatief heeft als doel het verzamelpunt (onderdeel 3), de zeeleiding (onderdeel 4) en de injectie (onderdeel 5) te realiseren. Hiervoor wordt door het Aramis consortium (bestaande uit Shell, TotalEnergies, Gasunie en EBN) samengewerkt met CO2next (voor de terminal) en Porthos (voor het compressorstation). De opslag vindt plaats vanaf de platforms van Shell, TotalEnergies en Neptune Energy.

De afvang (onderdeel 1) en transport van CO_2 naar het verzamelpunt (onderdeel 2) vallen buiten het Aramis initiatief[1]. In het MER worden deze aspecten wel benoemd en op hoofdlijnen beschreven, omdat ze integraal onderdeel uitmaken van de integrale Aramis CCS keten.

De opslag in de diepe ondergrond (onderdeel 6) valt eveneens buiten het initiatief. Voor de diepe ondergrond gelden geen milieuregels. De mogelijke gevolgen van opslag in de diepe ondergrond wordt echter wel apart beschreven in het MER middels de deelrapporten opslag diepe ondergrond.

[1] *Een deel van de schepen die CO_2 leveren aan de terminal is afkomstig van Aramis-initiatiefnemers.*

Bij de aanleg van Aramis wordt rekening gehouden met toekomstige uitbreiding met meer leveranciers van CO_2 en meer opslagpartijen. In eerste instantie wordt vergunning aangevraagd voor een startsituatie en de eerste uitbreidingssituatie. Dit wordt in het MER getoetst. Toekomstige initiatieven *na* de eerste uitbreidingssituatie behoren niet tot de vergunningaanvraag maar worden in het MER wel (globaal) beschreven.

De ingebruikname verwachten de Aramis initiatiefnemers in 2028, waarbij tegelijk al de eerste activiteiten zoals beschreven in de eerste uitbreidingsituatie kunnen starten. Voor het bereiken van de maximale doorvoercapaciteit is enkele jaren later als uitgangspunt in het MER aangehouden.

Een uitgebreide beschrijving van het Aramis initiatief is opgenomen in het deelrapport technische beschrijving en het samenvattend hoofdrapport MER (zie figuur 1-2).

1.2 Korte introductie op het thema Nautische Veiligheid

Bij het milieuthema nautische veiligheid worden risico's in beeld gebracht. Andere milieuthema's hebben veelal betrekking op milieueffecten, dat wil zeggen gevolgen die zullen optreden ten gevolgen van activteiten. Bij nautische veiligheid wordt in beeld gebracht wat de kans en gevolgen van een gebeurtenis zijn. Dat wordt voor de eenduidigheid met de andere thema's als effect omschreven.

Voor het milieuthema nautische veiligheid zijn de aspecten *scheepvaart, aanvaring (van de buisleiding, van de steiger, van het platform, van derden, door derden)* van belang. Daarnaast is ook het *falen van de buisleiding* een aspect dat onderdeel is van nautische veiligheid.

Voor het aspect Nautische Veiligheid is daarom gekeken naar:

1. Verscheping in de omgeving Rotterdam
    a. Doorvaart van CO_2 zeeschepen in de Maasgeul;
    b. Doorvaart van CO_2 binnenvaart door Rotterdam;
    c. Afmeren;
    d. Verlading;
    e. Effecten van (gebruik van) de marine terminal van CO_2next.
2. Zeedeel Leiding
    a. Aanlanding in Rottterdam;
    b. kruising van de Maasgeul;
    c. Zeeleiding tracé (op de zeebodem en ingegraven) naar het distributieplatform;
    d. Verbindingsleidingen (op zeebodem en deels ingegraven) van het distributieplatform naar de injectieplatforms
    e. Kruisingen van pijpleidingen en kabels;
    f. Kruisingen met navigatiegebieden.
3. Platforms
    a. Distributieplatform;
    b. Nieuwe platforms (Neptune Energy en Shell);
    c. Connectie op bestaand platform (TotalEnergies).

Zowel de aanlegfase als de operationele fase is beschouwd.

1.2.1 Relevante fases

Het MER bestudeert die aspecten van een activiteit die de fysieke leefomgeving kunnen beïnvloeden. De milieueffecten van de alternatieven en varianten voor het milieuthema nautische veiligheid worden

beschreven. Daarbij wordt onderscheid gemaakt tussen de aanlegfase en gebruiksfase, en worden de mogelijke effecten van een incident beschreven; namelijk bijvoorbeeld:

- De aanlegfase bestaat uit de aanleg van de terminal, het aanpassen van het compressorstation, plaatsen van de buisleiding op en in de zeebodem) en het installeren en aanpassen van platforms.
  - De effecten tijdens de aanleg betreffen het hinderen van de scheepvaart en de risico's van een aanvaring. Bij inspectie, reparaties en/of herbegraven zijn vergelijkbare effecten op de scheepvaart te verwachten als bij de aanleg.

- De gebruiksfase bestaat uit de start-up en shutdown van de buisleiding waarbij de druk en temperatuur van CO_2 in de buisleiding zal toenemen en afnemen. Gedurende de normale gebruiksfase wordt een constante druk en temperatuur aangenomen.
  - De effecten tijdens de gebruiksfase zijn met name het beschadigen van de buisleiding en platforms door ongecontroleerde aanvaring van schepen (met name derden)

Een verdere uiteenzetting van de effecten tijdens aanleg en gebruiksfase kan gevonden worden in hoofdstuk 3.2.
In de eerste fase van de m.e.r.-procedure voor het Aramis initiatief is afgebakend welke onderwerpen binnen dit thema relevant zijn om te onderzoeken en hoe. Dit is beschreven in de Notitie Reikwijdte en Detailniveau die 18 november 2022 definitief is vastgesteld door de Minister voor Klimaat en Energie.

1.2.2 Relevante milieuaspecten

Voor het milieuthema nautische veiligheid zijn met name de volgende potentiële gebeurtenissen relevant:

- Aanvaring van platforms en aanmeervoorzieningen
- Beschadiging van buisleidingen

Voor meer details wordt verwezen naar de tekst in hoofdstuk 1.2 en de gedetailleerde effect inventarisatie in hoofdstuk 3.2.

Dit detailrapport beschrijft de milieueffecten van de potentiële gebeurtenissen.

Cumulatie
De term cumulatie wordt gebruikt voor het opstapelen van effecten veroorzaakt door verschillende gebeurtenissen. Door dit opstapelen kunnen de *gezamenlijke* effecten groter zijn dan die van een enkel gebeurtenissen.

1.2.3 Relevante alternatieven en varianten

In het MER zijn verschillende alternatieven en varianten onderzocht. Deze alternatieven en varianten zijn voor het milieuthema nautische veiligheid niet allemaal relevant. In Tabel 1-1 zijn de relevante varianten opgenomen.

Tabel 1-1. Relevante alternatieven en varianten voor het aspect nautische veiligheid.

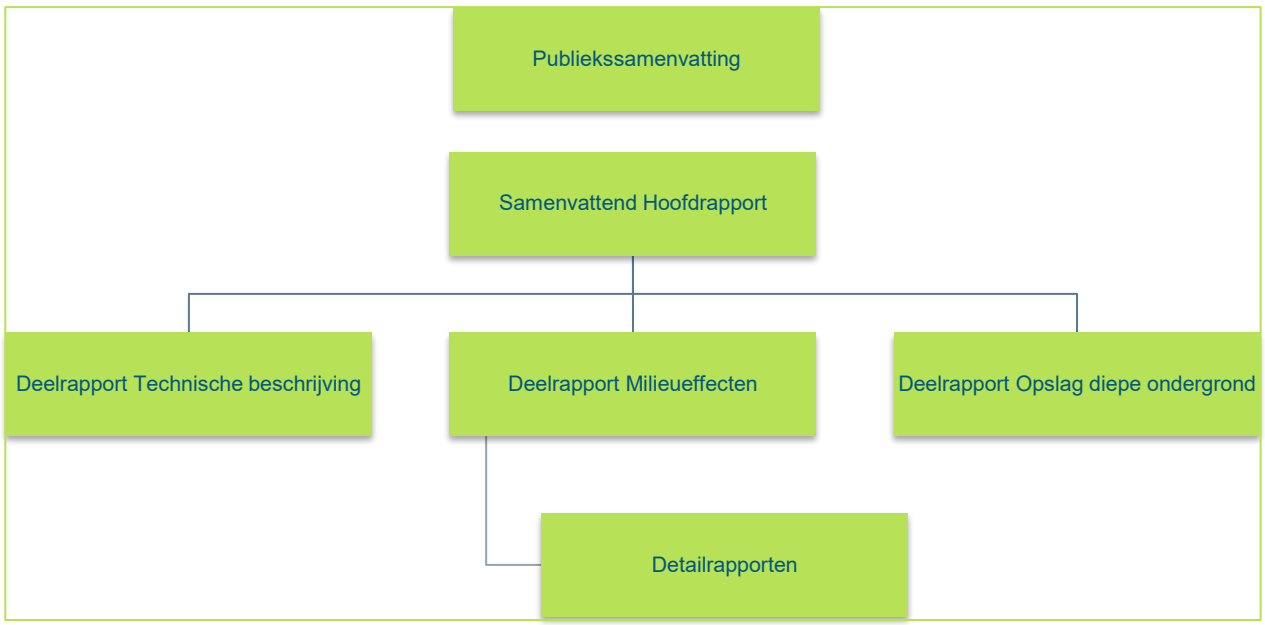
Locatie	Voorgenomen activiteit	Alternatief/ variant
Locatie van de terminal	Op het MOT-terrein, ten zuidoosten van de meest oostelijke opslagtanks voor aardolie	Tank 05 locatie bij Gate, ten oosten van de Yukonhaven
Kruising Maasgeul	Microtunnel vanaf haaienvin bij Edisonbaai	Direct Pipe boring nabij kruising Porthos leiding
Leiding tracé	Tracé volgens figuur 4.5	NA

Een uitgebreide beschrijving van al de alternatieven en varianten is opgenomen in het deelrapport Technische beschrijving bij het MER.

1.3 Opbouw van het MER en dit detailrapport

Voor het Aramis initiatief is een gecombineerd Plan-/ProjectMER opgesteld. Figuur 1-2 geeft de rapportagestructuur van het MER Aramis. Het MER bestaat uit een Samenvattend Hoofdrapport, voorzien van een Publiekssamenvatting. Ter onderbouwing van het Samenvattend Hoofdrapport zijn deelrapporten opgesteld. Dit betreft het deelrapport Technische beschrijving van Aramis, het deelrapport Milieueffecten met daarbij de onderliggende technische detailstudies en de deelrapporten Opslag diepe ondergrond. Doordat CO_2 in meerdere geologische voorkomens wordt opgeslagen, zijn er voor de opslag diepe ondergrond meerdere deelrapporten opgesteld.

Het voorliggende rapport is het detailrapport nautische veiligheid. De bevindingen uit dit detailrapport zijn opgenomen in het Deelrapport Milieueffecten, en op hoofdlijnen in het Samenvattend Hoofdrapport.



Figuur 1-2. Overzicht rapportagestructuur MER Aramis

Opbouw van dit detailrapport

Dit deelrapport beschrijft in het volgende hoofdstuk allereerst welk kader van beleid, wet- en regelgeving van toepassing is voor het thema Nautische Veiligheid. Nadat in hoofdstuk 3 is toegelicht hoe het onderzoek is uitgevoerd en hoe de effecten zijn beoordeeld, beschrijft hoofdstuk 4 de referentiesituatie. De referentiesituatie is de situatie die ontstaat op grond van de huidige situatie en alle relevante autonomie ontwikkelingen die verwacht worden in het studiegebied. Het dent veelal als vergelijkingsbasis voor het bepalen van de milieueffecten. In de dan volgende hoofdstukken (5, 6 en 7) worden de milieueffecten beschreven en beoordeeld, voor:

- de gebruiksfase, inclusief onderhoudswerkzaamheden en onvoorziene situaties
- tijdens de aanleg en ontmanteling.

Hoofdstuk 8 gaat op globaal niveau in op de effecten van alle ketenonderdelen die niet binnen de scope vallen van het Aramis initiatief, maar hier wel mee samenhangen. Tot slot bevat hoofdstuk 9 een opsomming van alle ontbrekende informatie voor het thema Nautische Veiligheid en een voorstel voor hoe de effecten op Nautische Veiligheid gemonitord kunnen worden.

2 Beleid, wet- en regelgeving

Dit hoofdstuk beschrijft welk beleid en welke wet- en regelgeving relevant is voor het Aramis initiatief voor het thema Nautische veiligheid. Dit maakt duidelijk binnen welke randvoorwaarden het Aramis initiatief tot stand moet komen.

2.1 Wettelijk kader

Deze paragraaf beschrijft het wettelijk kader voor het thema van dit deelrapport, inclusief alle criteria specifieke wettelijke kaders. Dit wordt weergegeven in onderstaande tabel.

Tabel 2-1. Wettelijk kader scheepvaart en veiligheid

Omgevingswet (2024)	Per 1 januari 2024 zijn de bepalingen van de Waterwet opgenomen in de Omgevingswet. De normen voor de primaire waterkeringen zijn vastgelegd als omgevingswaarde in het Besluit kwaliteit leefomgeving.
Arbeidsomstandighedenbesluit (2023)	Dit besluit stelt eisen aan de opsporing van niet-gesprongen explosieven. In artikel 4.10 van het Arbobesluit is bepaald dat bedrijven die werkzaamheden samenhangende met het opsporen van Niet-Gesprongen Explosieven (NGE) verrichten in het bezit dienen te zijn van een ‘procescertificaat opsporen conventionele explosieven dat is afgegeven door onze minister of een certificerende instelling’. De certificatieplicht geldt per 2007. In artikel 4.17f van de Arboregeling wordt als grondslag voor certificatie van opsporingsbedrijven verwezen naar het werkveldspecifieke certificatieschema voor het systeemcertificaat opsporing conventionele explosieven (WSCSOCE), zoals opgenomen in bijlage XII van de Arboregeling.
Noordzeeakkoord (2020) (waaronder OSPAR5, ASCOBANS6, Kaderrichtlijn Mariene Strategie);	Met het Noordzeeakkoord (NZA) geven overheid en stakeholders samen invulling aan de opgaven voor de Noordzee, zoals aan de natuur-, voedsel- en energietransities op de Noordzee. Ook wordt met het NZA een bijdrage geleverd aan de invulling van het klimaatakkoord. De afspraken, ook over de winning van fossiele energie, zijn gemaakt in het licht van de afspraken van COP-Parijs.
Regeling provinciale risicokaart	Provincies maken en beheren de Risicokaart. Dit is wettelijk verankerd in de Wet Veiligheidsregio’s. In een ministeriële regeling zijn nadere, algemeen verbindende voorschriften voor de Risicokaart opgenomen. Op de risicokaart staan kwetsbare objecten en risicovolle situaties. Bevat o.a. maximale waterhoogte bij dijkdoorbraak.

2.2 Beleidskader

Deze paragraaf beschrijft het beleidskader voor het thema van dit deelrapport, inclusief alle criteria specifieke beleidskaders. Dit wordt weergegeven in onderstaande tabel.

Tabel 2-2. Beleidskader scheepvaart en veiligheid

CS-OOO (2021)	Certificatieschema voor het managementsysteemcertificaat Opsporen van ontplofbare oorlogsresten. Certificatie van opsporingsbedrijven vindt plaats op basis van het Certificatieschema opsporen ontplofbare oorlogsresten (CS-OOO). Het CS-OOO heeft per 1 januari 2021 het zogenoemde WSCS-OCE vervangen. Het certificatieschema heeft betrekking op het opsporen van ontplofbare oorlogsresten die in de (water)bodem zijn achtergebleven tijdens en na de Eerste en Tweede wereldoorlog.

Nationaal Water Programma 2022-2027 (2022)	Het Nationaal Water Programma 2022–2027 (NWP) geeft een overzicht van de ontwikkelingen binnen het waterdomein en legt nieuw ontwikkeld beleid vast. Er wordt omschreven hoe er wordt gewerkt aan schoon, veilig en voldoende water dat klimaatadaptief en toekomstbestendig is. Het NWP beschrijft de nationale beleids- en beheerdoelen op het gebied van o.a. waterveiligheid en scheepvaart.
Programma Noordzee 2022-2027 (2022)	Het Programma Noordzee 2022-2027 richt zich op het bereiken van een duurzaam en veilig gebruik van de Noordzee dat bijdraagt aan de maatschappelijke, economische en ecologische doelstellingen van Nederland. Het plan is als bijlage onderdeel van het Nationaal Water Programma 2022-2027 en bevat onder andere nieuw beleid over het in stand houden en verder ontwikkelen van hoofdinfrastructuur (o.a. scheepvaartroutes).
Recente aanwijzingen van Natura 2000-gebieden op Noordzee, zoals Bruine Bank.	

2.3 Relevantie wet- en regelgeving voor criteria en beoordeling

In deze paragraaf wordt van een aantal beleidskaders aangegeven hoe deze de criteria en beoordeling daarvan beïnvloeden.

2.3.1 Programma Noordzee 2022-2027

Voor het goed kunnen functioneren en de toekomstbestendigheid van de zeehavens zijn voldoende ankergebieden van voldoende grootte essentieel. Aangrenzend aan deze ankergebieden wordt voldoende manoeuvreerruimte (c.q. voldoende afstand tot windparken) voor zeeschepen in stormsituaties vrijgehouden. Dit is belangrijk voor schepen die niet langer veilig ten anker kunnen liggen. Zij hebben voldoende ruimte nodig om snelheid te kunnen maken ter wille van de manoeuvreerbaarheid. gedurende de storm. In verkeersscheidingsstelsels, diepwaterroutes, ankergebieden, precautionary area's en clearways gaat scheepvaart vóór ander gebruik.

2.3.2 Relevante wet- en regelgeving voor waterkeringen

Waterkeringen (dijken, dammen en andere verhogingen die water kunnen keren) beschermen het Nederlandse land en haar bewoners tegen hoogwater van de zee of de binnenwateren. Waterkeringen zijn verdeeld in primaire, secundaire en regionale waterkeringen. Elke waterkering heeft een bepaalde normering die beschrijft hoe hevig de situatie is waartegen deze waterkering minimaal bestand moet zijn. Ook heeft elke waterkering een beschermingszone waarbinnen beperkte functies kunnen plaatsvinden. De normeringen en beschermingszones kunnen per waterkering verschillen, en staan beschreven in nationaal, provinciaal en regionaal (waterschappen) beleid. Deze staan tot 1 januari 2024 beschreven in de Waterwet, de provinciale omgevingsverordeningen van de provincies. Inmiddels zijn deze opgenomen in de Omgevingswet, Omgevingsregeling, Besluit kwaliteit leefomgeving en, voor zover al vastgesteld, de Waterschapsverordeningen[2].

De relevante zeewering voor Aramis wordt door RWS beschouwd als een primaire zeewering. Deze ligt echter buitendijks en helpt dus niet mee om overstromingen te voorkomen.

Het aanleggen van kabels, leidingen en tunnels mag niet leiden tot een vermindering van de veiligheid van een waterkering. In principe doorkruist elk mogelijk concept minimaal een waterkering. Dit gebeurt in de regel door middel van een boring onder de kering door, om eventuele effecten op de waterkering

[2] *Waterschappen moeten op 1 januari 2026 een waterschapverordening hebben vastgesteld*

zoveel mogelijk te minimaliseren. Tijdens het vormgeven van het concept, moet per tracé worden meegenomen wat de specifieke normeringen en beschermingszones van een waterkering zijn. Voor het abstractieniveau van dit deelrapport echter, is slechts de hoeveelheid kruisingen met een waterkering van belang.

2.3.3 Gronddekking kabels en leidingen vanuit Rijkswaterstaat

Indien het begraven van leidingen en kabels nodig is en toegepast, hanteert Rijkswaterstaat een minimale gronddekking op de kabel of leiding ten opzichte van de actuele bodem.

Rijkswaterstaat hanteert hiervoor de volgende categorieën en gronddekkingen:

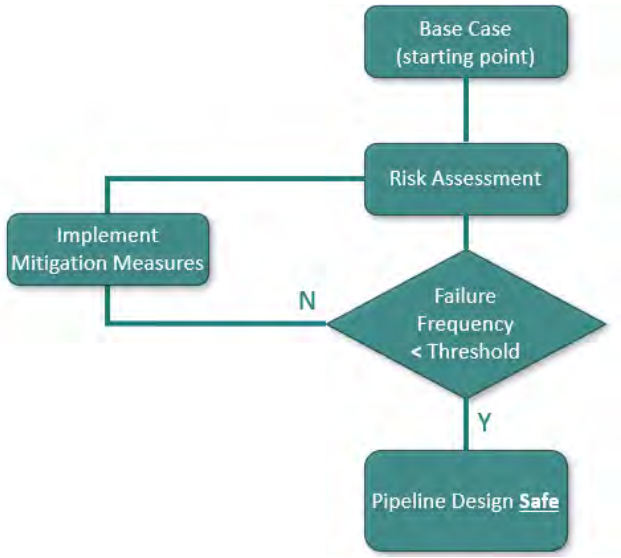
- Gronddekking buiten vaarwegen ≥ 1 meter;
- Gronddekking in vaarwegen ≥ 2,5 meter;
- Gronddekking kruising vaarwegen ≥ 2,5 meter

2.3.4 Normering

Het project wordt uitgevoerd conform onder andere de volgende relevante NEN- normen, waardoor de optredende risico's aanzienlijk worden gemitigeerd. Het recht wordt voorbehouden om gelijkwaardige normen toe te passen.

- NEN 3650-1 (2020) – Eisen voor buisleidingsystemen – Deel 1: Algemene eisen
- NEN 3650-2 (2020) - Eisen voor buisleidingsystemen – Deel 2: Aanvullende eisen voor leidingen van staal
- NEN 3651 (2020) - Aanvullende Eisen voor buisleidingen in of nabij belangrijke waterstaatswerken
- NEN 3655 (2020) - Veiligheidsbeheerssysteem (VBS) voor buisleidingsystemen voor het transport van gevaarlijke stoffen – Functionele eisen
- NEN 3656 (2022) - Eisen voor stalen zeeleidingsystemen.

De toe te passen methode is dat een risico assessment wordt uitgevoerd als onder deel van ontwerp. Het ontwerp wordt zo aangepast dat de risico's acceptabel zijn, omdat voldaan wordt aan de grenswaarde genoemd in de (NEN) normen. Deze methodiek is als volgt grafisch weergegeven.



3 Beschrijving onderzoeks- en beoordelingsmethodiek

Dit hoofdstuk beschrijft de aanpak waarmee de milieueffecten worden bepaald en beoordeeld. De beoordeling maakt gebruik van een risico inventarisatie.

In het kader van het vervolg van de studie wordt hier het onderscheid gemaakt tussen effecten en risico's.

De effecten zijn de gevolgen van het ontwikkelen, bouwen en opereren van de elementen binnen het kader van de Aramis m.e.r. Deze effecten worden in dit rapport geïnventariseerd en beoordeeld.

Risico is de kans dat een potentieel gevaar resulteert in een daadwerkelijk incident en de ernst van het letsel of de schade die dit tot gevolg heeft. In het kader van deze studie wordt het risico gebruikt om tot een beoordeling van het effect te komen.

3.1 Onderzoeksmethodiek

Onafhankelijk van de ontwerpen en uitgevoerde studies heeft een team van (Maritieme) Veiligheidsexperts op basis van de geplande activiteiten en onderdelen een interne effect-inventarisatie gemaakt, waarin ook de relevante nautische risico's zijn onderkend.

De effecten zijn gekwalificeerd en voor elk relevant effect is onderzocht

- hoe het project omgaat met het risico in ontwerp en uitvoering;
- Welke alternatieven zijn onderzocht;
- Welke mitigerende maatregelen zijn voorgesteld;
- Hoe bovenstaande is vastgelegd in studies.

Voor elk niet voldoende gemitigeerd effect is een voorstel gedaan voor verdere mitigatie.

Wijze van bepalen en beoordelen van effecten Nautische Veiligheid
In een milieueffectrapportage worden de milieueffecten van een voornemen in beeld gebracht en beoordeeld. De effecten bepalen we veelal door de toekomstige situatie die ontstaat door het voornemen te vergelijken met de situatie die ontstaat zonder het voornemen, ook wel de referentiesituatie genoemd.

Aan het verschil tussen die twee situaties, het effect, wordt een kwalitatief oordeel toegekend. Hierbij passen we een zeven-punts scoreschaal toe van plussen en minnen zoals hieronder voor elk beoordelingscriterium weergegeven. Op die manier worden de effecten voor alle relevante milieuthema's bepaald en beoordeeld.

Tabel 2-1. Maatlat effectbeoordeling Nautische Veiligheid

Effect	Omschrijving
+ + +	Sterk positief effect, groot van omvang en zodanig dat een overschrijding van normen wordt opgeheven
+ +	Positief effect, relatief groot of in een kritische periode of gebied
+	Licht positief effect, relatief beperkt, tijdelijk of lokaal
0	Geen effect
-	Licht negatief effect, relatief beperkt, tijdelijk of lokaal
- -	Negatief effect, relatief groot of in een kritische periode of gebied, mitigatie in de vorm van nader onderzoek naar risico's is nodig

- - -	Zeer negatief effect, zodanig dat milieueffect buiten de normen van regelgeving en beleid valt, nader onderzoek naar risico's in nodig en mitigerende maatregelen moeten worden toegepast
Nvt	Niet van toepassing

3.2 Nautische risico's

3.2.1 Terminal en scheepvaart

Met scheepvaart wordt hier bedoeld de schepen die CO_2 aanleveren in Rotterdam. Het gaat hier om zowel binnenvaart schepen als zeevaartschepen. Voor de zeevaart wordt het traject vanaf de Maasgeul tot aan de aanlegplaats beschouwd, voor de binnenvaart is het traject in de haven van Rotterdam naar de aanlegplaats beschouwd.

Aanlegfase
In de aanlegfase worden de steigers gebouwd, veelal gebruik makend van drijvend materieel.

Tabel 3-2. Effect inventarisatie terminal Aanlegfase

Nummer	Aspect	Effect	Risico
1.1.1	Marine terminal	Ongecontroleerd drijvend bouwmaterieel	Rammen van derden met als gevolg materiele schade, stremming van het Beerkanaal of Yangtzekanaal
1.1.2		Verankeringen voor drijvend materieel hinderen doorgaand scheepvaartverkeer	Rammen door derden met als gevolg materiele schade, stremming van het Beerkanaal of Yangtzekanaal
1.1.3		Rammen van bouwmaterieel of mariene constructies door derden	Rammen door derden met als gevolg materiele schade, stremming van het Beerkanaal of Yangtzekanaal

Gebruiksfase
In de gebruiksfase meren CO_2 zeeschepen en CO_2 binnenvaartschepen aan de steigers aan, waarna zij CO_2 verladen. De steigers liggen aan de rand van het Yangtzekanaal, de doorgaande ingang naar de Tweede Maasvlakte.

Tabel 3-3. Effect inventarisatie terminal Gebruiksfase

Nummer	Aspect	Effect	Risico
1.2.1	Doorvaart CO_2 zeeschepen	Uit de koers lopen door ondeugdelijk materiaal of menselijke fouten	Rammen van andere schepen, met als gevolg lekken CO_2, materiele schade, milieutechnische schade en economische schade door stremming van de Nieuwe Waterweg, het Beerkanaal of Yangtzekanaal
1.2.2		Uit de koers lopen door ondeugdelijk materiaal of menselijke fouten	Rammen van assets, zoals buisleidingen, steigers en oevers, met als gevolg lekken CO_2, materiele schade, milieutechnische schade en economische schade door stremming van de Nieuwe Waterweg, het Beerkanaal of Yangtzekanaal

Nummer	Aspect	Effect	Risico
1.2.3	Doorvaart CO_2 binnenvaart	Uit de koers lopen door ondeugdelijk materiaal of menselijke fouten	Rammen van andere schepen, met als gevolg materiele schade, milieutechnische schade en economische schade door stremming Nieuwe Waterweg
1.2.4		Uit de koers lopen door ondeugdelijk materiaal of menselijke fouten	Rammen van assets, zoals buisleidingen, steigers en oevers, met als gevolg materiele schade, milieutechnische schade en economische schade door stremming Nieuwe Waterweg
1.2.5	Afmeren van CO_2 zee schepen of CO_2 binnenvaart	Uit de koers lopen door ondeugdelijk materiaal of menselijke fouten	Rammen van andere schepen, met als gevolg materiele schade, milieutechnische schade en economische schade door stremming van het Beerkanaal of Yangtzekanaal
1.2.6	Verlading van CO_2	Verlies van CO_2 product tijdens de verlading door proces fouten, ondeugdelijk materiaal of brekende afmeerlijnen, bijvoorbeeld door passerende schepen of stroming uit uitlaat	Verlies van product met als gevolg milieuschade of persoonlijk gevaar
1.2.7	Marine terminal	Rammen van de constructie door derden	Rammen door derden met als gevolg materiele schade, stremming van het Beerkanaal of Yangtzekanaal

3.2.2 Zeeleidingen

Aanlegfase

De effecten tijdens de aanleg betreffen het hinderen van de scheepvaart en de risico's van een aanvaring. Bij inspectie, reparaties en/of herbegraven zijn vergelijkbare effecten op de scheepvaart te verwachten als bij de aanleg.

Tabel 3-4. Effect inventarisatie zeeleidingen Aanlegfase

Nummer	Aspect	Effect	Risico
2.1.1	Aanlanding pijpleiding op Maasvlakte	Aanlegwerkzaamheden doorkruising leiding tasten stabiliteit waterkering aan	Overstroming, economische schade voor herstel werkzaamheden
2.1.2	Kruising van de Maasgeul	Beschadigen bestaande pijplijnen door: a. gestuurde boring b. Drijvend materieel verankering c. Spudpalen/ heien d. Baggeren	Milieuschade, Economische schade voor herstel werkzaamheden Economische schade door onbruikbaar zijn van pijpleiding
2.1.3		hinderen doorgaand scheepvaartverkeer, bijvoorbeeld door verankeringen voor drijvend materieel of druktesten leiding	Rammen door derden met als gevolg materiele schade, Geplande stremming van de Nieuwe Waterweg, met als gevolg economische schade voor Haven van Rotterdam

Nummer	Aspect	Effect	Risico
2.1.4		Rammen van bouwmaterieel of mariene constructies, inclusief ontvangstschacht, door derden	Rammen door derden met als gevolg materiele schade, stremming van de Nieuwe Waterweg Beschadigen ontvangstschacht, met potentieel vollopen van tunneldeel. Personele risico's.
2.1.5		Ongecontroleerd drijvend bouwmaterieel	Rammen van derden met als gevolg materiele schade, stremming van de Nieuwe Waterweg
2.1.6	Zeeleiding tracé tot distributieplatform	Beschadigen bestaande- Niet bekende-pijpleidingen door baggeren of verankering drijvend materieel	Milieuschade, Economische schade voor herstel werkzaamheden Economische schade door onbruikbaar zijn van pijpleiding
2.1.7	Kruisingen van pijpleidingen en kabels	Beschadigen bestaande pijpleidingen en kabels door baggeren, verankering drijvend materieel of kruisingswerkzaamheden	Milieuschade, Economische schade voor herstelwerkzaamheden Economische schade door onbruikbaar zijn van pijpleiding
2.1.8	Kruisingen met navigatiegebieden	Verankeringen voor drijvend materieel hinderen doorgaand scheepvaartverkeer	Rammen door derden met als gevolg materiele schade, Geplande stremming van de navigatiegebieden, met als gevolg economische schade voor Haven van Rotterdam
2.1.9		Rammen van bouwmaterieel of mariene constructies door derden	Rammen door derden met als gevolg materiele schade, stremming van de navigatiegebieden
2.1.10		Ongecontroleerd drijvend bouwmaterieel	Rammen van derden met als gevolg materiele schade, stremming van navigatiegebieden

Gebruiksfase

De zeeleiding heeft een zeker faalkans (*falen buisleiding)*. Indien de CO_2 vrijkomt onderwater, dan zal zich een zogenaamde "bubble plume" vormen. De effecten van de zeeleiding op de visserij wordt bepaald door de kans op een ongeval door contact van vissersgerei en ankers met de transportleiding (*schade buisleiding door netten en ankers*).

Tabel 3-5. Effect inventarisatie zeeleidingen Gebruiksfase

Nummer	Aspect	Effect	Risico
2.2.1	Aanlanding in Rotterdam	Lekken primaire waterkering door doorkruising van de leiding	Overstroming, economische schade voor herstel werkzaamheden
2.2.2	Kruising van de Maasgeul	Verankeringen voor drijvend materieel tijdens onderhoud hinderen doorgaand scheepvaartverkeer	Rammen door derden met als gevolg materiele schade, Geplande stremming van de Nieuwe Waterweg, met als gevolg economische schade voor Haven van Rotterdam

Nummer	Aspect	Effect	Risico
2.2.3	Zeeleiding tracé tot distributieplatform Zeeleiding tracé to platforms	Falen van de buisleiding door: a. Corrosie b. Te hoge druk in de pijplijn	Zinkend schip van derden door verlies van hydrostatische druk
2.2.4		Beschadigen van de buisleiding door: a. Zinken schip na rammen of anderszins b. Slepen van ankers c. Slepen van vissers gerei d. Gevallen lading e. Aanraking door kiel schip of bouwmaterieel	Milieuschade, Economische schade voor herstel werkzaamheden Economische schade door onbruikbaar zijn van pijpleiding Zinkend schip van derden door verlies van hydrostatische druk Reputatieschade en obstructie
2.2.5	Kruisingen van pijpleidingen en kabels	Beoogd tracé interfereert met bestaande infrastructuur	Verplaatsen bestaande infrastructuur, verlengd vergunningen traject, reputatieverlies, obstructie
2.2.6	Kruisingen met navigatiegebieden	Beoogd tracé interfereert met bestaande navigatiegebieden	Verplaatsen bestaande navigatiegebieden, verlengd vergunningen traject, reputatieverlies, obstructie

3.2.3 Platformen; distributieplatform, nieuwe en bestaande platforms

De nautische veiligheid heeft betrekking op het risico van aanvaring van het platform. Tijdens werkzaamheden op het platform bevinden zich schepen bij het platform. Deze kunnen tegen het platform komen, wat wordt aangeduid als driften (of aandrijven). In de gebruiksfase varen schepen rond het platform. Als deze tegen het platform komen, wordt dit als rammen omschreven.

Aanlegfase

Tabel 3-6. Effect inventarisatie platformen Aanlegfase

Nummer	Aspect	Effect	Risico
3.1.1	Nieuwe platforms (Neptune Energy en Shell)	Schade aan het platform bij - de load out (Door vallende kraan , vallende objecten), - transport (Door zinkend transport schip, overbelaste constructie) of - installatie (Door botsend installatieschip, overbelaste constructie)	Schade aan platform, vertraging project
3.1.2	Distributieplatform Connectie bestaande en nieuwe platforms	Schade aan het platform bij connectie (Door botsend installatieschip, overbelaste constructie)	Schade aan platform, vertraging project
3.1.3	Veranderingen aan bestaande platforms	Schade aan het platform door extra functionaliteit van CO_2 transport over het platform, overbelaste constructie	Schade aan platform, vertraging project

Gebruiksfase

Tijdens de gebruiksfase worden de platforms ge-serviced, gebruik makend van Offshore Support Vessels (OSV's). De platforms zijn gesitueerd in de drukbevaren Noordzee. Er bestaat daarom een risico dat de platforms worden aangevaren en beschadigd door ongecontroleerde schepen.

Tabel 3-7. Effect inventarisatie platformen Gebruiksfase

Nummer	Aspect	Effect	Risico
3.2.1	Distributieplatform Nieuwe platforms (Neptune Energy en Shell) Connectie op bestaande platforms (Shell Total en distributieplatform)	Platform faalt door aanvaring service schip	Platform buiten gebruik, met als gevolg verlies van operability Aramis, of opslagcapaciteit bij opslagpartij. Service schip beschadigd
3.2.2		Platform faalt door aanvaring schip van derden	Platform buiten gebruik, met als gevolg verlies van operability Aramis, of opslagcapaciteit bij opslagpartij. Schip van derden beschadigd
3.2.3		Impact van service operaties op marine leven	Additionele milieuschade door toename aantal scheepsbewegingen
3.2.4		Service schepen botsen met derden (Scheepvaart, platforms, windpark)	Materiele schade,

4 Beschrijving referentiesituatie

In een milieueffectrapportage worden de milieueffecten van een voornemen in beeld gebracht en beoordeeld. De effecten bepalen we veelal door de toekomstige situatie die ontstaat door het voornemen te vergelijken met de situatie die ontstaat zonder het voornemen, ook wel de referentiesituatie genoemd. Aan het verschil tussen die twee situaties, het effect, wordt een kwalitatief oordeel toegekend. Dit hoofdstuk beschrijft allereerst de huidige situatie en de situatie die ontstaat als gevolg van alle autonome ontwikkelingen; de referentiesituatie. Daarna wordt de toekomstige situatie gecreëerd door Aramis geschetst.

4.1 Huidige situatie en autonome ontwikkeling

Verschillende activiteiten vinden plaats op de Noordzee:

- Scheepvaart (navigatie)
- Windparken
- Offshore platformen
- Visserij
- Kabels en pijpleidingen

De Noordzee is een van de drukst bevaren zeeën ter wereld. Een deel van de scheepvaart verlaat of komt de haven van Rotterdam binnen via de Maasgeul. Het deel van de scheepvaart met een grote diepgang vaart enkele tientallen kilometers westwaarts om vervolgens naar het zuiden of noorden af te buigen. Scheepvaart met een kleinere diepgang met bestemming IJmuiden, Hamburg of andere havens in de omgeving slaat al eerder af in noordelijke richting. Hier bevindt zich ook een verkeersscheidingsstelsel (het Maas Noord VSS).



Figuur 4-1: Overzicht van de geplande pijpleidingen nabij landingspunt Source: Imagery from © 2022 Microsoft Corporation © 2022 Maxar © CNES (2022) Distribution Airbus DS, assets from drawing ARM-CPT-BB3-PLR-LAY-0045

De Tennet kabels en TAQA gas pijplijn zijn bestaand.

De zeescheepvaart, welke de Rotterdamse haven binnenvaart, passeert onder andere het scheepvaartkanaal de Maasgeul. Dit is een regelmatig gebaggerd kanaal met een breedte van circa 1km. Door de intensieve bevaring en het belang van de Maasgeul voor de haven van Rotterdam is het van groot belang dat stremmingen tot een minimum beperkt blijven.

Het gebied is intensief gebombardeerd in WWII en achtergelaten niet-ge explodeerde bommen (NGE) moeten verwacht worden.

Nabij het landingspunt op de Maasvlakte zijn de volgende bestaande en geplande assets geïdentificeerd:

- Tennet Power kabels. Deze worden geïnstalleerd, gebruik maken van de HDD methode bij de oeverkruising. Ze worden begraven ter plaatse van de Maasgeul.
- 26 Inch gas pijplijn (TAQA Energy B.V.) aan de oostzijde,

Autonome ontwikkeling

Voor het Aramis initiatief relevante autonome ontwikkelingen betreffen in ieder geval:

- Ontwikkeling van het Porthos project;
  - Voorgestelde Porthos (CO_2) pipeline aan de westzijde van het Aramis tracé
- Ontwikkeling aanlanding van TenneT kabels en nieuwe installaties;
- Beëindigen aardgasproductie in de geselecteerde opslagvelden;
- Windparken op zee (bijvoorbeeld IJmuiden Ver Beta, Gamma en Nederwiek Beta);

- Verwachte toename scheepvaart komende 40 jaar door verder ontwikkeling van de Maasvlakte (Alexiahaven en Amaliahaven).

4.2 Geplande Aramis ontwikkeling

In het Deelrapport Technische beschrijving zijn de technische aspecten van het Aramis initiatief inclusief de aanlegfase beschreven. Relevant voor het milieuaspect Nautische Veiligheid zijn:

- De terminal met de bijbehorende scheepsvaart
- De leidingen op of in de zeebodem en de kruisingen met de waterkering
- De platforms

Onderstaand wordt op deze elementen ingegaan.

4.2.1 Terminal en scheepvaart

Het aantal jaarlijks verwachte schepen, weergegeven in tabel 4-1, welke de basis is van de beoordeling in dit rapport, is gebaseerd op de stand per 1 November 2023 en is als volgt.

Gedurende de verder ontwikkeling van het project wordt het aantal scheepsbewegingen aangepast aan bijvoorbeeld de aanwezige stikstofruimte. In het geval de aantallen schepen significant afwijken van de getoetste hoeveelheden, zal een nieuwe toetsing moeten plaatsvinden.

Tabel 4-1. Aantal CO2next schepen per jaar

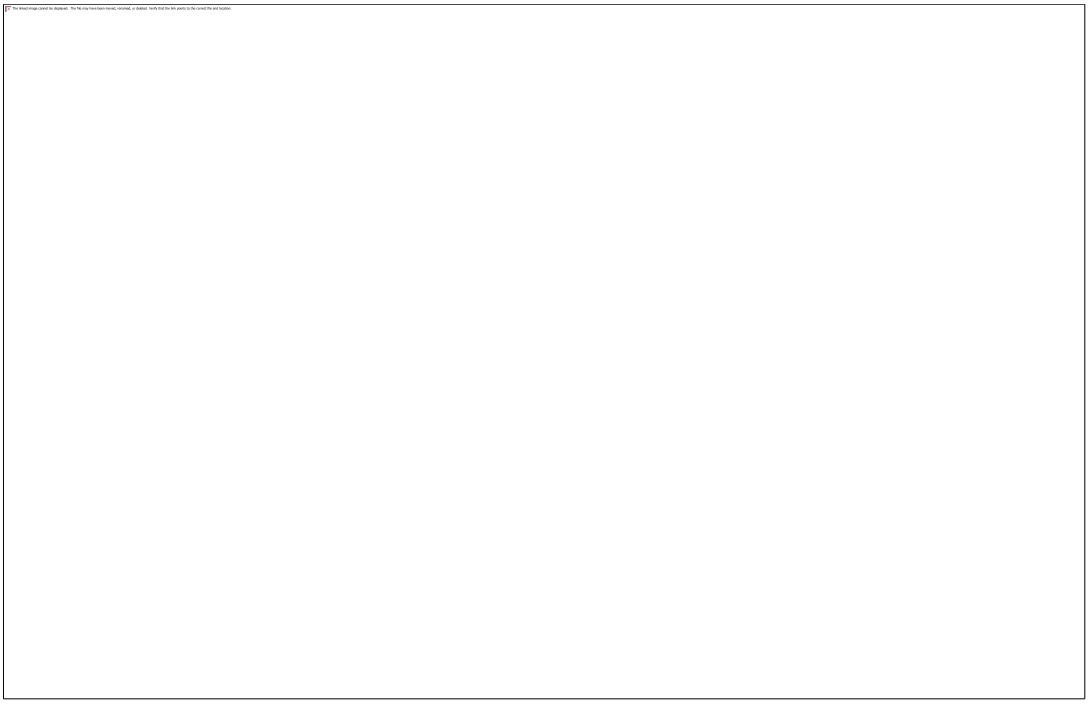
		Start	Eerste uitbreiding	Maximaal
Capaciteit Terminal		5.4 mtpa	10 mtpa	15 mtpa
#vessel arrivals				
	2,1k-barge	6	6	6
	6k-barge			
	7,5k-barge	431	431	431
	11,7k-barge	207	739	1059
	16k-coaster (Export)	76	76	83
	Totaal	720	1252	1579

De CO_2 zeeschepen zullen door de Maasgeul de haven van Rotterdam binnenvaren en direct door het Beerkanaal naar de locatie van de steigers koers vatten. Het verkeer in de haven wordt gereguleerd door de Havenautoriteit. Het totaal aantal zeeschepen dat de haven van Rotterdam aandoet is gemiddeld 80 per dag.

Het plan is de terminal te ontwikkelen op het terrein van de Maasvlakte Olie Terminal (MOT), of als alternatief op het huidige terrein van Gate terminal. Het is de bedoeling dat de activiteiten van Gate terminal en MOT ongestoord kunnen blijven doorgaan. Aan de zuidzijde van het terrein wordt ruimte gereserveerd voor het aanmeren van schepen.

De aanlandingsactiviteit wordt als voorgenomen activiteit gerealiseerd door de aanleg van steigers, die parallel aan de zuidoever van het Gate terminalterrein met het Yangtzekanaal gaan lopen. Voor de vergunningaanvragen wordt uitgegaan van 3 steigers. De eindsituatie is 3 of 4 steigers.

Indien een alternatieve locatie wordt gebruikt voor de terminal, zal dit niet leiden tot een wijziging van de locatie van de steigers, zoals weergegeven in onderstaande figuur.



Figuur 4-2. Overzicht van de locatie van CO2next.

4.2.2 Zeeleidingen

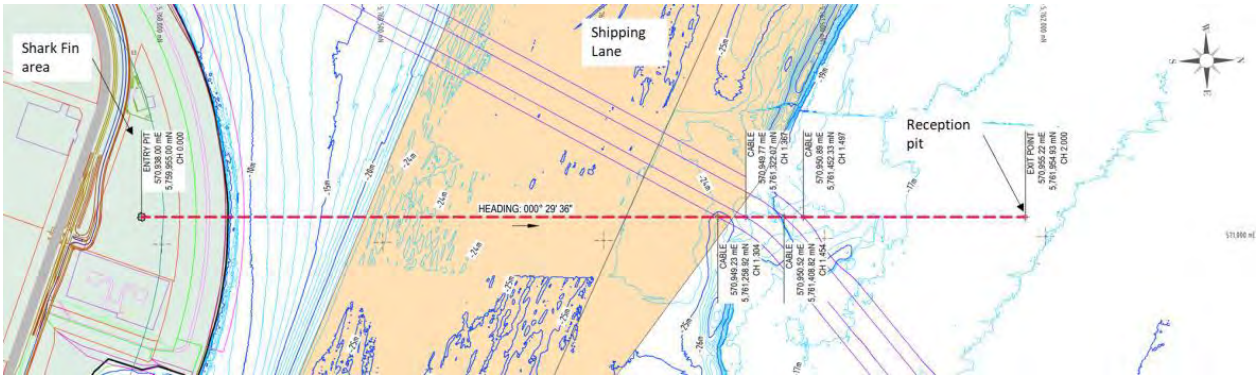
Er is gekozen voor de diameter die dermate groot is dat in de toekomst tot 22 Mton CO_2 per jaar kan worden getransporteerd. In het ontwerp wordt uitgegaan van een diameter van 32 inch (circa 80 cm). De druk in de leiding is 140 tot 180 bar, met ontwerpdruk van 200 bar. De CO_2 wordt in vloeibare vorm (dense phase) getransporteerd. De druk en temperatuur in de zeeleiding wordt aangestuurd vanaf het compressorstation en de hogedrukpompen bij de terminal.

Het zeedeel van de Aramis leiding bevindt zich vanaf de Maasvlakte in voornamelijk noordwaartse richting.



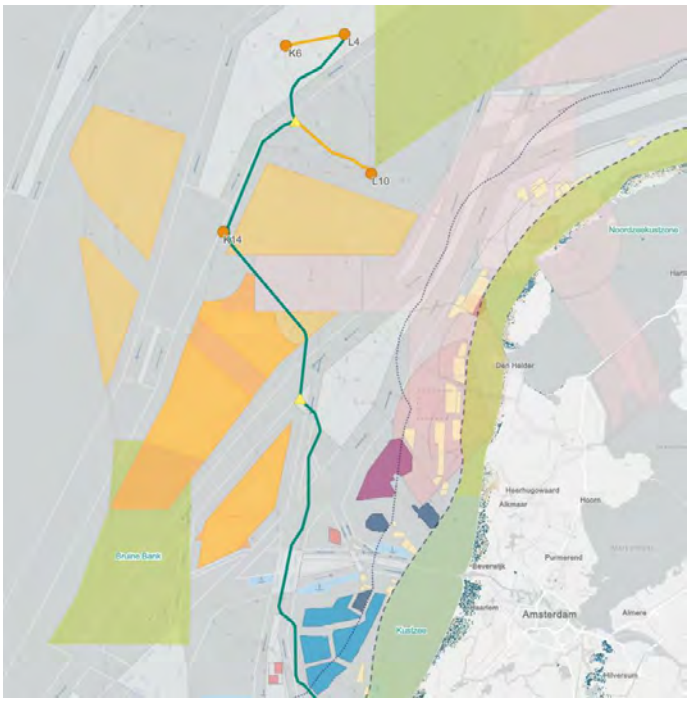
Figuur 4-3. Overzicht locatie aanlanding Aramis zeeleiding

Direct voor de kust van de Maasvlakte bevindt zich de Maasgeul. Deze vaargeul is bestemd voor (zee-) schepen van en naar de Rotterdamse haven.



Figuur 4-4. Overzicht van de kruising van de Maasgeul. Bron: "Mircotunnel Trajectory - North Option Plan View & Profile" Uit scope of work document 416010-00257 - ARM-CPT-BB3-PLR-REP-0047_1.0

De zeeleiding scope is weergegeven in onderstaande figuur.



Figuur 4-5. Overzicht zeeleiding tracé CCS Aramis

4.2.3 Platformen; distributieplatform, nieuwe en bestaande platforms

Er komt een nieuw platform aan het uiteinde van de zeeleiding, het distributieplatform. Verder gaan Shell en Neptune Energy een nieuw platform plaatsen, terwijl TotalEnergies gebruik maakt van een bestaand platform.

De platformen zullen ge-serviced worden met OSV's.

Autonoom zal er op de Noordzee ook rekening gehouden moeten worden met een toename van het aantal schepen. Rondom offshore mijnbouwinstallaties is een veiligheidszone van 500 m aanwezig. Hierbinnen is geen enkele activiteit is toegestaan, tenzij ten bate van de mijnbouw activiteit.

5 Milieuaspecten Gebruiksfase, inclusief onderhoud, calamiteiten

Dit hoofdstuk gaat per Aramis onderdeel in op de effecten op het thema Nautische veiligheid, zoals die verwacht worden tijdens het gebruik van de CCS-keten.

In dit hoofdstuk wordt de nautische veiligheid getoetst voor de gebruiksfase. De effecten zijn genummerd conform de aanduiding in hoofdstuk 3.

5.1 Terminal en scheepvaart

Effect 1.2.1 - Doorvaart CO_2 zeeschepen – rammen van schepen (0)
Uit de koers lopen door ondeugdelijk materiaal of menselijke fouten

De risicobepaling is gebaseerd op de MARIN studie 33932.601_v1 van 7 maart 2022, waarin het aanvaarrisico van de geplande CO_2 faciliteiten middels een desktopstudie is bepaald.

In deze studie is het aantal scheepvaart bewegingen in het Yangtzekanaal bepaald middels AIS data. Deze AIS data geeft aan dat er momenteel (2020) circa 330 schepen per dag passeren (120 zeeschepen en 210 binnenvaart). Autonome ontwikkelingen zullen verder leiden tot een significante vermeerdering. Het totaal aantal zeeschepen dat de haven van Rotterdam binnen vaart is circa 80 per dag.

Omdat de intensiteit van de CO2next zeeschepen te verwaarlozen is in vergelijking met het totaal aantal schepen in de haven van Rotterdam, het Beerkanaal en de Yangtzehaven wordt het effect als nihil (0) ingeschaald.

Effect 1.2.2 - Doorvaart CO_2 zeeschepen – rammen van assets (-)
Uit de koers lopen door ondeugdelijk materiaal of menselijke fouten

Met betrekking tot de doorvaart naar de Maasvlakte, het aantal incidenten in de haven van Rotterdam (Zeevaart en Binnenvaart) per jaar is circa 140, wat neerkomt op ongeveer 0,05% van de scheepsbewegingen in Rotterdam. Het aantal zeeschepen dat de CO2next terminal aan zal doen bedraagt maximaal 83 per jaar. In de te volgen route is het aantal obstakels en belendende terminals gering.

Met betrekking tot de manoeuvre naar de steiger:
De volgende faciliteiten zijn kwetsbaar (Zie ook figuur 5-1):

1. Indorama jetty in de Tenesseehaven
2. Loodswezen faciliteiten in de Pistoolhaven
3. MOT faciliteiten in de 8e Petroleum haven en LNG Gate activiteiten in de Yukonhaven



Figuur 5-1. Schets van aanvaarmanoeuvre zeeschepen naar CO2next steigers

De route is vanuit nautisch oogpunt uitdagend, hoewel het een bestaande route is, die gecontroleerd wordt door de Havenauthoriteit.

In de brief HBR-2244094 (3-3-2022) geeft de havenmeester aan dat hij het risico van aanvaren acceptabel vindt, gebaseerd op de huidige ervaringen en uitgevoerde studies.

Maatregelen
Aangeraden wordt om de volgende voorzorgsmaatregelen in te stellen:

- Door middel van Real Time Simulaties het risico voor de specifieke te verwachten schepen inschatten
- Operationele grenzen bepalen
- Training

Met deze maatregelen wordt het effect als licht negatief beschouwd (-). Er zijn voorzorgsmaatregelen benodigd in de voorbereiding, waarmee de effecten afdoende beperkt worden.

Effect 1.2.3 - Doorvaart CO_2 binnenvaartschepen – rammen van schepen (0)
Uit de koers lopen door ondeugdelijk materiaal of menselijke fouten

Informatie is afkomstig uit MARIN studie 33932.601_v1 van 7 maart 2022, waarin het aanvaarrisico van de geplande CO_2 faciliteiten middels een desktopstudie is bepaald.

In deze studie is het aantal scheepvaart bewegingen in het Yangtzekanaal bepaald middels AIS data. Deze AIS data geeft aan dat er momenteel (2020) circa 330 schepen per dag passeren (120 zeeschepen en 210 binnenvaart). Autonome ontwikkelingen zullen verder leiden tot een significante vermeerdering.

De binnenvaart schepen zullen door het Hartelkanaal of de Nieuwe Waterweg door de haven van Rotterdam varen, om vervolgens door het Beerkanaal naar de locatie van de steigers koers te vatten. Het verkeer in de haven wordt gereguleerd door de Havenauthoriteit. Het totaal aantal binnenvaartschepen dat de haven van Rotterdam dagelijks aandoet is gemiddeld 275 per dag.

Omdat de intensiteit van de CO2next binnenvaartschepen te verwaarlozen is (Maximaal circa 4,5 per dag) op het totaal aantal schepen in de haven van Rotterdam en het Beerkanaal wordt het effect als nihil (0) ingeschaald.

Effect 1.2.4 - Doorvaart CO_2 zeeschepen – rammen van assets (-)
Uit de koers lopen door ondeugdelijk materiaal of menselijke fouten

Met betrekking tot de doorvaart naar de Maasvlakte, het aantal incidenten in de haven van Rotterdam (Zeevaart en Binnenvaart) per jaar is circa 140, wat neerkomt op ongeveer 0,05% van de schepen die Rotterdam aandoen.

Het aantal binnenvaart schepen dat de CO2next terminal aan zal doen bedraagt 1496 per jaar. In de te volgen route binnen de haven van Rotterdam zit een groot aantal obstakels en belendende terminals. Desondanks is de route vanuit nautisch oogpunt voor binnenvaartschepen niet uitdagend. Het is een bestaande route die dagelijks door vele schepen wordt bevaren, zonder noemenswaardige incidenten.

Met betrekking tot de manoeuvre naar de steigers, verwezen wordt naar brief HBR-2244094 (3-3-2022) waarin de havenmeester aangeeft dat hij het risico van aanvaren acceptabel vindt, gebaseerd op de huidige ervaringen en uitgevoerde studies.

Het effect wordt als licht negatief ingeschat (-), wat aangeeft dat voorzorgsmaatregelen benodigd zijn in de voorbereiding, maar dat verwacht wordt dat de effecten daarmee afdoende gemitigeerd zullen kunnen worden. Zie voor de voorzorgsmaatregelen de beschrijving bij Effect 1.2.2.

Effect 1.2.5 - Afmeren van CO2 zee schepen of CO_2-binnenvaart (0)
Uit de koers lopen door ondeugdelijk materiaal of menselijke fouten

Informatie afkomstig uit de brief HBR-2244094 (3-3-2022) waarin de havenmeester aangeeft dat hij het risico van aanvaren acceptabel vindt, gebaseerd op de huidige ervaringen en uitgevoerde studies.

De finale benadering van de afmeervoorzieningen wordt niet als uitdagend gezien. Het volgen van een normaal ontwerp proces, inclusief Real Time Simulatie van de afmeerprocedure zal verder bevestigen dat er geen zorgen zijn met betrekking tot de nautische veiligheid. Het effect wordt als nihil ingeschat (0).

Effect 1.2.6 - Verlading van CO_2 (0)
Verlies van CO_2-product tijdens de verlading door proces fouten, ondeugdelijk materiaal of brekende afmeerlijnen, bijvoorbeeld door passerende schepen of stroming uit uitlaat

De veiligheid van het verladen van CO_2 op de steiger is geen onderdeel van de Nautische veiligheidsaspecten, behalve daar waar het gaat om de stabiliteit van het afmeersysteem. Specifieke aspecten voor de situatie in de Yangtze haven zijn:

- Hydraulische belastingen ten gevolge van passerende schepen
- Stromingen ter plaatse van de koelwater uitlaat

Informatie is afkomstig uit studie D10054101:43 (19-5-2022) van ARCADIS en naar 33932.600/v2 (8-2-2022) van MARIN, waarin het afmeersysteem is geconfirmeerd middels Dynamische Mooring Analysis (DMA), rekening houdend met passerende schepen en stromingen uit het uitlaatsysteem.
In overleg met de havenautoriteit zouden voorzorgsmaatregelen zoals een snelheidsbeperking ingesteld kunnen worden.

Deze effecten zijn goed te voorspellen in gedetailleerde studies en vormen daarom geen significante bedreiging voor het afmeersysteem. Het effect wordt als nihil ingeschat (0).

Effect 1.2.7 - Marine terminal - Rammen van de constructie door derden (-)
Informatie is afkomstig uit MARIN studie 33932.601_v1 van 7 maart 2022, waarin het aanvaarrisico van de geplande ligplaatsen voor Liquid CO_2 (LCO2) schepen middels een desktopstudie is bepaald.

In deze studie is het aantal scheepvaart bewegingen in het Yangtzekanaal bepaald middels AIS data. Deze AIS data geeft aan dat er momenteel (2020) circa 330 schepen per dag passeren (120 zeeschepen en 210 binnenvaart). Autonome ontwikkelingen zullen verder leiden tot een significante vermeerdering.

Verwezen wordt naar brief HBR-2244094 (3-3-2022) waarin de havenmeester aangeeft dat hij het risico van aanvaren acceptabel vindt, gebaseerd op de huidige ervaringen en uitgevoerde studies.

In de MARIN studie worden de risico's ingeschat als soortgelijk aan de risico's in een studie uitgevoerd in 2011 voor toendertijd geplande ligplaatsen voor LNG schepen. De praktijk in de laatste 10 jaar bevestigt het gemodelleerde beeld.

Omdat autonome ontwikkelingen zullen leiden tot een toename van het aantal scheepsbewegingen in het Yangtzekanaal wordt geadviseerd, in navolging van de voorwaarde van de havenmeester, om een Risico studie en effectenstudie voor de situatie 2040/2050 uit te voeren.

Ondanks de uitgevoerde studies, wordt het risico van aanvaring van de steiger door derden vooralsnog als significant ingeschat en daarom licht negatief gescoord (-). Verdere probabilistische analyse, zoals gepland te worden uitgevoerd in 2023, zal uitwijzen in hoeverre het risico gemitigeerd zal moeten worden.

5.2 Zeeleidingen

Effect 2.2.1 - Aanlanding in Rotterdam (0)
Lekken primaire waterkering door doorkruising van de leiding.

De zeewering wordt door RWS beschouwd als een primaire zeewering. Deze ligt echter buitendijks en helpt dus niet om overstromingen te voorkomen. Er mag vanuit gegaan worden dat het ontwerp en de constructie van de aanlanding voldoende adequaat zal zijn. Aangezien het haventerrein boven het waterniveau ligt, is er geen risico van overstroming (0).

Effect 2.2.2 - Kruising van de Maasgeul (0)
Verankeringen voor drijvend materieel tijdens onderhoud hinderen doorgaand scheepvaartverkeer

Er wordt vanuit gegaan dat er geen uitwendig onderhoud nodig is gedurende de levensduur van de buisleiding en het effect is daarom nihil (0).

Effect 2.2.3 - Zeeleiding tracé tot distributieplatform (0)
Falen van de buisleiding door:
a. Corrosie

b. Te hoge druk in de pijplijn

Volgens de MER Porthos, I&BBF8260R001.D0.1, datum 1-9-2020, heeft de zeeleiding een zekere faalkans. De kans op falen wordt voor circa 50% bepaald door corrosie en materiaal defecten en voor 25% door impact van bijvoorbeeld ankers. De faalkans van niet-begraven transportleidingen over zee, met een diameter kleiner dan 24 inch is circa 5,0 * 10-5 per km per jaar. De Aramis pijplijn is 32” en kent een soortgelijk risico van falen.

Indien de CO_2 vrijkomt onderwater, dan zal zich een zogenaamde “bubble plume” vormen. Deze bubble plume zal de uitstromingssnelheid van het CO_2 reduceren en voorkomen dat er jet dispersie optreedt. De intensieve menging van CO_2 bij vrijkomen met het zeewater zal ervoor zorgen dat vrijgekomen CO_2 direct de temperatuur aanneemt van het zeewater. Daarnaast kan een gedeelte van het CO_2 in het water oplossen. Bij kleinere waterdieptes zal de “bubble plume” leiden tot verminderde dichtheid van het water en potentieel instabiliteit van een schip.

De kans dat een (vissers-) schip zich direct boven een falende buisleiding zal bevinden wordt als zeer klein ingeschat, tenzij het (vissers-) schip zelf de oorzaak is van het falen. Het wordt daarnaast niet waarschijnlijk geacht dat het plaatselijke verlies van hydrostatische druk zal leiden tot verlies van stabiliteit van een (Vissers-) schip (0).

Effect 2.2.4 Zeeleiding tracé tot distributieplatform (--)
Beschadigen van de buisleiding door:
a. Zinken schip na rammen of anderszins
b. Slepen van ankers
c. Slepen van vissers gerei
d. Gevallen lading
e. Aanraking door kiel schip of bouwmaterieel

Het risico op een ongeval is aanwezig bij beschadiging van de buisleiding door aanvaring door de scheepvaart.

In 2011 heeft MARIN voor een soortgelijk project uitgevoerd (CO_2 opslag met een buisleiding vanaf de Maasvlakte), ref. 24114.620/3B, gedateerd 22 februari 2011. Daarin is onderzoek gedaan naar de kans op een incident met de buisleiding door passerende scheepvaart.

De kans op een incident is bepaald met ongevalskansmodules van het SAMSON model (Safety Assessment Model for Shipping and Offshore on the North Sea). Het model is ontwikkeld voor Rijkswaterstaat Noordzee en wordt gebruikt om de kansen en consequenties van alle type ongevallen op zee te schatten. Ook wordt het SAMSON model gebruikt om de impact van deze ongevallen op het veiligheidsniveau te voorspellen. Voor de berekeningen wordt gebruik gemaakt van een verkeersdatabase die de dichtheid, samenstelling en het gedrag van het scheepvaartverkeer beschrijft.

Het verkeer op zee wordt onderverdeeld in twee groepen, namelijk het ‘routegebonden’ en het ‘niet routegebonden’ verkeer (R-schepen en N-schepen). Het routegebonden verkeer bevat de scheepsbewegingen van de koopvaardijschepen, die op weg zijn van haven A naar haven B. Het niet routegebonden verkeer bevat de scheepsbewegingen van de schepen die een missie ergens op zee hebben, zoals visserij, bevoorradingsvaart, werkvaart en recreatievaart.
De vier hoogste ongevalfrequenties zijn:

- Vissende vissersschepen die over de buisleiding varen;
- Anker haakt achter de buisleiding;

- Containers vallen overboord op de buisleiding;
- Schip zinkt op buisleiding (wel of niet als gevolg van een aanvaring).

Tabel 5-1. Frequenties gebeurtenissen voor elk deel van de zeeleiding

Tabel 4-1 Frequentie per gebeurtenis voor elk deel van de pijpleiding

Pijp	Van		Naar		Lengte	Passages over pijp			Gezonken op pijp na een aanvaring			Gezonken op pijp zonder aanvaring		
	NB	OL	NB	OL		aantal/km/jaar			aantal/km/miljoen jaar			aantal/km/miljoen jaar		
Sectie	° ‘	° ‘	° ‘	° ‘	km	R-schip	N-schip	Totaal	R-schip	N-schip	Totaal	R-schip	N-schip	Totaal
1	5208	356	5208	357	0.446	0	89	89	0.000	0.593	0.593	0.000	0.256	0.256
2	5208	357	5204	403	10.383	878	301	1179	1.556	1.128	2.684	1.426	0.517	1.943
3	5204	403	5202	403	3.496	0	706	706	0.000	1.868	1.868	0.000	0.827	0.827
4	5202	403	5200	402	2.575	0	699	699	0.000	1.651	1.651	0.000	0.707	0.707
5	5200	402	5159	402	2.380	27253	699	27952	39.098	1.649	40.748	32.699	0.707	33.406
Totaal					19.280	3837	472	4309	5.664	1.384	**7.048**	4.804	0.616	**5.420**

Tabel 4-2 Frequentie per gebeurtenis voor elk deel van de pijpleiding (vervolg)

Pijp	Container overboord op pijp			Dek lading op pijp			Anker op pijp			Anker haakt achter pijp			Vissend vissersschip vaart over pijp
	aantal/km/miljoen jaar			aantal/km/miljoen jaar			aantal/km/miljoen jaar			aantal/km/miljoen jaar			aantal/km/jaar
Sectie	R-schip	N-schip	Totaal	R-schip	N-schip	Totaal	R-schip	N-schip	Totaal	R-schip	N-schip	Totaal	Vissersschip
1	0.000	0.000	0.000	0.000	0.006	0.006	0.000	0.076	0.076	0.000	0.272	0.272	57
2	20.787	0.000	20.787	0.129	0.018	0.148	0.401	0.171	0.572	4.166	0.574	4.741	67
3	0.000	0.000	0.000	0.000	0.037	0.037	0.000	0.327	0.327	0.000	0.913	0.913	90
4	0.000	0.000	0.000	0.000	0.034	0.034	0.000	0.306	0.306	0.000	0.773	0.773	78
5	62.678	0.000	62.678	4.205	0.034	4.239	12.916	0.305	13.221	140.784	0.772	141.555	78
Totaal	18.932	0.000	**18.932**	0.589	0.026	0.614	1.810	0.232	2.042	19.623	0.680	**20.302**	74

De frequenties die samenhangen met R-schepen zijn uitsluitend relevant voor trajecten in de directe nabijheid van navigatiekanalen. Op die lokaties zullen mitigerende maatregelen getroffen worden zoals bijvoorbeeld het begraven van de buisleiding.

Op andere lokaties wordt er mitigerende maatregelen getroffen om het risico te verminderen van zinkende schepen en vallende lading, zoasl bijvoorbeeld het aanhouden van een minimale afstand van 1 nautical mile tussen de vaarweg en het tracé van de zeeleiding De inschatting binnen het kader van dit rapport is dat de kans op vallende lading buiten de vaargeul verwaarloosbaar is. Begraven zou een passende mitigerende maatregel zijn.

Voor de N-schepen is met name de frequentie van passerende vissende vissersschepen van belang. Op basis van de analyse van MARIN voor het soortgelijke project, worden alle andere risico’s als beperkt ingeschaald.

Voor het risico van beschadigingen ten gevolge van vissende vissersschepen, waarbij de slepende netten de pijpleiding beschadigen, (Er passeren circa 80 vissende schepen/ km/ jaar) wordt geadviseerd aanvullende maatregelen te treffen.

In afwachting van deze studie en op basis van de MARIN studie wordt het risico op beschadiging vooralsnog als hoog ingeschat en daarom negatief gescoord (- -).

Opgemerkt wordt dat er een risico gedreven aanpak in het ontwerp zal worden toegepast waarin de risico’s geïnventariseerd worden en het ontwerp aangepast totdat de risico’s acceptabel zijn in overeenstemming met de geldende (NEN) normen.

Effect 2.2.5 - Kruisingen van pijpleidingen en kabels (0)

Beoogd tracé interfereert met bestaande infrastructuur

Het traject van de buisleiding is bepaald, rekening houdend met de bestaande infrastructuur. Informatie is afkomstig uit rapport 416010-00257 - ARM-CPT-BB3-PLR-REP-0066_1, 05 April 2023, Routing.

Informatie is afkomstig uit rapport 416010-00257 - ARM-CPT-BB3-PLR-REP-0048_2, van datum 19 March 2023; Crossing inventory.
Het totaal aantal kruisingen van pijpleidingen is 47, exclusief Neptune Energy aansluiting.

Tabel 5-2. Aantal kruisingen pijpleidingen

Section	Type 1	Type 2	Type 4	Type 5	Type 6	Type 7	Type 8	Type 9	Type 10	Total
NS HDD	1		1	1				2	1	6
A	5				1	9	1	7	5	28
C		2	1				1		2	6
D		1			1				1	3
F			3		1					4
Total	6	3	5	1	3	9	2	9	9	47

De kruisingen zijn onderverdeeld in 10 typen.

Tabel 5-3. Definitie typen kruisingen

Crossed infrastructure	Aramis buried	Aramis on seabed
Pipeline buried, < 16-inch	Type 1	Type 2
Pipeline on seabed, 16 to 24-inch	Type 3	Type 4
Pipeline on seabed, 24 to 36-inch	Type 5	Type 6
cable buried	Type 7	Type 8
cable abandoned/OOS	Type 9 cut and remove section	Type 10 no action

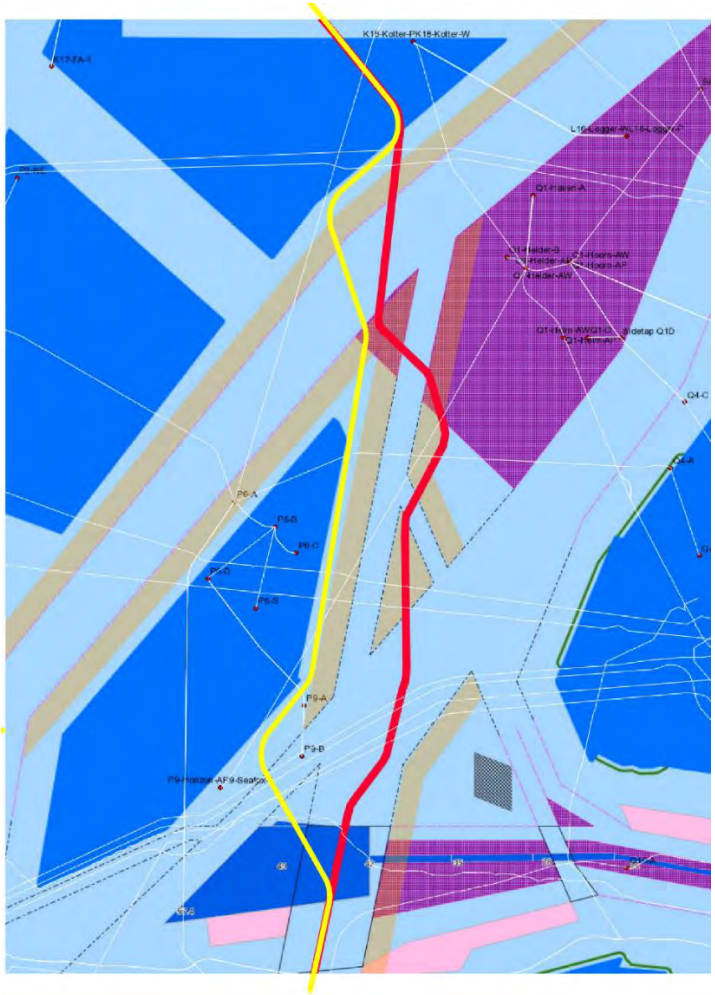
Voor elk type is een ontwerp gemaakt, waarin op gecontroleerde wijze de kruising tot stand gebracht kan worden.

De impact van het traject wordt daarom als nihil beschouwd (0).

Effect 2.2.6 - Kruisingen met navigatiegebieden (0)

Beoogd tracé interfereert met bestaande navigatiegebieden
Het traject van de buisleiding is bepaald, rekening houdend met bestaande infrastructuur, zoals het Verkeers Scheidings Stelsel en bestaande pijpleidingen en kabels. Informatie is afkomstig uit rapport 416010-00257 – ARM-CPT-BB3-PLR-REP-0066_1, 05 April 2023, Routing.

Er wordt een bufferzone tussen de navigatieroute en de leidingen tracé aangehouden van minimaal 1 nm. Daarnaast wordt de navigatieroute gekruist met een minimale hoek van 30 graden.



Figuur 5-2: Alternatieve leidingen tracés nabij BBL gaspijplijn

Ter plaatse van de BBL gas pijplijn zijn er twee alternatieve routes gedefinieerd. De rode route is de gekozen route. De alternatieve (Gele) route is niet geprefereerd met name omdat in die route meer leidingen worden gekruisd.

Het traject van de buisleiding is bepaald, rekening houdend met de bestaande infrastructuur en vaarroutes. De impact van het traject wordt daarom als nihil beschouwd (0).

5.3 Platforms; distributieplatform, nieuwe en bestaande platforms

Tijdens de gebruiksfase worden de platforms ge-serviced, gebruik makend van Offshore Support Vessels (OSV's). De platforms zijn gesitueerd in de drukbevaren Noordzee. Er bestaat daarom een risico dat de platforms worden aangevaren en beschadigd door ongecontroleerde schepen.

Effect 3.2.1 - Platform faalt door aanvaring service schip (-)
Informatie is afkomstig uit:

- rapport A4863-SHE-CRA-1, gedateerd 1 juni 2022, Aramis project, Vessel collision risk assessment.
- A07 External Hazards Assessment, K6CC, March 2023

- Abbott risk consulting, ARC-001-231-R004, April 2022, TEPNL Passing Vessel Collision Study L4A

In deze rapporten worden de risico's van rammen door "Infield" schepen (Schepen direct betrokken bij de operatie van de platforms) bepaald. De geschiedenis geeft aan dat met dit soort schepen de risico's van rammen relatief groot zijn:

- De schepen zijn per definitie regelmatig in de nabijheid van de platforms
- De afmeting van de schepen is relatief groot
- De schepen hebben een relatief grote aankomstsnelheid

Veel operaties worden uitgevoerd met walk-to-work vessels (W2W), welke voorzien zijn van 3D bewegingscompensatie voor de kranen en loopbruggen. Ook jack up platforms (JUP) kunnen gebruikt worden, welke een stabiel platform bieden. W2W vessels zijn self propelled, terwijl JUP's door sleepboten naar hun positie worden gebracht.

Door meer betrouwbaar materieel en betere veiligheidsprocedures is het aantal incidenten over de afgelopen jaren significant afgenomen. De kans op impact wordt uitgerekend als 1/150 jaar, wat hoger is dan voor passerende schepen. De impact energie is echter, door de lage snelheid, lager.

Voorzorgsmaatregelen kunnen bestaan uit bijvoorbeeld

- Instellen van operationele beperkingen
- Ontwerpen van afmeervoorziening welke geen invloed heeft op de product verlading
- Emergency ShutDown faciliteiten
- Training
- Adequaat liftplan
- Collision risk management plan, inclusief remote monitoring
- Remote operations waar mogelijk
- Platform voldoende sterk ontwerpen;
- Kwetsbare elementen zoals conductors en stijgpijp beschermen door constructie

Al met al, met name door de mogelijke goede voorbereiding en de geringe gevolgen, wordt het effect van aanvaring en beschadiging door werkschepen als klein ingeschat (-).

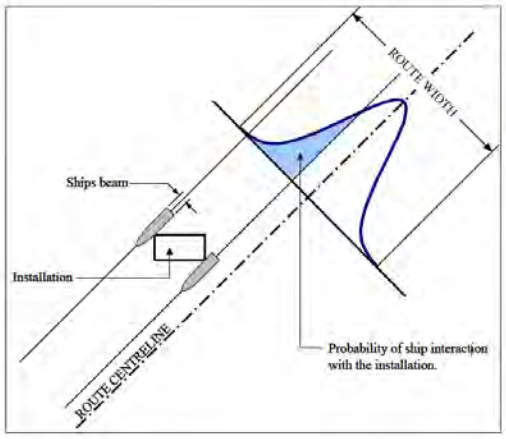
Effect 3.2.2 - Platform faalt door aanvaring schip van derden (--)
Informatie is afkomstig uit:

- rapport A4863-SHE-CRA-1, gedateerd 1 juni 2022, Aramis project, Vessel collision risk assessment.
- A07 External Hazards Assessment, K6CC, March 2023
- Abbott risk consulting, ARC-001-231-R004, April 2022, TEPNL Passing Vessel Collision Study L4A

In deze rapporten worden de risico's van rammen van de platforms door verschillende schepen geanalyseerd:

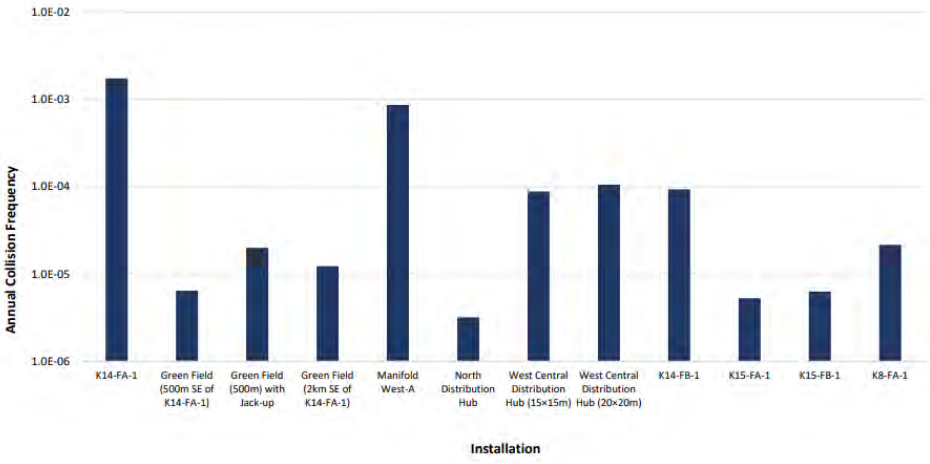
1. Passerende schepen
2. Passerende driftende schepen
3. Passerende vissersschepen

Ad 1:
Het programma COLLRISK is gebruikt om de risico's op aanvaring van de offshore platforms door derden te bepalen. Het model is erop gebaseerd dat de aanvaring frequentie proportioneel is met het volume en de nabijheid van naburige schepen. Historische data laat zien dat de meest waarschijnlijke oorzaak van het rammen van schepen ligt in menselijke fouten.
In het model is de verkeersintensiteit, gemiddelde positie en standaarddeviatie van de scheepsvaartroutes gebruikt om het ram risico van de platforms te bepalen.



Figuur 5-3: Definitieschets standaarddeviatie scheepvaartroute

De hoogste bepaalde frequentie is een kans op voorkomen van 1 op de 570 jaar. Platform K14-F-1A en Manifold West A hebben de hoogste kans op aanvaring.



Figuur 5-4: Kans op aanvaring Aramis platformen (Bron: rapport A4863-SHE-CRA-1, gedateerd 1 juni 2022, Aramis project, Vessel collision risk assessment)

Het centrale platform is nog in ontwikkeling. Meer studie is nodig om de exacte risico's en effecten van passerende schepen op het centrale platform in kaart te brengen. In afwachting van deze studie is het effect op significant ingeschat.

Ad 2.
Het programma COLLRISK is gebruikt om de risicos op aanvaring van de offshore platforms door derden te bepalen. De module voor driftende schepen gaat ervan uit dat de motor moet falen voordat een schip

gaat driften. Het model houdt rekening met de mogelijkheid dat schepen meerder motoren kunnen hebben.

De hoogste bepaalde frequentie is een kans op voorkomen van 1 op de 6800 jaar.

Ad 3.
De activiteiten door vissers schepen zijn niet-routine activiteiten en kunnen daarom niet met COLLRISK worden gesimuleerd. Het gebruikte model benut AIS data om de kans te bepalen dat vissersschepen in de buurt van de platforms komen, met het risico op rammen als gevolg.

De hoogst gevonden frequentie dat een vissersschip een platform raakt is eens per 12.000 jaar.

Aangezien een aantal platforms relatief dicht bij de VSS liggen, is de kans op rammen daardoor relatief hoog. De mogelijke voorzorgsmaatregelen om rammen te voorkomen, zoals NAVAIDS, lichten voor zichtbaarheid vanuit platforms, lijken beperkt, alhoewel de veiligheidsafstand van 500m bijdraagt aan de vermindering van het risico. Er zijn wel maatregelen mogelijk om de nadelige gevolgen te mitigeren, zoals bijvoorbeeld robuust constructief ontwerp of implementatie van Emergency Shutdown Systems.

Met name vanwege de onzekerheden en nog niet definitieve studies omtrent het centrale platform wordt het effect als significant ingeschat (--).

Effect 3.2.3 - Impact van service operaties op marine leven (0)
Het aantal additionele service schepen is beperkt, in vergelijking tot het aantal schepen op de Noordzee. De effecten zijn daarom nihil (0).

Effect 3.2.4 - Service schepen botsen met derden (Scheepvaart, platforms, windpark) (0)
Het aantal service activiteiten per platform wordt ingeschat als volgt (Referentie rapport A4863-SHE-CRA-1, gedateerd 1 juni 2022, Aramis project, Vessel collision risk assessment).

Tabel 5-4. Service activiteiten per platform

Type of Operation	Vessel type	Typical Vessel	Number of Days over 15 Years	Annual Hours
Planned	W2W / Support vessel	Kasteelborg / Kroonborg	299	239
	Stimulation vessel	Island Captain / Island Centurion	48	38
	Supply Vessel	VOS Patience	100*	27
Unplanned	50% W2W / 50% using synergy with other works (i.e., no additional visits)	Kasteelborg / Kroonborg	30	24
	50% W2W / 50% using synergy with other works (i.e., no additional visits)		30	24

*The number of supply vessel visits is based on information provided by the client. Visits are conservatively assumed to take an average of four hours.

Het aantal additionele service schepen is beperkt, in vergelijking tot het huidig aantal schepen op de Noordzee. De effecten zijn daarom nihil (0).

5.4 Samenvatting en conclusies

Tabel 5-5. Samenvatting effectbeoordeling Gebruiksfase

Nummer	Aspect	Effect	Effectbeoordeling	Gebruikte studie
1.2.1	Doorvaart zeeschepen	Uit de koers lopen door ondeugdelijk materiaal of menselijke fouten, met als gevolg rammen van schepen	(0)	AIS Data, MARIN studie 33932.601_v1 7-3-2022 Data Website HbR Inschatting CO2next schepen
1.2.2		Uit de koers lopen door ondeugdelijk materiaal of menselijke fouten, met als gevolg rammen van assets	(-)	brief HBR-2244094 (3-3-2022) Data website HbR
1.2.3	Doorvaart binnenvaart	Uit de koers lopen door ondeugdelijk materiaal of menselijke fouten, met als gevolg rammen van schepen	(0)	AIS Data, MARIN studie 33932.601_v1 7-3-2022 AIS Data Data website HbR Inschatting CO2next schepen
1.2.4		Uit de koers lopen door ondeugdelijk materiaal of menselijke fouten, met als gevolg rammen van assets	(-)	HBR-2244094 (3-3-2022) Data website HbR
1.2.5	Afmeren	Uit de koers lopen door ondeugdelijk materiaal of menselijke fouten	(0)	HBR-2244094 (3-3-2022) Expert judgement
1.2.6	Verlading	Verlies van CO_2 product tijdens de verlading door proces fouten, ondeugdelijk materiaal of rammen door derden	(0)	D10054101:43 (19-5-2022) van ARCADIS 33932.600/v2 (8-2-2022) MARIN
1.2.7	Marine terminal	Rammen van de constructie door derden	(-)	HBR-2244094 (3-3-2022) MARIN studie 33932.601_v1 7-3-2022
2.2.1	Aanlanding in Rotterdam	Lekken primaire waterkering door doorkruising van de leiding	(0)	Expert judgement
2.2.2	Kruising van de Maasgeul	Verankeringen voor drijvend materieel tijdens onderhoud hinderen doorgaand scheepvaartverkeer	(0)	Expert judgement
2.2.3	Zeeleiding tracé tot distributieplatform Zeeleiding tracé to platforms	Falen van de buisleiding door: a. Corrosie b. Te hoge druk in de pijplijn	(0)	MER Porthos, I&BBF8260R001.D0.1, datum 1-9-2020
2.2.4		Falen van de buisleiding door: a. Zinken schip na clash of anderszins b. Draggen van ankers c. Draggen van vissers netten d. Gevallen lading e. Aanraking door kiel schip	(- -)	MARIN ref. 24114.620/3, 22 februari 2011

Nummer	Aspect	Effect	Effectbeoordeling	Gebruikte studie
2.2.5	Kruisingen van pijpleidingen en kabels	Beoogd tracé interfereert met bestaande infrastructuur	(0)	416010-00257 – ARM-CPT-BB3-PLR-REP-0066_1, 05 April 2023, Routing. 416010-00257 – ARM-CPT-BB3-PLR-REP-0048_2, 19 March 2023; Crossing inventory
2.2.6	Kruisingen met navigatiegebieden	Beoogd tracé interfereert met bestaande navigatiegebieden	(0)	416010-00257 – ARM-CPT-BB3-PLR-REP-0066_1, 05 April 2023, Routing.
3.2.1	Distributieplatform Nieuwe platforms (Neptune Energy en Shell) Connectie op bestaande platforms	Platform faalt door aanvaring service schip	(-)	A4863-SHE-CRA-1, 1 juni 2022, Vessel collision risk A07 External Hazards Assessment, K6CC, March 2023 ARC-001-231-R004, April 2022, TEPNL L4A
3.2.2		Platform faalt door aanvaring schip van derden	(--)	A4863-SHE-CRA-1, 1 juni 2022, Vessel collision risk A07 External Hazards Assessment, K6CC, March 2023 ARC-001-231-R004, April 2022, TEPNL L4A
3.2.3		Impact van service operaties op marine leven	(0)	Expert judgement
3.2.4		Service schepen botsen met derden (Scheepvaart, platforms, windpark)	(0)	A4863-SHE-CRA-1, 1 juni 2022, Vessel collision risk

De belangrijkste aandachtspunten zijn:

- De LCO_2 schepen zullen moeten manoeuvreren door de druk bevaren Rotterdamse haven. Dit is niet ongebruikelijk, maar zal wel met de nodige afstemming gepand moeten worden.
- De platforms zijn kwetsbaar voor passerende schepen, als ook serviceschepen.
- Het aantal passerende schepen in het Yangtzekanaal zal autonoom verder groeien, met significante kans op aanvaring van de CO2next steigers. De afgemeerde CO2next schepen dienen fysiek of operationeel beschermd te worden tegen aanvaring.
- Met name de vissersschepen hebben een redelijke kans om de buisleiding te beschadigen op lokaties waar de buisleiding niet begraven is.

6 Milieuaspecten aanlegfase en ontmantelingsfases

Dit hoofdstuk gaat per Aramis onderdeel in op de effecten op het thema nautische veiligheid, zoals die verwacht worden tijdens de aanleg en de ontmanteling van de CCS-keten. Waar nodig wordt onderscheid gemaakt naar de startfase en de eerste uitbreidingsfase. Tevens bevat het hoofdstuk een doorkijk naar de effecten (Consequenties) die verwacht worden voor de eindfase.

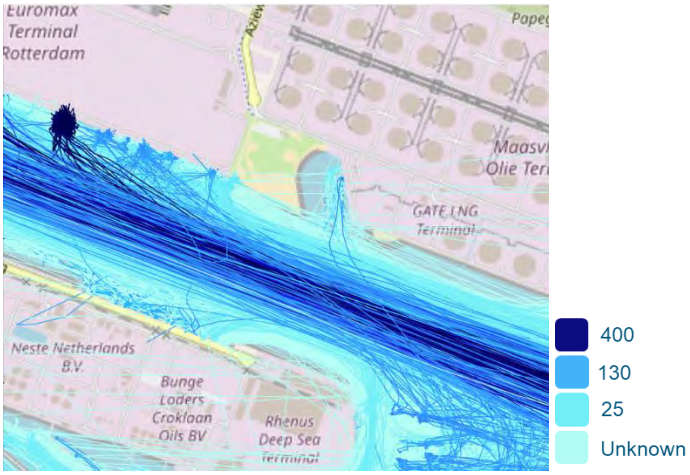
6.1 Terminal en scheepvaart

De effecten tijdens de aanleg betreffen het hinderen van de scheepvaart en de risico's van een aanvaring. Bij inspectie, reparaties en/of herbegraven zijn vergelijkbare effecten op de scheepvaart te verwachten als bij de aanleg.

Effect 1.1.1 - Ongecontroleerd drijvend bouwmaterieel (-)
Informatie is afkomstig uit MARIN studie 33932.601_v1 van 7 maart 2022, waarin het aanvaarrisico van de geplande CO_2 faciliteiten middels een desktopstudie is bepaald.

De breedte van het Yangtzekanaal is circa 500m, waarvan 300m beschikbaar is voor doorvaart. Het Yangtzekanaal biedt daarom relatief weinig ruimte voor drijvend materieel, terwijl de normale scheepvaart doorgang zal moeten hebben. In het geval van ongecontroleerd drijvend materieel, zal er redelijke kans zijn dat de doorgaande scheepvaart daar hinder van zal ondervinden.

Een overzicht van de huidige scheepvaart bewegingen in het Yangtzekanaal gebaseerd op AIS data. Deze AIS data geeft aan dat er momenteel (2020) circa 330 schepen per dag passeren (120 zeeschepen en 210 binnenvaart). Autonome ontwikkelingen zullen leiden tot een significante vermeerdering.



Figuur 6-1: Overzicht scheepvaartbewegingen in de nabijheid van Gate terminal, in een periode van 4 weken in 2023, colour-coded op scheepslengte

De werkmethodiek van de aanleg van de CO2next steigers zal hier rekening mee moeten houden, door voorzorgsmaatregelen te treffen in bijvoorbeeld extra verankeringen of het gebruik van Jack up platformen (JUP), welke niet verankerd zijn maar op spudpalen staan, danwel de inzet van sleepboten.

Het effect wordt licht negatief gescoord (-).

Effect 1.1.2 - Verankeringen voor drijvend materieel hinderen doorgaand scheepvaartverkeer (0)
Informatie is afkomstig uit MARIN studie 33932.601_v1 van 7 maart 2022, waarin het aanvaarrisico van de geplande CO_2 faciliteiten middels een desktopstudie is bepaald.
Het Yangtzekanaal biedt relatief weinig ruimte voor drijvend materieel, terwijl de normale scheepvaart doorgang zal moeten hebben. Drijvend materieel wordt vaak op ankers vastgelegd, waar hier beperkte ruimte voor is.
Mitigerende maatregelen zouden kunnen inhouden dat de constructiemethode van de steigers aangepast wordt, bijvoorbeeld door vanaf de oever uit te bouwen, of middels het gebruik van JUP's.

Daarmee zal de beperking van het scheepsvaartverkeer in het Yangtze kanaal tot een minimum beperkt kunnen worden, en dit effect is daarom neutraal gescoord (0).

Effect 1.1.3 - Rammen van bouwmaterieel of mariene constructies door derden (-)
Informatie is afkomstig uit MARIN studie 33932.601_v1 van 7 maart 2022, waarin het aanvaarrisico van de geplande CO_2 faciliteiten middels een desktopstudie is bepaald.

Het Yangtzekanaal biedt relatief weinig ruimte voor drijvend materieel, terwijl de normale scheepvaart doorgang zal moeten hebben. In het geval van ongecontroleerde scheepvaart, zal er redelijke kans zijn dat zij de in aanbouw zijnde faciliteiten rammen.

Een overzicht van de huidige scheepvaart bewegingen in het Yangtzekanaal gebaseerd op AIS data. Deze AIS data geeft aan dat er momenteel (2020) circa 330 schepen per dag passeren (120 zeeschepen en 210 binnenvaart). Autonome ontwikkelingen zullen leiden tot een significante vermeerdering.

De werkmethodiek van de CO2next steigers zal hier rekening mee moeten houden, bijvoorbeeld door mitigerende maatregelen te treffen in bijvoorbeeld extra beschermende maatregelen, zoals boeien of sleepboot bescherming of operationele beperkingen van de scheepvaart in overleg met de Havenauthoriteit.

Het effect wordt licht negatief gescoord (-).

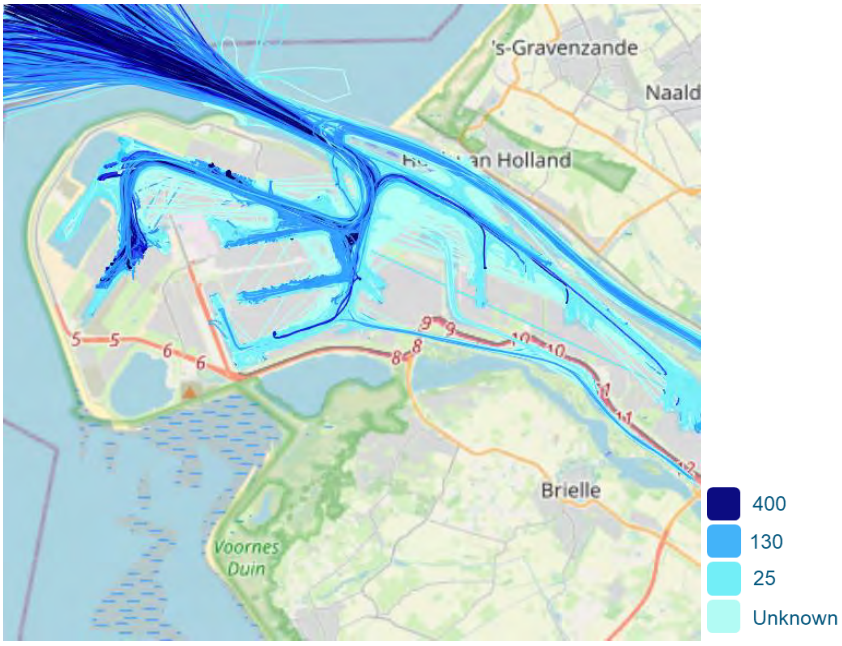
6.2 Zeeleidingen

Informatie is afkomstig uit “Overall Method Statement Construction Activities Aramis” gedateerd 11 Mei 2023, waarin globaal de constructiemethodiek van de zeeleiding wordt beschreven.

Effect 2.1.1 - Aanlanding pijpleiding op Maasvlakte (0)
Aanlegwerkzaamheden doorkruising leiding tasten stabiliteit waterkering aan.

Bij adequaat ontwerp en de uitvoering van de aanlanding zal er geen risico zijn voor instabiliteit van de oever. Aangezien het haventerrein boven het waterniveau ligt, is er geen risico van overstroming.

De drukte van de Maasgeul wordt weergegeven in de volgende figuur.



Figuur 6-2: Overzicht scheepvaartbewegingen in de Maasgeul (four weeks 2023), colour-coded by vessel length

In principe zullen de werkzaamheden voor de aanleg van een kruising op het land gedaan worden, van waaruit onder de waterkering en de Maasgeul geboord zal worden.

Het effect wordt als verwaarloosbaar gescoord (0).

Effect 2.1.2 - Kruising van de Maasgeul - Beschadigen bestaande pijplijnen (0)
Beschadigen bestaande pijplijnen door:
a) gestuurde boring
b) Drijvend materieel verankering
c) Spudpalen/ heien
d) Baggeren

De locatie van de bestaande leidingen is bekend en daar zal in de constructie rekening mee gehouden worden. Wel zal er NGE onderzoek (Onderzoek naar niet gesprongen oorlogsresten/ explosieven) uitgevoerd moeten worden voorafgaand aan de aanleg van de leiding.

De kans dat er onbekende leidingen beschadigd raken wordt als nihil ingeschat (0).

Effect 2.1.3 - Kruising van de Maasgeul - hinderen doorgaand scheepvaartverkeer (0) / (--)
Hinderen doorgaand scheepvaartverkeer bijvoorbeeld door verankeringen voor drijvend materieel of druktesten leiding

Er zijn twee alternatieven voor de kruising van de Maasgeul, welke beide uitgaan van een gestuurde boring.

In de varianten met tunnel boringen ligt de geboorde buisleiding circa 10 m diep onder het diepste punt van de vaargeul en heeft daardoor geen impact op de scheepvaart en geen risico op aanvaring van de buisleiding. Een tijdelijk werkschip om de transportleiding en eventuele kabel te begeleiden die onder de Maasgeul wordt getrokken bij de boring onder de Maasgeul, zal ten noorden van de Maasgeul liggen. Gezien de vaste ligging van dit werkvaartuig is effect op het scheepvaartverkeer in de Maasgeul niet te verwachten. Scheepvaart ondervindt daarom nagenoeg geen hinder voor de aanleg van de leiding onder de Maasgeul door en worden de effecten als nihil beschouwd (0).

Voor de Direct Pipe uitvoeringsmethode wordt er een sleuf gegraven door de Maasgeul . Het verkeer in de Maasgeul zal daardoor enige tijd hinder ondervinden. Door een slimme planning waarbij de vaargeul niet volledig wordt afgesloten en geen gebruik gemaakt wordt van brede ankerlijnen, zal het effect nog enigszins beperkt kunnen worden. Tevens is het van belang dat de mogelijke stremming goed wordt gecommuniceerd aan de scheepvaart en loodsen, voorafgaand aan de werkzaamheden. Het effect wordt desalniettemin als hoog ingeschat en daarom negatief gescoord (- -).

Effect 2.1.4 - Kruising van de Maasgeul – rammen materiaal (-) / (0)
Rammen van bouwmaterieel of mariene constructies, inclusief ontvangstschacht, door derden

Voor de gestuurde boring, zal er een ontvangstschacht worden aangelegd ten noorden van de Maasgeul. Deze ontvangstschacht zal enkele weken in bedrijf zijn, voordat de buisleiding aan beide zijden aangesloten is. De ontvangstschacht ligt buiten de Maasgeul. Hoewel de werkzaamheden gecontroleerd worden uitgevoerd en er mitigerende maatregelen kunnen worden ingesteld om de schacht te beschermen, zoals bijvoorbeeld een beschermingsconstructie of permanente wachtschepen, wordt het effect als licht negatief gescoord (-). De reden is het grote aantal schepen dat passeert en de grote potentiële consequenties (Overlijden).

Voor het Direct pipe alternatief is dit geen issue (0).

Effect 2.1.5 - Kruising van de Maasgeul – Ongecontroleerd drijvend bouwmaterieel (0)
Tijdens de aanleg van de transportleiding zullen werkvaartuigen in de Maasmond aanwezig zijn. De werkzaamheden zijn van tijdelijke aard. Maatregelen zullen worden ingesteld in overleg met de Havenmeester zodanig dat de kans op rammen nihil zal zijn (0).

Effect 2.1.6 – zeeleiding tracé – beschadiging leidingen (0)
Beschadigen bestaande, niet bekende, pijpleidingen door baggeren of verankering drijvend materieel

Het werkvaartuig dat de transportleiding legt, start de werkzaamheden ten noorden van de Maasgeul in het geval van de microtunnel optie. De drukke Maasgeul scheepvaartroute zal dus niet gekruist worden.

Voor de Direct Pipe optie wordt de Maasgeul wel gekruist.

Informatie is afkomstig uit rapport 416010-00257 - ARM-CPT-BB3-PLR-REP-0048_2, van datum 19 March 2023; Crossing inventory. Er is een inventarisatie gemaakt van de kruisingen op het tracé van de buisleiding, gebaseerd op Noordzeeloket, https://www.noordzeeloket.nl/en/up-date-atlas/.

De buisleiding zal worden begraven op de lokaties waar een navigatiekanaal wordt gekruist, of op de lokaties waar zand duinen kunnen zorgen voor constructieve instabiliteit. De totale lengte van de buisleiding die begraven zal worden is 110 km (105 km Sectie A, 5 km Sectie C),

- lengte 10 km, startend bij de aanlanding; reden scheepvaartactiviteiten
- lengte 75 km, start bij platform P18-A, reden zand duinen
- lengte 20 km, reden ondiep water scheepvaartactiviteiten
- Lengte 5 km, sectie C, reden diepwater scheepvaartactiviteiten

De locatie van de bestaande leidingen is bekend en daar zal in de constructie rekening mee gehouden worden. De kans dat er onbekende leidingen beschadigd raken wordt als nihil ingeschat (0).

Effect 2.1.7 – Kruisng leidingen en kabels (0)
Beschadigen bestaande pijpleidingen en kabels door baggeren, verankering drijvend materieel of kruisingswerkzaamheden
Informatie is afkomstig uit rapport 416010-00257 - ARM-CPT-BB3-PLR-REP-0048_2, van datum 19 March 2023; Crossing inventory.

Het totaal aantal kruisingen van pijpleidingen is 47, exclusief Neptune Energy aansluiting.

Tabel 6-1. Aantal kruisingen pijpleidingen

Section	Type 1	Type 2	Type 4	Type 5	Type 6	Type 7	Type 8	Type 9	Type 10	Total
NS HDD	1		1	1				2	1	6
A	5				1	9	1	7	5	28
C		2	1				1		2	6
D		1			1				1	3
F			3		1					4
Total	6	3	5	1	3	9	2	9	9	47

De kruisingen zijn onderverdeeld in 10 typen.

Tabel 6-2. Definitie typen kruisingen

Crossed infrastructure	Aramis buried	Aramis on seabed
Pipeline buried, < 16-inch	Type 1	Type 2
Pipeline on seabed, 16 to 24-inch	Type 3	Type 4
Pipeline on seabed, 24 to 36-inch	Type 5	Type 6
cable buried	Type 7	Type 8
cable abandoned/OOS	Type 9 cut and remove section	Type 10 no action

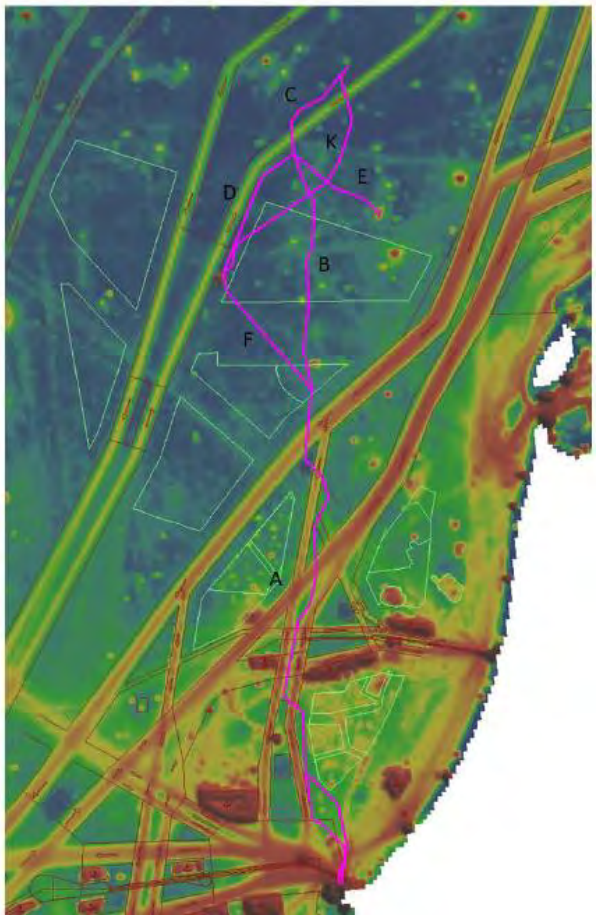
Voor elk type is een ontwerp gemaakt, waarin op gecontroleerde wijze de kruising tot stand gebracht kan worden. De kans op schade aan bestaande leidingen wordt daarom als nihil ingeschat (0).

Effect 2.1.8 - Kruisingen met navigatiegebieden (-)
Verankeringen voor drijvend materieel hinderen doorgaand scheepvaartverkeer.

Het tracé kruist meerdere Verkeers Scheiding Stelsels (VSS). Het tracé kruist, naast de Maasgeul, 6 maal een navigatieroute en grenst op 2 lokaties aan een navigatieroute.

Het leggen van een ingegraven buisleiding zal gedaan worden door een combinatie van een legschip en een ingraafmachine. Afhankelijk van het type ingraafmachine, wordt de ingraafmachine begeleid door een ingraafschip of heeft deze een eigen aandrijving. In de effectbepaling wordt uitgegaan van een combinatie met een geschatte lengte van maximaal 2.000 m. De snelheid waarmee gevaren wordt is geschat op 3 km per dag.

Veelal zijn de hoeken van het werkvaartuig en het VSS niet haaks, en zal naar schatting maximaal 50% door het werkvaartuig worden ingenomen. Gezien de korte afstand en de werksnelheid, zal deze hinder naar verwachting gedurende een dag plaats vinden en is daarom licht negatief gescoord (-).



Figuur 6-3: Overzicht scheepvaartbewegingen in de Noordzee

Effect 2.1.9 – Kruising navigatiegebieden – rammen materieel (0)
Rammen van bouwmaterieel of mariene constructies door derden

Tijdens de aanleg van de transportleiding zullen werkvaartuigen in de VSS aanwezig zijn. Aanwezigheid van een guardvessel of sleepboot als begeleiding kan een goede voorzorgsmaatregel zijn. De werkzaamheden zijn van tijdelijke aard. Maatregelen zullen worden ingesteld in overleg met de Havenmeester en Kustwacht zodanig dat de kans op rammen nihil zal zijn (0).

Effect 2.1.10 – Kruising navigatiegebieden - ongecontroleerd drijvend bouwmaterieel (0)
Tijdens de aanleg van de transportleiding zullen werkvaartuigen in de VSS aanwezig zijn. De werkzaamheden zijn van tijdelijke aard. Maatregelen zullen worden ingesteld in de constructie methodes zodanig dat de kans op losbreken nihil zal zijn (0).

Aanwezigheid van een sleepboot als begeleiding kan een goede mitigerende maatregel zijn.

6.3 Platforms; distributieplatform, nieuwe en bestaande platforms

Effect 3.1.1 - Nieuwe platforms (Neptune Energy en Shell) – (0)
Schade aan het platform bij:

- de load out (Door vallende kraan , vallende objecten);
- transport (Door zinkend transport schip, overbelaste constructie) of;
- installatie (Door botsend installatieschip, overbelaste constructie).

Informatie is afkomstig uit document 27.1726-GMT-210, offshore installation manual- Volume 1, Installation Manual for the D18a-A platforms van Seaway Heavy Lifting, waarin de installatie van 4 platforms wordt beschreven, inclusief:

- Transport;
- Pre-installatie activiteiten;
- Jacket installatie;
- Topsides installatie en;
- Commissioning.

Deze methodologie is beschreven voor daadwerkelijk in 2013 geïnstalleerde platforms. Er wordt vanuit gegaan dat een soortgelijke methodologie zal worden opgesteld voor de Aramis en Neptune platforms, waarbij de geleerde lessen uit 2013 zullen worden meegenomen.

Hoewel de activiteiten, door bijvoorbeeld de gewichten en de complexiteit van de activiteiten als risicovol beschouwd kunnen worden, is in de methodologie duidelijk dat de risico's onder controle zijn en afdoende gemitigeerd. De risico's op beschadiging van de platforms wordt daarom als nihil (0) beoordeeld.

Effect 3.1.2 – Distributieplatform - Connectie bestaande en nieuwe platforms (0)
Schade aan het platform bij connectie door botsend installatieschip, overbelaste constructie

Informatie is afkomstig uit het rapport A4863-SHE-CRA-1, gedateerd 1 juni 2022, Aramis project, Vessel collision risk assessment. In dit rapport wordt het risico van rammen door "Infield" schepen (Schepen direct betrokken bij de operatie van de platforms) bepaald. De geschiedenis geeft aan dat met dit soort schepen de risico's van rammen relatief groot zijn:

- De schepen zijn per definitie regelmatig in de nabijheid van de platforms.
- De afmeting van de schepen is relatief groot.
- De schepen hebben een relatief grote aanmeersnelheid.

Veel operaties worden uitgevoerd met walk-to-work vessels (W2W), welke voorzien zijn van 3D bewegingscompensatie voor de kranen en loopbruggen. Ook jack up platforms (JUP) kunnen gebruikt worden, welke een stabiel platform bieden. W2W vessels zijn self propelled, terwijl JUP's door sleepboten naar hun positie worden gebracht.

Door meer betrouwbaar materieel en betere veiligheidsprocedures is het aantal incidenten over de afgelopen jaren significant afgenomen. De kans op impact wordt uitgerekend als 1/150 jaar, wat hoger is dan voor passerende schepen. De impact energie is echter, door de lage snelheid, lager.

Mitigerende maatregelen kunnen bestaan uit bijvoorbeeld

- Instellen van operationele beperkingen;
- Goed liftplan.

Al met al, met name door de tijdelijke natuur en de mogelijke goede voorbereiding, inclusief het instellen van operationele restricties, wordt het effect van aanvaring en beschadiging door werkschepen als nihil ingeschat (0).

Effect 3.1.3 - Veranderingen aan bestaande platforms (0)
Schade aan het platform door extra functionaliteit van CO_2-transport over het platform, overbelaste constructie

De extra functionaliteit bestaat bijvoorbeeld uit een riser, pompen, etc. Er wordt geadviseerd een technische inspectie uit te voeren op het platform, waarbij ook de onderhoudsrapporten worden beschouwd.

De aanpassing van de constructie zal worden ontworpen, rekening houdend met de huidige staat van het platform en de benodigde versterking. De kans op schade aan de constructie door de extra belasting wordt daarom als nihil ingeschat (0).

6.4 Samenvatting en conclusies

Tabel 6-3. Samenvatting effectbeoordeling Constructiefase

Nummer	Aspect	Effect	Effect-beoor-deling	Gebruikte studie
1.1.1	Marine terminal	Ongecontroleerd drijvend bouwmaterieel	(-)	AIS data, MARIN studie 33932.601_v1 van 7 maart 2022
1.1.2		Verankeringen voor drijvend materieel hinderen doorgaand scheepvaartverkeer	(0)	AIS data, MARIN studie 33932.601_v1 van 7 maart 2022
1.1.3		Rammen van bouwmaterieel of mariene constructies door derden	(-)	AIS data MARIN studie 33932.601_v1 van 7 maart 2022
2.1.1	Aanlanding in Rotterdam	Lekken waterkering door doorkruising van de leiding Impact op doorgaand scheepvaartverkeer	(0)	Overall Method Statement Construction Activities Aramis, (11 Mei 2023)
2.1.2	Kruising van de Maasgeul	Beschadigen bestaande pijplijnen door: a. gestuurde boring	(0)	Overall Method Statement Construction Activities Aramis, (11 Mei 2023)

Nummer	Aspect	Effect	Effect-beoor-deling	Gebruikte studie
		b. Drijvend materieel verankering c. Spudpalen/ heien d. Baggeren		
2.1.3		Verankeringen voor drijvend materieel hinderen doorgaand scheepvaartverkeer Tunnel Direct pipe	(0) (- -).	Overall Method Statement Construction Activities Aramis, (11 Mei 2023)
2.1.4		Rammen van bouwmaterieel of mariene constructies, inclusief ontvangstschaft, door derden Tunnel Direct Pipe	(-) (0).	Overall Method Statement Construction Activities Aramis, (11 Mei 2023)
2.1.5		Ongecontroleerd drijvend bouwmaterieel	(0)	Overall Method Statement Construction Activities Aramis, (11 Mei 2023)
2.1.6	Zeeleiding tracé tot distributieplatform Zeeleiding tracé tot platforms	Beschadigen bestaande- Niet bekende- pijpleidingen door baggeren of verankering drijvend materieel	(0)	Overall Method Statement Construction Activities Aramis, (11 Mei 2023) 416010-00257 – ARM-CPT-BB3-PLR-REP-0048_2, van datum 19 March 2023; Crossing inventory
2.1.7	Kruisingen van pijpleidingen en kabels	Beschadigen bestaande pijpleidingen door baggeren, verankering drijvend materieel of kruisingswerkzaamheden	(0)	Overall Method Statement Construction Activities Aramis, (11 Mei 2023) 416010-00257 – ARM-CPT-BB3-PLR-REP-0048_2, 19 March 2023; Crossing inventory
2.1.8	Kruisingen met navigatiegebieden	Verankeringen voor drijvend materieel hinderen doorgaand scheepvaartverkeer	(-)	Overall Method Statement Construction Activities Aramis, (11 Mei 2023)
2.1.9		Rammen van bouwmaterieel of mariene constructies door derden	(0)	Overall Method Statement Construction Activities Aramis, (11 Mei 2023)
2.1.10		Ongecontroleerd drijvend bouwmaterieel	(0)	Overall Method Statement Construction Activities Aramis, (11 Mei 2023)
3.1.1	Nieuwe platforms (Neptune Energy en Shell)	Schade aan het platform bij de load out (Door vallende kraan, vallende objecten), transport (Door zinkend transport schip, overbelaste constructie) of installatie (Door botsend installatieschip, overbelaste constructie)	(0)	Constructie methode installatie platform 27.1726-GMT-210, 14 juni 2013

Nummer	Aspect	Effect	Effect-beoor-deling	Gebruikte studie
3.1.2	Distributie-platform Connectie op bestaande platforms	Schade aan het platform bij connectie (Door botsend installatieschip)	(0)	A4863-SHE-CRA-1, gedateerd 1 juni 2022, Aramis project, Vessel collision risk assessment
3.1.3		Schade aan het platform door extra functionaliteit, overbelaste constructie	(0)	Expert judgement

De belangrijkste aandachtspunten zijn:

- De CO2next steigers worden geconstrueerd direct naast het drukbevaren Yangtzekanaal. Mitigerende maatregelen dienen te worden genomen om de invloed van het drijvend bouwmaterieel op de passerende schepen te minimaliseren. Daarnaast dienen de te bouwen constructies fysiek of operationeel beschermd te worden tegen aanvaring.
- De Maasgeul is drukbevaren. Elke belemmering, bijvoorbeeld door de bouwactiviteiten van de aanlanding zullen impact hebben.
- Voor de gestuurde boring, benodigd voor de kruising van de Maasgeul, is een ontvangstschacht nodig. De eventuele consequenties van aanvaring van deze ontvangstschacht zijn zeer groot.
- Het doorgaand verkeer in de VSS dient beschermd te worden voor impact van verankeringen van drijvend materieel.

7 Milieuaspecten van Aramis als integraal systeem

In voorgaande hoofdstukken zijn de milieueffecten beschreven die de verschillende onderdelen van het Aramis initiatief teweegbrengen. Sommige aspecten zijn echter afhankelijk van het presteren van het systeem als geheel. Deze aspecten zijn in dit hoofdstuk beschreven.

Voor het aspect Nautische Veiligheid zijn geen aspecten met betrekking tot het integraal systeem geïdentificeerd. Dit hoofdstuk is daarom opzettelijk leeg gelaten.

8 Milieueffecten buiten Aramis scope

Zoals eerder beschreven behoren sommige CCS-ketenonderdelen niet tot het Aramis initiatief. Het is belangrijk om van deze onderdelen op hoofdlijnen wel de milieugevolgen in beeld te brengen. Het betreft immers effecten die mede via het Aramis initiatief ontstaan. Door de effecten van deze onderdelen ook te beschouwen ontstaat een beeld van de gevolgen van de totale CCS keten. Omdat deze onderdelen niet door de Aramis initiatiefnemers worden ondernomen en omdat hierover slechts beperkt informatie beschikbaar is, worden deze milieugevolgen slechts op globaal niveau beschouwd.

De levering van CO_2 vanaf leveranciers naar het verzamelpunt, zal deels plaatsvinden in gasvorm via de Porthos landleiding en deels in vloeibare vorm via schepen. In het MER is onderzoek gedaan naar de nautische veiligheid voor de schepen nabij de terminal, vanaf het heersende verkeersbeeld. Buiten de Aramis scope, maar wel ten gevolge van Aramis, vindt er het laden van de schepen bij de leverancier plaats en het transport vanaf de leverancier tot aan de haven van de terminal.

Het laden en transport heeft betrekking op CO_2 schepen, wat relatief nieuw is. De veiligheid bij het laden en transporteren, zowel de barges als de coasters zal door de leveranciers in beeld moeten worden gebracht en valt dus buiten de scope van dit MER.

Een deel van de transport en de constructie van 2 barges vindt plaats door de partijen betrokken bij Aramis. Deze activiteiten vallen echter niet onder de scope van de Aramis MER.

9 Leemten in kennis en voorstel voor monitoring

Dit beschrijft of en zo ja welke leemten in kennis er zijn voor de besluitvorming over het Aramis initiatief. Daarnaast bevat het een voorstel voor welke milieu-aspecten gemonitord moeten worden.

9.1 Leemten in kennis

Voorafgaand aan de werkzaamheden zal in overleg met de (Rijks)Havenmeester van Rotterdam, de Kustwacht en de directie Noordzee van RWS bepaald worden welke veiligheidsmaatregelen in acht genomen dienen te worden. Dit zal moeten gebeuren met de dan heersende kennis en ervaring.

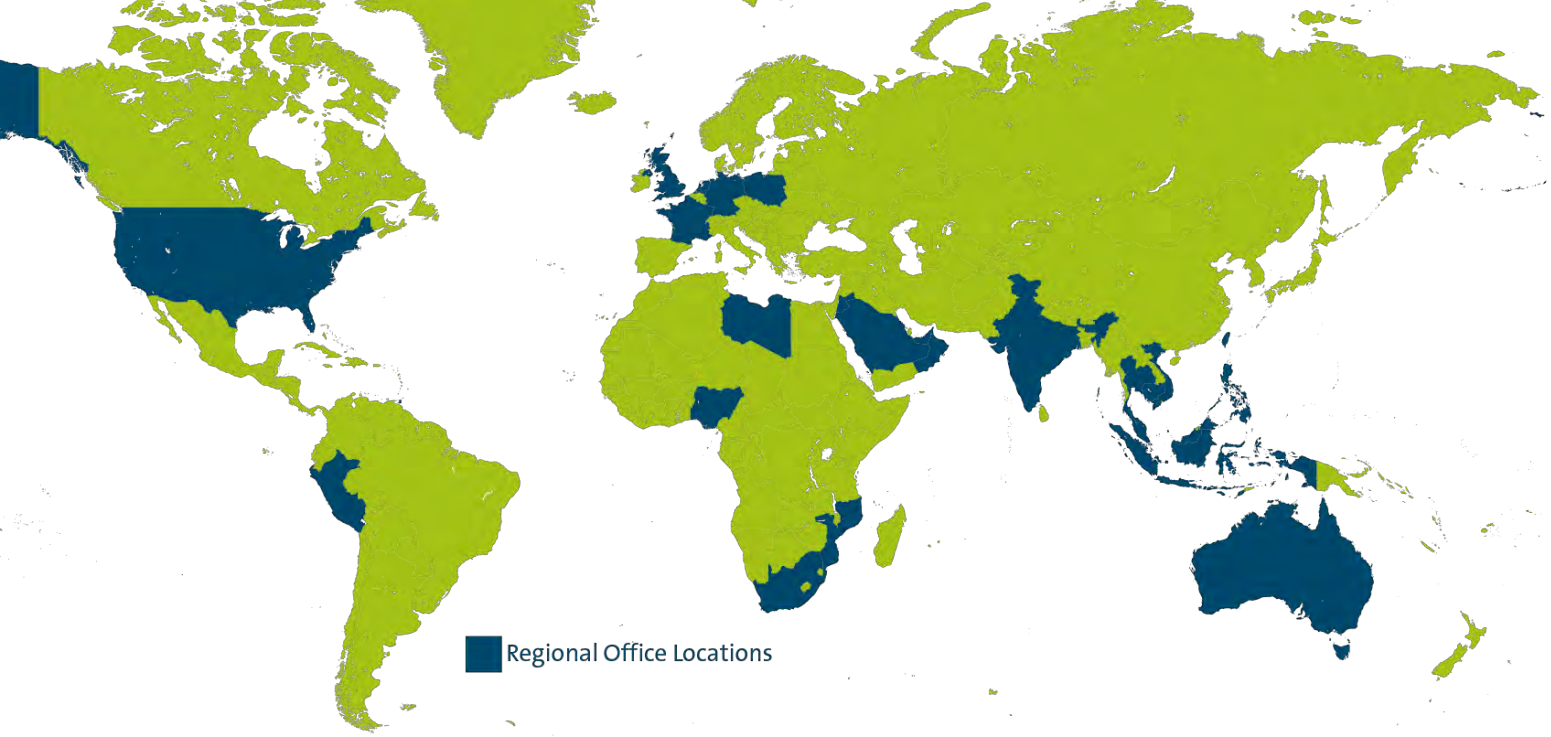
Hiermee zullen eventuele negatieve effecten als hinder en aanvaarrisico's zoveel mogelijk worden vermeden.

Rapportages die later beschikbaar komen

- MARIN rapport 'Effecten scheepvaartveiligheid (DHUB en leidingen)' met hierin oa. een indicatie van de aanvarings-/ aandrijvingskansen en drijfvermogen bij lekkage leiding

10 Samenvatting bevindingen en toetsing wet- en regelgeving

De samenvattingen van de bevindingen en toetsing zijn gegeven in hoofdstuk 5 en 6 en worden omwille van uniformiteit hier niet herhaald.



Royal HaskoningDHV is een onafhankelijk internationaal advies- en ingenieursbureau. We combineren 140 jaar engineering- en ontwerpexpertise met consultancy, software en technology diensten. We leveren hiermee toegevoegde waarde voor klanten en hebben een positieve impact op mensen en onze leefomgeving. Dat is onze drijfveer: Enhancing Society Together. Daar hoort bij dat we onszelf en anderen voortdurend uitdagen om bij te dragen aan duurzame oplossingen voor lokale en wereldwijde vraagstukken in de gebouwde omgeving en de industrie.

In onze snel veranderende wereld wordt de agenda bepaalt door onder meer klimaatverandering, de digitale transformatie, een veranderende consumentenvraag en hybride werken. Met onze geïntegreerde duurzame oplossingen willen we bijdragen aan het bredere technologische en maatschappelijke plaatje.

Gesteund door de kennis en ervaring van meer dan 6.000 collega's werken we vanuit kantoren in meer dan 20 landen. We ondersteunen klanten om de transitie te maken naar een slimme en duurzame organisatie. We koppelen onze engineering- en ontwerpexpertise aan onze software- en technologische diensten om toegevoegde waarde te leveren voor onze klanten en de lifecycle van hun assets.

We zijn oprecht, handelen integer en transparant in al onze activiteiten, ook onze bedrijfsvoering Ons team is divers en inclusief. De veiligheid en het welzijn van mensen, in ons team en daarbuiten, staat onder alle omstandigheden voorop.

In projecten en initiatieven werken we actief samen met overheden en het bedrijfsleven, partners en stakeholders. We zien een belangrijke rol voor onszelf in innovatieve duurzame ontwikkeling en willen bijdragen aan een betere leefomgeving, nu en in de toekomst.

Ons hoofkantoor is gevestigd in Nederland en we hebben kantoren in Europa, Azie, Afrika, Australie en Amerika.

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