# Bijlage 1: Advies MER-cie, 23 april 2019

Commissie voor de
**milieueffectrapportage**

# NeuConnect hoogspanningsverbinding

Advies over reikwijdte en detailniveau van het milieueffectrapport

23 april 2019 / projectnummer: 3376

# 1 Hoofdpunten van het milieueffectrapport (MER)

NeuConnect Great Britain Limited (NCGBL) wil een elektriciteitsverbinding aanleggen tussen Groot-Brittannië en Duitsland door het Nederlandse deel van de Noordzee. Voor het besluit hierover wordt milieueffectrapport (MER) opgesteld. De minister van Infrastructuur en Waterstaat heeft de Commissie gevraagd nu eerst te adviseren over de inhoud van het nog op te stellen MER.

Om het mogelijk te maken dat de minister het milieubelang straks volwaardig kan meewegen bij haar besluit, is het essentieel dat het MER straks in ieder geval onderstaande informatie bevat:

- beschrijf in het MER tenminste één alternatief waarbij de waarden van het Natura 2000-gebied 'Friese Front' worden ontzien;
- een beschrijving van de gevolgen voor:
  - het Natura 2000-gebied 'Friese Front' en het natuurgebied 'de Bruine bank' dat op de nominatie staat om aangewezen te worden als Natura 2000-gebied;
  - (toekomstige) bodembeschermingsgebieden;
  - beschermde soorten en de soorten waarvan deze soorten afhankelijk zijn;
- inzicht in de mogelijke maatregelen om effecten op natuur te voorkomen;
- inzicht in de risico's op blootlegging en beschadiging van de kabel, mogelijke maatregelen om deze risico's te beheersen en de milieueffecten van deze maatregelen;
- tijdelijke effecten van de werkzaamheden op het vrijkomen van sediment;
- de omvang van magnetische en (geïnduceerde) elektrische velden en de eventuele gevolgen hiervan op het aanwezige leven in zee.

*Figuur 1 Een mogelijke route voor de NeuConnect Hoogspanningsverbinding. In groen de grenzen van de Exclusief Economische zones. Bron: MER.*

Besluitvormers en insprekers lezen in de eerste plaats de samenvatting van het MER. Daarom verdient dit onderdeel bijzondere aandacht. De samenvatting moet als zelfstandig document leesbaar zijn en een goede afspiegeling zijn van de inhoud van het MER.

In de volgende hoofdstukken beschrijft de Commissie in meer detail welke informatie het MER moet bevatten. De Commissie bouwt in haar advies voort op de "Notitie Reikwijdte en Detailniveau" (NRD). Omdat deze op tal van punten al volledig en gedetailleerd is uitgewerkt, komt slechts een beperkt aantal te onderzoeken aspecten in dit advies aan de orde.

***Achtergrond***

*NeuConnect Great Britain Limited (NCGBL), een consortium van Meridiam SAS, Allianz Capital Partners, Kansai Electric Power Company en Greenage Power, wil een elektriciteitsverbinding aanleggen tussen Groot-Brittannië en Duitsland. Het doel is om twee van de grootste energiemarkten in Europa met elkaar te verbinden. Omdat het voorgestelde kabeltracé de Nederlandse Exclusieve Economische Zone (NEEZ) doorkruist, zijn vergunningen van de Nederlandse overheid vereist, waaronder een Watervergunning. Ter onderbouwing van een besluit over die vergunningen wordt een project-MER opgesteld. De Minister van Infrastructuur en Waterstaat (gedelegeerd aan Rijkswaterstaat) is bevoegd gezag voor de vergunningenprocedures.*

***Waarom een advies?***

*Aan het realiseren én plannen van activiteiten met grote milieugevolgen is de verplichting verbonden om eerst een MER op te stellen. In dit geval betreft het een grensoverschrijdende hoogspanningsverbinding.*

*De onafhankelijke Commissie m.e.r. is bij wet ingesteld en adviseert over de inhoud en de kwaliteit van het MER. Zij stelt voor ieder project een werkgroep samen van onafhankelijke deskundigen. De Commissie schrijft geen milieueffectrapporten, dat doet de initiatiefnemer. Het bevoegd gezag - in dit geval Rijkswaterstaat namens en de minister van Infrastructuur en Waterstaat - besluit over de vergunning voor de NeuConnect hoogspanningsverbinding.*

*De samenstelling en de werkwijze van de werkgroep van de Commissie en verdere projectgegevens staan in bijlage 1 van dit advies. U vindt de projectstukken die bij het advies zijn gebruikt door nummer 3376 op www.commissiemer.nl in te vullen in het zoekvak.*

# 2 Doel, kader en besluiten

## 2.1 Doel

Het voornemen betreft de realisatie van een hoogspanningsverbinding met een spanning van 500 kilovolt (kV), een capaciteit van 1400 MW en een lengte van om en nabij 700 km, die de uitwisseling van elektriciteit tussen Duitsland (via Fedderwarden) en het Verenigd Koninkrijk (via Isle of Grain) mogelijk moet maken. De voorgestelde route doorkruist daarbij ook de exclusieve economische zone van Nederland (NEEZ). Er wordt gebruik gemaakt van een gelijkstroomverbinding met retourkabel.

In paragraaf 1.2 van de NRD is het belang van de kabelverbinding beschreven. Werk deze informatie verder uit in het MER en besteed daarbij zowel aandacht aan de te behalen economische doelen als aan de beoogde milieuvoordelen (zoals reductie van de $CO_2$-uitstoot). Maak ook inzichtelijk hoe het voornemen bijdraagt aan de groei van duurzame energieproductie.[1] Maak dit zo concreet mogelijk, zodat de voordelen van het project (zoals duurzame energieproductie) tegen de nadelen (zoals schade aan de natuur) kunnen worden afgewogen.

## 2.2 Beleidskader en besluiten

### Beleidskader

In hoofdstuk 3 van de NRD zijn de relevante Europese en Nederlandse beleids- en wettelijke kaders opgesomd. Voor de KRM zijn de 11 descriptoren van belang, in het bijzonder 1) biodiversiteit, 4) voedselwebben, 6) bodemintegriteit en 11) energietoevoer, waaronder onderwatergeluid.

Het OSPAR-verdrag en de ASCOBANS-overeenkomst staan wel genoemd in de NRD. Werk de betekenis daarvan voor dit project in het MER verder uit.

Daarnaast moet het voornemen voldoen aan de kaders uit het Verenigd Koninkrijk en Duitsland. Ga in het MER in op de kaders uit andere landen voor zover ze randvoorwaarden en beperkingen opleveren voor het deel van het tracé in de NEEZ.

### Besluiten

De m.e.r.-procedure wordt voor het Nederlandse deel van het voornemen doorlopen voor de Waterwetvergunning. Ga in op de procedurele afstemming, zowel voor de vergunningen die in Nederland moeten worden verleend als voor de besluitvorming over het totale tracé. Geef aan:

- welke besluiten in de drie betrokken landen moeten worden genomen, wat hun relatie is met de m.e.r.-procedure en hoe de onderlinge afstemming plaatsvindt;
- wat onzekerheden zijn in het proces van besluitvorming;
- wie voor de diverse besluiten het bevoegde gezag is en wat globaal de tijdsplanning is.

[1] Leg daarnaast kort uit waarom het niet logisch is aan te sluiten bij windparken op zee die mogelijk op korte afstand gepasseerd worden.

# 3 Alternatieven voor het voornemen

## 3.1 Tracé-alternatieven

De NRD kondigt nu aan dat alleen het voorkeursalternatief wordt uitgewerkt in het MER. Andere alternatieven vallen direct af. Het is voor het MER van belang een gelijkwaardige uitwerking van reële alternatieven op te nemen, en zo milieuoverwegingen inzichtelijk te maken. Bij de vaststelling van het voorkeursalternatief kunnen kosten of kosteneffectiviteit uiteraard wel een rol spelen, maar dit vindt plaats nadat het MER af is. De milieu-informatie over de alternatieven kan dan meewegen bij het besluit voor een voorkeursalternatief.

Geef in het MER aan:
- hoe de onderzochte alternatieven tot stand zijn gekomen;
- welke criteria zijn gehanteerd om de tracé-opties te beoordelen;
- welke afwegingen hebben geleid tot de selectie van het voorkeursalternatief waarvoor nu een project-MER wordt opgesteld en vooral welke milieuargumenten daarbij hebben gespeeld.

### 3.1.1 Scenario's tracering Duitsland

In de NRD is aangegeven dat nog geen volledige zekerheid is over de Duitse tracering. Mocht deze onzekerheid nog blijven bestaan, werk dan voor de Nederlandse alternatieven twee (of waar nodig meerdere) scenario's uit voor de verschillen in aansluitingspunt met het Duitse deel van het tracé.

## 3.2 Alternatief voor het Friese Front

**Wat is het Friese Front?**
Het Friese Front is de overgangszone tussen de ondiepe zuidelijke en de diepe centrale Noordzee. In het zuiden is sprake van ondiep kustwater dat gedurende het hele jaar gemengd is. In het noorden bevindt zich een watermassa die afkomstig is van de Britse kust en daarin treedt stratificatie op. Het grensgebied vormt een zogenaamd 'front' waaraan het gebied haar naam dankt. In dit frontgebied treedt verrijking op van het water- en bodemleven.

**Natura 2000-gebied**
Het ondiepe deel van de zeebodem is zandig en het diepe deel is slibrijk. De overgang van zand naar slib is een relatief smalle zone binnen het Natura 2000-gebied en wordt gekarakteriseerd door een bentische zonering van soorten. Het gebied geldt hierdoor als een belangrijk foerageergebied voor vogels. Op 27 mei 2016 is het Friese Front aangewezen als Natura 2000-gebied in het kader van de Europese Vogelrichtlijn. De aanwijzing is gebaseerd op de betekenis voor de zeekoet, die hier in aantallen van groot internationaal belang voorkomen. Ruiende (van verenkleed wisselende) volwassen vogels zwemmen in de zomer vanuit de Britse broedkolonies met hun nog niet vliegvlugge jongen naar het Friese Front.

Deze jonge vogels zijn bijzonder kwetsbaar[2,3]. In het Friese Front is uitsluitend een instandhoudingsdoelstelling voor de Zeekoet geformuleerd (behoud omvang en kwaliteit leefgebied).

Wel is het zo dat het front zich niet elk jaar op precies dezelfde locatie manifesteert, zodat natuurwaarden, die ook van belang kunnen zijn voor de beschermde zeekoet, zich niet geheel beperken tot uitsluitend de smalle overgang van zand naar slib. Het is vanwege het bijzondere karakter van het bodemleven dat binnen de Kaderrichtlijn Mariene Strategie (KRM) is voorgesteld om een deel van het Friese Front en een gebied dat daaraan grenst in te richten als bodembeschermingsgebied.[4]

### Alternatief voor Friese Front

Beschrijf daarom in het MER tenminste één alternatief waarbij de waarden van het Natura 2000-gebied het Friese Front wordt ontzien. Hierbij is te denken aan:

- een tracéalternatief die buiten het Friese Front gaat;
- alternatieven waarbij alleen werkzaamheden plaatsvinden in de periode februari-juni en waarin maximaal maatregelen worden genomen om te bodemberoering te minimaliseren.

Onderbouw de gekozen uitwerking grondig. Ga hierbij in op de aanwezige natuurwaarden, hun staat van instandhouding, trends en de meest recente literatuur.

## 3.3 Uitvoeringsalternatieven en varianten

De uitvoeringsalternatieven voor het voornemen moeten in het MER worden beschreven voor zover relevant voor de beoordeling van de milieueffecten en op een detailniveau dat aansluit bij de te nemen besluiten. De uitvoeringsalternatieven dienen zich te richten op:

- de mogelijke aanlegmethoden zoals beschreven in tabel 2 van de NRD;
- de technische overwegingen bij de diepteligging van en de afstand tussen beide kabels.

Besteed in het MER per alternatief expliciet aandacht aan de volgende aspecten:

- de risico's verbonden aan het kruisen van pijpleidingen en kabels en hoe hiermee wordt omgegaan;
- inzicht in een veilige diepteligging, met mogelijke maatregelen om (de kans op) schade aan de kabel, zoals door bodemberoerende visserij of noodankers, of blootlegging door erosie of de mobiliteit van zandgolven, te voorkomen;
- tijdelijke en permanente voorzieningen om de kabel in zee aan te leggen en te onderhouden;

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2 Lindeboom H.J., Geurts van Kessel J. & Berkenbosch L. 2005. Gebieden met bijzondere ecologische waarden op het Nederlands Continentaal Plat. Rapport RIKZ/2005.008, Alterra Rapport nr. 1109.

3 In begin 2019 zijn ca. 20.000 Zeekoeten ten noorden van de Waddeneilanden gestorven. Een meerderheid (68%) van de onderzochte dode zeekoeten bleken vogels van een half jaar oud: het waren vooral de kuikens, die hun leven met een slechte start waren begonnen. Sterfte van jonge vogels is altijd relatief hoog, maar eenmaal volwassen zeekoeten leven lang en broeden vele jaren achtereen (zie Leopold M. et al. 2019. De Zoe en de zeekoet: een onderzoek naar de doodsoorzaak en de herkomst van de zeekoeten die massaal strandden op de Nederlandse kust in januari/februari 2019. Wageningen University &Research rapport C026/19.

4 In het gebied wordt een beperking voor bodemberoerende visserij voorzien. Zie kamerbrief van 14 december 2018, kamerstuk 32670 nr. 142, TK 2018-2019: https://zoek.officielebekendmakingen.nl/kst-33450-49.html.

- mogelijkheden om het voornemen vanuit milieuoogpunt te optimaliseren. Maak daarbij gebruik van de ervaringen die zijn opgedaan met andere kabelverbindingen en verwijs in het MER naar gebruikte ervaringsgegevens.

## 3.4 Varianten natuurwaarden

De Noordzee is geen homogeen gebied. De Noordzee kent zeer diverse natuurwaarden, waarbij sommige locaties 'hotspots' van biodiversiteit zijn.[5] Een aantal gebieden horen hier zeker toe, zoals de 'Borkumse Stenen', 'het Friese Front' en 'de Bruine Bank' als 'gebied met bijzondere ecologische waarde' (Lindeboom et al. 2005). Ook buiten deze gebieden zijn ecologische waarden aanwezig.

De Commissie adviseert voor zowel de kabeltracés door het Friese Front als die daarbuiten varianten te ontwikkelen die rekening houden met bovengenoemde aspecten. Gebruik onderzoeksgegevens en waar nodig eigen veldwerkgegevens[6] over de aanwezige beschermde en niet beschermde natuurwaarden om voor de alternatieven varianten te ontwikkelen om de aanwezige natuurwaarden te ontzien.

# 4 Bestaande milieusituatie en milieugevolgen

## 4.1 Algemeen

Houd bij het beschrijven van de milieugevolgen de volgende algemene aandachtspunten in acht:

- beschrijf de ernst van een effect in termen van aard, omvang, tijdsduur, reikwijdte, omkeerbaarheid, mitigeerbaarheid en/of compenseerbaarheid;
- vermeld de onzekerheden en onnauwkeurigheden in de gebruikte gegevens en in de methoden voor de bepaling van de effecten. Ga in op hun betekenis voor de effect-beoordeling en voor het onderscheid tussen alternatieven. Doe dit vooral voor milieugevolgen die bij het besluit over het voornemen een belangrijke rol spelen;
- maak de manier waarop milieugevolgen zijn bepaald controleerbaar door gebruikte gegevens in bijlagen op te nemen of eenduidig te verwijzen naar redelijkerwijs beschikbaar achtergrondmateriaal;
- besteed vooral aandacht aan die effecten die per alternatief verschillen en/of die grens- en streefwaarden (bijna) overschrijden.

Het is belangrijk dat de milieueffecten van het totale voornemen inzichtelijk worden gemaakt. Dit betekent dat in het MER met de effectbeschrijving voor de NEEZ ook een hoofdstuk aan de cumulatieve effecten van het totale voornemen gewijd moet zijn.

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[5] Tricas T & Gill AB. 2011. Effects of EMFs from Undersea Power Cables on Elasmobranchs and Other Marine Species. US Dept of the Interior, Bureau of Ocean Energy Management, Regulation, and Enforcement, Pacific OCS Region, Camarillo, CA. OCS Study BOEMRE 2011-09.

[6] Bevoegd gezag heeft aangegeven dat voor het tracé een survey uitgevoerd zal worden waarbij ook ecologische waarden worden meegenomen.

Tabel 7 van de NRD geeft een duidelijk overzicht van de (milieu)effecten die in het MER zullen worden beschreven en beschrijft het scoringssysteem. Gegeven de onzekerheden in de te verwachten milieueffecten is, naar het oordeel van de Commissie, een scoringssysteem met een vijfpuntsschaal voldoende informatief en nauwkeurig. Geef duidelijk aan of de scores tot stand komen mét of zonder het meenemen van mitigerende maatregelen.

**Ontmanteling**
Ga in het MER globaal in op de milieueffecten van de opties voor het einde van de levensduur van het project:

- verwijdering;
- het laten liggen van de kabel die buiten functie is.

## 4.2 Verstoring van de bodem en vertroebeling

Tijdens het aanleggen van de kabels wordt de bodem verstoord door ankers en het ingraven van de kabels en neemt de hoeveelheid zwevend materiaal toe. Of dat leidt tot effecten op de natuur, is afhankelijk van de omvang van de verstoring.[7] Geef aan of is uit te sluiten dat een dergelijke situatie zich voordoet. Is dat niet uit te sluiten, ga dan meer in detail in op de duur en omvang van de wijzigingen in de hoeveelheid zwevend materiaal.

## 4.3 Natuur

De NRD geeft al een goed beeld van de effecten die in de aanleg- of exploitatiefase kunnen optreden en die dus in het MER moeten worden beschreven. De Commissie heeft aanvullende opmerkingen over de beschrijving van de gevolgen voor beschermde gebieden of soorten.

**Gevolgen voor (toekomstige) Natura 2000-gebieden**
De Commissie heeft uit een gesprek[8] met bevoegd gezag en initiatiefnemers begrepen dat de gevolgen voor Natura 2000-gebieden in een Passende beoordeling worden onderzocht. Als mitigerende maatregelen in de effectbeoordeling worden betrokken dan dient dat in een Passende beoordeling te gebeuren. Vanwege mogelijke externe werking dient naast de (cumulatieve) gevolgen ook rekening te worden gehouden met het toekomstige Natura 2000-gebied Bruine Bank, en indien relevant ook met het Duitse Natura 2000-gebied Borkum Riffgrund.[9]. De Commissie adviseert de Passende beoordeling duidelijk herkenbaar op te nemen in het MER.

**Bodembeschermingsgebieden en mogelijk ecologische waardevolle gebieden**
In de Beleidsnota Noordzee 2016-2021 zijn zoekgebieden aangewezen voor extra bodembeschermende maatregelen bij het Friese Front en de Centrale Oestergronden. Ook zijn hierin mogelijk ecologisch waardevolle gebieden aangewezen (Bruine Bank en Borkumse

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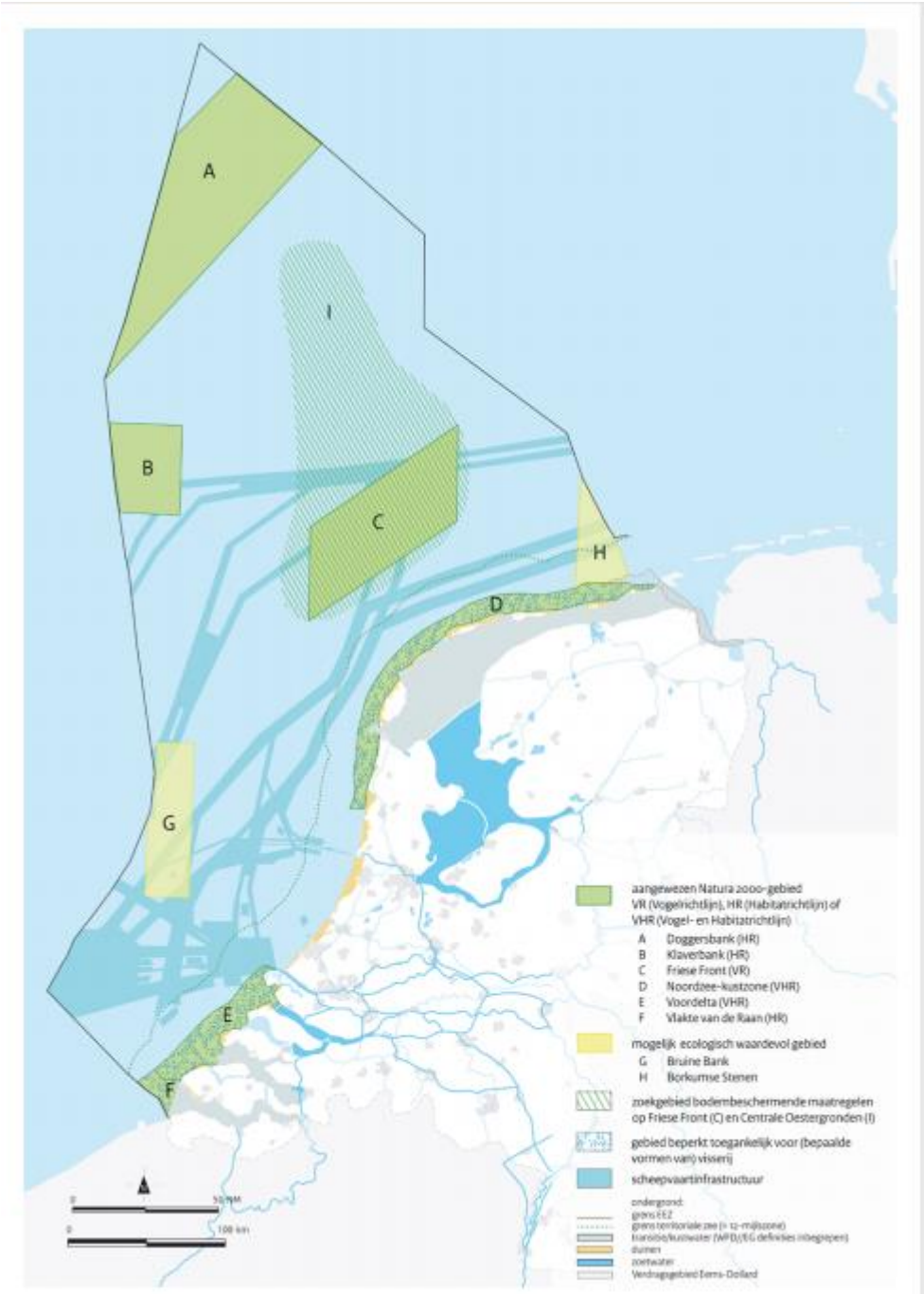
[7] Hoeveelheid materiaal, omvang van het verstoorde gebied, lengte van de periode met verhoogde concentraties zwevend materiaal en gereduceerd doorzicht. Zo is voorstelbaar dat sedimentverplaatsing in het zandige zuidelijk deel van het Natura 2000-gebied Friese Front tot minder vertroebeling leidt dan een vergelijkbare verplaatsing in het slibrijke noordelijke deel.

[8] Op 25 maart vond een gesprek plaats van de werkgroep van de Commissie met bevoegd gezag en vertegenwoordigers namens de initiatiefnemers.

[9] Het is dus niet voldoende als effecten op die gebieden alleen worden beschreven in het MER dat wordt opgesteld voor het land waarin de betreffende gebieden liggen.

Stenen). Geef in het MER aan of deze gebieden geraakt worden. Ga in op mogelijk effecten op deze gebieden en ga in op mogelijk mitigerende maatregelen.




*Figuur 2 'Mariene ecosysteem' bron: beleidsnota Noordzee 2016-2021.*

**Gevolgen voor (beschermde) soorten**

Ga voor zover relevant in op de gevolgen van het voornemen voor de staat van instandhouding van zeezoogdieren, zeevogels en vissen. Ga daarbij vooral in op die stadia uit de levenscyclus van iedere soort waarin ze het meest gevoelig is voor de effecten van vooral het aanleggen van de kabel. Voorbeelden zijn de geboorteperiode bij de bruinvis en de ruiperiode bij de zeekoet en andere zeevogels. Breng ook maatregelen in beeld om deze effecten te beperken.

In het noorden van het Friese Front komt de Noordkromp *Arctica islandica* voor.[10] Dit schelpdier kan honderden jaren oud worden en is daardoor erg kwetsbaar voor bodemberoering. De soort kent geen beschermde status in het kader van de Habitatrichtlijn, maar wel in het kader van OSPAR. [11,12,13] Ga in op de mogelijke gevolgen van het voornemen voor deze soort.

**Elektromagnetische velden**

Ga in op de gevolgen van veranderingen in elektromagnetische velden die ontstaan door de aanwezigheid van de kabels. Enerzijds gaat het om effecten van veranderingen in het lokale magnetische veld, anderzijds om veranderingen van elektrische velden die worden geïnduceerd door de stroming van zeewater of beweging van organismen door het magnetische veld. De sterkte van de velden is afhankelijk van de stroomsterkte (ampèrage en stroomsnelheid zeewater) en neemt toe als de afstand tussen beide kabels toeneemt.

Vooral bodemgebonden organismen kunnen hierdoor worden beïnvloed:

- Kraakbeenvissen zijn in het bijzonder gevoelig voor elektrische velden.[14] Haaien en roggen beschikken over het vermogen om elektrische velden van dieren in hun omgeving waar te nemen. Dit zetten ze in bij hun jacht.
- Zowel haaien en roggen als sommige vissen en zeezoogdieren oriënteren ze zich met behulp van het aardmagnetisch veld. Omdat de kabel de gehele Noordzee doorkruist zou een verandering van het magnetisch veld ook de noord-zuidmigratie van bijvoorbeeld zeezoogdieren kunnen beïnvloeden.

Kwantificeer de omvang van de velden. Beschrijf mogelijke gevolgen voor de soorten die hiervoor gevoelig zijn en mogelijke maatregelen om dit te voorkomen. Voor een recente review van effecten van submariene hoogspanningsverbindingen wordt verwezen naar Taormina et al. (2018) [15] en de daarin gerefereerde literatuur. Voor mogelijke effecten van elektromagnetische velden in de Nederlandse situatie is er Snoek et al (2016).[16]

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[10] Witbaard R & Bergman MJN. 2003. The distribution and population structure of the bivalve *Arctica islandica* L. in the North Sea: what possible factors are involved? J. Sea Res. 50: 11-25, en OSPAR Commission. 2009. OSPAR background for Ocean quahog *Arctica islandica*. Biodiversity Series Publication Number: 407/2009.

[11] https://minez.nederlandsesoorten.nl/content/noordkromp-arctica-islandica.

[12] OSPAR Commission 2008. Case reports for the OSPAR list of threatened and/or declining species and habitats. OSPAR Publication nr 358/2008.

[13] Witbaard R. 2009. De Noordkromp. De Levende Natuur 110 (6) 263-265.

[14] Taormina, B., J. Bald, A. Want, G. Thouzeau, M. Lejart, N. Desroy, A. Carlier 2018. *A review of potential impacts of submarine power cables on the marine environment: Knowledge gaps, recommendations and future directions.* Renewable and Sustainable Energy Reviews 96: 380-391.

[15] Bos, O.G., R. Witbaard, M. Lavaleye, G. van Moorsel, L.R. Teal, R. van Hal, T. van der Hammen, R. ter Hofstede, R. van Bemmelen, R.H. Witte, S. Geelhoed & E.M. Dijkman 2011. Biodiversity hotspots on the Dutch Continental Shelf, a Marine Strategy Framework Directive perspective. IMARES Report number C071/11.

[16] Snoek, R., R. de Swart, K. Didderen. W. Lengkeek & M. Teunis 2016. *Potential effects of electromagnetic fields in the Dutch North Sea Phase 1: Desk Study.* WaterProof Marine Consultancy & Research BV & Bureau Waardenburg BV.

# 5 Overige aspecten

## 5.1 Evaluatieprogramma

Het bevoegd gezag moet bij het besluit aangeven hoe en wanneer een evaluatieonderzoek zal worden uitgevoerd om de voorspelde effecten met de daadwerkelijk optredende effecten te vergelijken. Op basis daarvan kunnen zo nodig aanvullende mitigerende maatregelen getroffen worden. Het verdient aanbeveling om in het MER al een aanzet van een evaluatieonderzoek op te nemen. Daardoor kan het verkleinen van nu bekende onzekerheden in te verwachten effecten al worden meegenomen in het te zijner tijd te verrichten evaluatieonderzoek.

De Commissie beveelt aan om in het MER uit te werken hoe frequent de diepteligging van de kabel in de gebruiksfase dient te worden gemonitord om de kans op schade als gevolg van vrijkomen van de kabel te minimaliseren. Indien effecten van elektrische en magnetische velden op de verplaatsing van mariene organismen te verwachten zijn, is het raadzaam deze effecten te monitoren.

## 5.2 Vorm en presentatie

Bijzondere aandacht verdient de presentatie van de vergelijkende beoordeling van de alternatieven. Presenteer de vergelijking bij voorkeur met behulp van tabellen en figuren.
Zorg ervoor dat:

- het MER zo beknopt mogelijk is, onder andere door achtergrondgegevens niet in de hoofdtekst zelf te vermelden, maar in een bijlage op te nemen;
- een verklarende woordenlijst, een lijst van gebruikte afkortingen en een literatuurlijst zijn opgenomen;
- recent, goed leesbaar kaartmateriaal is gebruikt, met duidelijke legenda en goed leesbare topografische namen.

# BIJLAGE 1: Projectgegevens

**Advies van de Commissie over het op te stellen MER**
De Commissie bestaat uit een werkgroep van deskundigen. Deze werkgroep geeft aan welke onderwerpen naar zijn mening moeten worden behandeld in het MER en met welke diepgang. Meer informatie over de Commissie en over haar werkwijze vindt u op onze website.

**Samenstelling van de werkgroep**
Bij dit project bestaat de werkgroep uit:
dr. Theo Fens
dr. Kees Linse (voorzitter)
dr. Godfried van Moorsel
drs. Willemijn Smal (secretaris)
dr. Bert van der Valk
ing. Rob Vogel

**Besluit waarvoor dit milieueffectrapport wordt opgesteld**
Watervergunning.

**Waarom wordt hiervoor een milieueffectrapport opgesteld?**
Voor activiteiten die grote milieugevolgen kunnen hebben, kan in Nederland een MER vereist zijn. De bijlagen C en D bij het Besluit milieueffectrapportage geven aan om welke activiteiten het gaat. Voor deze procedure gaat het in ieder geval om de activiteit , D24.2 De aanleg, wijziging of uitbreiding van een ondergrondse hoogspanningsleiding met een spanning >=150 kilovolt of een lengte >= 5 km in een gevoelig gebied (in dit geval Natura 2000-gebied Friese front). Daarom wordt een project-MER opgesteld.

**Bevoegd gezag besluit(en)**
Minister van Infrastructuur en Waterstaat.

**Initiatiefnemer besluit(en)**
NeuConnect Great Britain Limited (NCGBL), een consortium van Meridiam SAS, Allianz Capital Partners, Kansai Electric Power Company en Greenage Power.

**Bevoegd gezag m.e.r.-procedure**
Minister van Infrastructuur en Waterstaat.

**Heeft de Commissie ook zienswijzen en adviezen bij haar advies betrokken?**
Het bevoegd gezag heeft de Commissie niet in de gelegenheid gesteld om zienswijzen en adviezen bij haar advies te betrekken.

**Waar vind ik de stukken die de Commissie heeft gebruikt?**
U vindt de projectstukken die bij het advies zijn gebruikt, door op www.commissiemer.nl projectnummer 3376 in te vullen in het zoekvak.

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# Bijlage 2: Overzicht NRD advies verwerkt in MER

| NR | Omschrijving | Referentie in MER (moederfile) |
|---|---|---|
| 1 | Beschrijf in het MER tenminste één alternatief waarbij de waarden van het Natura 2000-gebied 'Friese Front' worden ontzien; | Hoofdstuk 3 |
| 2 | Uit advies Cie MER op NRD: Neem een beschrijving op van de gevolgen voor:<br>- het Natura 2000-gebied 'Friese Front' en het natuurgebied 'de Bruine bank' dat op de nominatie staat om aangewezen te worden als Natura 2000-gebied;<br>- (toekomstige) bodembeschermingsgebieden;<br>- beschermde soorten en de soorten waarvan deze soorten afhankelijk zijn; | Paragrafen 2.2, 5.7, 6.3, 9.2, 9.4, 9.5, 9.6, 9.7, Tabel 9-3, Bijlage 12 |
| 3 | Uit advies Cie MER op NRD: Geef inzicht in de mogelijke maatregelen om effecten op natuur te voorkomen; | Hoofdstuk 6.3 en 7 |
| 4 | Inzicht in de risico's op blootlegging en beschadiging van de kabel, mogelijke maatregelen om deze risico's te beheersen en de milieueffecten van deze maatregelen; | Hoofdstuk 4 |
| 5 | Uit advies Cie MER op NRD: Wat zijn de tijdelijke effecten van de werkzaamheden op het vrijkomen van sediment; | Paragrafen 8.5 en 8.6 |
| 6 | Uit advies Cie MER op NRD: Wat is de omvang van magnetische en (geïnduceerde) elektrische velden en de eventuele gevolgen hiervan op het aanwezige leven in zee. | Paragrafen 4.14, 9.6, 9.7 en 11.6 |
| 7 | Uit advies Cie MER op NRD: Besluitvormers en insprekers lezen in de eerste plaats de samenvatting van het MER. Daarom verdient dit onderdeel bijzondere aandacht. De samenvatting moet als zelfstandig document leesbaar zijn en een goede afspiegeling zijn van de inhoud van het MER. | Hoofdstuk 15 |
| 8 | Uit advies Cie MER op NRD: In paragraaf 1.2 van de NRD is het belang van de kabelverbinding beschreven. Werk deze informatie verder uit in het MER en besteed daarbij zowel aandacht aan de te behalen economische doelen als aan de beoogde milieuvoordelen (zoals reductie van de CO2-uitstoot). Maak ook inzichtelijk hoe het voornemen bijdraagt aan de groei van duurzame energieproductie. Maak dit zo concreet mogelijk, zodat de voordelen van het project (zoals duurzame energieproductie) tegen de nadelen (zoals schade aan de natuur) kunnen worden afgewogen. Leg daarnaast kort uit waarom het niet logisch is aan te sluiten bij windparken op zee die mogelijk op korte afstand gepasseerd worden. | Paragraaf 1.2 |
| 9 | Het OSPAR-verdrag en de ASCOBANS-overeenkomst staan wel genoemd in de NRD. Werk de betekenis daarvan voor dit project in het MER verder uit. | Paragrafen 2.2, 9.2 |
| 10 | Uit advies Cie MER op NRD: Ga in het MER in op de kaders uit andere landen voor zover ze randvoorwaarden en beperkingen opleveren voor het deel van het tracé in de NEEZ. | Paragraaf 2.2, Hoofdstuk 14, Bijlage 15 |
| 11 | Uit advies Cie MER op NRD: De m.e.r.-procedure wordt voor het Nederlandse deel van het voornemen doorlopen voor de Waterwetvergunning. Ga in op de procedurele afstemming, zowel voor de vergunningen die in Nederland moeten worden verleend als voor de besluitvorming over het totale tracé. Geef aan:<br>• welke besluiten in de drie betrokken landen moeten worden genomen, wat hun relatie is met de m.e.r.-procedure en hoe de onderlinge afstemming plaatsvindt;<br>• wat onzekerheden zijn in het proces van besluitvorming;<br>• wie voor de diverse besluiten het bevoegde gezag is en wat globaal de tijdsplanning is. | Paragraaf 2.1 |
| 12 | Uit advies Cie MER op NRD: De NRD kondigt nu aan dat alleen het voorkeursalternatief wordt uitgewerkt in het MER. Andere alternatieven vallen direct af. Het is voor het MER van belang een gelijkwaardige uitwerking van reële alternatieven op te nemen, en zo milieuoverwegingen inzichtelijk te maken. Bij de vaststelling van het voorkeursalternatief kunnen kosten of kosteneffectiviteit uiteraard wel een rol spelen, maar dit vindt plaats nadat het MER af is. De milieu-informatie over de alternatieven kan dan meewegen bij het besluit voor een voorkeursalternatief.<br>Geef in het MER aan:<br>• hoe de onderzochte alternatieven tot stand zijn gekomen;<br>• welke criteria zijn gehanteerd om de tracé-opties te beoordelen;<br>• welke afwegingen hebben geleid tot de selectie van het voorkeursalternatief waarvoor nu een project-MER wordt opgesteld en vooral welke milieuargumenten daarbij hebben gespeeld. | Hoofdstuk 3 |
| 13 | In de NRD is aangegeven dat nog geen volledige zekerheid is over de Duitse tracering. Mocht deze onzekerheid nog blijven bestaan, werk dan voor de Nederlandse alternatieven twee (of waar nodig meerdere) scenario's uit voor de verschillen in aansluitingspunt met het Duitse deel van het tracé. | Paragraaf 3.5 |
| 14 | Beschrijf daarom in het MER tenminste één alternatief waarbij de waarden van het Natura 2000-gebied het Friese Front wordt ontzien. Hierbij is te denken aan:<br>• een tracéalternatief die buiten het Friese Front gaat;<br>• alternatieven waarbij alleen werkzaamheden plaatsvinden in de periode februari-juni en waarin maximaal maatregelen worden genomen om te bodemberoering te minimaliseren.<br>Onderbouw de gekozen uitwerking grondig. Ga hierbij in op de aanwezige natuurwaarden, hun staat van instandhouding, trends en de meest recente literatuur. | Hoofdstuk 3 |
| 15 | Uit advies Cie MER op NRD: De uitvoeringsalternatieven voor het voornemen moeten in het MER worden beschreven voor zover relevant voor de beoordeling van de milieueffecten en op een detailniveau dat aansluit bij de te nemen besluiten. De uitvoeringsalternatieven dienen zich te richten op:<br>• de mogelijke aanlegmethoden zoals beschreven in tabel 2 van de NRD;<br>• de technische overwegingen bij de diepteligging van en de afstand tussen beide kabels.<br>Besteed in het MER per alternatief expliciet aandacht aan de volgende aspecten:<br>• de risico's verbonden aan het kruisen van pijpleidingen en kabels en hoe hiermee wordt omgegaan;<br>• inzicht in een veilige diepteligging, met mogelijke maatregelen om (de kans op) schade aan de kabel, zoals door bodemberoerende visserij of noodankers, of blootlegging door erosie of de mobiliteit van zandgolven, te voorkomen;<br>• tijdelijke en permanente voorzieningen om de kabel in zee aan te leggen en te onderhouden;<br>• mogelijkheden om het voornemen vanuit milieuoogpunt te optimaliseren. Maak daarbij gebruik van de ervaringen die zijn opgedaan met andere kabelverbindingen en verwijs in het MER naar gebruikte ervaringsgegevens. | Hoofdstuk 4<br>Specifiek:<br>4.3 De Kabel<br>4.4 Voorbereidende werkzaamheden<br>4.5 en 4.8 Aanlegmethoden<br>4.7 Kabelkruisingen<br>4.9 Kabelbescherming<br>4.14 Emissies<br>11.6 Risico's in verband met schepen die met een anker de kabel haken |
| 16 | Uit advies Cie MER op NRD: De Noordzee is geen homogeen gebied. De Noordzee kent zeer diverse natuurwaarden, waarbij sommige locaties 'hotspots' van biodiversiteit zijn.Een aantal gebieden horen hier zeker toe, zoals de 'Borkumse Stenen', 'het Friese Front' en 'de Bruine Bank' als 'gebied met bijzondere ecologische waarde' (Lindeboom et al. 2005). Ook buiten deze gebieden zijn ecologische waarden aanwezig. De Commissie adviseert voor zowel de kabeltracés door het Friese Front als die daarbuiten varianten te ontwikkelen die rekening houden met bovengenoemde aspecten. Gebruik onderzoeksgegevens en waar nodig eigen veldwerk-gegevens over de aanwezige beschermde en niet beschermde natuurwaarden om voor de alternatieven varianten te ontwikkelen om de aanwezige natuurwaarden te ontzien. | Paragraaf 3.5 , Hoofdstuk 9 |

| | | |
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| 17 | Uit advies Cie MER op NRD: Houd bij het beschrijven van de milieugevolgen de volgende algemene aandachtspunten in acht:<br>• beschrijf de ernst van een effect in termen van aard, omvang, tijdsduur, reikwijdte, omkeerbaarheid, mitigeerbaarheid en/of compenseerbaarheid;<br>• vermeld de onzekerheden en onnauwkeurigheden in de gebruikte gegevens en in de methoden voor de bepaling van de effecten. Ga in op hun betekenis voor de effect-beoordeling en voor het onderscheid tussen alternatieven. Doe dit vooral voor milieugevolgen die bij het besluit over het voornemen een belangrijke rol spelen;<br>• maak de manier waarop milieugevolgen zijn bepaald controleerbaar door gebruikte gegevens in bijlagen op te nemen of eenduidig te verwijzen naar redelijkerwijs beschikbaar achtergrondmateriaal;<br>• besteed vooral aandacht aan die effecten die per alternatief verschillen en/of die grens- en streefwaarden (bijna) overschrijden.<br>Het is belangrijk dat de milieueffecten van het totale voornemen inzichtelijk worden gemaakt. Dit betekent dat in het MER met de effectbeschrijving voor de NEEZ ook **een hoofdstuk** aan de cumulatieve effecten van het totale voornemen gewijd moet zijn. | Hoofdstuk 5 (o.a. paragraaf 5.5) paragrafen 8.6, 9.6, 10.7, 11.6, 12.5, 13.7<br><br>Hoofdstuk 14 |
| 18 | Uit advies Cie MER op NRD: Tabel 7 van de NRD geeft een duidelijk overzicht van de (milieu)effecten die in het MER zullen worden beschreven en beschrijft het scoringssysteem. Gegeven de onzekerheden in de te verwachten milieueffecten is, naar het oordeel van de Commissie, een scoringssysteem met een vijfpuntsschaal voldoende informatief en nauwkeurig. Geef duidelijk aan of de scores tot stand komen mét of zonder het meenemen van mitigerende maatregelen. | Paragrafen 5.4 en 5.5 |
| 19 | Uit advies Cie MER op NRD: Ga in het MER globaal in op de milieueffecten van de opties voor het einde van de levensduur van het project:<br>• verwijdering;<br>• het laten liggen van de kabel die buiten functie is. | Paragraaf 4.16 |
| 20 | Uit advies Cie Mer op NRD: Tijdens het aanleggen van de kabels wordt de bodem verstoord door ankers en het ingraven van de kabels en neemt de hoeveelheid zwevend materiaal toe. Of dat leidt tot effecten op de natuur, is afhankelijk van de omvang van de verstoring. Geef aan of is uit te sluiten dat een dergelijke situatie zich voordoet. Is dat niet uit te sluiten, ga dan meer in detail in op de duur en omvang van de wijzigingen in de hoeveelheid zwevend materiaal. | Paragrafen 8.5 en 8.6 |
| 21 | Uit advies Cie Mer op NRD: Gevolgen voor (toekomstige) Natura 2000-gebieden<br>De Commissie heeft uit een gesprek met bevoegd gezag en initiatiefnemers begrepen dat de gevolgen voor Natura 2000-gebieden in een Passende beoordeling worden onderzocht. Als mitigerende maatregelen in de effectbeoordeling worden betrokken dan dient dat in een Passende beoordeling te gebeuren. Vanwege mogelijke externe werking dient naast de (cumulatieve) gevolgen ook rekening te worden gehouden met het toekomstige Natura 2000-gebied Bruine Bank, en indien relevant ook met het Duitse Natura 2000-gebied Borkum Riffgrund.De Commissie adviseert de Passende beoordeling duidelijk herkenbaar op te nemen in het MER. | Hoofdstuk 9.2, 9.4, 9.5 en 9.7, Bijlage 12 |
| 22 | Uit advies Cie Mer op NRD: Bodembeschermingsgebieden en mogelijk ecologische waardevolle gebieden<br>In de Beleidsnota Noordzee 2016-2021 zijn zoekgebieden aangewezen voor extra bodembeschermende maatregelen bij het Friese Front en de Centrale Oestergronden. Ook zijn hierin mogelijk ecologisch waardevolle gebieden aangewezen (Bruine Bank en Borkumse Stenen). Geef in het MER aan of deze gebieden geraakt worden. Ga in op mogelijk effecten op deze gebieden en ga in op mogelijk mitigerende maatregelen. | Paragrafen 2.2, 9.2, 9.4 en 9.5 |
| 23 | Uit advies Cie Mer op NRD: Ga voor zover relevant in op de gevolgen van het voornemen voor de staat van instandhouding van zeezoog-dieren, zeevogels en vissen. Ga daarbij vooral in op die stadia uit de levenscyclus van iedere soort waarin ze het meest gevoelig is voor de effecten van vooral het aanleggen van de kabel. Voorbeelden zijn de geboorteperiode bij de bruinvis en de ruiperiode bij de zeekoet en andere zeevogels. Breng ook maatregelen in beeld om deze effecten te beperken.<br>In het noorden van het Friese Front komt de Noordkromp Arctica islandica voor. Dit schelpdier kan honderden jaren oud worden en is daardoor erg kwetsbaar voor bodemberoering. De soort kent geen beschermde status in het kader van de Habitatrichtlijn, maar wel in het kader van OSPAR. Ga in op de mogelijke gevolgen van het voornemen voor deze soort. | Paragrafen 6.3 en 9.5<br>Noordkromp: 9.6.5 |
| 24 | Uit advies Cie Mer op NRD: Ga in op de gevolgen van veranderingen in elektromagnetische velden die ontstaan door de aanwezigheid van de kabels. Enerzijds gaat het om effecten van veranderingen in het lokale magnetische veld, anderzijds om veranderingen van elektrische velden die worden geïnduceerd door de stroming van zeewater of beweging van organismen door het magnetische veld. De sterkte van de velden is afhankelijk van de stroomsterkte (ampèrage en stroomsnelheid zeewater) en neemt toe als de afstand tussen beide kabels toeneemt.<br>Vooral bodemgebonden organismen kunnen hierdoor worden beïnvloed:<br>• Kraakbeenvissen zijn in het bijzonder gevoelig voor elektrische velden. Haaien en roggen beschikken over het vermogen om elektrische velden van dieren in hun omgeving waar te nemen. Dit zetten ze in bij hun jacht.<br>• Zowel haaien en roggen als sommige vissen en zeezoogdieren oriënteren ze zich met behulp van het aardmagnetisch veld. Omdat de kabel de gehele Noordzee doorkruist zou een verandering van het magnetisch veld ook de noord-zuidmigratie van bijvoorbeeld zeezoogdieren kunnen beïnvloeden.<br>Kwantificeer de omvang van de velden. Beschrijf mogelijke gevolgen voor de soorten die hiervoor gevoelig zijn en mogelijke maatregelen om dit te voorkomen. Voor een recente review van effecten van submariene hoogspanningsverbindingen wordt verwezen naar Taormina et al. (2018) en de daarin gerefereerde literatuur. Voor mogelijke effecten van elektromagnetische velden in de Nederlandse situatie is er Snoek et al (2016). | Paragrafen 4.14, 5.7, 9.6 en 9.7, tabellen 4-4 en 9-9 |
| 25 | Uit advies Cie Mer op NRD: Het verdient aanbeveling om in het MER al een aanzet van een evaluatieonderzoek op te nemen. Daardoor kan het verkleinen van nu bekende onzekerheden in te verwachten effecten al worden meegenomen in het te zijner tijd te verrichten evaluatieonderzoek. De Commissie beveelt aan om in het MER uit te werken hoe frequent de diepteligging van de kabel in de gebruiksfase dient te worden gemonitord om de kans op schade als gevolg van vrijkomen van de kabel te minimaliseren. Indien effecten van elektrische en magnetische velden op de verplaatsing van mariene organismen te verwachten zijn, is het raadzaam deze effecten te monitoren. | Paragrafen 4.2, 4.13, 7.2 |
| 26 | Uit advies Cie Mer op NRD: Vorm en presentatie: Bijzondere aandacht verdient de presentatie van de vergelijkende beoordeling van de alternatieven. Presenteer de vergelijking bij voorkeur met behulp van tabellen en figuren. Zorg ervoor dat:<br>• het MER zo beknopt mogelijk is, onder andere door achtergrondgegevens niet in de hoofdtekst zelf te vermelden, maar in een bijlage op te nemen;<br>• een verklarende woordenlijst, een lijst van gebruikte afkortingen en een literatuurlijst zijn opgenomen;<br>• recent, goed leesbaar kaartmateriaal is gebruikt, met duidelijke legenda en goed leesbare topografische namen. | |

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|---|---|---|
| 27 | Voorts is een zienswijze ontvangen van de eigenaar en beheerder van een hogedrukgasleiding tussen Nederland en het Verenigd Koninkrijk, die in het beoogde tracé door de NeuConnect wordt gekruist. De zienswijze is als bijlage bij deze brief gevoegd. De kruising van een hoog-spanningskabel met een stalen buisleiding heeft mogelijk invloed op de kathodische bescherming van de gasleiding en daarmee op de levensduur van de gasleiding, zo stelt de indiener van de zienswijze. Deze wijst bovendien op het gegeven dat de geplande kruising van de NeuConnect-kabel en de gasleiding is gesitueerd in een gebied met dynamische zandgolven. De uiteindelijke locatie en het ontwerp van de kruising is bepalend voor de te verwachte kans op blootspoeling van de gasleiding in de jaren na installatie. De afstand van de kabels tot de gasleiding bepaalt mede de omvang van de beschermingsconstructie, die vervolgens weer invloed kan hebben op de kans op blootspoeling. De indiener van de zienswijze is dan ook van mening dat de in de concept-NRD verwachte effecten op deze onderdelen te licht zijn ingeschat.<br>Gelet op deze zienswijze wil ik benadrukken dat de mogelijke effecten van de NeuConnect-kabel op (buis)leidingen en de wijze van kruising onderzocht moeten worden onderzocht in het milieueffectrapport. Ga daarbij ook specifiek in op de elektromagnetische compatibiliteit, het voorkomen van schade aan bestaande kabels en leidingen, en het toegankelijkheid houden van de bestaande infrastructuur. | Paragrafen 4.7 13.6 en 13.7 |
| 28 | Tenslotte heeft de nautisch adviseur aandacht gevraagd voor de mogelijke consequenties van het magneetveld rond de kabels op kompassen in schepen. Ook aan dit onderwerp moet aandacht besteed worden. | Paragraaf 4.14 en 11.6 |

# Bijlage 4: BAS (burial assesment study) 'Lite', Primo Marine, 9 juli 2019

# Burial Assessment Study "Lite"

for the proposed

NEUCONNECT INTERCONNECTOR
(Bundled Cable Asset)

For

NeuConnect

By

primo marine
Independent Marine Infrastructure Expertise

Document: 476-01-12
By: Primo Marine
Prepared by: Marcel Dieteren
Reviewed by: Wino Snip / Mike Travis / Maris Paap
Date: 09 July 2019
Revision: R3_00

# NeuConnect

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|---|---|
| Consultant:<br><br>primo marine<br>Independent Marine Infrastructure Expertise<br><br>PRIMO MARINE<br><br>Haringvliet 76<br>3011 TG Rotterdam<br>The Netherlands<br>www.primo-marine.com | Primo Marine Project Number:<br><br>0476-01-12<br><br>Document Number:<br><br>**476-01-12** |

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| R3_00 | 20190709 | For Client Review | MD | | |
| R2_00 | 20190708 | For Internal Review – All Sectors | MD | WS/JT/MP | N/A |
| R1_00 | 20190628 | For Client Review – UK Sector Only | MD | | |
| R0_00 | 20190627 | For Internal Review – UK Sector Only | MD | WS/MT | N/A |
| **Revision** | **Date** | **Description** | **Primo Author** | **Primo Reviewers** | **Client Approved** |

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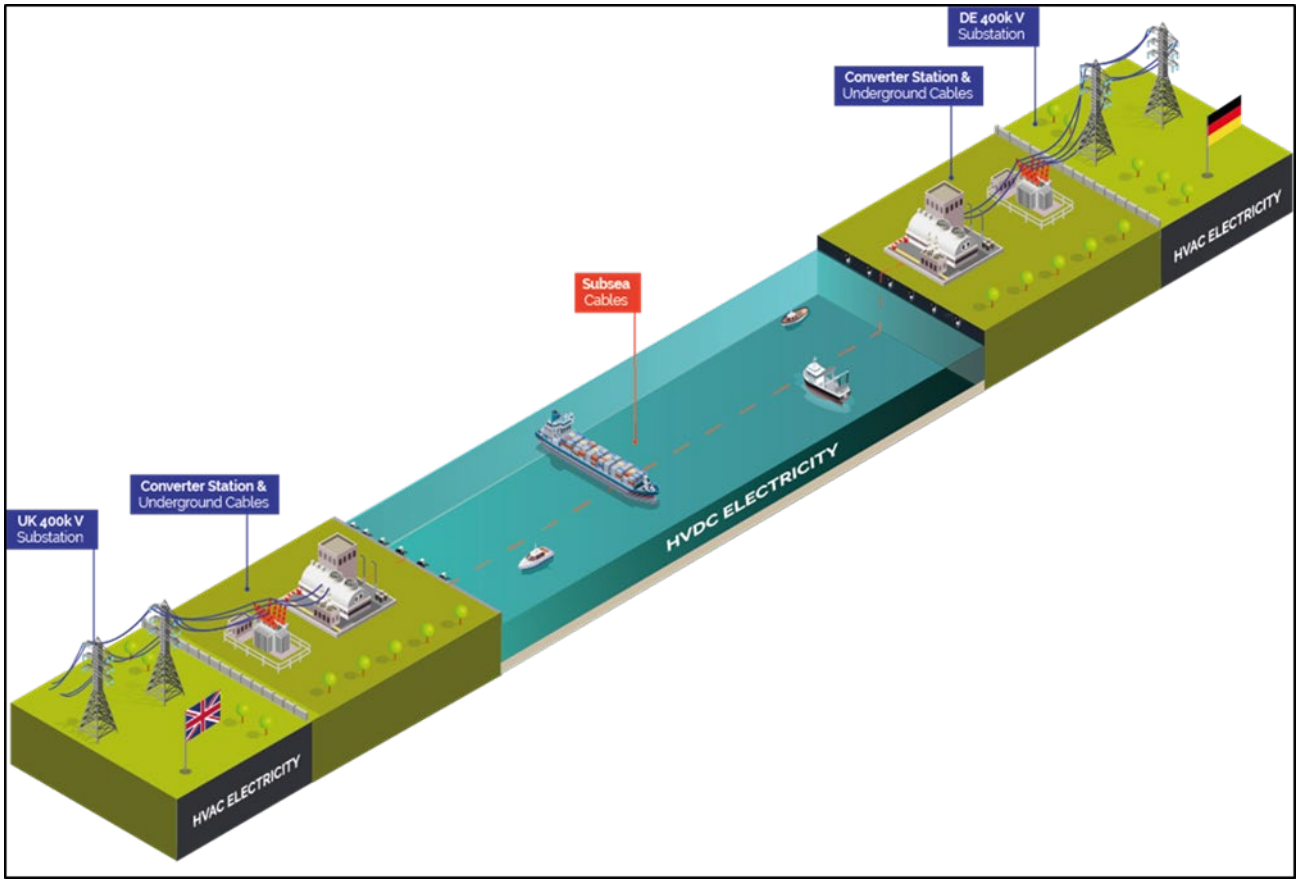
# 1. INTRODUCTION

The NeuConnect Interconnector Project involves a High Voltage Direct Current (HVDC) electrical interconnector with an approximate capacity of 1400MW, which will allow transfer of power between the electricity transmission systems of Germany and the United Kingdom (Figure 1-1).

By connecting two of Europe's largest energy markets for the first time, the NeuConnect project will offer a more diverse and sustainable energy supply, offering much needed resilience, security and flexibility in the United Kingdom and Germany. Increased competition in the UK market could also lead to lower costs for consumers and businesses, while in Germany the new link will help reduce 'bottlenecks' by opening up an important new market for excess renewable energy to be exported to.

**Figure 1-1: NeuConnect Project Schematic (source: NeuConnect website)**




The NeuConnect Interconnector will link the Isle of Grain in Kent, UK, with the Wilhelmshaven region in Germany, with a bundle of subsea cable assets crossing the Territorial Waters (TW) and Exclusive Economic Zone (EEZ) of the United Kingdom, the EEZ of The Netherlands, and the TW and EEZ of Germany. The route of the subsea cables and landfall locations in Germany and UK will be determined by project development work that is currently underway.

## 2. STUDY SCOPE AND OBJECTIVE

Primo Marine (PRIMO) have been commissioned to produce a Burial Assessment Study – "Lite".

This BAS "Lite" deals with the 700km-long undersea bundled cable(s) route, linking the Isle of Grain, in Kent (UK) with the Wilhelmshaven region in Germany.

The study scope of work is as follows:

- Perform a critical review of the Cable Burial Risk Assessment (CBRA) and advise if all relevant hazards have been considered and whether the proposed Target Depth of Lowering (TDOL) is practically feasible;
- Perform a high-level review of the available geophysical and geotechnical survey reports;
- Use the companion set of alignment charts and the GIS database to carry out an independent assessment of route sections, as input to BAS Lite, based on encountered bedforms, material types and strengths.
- Provide high level strategic recommendations for cable system protection such as:
    - opportunities for further route optimisation;
    - seabed preparation requirements (amongst which pre-sweeping);
    - appropriate burial techniques (tools) for cable protection;
    - any rock dumping, use of mattresses, or other additional protection methods.

Generally, cable system protection can be achieved through the design of a safe route and through cable lowering (burial) to an appropriate depth below the immobile seafloor level.

An optimised cable burial depth design profile (Target Depth of Lowering – TDOL: the key output of the Cable Burial Risk Assessment - CBRA - study) typically takes into account the Client's projected financial risk profile over the lifetime of the asset(s). The strategic balancing of CAPEX / OPEX / TOTEX budgets typically means that a low OPEX strategy (low maintenance, inspection, repairs during asset design lifetime) would have to be achieved through deeper system burial (higher CAPEX).

This BAS Lite, and future BAS studies aid in improving the general understanding of cable system burial feasibility risk, where the TDOL and Target Trench Depth (TTD) would have to be carefully selected such that burial to TTD is practically and economically achievable. A BAS will identify appropriate tools for achieving TTD in known ground conditions.

This information should allow Environmental Permitting and Consents teams in the three respective regulatory environments to progress with their various planning applications, in a timely and efficient manner.

# 3. GENERAL

## 3.1. List of Abbreviations

**Table 3-1: List of Abbreviations**

| Abbreviation | Description |
|---|---|
| BAS | Burial Assessment Study |
| bsf | below sea floor |
| BSH | Bundesamt fur Seeschifffahrt und Hydrographie (German authority) |
| CAPEX | Capital Expenditure |
| CBRA | Cable Burial Risk Assessment |
| CFE | Controlled Flow Excavator |
| CLIENT | NEUCONNECT BRITAIN LTD |
| CPS | Cable Protection System |
| CPT | Cone Penetration Test (in-situ test) |
| DOC | Depth of Cover |
| DTM | Digital Terrain Model |
| EEZ | Exclusive Economic Zone |
| GC | Gravity Core sample |
| GDWS | Generaldirektion Wasserstrassen und Shifffahrt (German authority) |
| GIS | Geographic Information System |
| HVDC | High Voltage Direct Current |
| INTERTEK | CBRA Consultant |
| KP | Kilometre Point |
| LAT | Lowest Astronomical Tide |
| MBES | Multi-Beam Echosounder |
| MBR | Minimum Bending Radius |
| MFE | Mass Flow Excavator |
| MMT | Survey Contractor |
| MRDOL | Minimum Recommended Depth of Lowering |
| OOS | Out of Service |
| OPEX | Operational Expenditure |
| PLB | Post-Lay Burial |
| ROV | Remotely Operated Vehicle |
| RPL | Route Position List |

| Abbreviation | Description |
|---|---|
| SBP | Sub Bottom Profiler (Chirp, Sparker) |
| SLB | Simultaneous Lay and Burial |
| SSS | Side Scan Sonar |
| SVP | Sound Velocity Profiler |
| TDOL | Target Depth of Lowering |
| TOTEX | Total Expenditure |
| TSO | Transmission System Operator |
| TTD | Target Trench Depth |
| TW | Territorial Waters |
| UK | United Kingdom |
| VC | Vibro-Core sample |
| VI (Jet Sled) | Vertical Injector (Jet Sled) |

### 3.2. Particular Definitions - Cable Burial and Trenching Requirements

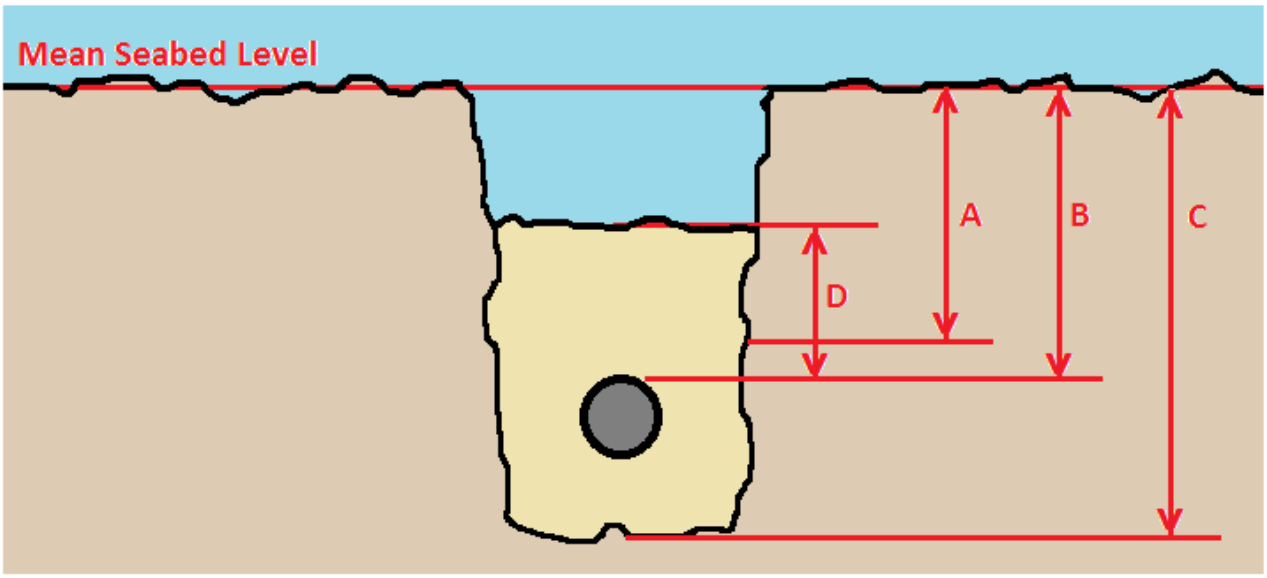
The particular definitions stated in the Carbon Trust Guidance Notes [/8/] are repeated here for ease for reference.

Note that in areas with no seabed sediment mobility risk, the reference seabed level is the virgin seabed level, or the "mean seabed level" as depicted in Figure 3-1 below. In areas with seabed mobility risk, the reference level is the interface level between mobile and immobile seabed sediments.

**(A) Recommended Minimum Depth of Lowering (RMDOL):**

RMDOL (relative to top of asset) is defined as the recommended minimum depth to ensure cable asset protection from external geo- and man-made hazards and threats. The RMDOL would be the direct output of a Cable Burial Risk Assessment (CBRA) study.

**Figure 3-1 : Sketch illustrating Definitions of Burial and Trenching Requirements**




**(B) Target Depth of Lowering (TDOL):**

The TDOL (relative to top of cable asset) is the depth that cable installers should target, as specified by the developer.

The TDOL should be equal to or greater than the RMDOL and may include a factor of safety. It may be prudent, for example, to increase the TDOL where the recommended RMDOL is relatively shallow (say less than 0.5m) thus mitigating the risk for burial tool operational instability issues.

Where the TDOL could not achieved, no remedial action would be required in principle, as long as the RMDOL is achieved.

**(C) Target Trench Depth (TTD):**

With TDOL known, Cable Installers then put forward a target trench depth (TTD) that can realistically be achieved in expected ground conditions based on the cable asset properties and the trenching tool(s) selected to safely and efficiently complete the works.

TTD would usually be the diameter of the cable asset plus between 0.1 m and 0.4 m beyond the TDOL.

For this study, and with reference to Section 5 below, the diameter of the bundled set of cables has been assumed to be 0.2m. TTD will be calculated as TDOL plus diameter plus an additional 0.2m margin, essentially adding a total of 0.4m to TDOL.

**(D) Depth of Cover (DOC)**

The DOC is the thickness of seabed material ending up on top of the cable after trenching. This could increase over time as the trench naturally backfills with mobile sediments up to the surrounding seabed level.

The DOC is not normally a consenting requirement to ensure cable protection.

However, in the German sector, the authorities impose the "2K criterion" meaning that the cable system heating up the seabed within a surficial zone of 20 or 30 cm (depending on the location in German waters) below the seafloor shall be, according to model calculations, no more than 2 degrees Kelvin during its operation.

At the same time, the minimum depth cover on the cable in German water shall be a minimum 1.5m.

These two criteria may potentially be conflicting, depending on specific geo-thermal properties of the surficial seabed soils.

This set of requirements has significant consequences with regards to the thermal design of the cable system, in particular a bundled set of cables, and typically result in a cable cross section and selection of metal for the core which (compared to non- Germany standards) and significant over-capacities for its intended usage.

### 3.3. Coordinate System

| | |
|---|---|
| Geodetic Datum: | WGS84 |
| Projection: | UTM Zone 31 N for UK and Dutch waters<br>UTM Zone 32 N for German waters |
| Depth datum: | LAT [metres] |

## 4. REFERENCES

**Table 4-1: List of References**

| Ref | Title | Author | Report Date | Document Nr. |
|---|---|---|---|---|
| /1/ | Geophysical Route Survey Reports<br><br>All but one report still have "preliminary" status !<br><br>Final Approved versions required for all reports ! | MMT | No Date<br>No Date<br>No Date<br>No Date<br>No Date<br>No Date<br>No Date<br>No Date<br>No Date<br>No Date<br>No Date<br>No Date<br>20180730<br>No Date | 102553-NEU-MMT-SUR-FSS-BLOCK02_Rev2<br>102553-NEU-MMT-SUR-FSS-BLOCK03_Rev2<br>102553-NEU-MMT-SUR-FSS-BLOCK04_Rev2<br>102553-NEU-MMT-SUR-FSS-BLOCK02_Rev3<br>102553-NEU-MMT-SUR-FSS-BLOCK06_Rev3<br>102553-NEU-MMT-SUR-FSS-BLOCK07_Rev3<br>102553-NEU-MMT-SUR-FSS-BLOCK08_Rev3<br>102553-NEU-MMT-SUR-FSS-BLOCK09<br>102553-NEU-MMT-SUR-FSS-BLOCK10R_Rev2<br>102553-NEU-MMT-SUR-FSS-BLOCK11_Rev2<br>102553-NEU-MMT-SUR-FSS-BLOCK12_Rev1<br>102553-NEU-MMT-SUR-FSS-BLOCK13_Rev3<br>102553-NEU-MMT-SUR-FSS-BLOCK14_Rev2<br>MMT_553_SURVEY_REPORT_B1_001_R02<br>NeuConnect_B15_Block Report_R02 |
| /2/ | Survey Alignment Sheets<br><br>Rev A (for Use)<br><br>Final status ? | MMT | 20190125 | 102553-NEU-MMT-SUR-DWG-AL531001<br><br>through<br><br>102553-NEU-MMT-SUR-DWG-AL531113 |
| /3/ | Survey Alignment Sheets<br><br>Rev A (for Use)<br><br>Final status ?! | MMT | 20190125 | 102553-NEU-MMT-SUR-DWG-AL532114<br><br>through<br><br>102553-NEU-MMT-SUR-DWG-AL532153 |
| /4/ | Multibeam Route DTM | MMT | 20180818 | 2018-08-18_B1-B15_MBES_DTM |
| /5/ | Survey Data GIS database<br><br>Final version not available? | MMT | 20180919 | 102553-NeuConnect-Draft-20180919.gdb<br>102553-NeuConnect-Draft-20180919.gdb.mxd |
| /6/ | Geotechnical Report<br><br>Rev A (for Use) | MMT | 2018-12-18 | 102553-NEU-MMT-SUR-GEOTECRE_RevA |

| Ref | Title | Author | Report Date | Document Nr. |
|---|---|---|---|---|
| /7/ | CBRA for NEUCONNECT | Intertek | 20190320 | P2131_R4592_Rev1 |
| /8/ | CBRA Methodology | Carbon Trust | 2015-02 | CTC835 |
| /9/ | Route Position List - Rev 5 | Unknown | 20180726 | 20180726_WGS84_NeuConnect_Issue_5_RPL |
| /10/ | Memo – Micro Routing | PRIMO | 2019-06-25 | 0476_01_13 NC_MEM_0001_R1_00_NeuConnect_Micro-routing |
| /11/ | Memo – Cable Routing in German Sector | PRIMO | 2019-06-12 | |
| /12/ | 2K Criterion – section 5.3.2.9 in BFO document | BFO | 2016/2017 | Bundesfachplan fur die deutsche ausschliessiche Wirtschaftszone der Nordsee 2016/2017 und Umweltbericht. |

## 5. BUNDLED CABLE ASSET(S)

No details or specification on the proposed cable asset were available at the time of writing this study, other than the asset involving more than one cable, bound together forming a bundle.

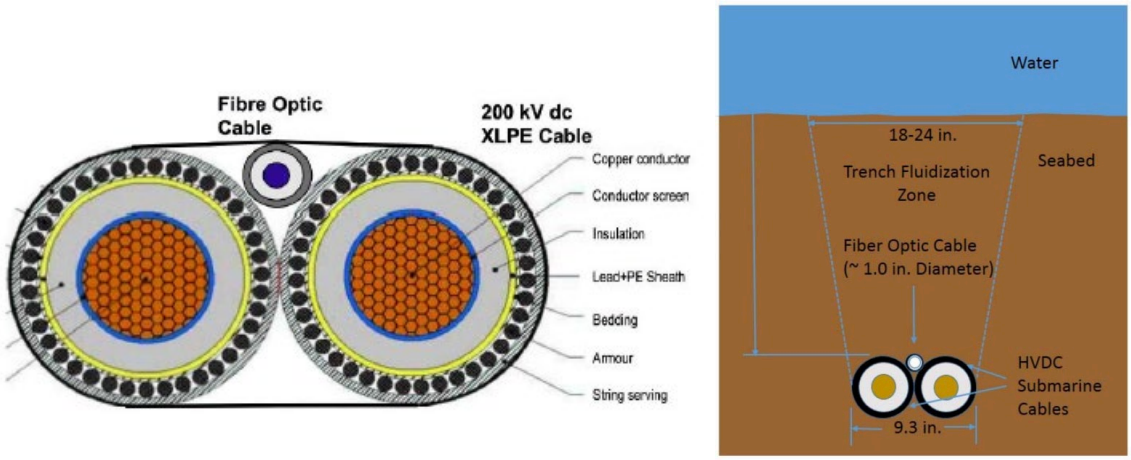
PRIMO assume that a typical bundle arrangement would be applicable as is shown in the three images shown below under Figure 5-1, and that the as-installed configuration involves the two HVDC cables, 700 MW each, positioned (buried) side by side.

The cables are bundled using strapping of twine installed around the 2-3 cables at regular spacing or continuously on the deck of the cable laying vessel before it is let into the water over the chute.

This side-by-side arrangement means that, the pertinent bundled asset diameter to be considered for BAS Lite would be the diameter of the individual cable on its own.

For this study, the cable diameter is assumed to be 0.2m (conservative) – dimensions in the Figures below are not specific to the NeuConnect project.

**Figure 5-1: Typical Symmetrical Cable Bundle Configuration (and as-installed configuration)**



# 6. REGULATORY CABLE BURIAL REQUIREMENTS

## 6.1. United Kingdom

The UK recommend a risk-based approach (reference CBRA /7/).

## 6.2. The Netherlands

The Netherlands generally recommend a risk-based approach (reference CBRA /7/).

The Dutch authorities however impose a DOC of 1.5 meter in traffic separation schemes (TSS) and a DOC of 1.0 meter outside of those.

These DOC burial depths shall be maintained over the asset design lifetime meaning that seabed mobility will have to be closely monitored (risk of exposure, as well as risk of over-burial and thus over-heating), and evaluated on an ongoing basis, through a program of annual inspection surveys.

## 6.3. Germany

German authorities impose:

- the so-called "2K criterion" for cable burial engineering;
- in general, a minimum DOC of 1.5m (exceptions being discussed further below).

The 2K criterion relates specifically to national regulations in Germany where there is a requirement to design a burial depth which will result in a temperature elevation of not more than 2 degrees C (equivalent to 2K) at a depth of 0.2-0.3m within overlying sediments. The 2K criterion was established as a precautionary measure to protect benthic life but is not understood to be underpinned by clear scientific evidence. Reference is made to the BFO document, section 5.3.2.9 [/12/].

The 2K criterion within TW (e.g. Wattenmer National Park) applies to the upper 0.3m of the seabed.
The 2K criterion within EEZ applies to the upper 0.2 m of the seabed.

German authorities may require a 5m burial depth (presumably this refers to TDOL), through the German Bight shipping channels, separated by the TSS. This requirement is currently under discussion, with requirements being proposed (assumed by two separate German authorities).

- The GDWS option which requires that a "construction-free" crossing be considered for any future cables. This option only applies to a 2km long area in the German Territorial Waters (TW), i.e. not the EEZ. Reference is made to Figure 6-1 below.
- Shipping Channels: the burial depth (again, assuming this refers to TDOL) has to be at least 3.0 m.
- This minimum 3m burial requirement is with reference to the minimum channel depth level, as stated in the nautical charts (if indeed stated), and not the bathymetric depth as determined during a survey. For the Jade, for example, this would be 17.6 m, see Figure 6-2 below.

  This minimum 3m burial depth requirement shall be maintained during the lifetime of the cable system.

**Figure 6-1: GDWS option – Potential Crossing Area (wide orange highlight) requiring a TDOL of 5 m.**

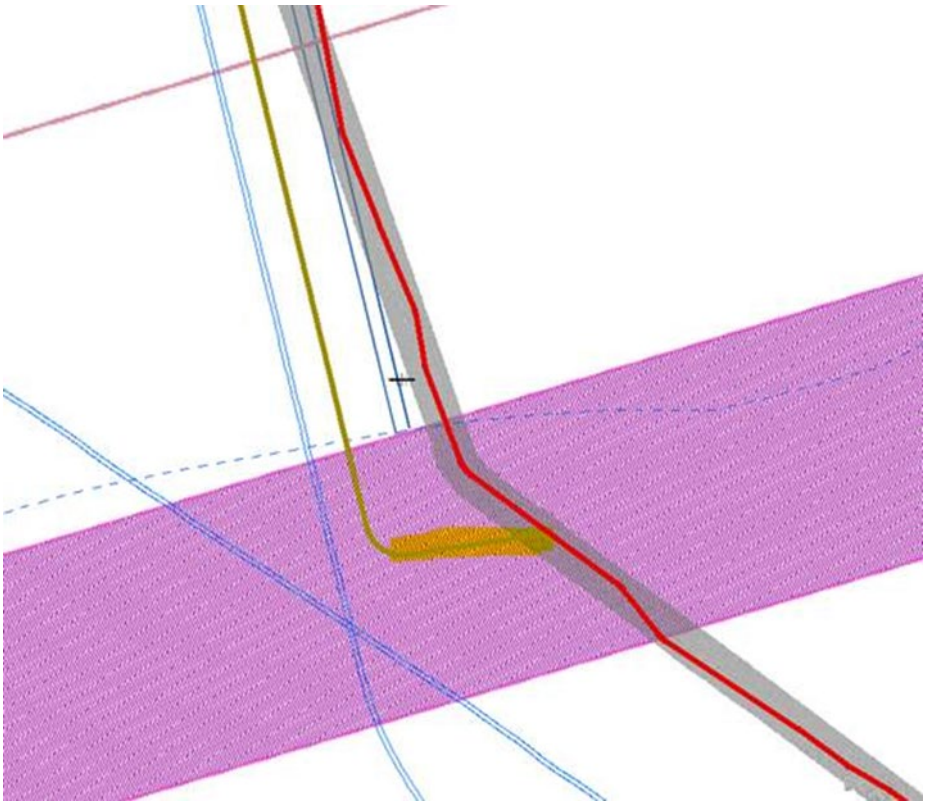
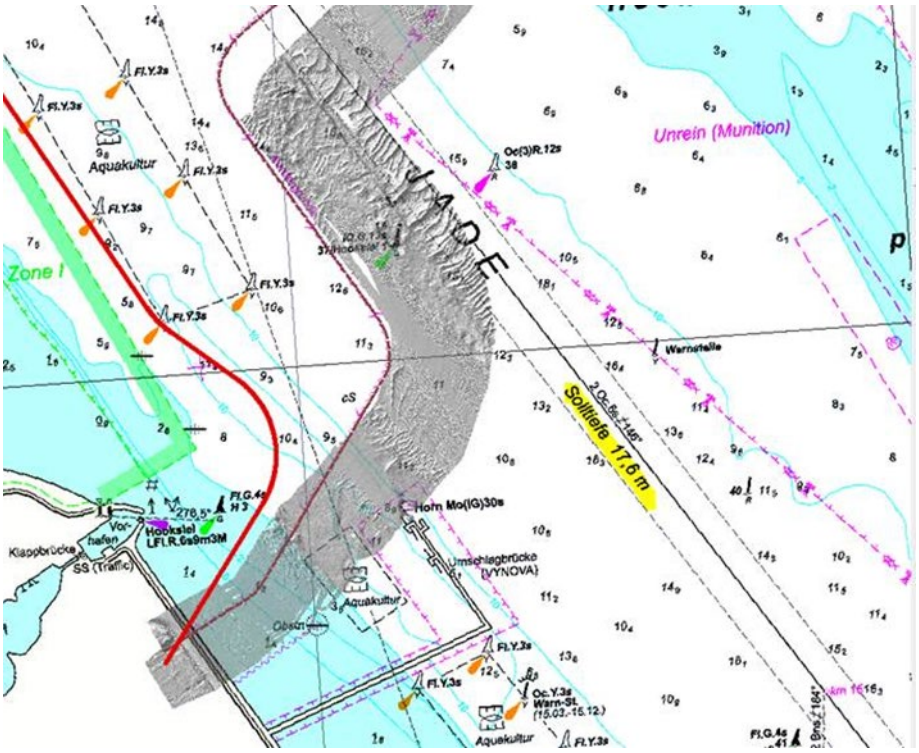


**Figure 6-2: Option 2 (BSH?): Navigation Channel Depth**

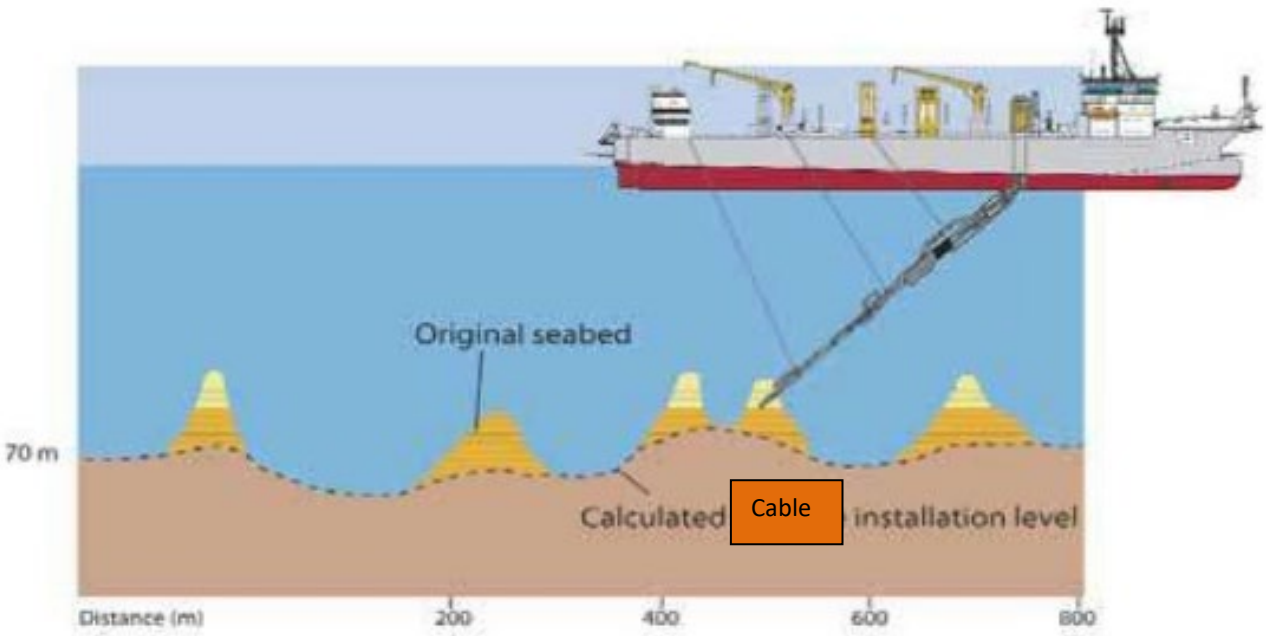


# 7. SEABED INTERVENTION TECHNIQUES

## 7.1. Mobile Seabed Preparation (Pre-Lay Sweeping)

The Figure 7-1 below illustrates the Trailing Suction Hopper Dredger technique, proposed for pre-sweeping large areas of the larger mega ripples and sand waves prevalent throughout the UK Sector, parts of the Netherlands sector, and the nearshore portion of the Germany sector.

**Figure 7-1: Trailing Suction Hopper Dredger**




## 7.2. Simultaneous Lay & Burial (SLB) versus Post-Lay Burial (PLB)

SLB involves the burial of the cable whilst being laid on the seabed – see Figure 7-2 below.

**Figure 7-2: SLB**

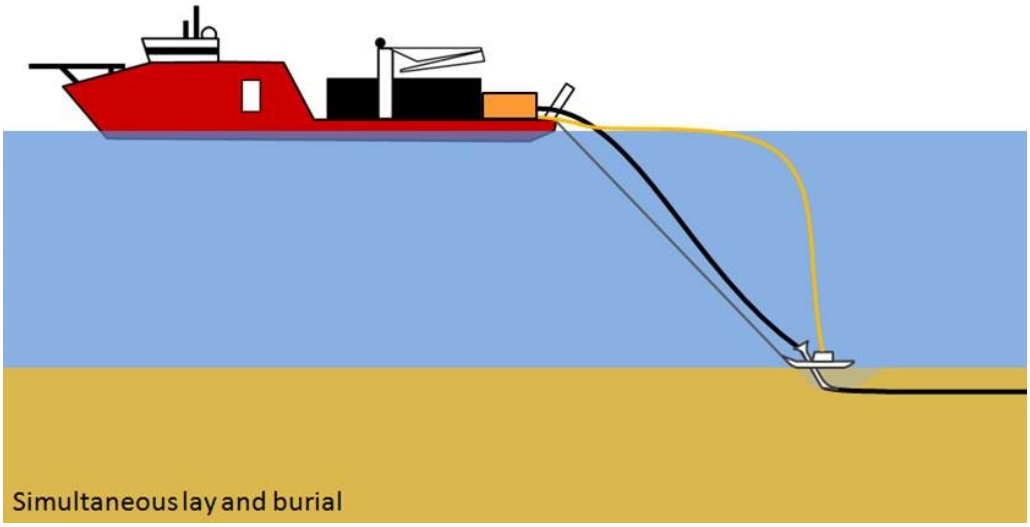
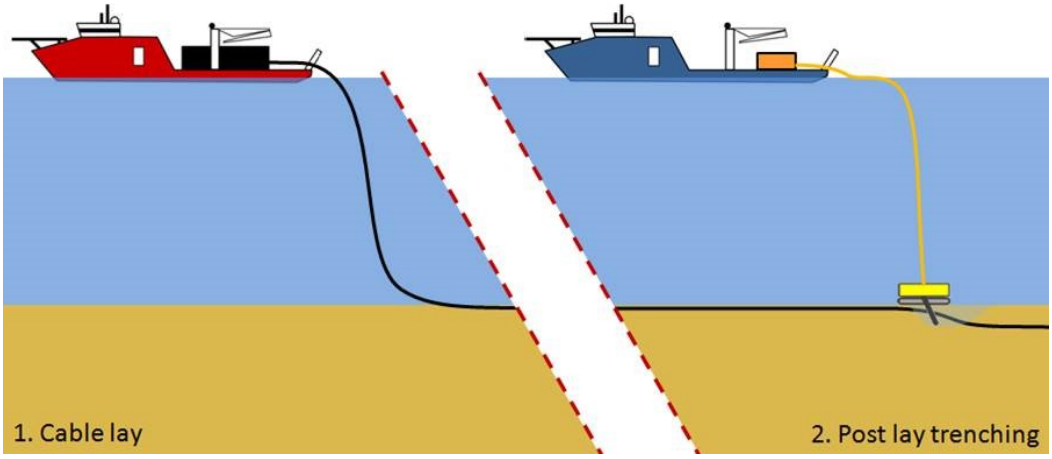


**Figure 7-3: Cable Surface Lay, followed by PLB.**




It should be noted that SLB is not necessarily always faster than surface laying the cable in a first pass, followed by post-lay burial (PLB) in a second pass (often with a different vessel) – see Figure 7-3.

## 7.3. SLB Techniques

Typical SLB techniques are:

- the passive marine plough (Force Balanced Blade);
- subsea jet trenchers;
- mechanical cutters.

A typical modern marine plough (Figure 7-4) is a vehicle on skids that is towed behind the cable laying vessel. The plough has an adjustable share that can be lowered into the seabed to the required burial depth and some are equipped with water jets on the blade to lower the pull forces required in certain seabed conditions, or with a vibrating blade.

The cable or cable bundle enters the "bell mouth" of the plough, is guided through the plough and released at the base of the share at the required burial depth. The seabed will close above the cable after the share has moved through.

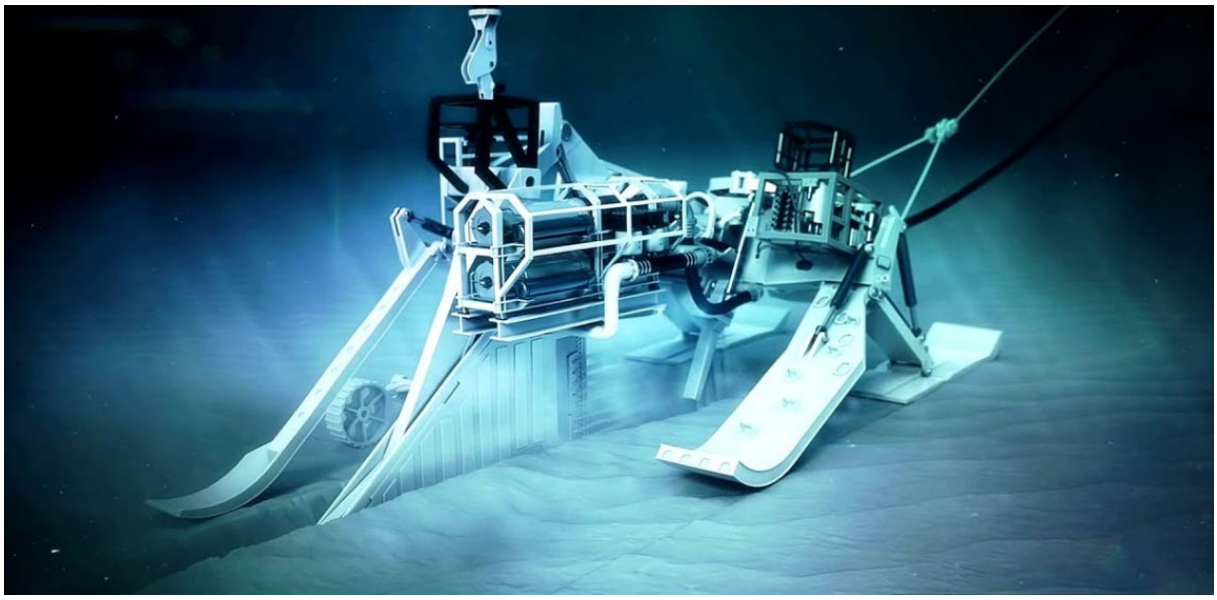
**Modern ploughs can bury cables up to a depth of 3 metres below seafloor.**

The plough technique can be fast, with minimal seabed impact, however some factors could make this solution not ideal, such as (too) hard soils and (numerous) occurrences of cable or pipeline crossings.

The plough method involves a lot of mechanical forces on the cable and could pose a risk to the integrity of the cable if not handled with care. The water depths at which this method can be applied is unlikely to be a constraining factor.

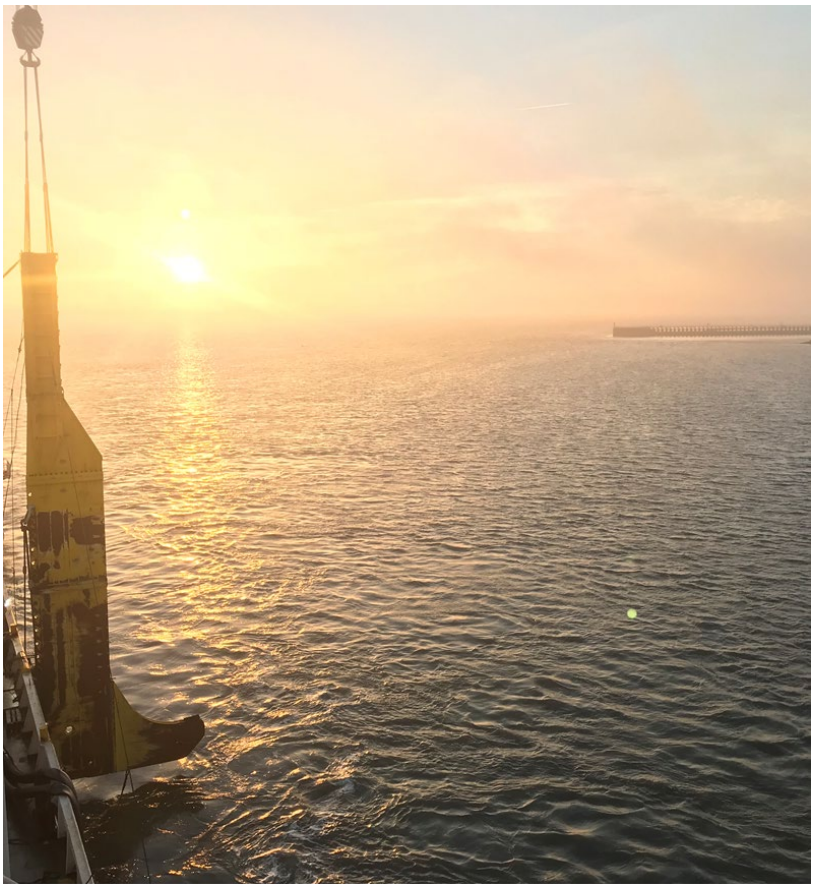
Ploughs can cope with material types and strengths ranging up to very dense sands, and firm to stiff clays, as well as weak (weathered, fractured) rock, in principle, depending on factors such as target trench depth.

**Figure 7-4: Modern Cable Plough**



For burial to depths considerably deeper than 2-3metres below seafloor, for example, up to 10meters into sands, in areas closer to shore, the Vertical Injector (VI) technique is recommended. Machines like the one shown in Figure 7-5 are designed for SLB operations.

**Figure 7-5: Vertical (Cable Guidance) Injector**

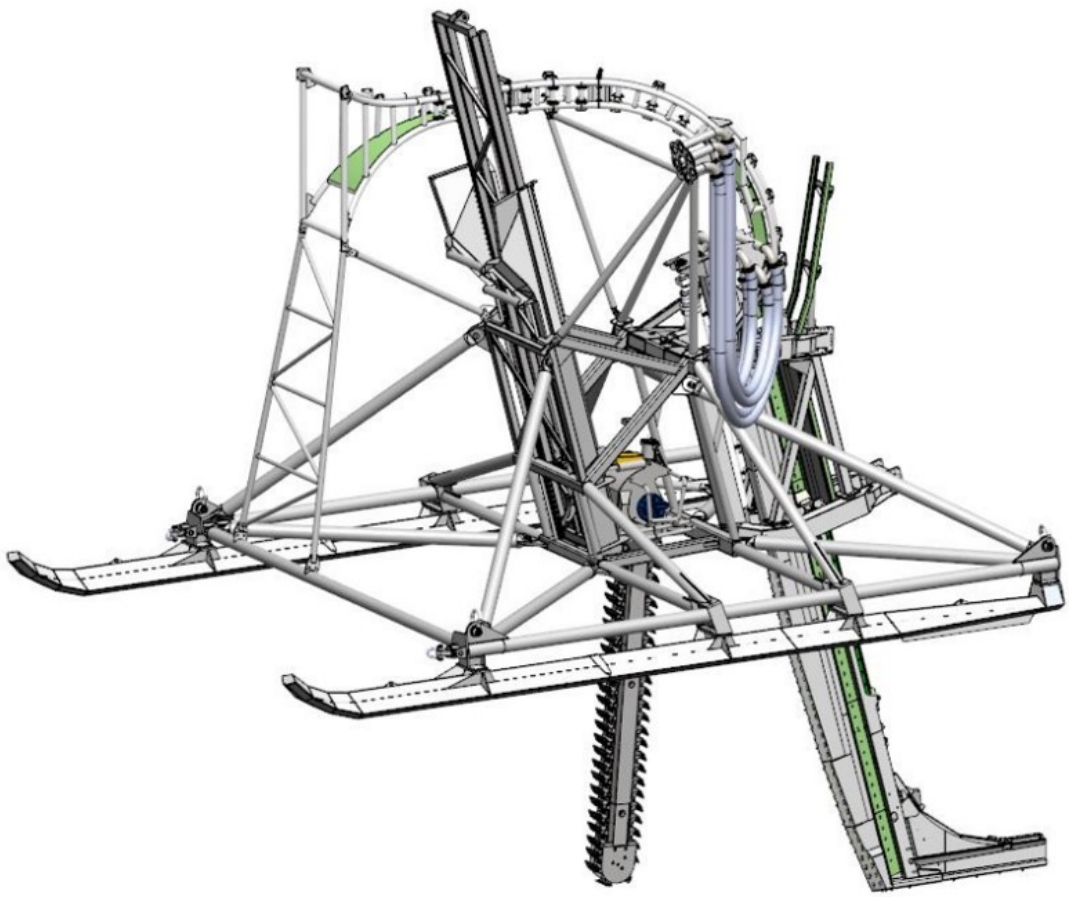


A Vertical Injector (VI) can be assisted by a dedicated mechanical chain cutter, if necessary, to pre-cut harder cohesive soils and rock, i.e. preceding the installation of the cables by the Vertical Injector (VI). For pre-cutting, the chain cutter will be passed along the selected route sections to the required depths.

VI spreads and associated field operations, however, have a high weather susceptibility (waves and swell). Therefore, VI spreads are not suitable for the installation of cables much further away from the coastline. Without heave compensation on the hoisting of the Vertical Injector, there is a real risk of cable damage caused by the movement of the VI relative to the seabed under heave.

For deeper installation into non-cohesive sand soils, but much further from shore, a suitable tool would be the VI mounted on a jet-sled. This tool can achieve burial depths of up to 8 meters below seafloor level. Such a jetting sled can be fitted with a long mechanical chain cutter cut able to deal with the harder cohesive type soils. An example is shown in Figure 7-6 below.

**Figure 7-6: VI Sled**



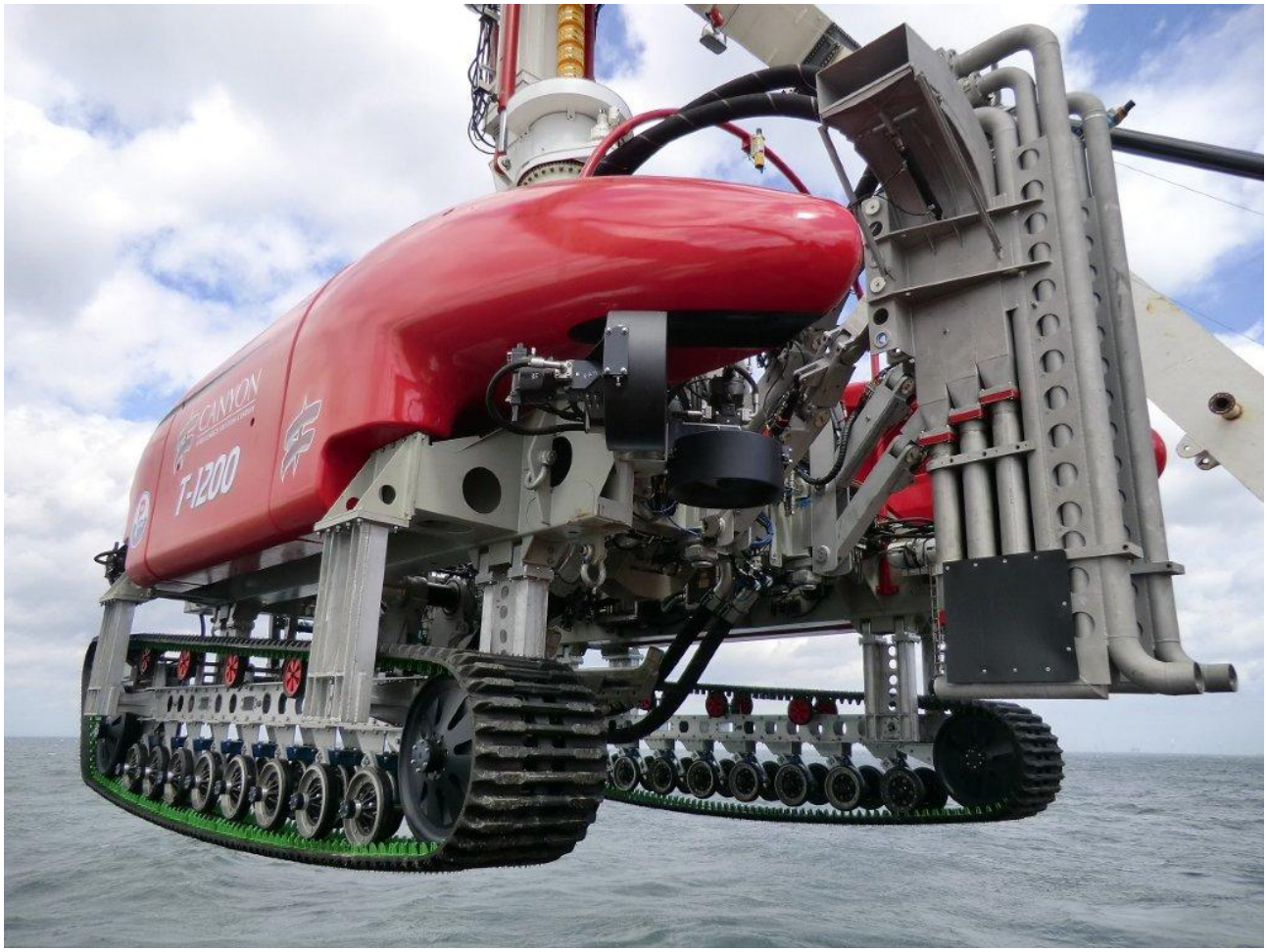
### 7.4. PLB Techniques

Common PLB techniques for burial of a pre-laid cable bundle include:

- Water jetting;
- Mechanical trenching.

Water jetting involves a technique where a Remotely Operated Vehicle (ROV), equipped with "swords" with high pressure water nozzles on its blade, straddles the as-laid cable or cable bundle and fluidises the seabed underneath, allowing the cables to sink into the seabed under their own weight.

**Figure 7-7: Modern Water Jet Trencher**




**Modern ROV water jetters can bury cables to a typical depth of 2-3 metres, and the latest models even up to 5m when using a cable depressor.**

Water jetting is typically employed in granular soils but can cope with cohesive soils with material strength up to 60-70kPa.

Where the seabed is too hard for water jetting, then mechanical cutting methods are available to be used, such as the mechanical rock trencher shown in Figure 7-8. These tools allow the cable to be loaded into it and held to a position out of the way while a wheel cutter or rock saw digs the trench to the required depth. The cables are guided into the trench by the profiled 'depressor' behind the cutter, though not all cutters have a depressor with others relying on the cable sinking to the bottom of the trench as with the jetting method above.

**Figure 7-8: Mechanical Cutting Trencher**

When using this method, the trench should remain as narrow as possible and the trench is typically filled in by the natural movement of the seabed materials. In hard soils where rock trenching is necessary, a reduced burial depth is typically acceptable considering reduced anchor and trawler penetrations into the seabed.

### 7.5. Depressors and Open vs Closed Jet Sword Trenchers

Jet trenchers with open swords and without a depressor are designed to straddle the surface laid or shallow buried cable. During trenching, the cable is not lifted by those trenchers. Without a depressor and without lifting the cable, the achievable burial depths strongly depend on the grain size of non-cohesive soils and on the capacity of the backwash system. In courser sandy and gravelly materials, the achievable burial depths with such open jet sword trenchers is limited to less than 1.5m, more likely around 1.0m.

Where jet trenchers are equipped with a cable depressor, this positively forces the cable down into the fluidised soil. The soil however will have to be fully fluidised and remain in this fluidised state long enough for the cable to be guided to the bottom of trench (a depressor cannot press a cable into resedimented soil). Therefore, for this type of trenchers, the achievable burial depths strongly depend on the granular material's grain size.

To improve burial capabilities, some trenchers of this category do lift the cable first from the seabed and guide it down back to the seabed at an angle. That significantly increases the possibilities to achieve greater

burial depths whilst reducing the forces exerted on the cable by the depressor. With this type of jet trencher, with a depressor and a cable lifting system, burial depths up to 5 meters can be achieved.

One of the primary advantages of open jet sword jet trenchers, with or without depressors, lies in the fact that these trenchers can be placed on the cable and lifted from the cable relatively easily. That makes it possible to start and stop trenching under slightly less favourable weather conditions. This flexibility can significantly increase the overall workability on the project i.e. significantly reduce the waiting on weather, but at the expense of potentially not achieving the intended burial depths, in areas with coarser grained soils. Open jet sword trenchers are more susceptible to debris and other obstacles in the seabed.

Adding a cable lifting system and a depressor increases the likelihood of achieving the intended burial depths, but that adds a risk of damage to the cable. There is quite a bit of controversy in the market with regards to the application of depressors and the risk of causing damage to cables. Meanwhile, it is a fact that significant lengths of cable have already successfully been installed using a depressor. Therefore, there is no clear answer to the question what the best or most effective jet trencher would be. This depends on a detailed risk assessment, balancing cable integrity on the one hand with feasibility of achieving the intended target trench depths (TTD).

With above in mind, open jet sword trenchers are to be compared with closed jet sword trenchers as for instance the discussed jetting sledges and the vertical injector type of trenchers. Those trenchers guide the cable down to the required depths through a closed stinger or blade, which physically ensures that the cable reaches the intended depth, whilst at the same time protecting the cable against debris and other obstacles in the seabed. The downside of this, however, is that cable loading and unloading in a closed jet type of sword trencher is significantly more complicated, cannot be readily disengaged and re-engaged, and requires significantly more favourable weather conditions. Therefore, closed jet sword trenchers typically have a lower workability with regards to weather and wave conditions. This affects the overall installation risk profile in a sense that workability of the trenching spread needs to be balanced against risk of (not) achieving the TTD and against the safeguarding of cable integrity.

It can be safely concluded that there is not one trenching system that is better or to be preferred over others. Each trenching system has its own advantages and disadvantages. This will have to be carefully assessed in a future BAS Proper, against the shallow geological conditions, the bedforms, the final TTDs along the cable route.

The role that a capable and experienced Cable Installation Contractor plays in this, working safely and efficiently under those conditions, whilst safeguarding the integrity of the cable, is not to be underestimated.

That is why the selection of a trenching spread is typically addressed via a BAS "Proper", where the BAS of the TSO serves to clearly identify risks (and options to deal with those), whereas the BAS of the Contractor(s) should ensure that appropriate trenchers are selected whilst having a clear view on the associated operational risks and with clear potential mitigating measures in mind.

This BAS Lite will seek to analyse the general soil types and provide guidance on the likely burial assets and those with the most significant environment impact for the purpose of licence and consent application

### 7.6. Other Post-Lay Cable Protection Methods

When the cable needs to cross other in-service 3rd party assets such as in-service telecom lines and pipelines, whether laid directly on the seabed or buried, burial operations are ceased a specified distance before the location of the service and recommenced a distance after.

This distance is to be agreed upon with the owner of the service in the crossing agreement. In this case, the cable or cable bundle will remain on the surface exposed for typically 50 meters either side of the asset to cross, although other cable protection methods can be applied to the cable as described further below.
During crossing agreement negotiations, the distance of 50 meters can be reduced, depending on the controllability of the trencher(s) or other methods used to bury the cable(s) in the seabed in the vicinity of the crossing.

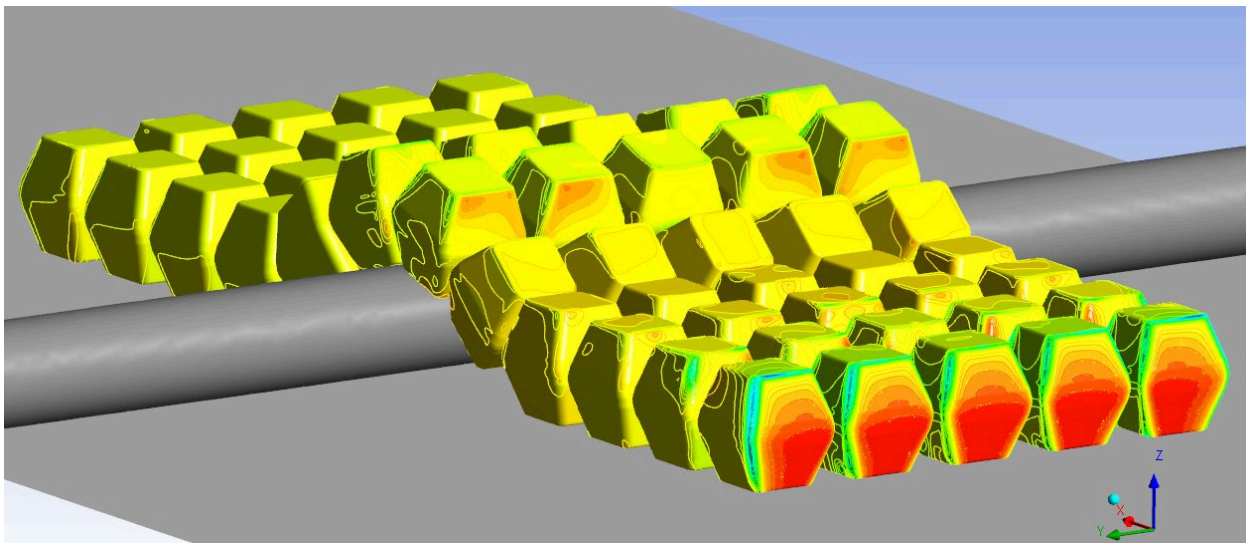
In some cases, other precautions are agreed with the service owner ("crossing agreements"), including applying cable protection on top of the service before it is crossed. Whilst burial of the cables is the common method for protecting the cables where hazards or risks exist, other protection methods could be considered, including:

- When crossing other seabed or buried services;
- In areas where burial to the required depth is not achievable; or
- In areas close to the shore, where burial is not possible due to water depth or environmental constraints.

In these instances, other forms of cable protection are applied post lay. Typical methods include:

**Mattresses** – the placement of pre-fabricated articulated concrete mattresses which are made up of individual concrete blocks connected by ropes or straps, directly on top of the cables or cable bundle (see Figure 7-9). Mattresses however can be susceptible to displacement by waves and currents or fishing gear, as has been seen on recent subsea power cable projects in the German Bight.

**Figure 7-9: Cable Mattress**



**Rock Placement** – the placement of large rocks over the cable or cable bundle.

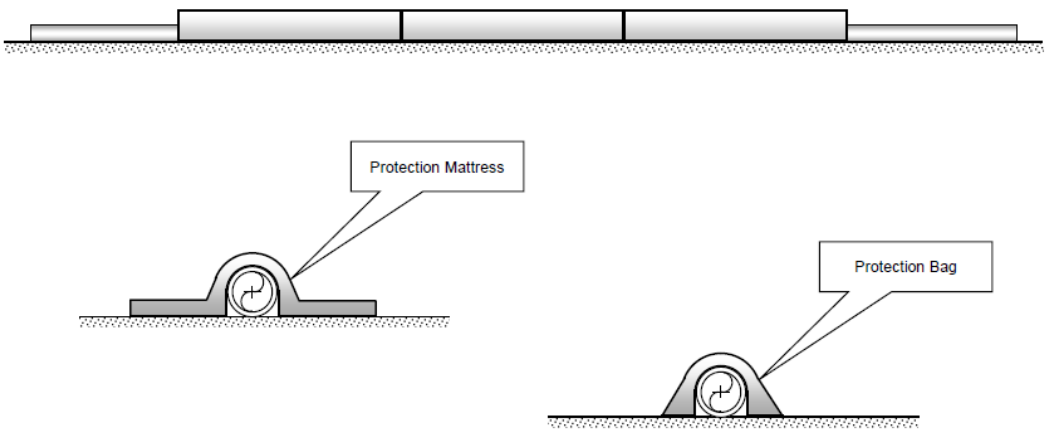
**Figure 7-10: Rock Placement on Cable**

The placement of specifically graded rock on a surface laid cable to protect against external threats such as fishing and dragged non holding anchors, is a well-established protection method in the North Sea area.

The grade of rock is engineered to resist movement by the predominant forces it will be exposed to, often hydrodynamic forces of waves and tidal currents.

**Grout bags** – the placement of bags of grout on top of the cable or cable bundle by divers or ROV which shape over the cables.

**Figure 7-11: Grout Bag Protection**



**Rock Nets–** nets with rock have the advantage over grout bags that they are more stable under design conditions and that those can be placed more easily without divers. There is quite some recent experience with rock nets to protect cables in the North Sea area gained over the recent years. As an example, the cables near wind turbine pylons and near J-tubes at the foot of offshore platforms have been successfully protected by rock nets.

**Figure 7-12: Rock Nets to protect linear assets**

**Cast Iron shells** – Articulate iron pipes installed around the cables. typically referred to as Cable Protection system (CPS) elements. These provide both impact protection and prevent the cable being over bent as the shells 'lock out' at a specified radius of curvature.

**Figure 7-13: Cast Iron Shells**

## 8. ROUTE OVERVIEW

In Figure 8-1, Figure 8-2,and Figure 8-3 below, the full route and the routes for UK, Netherlands and German sectors are shown.

Table 8-1 summarises the lengths of the individual country EEZs.

**Figure 8-1: Overview of NeuConnect Route (All EEZ Sectors)**

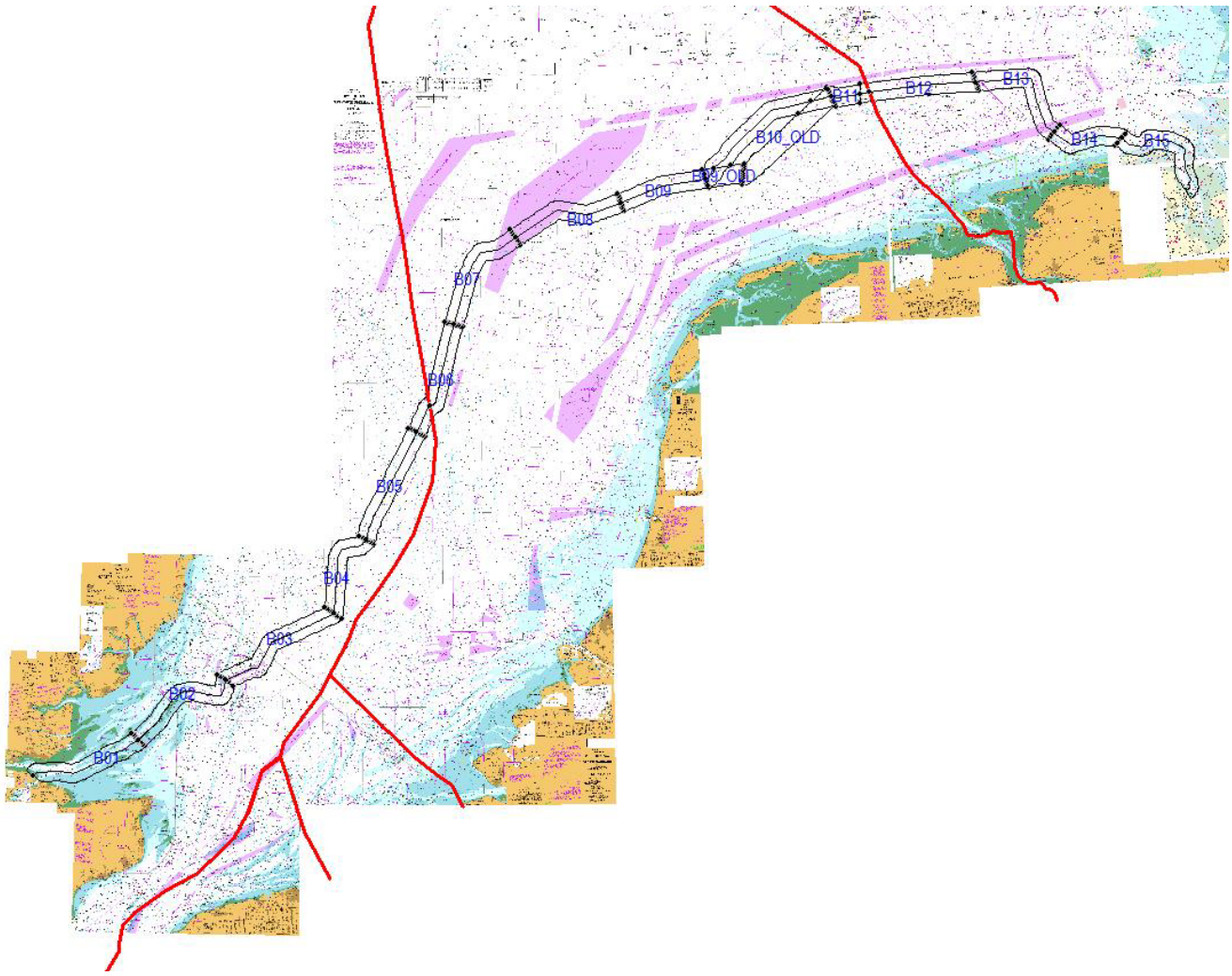
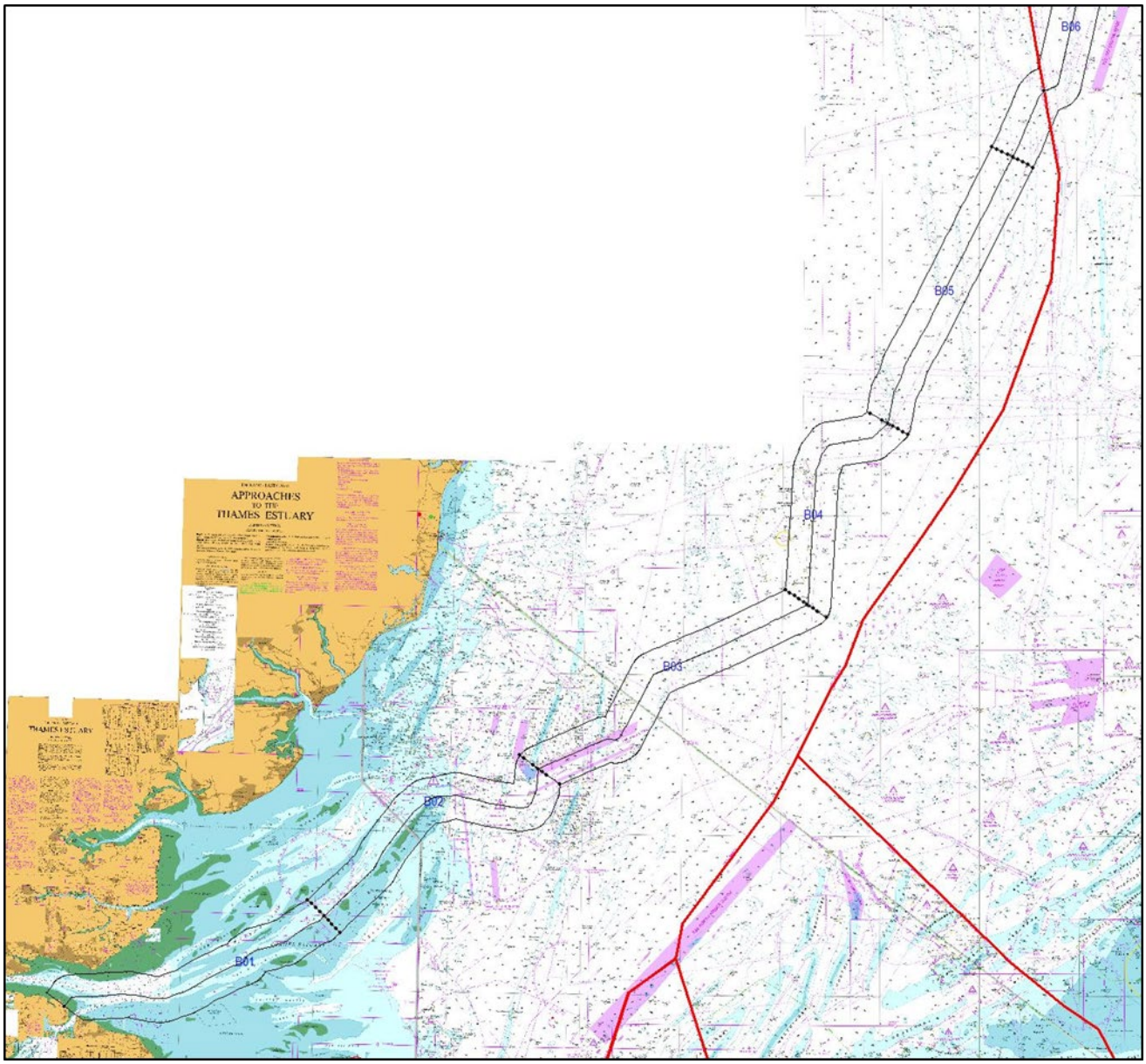



**Table 8-1: Summary Details of EEZ sectors**

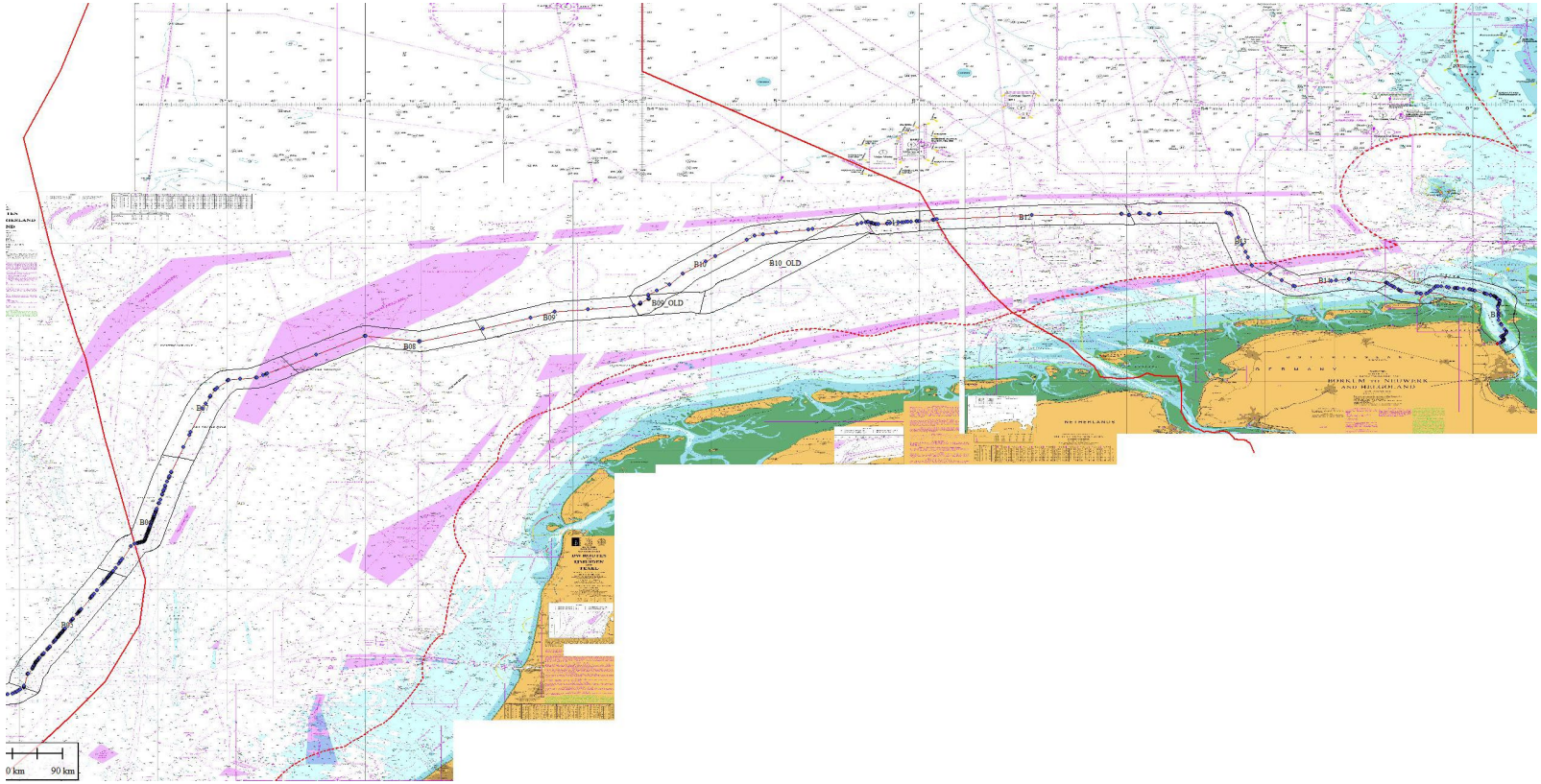
| NeuConnect EEZ Sector | KP FROM (Appr.) | KP TO (Appr.) | Length (Appr.) |
|---|---|---|---|
| | [km] | [km] | [km] |
| EEZ United Kingdom | 0.0 | ~262.850 | ~262.850 |
| EEZ The Netherlands | ~262.850 | ~522.900 | ~260.05 |
| EEZ Germany | ~522.900 | ~700.150 | ~177.25 |

**Figure 8-2: Overview of NeuConnect Route (UK Sector)**




(solid and dashed red lines refer to EEZ and TW boundaries, resp.)

**Figure 8-3: Overview of NeuConnect Route (NETHERLANDS and GERMANY Sectors)**




(solid and dashed red lines refer to EEZ and TW boundaries, resp.)

## 9. ROUTE POSITION LIST (RPL)

This study uses "20180726_WGS84_NeuConnect_Issue_5_RPL", the revision 5 of the RPL, issued on 20180726 [/9/].

More details are provided in Appendix A of this report.

# 10. SURVEY DATA, ALIGNMENT SHEETS AND GIS DATABASE

## 10.1. Geophysical Survey Blocks

The 700km-long cable route was split into 15 survey blocks, for reporting efficiency purposes.
A summary of the details of these survey blocks is provided in Table 10-1 below.

**Table 10-1: Summary Details of Survey Blocks**

| BLOCK ID | KP FROM [km] | KP TO [km] | Block Length [km] | Comment |
|---|---|---|---|---|
| B01 | 0 | 50 | 50 | |
| B02 | 50 | 101.814 | 51.814 | |
| B03 | 101.814 | 158.971 | 57.157 | |
| B04 | 158.971 | 198.67 | 39.699 | |
| B05 | 198.67 | 250 | 51.33 | |
| B06 | 250 | 300 | 50 | |
| B07 | 300 | 350 | 50 | |
| B08 | 350 | 400 | 50 | |
| B09 | 400 | 438.104 | 38.104 | |
| B10R | 438.104 | 506.071 | 67.967 | Note: Backward shift in KP |
| B11 | 505.775 | 518.674 | 12.899 | |
| B12 | 518.674 | 568.674 | 50 | |
| B13 | 568.674 | 618.674 | 50 | |
| B14 | 618.674 | 650 | 31.326 | |
| B15 | 650 | 699.86 | 49.86 | To be re-surveyed during summer 2019 |

It should be noted that the transition from Block 10R into Block 11, towards the end of the Netherlands sector, appears to coincide with a backward jump / shift in KP of about 300 meters (see highlighted cells in the table above). This needs to be queried with survey contractor.

## 10.2. Geophysical Data, Coverage and Reporting Deliverables

During the 2018 geophysical campaign, the survey sensors deployed from various vessels comprised the standard hydrographic / geophysical suite:

- Multi-Beam Echosounder (MBES) - Bathymetry;
- Side Scan Sonar (SSS) – Surficial Geology and Seabed Features;
- Sub-Bottom Profiler (SBP) - Chirp and Sparker reflection techniques – Shallow Geology;
- Magnetometer (anomalies);
- Sound Velocity Profiler (SVP).

Data Coverage – full route length coverage, survey corridor width more than 500m (250m either side of centreline). Fifteen (15) geophysical reports were produced, one for each survey block [ /1/].
It should be noted that all but one of these fifteen reports still have "preliminary" status.

One hundred and fifty-three (153) survey alignment charts have been produced covering the entire 700km-long route. The charts have "Rev A (for Use)" status, implying these are final approved versions.

Gravity Core (GC) preliminary field logs were supplied via separate pdf files.

Primo recommend that survey contractor MMT should be approached with request to provide following information:

- Final approved version of all fifteen (15) survey reports;
- Final approved version of survey alignment charts, or confirmation that Rev A versions are indeed "final";

It is our understanding that the route in nearshore Block 15, in the Germany sector, will be re-surveyed (geophysics) during the 2019 summer season.

### 10.3. Geotechnical Data, Coverage and Reporting Deliverables

The 2018 geotechnical campaign covered Blocks 01 through Block 14, with the nearshore Block 15 geotechnical acquisition prematurely abandoned presumably due to geotechnical survey permitting delays ("national park").

Primo understands that this outstanding geotechnical data acquisition work is also scheduled to take place during the 2019 summer season. The commencement of survey works may well be timed either just before, or immediately or shorty after completion of the geophysical re-survey in this Block 15.

The geotechnical report has "Rev A (for Use)" status, implying "final" approved status. Just as with the alignment charts, it would be prudent to seek confirmation that this version is indeed "final". The report does cover all CPT in-situ test logs (CPT), vibrocore (VC) logs, and laboratory test information.

Primo has requested that the electronic CPT and lab test data files be made available. This information has not been received at the time of carrying out this BAS Lite study. It is however recommended that this information be made available as it would form critical input data for a BAS Proper study in due course.

As mentioned before, GC samples were obtained as part of the geophysical campaign and therefore not included in this geotechnical report.

### 10.4. Survey GIS Database, Coverage

The electronic survey data base contains the following information relevant to this BAS Lite study:

- Geophysical data as presented on alignment sheets:
    - Bathymetry with contours;
    - Surficial Geology, Seabed Features and Bedforms;
    - Shallow Geology – Isopachs;
    - Shallow Geology – Longitudinal profiles.
- CPT locations as presented on alignment sheets;
- VC locations as presented on alignment sheets;
- Missing: GC Geotechnical locations.

Following comments apply to the GIS database:

- The database file name contains "draft", clearly indicating its "non-final" status.

  It is recommended that the final database file version be requested from the survey contractor MMT and made available to Primo.

- In terms of completeness, it would appear that the only information missing from the database is the Shallow Geology (isopachs) layer for the nearshore Block 01.

- The Seabed Features layer, and its sublayers (Ripples, Mega Ripples, Sand Waves, Occasional Boulders, Numerous Boulders) need checking by survey contractor MMT as discrepancies have come to light carrying out spot checks comparing information in the database with information on the alignment sheets.

## 11. CBRA

PRIMO have carried out a detailed review of the CBRA for NeuConnect [/7/] and compiled a comment response sheet which will be provided to the Client separately.

### 11.1. Hazards

From a CBRA (cable threat) perspective, all pertinent geo- and man-made hazards have been considered – see Table 11-1 below, with the main contributors being mobile sediments, shipping and anchoring.

From a BAS perspective however, hard ground and boulder fields need also be considered. Section 12 of this report provides a consolidated summary of hazards pertinent for BAS Lite, or BAS in general.

**Table 11-1: NeuConnect Route – Pertinent Hazards**

| Hazard Type | Description | Comments | |
|---|---|---|---|
| Geohazards | Seabed Mobility | Ripples | ($w_L$ < 15m, $w_H$ < 1m) |
| | | Mega Ripples | (15m < $w_L$ < 50m, 1m < $w_H$ < 3m) |
| | Steep Slopes | Sand Waves | (50m < $w_L$ < 200m, $w_H$ > 3m) |
| Man-Made Hazards | Shipping | Anchor strikes | |
| | Fishing / Trawling | Snagging | |

Note –a future BAS Proper will have to address seabed slopes in relation to length of burial tool.

It should be noted that for fishing and for anchor penetration assessments, the lower bound geotechnical material strength properties are governing (conservative), and the CBRA report consistently and correctly states that these have been indeed considered.

The CBRA report further states that:

- With mobile bedforms, it is wave height that is critical and governing, as opposed to wavelength;
- Ripples are minor mobile bedforms, not considered to adversely affect burial operations or as-installed cable integrity;
- Mega ripples, due to their larger size, are mobile bedforms that would likely affect the integrity of buried cable assets (either through exposure or over-burial) during their design lifetime if not buried deep enough;
- Sand waves do not get a specific mention implying that despite their considerable size (height) these are not considered to be mobile sediments per se.
- Based on the RMDOL & TDOL profiles, all Target Trench Depths (TTD) profiles shall be engineered with reference to trough depths and following consideration of pre-sweeping by flattening areas with mobile sediment peaks.

PRIMO principally agree with the above, although sand waves are not necessarily always immobile. This depends on location-specific environmental conditions. It is recommended that a morpho-dynamics study be carried out to establish these critical aspects at an early stage, at least at a high level.

## 11.2. Sector: United Kingdom

The CBRA document summarises the occurrence of various bedforms as follows:

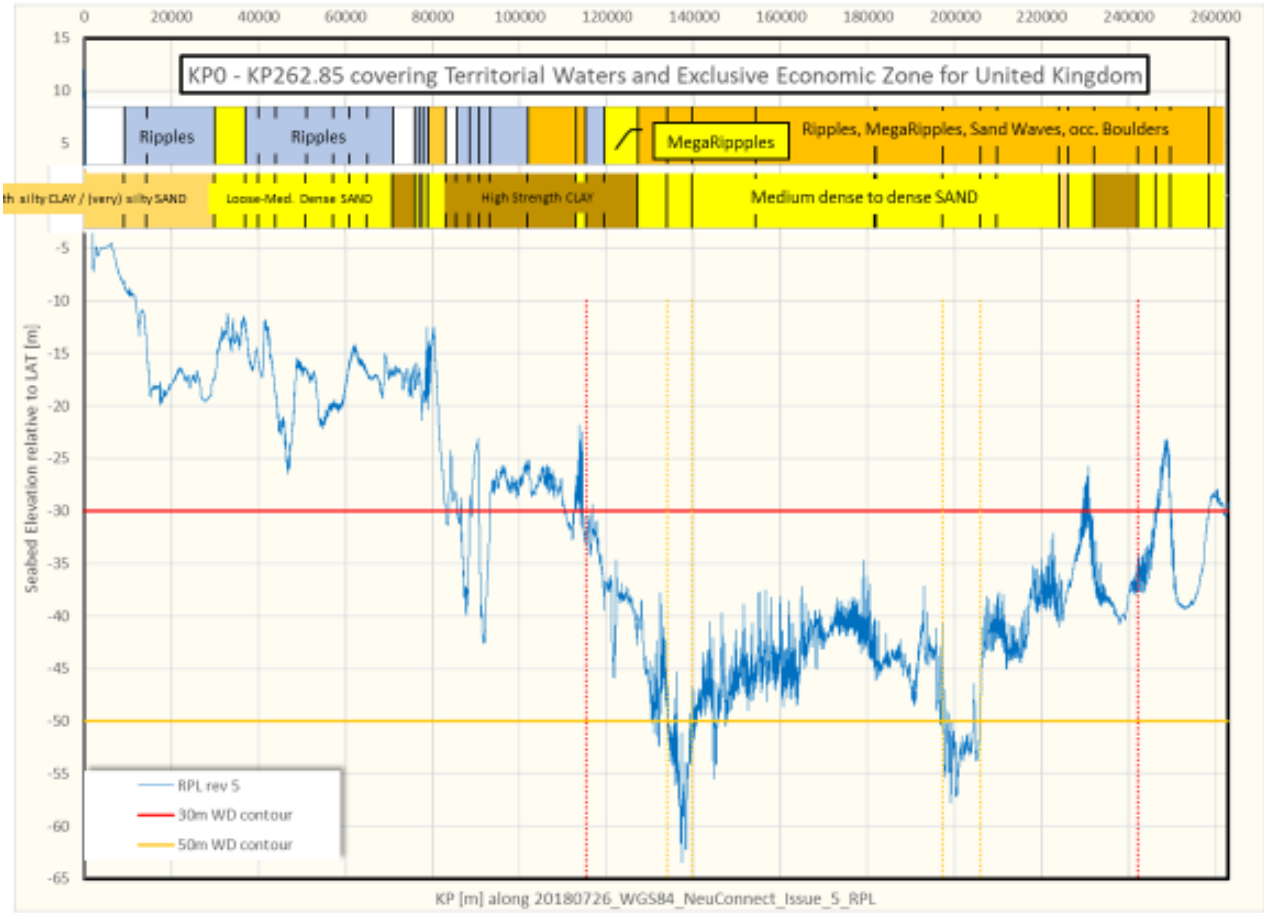
- Ripples between KP011 and KP304 (intermittently);
- Mega Ripples between KP108 and KP190 (intermittently);
- Sand Waves between KP078 and KP080 (intermittently);
  between KP106 and KP253 (intermittently);

PRIMO have summarised the CBRA results for this sector, as illustrated in the set of Figures below, showing:

- the water depth profile as function of KP, with the chosen water depth segmentations, segmentation of bedforms, and segmentation of shallow geology;
- The (geophysical) survey block segmentation by MMT, the geotechnical section segmentation by MMT, and segmentation of bedforms and shallow geology by Intertek (CBRA table);
- The RMDOL, TDOL, TTD profiles as function of KP, with segmentation of bedforms and shallow geology types.

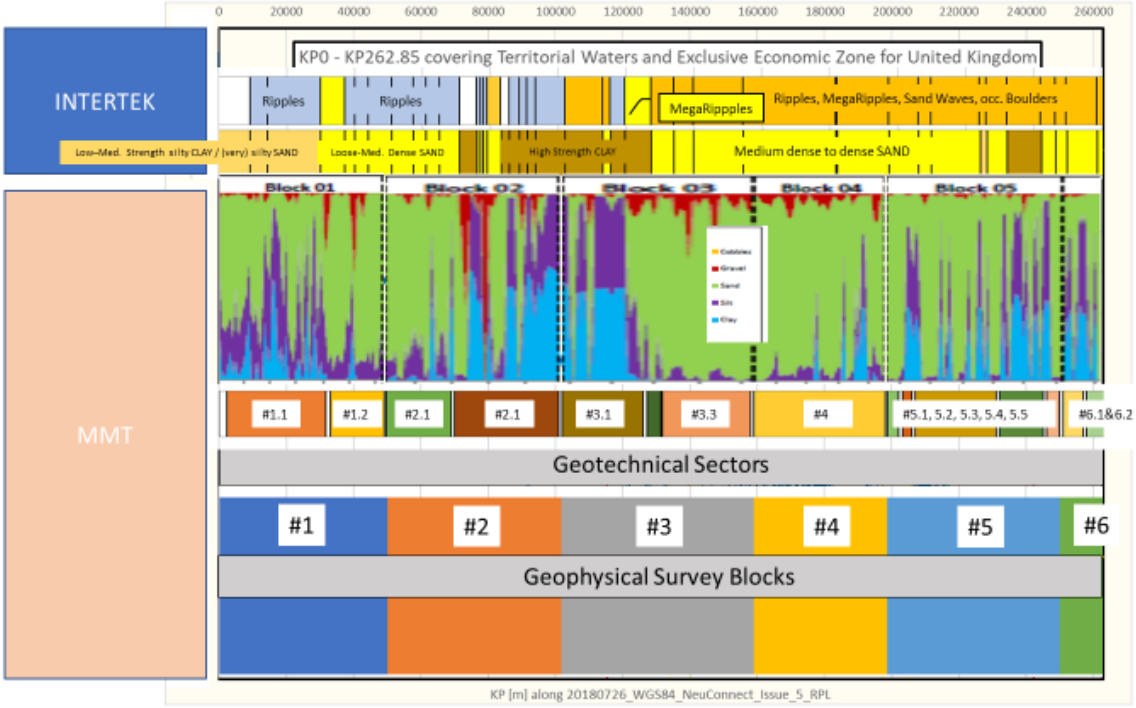
Enlarged versions of these figures are enclosed in Appendix B1 of this report.

**Figure 11-1: CBRA summary for UK Sector (plot 1 of 3)**



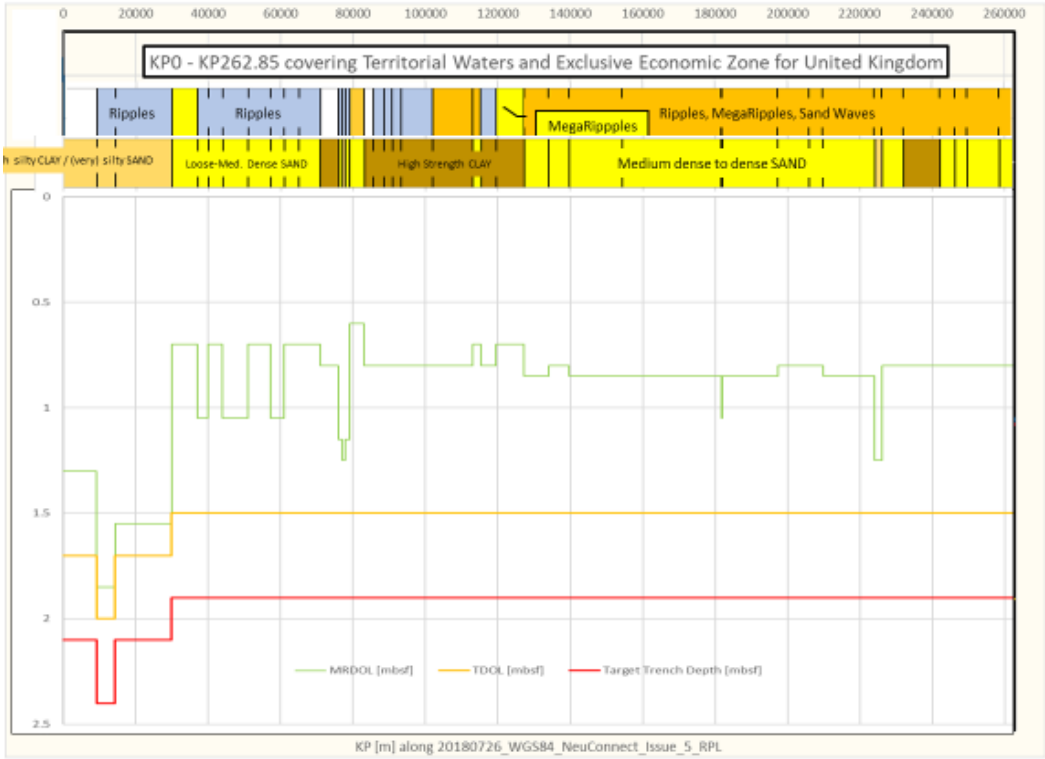

Comment: The chosen LAT 30m water depth segmentation at approximately KP 240+ to be re-considered.

**Figure 11-2: CBRA summary for UK Sector (plot 2 of 3)**




Comment: Moderate to Good correlation between geotechnical segmentation by MMT and sediment type segmentation by Intertek.

**Figure 11-3: CBRA summary for UK Sector (plot 3 of 3)**




Comment: Rationale behind TDOL (orange line) considering RMDOL (green) to be discussed / agreed.

### 11.3. Sector: The Netherlands

The CBRA document summarises the occurrence of various bedforms as follows:

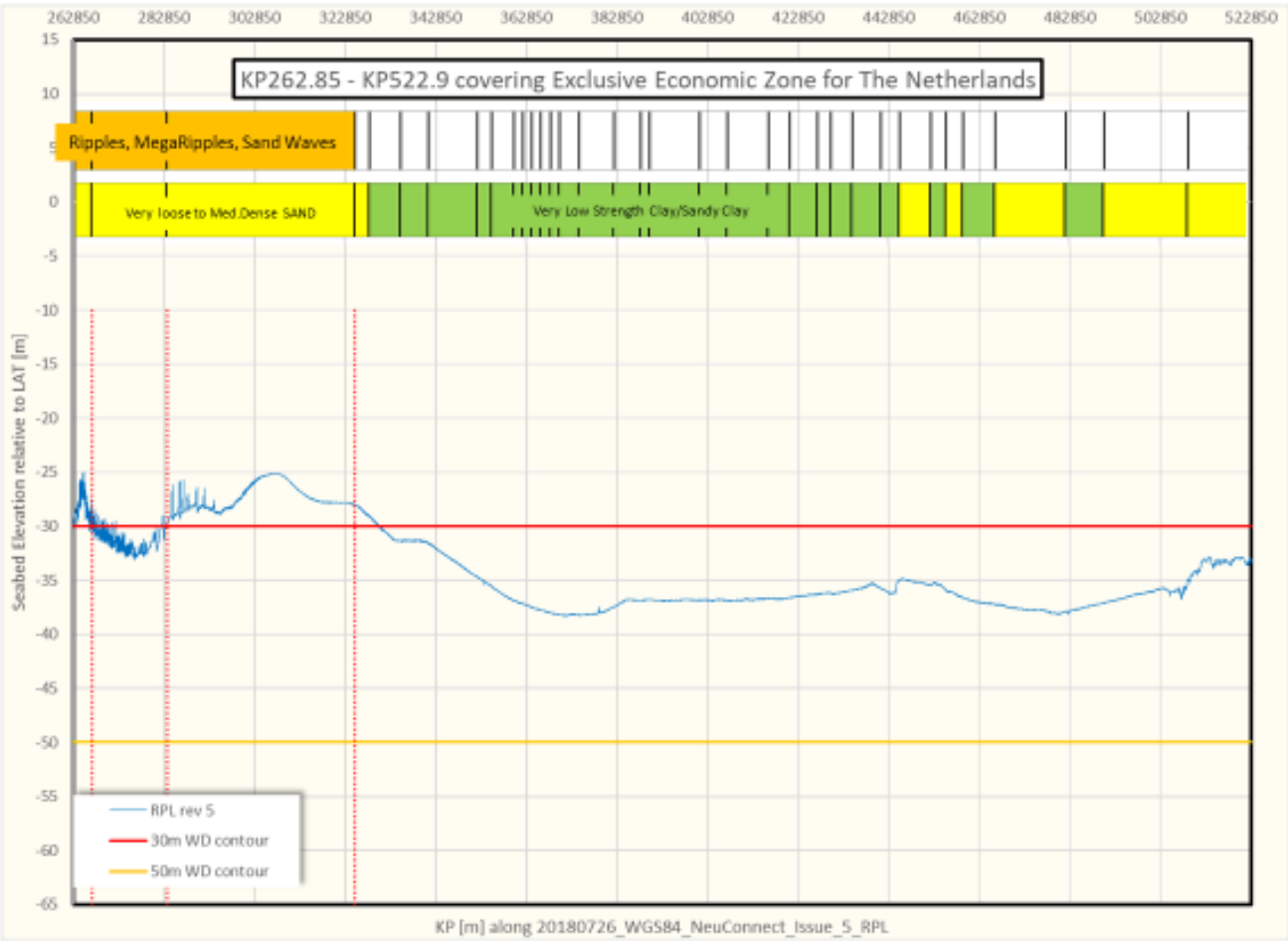
- Sand Waves between KP253 and KP294 (intermittently);

PRIMO have summarised the CBRA results for this sector, as illustrated in the set of Figures below, showing:

- the water depth profile as function of KP, with the chosen water depth segmentations, segmentation of bedforms, and segmentation of shallow geology;
- The (geophysical) survey block segmentation by MMT, the geotechnical section segmentation by MMT, and segmentation of bedforms and shallow geology by Intertek (CBRA table);
- The RMDOL, TDOL, TTD profiles as function of KP, with segmentation of bedforms and shallow geology types.

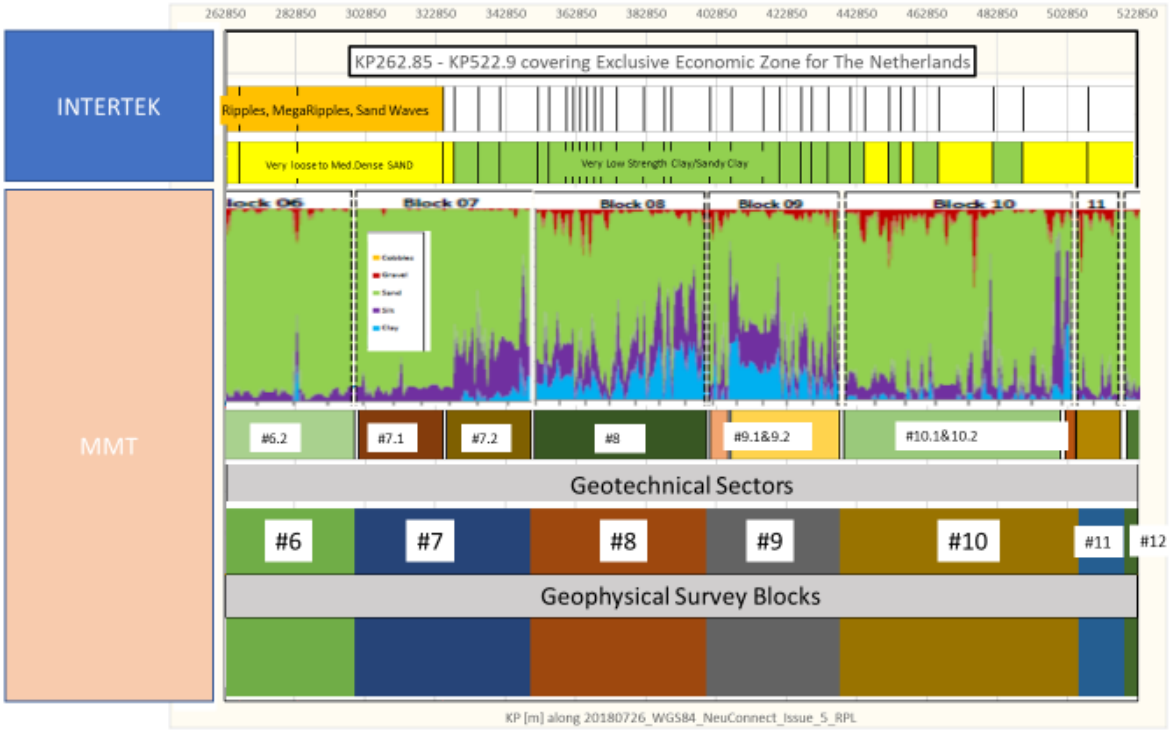
Enlarged versions of these figures are enclosed in Appendix B1 of this report.

**Figure 11-4: CBRA summary for Netherlands Sector (plot 1 of 3)**



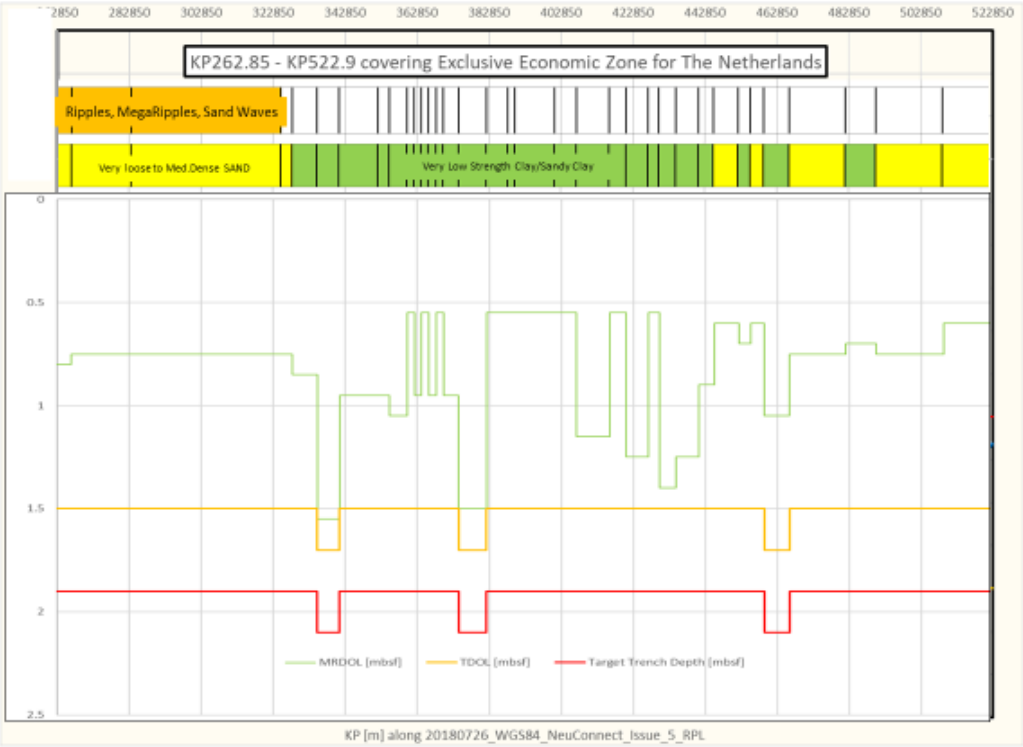

Comment: The chosen LAT 30m water depth segmentation at approximately KP 322.9 to be re-considered.

**Figure 11-5: CBRA summary for Netherlands Sector (plot 2 of 3)**




Comment: Moderate to Good correlation between geotechnical segmentation by MMT and sediment type segmentation by Intertek.

**Figure 11-6: CBRA summary for Netherlands Sector (plot 3 of 3)**




Comment: Rationale behind TDOL (orange line) considering RMDOL (green) to be discussed / agreed.

### 11.4. Sector: Germany

The CBRA document summarises the occurrence of various bedforms as follows:

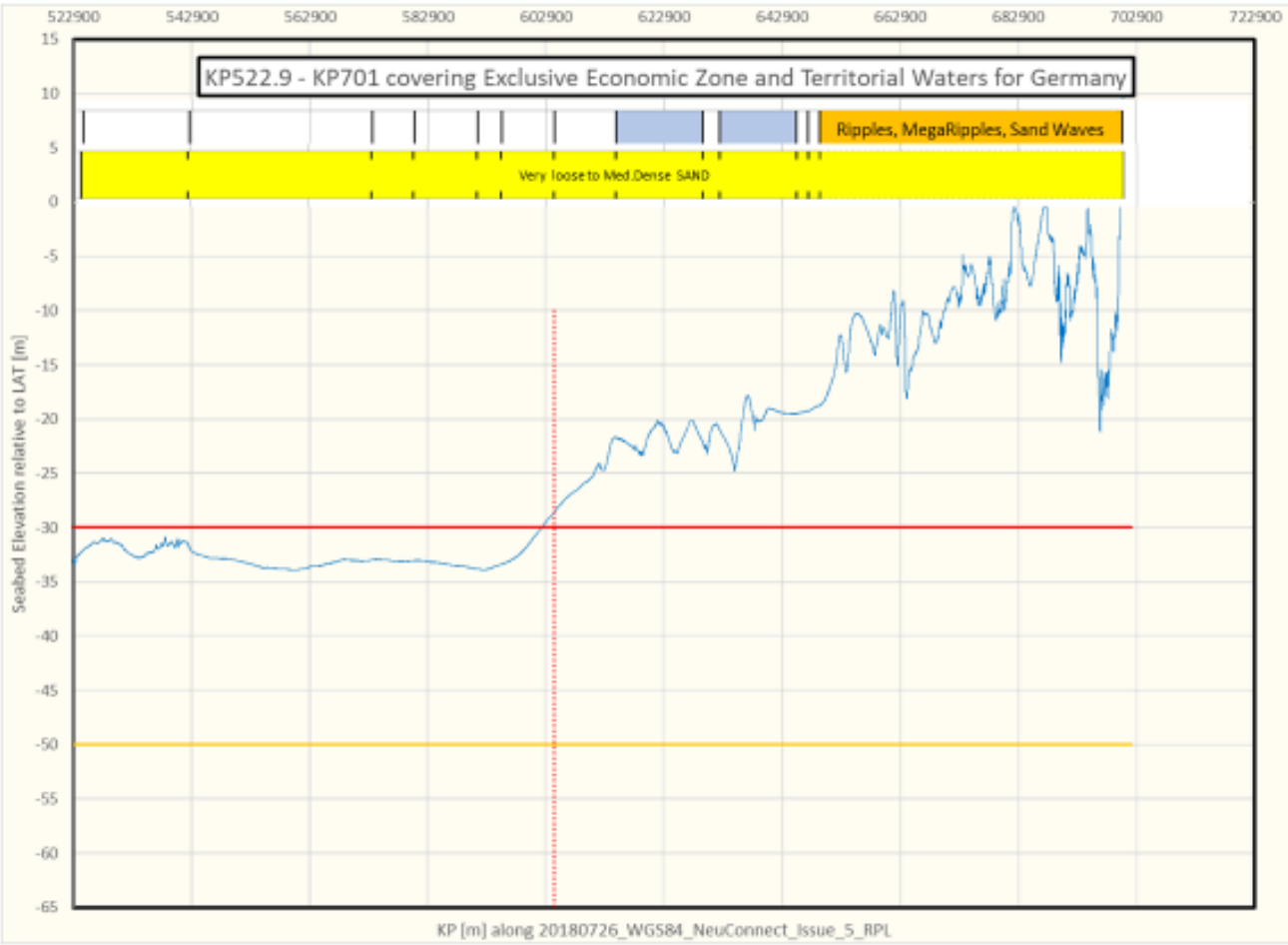
- Ripples between KP620 and KP700 (intermittently);
- Mega Ripples between KP669 and KP700 (intermittently);
- Sand Waves between KP673 and KP700 (intermittently);

PRIMO have summarised the CBRA results for this sector, as illustrated in the set of Figures below, showing:

- the water depth profile as function of KP, with the chosen water depth segmentations, segmentation of bedforms, and segmentation of shallow geology;
- The (geophysical) survey block segmentation by MMT, the geotechnical section segmentation by MMT, and segmentation of bedforms and shallow geology by Intertek (CBRA table);
- The RMDOL, TDOL, TTD profiles as function of KP, with segmentation of bedforms and shallow geology types.

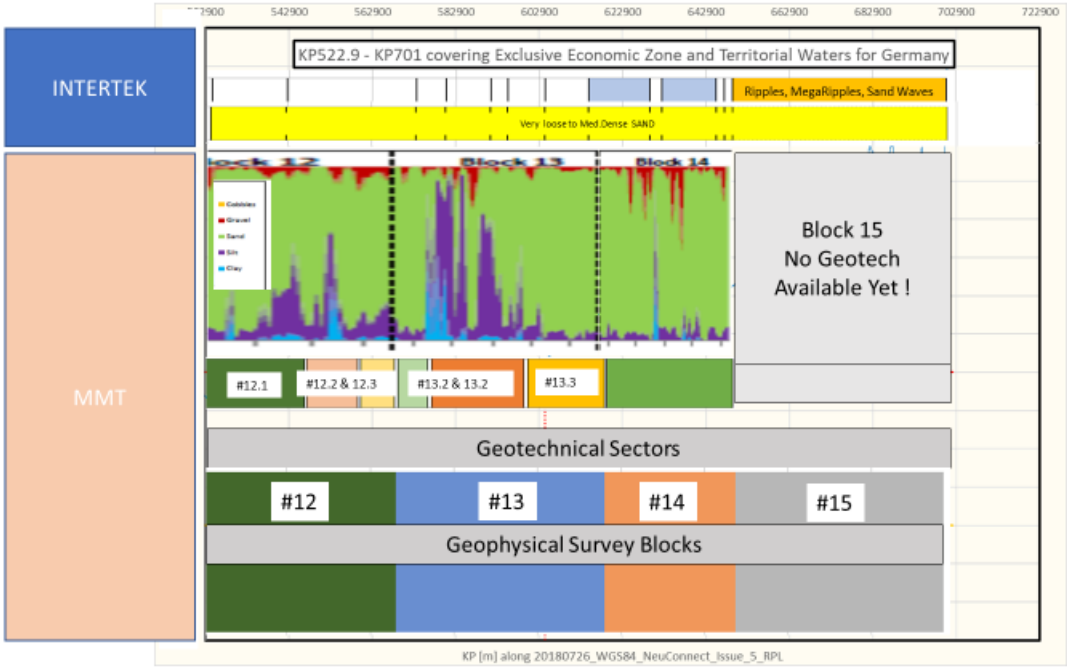
Enlarged versions of these figures are enclosed in Appendix B1 of this report.

**Figure 11-7: CBRA summary for Germany Sector (plot 1 of 3)**



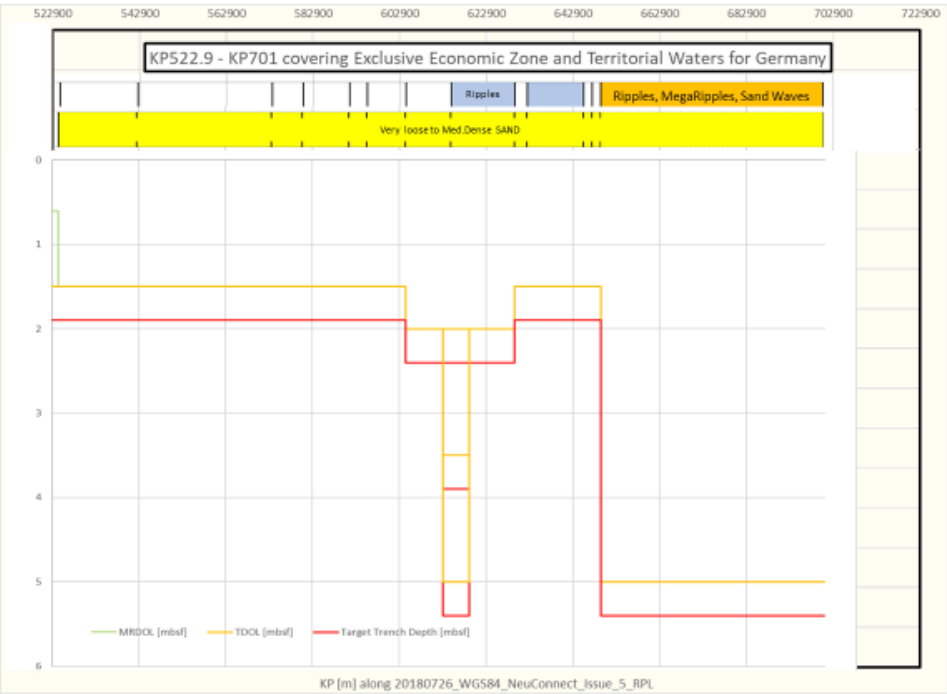

Comment: The chosen LAT 30m water depth segmentation at approximately KP 603 to be re-considered.

**Figure 11-8: CBRA summary for Germany Sector (plot 2 of 3)**




Comment: Moderate correlation between geotechnical segmentation by MMT and sediment type segmentation by Intertek.

**Figure 11-9: CBRA summary for Germany Sector (plot 3 of 3)**




Note: Increased Burial between KP613 and KP619 shown here for crossing of Traffic Separation Scheme.
Comment: Rationale behind TDOL (orange line) considering RMDOL (green) to be discussed / agreed.

## 12. TWO-STEP ROUTE SEGMENTATION – UK SECTOR

The focus of this BAS Lite has been on establishing accurate route segmentation by uncoupling the bedform segmentation from the shallow geology (geophysical/geotechnical) segmentation. This allows for a two-step cable system installation (seabed intervention) strategy to be designed and proposed, i.e. one for seabed preparation (pre-sweeping), and one for cable burial.

### 12.1. Hazards

The hazards pertinent to BAS are summarised in Table 12-1 below. The zone of interest is defined as the Target Trench Depth (TTD), in this case, the first 2-2.5m below seabed.

**Table 12-1: NeuConnect Route – Pertinent Hazards to be considered for BAS (Lite)**

| Hazard Type | Description | Comments |
|---|---|---|
| Geohazards | Seabed Mobility | Ripples ($w_L$ < 15m, $w_H$ < 1m) |
| | | Mega Ripples (15m < $w_L$ < 50m, 1m < $w_H$ < 3m) |
| | Steep Slopes | Sand Waves (50m < $w_L$ < 200m, $w_H$ > 3m) |
| | Hard Ground | (Very) High Strength CLAYS (75 kPa up to 200kPa) and ROCK – outcropping (affect full TTD) |
| | | High Strength CLAYS/ROCK– sub cropping (affect partial TTD) |
| | Peat / Chalk | Occasional occurrences but not within depth of interest. |
| | Boulder Fields | "Occasional Boulders" (5 < boulders < 20 per 100sqm)<br>Several relatively small areas identified in UK Sector |
| | | "Numerous Boulders" ( > 20 boulders per 100 sqm)<br>None identified in UK Sector |
| | Geological Folding and Faulting | None would appear to be present within zone of interest, but this requires a more in-depth study. |
| | Palaeo Channels | Sudden change in lithology – typically, infill materials are softer, less compact. Occurrences have been reported in Block 1 only (KP2.2, KP18.7, KP22-KP30.5, KP40.2, KP47). |
| | Shallow Gas | Not present within zone of interest but this may require a more in-depth study in future. |
| | Seismicity | North Sea lies within area of low seismic hazard risk |
| Man-Made Hazards | Crossings | A combined total of 89 known Cable / PL crossings for the entire 700km long route.<br><br>UK Sector: total 31x crossings, 12x active, 18x OOS, 1x planned. |
| | Dredging | Shipping channels in shallow areas with mobile sediments have their depth maintained via dredging. |
| | Other | Trawl Marks (considered insignificant hazards) |

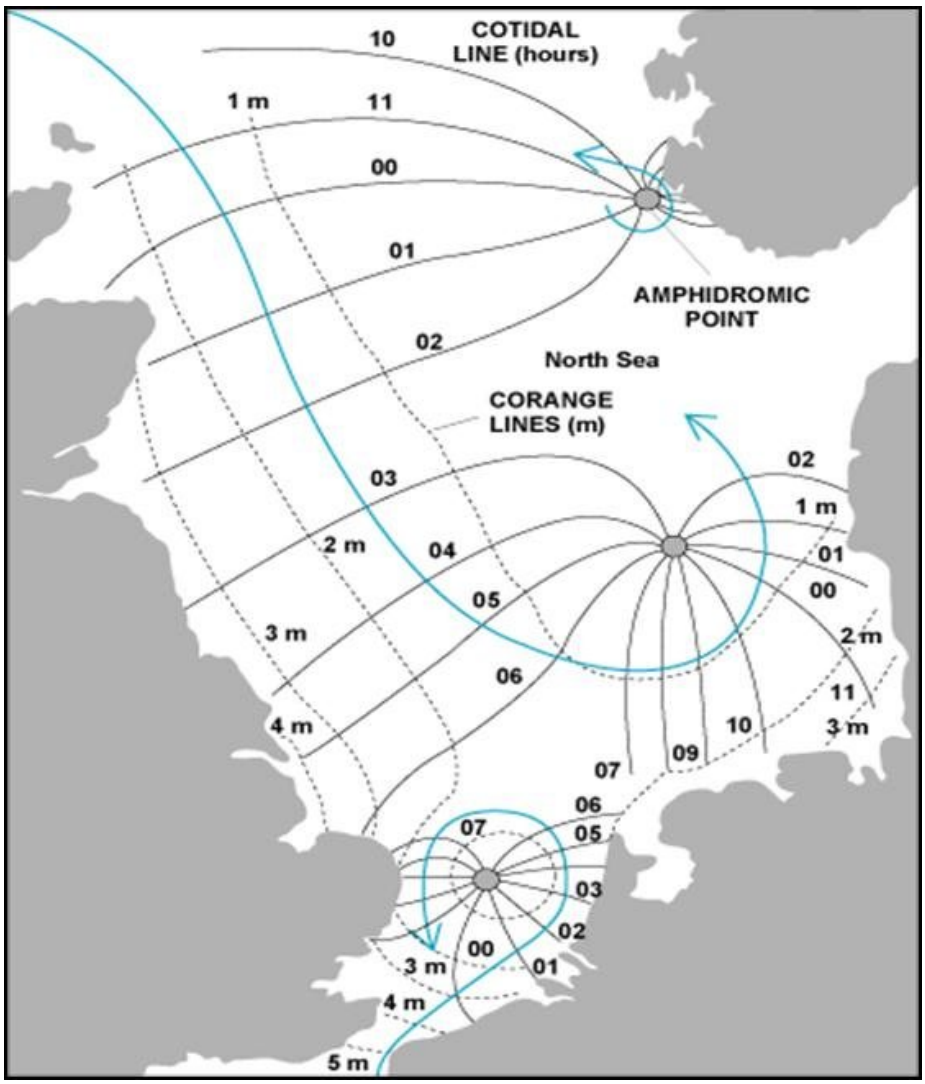
## 12.2. STEP1 – Bedform Segmentation

With regards to the seabed preparation (pre-sweeping) strategy, and to be able to identify zones with similar bedforms (ripples, mega ripples, sand waves), and areas with boulder fields for example, a detailed comparison of the information on alignment charts, the electronic GIS database information, and the longitudinal seabed slope profiles was carried out. This has resulted in a refined segmentation of various bedform and seabed features.

Mega ripples are driven by surface waves and their migration depends on location-specific wave conditions. Mega-ripples would be of exactly the right size range and mobility speed to cause problems with long term cable integrity (either through exposure or over-burial). Pre-sweeping of mega ripples may not be effective however seeing these can quickly re-form.

Sand waves can be mobile, depending again on location specific environmental conditions. Sand waves located near to any of the North Sea amphidromical points are however known to be considerably less mobile.

**Figure 12-1: North Sea Amphidromic Points**



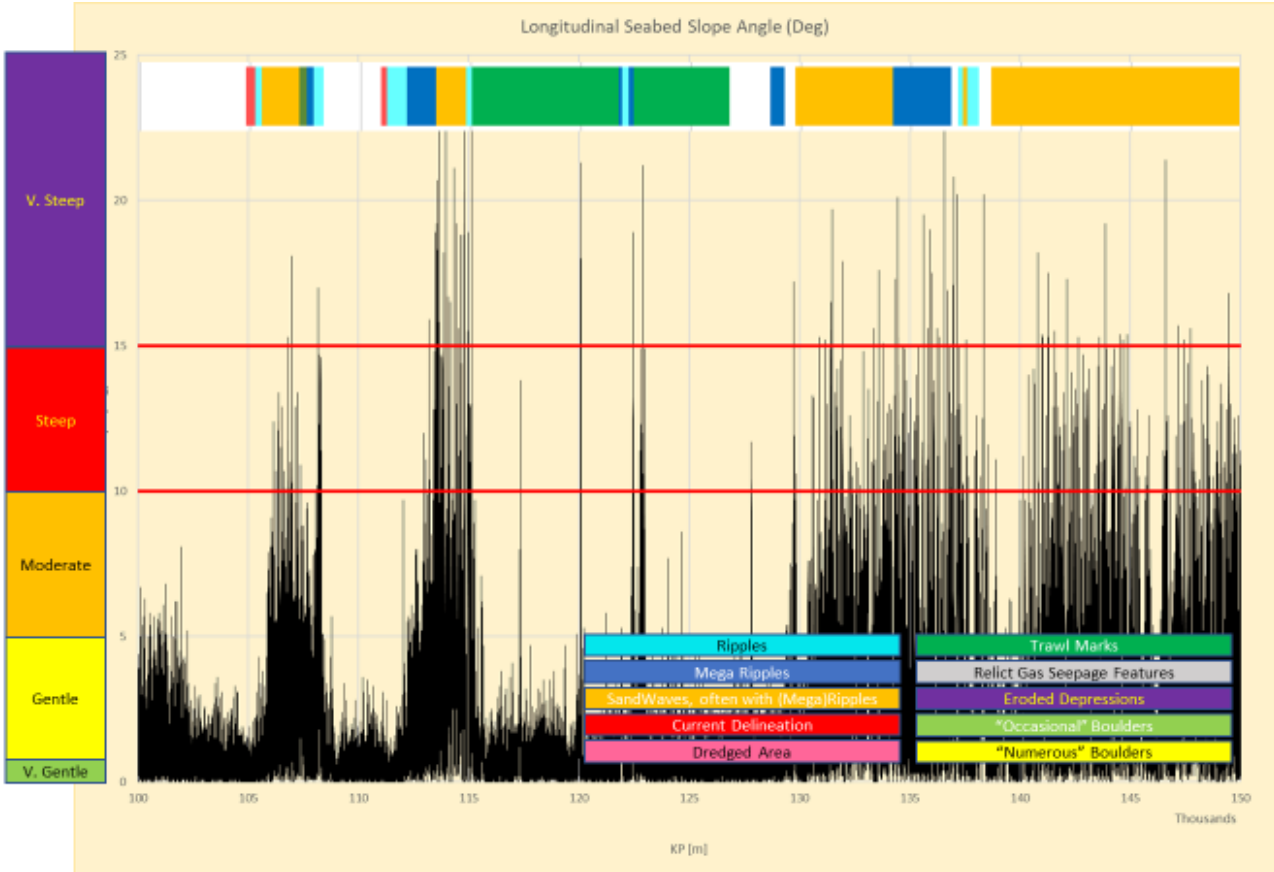
It should be noted that only mobile seabed features with a wave height, similar in magnitude to the target trench depth (TTD), should be of interest to pre-sweeping (mega ripples, sand waves) and only those that are (confirmed) mobile.

Seabed features that are not significantly mobile over the lifetime of the cables, and those which are relatively small compared to the TTD, are considered of less to no interest.

Therefore, the mobility of the bedform such as sand waves and the larger mega ripples should be studied as a matter of priority (see recommendations) to inform the seabed preparation (pre-sweeping) strategy and scope.

The Figure 12-2 below graphically illustrates the bedform segmentation between KP100- KP150, for example, showing areas with intermittent sand waves/mega ripples/ripples, areas with only intermittent ripples, and areas categorised as "occasional boulder fields".

**Figure 12-2: UK Sector (KP100-KP150) - Bedform Segmentation**




Enlarged versions of these figures, covering KP0-KP262.85, are enclosed in Appendix C1 of this report.

Table 12-2 below provides the detailed factual summary of "segmentation by bedform" for the UK sector.

**Table 12-2: UK Sector – Bedform Segmentation**

| ID | KP FROM [km] | KP TO [km] | Length [m] | Bedform / Feature Type |
|---|---|---|---|---|
| 1 | 0.000 | 7.474 | 7474 | None |
| 2 | 7.474 | 8.527 | 1053 | Trawl Mark (insignificant) |
| 3 | 8.527 | 10.552 | 2025 | Dredged Area |
| 4 | 10.552 | 11.087 | 536 | Trawl Mark (insignificant) |
| 5 | 11.087 | 12.150 | 1063 | None |
| 6 | 12.150 | 12.765 | 615 | Ripples |
| 7 | 12.765 | 16.319 | 3554 | None |
| 8 | 16.319 | 25.342 | 9022 | Ripples |
| 9 | 25.342 | 33.275 | 7934 | None |
| 10 | 33.275 | 68.829 | 35554 | Ripples |
| 11 | 68.829 | 68.990 | 161 | None |
| 12 | 68.990 | 75.097 | 6107 | Marine Growth |
| 13 | 75.097 | 78.235 | 3138 | None |
| 14 | 78.235 | 78.419 | 184 | Ripples |
| 15 | 78.419 | 80.273 | 1854 | Sand Waves |
| 16 | 80.273 | 81.153 | 880 | Ripples |
| 17 | 81.153 | 83.912 | 2759 | None |
| 18 | 83.912 | 88.757 | 4845 | Trawl Mark (insignificant) |
| 19 | 88.757 | 94.863 | 6105 | Ripples |
| 20 | 94.863 | 104.797 | 9935 | None |
| 21 | 104.797 | 105.207 | 410 | Current Lineation |
| 22 | 105.207 | 105.504 | 297 | Ripples |
| 23 | 105.504 | 107.234 | 1730 | Sand Waves |
| 24 | 107.234 | 107.549 | 314 | Ripples |
| 25 | 107.549 | 107.860 | 311 | Mega Ripples |
| 26 | 107.860 | 108.298 | 438 | Ripples |
| 27 | 108.298 | 110.924 | 2626 | None |
| 28 | 110.924 | 111.180 | 256 | Current Lineation |
| 29 | 111.180 | 112.087 | 907 | Ripples |
| 30 | 112.087 | 113.436 | 1349 | Mega Ripples |
| 31 | 113.436 | 114.784 | 1347 | Sand Waves |
| 32 | 114.784 | 115.039 | 255 | Ripples |
| 33 | 115.039 | 121.735 | 6696 | Trawl Mark (insignificant) |
| 34 | 121.735 | 121.863 | 128 | Mega Ripples |
| 35 | 121.863 | 122.189 | 326 | Ripples |
| 36 | 122.189 | 122.383 | 195 | Mega Ripples |
| 37 | 122.383 | 126.741 | 4358 | Trawl Mark (insignificant) |
| 38 | 126.741 | 128.607 | 1866 | None |
| 39 | 128.607 | 129.257 | 650 | Mega Ripples |
| 40 | 129.257 | 129.728 | 471 | None |

| ID | KP FROM [km] | KP TO [km] | Length [m] | Bedform / Feature Type |
|---|---|---|---|---|
| 41 | 129.728 | 134.188 | 4460 | Sand Waves |
| 42 | 134.188 | 136.839 | 2651 | Mega Ripples |
| 43 | 136.839 | 137.119 | 280 | None |
| 44 | 137.119 | 137.361 | 242 | Ripples |
| 45 | 137.361 | 137.553 | 191 | Sand Waves |
| 46 | 137.553 | 138.074 | 522 | Ripples |
| 47 | 138.074 | 138.635 | 560 | None |
| 48 | 138.635 | 168.186 | 29551 | Sand Waves, Mega Ripples |
| 49 | 168.186 | 168.945 | 760 | Ripples |
| 50 | 168.945 | 169.875 | 929 | Sand Waves |
| 51 | 169.875 | 170.006 | 131 | None |
| 52 | 170.006 | 171.570 | 1564 | "Occasional" Boulders |
| 53 | 171.570 | 172.594 | 1024 | Ripples |
| 54 | 172.594 | 178.868 | 6274 | Mega Ripples |
| 55 | 178.868 | 182.462 | 3594 | Sand Waves |
| 56 | 182.462 | 184.310 | 1848 | Ripples |
| 57 | 184.310 | 184.428 | 118 | Sand Waves |
| 58 | 184.428 | 187.361 | 2933 | Ripples |
| 59 | 187.361 | 187.411 | 51 | "Occasional" Boulders |
| 60 | 187.411 | 188.608 | 1197 | Ripples |
| 61 | 188.608 | 188.689 | 81 | "Occasional" Boulders |
| 62 | 188.689 | 188.986 | 297 | Ripples |
| 63 | 188.986 | 189.154 | 168 | "Occasional" Boulders |
| 64 | 189.154 | 192.005 | 2851 | Ripples |
| 65 | 192.005 | 192.940 | 934 | "Occasional" Boulders |
| 66 | 192.940 | 216.593 | 23653 | Sand Waves, Ripples |
| 67 | 216.593 | 216.852 | 259 | "Occasional" Boulders |
| 68 | 216.852 | 224.065 | 7213 | Sand Waves, Ripples |
| 69 | 224.065 | 224.655 | 590 | "Occasional" Boulders |
| 70 | 224.655 | 224.728 | 73 | Sand Waves |
| 71 | 224.728 | 224.772 | 44 | "Occasional" Boulders |
| 72 | 224.772 | 227.937 | 3165 | None |
| 73 | 227.937 | 238.299 | 10362 | Sand Waves, Ripples |
| 74 | 238.299 | 240.315 | 2016 | Marine Growth |
| 75 | 240.315 | 253.840 | 13525 | Ripples |
| 76 | 253.840 | 254.634 | 794 | None |
| 77 | 254.634 | 255.120 | 486 | Ripples |
| 78 | 255.120 | 256.030 | 910 | None |
| 79 | 256.030 | 262.850 | 6820 | Ripples |

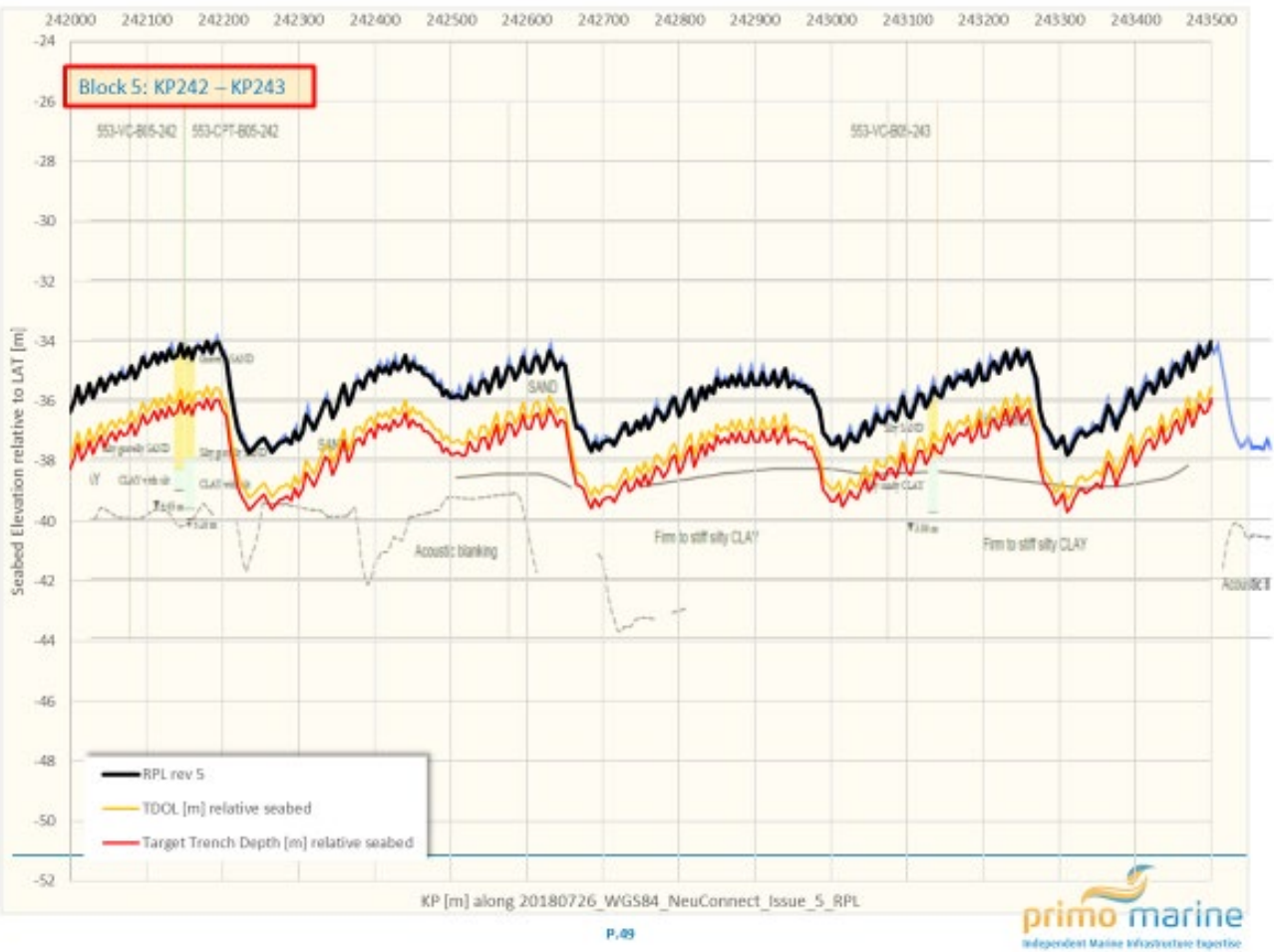
## 12.3. STEP 2 - Shallow Geology Segmentation

With regards to cable burial strategy, a segmentation based on shallow geology was carried out. And with regards to material strength properties, the upper bound strength properties (conservative) are considered.

To be able visually and with some appropriate level of accuracy perform the segmentation, the route alignment charts were split into 1-1.5km sections and the set of burial requirement profiles in terms of TDOL, TTD manually superimposed onto each of these sections.

An example is shown in Figure 12-3 below, a sand wave area, where the waves (peaks) consist of sand, but the troughs intersect a firm to stiff CLAY layer.

**Figure 12-3: UK Sector (KP242-KP243) – Shallow Geology Segmentation**




The Table 12-3 below provides a detailed summary of the segmentation of the UK Sector route based on Shallow Geology, with the depth of interest being the Target Trench Depth (TTD) profile (see red line in Figure 12-3, the orange line represents the TDOL profile).

The TTD profile has been established by adding 0.4m to the Target Depth of Lowering (TDOL) profile, outputted from the CBRA. The addition of 0.4m accounts for the assumed bundled cable diameter of 0.2m and an additional safety margin of 0.2m.

A distinction has been made for the various CLAY consistency ranges (low strength, medium strength, high and very high strength). For granular materials however, the state of compaction has been conservatively assumed to be dense to very dense. A future full, proper BAS would have to include a comprehensive analysis of all available geotechnical in-situ and laboratory test data to be able to distinguish with more accuracy the consistency and compaction ranges for the shallow geology segmentations outlined below.

**Table 12-3: UK Sector – Shallow Geology Segmentation**

| ID | KP FROM [km] | KP TO [km] | SHALLOW GEOLOGY within TARGET TRENCH DEPTH zone |
|---|---|---|---|
| 1 | 0.0 | 9.2 | MIXED MATERIALS - SANDS, SILTS, CLAYS …. Typically:<br>Layer of very low to medium strength silty CLAY of varying thickness<br>….overlying …<br>silty to very silty, occasionally gravelly, SAND (laminated with CLAY) |
| 2 | 9.2 | 14.3 | |
| 3 | 14.3 | 30.4 | |
| 4 | 30.4 | 31.8 | High Strength CLAY |
| 5 | 31.8 | 37.1 | slightly gravelly to gravelly, silty to very silty SAND |
| 6 | 37.1 | 51.0 | Gravelly to silty SAND |
| 7 | 51.0 | 57.2 | slightly gravelly to gravelly, silty to very silty SAND<br>Between KP56.2 - 57.2 - CLAY layer sub cropping to just within target trench depth |
| 8 | 57.2 | 61.0 | slightly gravelly to gravelly, silty to very silty SAND |
| 9 | 61.0 | 65.0 | slightly gravelly to gravelly, silty to very silty SAND<br>Between KP62.8 - 63.4 - CLAY layer sub cropping to just within target trench depth |
| 10 | 65.0 | 68.3 | slightly gravelly to gravelly, silty to very silty SAND |
| 11 | 68.3 | 68.9 | Medium to High Strength CLAY |
| 12 | 68.9 | 70.0 | slightly gravelly to gravelly, silty to very silty SAND |
| 13 | 70.0 | 75.8 | Veneer of SAND / GRAVEL overlying Medium to High to Very High Strength CLAY |
| 14 | 75.8 | 78.4 | gravelly SAND to gravelly CLAY<br>Between KP 77.85 - 78.15, stiff CLAY sub cropping to just within TTD |
| 15 | 78.4 | 80.0 | Gravelly SAND |
| 16 | 80.0 | 81.8 | Gravelly SAND and sandy GRAVEL |
| 17 | 81.8 | 82.5 | Low to High Strength CLAY |
| 18 | 82.5 | 94.0 | Veneer of clayey GRAVEL overlying High to Very High Strength CLAY |
| 19 | 94.0 | 95.2 | Veneer of clayey GRAVEL overlying Medium to High Strength CLAY |
| 20 | 95.2 | 99.0 | Veneer of clayey GRAVEL overlying High Strength CLAY |
| 21 | 99.0 | 101.8 | Veneer of clayey GRAVEL overlying Medium to High Strength CLAY |
| 22 | 101.8 | 103.6 | Veneer of clayey GRAVEL overlying High to Very High Strength CLAY |
| 23 | 103.6 | 105.6 | Veneer of clayey GRAVEL overlying High Strength CLAY |
| 24 | 105.6 | 107.8 | Veneer of GRAVEL / SAND overlying Medium to High Strength CLAY |
| 25 | 107.8 | 112.4 | Veneer of GRAVEL / SAND overlying High Strength CLAY |
| 26 | 112.4 | 114.7 | Layer of GRAVEL / SAND overlying Medium to High Strength CLAY |
| 27 | 114.7 | 121.7 | Layer of GRAVEL / SAND overlying Medium to High Strength CLAY |
| 28 | 121.7 | 122.4 | Veneer of clayey, gravelly SAND overlying High to Very High Strength CLAY |
| 29 | 122.4 | 127.1 | Veneer of gravelly CLAY overlying High to Very High Strength CLAY |
| 30 | 127.1 | 128.6 | Silty to gravelly calcareous SAND (band of CHALK below target trench |

| ID | KP FROM [km] | KP TO [km] | SHALLOW GEOLOGY within TARGET TRENCH DEPTH zone |
|---|---|---|---|
| | | | depth |
| 31 | 128.6 | 129.0 | Veneer of clayey, gravelly SAND overlying High to Very High Strength CLAY |
| 32 | 129.0 | 129.7 | Silty SAND to sandy SILT (band of CHALK below target trench depth |
| 33 | 129.7 | 130.5 | Silty SAND to sandy SILT (band of CHALK below target trench depth |
| 34 | 130.5 | 159.0 | Silty to gravelly SAND, occasionally with cobbles |
| 35 | 159.0 | 176.2 | Silty to gravelly SAND, occasionally with cobbles |
| 36 | 176.2 | 190.4 | SAND and GRAVEL |
| 37 | 190.4 | 192.5 | silty gravelly SAND and low to medium strength CLAY |
| 38 | 192.5 | 194.4 | Silty to gravelly SAND |
| 39 | 194.4 | 196.2 | SAND and low strength CLAY |
| 40 | 196.2 | 203.200 | silty gravelly SAND |
| 41 | 203.2 | 205.400 | silty SAND and silty medium strength CLAY |
| 42 | 205.4 | 224.100 | Silty, gravelly SAND |
| 43 | 224.1 | 226.800 | Low to Medium Strength silty, sandy CLAY |
| 44 | 226.8 | 233.000 | Silty, gravelly SAND |
| 45 | 233.0 | 240.650 | Veneer of silty SAND underlain by medium to High Strength CLAY |
| 46 | 240.7 | 245.200 | Silty gravelly SAND (sand wave peaks); mixed SAND and high strength CLAY (sand wave troughs) |
| 47 | 245.2 | 251.000 | Silty gravelly SAND |
| 48 | 251.0 | 252.800 | Veneer of SAND / GRAVEL overlying Low to High Strength CLAY |
| 49 | 252.8 | 256.300 | Veneer of SAND / GRAVEL overlying Medium to Very High Strength CLAY |
| 50 | 256.3 | 262.850 | Silty gravelly SAND |

**Notes:**

In line with British Standards, the CLAY consistency (strength) ranges are summarised as follows:

| | | |
|---|---|---|
| CLAYS | Very Low Strength (Very soft): | undrained shear strength less than 20kPa |
| CLAYS | Low Strength (Soft): | undrained shear strength ranging 20kPa – 40kPa |
| CLAYS | Medium Strength (Firm): | undrained shear strength ranging 40kPa – 75kPa |
| CLAYS | High Strength (Stiff): | undrained shear strength ranging 75kPa – 150kPa |
| CLAYS | Very High Strength (Very stiff): | undrained shear strength ranging 150kPa – 200kPa |
| CLAYS | Extremely High Strength (Hard): | undrained shear strength ranging > 200kPa |

# 13. TWO-STEP ROUTE SEGMENTATION – NETHERLANDS SECTOR

## 13.1. Hazards

The hazards pertinent to BAS are summarised in Table 13-1 below. The zone of interest is defined as the Target Trench Depth (TTD), in this case, the first 2-2.5m below seabed.

**Table 13-1: NeuConnect Route – Pertinent Hazards to be considered for BAS (Lite)**

| Hazard Type | Description | Comments |
|---|---|---|
| Geohazards | Seabed Mobility | Ripples ($w_L$ < 15m, $w_H$ < 1m) |
| | Steep Slopes | Mega Ripples (15m < $w_L$ < 50m, 1m < $w_H$ < 3m)<br>None identified in NETHS Sector. |
| | | Sand Waves (50m < $w_L$ < 200m, $w_H$ > 3m)<br>One area identified in NETHS sector. |
| | Hard Ground | (Very) High Strength CLAYS (75 kPa up to 200kPa) and ROCK – outcropping (affect full TTD) |
| | | High Strength CLAYS/ROCK– sub cropping (affect partial TTD) |
| | Peat / Chalk | Occasional occurrences within TTD zone |
| | Boulder Fields | "Occasional Boulders" (5 < boulders < 20 per 100sqm)<br>None identified in NETHS Sector. |
| | | "Numerous Boulders" ( > 20 boulders per 100 sqm)<br>None identified in NETHS Sector. |
| | Geological Folding and Faulting | None identified in NETHS Sector. |
| | Palaeo Channels | Sudden change in lithology – typically, infill materials are softer, less compact. |
| | Shallow Gas | Relict Gas Seepage Features |
| | Seismicity | North Sea lies within area of low seismic hazard activity |
| | Other | Eroded Depressions – several areas identified. |
| Man-Made Hazards | Crossings | A combined total of 89 known Cable / PL crossings for the entire 700km long route.<br><br>NETHS Sector: total 36x crossings.<br>13x active, 22x OOS, 1x planned. |
| | Dredging | Shipping channels in shallow areas with mobile sediments have their depth maintained via dredging. |
| | Other | Trawl Marks |

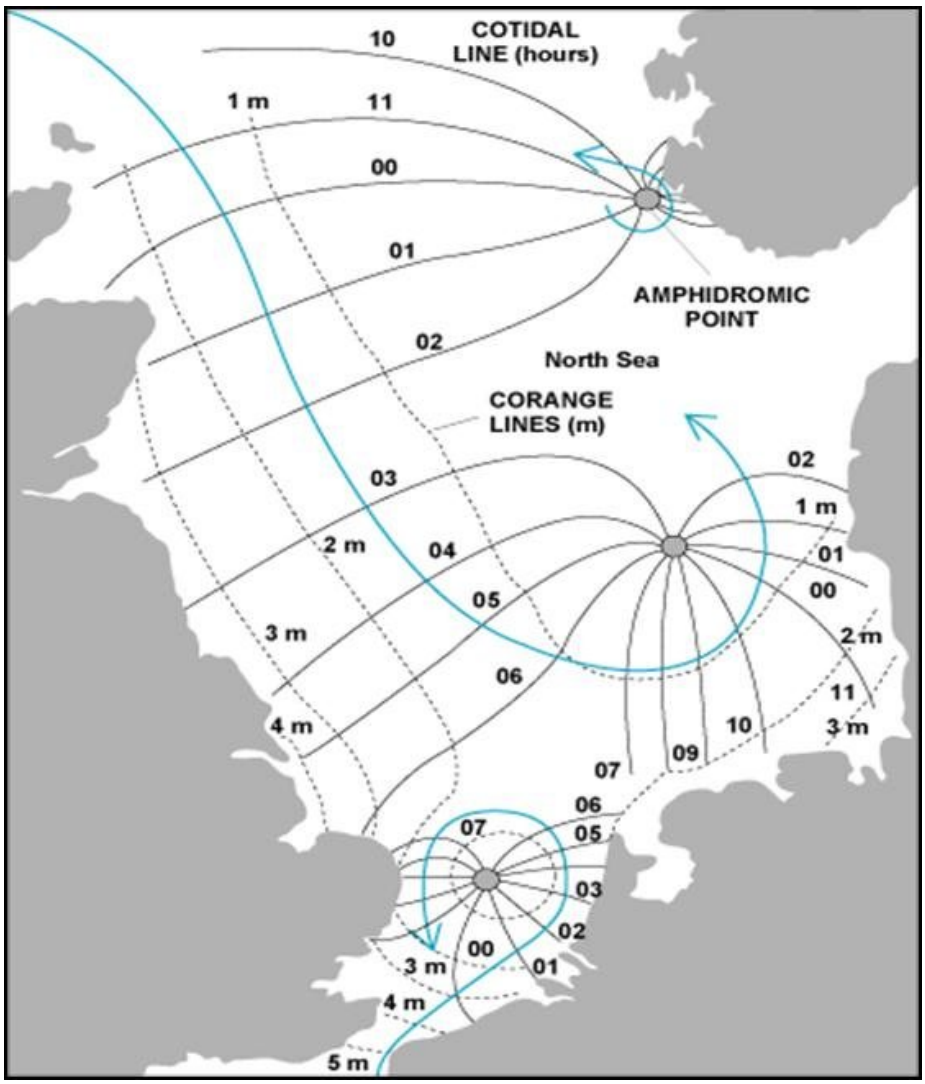
## 13.2. STEP1 – Bedform Segmentation

With regards to the seabed preparation (pre-sweeping) strategy, and to be able to identify zones with similar bedforms (ripples, mega ripples, sand waves), and areas with boulder fields for example, a detailed comparison of the information on alignment charts, the electronic GIS database information, and the longitudinal seabed slope profiles was carried out. This has resulted in a refined segmentation of various bedform and seabed features.

Mega ripples are driven by surface waves and their migration depends on location-specific wave conditions. Mega-ripples would be of exactly the right size range and mobility speed to cause problems with long term cable integrity (either through exposure or over-burial). Pre-sweeping of mega ripples may not be effective however seeing these can quickly re-form.

Sand waves can be mobile, depending again on location specific environmental conditions. Sand waves located near to any of the North Sea amphidromical points (Figure 13-1) are however known to be considerably less mobile.

**Figure 13-1: North Sea Amphidromic Points**



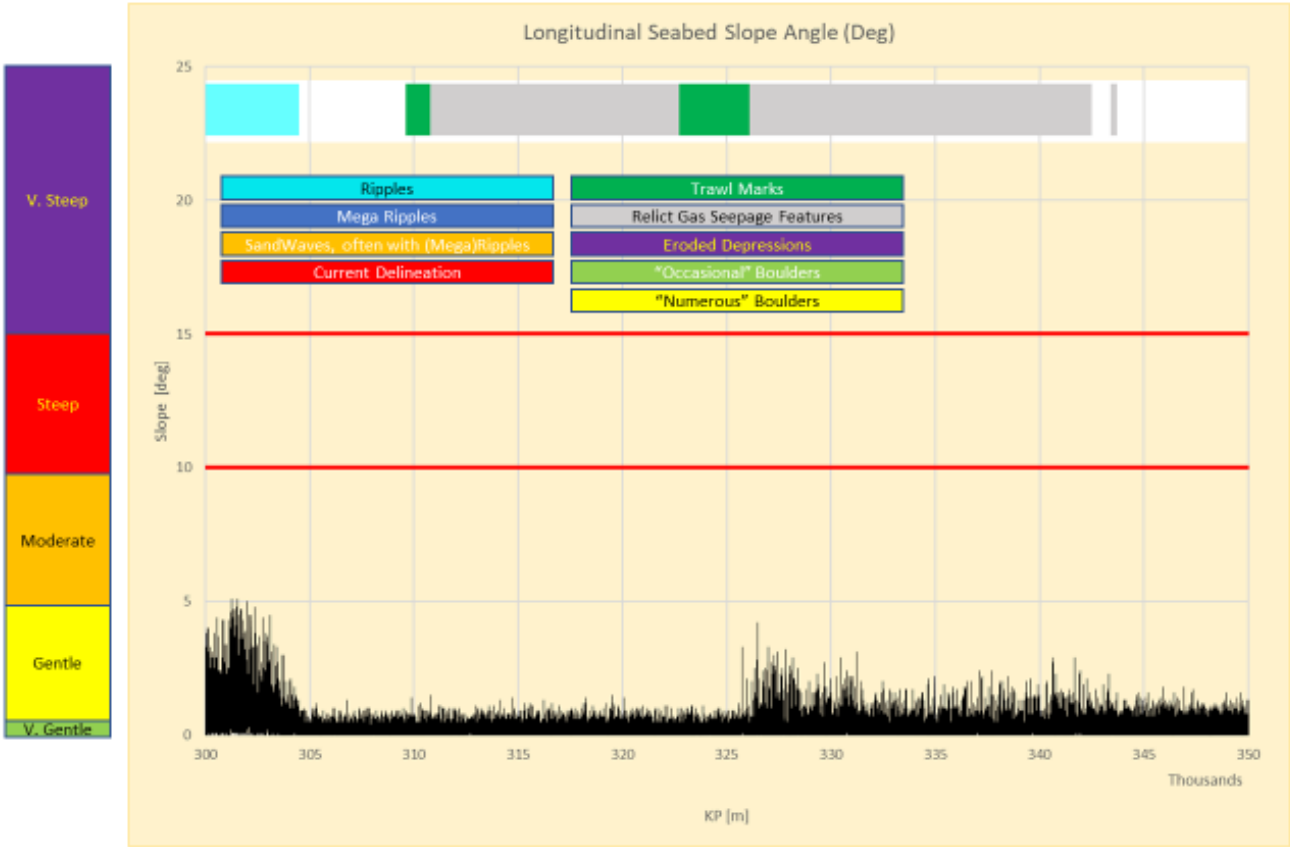
It should be noted that only mobile seabed features with a wave height, similar in magnitude to the target trench depth (TTD), should be of interest to pre-sweeping (mega ripples, sand waves) and only those that are (confirmed) mobile.

Seabed features that are not significantly mobile over the lifetime of the cables, and those which are relatively small compared to the TTD, are considered of less to no interest.

Therefore, the mobility of the bedform such as sand waves and the larger mega ripples should be studied as a matter of priority (see recommendations) to inform the seabed preparation (pre-sweeping) strategy and scope.

The Figure 13-2 below graphically illustrates the bedform segmentation between KP300 - KP350, for example, showing areas with seabed ripples, areas with trawl marks and relict gas seepage features.

**Figure 13-2: NETHERLANDS Sector (KP300-KP350) - Bedform Segmentation**




Enlarged versions of these figures, covering KP262.85 – KP522.9, are enclosed in Appendix C2 of this report.

Table 13-2 below provides the detailed summary of "segmentation by bedform" for the NETHERLANDS sector.

**Table 13-2: NETHERLANDS Sector – Bedform Segmentation**

| ID | KP FROM [km] | KP TO [km] | Length [m] | Bedform / Feature Type |
|---|---|---|---|---|
| 1 | 262.850 | 293.999 | 31149 | Sand Waves and Ripples |
| 2 | 293.999 | 304.479 | 10480 | Ripples |
| 3 | 304.479 | 309.601 | 5122 | None |
| 4 | 309.601 | 310.802 | 1201 | Trawl Mark (insignificant) |
| 5 | 310.802 | 322.732 | 11930 | Relict Gas Seepage |
| 6 | 322.732 | 326.103 | 3370 | Trawl Mark (insignificant) |
| 7 | 326.103 | 342.504 | 16401 | Relict Gas Seepage |
| 8 | 342.504 | 343.424 | 920 | None |
| 9 | 343.424 | 343.710 | 286 | Relict Gas Seepage |
| 10 | 343.710 | 357.809 | 14099 | None |
| 11 | 357.809 | 413.135 | 55327 | Trawl Mark (insignificant) |
| 12 | 413.135 | 427.303 | 14168 | None |
| 13 | 427.303 | 440.470 | 13166 | Trawl Mark (insignificant) |
| 14 | 440.470 | 447.262 | 6793 | None |
| 15 | 447.262 | 463.893 | 16631 | Trawl Mark (insignificant) |
| 16 | 463.893 | 466.871 | 2978 | None |
| 17 | 466.871 | 492.328 | 25457 | Trawl Mark (insignificant) |
| 18 | 492.328 | 507.509 | 15181 | None |
| 19 | 507.509 | 507.845 | 336 | Eroded Depressions |
| 20 | 507.845 | 507.962 | 117 | None |
| 21 | 507.962 | 508.026 | 63 | Eroded Depressions |
| 22 | 508.026 | 508.679 | 653 | None |
| 23 | 508.679 | 508.738 | 59 | Eroded Depressions |
| 24 | 508.738 | 508.791 | 52 | None |
| 26 | 508.791 | 508.820 | 29 | Eroded Depressions |
| 27 | 508.820 | 509.438 | 618 | None |
| 28 | 509.438 | 509.490 | 52 | Eroded Depressions |
| 29 | 509.490 | 511.453 | 1963 | None |
| 30 | 511.453 | 511.582 | 130 | Eroded Depressions |
| 31 | 511.582 | 512.316 | 733 | None |
| 32 | 512.316 | 512.370 | 54 | Eroded Depressions |
| 33 | 512.370 | 514.159 | 1789 | None |
| 34 | 514.159 | 515.072 | 913 | Eroded Depressions |
| 35 | 515.072 | 515.531 | 459 | None |
| 36 | 515.531 | 516.037 | 506 | Eroded Depressions |
| 37 | 516.037 | 516.498 | 461 | None |
| 38 | 516.498 | 517.194 | 696 | Eroded Depressions |
| 39 | 517.194 | 518.548 | 1354 | None |
| 40 | 518.548 | 518.688 | 140 | Eroded Depressions |
| 41 | 518.688 | 519.070 | 382 | None |

| ID | KP FROM [km] | KP TO [km] | Length [m] | Bedform / Feature Type |
|---|---|---|---|---|
| 42 | 519.070 | 519.116 | 46 | Eroded Depressions |
| 43 | 519.116 | 522.390 | 3274 | None |
| 44 | 522.390 | 522.673 | 283 | Eroded Depressions |
| 45 | 522.673 | 523.037 | 364 | None |
| 46 | 523.037 | 523.418 | 381 | Eroded Depressions |
| 47 | 523.418 | 620.287 | 96869 | None |
| 48 | 620.287 | 622.900 | 2613 | Ripples |

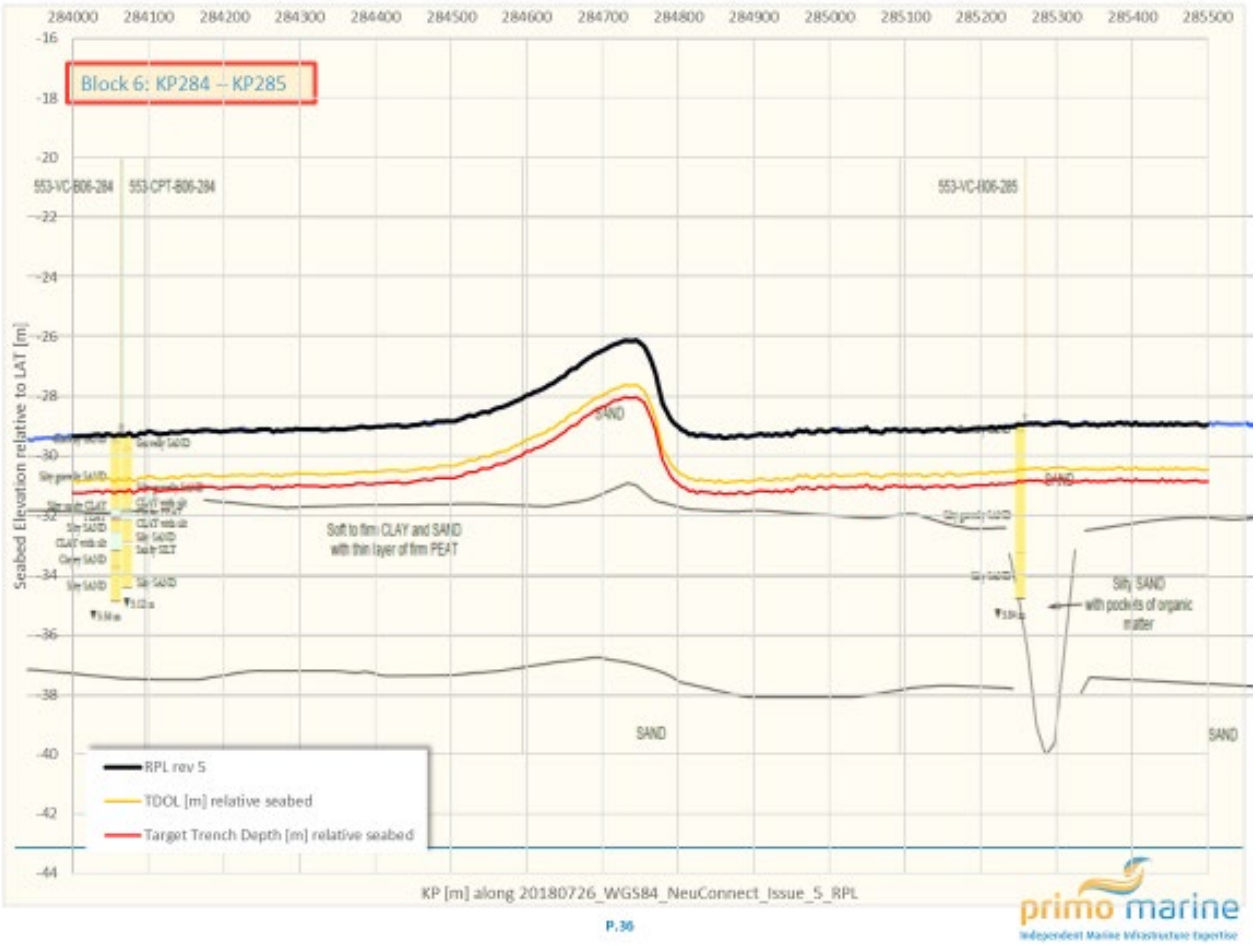
### 13.3. STEP 2 - Shallow Geology Segmentation

With regards to cable burial strategy, a segmentation based on shallow geology was carried out. And with regards to material strength properties, the upper bound strength properties (conservative) are considered.

To be able visually and with some appropriate level of accuracy perform the segmentation, the route alignment charts were split into 1-1.5km sections and the set of burial requirement profiles in terms of TDOL, TTD manually superimposed onto each of these sections.

An example is shown in Figure 13-3, where target trench depth (zone of interest) "sits" within the surficial sand layer, and neatly above and thus avoiding a soft to firm CLAY layer where thin layers of peat occurs.

**Figure 13-3: NETHERLANDS Sector (KP284-KP285) – Shallow Geology Segmentation**




The Table 13-3 below provides a detailed summary of the segmentation of the NETHERLANDS Sector route based on Shallow Geology, with the depth of interest being the Target Trench Depth (TTD) profile (see red line in Figure 13-3, with the orange line representing the TDOL profile).

The TTD profile has been established by adding 0.4m to the Target Depth of Lowering (TDOL) profile, outputted from the CBRA. The addition of 0.4m accounts for the assumed bundled cable diameter of 0.2m and an additional safety margin of 0.2m.

A distinction has been made for the various CLAY consistency ranges (low strength, medium strength, high and very high strength). For granular materials however, the state of compaction has been conservatively assumed to be dense to very dense. A future full, proper BAS would have to include a comprehensive analysis of all available geotechnical in-situ and laboratory test data to be able to distinguish with more accuracy the consistency and compaction ranges for the shallow geology segmentations outlined below.

**Table 13-3: NETHERLANDS Sector – Shallow Geology Segmentation**

| ID | KP FROM [km] | KP TO [km] | SHALLOW GEOLOGY within TARGET TRENCH DEPTH zone |
|---|---|---|---|
| 1 | 262.850 | 328.500 | Silty gravelly SAND |
| 2 | 328.500 | 351.600 | Silty (gravelly) SAND to sandy (gravelly, occasionally peaty) SILT |
| 3 | 351.600 | 354.700 | Low Strength silty sandy to gravelly CLAY |
| 4 | 354.700 | 360.700 | Silty gravelly SAND |
| 5 | 360.700 | 362.600 | Low Strength silty sandy to gravelly CLAY |
| 6 | 362.600 | 363.800 | Silty (gravelly) SAND layer overlying low strength sandy/gravelly CLAY layer |
| 7 | 363.800 | 368.700 | Low Strength silty sandy to gravelly CLAY |
| 8 | 368.700 | 369.500 | 20:20:60 SAND/CLAY/SAND: Silty (gravelly) SAND / low strength sandy/gravelly CLAY |
| 9 | 369.500 | 370.800 | 30:70 CLAY/SAND - Low Strength silty sandy to gravelly CLAY layer overlying SAND |
| 10 | 370.800 | 371.400 | 30:20:50: SAND/CLAY/SAND - Silty (gravelly) SAND / low strength sandy/gravelly CLAY; with PEAT pockets |
| 11 | 371.400 | 374.400 | 50:50 SAND/CLAY - Silty (gravelly) SAND / low strength sandy/gravelly CLAY, with PEAT pockets |
| 12 | 374.400 | 377.800 | 25:25:50: SAND/CLAY/SAND - Silty (gravelly) SAND / low strength sandy/gravelly CLAY; |
| 13 | 377.800 | 381.600 | 80:20 CLAY/SAND - Low Strength silty sandy to gravelly CLAY |
| 14 | 381.600 | 386.800 | Low Strength silty sandy to gravelly CLAY |
| 15 | 386.800 | 387.700 | 40:60 SAND/CLAY - Silty (gravelly) SAND / low strength sandy/gravelly CLAY, with PEAT pockets |
| 16 | 387.700 | 400.900 | Low Strength silty sandy to gravelly CLAY, with pockets of PEAT |
| 17 | 400.900 | 406.700 | Silty gravelly SAND |
| 18 | 406.700 | 429.500 | low strength sandy (gravelly) CLAY |
| 19 | 429.500 | 434.300 | 80:20 CLAY/SAND - Low Strength silty sandy to gravelly CLAY |
| 20 | 434.300 | 438.400 | 50:50 CLAY over SAND - Low Strength silty sandy to gravelly CLAY and silty gravelly SAND, occ. Firm PEAT |
| 21 | 438.400 | 457.100 | Silty, clayey gravelly SAND |

| ID | KP FROM [km] | KP TO [km] | SHALLOW GEOLOGY within TARGET TRENCH DEPTH zone |
|---|---|---|---|
| 22 | 457.100 | 461.400 | Silty SAND to sandy GRAVEL |
| 23 | 461.400 | 465.000 | 25:75 CLAY/SAND - silty sandy gravelly CLAY and silty gravelly SAND |
| 24 | 465.000 | 465.400 | 85:15 SAND / PEAT |
| 25 | 465.400 | 467.700 | Clay SAND to sandy GRAVEL |
| 26 | 467.700 | 476.000 | Silty gravelly SAND |
| 27 | 476.000 | 476.500 | 40:60 SAND/CLAY - Silty (gravelly) SAND / low strength sandy/gravelly CLAY, with PEAT pockets |
| 28 | 476.500 | 482.200 | Silty gravelly SAND |
| 29 | 482.200 | 483.500 | 30:20:50: SAND/CLAY/SAND - Silty (gravelly) SAND / low strength sandy/gravelly CLAY; with PEAT pockets |
| 30 | 483.500 | 485.900 | Silty gravelly SAND |
| 31 | 485.900 | 486.500 | 20:80 SAND/CLAY |
| 32 | 486.500 | 488.200 | gravelly clayey SAND |
| 33 | 488.200 | 490.700 | Silty gravelly SAND |
| 34 | 490.700 | 493.100 | clayey gravelly SAND |
| 35 | 493.100 | 497.000 | Silty gravelly SAND |
| 36 | 497.000 | 498.000 | clayey gravelly SAND |
| 37 | 498.000 | 499.300 | SAND with shell GRAVEL |
| 38 | 499.300 | 500.500 | Silty gravelly SAND |
| 39 | 500.500 | 501.400 | 80:20 SAND/CLAY - silty gravelly SAND and medium strength CLAY |
| 40 | 501.400 | 502.800 | 50:50 GRAVEL/CLAY – sandy GRAVEL and medium strength CLAY |
| 41 | 502.800 | 504.800 | 80:20 SAND/CLAY - silty gravelly SAND and medium strength CLAY |
| 42 | 504.800 | 505.400 | 20:80 SAND/CLAY |
| 43 | 505.400 | 522.900 | Silty gravelly SAND, occasional pocket of PEAT |

**Notes:**

In line with British Standards, the CLAY consistency (strength) ranges are summarised as follows:

| | | |
|---|---|---|
| CLAYS | Very Low Strength (Very soft): | undrained shear strength less than 20kPa |
| CLAYS | Low Strength (Soft): | undrained shear strength ranging 20kPa – 40kPa |
| CLAYS | Medium Strength (Firm): | undrained shear strength ranging 40kPa – 75kPa |
| CLAYS | High Strength (Stiff): | undrained shear strength ranging 75kPa – 150kPa |
| CLAYS | Very High Strength (Very stiff): | undrained shear strength ranging 150kPa – 200kPa |
| CLAYS | Extremely High Strength (Hard): | undrained shear strength ranging > 200kPa |

# 14. TWO-STEP ROUTE SEGMENTATION – GERMANY SECTOR

## 14.1. Hazards

The hazards pertinent to BAS are summarised in Table 14-1 below. The zone of interest is defined as the Target Trench Depth (TTD), in this case, the first 2-2.5m below seabed, and possibly up to 5-5.5m in areas between KP613-KP619 (to be confirmed), and KP650-KP700 (to be confirmed).

**Table 14-1: NeuConnect Route – Pertinent Hazards to be considered for BAS (Lite)**

| Hazard Type | Description | Comments |
|---|---|---|
| Geohazards | Seabed Mobility | Ripples ($w_L$ < 15m, $w_H$ < 1m) |
| | | Mega Ripples (15m < $w_L$ < 50m, 1m < $w_H$ < 3m) |
| | Steep Slopes | Sand Waves (50m < $w_L$ < 200m, $w_H$ > 3m) |
| | Hard Ground | (Very) High Strength CLAYS (75 kPa up to 200kPa) and ROCK – outcropping (affect full TTD) |
| | | High Strength CLAYS/ROCK– sub cropping (affect partial TTD) |
| | Peat / Chalk | Occasional occurrences within TTD zone |
| | Boulder Fields | "Occasional Boulders" (5 < boulders < 20 per 100sqm)<br>Several areas identified in GERMANY Sector |
| | | "Numerous Boulders" ( > 20 boulders per 100 sqm)<br>Several areas identified in latter 50km of GERMAN Sector. |
| | Geological Folding and Faulting | None would appear to be present within zone of interest but this requires a more in-depth study. |
| | Palaeo Channels | Sudden change in lithology – typically, infill materials are softer, less compact. |
| | Shallow Gas | None would appear to be present within zone of interest, but this requires a more in-depth study. |
| | Seismicity | North Sea lies within area of low seismic hazard activity |
| | Other | Current Lineations |
| Man-Made Hazards | Crossings | A combined total of 89 known Cable / PL crossings for the entire 700km long route.<br><br>GERMANY Sector: 20x crossings<br>9x active, 10x OOS,<br>1x planned |
| | Dredging | Shipping channels in shallow areas with mobile sediments have their depth maintained via dredging. |

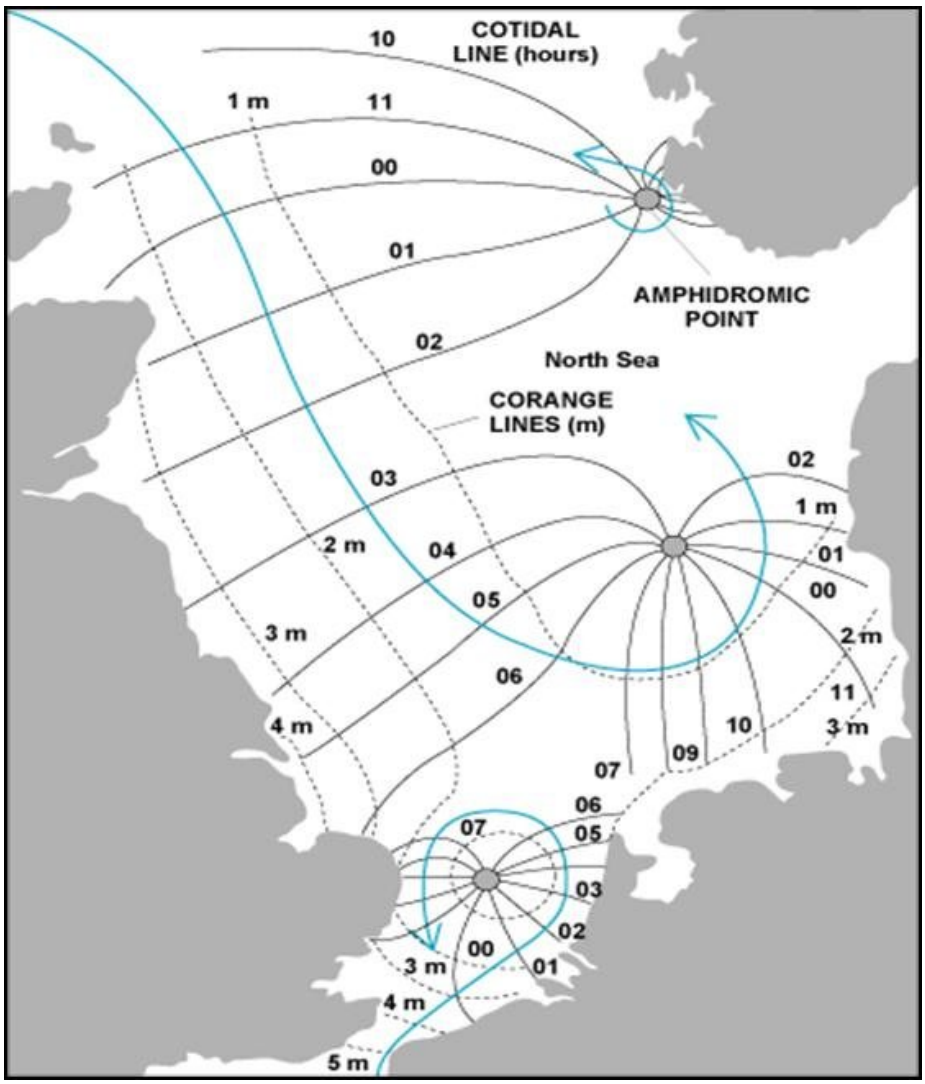
### 14.2. STEP1 – Bedform Segmentation

With regards to the seabed preparation (pre-sweeping) strategy, and to be able to identify zones with similar bedforms (ripples, mega ripples, sand waves), and areas with boulder fields for example, a detailed comparison of the information on alignment charts, the electronic GIS database information, and the longitudinal seabed slope profiles was carried out. This has resulted in a refined segmentation of various bedform and seabed features.

Mega ripples are driven by surface waves and their migration depends on location-specific wave conditions. Mega-ripples would be of exactly the right size range and mobility speed to cause problems with long term cable integrity (either through exposure or over-burial). Pre-sweeping of mega ripples may not be effective however seeing these can quickly re-form.

Sand waves can be mobile, depending again on location specific environmental conditions. Sand waves located near to any of the North Sea amphidromical points are however known to be considerably less mobile.

**Figure 14-1: North Sea Amphidromic Points**



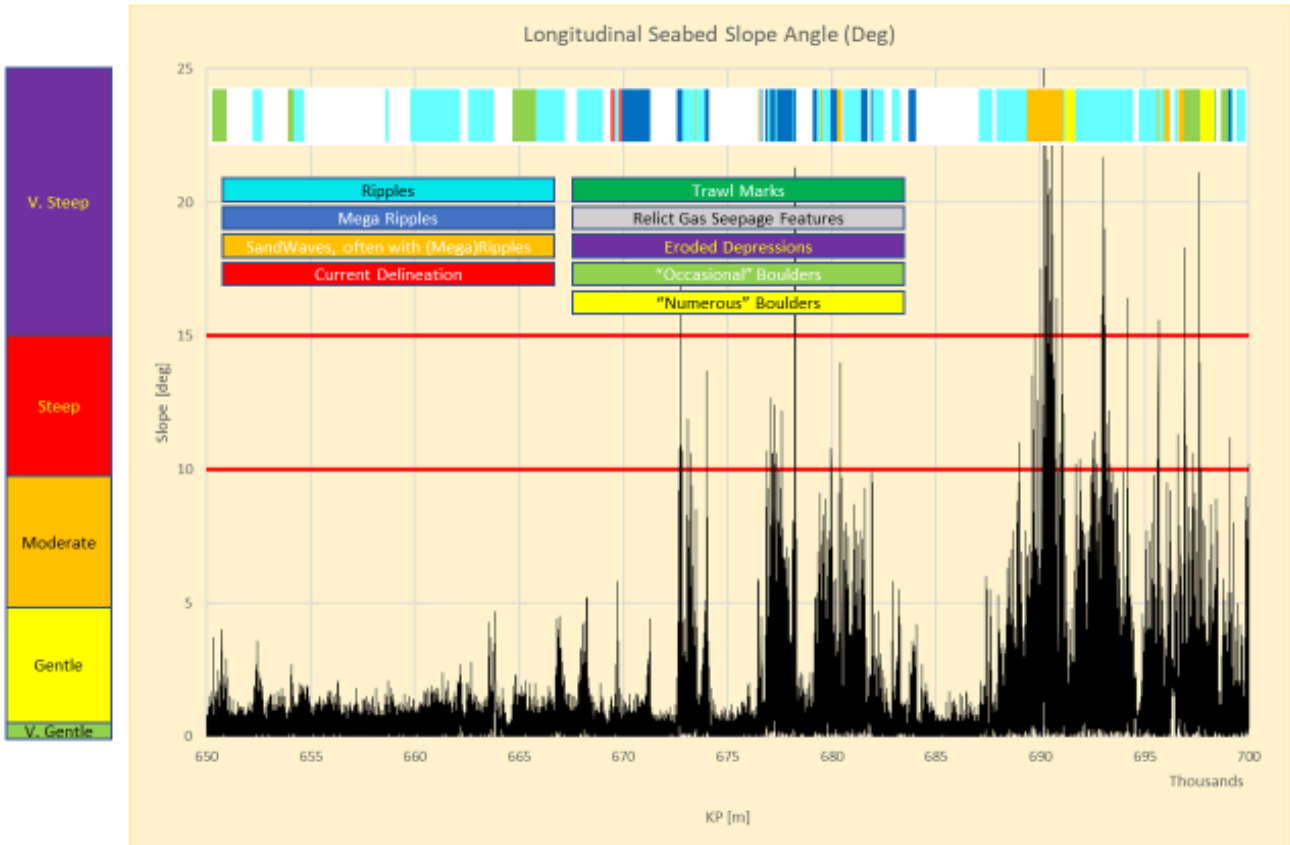
It should be noted that only mobile seabed features with a wave height, similar in magnitude to the target trench depth (TTD), should be of interest to pre-sweeping (mega ripples, sand waves) and only those that are (confirmed) mobile.

Seabed features that are not significantly mobile over the lifetime of the cables, and those which are relatively small compared to the TTD, are considered of less to no interest.

Therefore, the mobility of the bedform such as sand waves and the larger mega ripples should be studied as a matter of priority (see recommendations) to inform the seabed preparation (pre-sweeping) strategy and scope.

The Figure 14-2 below graphically illustrates the bedform segmentation between KP650- KP700, for example, showing areas with "occasional " and "numerous" boulders, ripples and mega ripples, sand waves.

**Figure 14-2: GERMANY Sector (KP650-KP700) - Bedform Segmentation**




Enlarged versions of these figures, covering KP522.9 – KP700.7, are enclosed in Appendix C3 of this report.

Table 14-2 below provides the detailed summary of "segmentation by bedform" for the GERMANY sector.

**Table 14-2: GERMANY Sector – Bedform Segmentation**

| ID | KP FROM [km] | KP TO [km] | Length [m] | Bedform / Feature Type |
|---|---|---|---|---|
| 1 | 622.900 | 623.790 | 890 | Ripples |
| 2 | 623.790 | 636.703 | 12913 | None |
| 3 | 636.703 | 637.799 | 1096 | Ripples |
| 4 | 637.799 | 650.274 | 12475 | None |
| 5 | 650.274 | 651.000 | 726 | "Occasional" Boulders |
| 6 | 651.000 | 652.219 | 1220 | None |
| 7 | 652.219 | 652.671 | 452 | Ripples |
| 8 | 652.671 | 653.935 | 1263 | None |
| 9 | 653.935 | 654.207 | 273 | "Occasional" Boulders |
| 10 | 654.207 | 654.713 | 506 | Ripples |
| 11 | 654.713 | 658.578 | 3865 | None |
| 12 | 658.578 | 658.745 | 167 | Ripples |
| 13 | 658.745 | 659.801 | 1056 | None |
| 14 | 659.801 | 660.929 | 2383 | Ripples |
| 15 | 662.183 | 662.571 | 388 | None |
| 16 | 662.571 | 662.631 | 1229 | Ripples |
| 17 | 663.800 | 664.587 | 890 | None |
| 18 | 664.690 | 665.104 | 1119 | "Occasional" Boulders |
| 19 | 665.809 | 667.205 | 1396 | Ripples |
| 20 | 667.205 | 667.775 | 569 | None |
| 21 | 667.775 | 669.020 | 1245 | Ripples |
| 22 | 669.020 | 669.399 | 381 | None |
| 23 | 669.401 | 669.592 | 191 | Current Lineation |
| 24 | 669.592 | 669.740 | 148 | Ripples |
| 25 | 669.740 | 669.791 | 51 | None |
| 26 | 669.791 | 669.954 | 162 | Current Lineation |
| 27 | 669.954 | 671.313 | 1359 | Mega Ripples |
| 28 | 671.313 | 672.574 | 1261 | None |
| 29 | 672.574 | 672.842 | 269 | Mega Ripples |
| 30 | 672.842 | 673.329 | 619 | Ripples |
| 31 | 673.461 | 673.467 | 55 | Sand Waves |
| 32 | 673.516 | 673.926 | 411 | Ripples |
| 33 | 673.926 | 674.133 | 206 | Mega Ripples |
| 34 | 674.133 | 676.465 | 2332 | None |
| 35 | 676.465 | 676.514 | 49 | Sand Waves |
| 36 | 676.514 | 676.600 | 87 | None |
| 37 | 676.600 | 676.667 | 67 | Mega Ripples |
| 38 | 676.667 | 676.817 | 151 | None |
| 39 | 676.817 | 676.931 | 114 | Mega Ripples |
| 40 | 676.931 | 677.044 | 113 | Ripples |

| ID | KP FROM [km] | KP TO [km] | Length [m] | Bedform / Feature Type |
|---|---|---|---|---|
| 41 | 677.044 | 677.335 | 291 | Mega Ripples |
| 42 | 677.335 | 678.197 | 862 | Ripples |
| 43 | 678.197 | 678.306 | 109 | Mega Ripples |
| 44 | 678.306 | 679.114 | 809 | None |
| 45 | 679.114 | 679.291 | 177 | Mega Ripples |
| 46 | 679.291 | 679.379 | 212 | Ripples |
| 47 | 679.503 | 679.555 | 52 | Sand Waves |
| 48 | 679.555 | 679.840 | 392 | Ripples |
| 49 | 679.947 | 680.161 | 330 | Mega Ripples |
| 50 | 680.276 | 680.414 | 201 | Sand Waves |
| 51 | 680.478 | 680.554 | 76 | None |
| 52 | 680.554 | 680.710 | 879 | Ripples |
| 53 | 681.433 | 681.722 | 289 | Mega Ripples |
| 54 | 681.722 | 681.880 | 158 | None |
| 55 | 681.880 | 681.949 | 69 | Mega Ripples |
| 56 | 681.949 | 682.508 | 560 | Ripples |
| 57 | 682.508 | 682.890 | 382 | None |
| 58 | 682.890 | 683.040 | 378 | Ripples |
| 59 | 683.268 | 683.717 | 448 | None |
| 60 | 683.717 | 683.861 | 343 | Mega Ripples |
| 61 | 684.060 | 685.295 | 2992 | None |
| 62 | 687.052 | 687.735 | 683 | Ripples |
| 63 | 687.735 | 687.925 | 191 | None |
| 64 | 687.925 | 689.398 | 1473 | Ripples |
| 65 | 689.398 | 689.576 | 1721 | Sand Waves |
| 66 | 691.119 | 691.197 | 79 | Ripples |
| 67 | 691.197 | 691.679 | 482 | "Numerous" Boulders |
| 68 | 691.679 | 693.380 | 2782 | Ripples |
| 69 | 694.461 | 694.734 | 274 | None |
| 70 | 694.734 | 695.097 | 880 | Ripples |
| 71 | 695.615 | 695.660 | 45 | Sand Waves |
| 72 | 695.660 | 695.962 | 302 | Ripples |
| 73 | 695.962 | 696.041 | 238 | Sand Waves |
| 74 | 696.200 | 696.213 | 12 | None |
| 75 | 696.213 | 696.262 | 49 | Ripples |
| 76 | 696.262 | 696.430 | 168 | None |
| 77 | 696.430 | 696.585 | 155 | Ripples |
| 78 | 696.585 | 696.632 | 47 | None |
| 79 | 696.632 | 696.902 | 269 | Sand Waves |
| 80 | 696.902 | 696.911 | 10 | None |
| 81 | 696.911 | 696.941 | 766 | "Occasional" Boulders |

| ID | KP FROM [km] | KP TO [km] | Length [m] | Bedform / Feature Type |
|---|---|---|---|---|
| 82 | 697.677 | 697.883 | 716 | "Numerous" Boulders |
| 83 | 698.393 | 698.422 | 28 | "Occasional" Boulders |
| 84 | 698.422 | 698.507 | 252 | None |
| 85 | 698.674 | 698.962 | 363 | "Occasional" Boulders |
| 86 | 699.011 | 699.153 | 142 | |
| 87 | 699.153 | 699.244 | 91 | Ripples |
| 88 | 699.244 | 699.398 | 154 | None |
| 89 | 699.398 | 699.804 | 405 | Ripples |
| 90 | 699.804 | 700.700 | 896 | None |

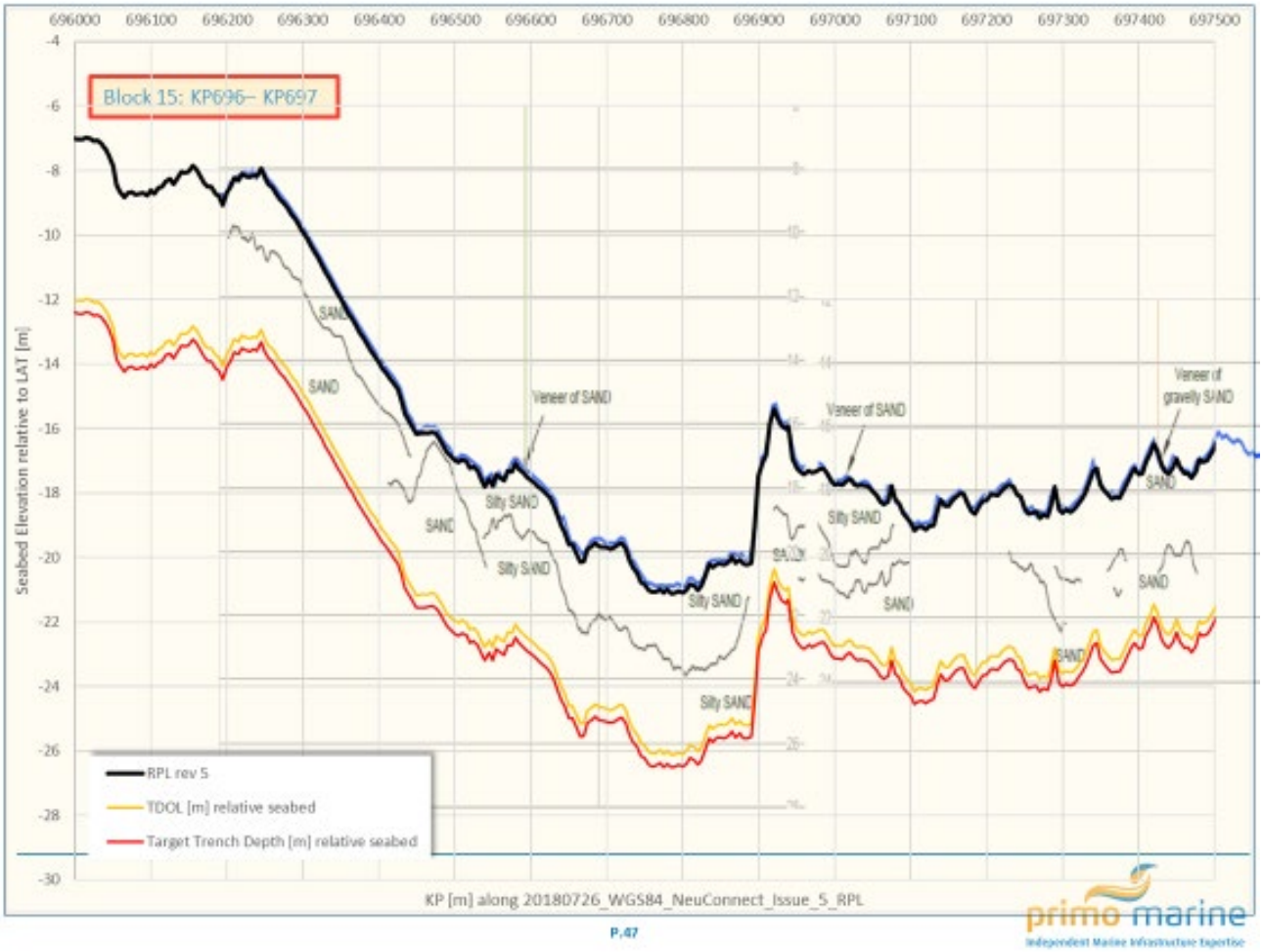
### 14.3. STEP 2 - Shallow Geology Segmentation

With regards to cable burial strategy, a segmentation based on shallow geology was carried out. And with regards to material strength properties, the upper bound strength properties (conservative) are considered.

To be able visually and with some appropriate level of accuracy perform the segmentation, the route alignment charts were split into 1-1.5km sections and the set of burial requirement profiles in terms of TDOL, TTD manually superimposed onto each of these sections.

An example is shown in Figure 14-3 below, of a sand wave area.

**Figure 14-3: GERMANY Sector (KP696-KP697) – Shallow Geology Segmentation**




The Table 14-3 below provides a detailed summary of the segmentation of the GERMANY Sector route based on Shallow Geology, with the depth of interest being the Target Trench Depth (TTD) profile (see red line in Figure 14-3, with the orange line representing the TDOL profile).

The TTD profile has been established by adding 0.4m to the Target Depth of Lowering (TDOL) profile, outputted from the CBRA. The addition of 0.4m accounts for the assumed bundled cable diameter of 0.2m and an additional safety margin of 0.2m.

A distinction has been made for the various CLAY consistency ranges (low strength, medium strength, high and very high strength). For granular materials however, the state of compaction has been conservatively assumed to be dense to very dense. A future full, proper BAS would have to include a comprehensive analysis of all available geotechnical in-situ and laboratory test data to be able to distinguish with more accuracy the consistency and compaction ranges for the shallow geology segmentations outlined below.

**Table 14-3: GERMANY Sector – Shallow Geology Segmentation**

| ID | KP FROM [km] | KP TO [km] | SHALLOW GEOLOGY within TARGET TRENCH DEPTH zone |
|---|---|---|---|
| 1 | 522.900 | 527.500 | Silty gravelly SAND |
| 2 | 527.500 | 528.600 | 80:20 SAND/PEAT - Silty gravelly SAND overlying PEAT layer |
| 3 | 528.600 | 542.000 | Silty gravelly SAND, occasional PEAT |
| 4 | 542.000 | 542.700 | Silty SAND to sandy GRAVEL |
| 5 | 542.700 | 577.200 | Silty gravelly SAND, occasional thin layer of clayey PEAT |
| 6 | 577.200 | 580.400 | 60:40 SAND/CLAY - Silty (gravelly) SAND / low strength sandy/gravelly CLAY, with PEAT pockets |
| 7 | 580.400 | 589.100 | Silty gravelly SAND |
| 8 | 589.100 | 592.400 | Silty gravelly SAND and sandy SILT, with CLAY laminations |
| 9 | 592.400 | 595.500 | Sandy SILT with CLAY laminations |
| 10 | 595.500 | 602.100 | Silty gravelly SAND, occasional thin PEAT layer(s) |
| 11 | 602.100 | 603.200 | Silty gravelly SAND and PEAT |
| 12 | 602.100 | 613.000 | Silty gravelly SAND |
| 13 | 613.000 | 619.000 | Silty gravelly SAND |
| 14 | 619.000 | 629.900 | Silty gravelly SAND |
| 15 | 629.900 | 631.500 | 70:30 CLAY/PEAT Medium to High Strength CLAY overlying medium strength PEAT |
| 16 | 631.500 | 638.700 | Silty gravelly SAND |
| 17 | 638.700 | 640.000 | 50:50 SAND/CLAY - situ gravelly SAND overlying low strength CLAY |
| 18 | 640.000 | 646.200 | Silty gravelly SAND |
| 19 | 646.200 | 649.300 | clayey gravelly SAND, with layer of sandy CLAY and PEAT. |
| 20 | 649.300 | 656.000 | gravelly SAND with CLAY pockets |
| 21 | 656.000 | 672.600 | silty to gravelly SAND |
| 22 | 672.600 | 676.200 | SAND |
| 23 | 676.200 | 679.900 | SAND and SILT |
| 24 | 679.900 | 681.900 | SAND |

| ID | KP FROM [km] | KP TO [km] | SHALLOW GEOLOGY within TARGET TRENCH DEPTH zone |
|---|---|---|---|
| 25 | 681.900 | 686.800 | Silty SAND to SAND |
| 26 | 686.800 | 690.300 | SAND |
| 27 | 690.300 | 692.700 | Silty gravelly SAND |
| 28 | 692.700 | 695.200 | Silty SAND to SAND |
| 29 | 695.200 | 696.500 | SAND |
| 30 | 696.500 | 697.200 | Silty SAND |
| 31 | 697.200 | 698.400 | SAND |
| 32 | 698.400 | 699.400 | Silty SAND |
| 33 | 699.400 | 699.800 | SAND |
| 34 | 699.800 | 700.700 | gravelly SAND |

# 15. BAS LITE – UK SECTOR

## 15.1. STEP 1 – Pre-Sweeping

PRIMO recommend that pre-sweeping be considered in areas with mobile sand waves, and possibly in areas with larger size (height) mega ripples. A morpho-dynamics study is required to confirm whether any of these larger bedforms are indeed mobile or not. This document shall form the basis for the design of the final pre-sweeping strategy and scope.

The objective of pre-sweeping is to flatten the seabed and to increase the likelihood for successful cable lowering and burial below the (im-)mobile interface seabed level. Pre-sweeping would also reduce risks associated with slopes >15° during subsequent SLB, or PLB operations, where burial tool instability would otherwise likely become an issue with potential for damage to any of the asset(s).

Where boulders fields occur ("occasional", or "numerous" boulders), areas with trawl marks, relict seepage features, or eroded depressions, for example, these areas should be considered avoiding where possible, through micro-routing, or that boulders be removed, or that surface laid cable assets be protected through rock placement, mattresses, or otherwise.

**Table 15-1: UK Sector – Pre-Sweeping based on Bedform Segmentation**

| ID | KP FROM [km] | KP TO [km] | Length [m] | Bedform / Feature Type | Recommend Pre-Sweeping ? |
|---|---|---|---|---|---|
| 1 | 0.000 | 7.474 | 7474 | None | |
| 2 | 7.474 | 8.527 | 1053 | Trawl Mark | |
| 3 | 8.527 | 10.552 | 2025 | Dredged Area | Try avoiding via Micro-routing |
| 4 | 10.552 | 11.087 | 536 | Trawl Mark | |
| 5 | 11.087 | 12.150 | 1063 | None | |
| 6 | 12.150 | 12.765 | 615 | Ripples | |
| 7 | 12.765 | 16.319 | 3554 | None | |
| 8 | 16.319 | 25.342 | 9022 | Ripples | |
| 9 | 25.342 | 33.275 | 7934 | None | |
| 10 | 33.275 | 68.829 | 35554 | Ripples | |
| 11 | 68.829 | 68.990 | 161 | None | |
| 12 | 68.990 | 75.097 | 6107 | Marine Growth | |
| 13 | 75.097 | 78.235 | 3138 | None | |
| 14 | 78.235 | 78.419 | 184 | Ripples | |
| 15 | 78.419 | 80.273 | 1854 | Sand Waves | YES (only if mobile) |
| 16 | 80.273 | 81.153 | 880 | Ripples | |
| 17 | 81.153 | 83.912 | 2759 | None | |
| 18 | 83.912 | 88.757 | 4845 | Trawl Mark | |
| 19 | 88.757 | 94.863 | 6105 | Ripples | |
| 20 | 94.863 | 104.797 | 9935 | None | |
| 21 | 104.797 | 105.207 | 410 | Current Lineation | |
| 22 | 105.207 | 105.504 | 297 | Ripples | |
| 23 | 105.504 | 107.234 | 1730 | Sand Waves | YES (only if mobile) |
| 24 | 107.234 | 107.549 | 314 | Ripples | |

| ID | KP FROM [km] | KP TO [km] | Length [m] | Bedform / Feature Type | Recommend Pre-Sweeping ? |
|---|---|---|---|---|---|
| 25 | 107.549 | 107.860 | 311 | Mega Ripples | YES (larger mega ripples) – only if mobile |
| 26 | 107.860 | 108.298 | 438 | Ripples | |
| 27 | 108.298 | 110.924 | 2626 | None | |
| 28 | 110.924 | 111.180 | 256 | Current Lineation | |
| 29 | 111.180 | 112.087 | 907 | Ripples | |
| 30 | 112.087 | 113.436 | 1349 | Mega Ripples | YES (larger mega ripples) – only if mobile) |
| 31 | 113.436 | 114.784 | 1347 | Sand Waves | YES (only if mobile) |
| 32 | 114.784 | 115.039 | 255 | Ripples | |
| 33 | 115.039 | 121.735 | 6696 | Trawl Mark | |
| 34 | 121.735 | 121.863 | 128 | Mega Ripples | YES (larger mega ripples) – only if mobile |
| 35 | 121.863 | 122.189 | 326 | Ripples | |
| 36 | 122.189 | 122.383 | 195 | Mega Ripples | YES (larger mega ripples) – only if mobile |
| 37 | 122.383 | 126.741 | 4358 | Trawl Mark | |
| 38 | 126.741 | 128.607 | 1866 | None | |
| 39 | 128.607 | 129.257 | 650 | Mega Ripples | YES (larger mega ripples) – only if mobile |
| 40 | 129.257 | 129.728 | 471 | None | |
| 41 | 129.728 | 134.188 | 4460 | Sand Waves | YES (only if mobile) |
| 42 | 134.188 | 136.839 | 2651 | Mega Ripples | YES (larger mega ripples) – only if mobile |
| 43 | 136.839 | 137.119 | 280 | None | |
| 44 | 137.119 | 137.361 | 242 | Ripples | |
| 45 | 137.361 | 137.553 | 191 | Sand Waves | YES (only if mobile) |
| 46 | 137.553 | 138.074 | 522 | Ripples | |
| 47 | 138.074 | 138.635 | 560 | None | |
| 48 | 138.635 | 168.186 | 29551 | Sand Waves, Mega Ripples | YES (only if mobile) |
| 49 | 168.186 | 168.945 | 760 | Ripples | |
| 50 | 168.945 | 169.875 | 929 | Sand Waves | YES (only if mobile) |
| 51 | 169.875 | 170.006 | 131 | None | |
| 52 | 170.006 | 171.570 | 1564 | "Occasional" Boulders | Avoided via Micro-routing |
| 53 | 171.570 | 172.594 | 1024 | Ripples | |
| 54 | 172.594 | 178.868 | 6274 | Mega Ripples | YES (larger mega ripples) – only if mobile |
| 55 | 178.868 | 182.462 | 3594 | Sand Waves | YES (only if mobile) |
| 56 | 182.462 | 184.310 | 1848 | Ripples | |
| 57 | 184.310 | 184.428 | 118 | Sand Waves | YES (only if mobile) |
| 58 | 184.428 | 187.361 | 2933 | Ripples | |
| 59 | 187.361 | 187.411 | 51 | "Occasional" Boulders | Avoided via Micro-routing |
| 60 | 187.411 | 188.608 | 1197 | Ripples | |

| ID | KP FROM [km] | KP TO [km] | Length [m] | Bedform / Feature Type | Recommend Pre-Sweeping ? |
|---|---|---|---|---|---|
| 61 | 188.608 | 188.689 | 81 | "Occasional" Boulders | Avoided via Micro-routing |
| 62 | 188.689 | 188.986 | 297 | Ripples | |
| 63 | 188.986 | 189.154 | 168 | "Occasional" Boulders | Avoided via Micro-routing |
| 64 | 189.154 | 192.005 | 2851 | Ripples | |
| 65 | 192.005 | 192.940 | 934 | "Occasional" Boulders | Avoided via Micro-routing |
| 66 | 192.940 | 216.593 | 23653 | Sand Waves, Ripples | YES (only if mobile) |
| 67 | 216.593 | 216.852 | 259 | "Occasional" Boulders | Avoided via Micro-routing |
| 68 | 216.852 | 224.065 | 7213 | Sand Waves, Ripples | YES (only if mobile) |
| 69 | 224.065 | 224.655 | 590 | "Occasional" Boulders | Avoided via Micro-routing |
| 70 | 224.655 | 224.728 | 73 | Sand Waves | YES (only if mobile) |
| 71 | 224.728 | 224.772 | 44 | "Occasional" Boulders | Avoided via Micro-routing |
| 72 | 224.772 | 227.937 | 3165 | None | |
| 73 | 227.937 | 238.299 | 10362 | Sand Waves, Ripples | YES (only if mobile) |
| 74 | 238.299 | 240.315 | 2016 | Marine Growth | |
| 75 | 240.315 | 253.840 | 13525 | Ripples | YES (only if mobile) |
| 76 | 253.840 | 254.634 | 794 | None | |
| 77 | 254.634 | 255.120 | 486 | Ripples | |
| 78 | 255.120 | 256.030 | 910 | None | |
| 79 | 256.030 | 262.850 | 6820 | Ripples | |

Areas with mainly sand waves (wave height more than 3m) and mega ripples amount to 110,158 m in total, equivalent to 41.9% of UK Sector.

Areas with occasional boulders amount to 3,692 m in total (1.4 % of UK Sector).

Ongoing micro-routing will have to consider (if not considered already) those areas that are highlighted should avoided where feasible.

## 15.2. STEP 2 – Cable Burial

In areas where the target trench depth requirement is less than 2-2.5m ( applies to majority of the UK route sector – see Figure 11-3), and provided that pre-sweeping has taken place, PRIMO recommend that, the "Plough with Jet-Assist" should be considered as the principle tool for SLB operations.

This recommendation is based on the tool's burial depth capability, its ability to handle most soil types and strengths (other than stiff to very stiff CLAYS and fresh, competent ROCK), its operational reliability and efficiency, and despite the considerable number of crossings of other seabed or subsea services.

The ROV jet trencher could be an alternative concept to the plough, with similar depth capability. The range of soil types (and material) strengths that these machines can cope with, however, are somewhat narrowed when compared with the plough, with granular materials of up to very dense compaction states and CLAYS with up to medium strength all being jettable materials in principle.

For deeper installation, PRIMO recommend the Vertical Injector (VI) mounted on a jet-sled. This tool can achieve burial depths of up to 8 meters below seafloor level, in granular soils and low strength cohesive materials. PRIMO recommend that such a jetting sled be fitted with a long mechanical chain cutter able to deal with the harder cohesive type soils.

These tools are reliable and efficient (quick).

For areas with shallow geology comprising stiff to very stiff CLAY, or competent, fresh ROCK, the only tools that can feasibly handle these are the mechanical cutter trenchers.

Based on these principles, PRIMO have made their burial tool selection, as summarised in the Table 15-2 below, to be read in conjunction with the earlier Table 12-3 where shallow geology segmentation is summarised. Segments with deep burial requirements are marked through red font.

**Table 15-2: UK Sector – Proposed Burial Techniques based on Shallow Geology Segmentation**

| ID | KP FROM [km] | KP TO [km] | Proposed Techniques for SLB only | Proposed Techniques for SLB as well as PLB |
|---|---|---|---|---|
| 1 | 0.0 | 9.2 | 1st option: Plough + Jet Assist | 2nd option: Jet Trencher |
| 2 | 9.2 | 14.3 | 1st option: Plough + Jet Assist | 2nd option: Jet Trencher |
| 3 | 14.3 | 30.4 | 1st option: Plough + Jet Assist | 2nd option: Jet Trencher |
| 4 | 30.4 | 31.8 | | Mechanical Cutter |
| 5 | 31.8 | 37.1 | 1st option: Plough + Jet Assist | 2nd option: Jet Trencher |
| 6 | 37.1 | 51.0 | 1st option: Plough + Jet Assist | 2nd option: Jet Trencher |
| 7 | 51.0 | 57.2 | 1st option: Plough + Jet Assist | 2nd option: Jet Trencher |
| 8 | 57.2 | 61.0 | 1st option: Plough + Jet Assist | 2nd option: Jet Trencher |
| 9 | 61.0 | 65.0 | 1st option: Plough + Jet Assist | 2nd option: Jet Trencher |
| 10 | 65.0 | 68.3 | 1st option: Plough + Jet Assist | 2nd option: Jet Trencher |
| 11 | 68.3 | 68.9 | | Mechanical Cutter |
| 12 | 68.9 | 70.0 | 1st option: Plough + Jet Assist | |
| 13 | 70.0 | 75.8 | | Mechanical Cutter |
| 14 | 75.8 | 78.4 | 1st option: Plough + Jet Assist | 2nd option: Jet Trencher |

| ID | KP FROM [km] | KP TO [km] | Proposed Techniques for SLB only | Proposed Techniques for SLB as well as PLB |
|---|---|---|---|---|
| 15 | 78.4 | 80.0 | 1st option: Plough + Jet Assist | 2nd option: Jet Trencher |
| 16 | 80.0 | 81.8 | 1st option: Plough + Jet Assist | 2nd option: Jet Trencher |
| 17 | 81.8 | 82.5 | | Mechanical Cutter |
| 18 | 82.5 | 94.0 | | Mechanical Cutter |
| 19 | 94.0 | 95.2 | | Mechanical Cutter |
| 20 | 95.2 | 99.0 | | Mechanical Cutter |
| 21 | 99.0 | 101.8 | | Mechanical Cutter |
| 22 | 101.8 | 103.6 | | Mechanical Cutter |
| 23 | 103.6 | 105.6 | | Mechanical Cutter |
| 24 | 105.6 | 107.8 | | Mechanical Cutter |
| 25 | 107.8 | 112.4 | | Mechanical Cutter |
| 26 | 112.4 | 114.7 | | Mechanical Cutter |
| 27 | 114.7 | 121.7 | | Mechanical Cutter |
| 28 | 121.7 | 122.4 | | Mechanical Cutter |
| 29 | 122.4 | 127.1 | | Mechanical Cutter |
| 30 | 127.1 | 128.6 | 1st option: Plough + Jet Assist | 2nd option: Jet Trencher |
| 31 | 128.6 | 129.0 | | Mechanical Cutter |
| 32 | 129.0 | 129.7 | 1st option: Plough + Jet Assist | 2nd option: Jet Trencher |
| 33 | 129.7 | 130.5 | 1st option: Plough + Jet Assist | 2nd option: Jet Trencher |
| 34 | 130.5 | 159.0 | 1st option: Plough + Jet Assist | 2nd option: Jet Trencher |
| 35 | 159.0 | 176.2 | 1st option: Plough + Jet Assist | 2nd option: Jet Trencher |
| 36 | 176.2 | 190.4 | 1st option: Plough + Jet Assist | 2nd option: Jet Trencher |
| 37 | 190.4 | 192.5 | 1st option: Plough + Jet Assist | 2nd option: Jet Trencher |
| 38 | 192.5 | 194.4 | 1st option: Plough + Jet Assist | 2nd option: Jet Trencher |
| 39 | 194.4 | 196.2 | 1st option: Plough + Jet Assist | 2nd option: Jet Trencher |
| 40 | 196.2 | 203.200 | 1st option: Plough + Jet Assist | 2nd option: Jet Trencher |
| 41 | 203.2 | 205.400 | 1st option: Plough + Jet Assist | 2nd option: Jet Trencher |
| 42 | 205.4 | 224.100 | 1st option: Plough + Jet Assist | 2nd option: Jet Trencher |
| 43 | 224.1 | 226.800 | | Mechanical Cutter |
| 44 | 226.8 | 233.000 | 1st option: Plough + Jet Assist | 2nd option: Jet Trencher |
| 45 | 233.0 | 240.650 | | Mechanical Cutter |
| 46 | 240.7 | 245.200 | 1st option: Plough + Jet Assist | 2nd option: Jet Trencher |
| 47 | 245.2 | 251.000 | 1st option: Plough + Jet Assist | 2nd option: Jet Trencher |
| 48 | 251.0 | 252.800 | | Mechanical Cutter |
| 49 | 252.8 | 256.300 | | Mechanical Cutter |
| 50 | 256.3 | 262.850 | 1st option: Plough + Jet Assist | 2nd option: Jet Trencher |

# 16. BAS LITE – NETHERLANDS SECTOR

## 16.1. STEP 1 – Pre-Sweeping

PRIMO recommend that pre-sweeping be considered in areas with sand waves, and possibly in areas with larger size (height) mega ripples. A morpho-dynamics study is required to confirm whether any of these larger bedforms are indeed mobile or not. This document shall form the basis for the design of the final pre-sweeping strategy and scope.

The objective of pre-sweeping is to flatten the seabed and to increase the likelihood for successful cable lowering and burial below the (im-)mobile interface seabed level. Pre-sweeping would also reduce risks associated with slopes >15° during subsequent SLB, or PLB operations, where burial tool instability would otherwise likely become an issue with potential for damage to any of the asset(s).

Where boulders fields occur ("occasional", or "numerous" boulders), areas with trawl marks, relict seepage features, or eroded depressions, for example, these areas should be considered avoiding where possible, through micro-routing, or that boulders be removed, or that surface laid cable assets be protected through rock placement, mattresses, or otherwise.

**Table 16-1: NETHERLANDS Sector – Pre-Sweeping based on Bedform Segmentation**

| ID | KP FROM [km] | KP TO [km] | Length [m] | Bedform / Feature Type | Recommend Pre-Sweeping ? |
|---|---|---|---|---|---|
| 1 | 262.850 | 293.999 | 31149 | Sand Waves and Ripples | YES (only if mobile) |
| 2 | 293.999 | 304.479 | 10480 | Ripples | |
| 3 | 304.479 | 309.601 | 5122 | None | |
| 4 | 309.601 | 310.802 | 1201 | Trawl Mark | |
| 5 | 310.802 | 322.732 | 11930 | Relict Gas Seepage | Try avoiding via Micro-routing |
| 6 | 322.732 | 326.103 | 3370 | Trawl Mark | |
| 7 | 326.103 | 342.504 | 16401 | Relict Gas Seepage | Try avoiding via Micro-routing |
| 8 | 342.504 | 343.424 | 920 | None | |
| 9 | 343.424 | 343.710 | 286 | Relict Gas Seepage | Try avoiding via Micro-routing |
| 10 | 343.710 | 357.809 | 14099 | None | |
| 11 | 357.809 | 413.135 | 55327 | Trawl Mark | |
| 12 | 413.135 | 427.303 | 14168 | None | |
| 13 | 427.303 | 440.470 | 13166 | Trawl Mark | |
| 14 | 440.470 | 447.262 | 6793 | None | |
| 15 | 447.262 | 463.893 | 16631 | Trawl Mark | |
| 16 | 463.893 | 466.871 | 2978 | None | |
| 17 | 466.871 | 492.328 | 25457 | Trawl Mark | |
| 18 | 492.328 | 507.509 | 15181 | None | |
| 19 | 507.509 | 507.845 | 336 | Eroded Depressions | Try avoiding via Micro-routing |
| 20 | 507.845 | 507.962 | 117 | None | |
| 21 | 507.962 | 508.026 | 63 | Eroded Depressions | Try avoiding via Micro-routing |
| 22 | 508.026 | 508.679 | 653 | None | |
| 23 | 508.679 | 508.738 | 59 | Eroded Depressions | Try avoiding via Micro-routing |

| ID | KP FROM [km] | KP TO [km] | Length [m] | Bedform / Feature Type | Recommend Pre-Sweeping ? |
|---|---|---|---|---|---|
| 24 | 508.738 | 508.791 | 52 | None | |
| 26 | 508.791 | 508.820 | 29 | Eroded Depressions | Try avoiding via Micro-routing |
| 27 | 508.820 | 509.438 | 618 | None | |
| 28 | 509.438 | 509.490 | 52 | Eroded Depressions | Try avoiding via Micro-routing |
| 29 | 509.490 | 511.453 | 1963 | None | |
| 30 | 511.453 | 511.582 | 130 | Eroded Depressions | Try avoiding via Micro-routing |
| 31 | 511.582 | 512.316 | 733 | None | |
| 32 | 512.316 | 512.370 | 54 | Eroded Depressions | Try avoiding via Micro-routing |
| 33 | 512.370 | 514.159 | 1789 | None | |
| 34 | 514.159 | 515.072 | 913 | Eroded Depressions | Try avoiding via Micro-routing |
| 35 | 515.072 | 515.531 | 459 | None | |
| 36 | 515.531 | 516.037 | 506 | Eroded Depressions | |
| 37 | 516.037 | 516.498 | 461 | None | |
| 38 | 516.498 | 517.194 | 696 | Eroded Depressions | Try avoiding via Micro-routing |
| 39 | 517.194 | 518.548 | 1354 | None | |
| 40 | 518.548 | 518.688 | 140 | Eroded Depressions | Try avoiding via Micro-routing |
| 41 | 518.688 | 519.070 | 382 | None | |
| 42 | 519.070 | 519.116 | 46 | Eroded Depressions | Try avoiding via Micro-routing |
| 43 | 519.116 | 522.390 | 3274 | None | |
| 44 | 522.390 | 522.673 | 283 | Eroded Depressions | Try avoiding via Micro-routing |
| 45 | 522.673 | 523.037 | 364 | None | |
| 46 | 523.037 | 523.418 | 381 | Eroded Depressions | Try avoiding via Micro-routing |
| 47 | 523.418 | 620.287 | 96869 | None | |
| 48 | 620.287 | 622.900 | 2613 | Ripples | |

Areas with sand waves (wave height more than 3m) amount to 31149 m in total, equivalent to12.9% of The Netherlands Sector (260.05 km).

This sector includes numerous areas with trawl marks, relict gas seepage and eroded depression features.

Ongoing micro-routing will have to consider (if not being considered already) that those areas should avoided where feasible.

### 16.2. STEP 2 – Cable Burial

Similar to section 15.2, in areas where the target trench depth requirement is less than 2-2.5m (applies to the majority part of the NETHERLANDS sector - see Figure 11-6), and provided that pre-sweeping has taken place, PRIMO recommend that, the "Plough with Jet-Assist" should be considered as the principle tool for SLB operations.

This recommendation is based on the tool's burial depth capability, its ability to handle most soil types and strengths (other than stiff to very stiff CLAYS and fresh, competent ROCK), its operational reliability and efficiency, and despite the considerable number of crossings of other seabed or subsea services.

The ROV jet trencher could be an alternative concept to the plough, with similar depth capability. The range of soil types (and material) strengths that these machines can cope with, however, are somewhat narrowed when compared with the plough, with granular materials of up to very dense compaction states and CLAYS with up to medium strength all being jettable materials in principle.

For deeper installation, PRIMO recommend the Vertical Injector (VI) mounted on a jet-sled. This tool can achieve burial depths of up to 8 meters below seafloor level, in granular soils and low strength cohesive materials. PRIMO recommend that such a jetting sled be fitted with a long mechanical chain cutter able to deal with the harder cohesive type soils.

These tools are reliable and efficient (quick).

For areas with shallow geology comprising stiff to very stiff CLAY, or competent, fresh ROCK, the only tools that can feasibly handle these are the mechanical cutter trenchers.

Based on these principles, PRIMO have made their burial tool selection, as summarised in the Table 15-2 below, to be read in conjunction with the earlier Table 13-3 where shallow geology segmentation is summarised. Segments with deep burial requirements are marked through red font (none for NETHS sector).

**Table 16-2: NETHERLANDS Sector – Proposed Burial Techniques based on Shallow Geology Segmentation**

| ID | KP FROM [km] | KP To [km] | Proposed Techniques for SLB only | Proposed Techniques for SLB as well as PLB |
|---|---|---|---|---|
| 1 | 262.850 | 328.500 | 1st option: Plough + Jet Assist | 2nd option: Jet Trencher |
| 2 | 328.500 | 351.600 | 1st option: Plough + Jet Assist | 2nd option: Jet Trencher |
| 3 | 351.600 | 354.700 | 1st option: Plough + Jet Assist | 2nd option: Jet Trencher |
| 4 | 354.700 | 360.700 | 1st option: Plough + Jet Assist | 2nd option: Jet Trencher |
| 5 | 360.700 | 362.600 | 1st option: Plough + Jet Assist | 2nd option: Jet Trencher |
| 6 | 362.600 | 363.800 | 1st option: Plough + Jet Assist | 2nd option: Jet Trencher |
| 7 | 363.800 | 368.700 | 1st option: Plough + Jet Assist | 2nd option: Jet Trencher |
| 8 | 368.700 | 369.500 | 1st option: Plough + Jet Assist | 2nd option: Jet Trencher |
| 9 | 369.500 | 370.800 | 1st option: Plough + Jet Assist | 2nd option: Jet Trencher |

| ID | KP FROM [km] | KP To [km] | Proposed Techniques for SLB only | Proposed Techniques for SLB as well as PLB |
|---|---|---|---|---|
| 10 | 370.800 | 371.400 | 1st option: Plough + Jet Assist | 2nd option: Jet Trencher |
| 11 | 371.400 | 374.400 | 1st option: Plough + Jet Assist | 2nd option: Jet Trencher |
| 12 | 374.400 | 377.800 | 1st option: Plough + Jet Assist | 2nd option: Jet Trencher |
| 13 | 377.800 | 381.600 | 1st option: Plough + Jet Assist | 2nd option: Jet Trencher |
| 14 | 381.600 | 386.800 | 1st option: Plough + Jet Assist | 2nd option: Jet Trencher |
| 15 | 386.800 | 387.700 | 1st option: Plough + Jet Assist | 2nd option: Jet Trencher |
| 16 | 387.700 | 400.900 | 1st option: Plough + Jet Assist | 2nd option: Jet Trencher |
| 17 | 400.900 | 406.700 | 1st option: Plough + Jet Assist | 2nd option: Jet Trencher |
| 18 | 406.700 | 429.500 | 1st option: Plough + Jet Assist | 2nd option: Jet Trencher |
| 19 | 429.500 | 434.300 | 1st option: Plough + Jet Assist | 2nd option: Jet Trencher |
| 20 | 434.300 | 438.400 | 1st option: Plough + Jet Assist | 2nd option: Jet Trencher |
| 21 | 438.400 | 457.100 | 1st option: Plough + Jet Assist | 2nd option: Jet Trencher |
| 22 | 457.100 | 461.400 | 1st option: Plough + Jet Assist | 2nd option: Jet Trencher |
| 23 | 461.400 | 465.000 | 1st option: Plough + Jet Assist | 2nd option: Jet Trencher |
| 24 | 465.000 | 465.400 | 1st option: Plough + Jet Assist | 2nd option: Jet Trencher |
| 25 | 465.400 | 467.700 | 1st option: Plough + Jet Assist | 2nd option: Jet Trencher |
| 26 | 467.700 | 476.000 | 1st option: Plough + Jet Assist | 2nd option: Jet Trencher |
| 27 | 476.000 | 476.500 | 1st option: Plough + Jet Assist | 2nd option: Jet Trencher |
| 28 | 476.500 | 482.200 | 1st option: Plough + Jet Assist | 2nd option: Jet Trencher |
| 29 | 482.200 | 483.500 | 1st option: Plough + Jet Assist | 2nd option: Jet Trencher |
| 30 | 483.500 | 485.900 | 1st option: Plough + Jet Assist | 2nd option: Jet Trencher |
| 31 | 485.900 | 486.500 | 1st option: Plough + Jet Assist | 2nd option: Jet Trencher |
| 32 | 486.500 | 488.200 | 1st option: Plough + Jet Assist | 2nd option: Jet Trencher |
| 33 | 488.200 | 490.700 | 1st option: Plough + Jet Assist | 2nd option: Jet Trencher |
| 34 | 490.700 | 493.100 | 1st option: Plough + Jet Assist | 2nd option: Jet Trencher |
| 35 | 493.100 | 497.000 | 1st option: Plough + Jet Assist | 2nd option: Jet Trencher |
| 36 | 497.000 | 498.000 | 1st option: Plough + Jet Assist | 2nd option: Jet Trencher |
| 37 | 498.000 | 499.300 | 1st option: Plough + Jet Assist | 2nd option: Jet Trencher |
| 38 | 499.300 | 500.500 | 1st option: Plough + Jet Assist | 2nd option: Jet Trencher |
| 39 | 500.500 | 501.400 | 1st option: Plough + Jet Assist | 2nd option: Jet Trencher |
| 40 | 501.400 | 502.800 | 1st option: Plough + Jet Assist | 2nd option: Jet Trencher |

| ID | KP FROM [km] | KP To [km] | Proposed Techniques for SLB only | Proposed Techniques for SLB as well as PLB |
|---|---|---|---|---|
| 41 | 502.800 | 504.800 | 1st option: Plough + Jet Assist | 2nd option: Jet Trencher |
| 42 | 504.800 | 505.400 | 1st option: Plough + Jet Assist | 2nd option: Jet Trencher |
| 43 | 505.400 | 522.900 | 1st option: Plough + Jet Assist | 2nd option: Jet Trencher |

# 17. BAS LITE – GERMANY SECTOR

## 17.1. STEP 1 – Pre-Sweeping

PRIMO recommend that pre-sweeping be considered in areas with sand waves, and possibly in areas with larger size (height) mega ripples. A morpho-dynamics study is required to confirm whether any of these larger bedforms are indeed mobile or not. This document shall form the basis for the design of the final pre-sweeping strategy and scope.

The objective of pre-sweeping is to flatten the seabed and to increase the likelihood for successful cable lowering and burial below the (im-)mobile interface seabed level. Pre-sweeping would also reduce risks associated with slopes >15° during subsequent SLB, or PLB operations, where burial tool instability would otherwise likely become an issue with potential for damage to any of the asset(s).

Where boulders fields occur ("occasional", or "numerous" boulders), areas with trawl marks, relict seepage features, or eroded depressions, for example, these areas should be considered avoiding where possible, through micro-routing, or that boulders be removed, or that surface laid cable assets be protected through rock placement, mattresses, or otherwise.

**Table 17-1: GERMANY Sector – Pre-Sweeping based on Bedform Segmentation**

| ID | KP FROM [km] | KP TO [km] | Length [m] | Bedform / Feature Type | Recommend Pre-Sweeping? |
|---|---|---|---|---|---|
| 1 | 622.900 | 623.790 | 890 | Ripples | |
| 2 | 623.790 | 636.703 | 12913 | None | |
| 3 | 636.703 | 637.799 | 1096 | Ripples | |
| 4 | 637.799 | 650.274 | 12475 | None | |
| 5 | 650.274 | 651.000 | 726 | "Occasional" Boulders | Avoided via Micro-routing |
| 6 | 651.000 | 652.219 | 1220 | None | |
| 7 | 652.219 | 652.671 | 452 | Ripples | |
| 8 | 652.671 | 653.935 | 1263 | None | |
| 9 | 653.935 | 654.207 | 273 | "Occasional" Boulders | Avoided via Micro-routing |
| 10 | 654.207 | 654.713 | 506 | Ripples | |
| 11 | 654.713 | 658.578 | 3865 | None | |
| 12 | 658.578 | 658.745 | 167 | Ripples | |
| 13 | 658.745 | 659.801 | 1056 | None | |
| 14 | 659.801 | 660.929 | 2383 | Ripples | |
| 15 | 662.183 | 662.571 | 388 | None | |
| 16 | 662.571 | 662.631 | 1229 | Ripples | |
| 17 | 663.800 | 664.587 | 890 | None | |
| 18 | 664.690 | 665.104 | 1119 | "Occasional" Boulders | Avoided via Micro-routing |
| 19 | 665.809 | 667.205 | 1396 | Ripples | |
| 20 | 667.205 | 667.775 | 569 | None | |
| 21 | 667.775 | 669.020 | 1245 | Ripples | |
| 22 | 669.020 | 669.399 | 381 | None | |
| 23 | 669.401 | 669.592 | 191 | Current Lineation | |
| 24 | 669.592 | 669.740 | 148 | Ripples | |

| ID | KP FROM [km] | KP TO [km] | Length [m] | Bedform / Feature Type | Recommend Pre-Sweeping? |
|---|---|---|---|---|---|
| 25 | 669.740 | 669.791 | 51 | None | |
| 26 | 669.791 | 669.954 | 162 | Current Lineation | |
| 27 | 669.954 | 671.313 | 1359 | Mega Ripples | YES (larger mega ripples) – only if mobile |
| 28 | 671.313 | 672.574 | 1261 | None | |
| 29 | 672.574 | 672.842 | 269 | Mega Ripples | YES (larger mega ripples) – only if mobile |
| 30 | 672.842 | 673.329 | 619 | Ripples | |
| 31 | 673.461 | 673.467 | 55 | Sand Waves | YES (only if mobile) |
| 32 | 673.516 | 673.926 | 411 | Ripples | |
| 33 | 673.926 | 674.133 | 206 | Mega Ripples | YES (larger mega ripples) – only if mobile |
| 34 | 674.133 | 676.465 | 2332 | None | |
| 35 | 676.465 | 676.514 | 49 | Sand Waves | YES (only if mobile) |
| 36 | 676.514 | 676.600 | 87 | None | |
| 37 | 676.600 | 676.667 | 67 | Mega Ripples | YES (larger mega ripples) – only if mobile |
| 38 | 676.667 | 676.817 | 151 | None | |
| 39 | 676.817 | 676.931 | 114 | Mega Ripples | YES (larger mega ripples) – only if mobile |
| 40 | 676.931 | 677.044 | 113 | Ripples | |
| 41 | 677.044 | 677.335 | 291 | Mega Ripples | YES (larger mega ripples) – only if mobile |
| 42 | 677.335 | 678.197 | 862 | Ripples | |
| 43 | 678.197 | 678.306 | 109 | Mega Ripples | YES (larger mega ripples) – only if mobile |
| 44 | 678.306 | 679.114 | 809 | None | |
| 45 | 679.114 | 679.291 | 177 | Mega Ripples | YES (larger mega ripples) – only if mobile |
| 46 | 679.291 | 679.379 | 212 | Ripples | |
| 47 | 679.503 | 679.555 | 52 | Sand Waves | YES (only if mobile) |
| 48 | 679.555 | 679.840 | 392 | Ripples | |
| 49 | 679.947 | 680.161 | 330 | Mega Ripples | YES (larger mega ripples) – only if mobile |
| 50 | 680.276 | 680.414 | 201 | Sand Waves | YES (only if mobile) |
| 51 | 680.478 | 680.554 | 76 | None | |
| 52 | 680.554 | 680.710 | 879 | Ripples | |
| 53 | 681.433 | 681.722 | 289 | Mega Ripples | YES (larger mega ripples) – only if mobile |
| 54 | 681.722 | 681.880 | 158 | None | |
| 55 | 681.880 | 681.949 | 69 | Mega Ripples | YES (larger mega ripples) – only if mobile |
| 56 | 681.949 | 682.508 | 560 | Ripples | |
| 57 | 682.508 | 682.890 | 382 | None | |
| 58 | 682.890 | 683.040 | 378 | Ripples | |

| ID | KP FROM [km] | KP TO [km] | Length [m] | Bedform / Feature Type | Recommend Pre-Sweeping? |
|---|---|---|---|---|---|
| 59 | 683.268 | 683.717 | 448 | None | |
| 60 | 683.717 | 683.861 | 343 | Mega Ripples | YES (larger mega ripples) – only if mobile |
| 61 | 684.060 | 685.295 | 2992 | None | |
| 62 | 687.052 | 687.735 | 683 | Ripples | |
| 63 | 687.735 | 687.925 | 191 | None | |
| 64 | 687.925 | 689.398 | 1473 | Ripples | |
| 65 | 689.398 | 689.576 | 1721 | Sand Waves | YES (only if mobile) |
| 66 | 691.119 | 691.197 | 79 | Ripples | |
| 67 | 691.197 | 691.679 | 482 | "Numerous" Boulders | Avoided via Micro-routing |
| 68 | 691.679 | 693.380 | 2782 | Ripples | |
| 69 | 694.461 | 694.734 | 274 | None | |
| 70 | 694.734 | 695.097 | 880 | Ripples | |
| 71 | 695.615 | 695.660 | 45 | Sand Waves | YES (only if mobile) |
| 72 | 695.660 | 695.962 | 302 | Ripples | |
| 73 | 695.962 | 696.041 | 238 | Sand Waves | YES (only if mobile) |
| 74 | 696.200 | 696.213 | 12 | None | |
| 75 | 696.213 | 696.262 | 49 | Ripples | |
| 76 | 696.262 | 696.430 | 168 | None | |
| 77 | 696.430 | 696.585 | 155 | Ripples | |
| 78 | 696.585 | 696.632 | 47 | None | |
| 79 | 696.632 | 696.902 | 269 | Sand Waves | YES (only if mobile) |
| 80 | 696.902 | 696.911 | 10 | None | |
| 81 | 696.911 | 696.941 | 766 | "Occasional" Boulders | Avoided via Micro-routing |
| 82 | 697.677 | 697.883 | 716 | "Numerous" Boulders | Avoided via Micro-routing |
| 83 | 698.393 | 698.422 | 28 | "Occasional" Boulders | Avoided via Micro-routing |
| 84 | 698.422 | 698.507 | 252 | None | |
| 85 | 698.674 | 698.962 | 363 | "Occasional" Boulders | Avoided via Micro-routing |
| 86 | 699.011 | 699.153 | 142 | Mega Ripples | YES (larger mega ripples) – only if mobile |
| 87 | 699.153 | 699.244 | 91 | Ripples | |
| 88 | 699.244 | 699.398 | 154 | None | |
| 89 | 699.398 | 699.804 | 405 | Ripples | |
| 90 | 699.804 | 700.700 | 896 | None | |

Areas with sand waves (wave height more than 3m) and mega ripples amount to 6394 m in total, equivalent to 3.6% of the GERMANY Sector (177.25 km).

Areas with "occasional" and "numerous" boulders amount to 4473 m in total, equivalent to 2.5% of the GERMANY sector.

Ongoing micro-routing will have to consider (if not being considered already) that those areas should avoided where feasible.

### 17.2. STEP 2 – Cable Burial

Similar to sections 15.2 and 16.2, in areas where the target trench depth requirement is less than 2-2.5m (applies to approximately the first 50% of the GERMANY sector – see Figure 11-9), and provided that pre-sweeping has taken place, PRIMO recommend that, the "Plough with Jet-Assist" should be considered as the principle tool for SLB operations.

This recommendation is based on the tool's burial depth capability, its ability to handle most soil types and strengths (other than stiff to very stiff CLAYS and fresh, competent ROCK), its operational reliability and efficiency, and despite the considerable number of crossings of other seabed or subsea services.

The ROV jet trencher could be an alternative concept to the plough, with similar depth capability. The range of soil types (and material) strengths that these machines can cope with, however, are somewhat narrowed when compared with the plough, with granular materials of up to very dense compaction states and CLAYS with up to medium strength all being jettable materials in principle.

For deeper installation, applies to the majority of the latter 50km of the GERMANY sector, PRIMO recommend the Vertical Injector (VI) mounted on a jet-sled. This tool can achieve burial depths of up to 8 meters below seafloor level, in granular soils and low strength cohesive materials. PRIMO recommend that such a jetting sled be fitted with a long mechanical chain cutter able to deal with the harder cohesive type soils.

These tools are reliable and efficient (quick).

For areas with shallow geology comprising stiff to very stiff CLAY, or competent, fresh ROCK, the only tools that can feasibly handle these are the mechanical cutter trenchers.

Based on these principles, PRIMO have made their burial tool selection, as summarised in the Table 17-2 below, to be read in conjunction with the earlier Table 14-3 where shallow geology segmentation is summarised.

Segments with deep burial requirements are marked through red font. Burial requirements for segments KP613-KP619 are being discussed and are yet to be confirmed. Same applies the majority of the latter 50km segment. Conservative for now would be to assume that the TTD is in the order of 5-5.5m.

**Table 17-2: GERMANY Sector – Proposed Burial Techniques based on Shallow Geology Segmentation**

| ID | KP FROM | KP TO | Proposed Techniques for SLB only | Proposed Techniques for SLB as well as PLB |
|---|---|---|---|---|
| 1 | 522.900 | 527.500 | 1st option: Plough + Jet Assist | 2nd option: Jet Trencher |
| 2 | 527.500 | 528.600 | 1st option: Plough + Jet Assist | 2nd option: Jet Trencher |
| 3 | 528.600 | 542.000 | 1st option: Plough + Jet Assist | 2nd option: Jet Trencher |
| 4 | 542.000 | 542.700 | 1st option: Plough + Jet Assist | 2nd option: Jet Trencher |
| 5 | 542.700 | 577.200 | 1st option: Plough + Jet Assist | 2nd option: Jet Trencher |
| 6 | 577.200 | 580.400 | 1st option: Plough + Jet Assist | 2nd option: Jet Trencher |

| ID | KP FROM | KP TO | Proposed Techniques for SLB only | Proposed Techniques for SLB as well as PLB |
|---|---|---|---|---|
| 7 | 580.400 | 589.100 | 1st option: Plough + Jet Assist | 2nd option: Jet Trencher |
| 8 | 589.100 | 592.400 | 1st option: Plough + Jet Assist | 2nd option: Jet Trencher |
| 9 | 592.400 | 595.500 | 1st option: Plough + Jet Assist | 2nd option: Jet Trencher |
| 10 | 595.500 | 602.100 | 1st option: Plough + Jet Assist | 2nd option: Jet Trencher |
| 11 | 602.100 | 603.200 | 1st option: Plough + Jet Assist | 2nd option: Jet Trencher |
| 12 | 602.100 | 613.000 | 1st option: Plough + Jet Assist | 2nd option: Jet Trencher |
| **13** | **613.000** | **619.000** | **1st Option: Jet Sled with VI** | |
| 14 | 619.000 | 629.900 | 1st option: Plough + Jet Assist | 2nd option: Jet Trencher |
| 15 | 629.900 | 631.500 | | Mechanical Cutter |
| 16 | 631.500 | 638.700 | 1st option: Plough + Jet Assist | 2nd option: Jet Trencher |
| 17 | 638.700 | 640.000 | 1st option: Plough + Jet Assist | 2nd option: Jet Trencher |
| 18 | 640.000 | 646.200 | 1st option: Plough + Jet Assist | 2nd option: Jet Trencher |
| 19 | 646.200 | 649.300 | 1st option: Plough + Jet Assist | 2nd option: Jet Trencher |
| **20** | **649.300** | **656.000** | **1st Option: Jet Sled with VI** | |
| **21** | **656.000** | **672.600** | **1st Option: Jet Sled with VI** | |
| **22** | **672.600** | **676.200** | **1st Option: Jet Sled with VI** | |
| **23** | **676.200** | **679.900** | **1st Option: Jet Sled with VI** | |
| **24** | **679.900** | **681.900** | **1st Option: Jet Sled with VI** | |
| **25** | **681.900** | **686.800** | **1st Option: Jet Sled with VI** | |
| **26** | **686.800** | **690.300** | **1st Option: Jet Sled with VI** | |
| **27** | **690.300** | **692.700** | **1st Option: Jet Sled with VI** | |
| **28** | **692.700** | **695.200** | **1st Option: Jet Sled with VI** | |
| **29** | **695.200** | **696.500** | **1st Option: Jet Sled with VI** | |
| **30** | **696.500** | **697.200** | **1st Option: Jet Sled with VI** | |
| **31** | **697.200** | **698.400** | **1st Option: Jet Sled with VI** | |
| **32** | **698.400** | **699.400** | **1st Option: Jet Sled with VI** | |
| **33** | **699.400** | **699.800** | **1st Option: Jet Sled with VI** | |
| **34** | **699.800** | **700.700** | **1st Option: Jet Sled with VI** | |

## 18. CONCLUSIONS AND RECOMMENDATIONS – UK SECTOR

Conclusions and recommendations are as follows:

1. The CBRA has been reviewed.

   PRIMO recommend seeking clarification as to the large margin applied to the calculated RMDOL to arrive at TDOL. For the very large majority part of the UK sector, the RMDOL has been calculated to be at less than 1.0m below seafloor whilst the TDOL would appear to be set at a fixed 1.5m below seafloor.

   A reduction of this margin of 0.5m+ with, say, 0.2m, down to 0.3m+, would still be adequate considering RMDOL already has an appropriate factor of safety built-in of 20%.

   Overall this then reduces the TTD to within the lower end of the 1.5m – 2m range, as opposed to the upper end at which it currently sits. This would make a significant difference in the available range of capable and suitable tools to carry out the works, and at competitive prices.

   The CBRA should be re-assessed (optimised) taking the client-specified CAPEX/OPEX/TOTEX strategies into account.

2. Lifetime OPEX can be significantly affected by bedform migration potentially leading to either exposure or over-burial of the cable, if not properly catered for during design and installation.

   PRIMO recommend that a detailed morpho-dynamics desk study be carried out for the entire route, including the landfall areas, to establish seabed mobility in relation to the larger bedforms.

3. The survey deliverables that were made available for this study, particularly the geophysical reports, the GIS database, and the Crossing Reports, do NOT have "final approved" status.

   It is highly advisable that final approved survey end-deliverables are being requested from MMT seeing these will form key input data to a BAS "Proper".

4. No electronic geotechnical data files have been made available. That has not affected the BAS Lite as such, but these data are essential to inform a BAS Proper in due course. These data include:

   - All CPT data files (XLSX or ASCII data formats);
   - All laboratory test data (XLS).

5. No cable details could be made available at the time of this study. A future Bas "Proper" study would ideally require details such as diameter, minimum bending radius and maximum burial depth.

6. A detailed assessment of available geophysical GIS data has highlighted that there is a further opportunity for micro-routing, other than avoidance of areas with onerous bedforms, areas with boulders etc – the shallow geology isopachs allow for (very) high strength CLAY areas to be identified for avoidance, with accuracy.

7. The UK Sector is complex with numerous occurrences of large and mobile bedforms, "occasional boulder" fields, as well as the variation in shallow geology ranging from very soft / loose materials to very high strength clays.

Shallow-geology wise, this sector has large stretches of the route where high strength (stiff) to very high strength (very stiff) CLAYS occur within the TTD zone.

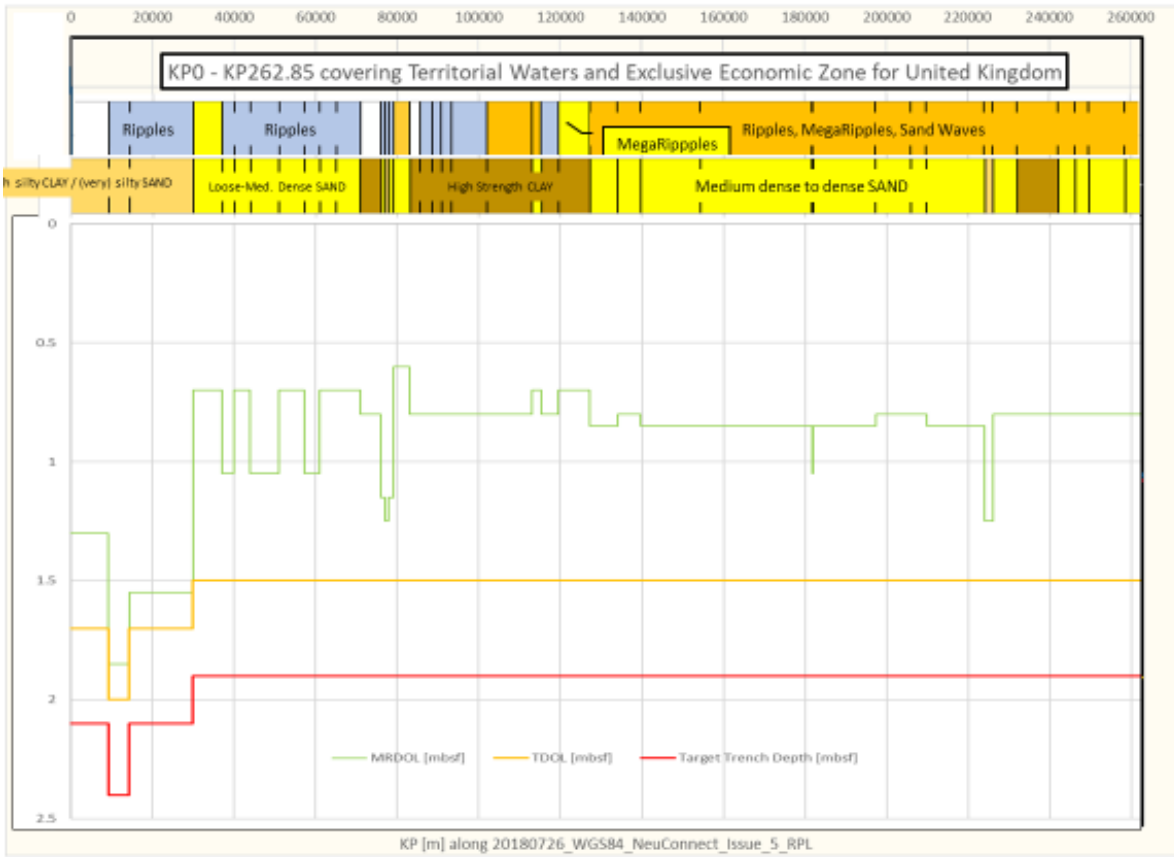
No rock, and no peat was encountered in this sector, at least not within the zone of interest (TTD).

In addition, there are some 31 crossings in this UK sector alone (12x in-service, 18x OOS, 1x planned).

Areas with sand waves amount to 105.448 km in total (40.1% of UK Sector).
Areas with occasional boulders amount to 2,146m in total (0.8% of UK Sector).

The Figure 18-1 below provides a useful summary of the CBRA results showing segmentation of bedforms, shallow geology and burial requirements in one snapshot. Note however that PRIMO's shallow geology segmentation is shown in detail in Appendix C1 (UK Sector) and considered a refinement of the one shown below.

**Figure 18-1: CBRA summary for UK Sector (showing Burial Requirement Profiles)**



8. PRIMO recommend a two-step seabed intervention strategy as follows:

   a) Step 1: pre-sweeping of areas with larger bedforms but only where these are confirmed to be mobile.

      Pre-sweeping should be carried out using Trailer Suction Hopper Dredging techniques.

   b) Step 2: burial of the assets using either SLB or PLB techniques.

   There is not one trenching system that is better or to be preferred over others. Each trenching system has its own advantages and disadvantages. This will have to be carefully assessed in a future BAS Proper, against the shallow geological conditions, the bedforms, the final TTDs along the cable route.

   The recommended burial tool in ground conditions other than (very) high strengths CLAY, and to target depths less than 2-2.5m below the seafloor, is the "plough with jet-assist". The alternative to the plough would be the water jet trencher.

   In areas with high to very high strength CLAYS, a mechanical cutter is recommended.

## 19. CONCLUSIONS AND RECOMMENDATIONS – NETHERLANDS SECTOR

1. Conclusions 1 through 6 from previous section 18 apply to the NETHERLANDS sector.

2. In terms of bedforms, the NETHERLANDS sector starts a 60km long sand wave area between approximately KP263 – KP323. The remainder of this sector has no bedforms of significance.

3. In shallow geology terms, the entire sector comprises of soils that are generally of low risk to cable burial operations – only granular type soils and low to medium strength CLAYS.

4. Similar to the UK Sector, PRIMO recommend a two-step seabed intervention strategy as follows:

   a) Step 1: pre-sweeping of the area with larger bedforms but only where these are confirmed to be mobile.

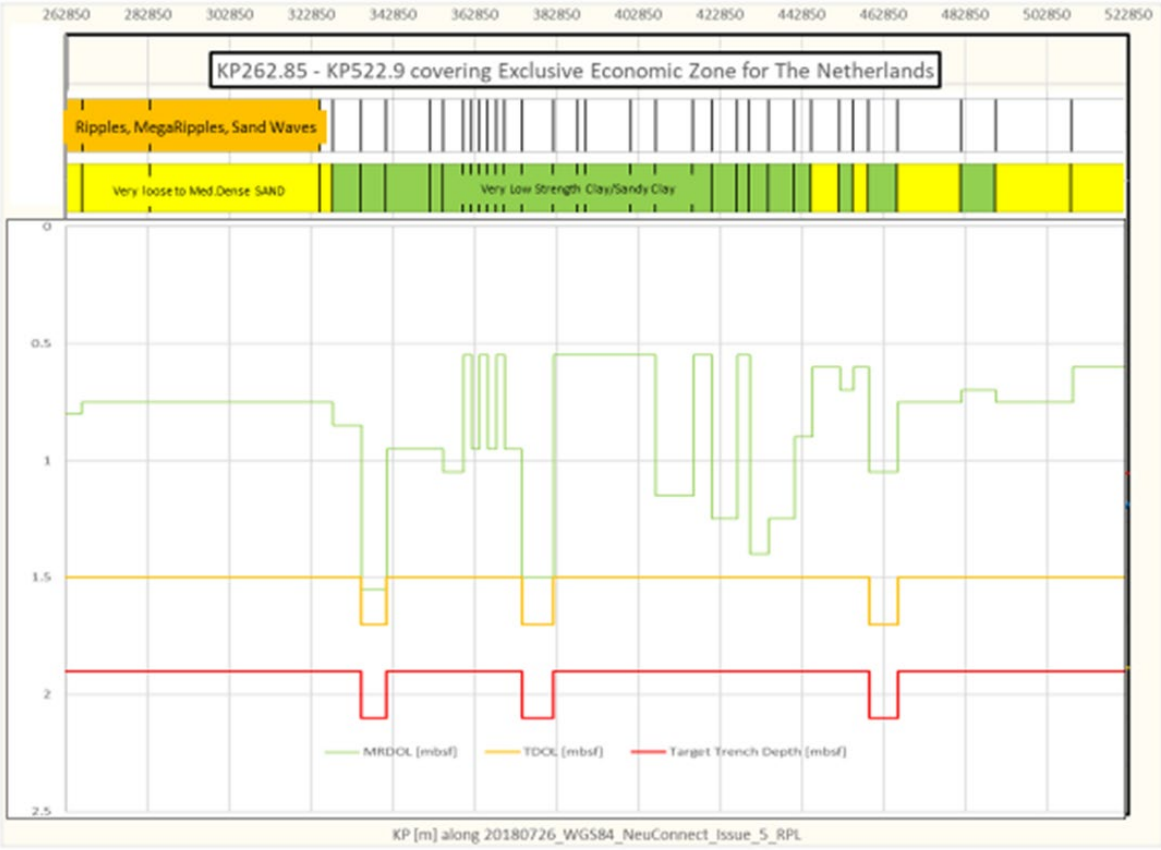
      Pre-sweeping should be carried out using Trailer Suction Hopper Dredging techniques.

   b) Step 2: burial of the assets using either SLB or PLB techniques.

   The recommended burial tool in these ground conditions, and for target depths less than 2-2.5m below the seafloor, is the "plough with jet-assist". The alternative to the plough would be the water jet trencher.

   The Figure 19-1 below provides a useful summary of the CBRA results showing segmentation of bedforms, shallow geology and burial requirements in one snapshot. Note however that PRIMO's shallow geology segmentation is shown in detail in Appendix C2 (NETHS Sector) and considered a refinement of the one shown below.

**Figure 19-1: CBRA summary for NETHERLANDS Sector (showing Burial Requirement Profiles)**



## 20. CONCLUSIONS AND RECOMMENDATIONS – GERMANY SECTOR [HOLD]

1. Conclusions 1 through 6 from section 18 apply to the GERMANY sector.

2. The full German route sector will be re-surveyed during the summer months of 2019. These BAS Lite results and the conclusions therefore may only be applicable in a general sense as these may have to be revised once the new to be-acquired survey data becomes available.

3. Similarly, the outstanding "Block 15" geotechnical data acquisition is scheduled to take place during summer of 2019. BAS Lite conclusion may only be applicable in a general sense as these may have to be revised once the new to be-acquired data becomes available.

4. In terms of bedform and seabed features, the last 50km of the GERMANY sector between KP650 and KP700 comprises areas with intermittent sand waves and mega ripples, and "occasional" and even "numerous" boulders.

   Areas with sand waves (wave height more than 3m) and mega ripples amount to 6394 m in total, equivalent to 3.6% of the GERMANY Sector (177.25 km).

   Areas with "occasional" and "numerous" boulders amount to 4473 m in total, equivalent to 2.5% of the GERMANY sector.

   Through micro-routing, boulder "anomalies" have largely been avoided.

5. Shallow geology -wise, this GERMANY route sector appears to predominantly comprise of granular materials apart from one 1.5km long area, between KP630 and KP631.5, where high strength CLAYS were encountered.

   PEAT layers occur intermittently but throughout the GERMANY sector, within the TTD zone.

6. Similar to UK and NETHS Sectors, PRIMO recommend a two-step seabed intervention strategy as follows:

   a) Step 1: pre-sweeping of areas with larger bedforms but only where these are confirmed to be mobile.

      Pre-sweeping should be carried out using Trailer Suction Hopper Dredging techniques.

   b) Step 2: burial of the assets using either SLB or PLB techniques.

   The recommended burial tool in these ground conditions, and for target depths less than 2-2.5m below the seafloor, is the "plough with jet-assist". The alternative to the plough would be the water jet trencher.

   In areas that require burial to depth much deeper than 2-2.5m, the Vertical Injector Sled is recommended.

   The Figure 20-1 below provides a useful summary of the CBRA results showing segmentation of bedforms, shallow geology and burial requirements in one snapshot. Note however that PRIMO's

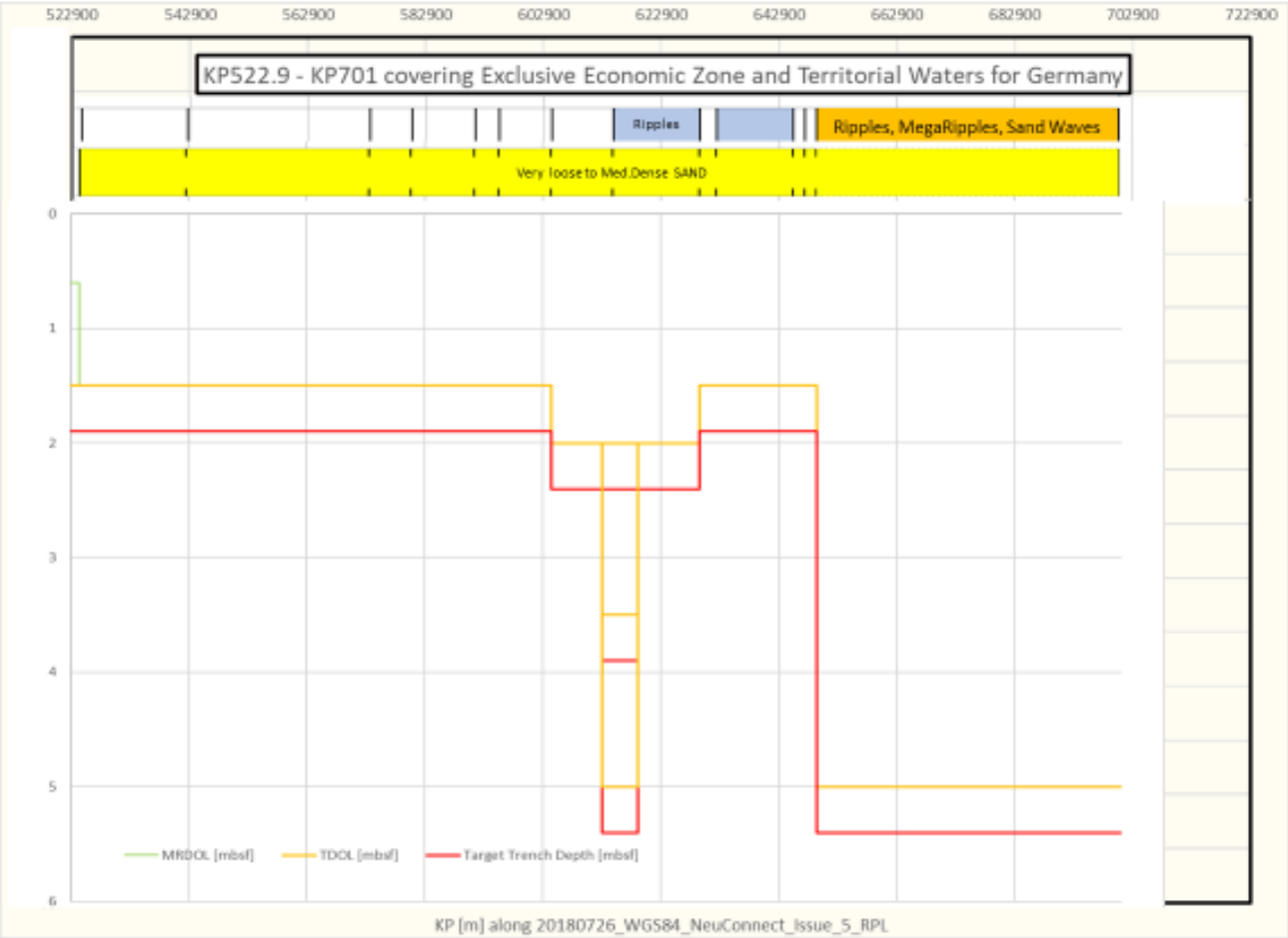
shallow geology segmentation is shown in detail in Appendix C3 (GERMANY Sector) and considered a refinement of the one shown below.

A non-heave compensated VI trenching operation should be limited to short sections, closer to shore.

For sections with significant swell, and further offshore, a jetting sledge with VI is recommended as it is safer to operate and less risky to cable integrity.

The implications of swell on the operations with the latter type trenchers is to be carefully considered.

**Figure 20-1: CBRA summary for GERMANY Sector (showing Burial Requirement Profiles)**



**APPENDIX A – Route Position List**

20180726_NeuConnect_Issue_5_RPL.xls

**APPENDIX B – CBRA Summary**

Appendix B1 – Sector: United Kingdom
Appendix B2 – Sector: The Netherlands
Appendix B3 – Sector: Germany

**APPENDIX B1 – CBRA Summary (Sector: United Kingdom)**

**Figure B1- 1: UK SECTOR, CBRA RESULTS SUMMARY - Water Depth Profile + Bedforms & Shallow Geology**

**Figure B1- 2: UK SECTOR CBRA RESULTS SUMMARY - Blocks, Sections + Bedforms & Shallow Geology**

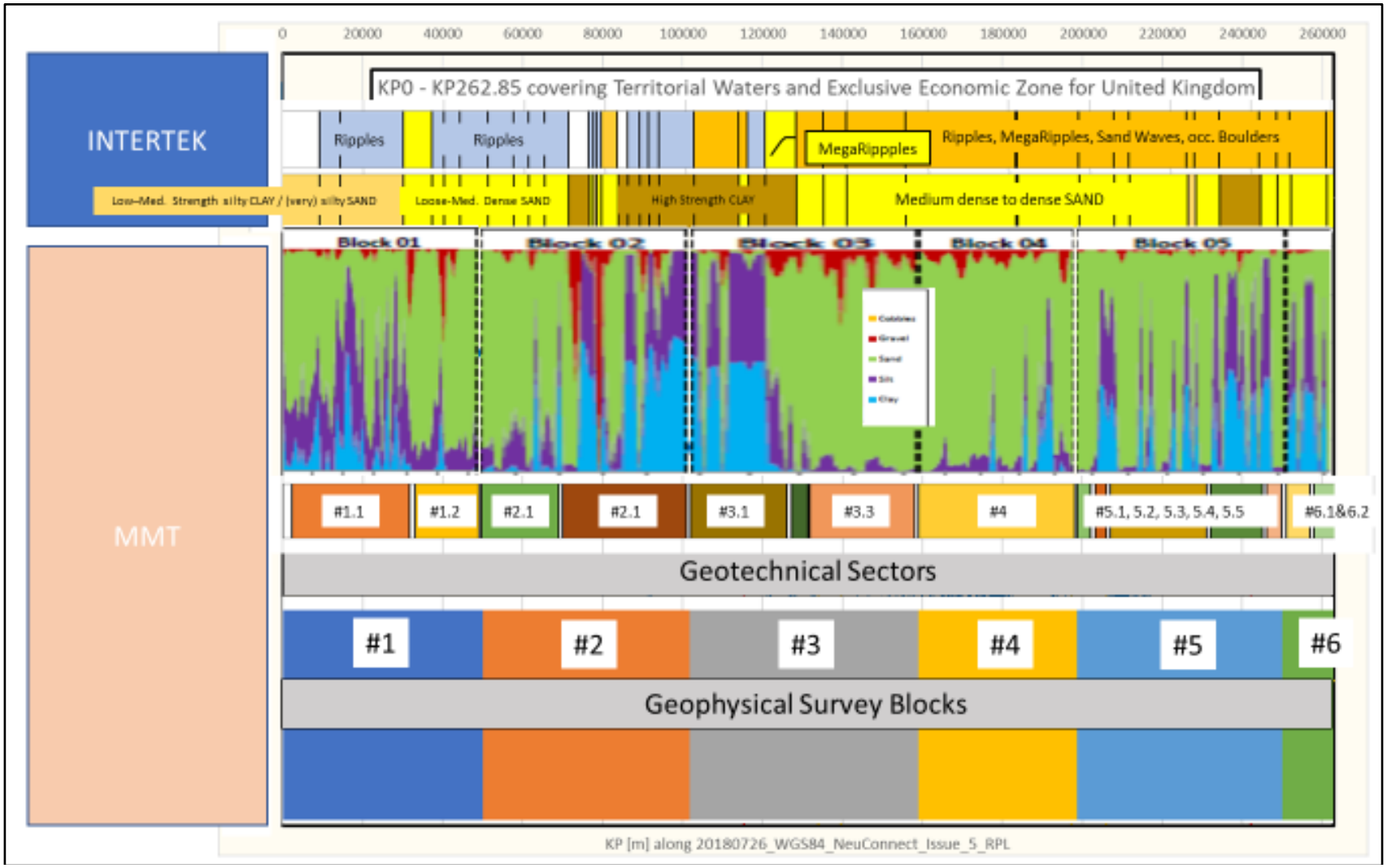
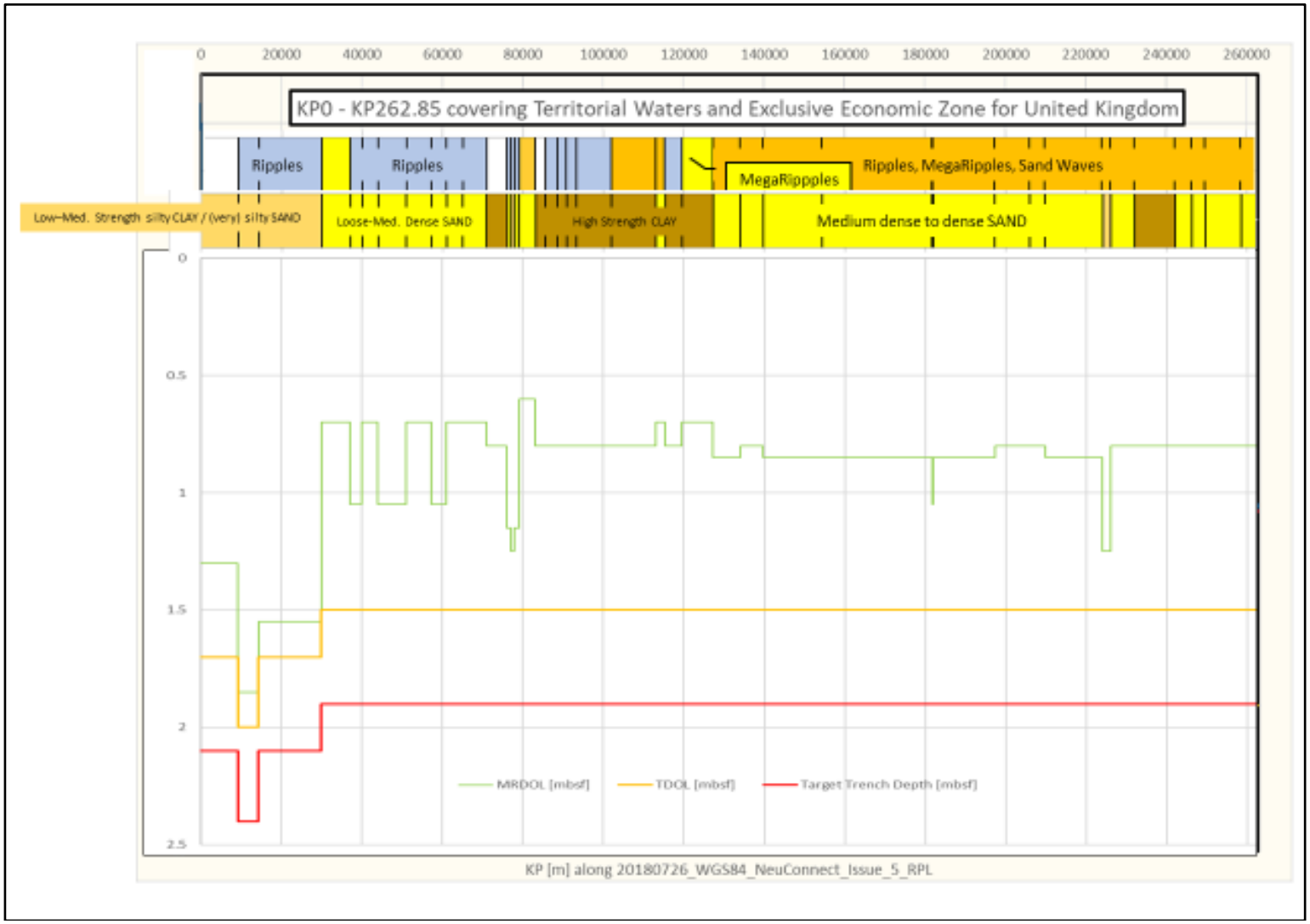


**Figure B1- 3: UK SECTOR CBRA RESULTS SUMMARY - RMDOL, TDOL, TTD + Bedforms & Shallow Geology**



**APPENDIX B2 – CBRA Summary (Sector: The Netherlands)**

**Figure B2- 1: NETHS SECTOR, CBRA RESULTS SUMMARY - Water Depth Profile + Bedforms & Shallow Geology**

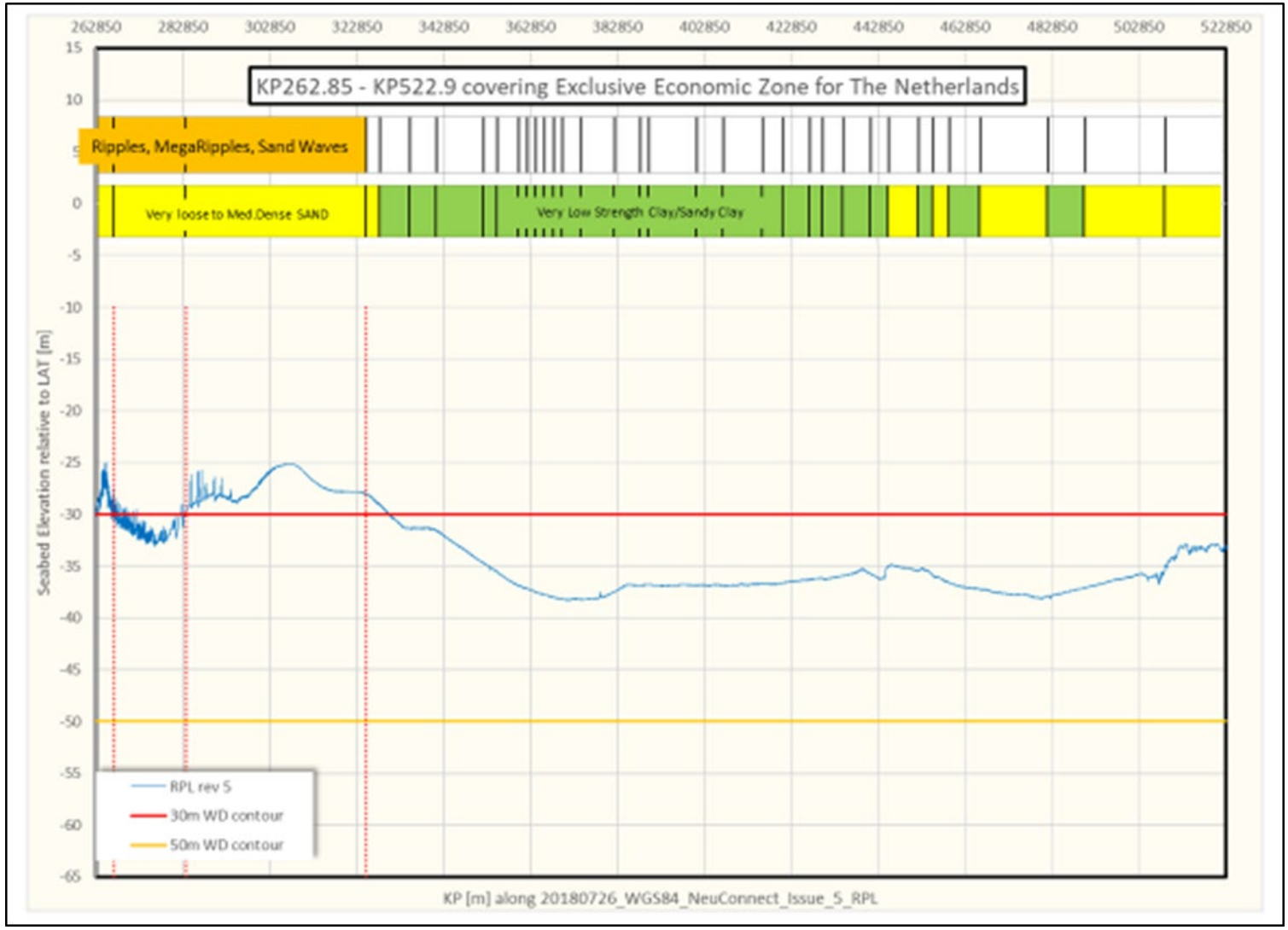


**Figure B2- 2: NETHS SECTOR, CBRA RESULTS SUMMARY - Blocks, Sections + Bedforms & Shallow Geology**

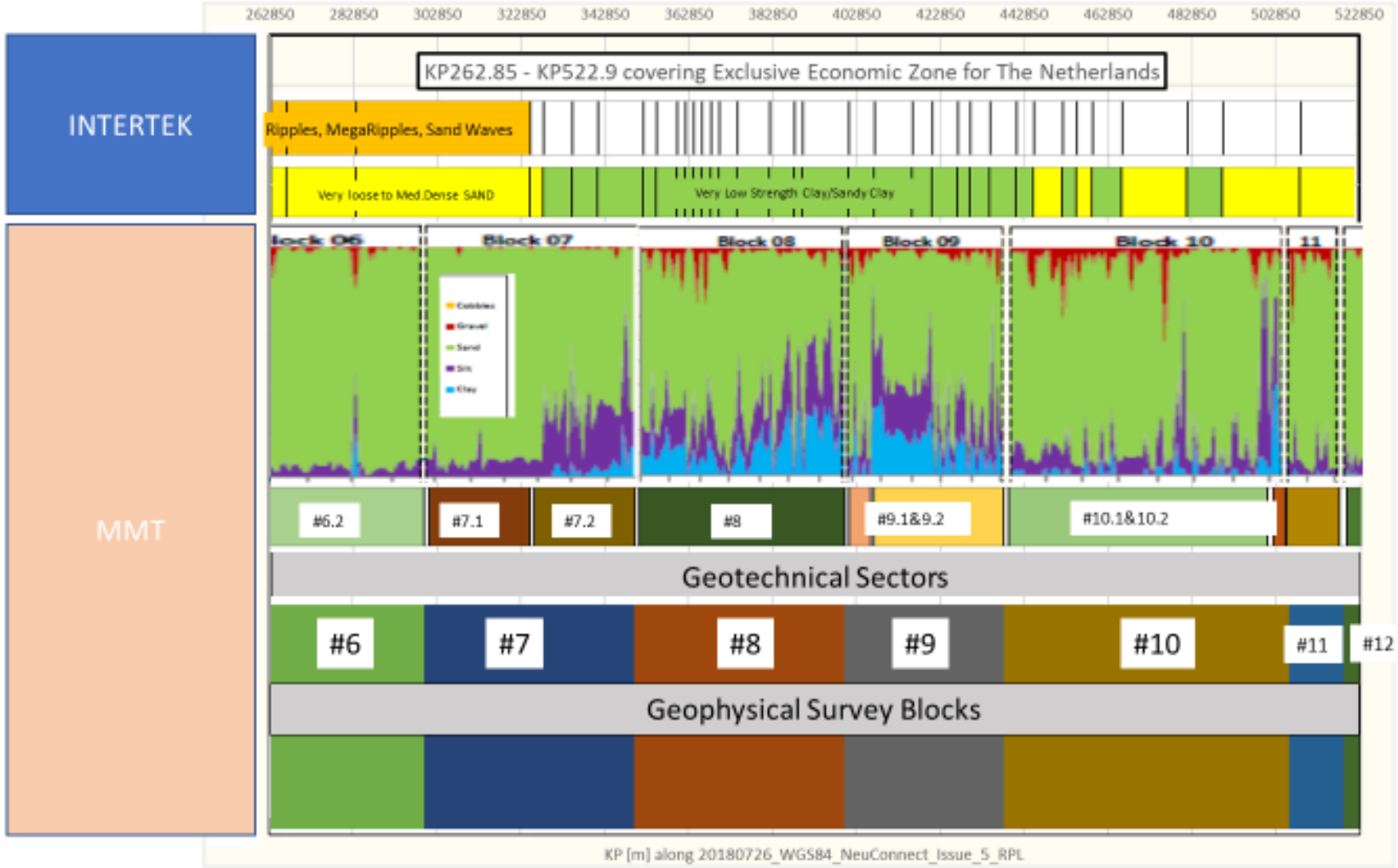
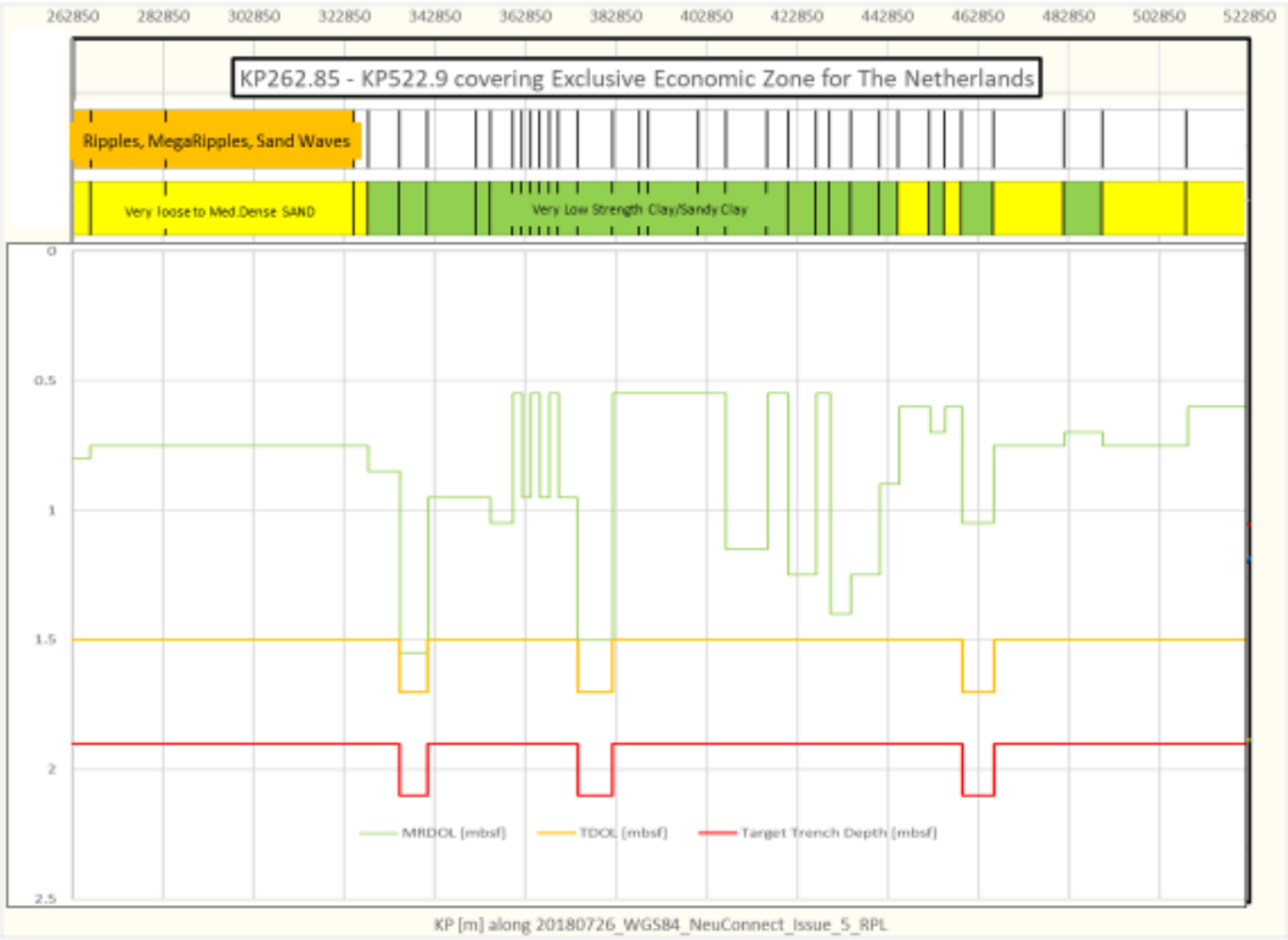


**Figure B2- 3: NETHS SECTOR, CBRA RESULTS SUMMARY - RMDOL, TDOL, TTD + Bedforms & Shallow Geology**



**APPENDIX B3 – CBRA Summary (Sector: Germany)**

**Figure B3- 1: GERMANY SECTOR, CBRA RESULTS SUMMARY - Water Depth Profile + Bedforms & Shallow Geology**

**Figure B3- 2: GERMANY SECTOR, CBRA RESULTS SUMMARY - Blocks, Sections + Bedforms & Shallow Geology**

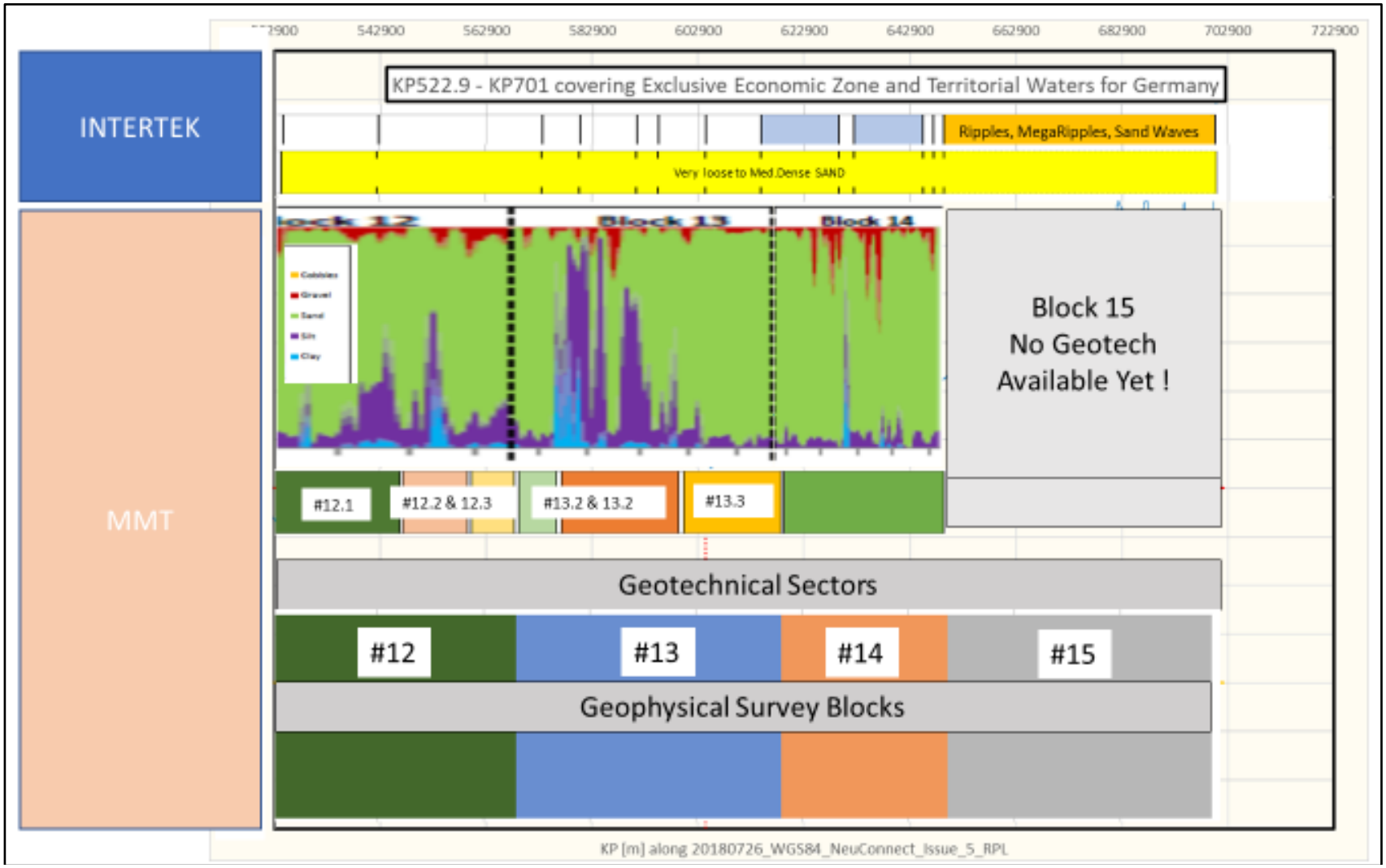
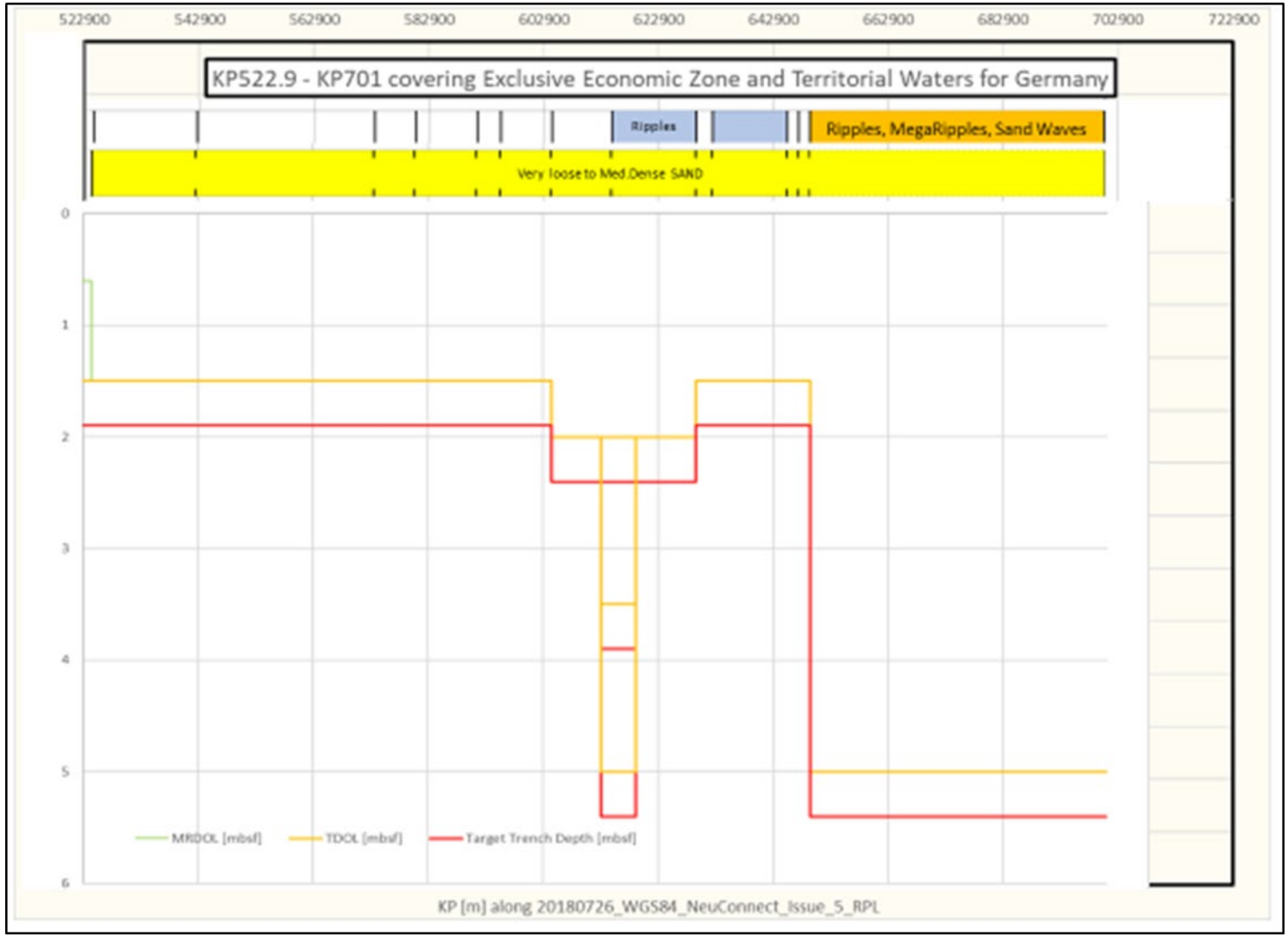


**Figure B3- 3: GERMANY SECTOR, CBRA RESULTS SUMMARY - RMDOL, TDOL, TTD + Bedforms & Shallow Geology**



**APPENDIX C – BAS Lite Results**

Appendix C1 – Sector: United Kingdom
Appendix C2 – Sector: The Netherlands
Appendix C3 – Sector: Germany

**APPENDIX C1 – BAS Lite Results (Sector: United Kingdom)**

**Figure C1- 1: UK SECTOR SUMMARY - Seabed Slope Profile and Bedforms (KP0 - KP50)**

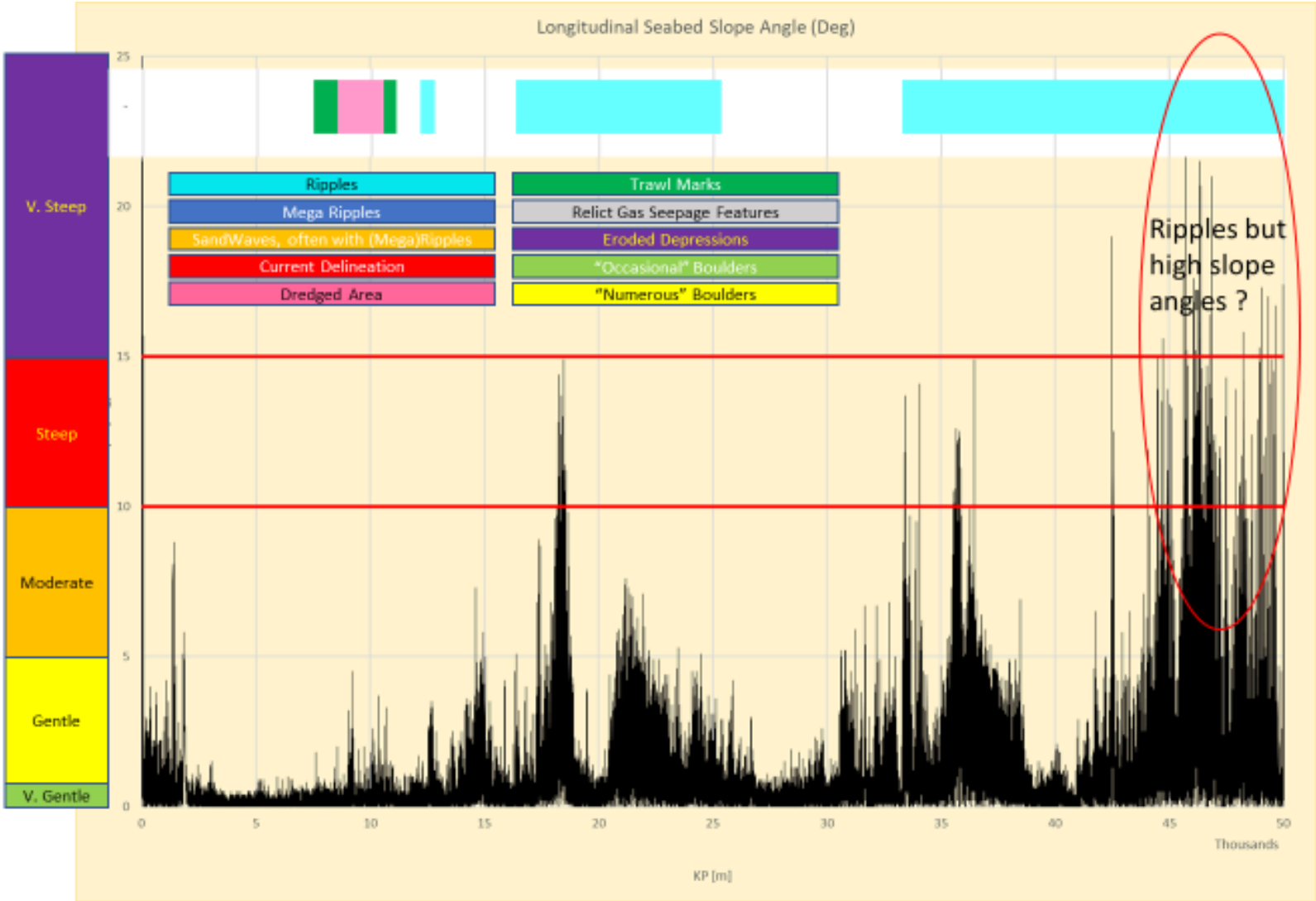


**Figure C1- 2: UK SECTOR SUMMARY - Seabed Slope Profile and Bedforms (KP50 - KP100)**

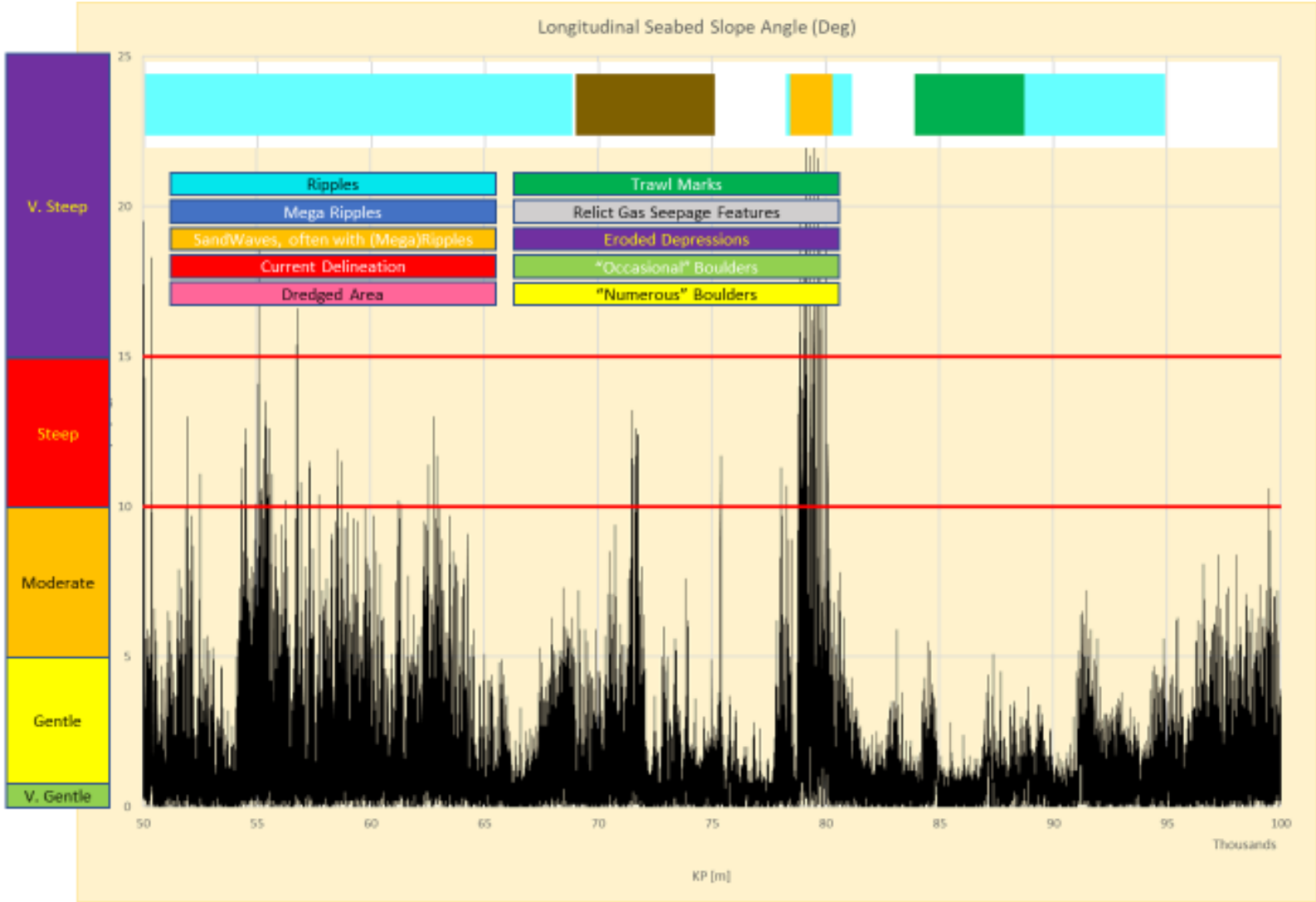


**Figure C1- 3: UK SECTOR SUMMARY - Seabed Slope Profile and Bedforms (KP100 - KP150)**

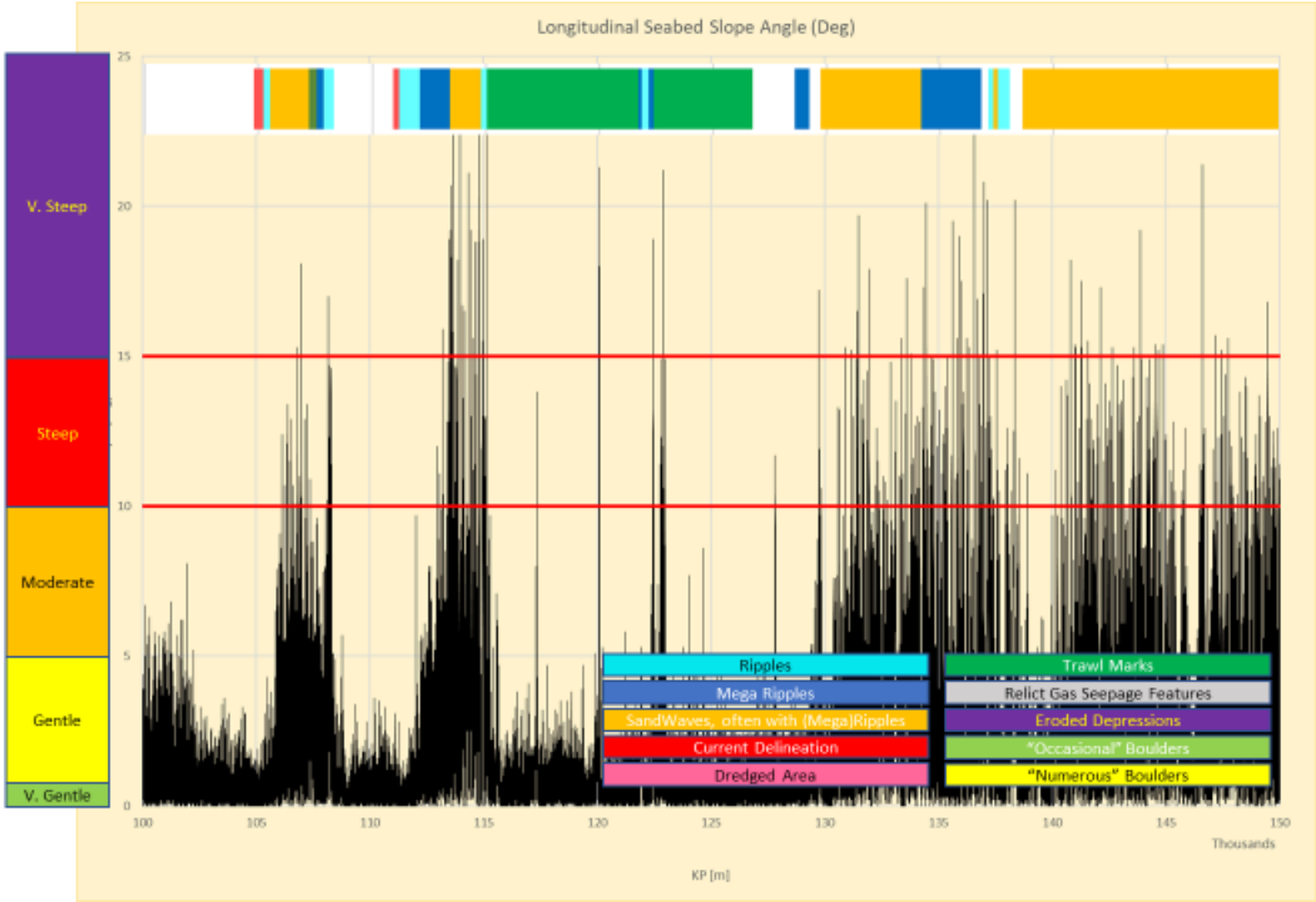


**Figure C1- 4: UK SECTOR SUMMARY - Seabed Slope Profile and Bedforms (KP150 - KP200)**

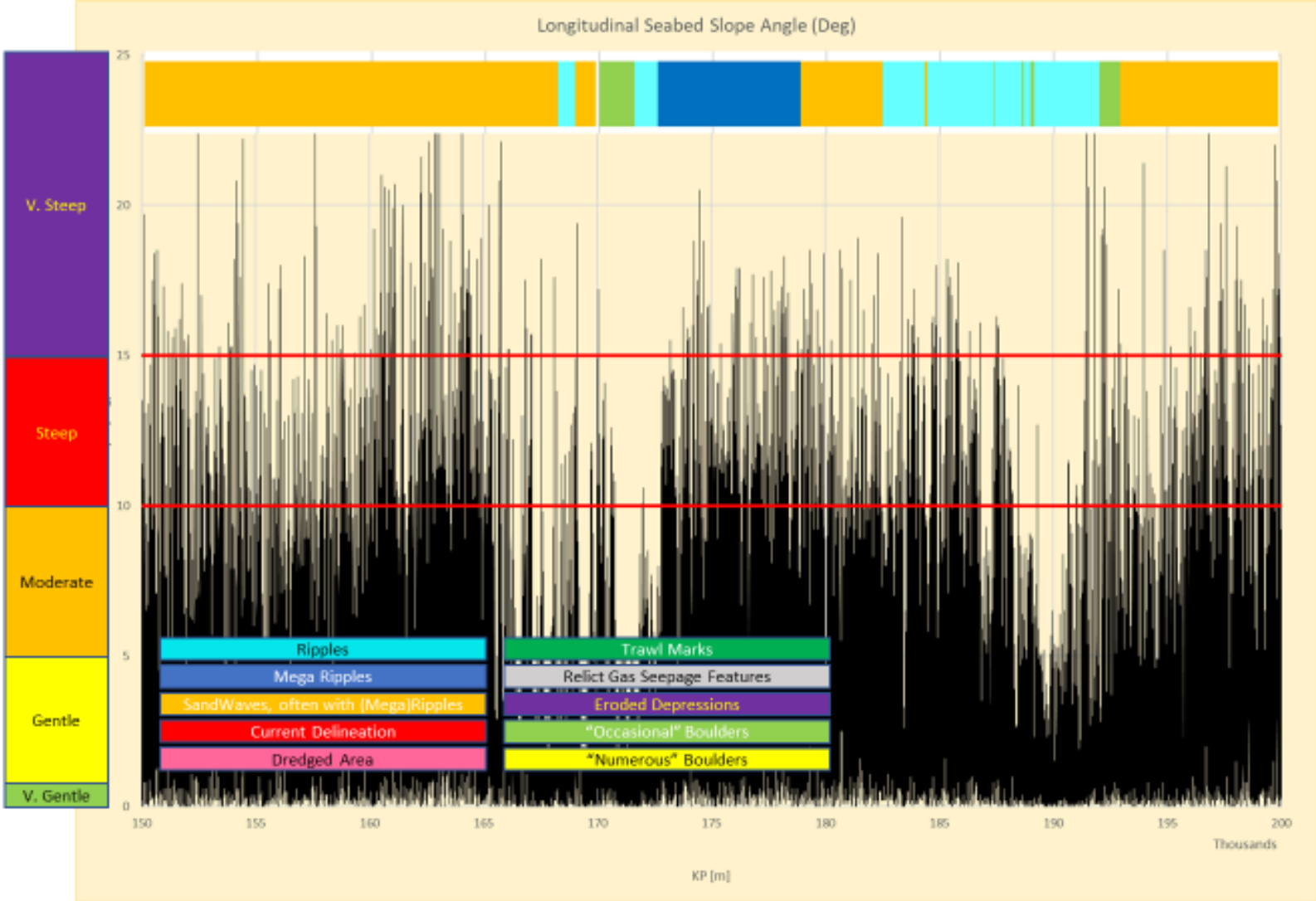


**Figure C1- 5: UK SECTOR SUMMARY - Seabed Slope Profile and Bedforms (KP200 - KP250)**

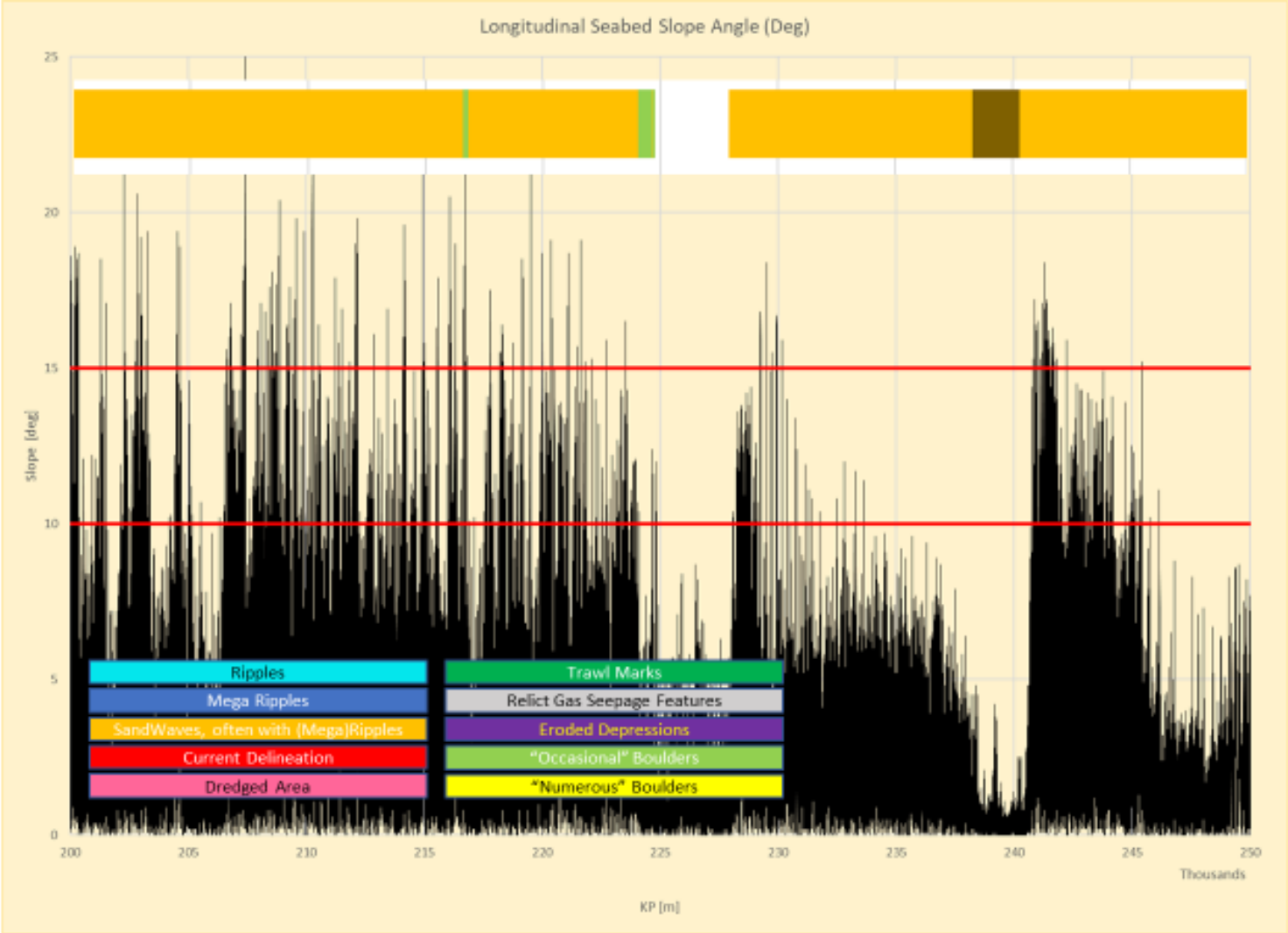


**Figure C1- 6: UK SECTOR SUMMARY - Seabed Slope Profile and Bedforms (KP250 - KP262.850)**

**APPENDIX C2 – BAS Lite Results (Sector: The Netherlands)**

**Figure C2- 1: NETHERLANDS SECTOR SUMMARY - Seabed Slope Profile and Bedforms (KP262.850 – KP300)**

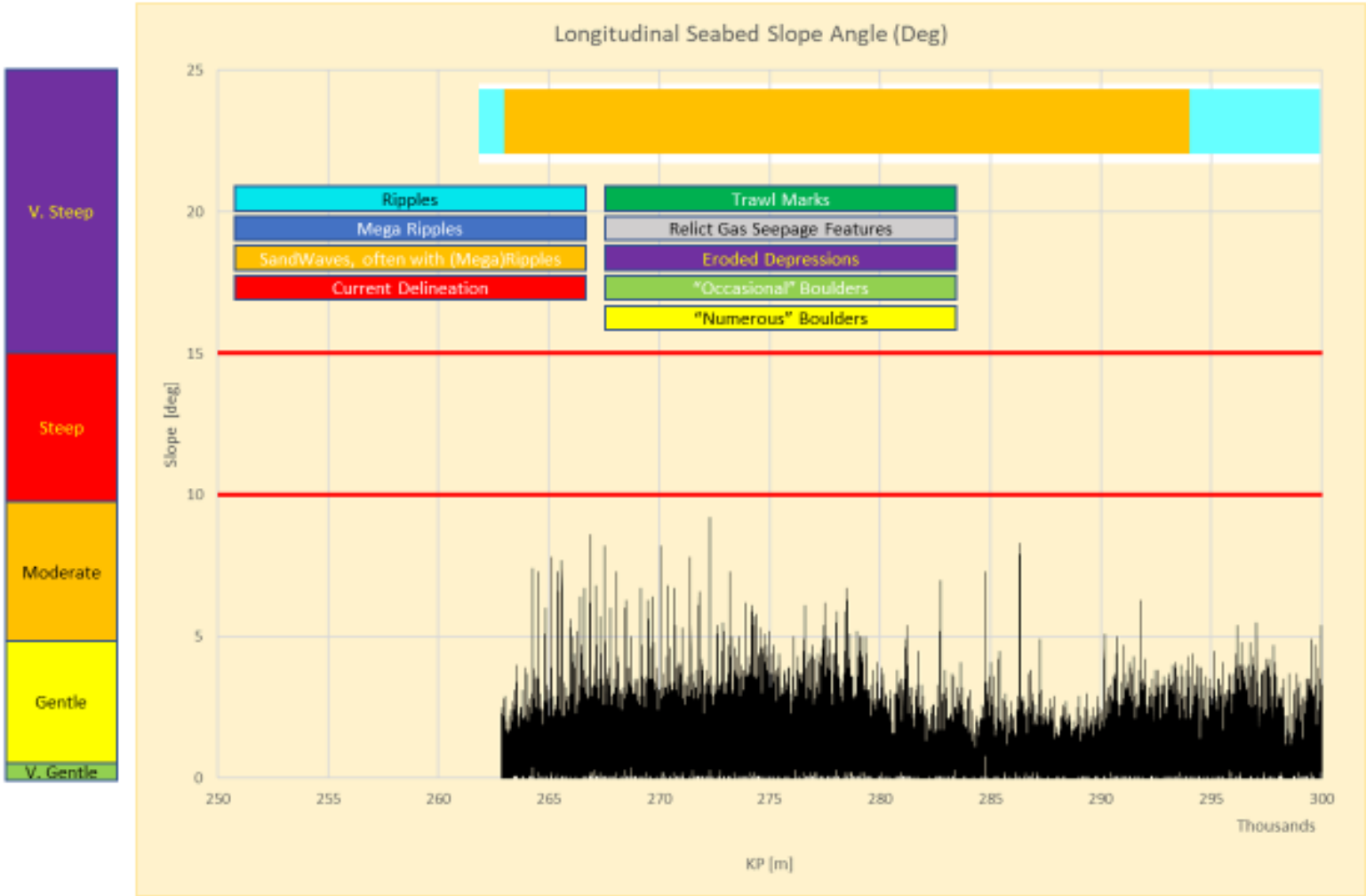


**Figure C2- 2: NETHERLANDS SECTOR SUMMARY - Seabed Slope Profile and Bedforms (KP300 – KP350)**

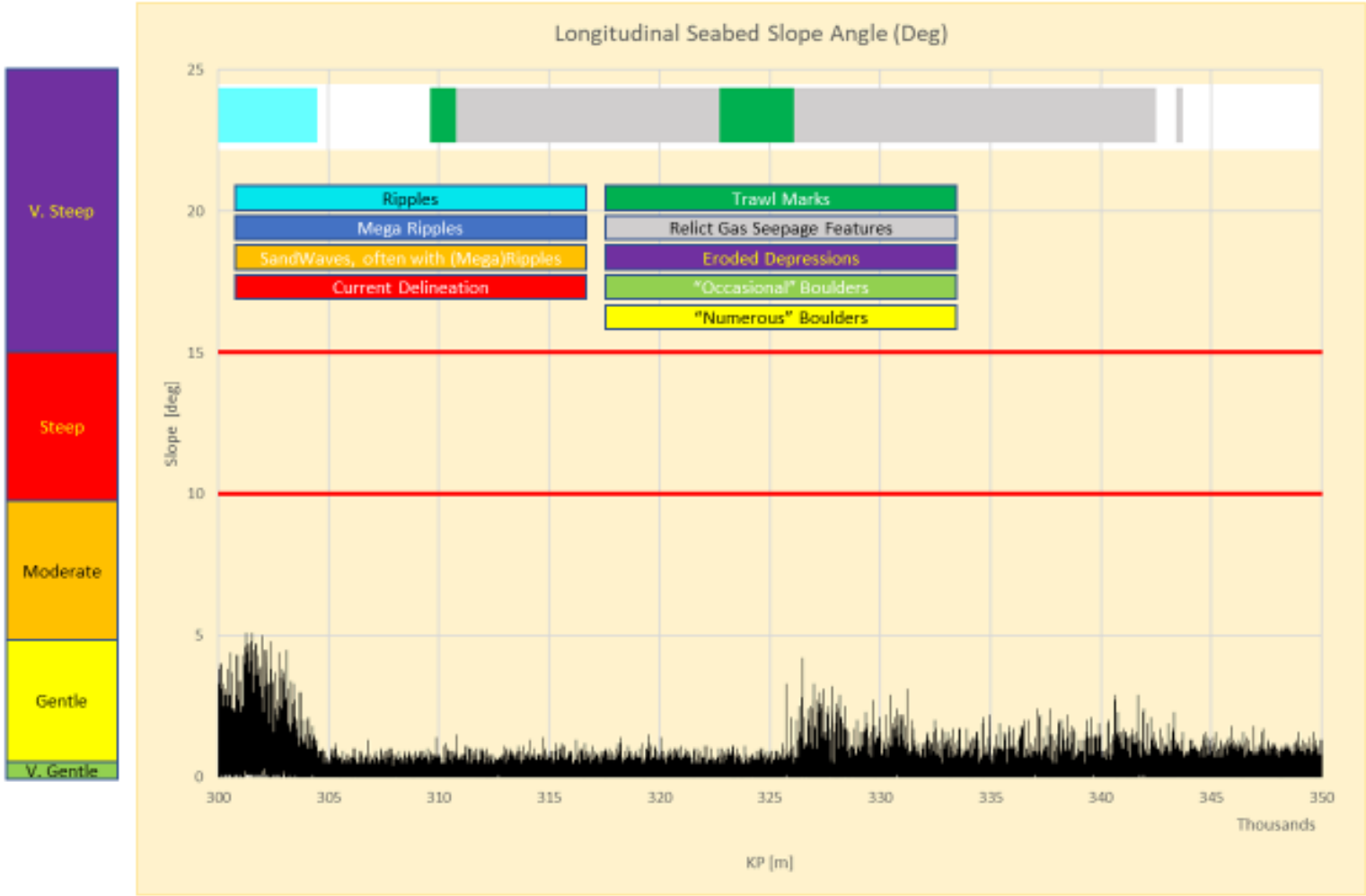


**Figure C2- 3: NETHERLANDS SECTOR SUMMARY - Seabed Slope Profile and Bedforms (KP350 – KP400)**

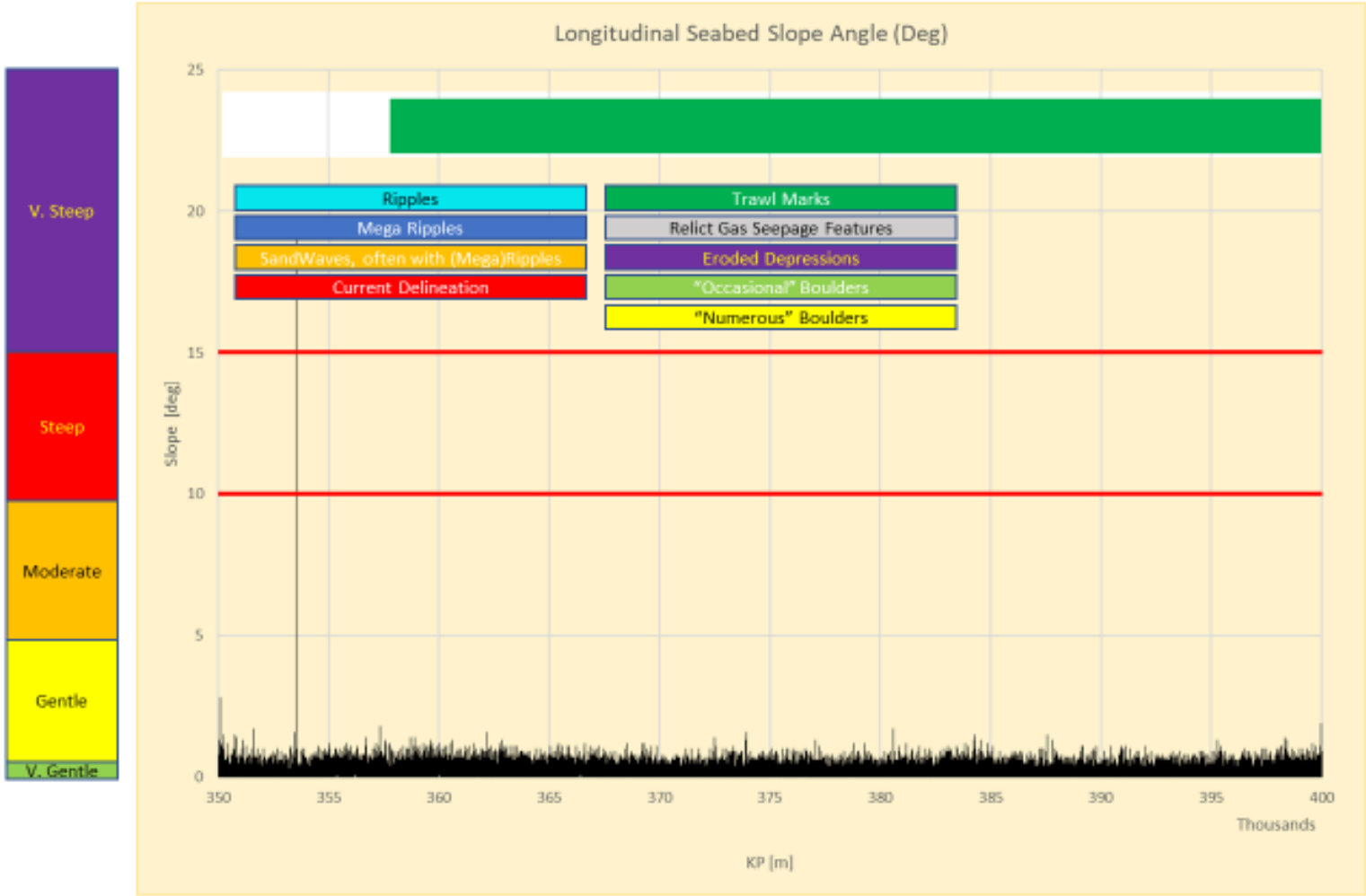


**Figure C2- 4: NETHERLANDS SECTOR SUMMARY - Seabed Slope Profile and Bedforms (KP400 – KP450)**

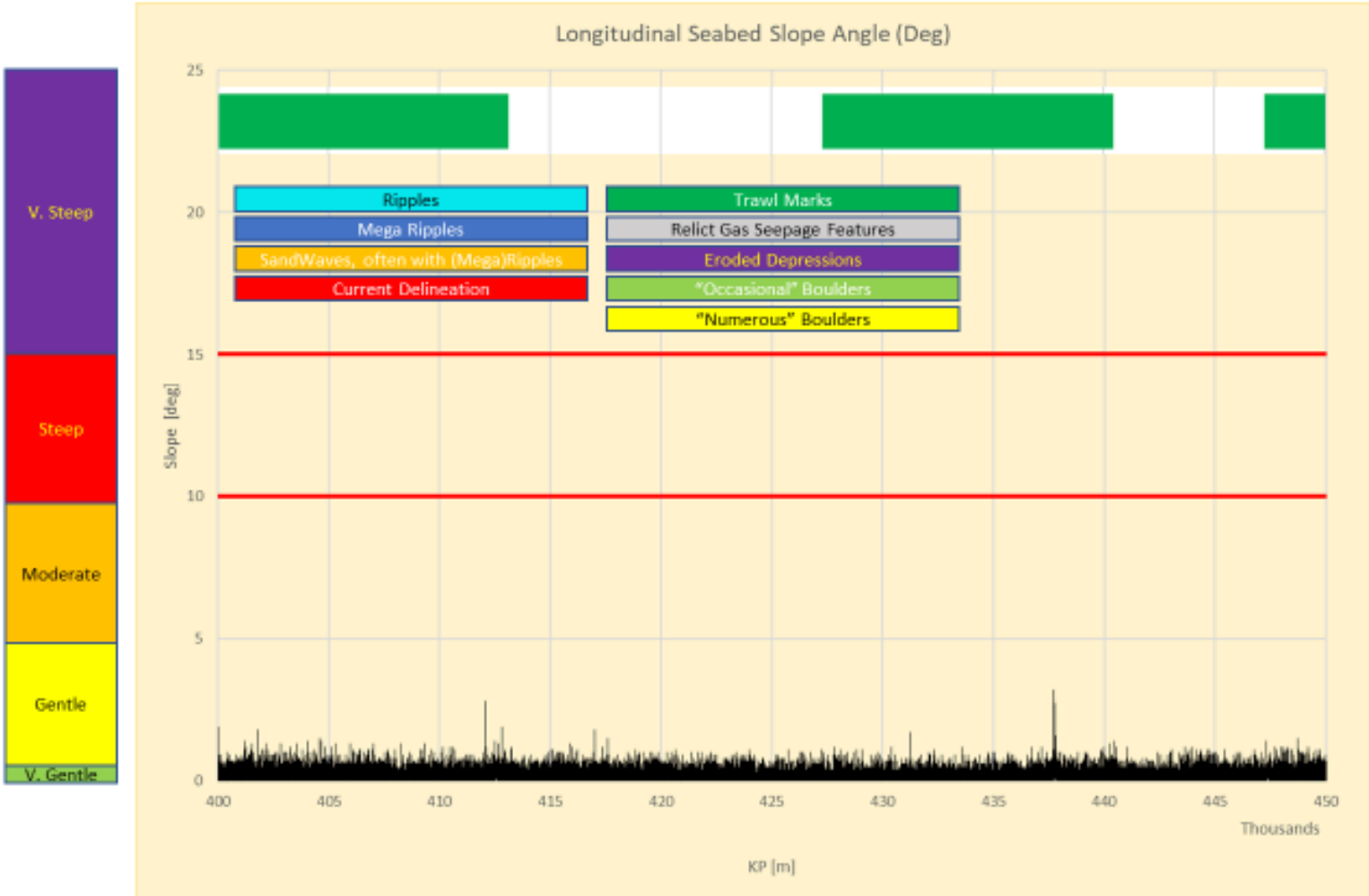


**Figure C2- 5: NETHERLANDS SECTOR SUMMARY - Seabed Slope Profile and Bedforms (KP450 – KP500)**

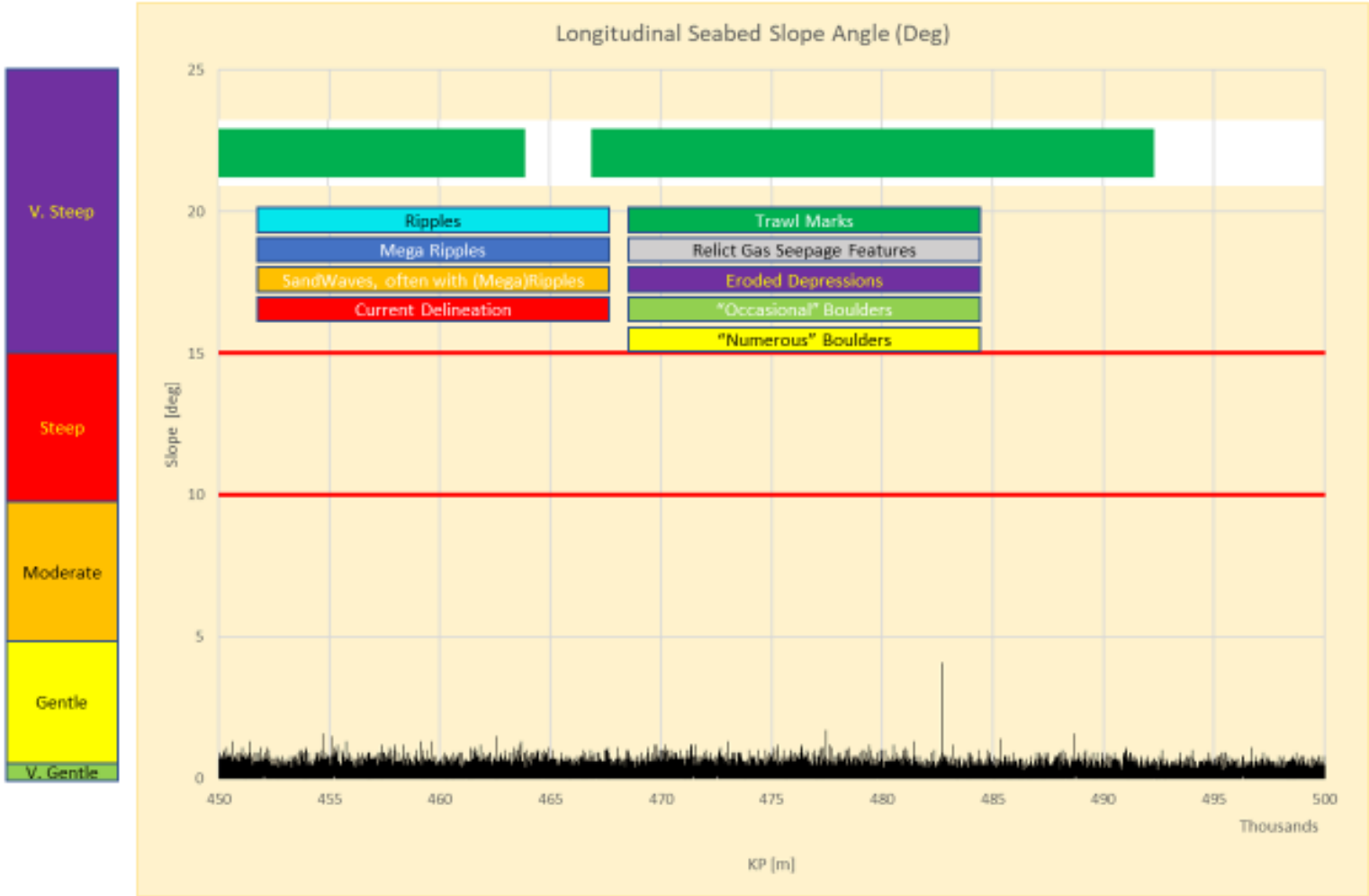
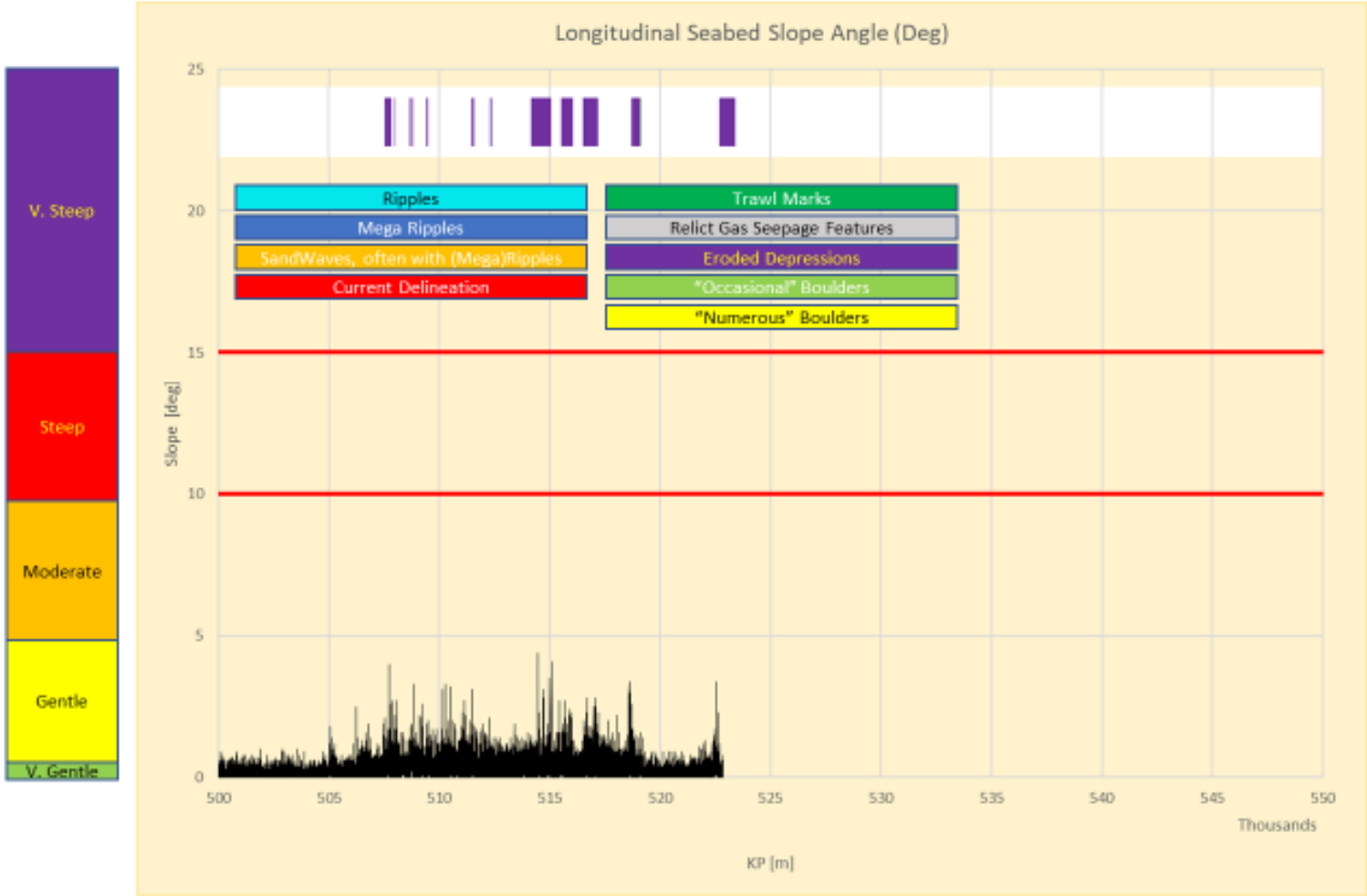


**Figure C2- 6: NETHERLANDS SECTOR SUMMARY - Seabed Slope Profile and Bedforms (KP500 – KP522.9)**



**APPENDIX C3 – BAS Lite Results (Sector: Germany)**

**Figure C3- 1 GERMANY SECTOR SUMMARY - Seabed Slope Profile and Bedforms (KP522.9 – KP550)**

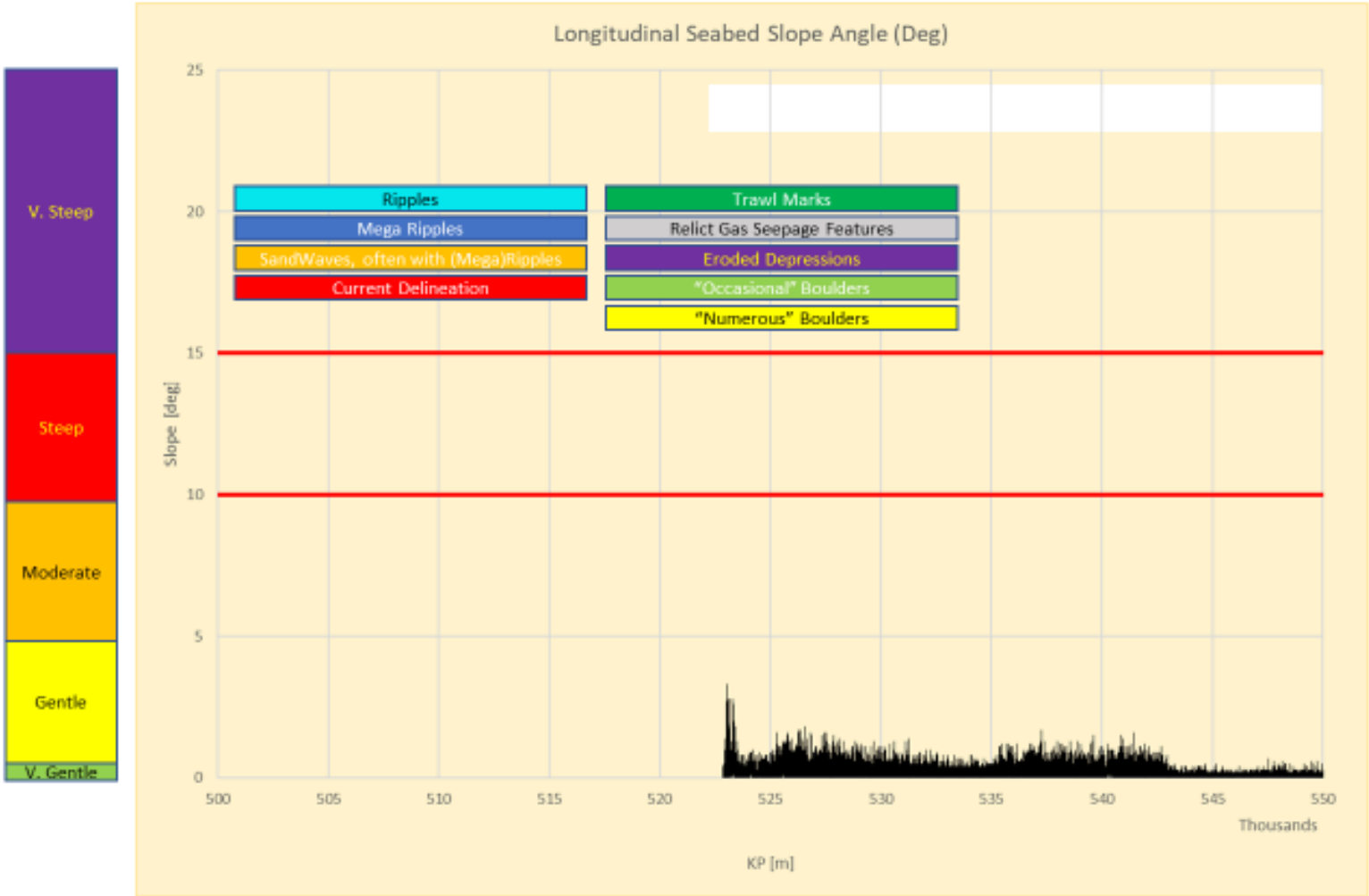


**Figure C3- 2 GERMANY SECTOR SUMMARY - Seabed Slope Profile and Bedforms (KP550 – KP600)**

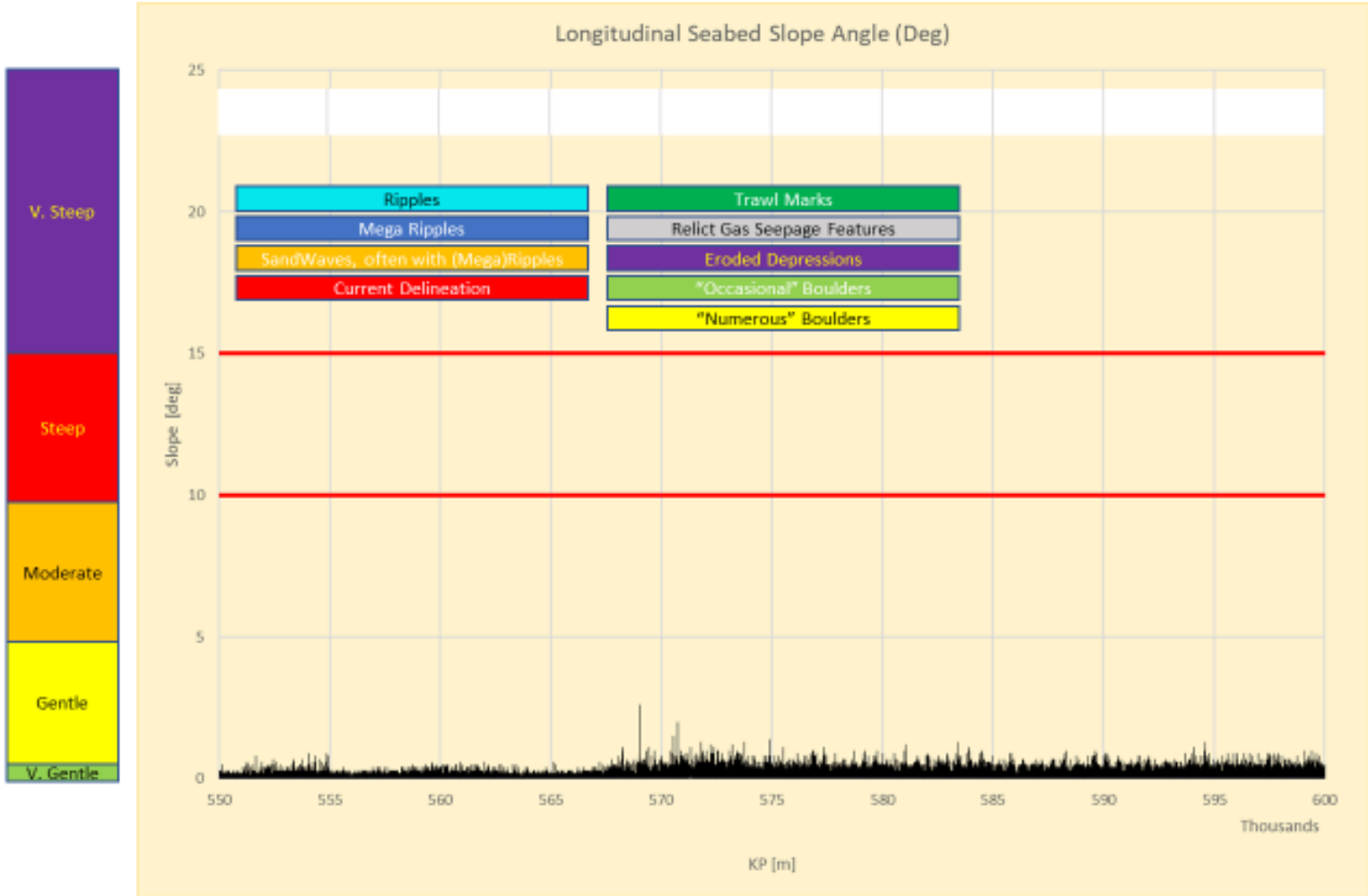


**Figure C3- 3 GERMANY SECTOR SUMMARY - Seabed Slope Profile and Bedforms (KP600 – KP650)**

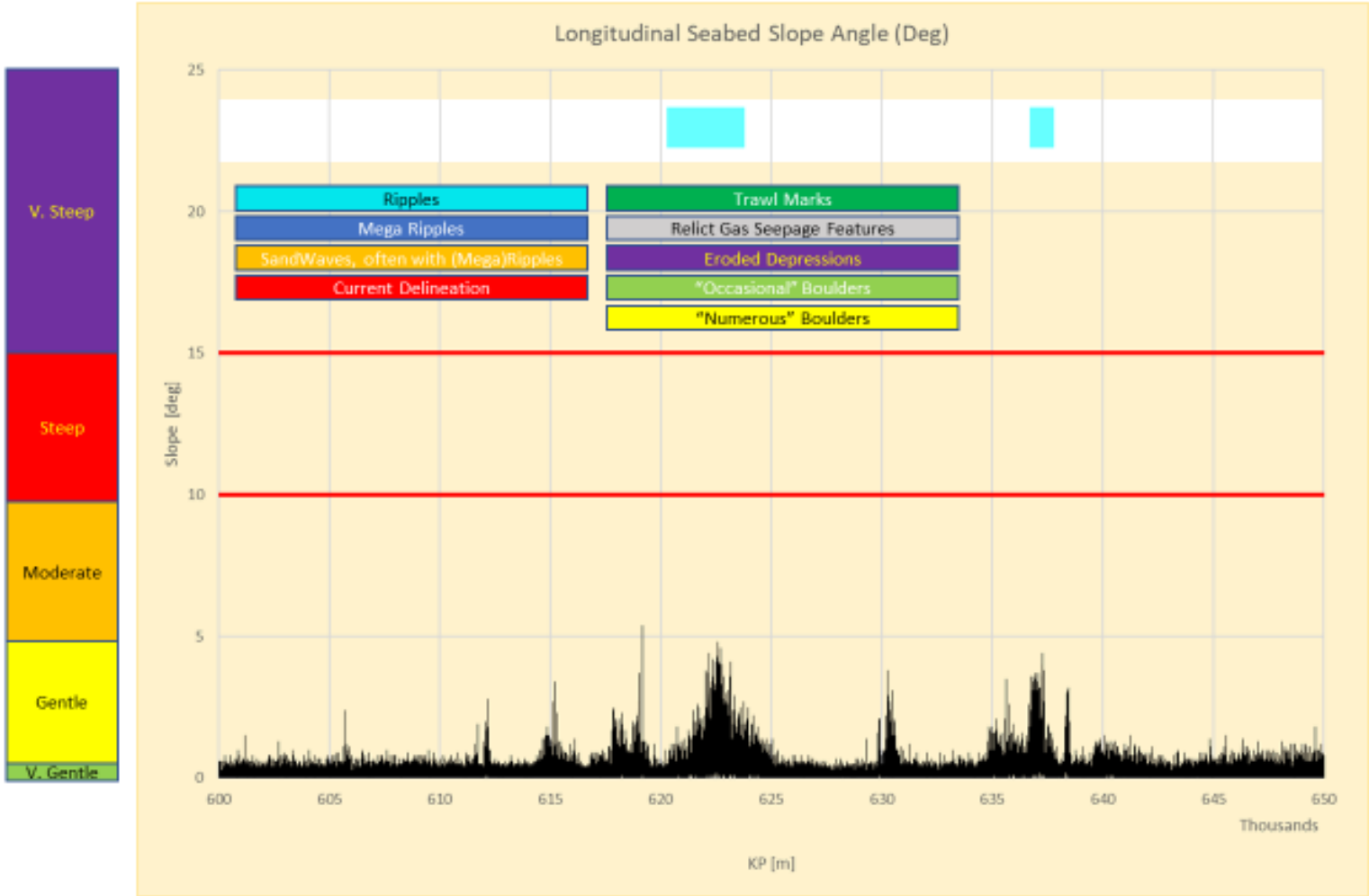
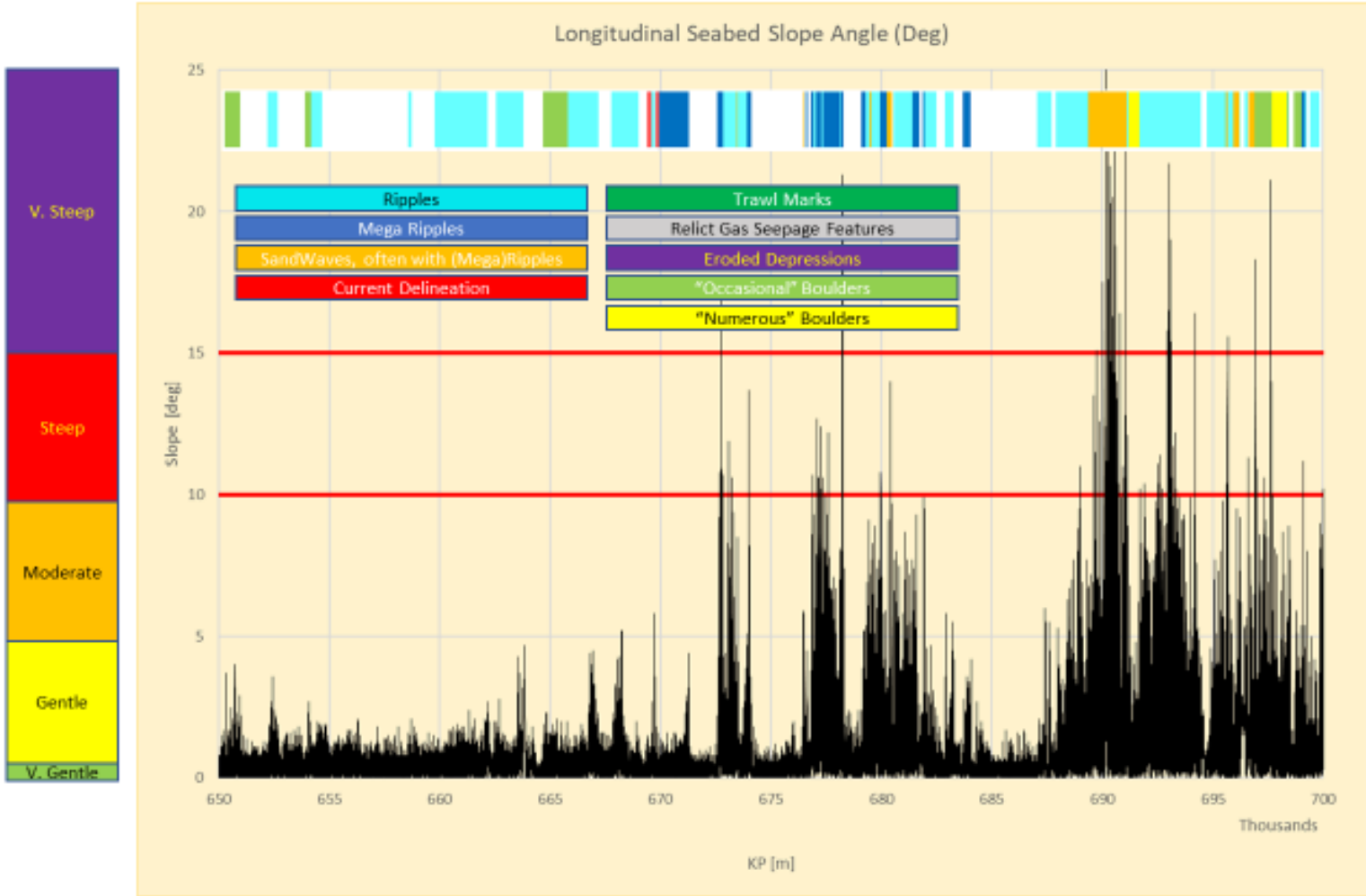


**Figure C3- 4 GERMANY SECTOR SUMMARY - Seabed Slope Profile and Bedforms (KP650 – KP700)**



# Bijlage 5: Generic crossing design (algemeen ontwerp kruisingen), Primo Marine, 20 juli 2019

NeuConnect

# NeuConnect Interconnector
# Generic Crossing Design

primo marine
Independent Marine Infrastructure Expertise

By: Primo Marine
Written by: Martijn Hovestad

**NeuConnect Interconnector**

**Generic Crossing Design**

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*Document No:* 0476_01_NC_ER_0001

*Revision No:* R1_00

*Date:* 20 June 2019

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| R1_00 | 20 June 2019 | Issue for Comments | MaH | - | |
| **Revision** | **Date** | **Description** | **Primo Original** | **Primo Reviewed** | **Client Approved** |

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## 1.0 Introduction

This document shows a high-level outline of possible crossing designs for the NeuConnect Power Cable with third-party assets. The sole purpose for these designs is serve as a discussion document, to start negotiations with the owners of the third-party assets.

In total, five different potential solutions will be shown. Three of these are for crossings where the existing asset is buried into the seabed, two are for crossings with the existing asset on top of the seabed.

The solution types for buried third-party assets:

- Type A: passing NeuConnect over the crossed asset at seabed, final protection with rock;
- Type B: installation of a pre-lay rock berm, passing NeuConnect over this pre-lay berm, final protection with rock;
- Type C: fit the NeuConnect cable with a spacer, pass NeuConnect with spacer over the third-party asset at seabed;

The solution types for third-party assets on top of the seabed:

- Type D: installation of a pre-lay rock berm, passing NeuConnect over this pre-lay berm, final protection with rock;
- Type E: fit the NeuConnect cable with a spacer, pass NeuConnect with spacer over the third-party asset at seabed;

Solution type A only applies to third-party assets buried deep enough to ensure sufficient separation, else B or C shall be used. Solution types B and C are in principle the same as respectively solution types D and E, but whether the crossed assets are in or on the seabed makes a substantial difference to the lay-out. Hence these solution types will be assessed separately.

Only solutions using rock and/or spacers will be considered. Solutions using e.g. sand bags, or concrete mattresses, as well as solutions requiring handling of third-party assets (e.g. retrenching) will not be considered.

All drawings that follow in the remainder of this document are not to scale and have been optimised to demonstrate the most important parameters.

The dimensions that will be discussed are proposed minimum dimensions. However, circumstances may dictate different dimensions. For example, governing hydrodynamic conditions may require a leaner side slope and/or thicker rock layers than shown. Such details shall be subject to a later detailed design; the purpose of this document is only to define the minimal requirements.

Not shown in the drawings are:

- Cable protection systems (e.g. uraduct), which the NeuConnect cable may optionally be fitted with at crossings;
- Sprinkle layers of rock (mandatory in the Dutch sector of the North Sea only);
- Exact diameters of the NeuConnect cable, the crossed third-party assets, as well as the exact shape of the spacers, including their dimensions.

In the next section, a top view shall be shown first, the principle of which applies to all solution types. Thereafter, the solution types A-E will be specified in longitudinal and cross-sectional drawings.

Note that this report only addresses possible solutions, which can be used for further assessment. It does not address any specific crossings or recommend a particular solution. As such, it does not contain a conclusion.

## 2.0 All solutions: Top View

The top view defines the crossing angle, valid for all solutions A-E. The crossing angle is always defined as the smallest angle in the crossing, i.e. always 90° or less. This is shown in Figure 1 below.

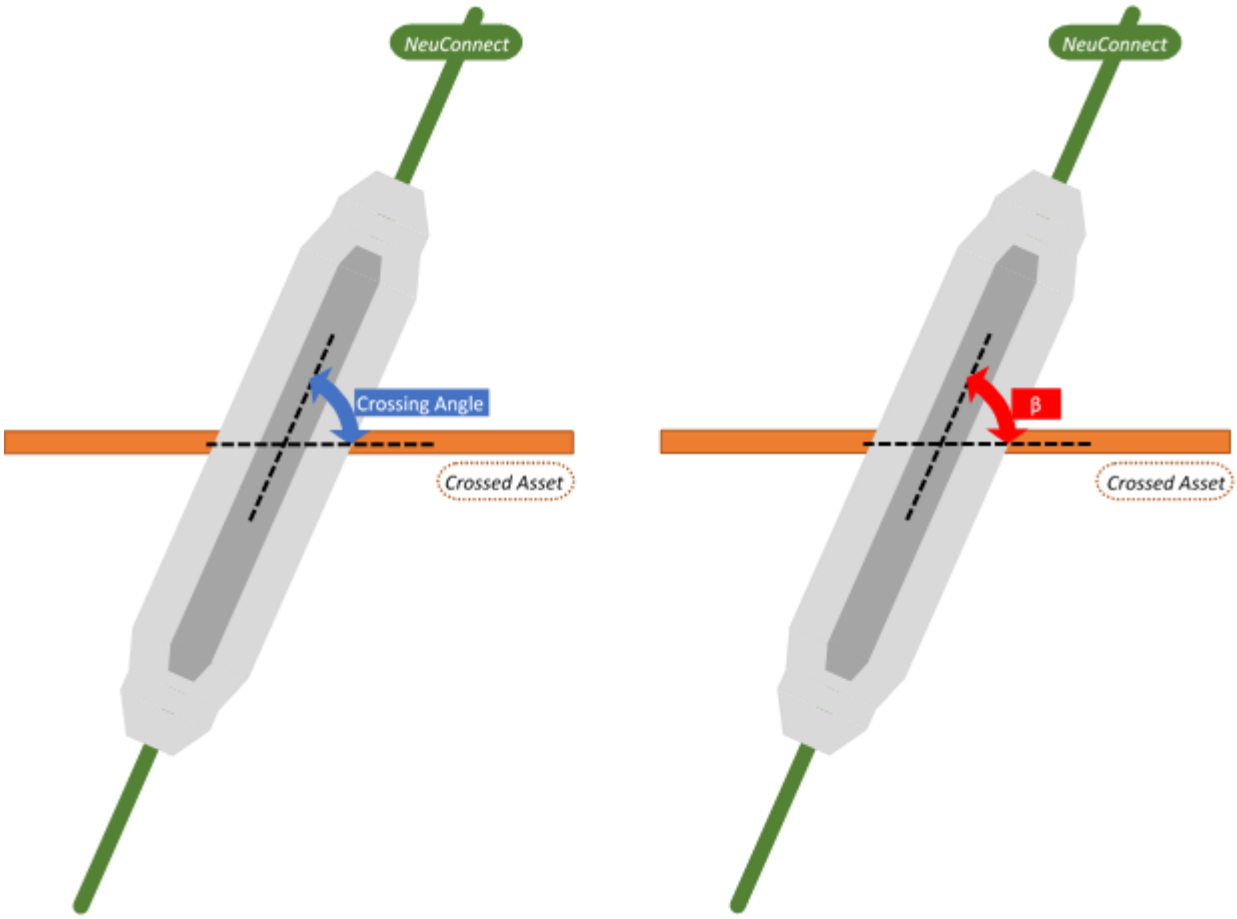


*Figure 1 - Generic Top View*

β Crossing Angle 60-90°

For the following sections, a longitudinal section is defined as being along the NeuConnect Cable, a cross-section as being along the crossed asset.

## 3.0 Solution Type A

In solution A, the NeuConnect cable passes the crossed asset at seabed. This solution assumes the crossed asset buried deep enough into the seabed to ensure sufficient vertical separation. Figure 2 below shows a typical longitudinal section and cross-section.

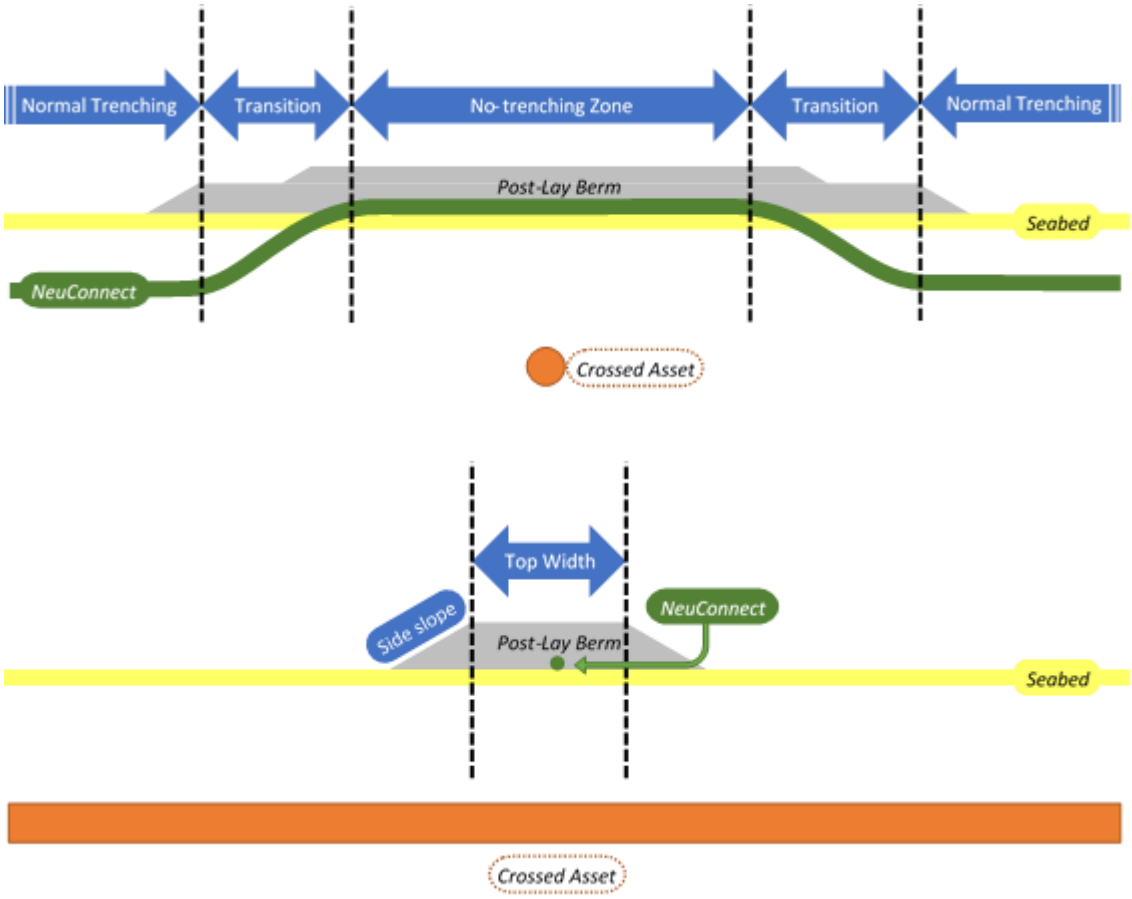


*Figure 2 - Longitudinal section and cross-section of Type A crossing*

Trenching will stop at a certain distance before the crossing, leading to a transition zone. On both sides of the crossed asset, there will be a no-trenching zone. After passing the no-trenching area, trenching will be resumed (with another transition). After completion of the crossing, including the transition zone, will be covered with rock.

This solution type is only recommended for crossed third-party assets that are buried relatively deep and of which the location can be accurately determined.

Figure 3 on the next page shows the definition of the proposed dimensions.

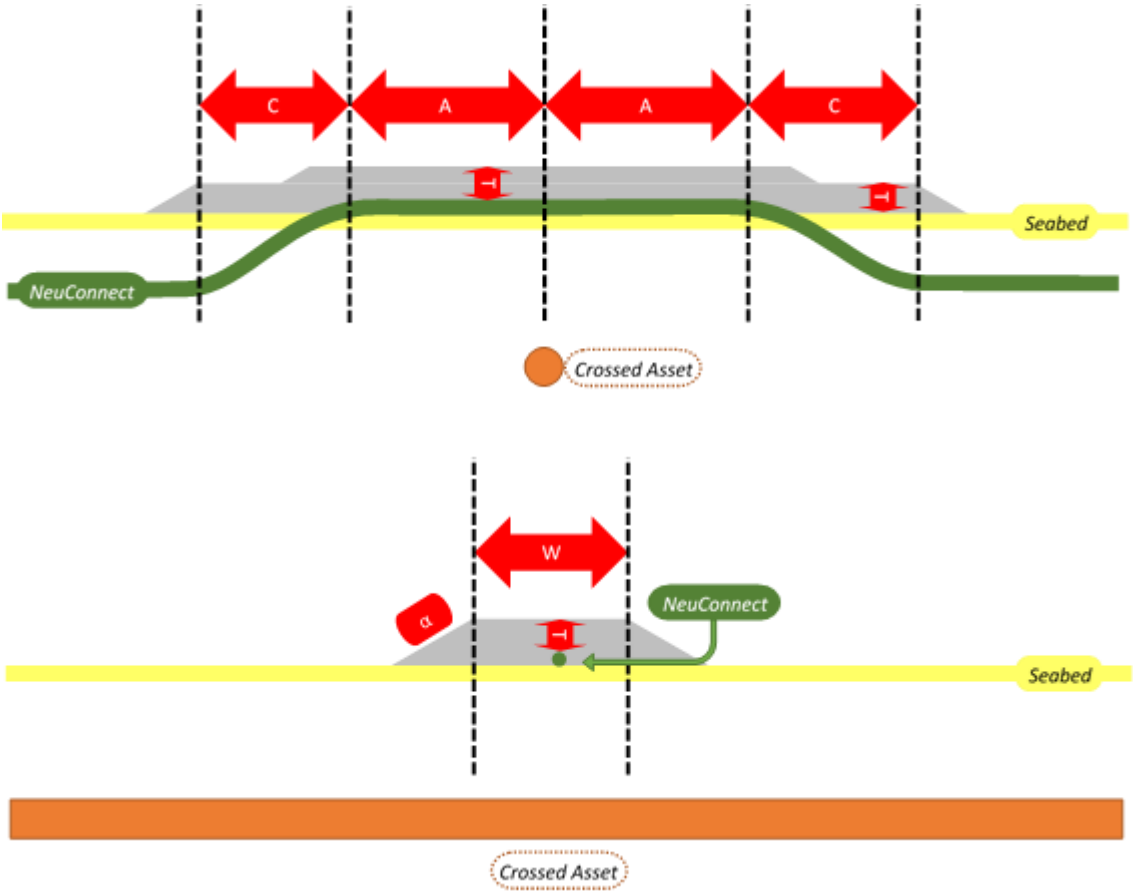


*Figure 3 - Definition of Proposed Dimensions Type A Crossing*

Proposed values for type A-crossings are:

| | | |
|---|---|---|
| A | No-trenching zone/Crossing | 25 m |
| C | Transition zone | 5 m |
| T | Layer Thickness | 0.5 m on Top of Cable/Seabed |
| W | Top Width | 1 m |
| α | Side Slope | 1:3 |

## 4.0 Solution Type B

In solution type B, a pre-lay rock berm will be applied on the seabed, to ensure sufficient separation of the NeuConnect cable with the third-party asset. Figure 4 below shows a typical longitudinal section and cross-section.

Such pre-lay berms are typically much wider that post-lay-only berms, in order to allow for cable-lay tolerances. The actual required/possible tolerance shall be discussed with cable-lay contractors, hence the value shown here is to be considered as an initial proposal.

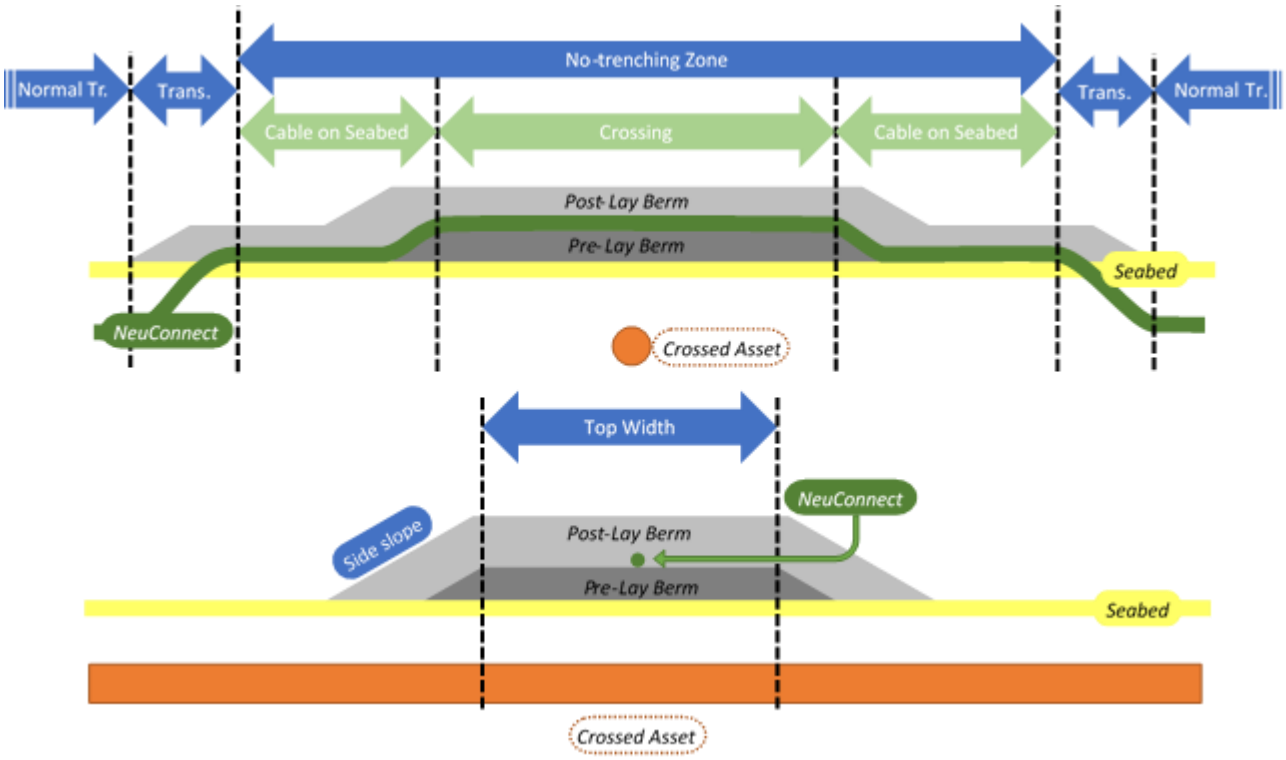


*Figure 4 - Longitudinal section and cross-section of Type B crossing*

When trenching, the trencher will have to get out of the seabed at some distance before the pre-lay berm. Therefore, there is an additional distance of cable on the seabed, when compared to type A. This distance is also considered as part of the no-trenching zone.

This solution can be applied for assets that are shallowly buried, up to top-of-pipe flush with seabed.

Figure 5 on the next page shows the definition of the proposed dimensions.

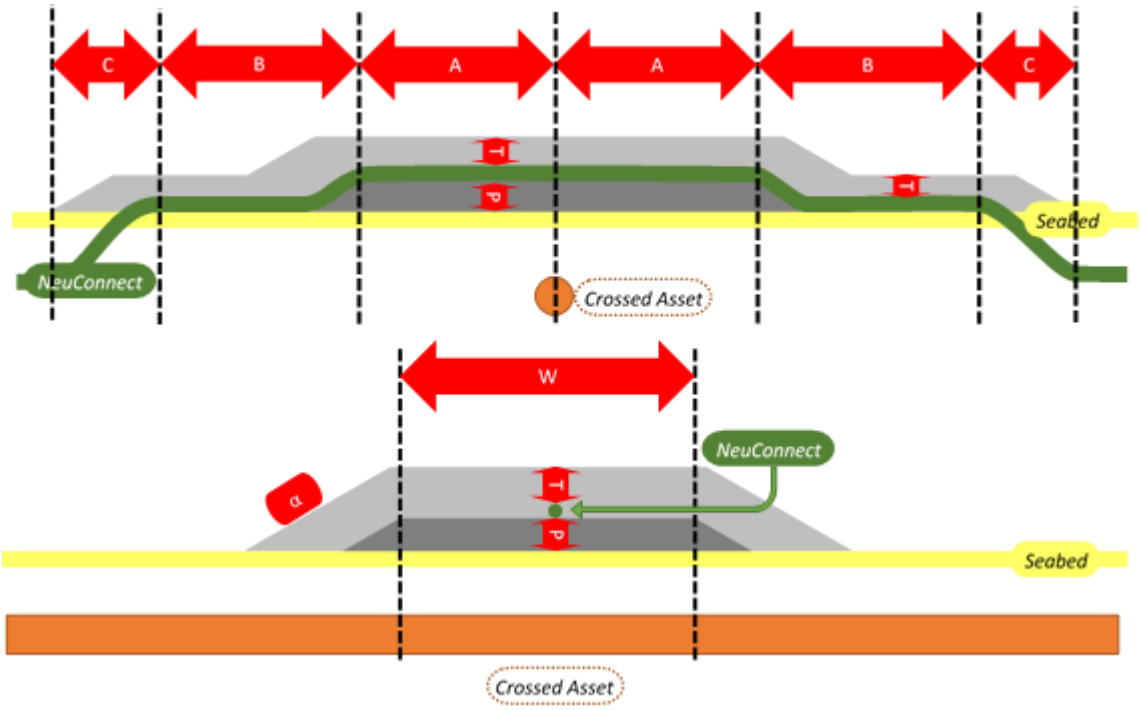


*Figure 5 - Definition of Proposed Dimensions Type B Crossing*

Proposed values for type B-crossings are as shown below. The no-trenching zone consist of zones A+B, on both sides of the crossed asset.

| | | |
|---|---|---|
| A | Crossing | 25 m |
| B | Cable on Seabed | 10 m |
| C | Transition zone | 5 m |
| P | Pre-lay Berm Thickness | 0.3 m on Top of Seabed |
| T | Layer Thickness | 0.5 m on Top of Cable/Seabed |
| W | Top Width | 3 m |
| α | Side Slope | 1:3 |

## 5.0 Solution Type C

In solution type C, a spacer will be fitted on the NeuConnect cable, to ensure sufficient separation of the NeuConnect cable with the third-party asset. This eliminates the need for a pre-lay rock berm. Figure 6 below shows a typical longitudinal section and cross-section.

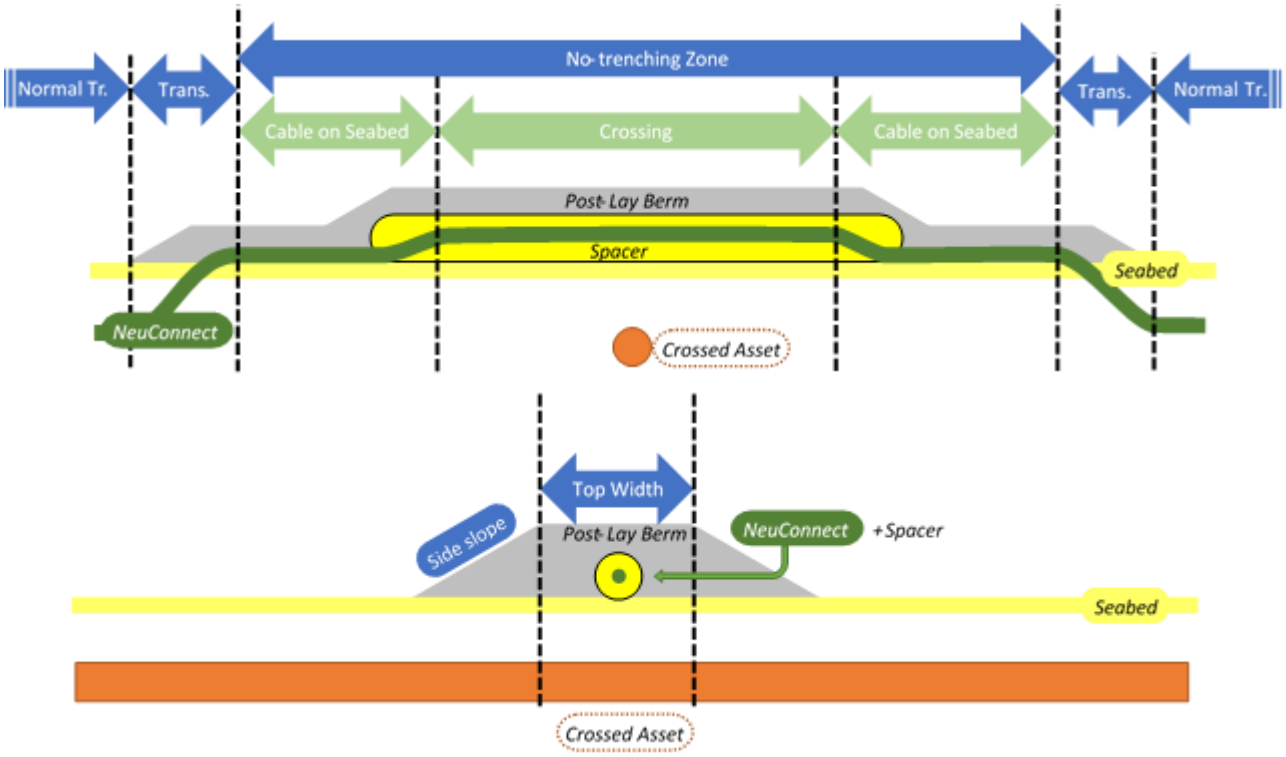


*Figure 6 - Longitudinal section and cross-section of Type C crossing*

When trenching, the trencher will have to get out of the seabed at some distance before the spacer is encountered. Therefore, there is an additional distance of cable on the seabed, when compared to type A. This distance is also considered as part of the no-trenching zone.

This solution can be applied for assets that are shallowly buried, up to top-of-pipe flush with seabed.

Figure 7 on the next page shows the definition of the proposed dimensions.

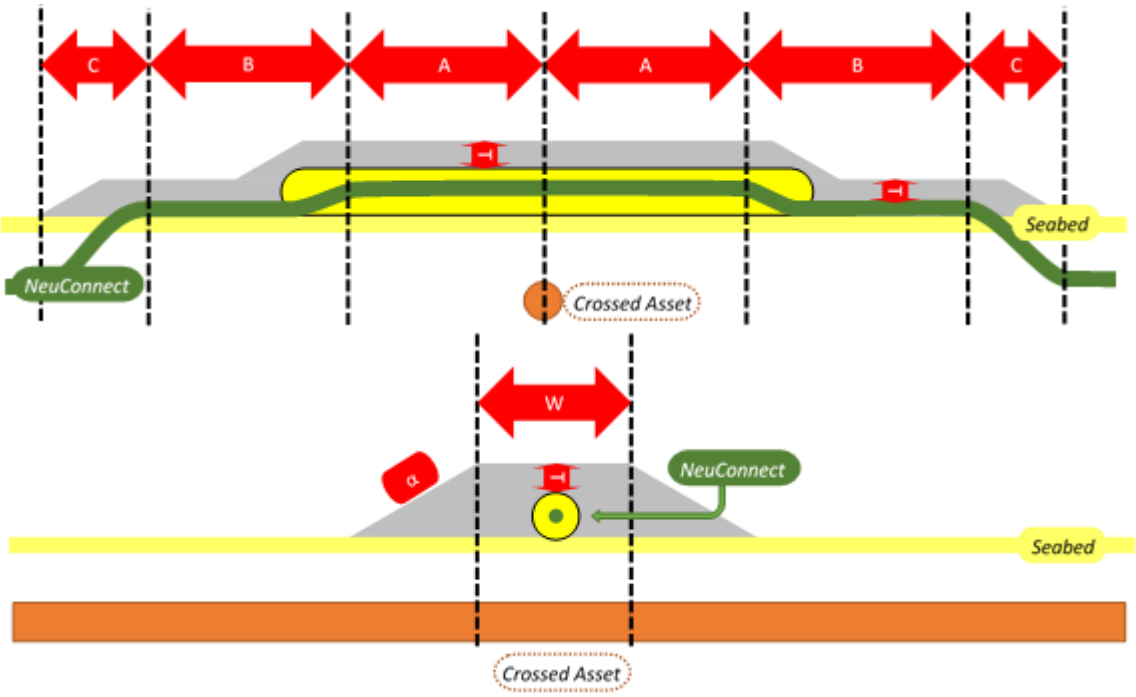


*Figure 7 - Definition of Proposed Dimensions Type C Crossing*

Proposed values for type C-crossings are as shown below. The no-trenching zone consist of zones A+B, on both sides of the crossed asset.

| | | |
|---|---|---|
| A | Crossing | 25 m |
| B | Cable on Seabed | 10 m |
| C | Transition zone | 5 m |
| W | Top Width | 1 m |
| T | Layer Thickness | 0.5 m on Top of Cable (incl. Spacer)/Seabed |
| α | Side Slope | 1:3 |

## 6.0 Solution Type D

In solution type D, a pre-lay rock berm will be applied over the crossed asset, to ensure sufficient separation of the NeuConnect cable with the third-party asset. Figure 8 below shows a typical longitudinal section and cross-section.

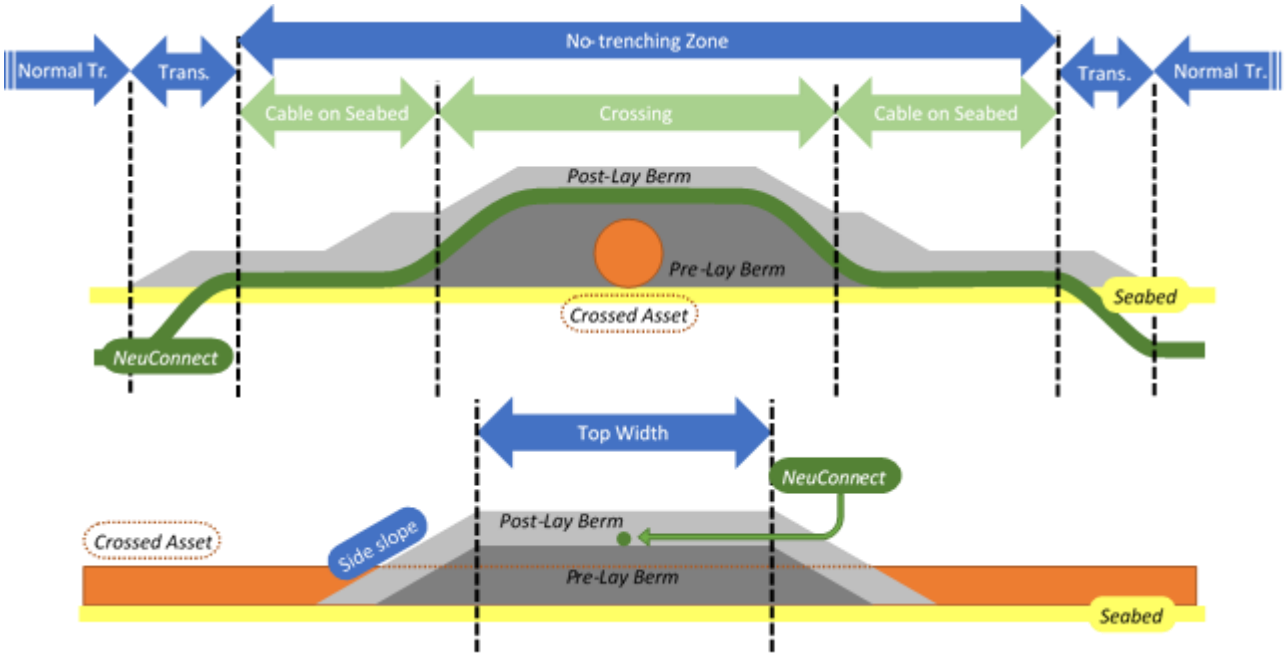


*Figure 8 - Longitudinal section and cross-section of Type D crossing*

Such pre-lay berms are typically much wider that post-lay-only berms, in order to allow for cable-lay tolerances. Moreover, the height will be more than for buried assets, as non-buried assets are typically large diameter pipelines. Due to this combination, the volumes for such pre-lay berms can become considerable.

The actual required/possible cable-lay tolerance shall be discussed with cable-lay contractors, hence the value shown here is to be considered as an initial proposal.

When trenching, the trencher will have to get out of the seabed at some distance before the pre-lay berm. Therefore, there is an additional distance of cable on the seabed, when compared to type A. This distance is also considered as part of the no-trenching zone.

This solution can be applied for assets that are on the seabed, including partially buried ones.

Figure 9 on the next page shows the definition of the proposed dimensions.

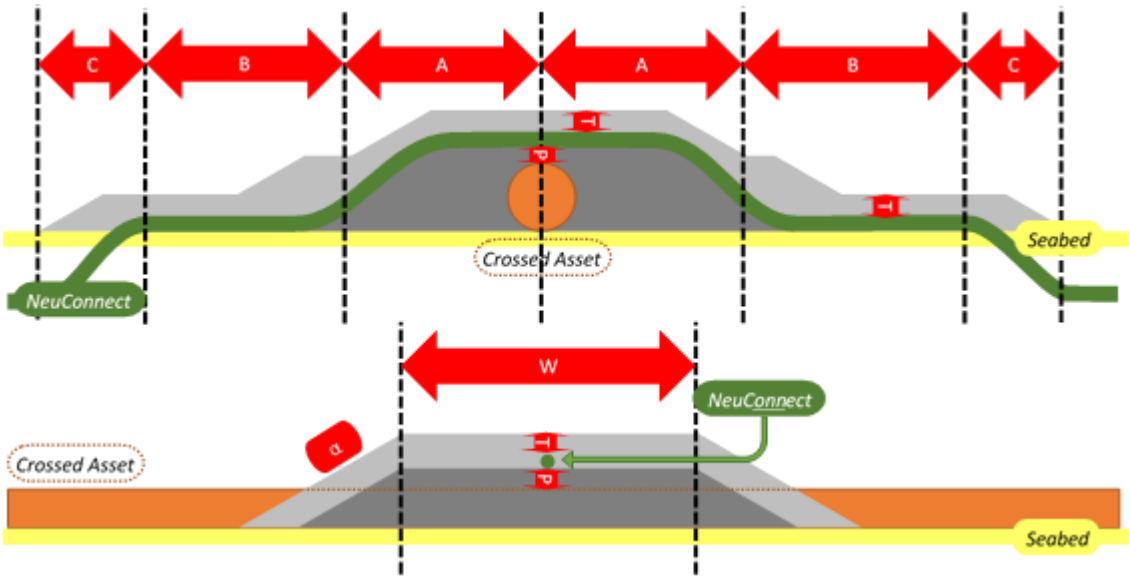


*Figure 9 - Definition of Proposed Dimensions Type D Crossing*

Proposed values for type D-crossings are as shown below. The no-trenching zone consist of zones A+B, on both sides of the crossed asset.

| | | |
|---|---|---|
| A | Crossing | 25 m |
| B | Cable on Seabed | 10 m |
| C | Transition zone | 5 m |
| P | Pre-lay Berm Thickness | 0.3 m on Top of Third-Party Asset |
| T | Layer Thickness | 0.5 m on Top of Cable/Seabed |
| W | Top Width | 3 m |
| α | Side Slope | 1:3 |

## 7.0 Solution Type E

In solution type E, a spacer will be fitted on the NeuConnect cable, to ensure sufficient separation of the NeuConnect cable with the third-party asset. This eliminates the need for a pre-lay rock berm. Figure 10 below shows a typical longitudinal section and cross-section.

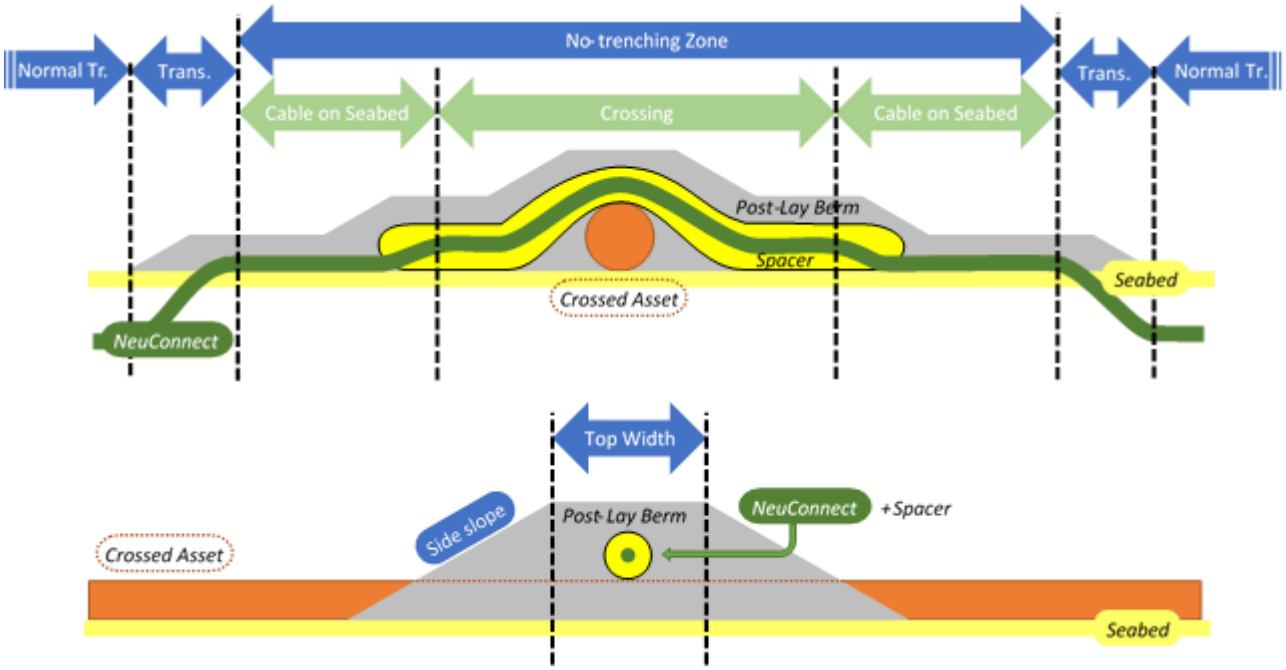


*Figure 10 - Longitudinal section and cross-section of Type E crossing*

Like type D, the height of the post-lay rock berms will be more than for buried assets. The total volume rock volume will be smaller than for type D, due to the smaller top width.

When trenching, the trencher will have to get out of the seabed at some distance before encountering the spacer. Therefore, there is an additional distance of cable on the seabed, when compared to type A. This distance is also considered as part of the no-trenching zone.

This solution can be applied for assets that are on the seabed, including partially buried ones.

Figure 11 on the next page shows the definition of the proposed dimensions.

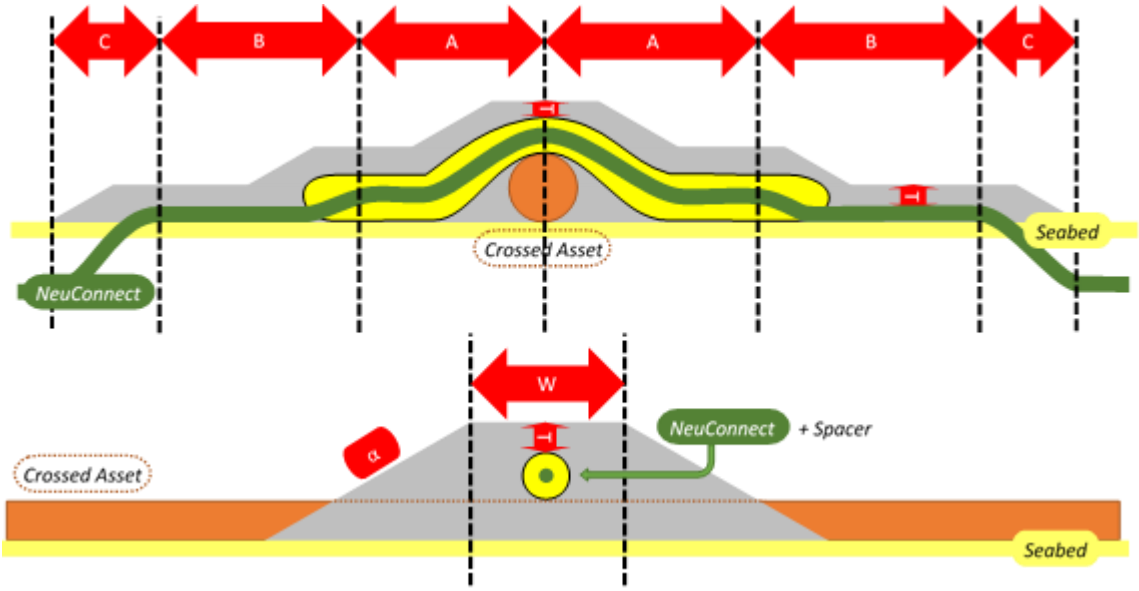


*Figure 11 - Definition of Proposed Dimensions Type E Crossing*

Proposed values for type E-crossings are as shown below. The no-trenching zone consist of zones A+B, on both sides of the crossed asset.

| | | |
|---|---|---|
| A | Crossing | 25 m |
| B | Cable on Seabed | 10 m |
| C | Transition zone | 5 m |
| T | Layer Thickness | 0.5 m on Top of Cable/Seabed |
| W | Top Width | 1 m |
| α | Side Slope | 1:3 |

# Bijlage 6a: Stikstofdepositie onderzoek tbv de aanleg van de NeuConnect kabel,

# Ingenia, 17 maart 2021

# Stikstofdepositie onderzoek t.b.v. de aanleg van de NeuConnect kabel in Nederlandse EEZ

## Verantwoording

| | |
|---|---|
| **Titel** | Stikstofdepositie onderzoek t.b.v. de aanleg van de NeuConnect kabel in Nederlandse EEZ |
| **Opdrachtgever** | NeuConnect |
| **Projectnummer** | 1958639 |
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| **Auteur(s)** | ing. N. Voets |
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| **Datum** | 17 maart 2021 |

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# 1 Inleiding

## 1.1 Achtergrond en doel

NeuConnect wordt ontwikkeld door een consortium van investeerders: Meridiam SAS, Allianz Capital Partners, Kansai Electric Power Company en Greenage Power. Voor de ontwikkeling van het project hebben zij NeuConnect Great Britain Limited (NCGBL, verder NeuConnect genoemd) opgericht. De voorgestelde NeuConnect kabel is een 1.400 megawatt (MW) interconnector tussen de hoogspanning elektriciteitsnetwerken van Groot-Brittannië en Duitsland met een geschatte lengte van in totaal circa 720 km tussen de twee converterstations. In Groot-Brittannië loopt dit via de Isle of Grain te Medway en in Duitsland via Fedderwarden te Wilhelmshaven. De route van de kabel doorkruist de Nederlandse Exclusieve Economische Zone (EEZ) over een lengte van circa 265 km. AECOM heeft in opdracht van NeuConnect een milieueffectrapport (MER) opgesteld. De mogelijke effecten die de aanleg, het gebruik en de ontmanteling van de kabel kunnen hebben op het milieu in de Nederlandse EEZ zijn omschreven in dat MER. De aanleg van de kabel en vervolgens de exploitatiefase leiden tot stikstofemissies en mogelijk tot stikstofdepositie in Natura 2000-gebieden. Voor de aanleg en de exploitatiefase zijn meerdere en verschillende soorten schepen nodig, die op- en afvaren gedurende beide fases. De stikstofdepositie wordt veroorzaakt door de NOx emissie die schepen emitteren.

AECOM heeft Ingenia opdracht gegeven om de stikstofemissie voor zowel de aanlegfase van de kabel in de Nederlandse EEZ als de exploitatiefase van de kabel in de Nederlandse EEZ te berekenen om vervolgens aan de hand daarvan de stikstofdepositie te berekenen. In dit rapport is de stikstofdepositie berekend voor de aanlegfase van de NeuConnect kabel.

In een separaat rapport wordt de stikstofdepositie van de exploitatiefase vastgesteld, dit betreft rapport *“Stikstofdepositie onderzoek t.b.v. de exploitatiefase NeuConnect kabel in Nederlandse EEZ (1958639-RAP-0004-05)”*.

## 1.2 Leeswijzer

In hoofdstuk 2 zijn de uitgangspunten beschreven. De uitgangspunten bestaan uit de technische gegevens van de benodigde schepen, snelheid van het proces, duur van het project en het kabeltracé. In hoofdstuk 3 zijn de stikstof emitterende activiteiten en onderbouwing van de berekeningen beschreven. De stikstofdepositie berekening inclusief de resultaten zijn weergeven in hoofdstuk 4. In hoofdstuk 5 is de conclusie beschreven.

# 2 Uitgangspunten

## 2.1 Iteratief proces

De emissieberekeningen voor de aanleg van de NeuConnect kabel is een iteratief proces. Dit komt doordat er steeds meer informatie bekend is omtrent de benodigde activiteiten en door NeuConnect zorgvuldig is en wordt bekeken of de stikstofimpact van de aanleg verder beperkt kan worden.

**Najaar 2019 – voorjaar 2020**

In het najaar van 2019 zijn de eerste berekeningen voor de stikstofemissie gemaakt op basis van op dat moment beschikbare documenten. Op dat moment was nog niet gespecificeerd hoe de kabel aangelegd zou worden. Er is daarom besloten om 4 verschillende uitvoeringsvarianten op te stellen. Voor de stikstofdepositieberekening is uitgegaan van de worst-case uitvoeringsvariant. De depositieberekening is opgenomen en toegelicht in rapportage “Stikstofdepositie onderzoek t.b.v. de aanleg van de NeuConnect kabel in Nederlandse EEZ (1958639-RAP-0002-02)” uit mei 2020. Deze rapportage is met het ministerie van LNV besproken.

**Najaar 2020**

Vanuit de wens om de stikstofimpact van de aanleg op realistische wijze in kaart te brengen en een zo beperkt mogelijke stikstofimpact te veroorzaken, heeft voor het in kaart brengen van de stikstofimpact een iteratief proces plaatsgevonden. In het najaar van 2020 is in het kader van inschrijvingen op de tender voor het project gedetailleerde informatie beschikbaar gekomen over de voor de aanleg benodigde activiteiten. Op basis van deze gedetailleerde informatie zijn in samenwerking met Primo Marine, expert op het gebied van onderwaterinfrastructuur, de nieuwe, realistische uitgangspunten vastgesteld voor de emissieberekeningen. De grootste verandering ten opzichte van de berekeningen uit het najaar 2019 heeft betrekking op het afgraven van de mobiele zeebodem. In het najaar van 2019 was met een worst-case uitvoeringsvariant gerekend waarbij er ca. 1.000.000 m³ afgegraven diende te worden. Uit de tenderdocumenten blijkt dat er ca. 175.000 m³ zand afgegraven dient te worden.

De nieuwe uitgangspunten zijn gebruikt voor de berekening van de realistische uitvoeringsvariant 1. Vanuit de wens van NeuConnect om een zo beperkt mogelijke stikstofimpact te veroorzaken is onderzocht of de emissie verder gereduceerd kon worden ook in het licht van eisen die gesteld kunnen worden aan in te zetten schepen. Hieruit zijn twee realistische aanpassingen aan de uitgangspunten naar voren gekomen. Deze aanpassingen hebben betrekking op activiteit 4 afgraven van mobiele zeebodem. In de onderstaande varianten zijn de wijzigingen beschreven ten opzichte van variant 1:

<u>Variant 1A</u>: uit de tenderdocumenten blijkt dat Boskalis Gateway wordt genoemd om activiteit 4 uit te voeren. Uit het specificatie document van dit schip blijkt dat het schip gebouwd is in 2009, dit betekent dat het schip nog in de IMO emissie klasse TIER I valt. Bij variant 1A is gerekend dat dit schip voldoet aan de IMO emissie klasse TIER II. Dit wordt dan als voorwaarde opgelegd in de opdrachtverstrekking voor de aanleg.

<u>Variant 1B</u>: In de ontvangen tenderdocumenten is niet gespecificeerd of het schip (Boskalis Gateway) gereed gemaakt wordt in een Nederlandse of Britse haven. In variant 1 is ervan uitgegaan dat het schip gereed gemaakt wordt in een Nederlandse haven. In variant 1B is ervan uitgegaan dat dit gebeurt in een Britse haven. Dit is reëel omdat de verwachting is dat het schip begint met het afgraven in het Britse deel en vervolgens verder gaat in Nederlandse deel. Het enige deel van het tracé in de Nederlandse EEZ dat een mobiele zeebodem heeft is gelegen tegen de Britse zeegrens. Dit wordt dan als voorwaarde opgelegd in de opdrachtverstrekking voor de aanleg.

Variant 1C: variant 1C is een combinatie van bovengenoemde aanpassingen. Deze variant is gebruikt voor de stikstofdepositieberekeningen.

In dit rapport is variant 1C verder uitgewerkt. De aanpassingen ten opzichte van variant 1 zullen worden opgenomen als voorwaarden in de opdrachtverstrekking voor de aanleg van de NeuConnect kabel. In Bijlage E is een overzicht van de emissies per variant weergeven.

## 2.2 Technische gegevens

NeuConnect wordt ontwikkeld door een consortium van investeerders: Meridiam SAS, Allianz Capital Partners, Kansai Electric Power Company en Greenage Power. Voor de ontwikkeling van het project hebben zij NeuConnect Great Britain Limited (NCGBL, verder NeuConnect genoemd) opgericht. De voorgestelde NeuConnect kabel is een 1.400 megawatt (MW) interconnector tussen de hoogspanning elektriciteitsnetwerken van Groot-Brittannië en Duitsland met een geschatte lengte van in totaal circa 720 km tussen de twee converterstations. In Groot-Brittannië loopt dit via de Isle of Grain te Medway en in Duitsland via Fedderwarden te Wilhelmshaven. De route van de kabel doorkruist de Nederlandse Exclusieve Economische Zone (EEZ) over een lengte van circa 265 km.

Het aanleggen van de kabel bestaat uit meerdere stappen. De stappen die uitgevoerd moeten worden, zijn afhankelijk van het bodemprofiel van de zeebodem. De zeebodem is geofysisch en geotechnisch onderzocht. Mede op die basis heeft NeuConnect een tender uitgeschreven voor de aanleg van de kabel. De tenderpartijen beschikken over deze informatie en hebben op basis hiervan een aanbieding gemaakt. Primo Marine, expert op het gebied van onderwaterinfrastructuur, heeft op basis van de tenderdocumenten een overzicht opgesteld met de benodigde activiteiten voor de aanleg van de kabel. Deze activiteiten zijn vastgelegd in Tabel 2-1. In Tabel 2-1 is verder aangegeven welk schip geschikt is om de activiteit uit te voeren. De activiteiten uit Tabel 2-1 zijn in detail beschreven in het MER en de vergunningaanvragen.

*Tabel 2-1 Uitgangsgegevens van benodigde schepen*

| nr. | Activiteit | Geschikt schip of soortgelijk | IMO emissie klasse |
|---|---|---|---|
| 1 | Pre-engineering geofysisch onderzoek | Fugro Pionier | TIER II |
| 2 | Niet-gesprongen explosieven (NGE) geofysisch onderzoek | Fugro Pionier | TIER II |
| 3 | Pre-installatie geofysisch onderzoek | Fugro Pionier | TIER II |
| 4 | Afgraven mobiele zeebodem | Boskalis Gateway | TIER II |
| 5 | Vrijmaken van route en ‘PLGR’ | AHTS Sima | TIER II |
| 6 | Pre-aanlegfase aanbrengen rotsen t.b.v. bescherming kruisingen | JdN Adhémar Saint-Venant | TIER II |
| 7 | Simultaan aanleggen en begraven kabel incl. lassen verbindingspunten | NKT Victoria | TIER III |
| 8 | Begraven van verbindingspunten | Normand Pacific | TIER I |
| 9 | Na aanlegfase aanbrengen rotsen t.b.v. bescherming kruisingen | JdN Simon Stevin | TIER I |
| 10 | Bescherming van de kabel | Asper Malene | Pre TIER I |

In hoofdstuk 3 worden de technische uitgangspunten van de activiteiten beschreven.

## 2.3 Beschrijving kabeltracé

De NeuConnect kabel heeft een lengte van circa 265 km in Nederland. De kabel wordt gelegd in Noordzee. In figuur 2-1 is het tracé van de kabel weergeven. Het NeuConnect kabeltracé kruist in Nederlandse wateren het volgende Natura 2000 gebied:

- Friese Front over een lengte van circa 78 km;
    - Voor het Friese Front zijn geen instandhoudingsdoelstellingen vastgesteld voor soorten met stikstofgevoelig leefgebied, zodat voor stikstofeffecten van het project op het Friese Front geen vergunning op grond van de Wet natuurbescherming nodig is.[1]

*Figuur 2-1 Kabeltracé NeuConnect (rechts) kaart met Natura 2000 gebieden(links)[2]*

Ten zuiden van het kabeltracé liggen de volgende Natura 2000 gebieden[2]:

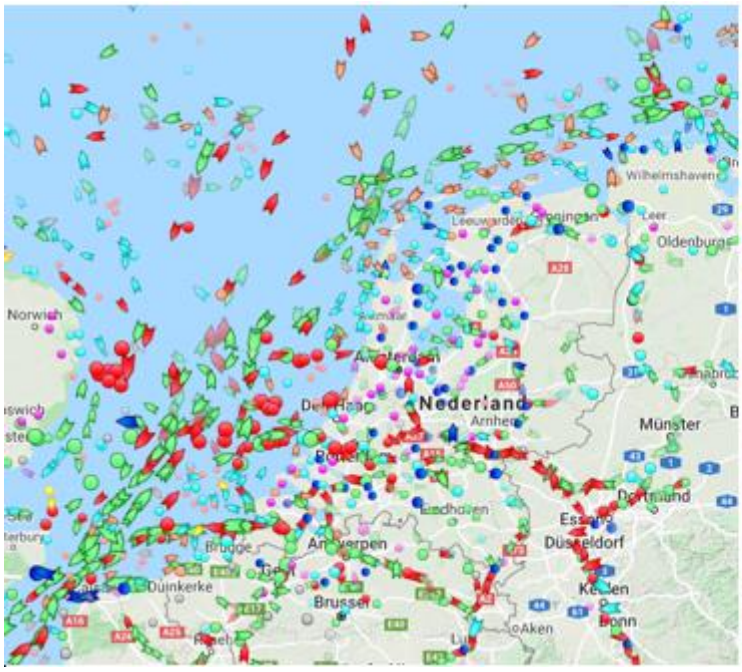
1. Duinen en lage land Texel
2. Duinen Vlieland
3. Duinen Terschelling
4. Duinen Ameland
5. Duinen Schiermonnikoog
6. Waddenzee
7. Noordzeekustzone

De hierboven genoemde Natura 2000 gebieden zijn stikstofgevoelige natuurgebieden, behalve het gebied Noordzeekustzone[1]. Voor de Noordzeekustzone geldt hetzelfde als voor de Friese Front, hier geldt dus geen vergunningsverplichting ter behoeve van de stikstofdepositie. Voor de Natura 2000 gebieden 1 t/m 6 geldt dat de stikstofdepositie in deze gebieden vastgesteld moet worden. Vanuit het kabeltracé is Duinen Terschelling het dichtstbijzijnde Natura 2000 gebied dat getoetst moet worden op de stikstofdepositie. Op het dichtstbijzijnde punt is de afstand ongeveer 45 km tussen het tracé en het Natura 2000 gebied.

[1] Bron: https://zoek.officielebekendmakingen.nl/stcrt-2017-70696.html#d17e7416

[2] Bron: https://www.synbiosys.alterra.nl/natura2000/googlemapszoek2.aspx

De Noordzee is een druk bevaren gebied. Iedere dag leggen tientallen tot honderden schepen ongeveer dezelfde route af als het kabeltracé. Dit wordt vastgelegd door MarineTraffic. Op het linkse deel van Figuur 2-2 zijn de schepen te zien die op 10-12-2020 varen in de Noordzee, ieder pijltje is een schip. In het rechter deel van Figuur 2-2 is de vaarintensiteit weergeven. De kleur geeft de intensiteit aan. Op basis van de bordeaux rode vaarlijnen is te zien dat vaarintensiteit hoog is in de EEZ, die kunnen oplopen tot meer dan 300.000 vaarbewegingen[3] per 1,22 km² per jaar.




*Figuur 2-2 Weergave van scheepvaart op 10-12-2020*

[3] Bron: https://www.marinetraffic.com/en/ais/home/centerx:4.8/centery:53.3/zoom:8

# 3 Beschrijving emissieberekening

## 3.1 Uitgangspunten activiteiten

Primo Marine heeft op basis van de aangeleverde tenderdocumenten een overzicht opgesteld van de voor de aanleg benodigde activiteiten. Hierbij zijn per activiteit de volgende punten beschreven:

- Locatie per (deel)activiteit
- Aantal benodigde schepen
- Tijdsduur van (deel)activiteit
- Gemiddeld gebruik vermogen per (deel)activiteit
- Wachttijd t.b.v. veranderende weersomstandigheden (WoW – Waiting on Weather)
    - Geldt voor hoofdactiviteit en transit. Heeft geen invloed op schip gereedmaken in haven
- Aantal dagen dat een schip op zee kan blijven

Het door Primo Marine opgestelde overzicht is weergeven in BIJLAGE A.

Om de hoofdactiviteiten te kunnen realiseren is het nodig om het schip gereed te maken in de haven en de vervoerbeweging van en/ naar het kabeltracé.

- Benodigde deelactiviteiten
    - Schip gereedmaken in haven
    - Vervoersbeweging van en/ of naar kabeltracé
    - Wisseling van de bemanning

Onafhankelijk van dit project wordt ieder schip ingezet en dus voorbereid in de haven. Dit is dan ook opgenomen in activiteiten van de desbetreffende havens. De emissies die vrijkomen bij de voorbereiding van het schip in de haven zijn onderdeel van de emissies die bij die haven horen en zijn al betrokken in het AERIUS model. Dit betekent dus dat het niet nodig is om deze emissie te berekenen voor de activiteiten van NeuConnect omdat het anders dubbel in AERIUS gemodelleerd wordt. De emissie van de vaarbewegingen vanuit de haven naar de dichtstbijzijnde hoofdvaarweg is ook reeds opgenomen in het AERIUS model.

De schepen varen vanuit de havens, IJmuiden of de Eemshaven, direct de zeevaartroutes op tot dat ze het kabeltracé bereiken. Dit geldt ook voor de vaarbewegingen voor de wisseling van de bemanning. Dit betekent dat ze direct worden opgenomen in het heersende vaarbeeld, wat reeds is verwerkt in de achtergronddepositie. Conform het document “Instructie gegevensinvoer voor AERIUS Calculator 2020” opgesteld door Expertiseteam Stikstof en Natura 2000 is het daarom niet nodig deze activiteiten op te nemen in de AERIUS calculatie.

De emissie van voornoemde deelactiviteiten worden niet opgenomen in de AERIUS berekeningen.

In dit hoofdstuk zijn de uitgangspunten per activiteit beschreven. Dit dient als de basis van de emissieberekeningen. Per activiteit is de emissie berekend. Er worden 10 verschillende activiteiten onderscheiden die hieronder nader worden toegelicht.

**Activiteit 1 / 2 / 3: Geofysisch onderzoek (pre-engineering/NGE/pre-installatie)**

De zeebodem dient voor de start van de aanleg van de kabel goed in kaart gebracht te worden. Dit kan worden opgesplitst in 3 fases, namelijk 1) pre-engineering, 2) NGE en 3) pre-installatie. Het pre-engineersonderzoek dient als aanvullende informatie voor het ontwerp van de kabel. Uit het NGE onderzoek moet blijken dat er geen onontplofte objecten aanwezig zijn op het kabeltracé. Dit NGE onderzoek dient uitgevoerd te worden voordat veilig gestart kan worden met zeebodem bouwrijp te maken (de plaatselijke afgraving van de mobiele zeebodem en het vrijmaken van de route d.m.v. 'PLGR[4]'). Na het bouwrijp maken van de zeebodem wordt de zeebodem nogmaals geofysisch onderzocht in pre-installatiefase.

Voor alle drie fases geldt dat het gehele Nederlandse kabeltracé onderzocht dient te worden, dit is ca. 265 km. Tijdens de pre-engineeringsfase dienen ook 12 kruisingen[5] met bestaande kabels/leidingen in kaart gebracht te worden. De snelheid van de geofysische onderzoeken ligt op ca. 15 km per dag. Wat betreft het in kaart brengen van de kruisingen wordt uitgegaan van 2 kruisingen per dag.

Voor de emissieberekening is uitgegaan dat het geofysisch onderzoek wordt uitgevoerd door een soortgelijk schip als bijvoorbeeld 'Fugro Pioneer'. De datasheet van het schip is weergeven in BIJLAGE B.

**Activiteit 4: Voorbereiding van de route ter plaatse van zandgolven (pre-sweeping)**

In het Nederlandse tracé van de NeuConnect kabel bevindt zich naar schatting over een lengte van 31 km een mobiele zeebodem. Het is mogelijk dat delen van de kabel die hoog in mobiele zeebodems(zandgolven) zijn ingegraven, bloot komen te liggen als het bodemprofiel van de zeebodem verandert. De inschatting van het project is dat er over de 31 km mobiele zeebodem in totaal 175.000 m³ afgegraven dient te worden, zodat de kabel onder het niet mobiele zeebodem niveau komt te liggen. De afgraafcapaciteit is ingeschat op een gemiddelde van 8.000 m³ per dag.

De mobiele zeebodem in het Nederlandse tracé sluit aan het Britse tracé waar zich ook nog delen met mobiele zeebodem bevindt. Het schip wordt geprepareerd in Groot-Brittannië en voltooit eerst het Britse deel en graaft vervolgens het Nederlandse deel af.

Voor de emissieberekening is uitgegaan dat het afgraven wordt uitgevoerd door een schip zoals bijvoorbeeld 'Boskalis Gateway' of soortgelijk dat voldoet aan TIER II. De datasheet van het schip is weergeven in BIJLAGE B.

**Activiteit 5: Vrijmaken van route d.m.v. 'PLGR'**

Net voor de aanleg van de kabels dient de route over de gehele lengte vrijgemaakt te worden van allerlei obstakels. Dit wordt gedaan door middel van slepen van een serie PLGR over de bodem. Dit gebeurt met een gemiddelde snelheid van

---

[4] PLGR staat voor Pre-lay grapnel run. Het PLGR-schip sleept een draad met een reeks speciaal ontworpen haken of grijpers langs de hartlijn van het kabeltracé tot het puin aantreft. De lier is uitgerust met een voorziening die de toename van de spanning detecteert wanneer een voorwerp wordt vastgehaakt. De grijper is ontworpen om objecten op en net onder het oppervlak te grijpen. Door middel van de PLGR wordt de zeebodem omgeploegd om het leggen van de kabel te vereenvoudigen.

[5] Het NeuConnect project kruist in de Nederlandse sectorkabels en pijpleidingen op 33 kruisingslocaties. De kruisingen dienen niet allemaal beschermd te worden. Er zijn in totaal 15 kruisingen die beschermd dienen te worden en de overige 18 behoeven geen bescherming. De 15 kruisingen betreffen actieve kabels en OOS pijpleidingen. Er zijn 3 dubbele kruisingen, waar 2 pijpleidingen nabij elkaar gelegen zijn. Deze dubbele kruisingen zijn in de berekeningen beschouwd als één kruising. De 2 pijpleidingen worden gezamenlijk beschermd. Dit betekent dat in totaal 12 kruisingen onderzocht en beschermd dienen te worden.

circa 20 km per dag. Er zijn geen gespecialiseerde schepen die dit uitvoeren. Er is daarom voor gekozen een AHT schip, dit is een multifunctioneel werkschip.

Voor de emissieberekening is uitgegaan dat het vrijmaken van de route wordt uitgevoerd door een schip zoals 'AHTS Sima' of soortgelijk. De datasheet van het schip is weergeven in bijlage B.

**Activiteit 6: Pre-aanlegfase aanbrengen rotsen t.b.v. bescherming kruisingen**

De 12 locaties, waar de NeuConnect kabel actieve kabels en OOS leidingen kruisen, dienen te worden beschermd. De bescherming bestaat uit een laag tussen de actieve kabels en OOS leidingen en de NeuConnect kabel. Vervolgens wordt de kabel gelegd en dient de kabel ook weer afgedekt te worden met een beschermlaag. De eerste laag dient aangelegd te worden voorafgaand aan het leggen van de NeuConnect kabel.

De beschermlaag bestaat uit rotsachtig materiaal dat met hoge precisie wordt geplaatst. Voorafgaand aan het kabelleggen kan de kruisingsbescherming geplaatst worden met een relatief klein schip. Er kunnen twee kruisingen per dag beschermd worden.

Voor de emissieberekening is uitgegaan dat het aanbrengen van rotsen wordt uitgevoerd door een schip zoals 'JdN Adhémar Saint-Venant' of soortgelijk. De datasheet van het schip is weergeven in BIJLAGE B.

**Activiteit 7: Simultaan aanleggen en begraven kabel incl. lassen verbindingspunten**

Het simultaan leggen en begraven van de kabel bestaat uit diverse onderdelen die met één schip uitgevoerd kunnen worden. De volgende acties vallen onder deze activiteit:

- Pre-installatie aanleggen van beschermingsmatrassen kruisingen (12 kruisingen à 4 kruisingen per dag)
- Proeven en testen equipment (ca. 6 dagen)
- Het leggen van de kabel
    - Simultaan leggen en begraven (251 km à ca. 200 m per uur)
    - Aanleggen van de kabel ter hoogte van de kruisingen en lasverbindingen (14 km à ca. 550 m per uur)
- Lasverbinding maken tussen de twee kabel (2 stuks à 7 dagen per lasverbinding)
- Testen, afdichten en neerleggen einde van de kabel (2 lasverbindingen à 1 dag per lasverbinding)

Voor de emissieberekening is uitgegaan dat het simultaan leggen en begraven wordt uitgevoerd door een schip zoals 'NKT Victoria' of soortgelijk. De datasheet van het schip is weergeven in BIJLAGE B.

**Activiteit 8: Ingraven verbindingspunten**

De gelaste verbindingspunten kunnen niet direct gelegd en begraven worden. Het is daarom noodzakelijk om het verbindingspunt apart nog in te graven onder de niet-mobiele zeebodem. Het verbindingspunt heeft een gemiddelde lengte van ca. 1 km. Dit is mogelijk met een (post-lay inspection and burial) PLIB schip. Tevens dient de nog openliggende kabel bij 12 kruisingen begraven te worden. Om zeker te zijn dat tijdens het simultaan leggen en begraven niet de tracé kruisende kabels/leidingen geraakt worden, wordt een gemiddelde afstand van 500m voor en 500m na de kruising niet direct begraven. De openliggende kabel ter hoogte van de kruisingen wordt ingegraven met een PLIB schip. Dit gebeurt met een snelheid van ca. 300m per uur.

Voor de emissieberekening is uitgegaan dat het ingraven van de verbindingspunten wordt uitgevoerd door een schip zoals 'Normand Pacific' of soortgelijk. De datasheet van het schip is weergeven in BIJLAGE B.

**Activiteit 9: Na aanlegfase aanbrengen rotsen t.b.v. bescherming kruisingen**

Om de kruisingen te beschermen nadat de kabel gelegd is, dient er een uitgebreide beschermlaag aan gebracht te worden voor de 12 kruisingen. Op deze locaties is het namelijk niet mogelijk om de kabel in te graven. De beschermlaag bestaat uit rotsachtig materiaal wat met hoge precisie wordt geplaatst. Hierbij dient gebruik gemaakt te worden van een groter schip in vergelijking met de pre-aanlegfase. De benodigde tijd van het aanbrengen van deze beschermlaag is daarbij ook een stuk hoger, namelijk 2,5 dag per kruising.

Voor de emissieberekening is uitgegaan dat het aanbrengen van rotsen wordt uitgevoerd door een schip zoals 'JdN Simon Stevin' of soortgelijk. De datasheet van het schip is weergeven in BIJLAGE B.

**Activiteit 10: Bescherming van de kabel**

Bij het leggen van de zeekabel is er continu een stuk van de kabel dat nog niet ingegraven is. Om de openliggende kabel te beschermen zijn 'guard' schepen nodig. Deze schepen liggen dan in de buurt van de kabel ter waarschuwing dat andere schepen niet 'door' de kabel heen kunnen varen. Het aantal van deze 'guard' schepen is afhankelijk van de methode van het aanleggen van het schip. Voor het simultaan leggen en begraven van de kabel zijn 4 schepen nodig.

Voor de emissieberekening is uitgegaan dat het beschermen van de kabel wordt uitgevoerd door een schip zoals 'Asper Malene' of soortgelijk. door De datasheet van het schip is weergeven in BIJLAGE B.

In tabel 3-1 is een overzicht weergeven van uitgangspunten per (deel)activiteit. Dit dient als basis voor de emissie-berekeningen.

*Tabel 3-1 overzicht uitgangspunten per activiteit*

| ***Nr.*** | ***Omschrijving activiteit*** | ***Naam schip*** | **Operationele uren** | **WoW [%]** |
|---|---|---|---|---|
| 1 | Pre-engineering geofysisch onderzoek | Fugro Pionier | 473 | 30% |
| 2 | NGE geofysisch onderzoek | Fugro Pionier | 353 | 30% |
| 3 | Pre-installatie geofysisch onderzoek | Fugro Pionier | 353 | 30% |
| 4 | Afgraven mobiele zeebodem | Boskalis Gateway | 467 | 10% |
| 5 | Vrijmaken van route en 'PLGR' | AHTS Sima | 665 | 30% |
| 6 | pre-aanlegfase aanbrengen rotsen t.b.v. bescherming kruisingen | JdN Adhémar Saint-Venant | 120 | 2% |
| 7 | Simultaan aanleggen en begraven kabel incl. lassen verbindingspunten | NKT Victoria | 2.115 | 12% |
| 8 | Begraven van verbindingspunten | Normand Pacific | 185 | 9% |
| 9 | Na aanlegfase aanbrengen rotsen t.b.v. bescherming kruisingen | JdN Simon Stevin | 600 | 2% |
| 10 | Bescherming van de kabel | Asper Malene | 1.300 | 0% |

## 3.2 Onderbouwing berekening

De emissieberekening wijkt af van de standaardmethode van AERIUS om de emissie van schepen te berekenen. Dit is gedaan omdat de standaard AERIUS berekenmethode gebaseerd is op enkel het varen van A naar B of het laden en lossen in de haven. De activiteiten maken op een andere manier en intensiteit gebruik van het desbetreffende opgesteld vermogen. De gehanteerde berekenmethodes voor dit rapport komen overeen met de achterliggende berekeningen van AERIUS.

### 3.2.1 Emissiekengetal

Voor de emissieberekening is gebruik gemaakt van de emissiekengetallen afkomstig uit IMO emissie klassen[6][7]. De emissiekengetallen zijn gegeven in g $NO_x$ per kWh. Om de emissiekengetallen te kunnen gebruiken, dient de nuttige gebruikte energie berekend te worden. De nuttig gebruikte energie is uitgedrukt op kWh/km en kWh per uur. De nuttig gebruikte energie is volgens de volgende twee rekenmethodes berekend:

- Rekenmethode 1: Op basis van het brandstofverbruik;
- Rekenmethode 2: Op basis van het opgestelde vermogen in combinatie met gemiddeld gebruik van het vermogen.

Rekenmethode 1 is de meest nauwkeurige methode om de nuttig gebruikte energie te berekenen. Het brandstofverbruik is gebaseerd op de praktijk, waarbij er onderscheid wordt gemaakt tussen de verschillende activiteiten van een schip. Rekenmethode 2 is gebaseerd op het opgestelde vermogen en een inschatting gemiddeld percentage dat gebruikt wordt van het opgesteld vermogen. Rekenmethode 2 leidt tot een hogere emissie in vergelijking met rekenmethode 1. Dat betekent indien er gebruik wordt gemaakt van rekenmethode 2 de nuttig gebruikte energie wordt overschat ten opzichte van de praktijk. Dit leidt dus tot een hogere $NO_x$ emissie.

Voor het berekenen van de emissie is in eerste instantie gebruik gemaakt van rekenmethode 1. Indien de benodigde gegevens niet (volledig) beschikbaar zijn, is gebruik gemaakt van rekenmethode 2.

### 3.2.2 Rekenmethode 1: Op basis van het brandstofverbruik

Primo Marine beschikt over gegevens van het brandstofverbruik van diverse schepen en activiteiten. Deze zijn weergeven in BIJLAGE C. Het brandstofverbruik is gegeven in m³/dag. Om op basis van het brandstofverbruik de nuttig gebruikte energie te berekenen zijn de volgende formules gebruikt:

$$Nuttige\ gebruikte\ energie\ [kWh\ /\ uur] = (Brandstofverbruik * \rho * LHV\ *\ \eta\_motor)/(24\ uur\ /\ dag)$$

(formule 3-1)

$$Nuttige\ gebruikte\ energie\ [kWh\ /\ km] = (Brandstofverbruik\ * \rho * LHV\ *\ \eta\_motor)/(V\ \ * 1{,}852 * 24\ uur/dag)$$

(formule 3-2)

Brandstofverbruik in m³/dag afkomstig uit gegevens Primo Marine (afhankelijk per activiteit en of vaarsnelheid)
ρ : dichtheid (MDO[8] = 0,88 ton/m³)

[6] https://dieselnet.com/standards/inter/imo.php

[7] Marin report no. 29555-1-MSCN-rev.2; sea shipping emissions 2015: Dutch continental Shelf, 12-mile zone and port areas; juni 2017

[8] Marine Diesel Oil

LHV : stookwaarde (MDO = 42.700 MJ/ton)
ηmotor : motorefficiency (45%)
V: snelheid in km/uur (afhankelijk per schip)

### 3.2.3 Rekenmethode 2: Op basis van het opgestelde vermogen

De emissiefactoren zijn met behulp van twee verschillende formules berekend. De eerste is voor de berekening van de emissiefactor uitgedrukt in kg NOx per km. Om de emissiefactor te kunnen bepalen is gebruik gemaakt van formule 3-3. Deze formule is afkomstig uit rapport "Marin report no. 29555-1-MSCN-rev.2"[1]. Voor elke activiteit is op basis van deze formule een emissiefactor berekend.

$$EF^{\wedge\prime} = EF \times (P \times fMCR)/V \qquad \text{(Formule 3-3)}$$

EF' Emissiefactor uitgedrukt als kg NOx per km
EF standaard motor emissiefactor als kg/kWh → Tier I/Tier II/Tier III afhankelijk van bouwjaar.
P Opgesteld vermogen in kW → data komt uit datasheets per schip
fMCR Gemiddeld percentage dat gebruikt wordt van het opgesteld vermogen P → inschatting Primo
V Actuele snelheid in km/uur → Inschatting Primo Marine of datasheet schip

De tweede emissiefactor is uitgedrukt in kg NOx per uur. Voor deze emissiefactorberekening is gebruik gemaakt van formule 3-4. Formule 3-4 is afgeleid van formule 3-3. In formule 3-4 is de vaarsnelheid uit de formule gehaald, dit resulteert in een formule gebaseerd op tijdsbasis.

$$EF'' = EF \times P \times P\_(act.) \qquad \text{(Formule 3-4)}$$

EF'' Emissiefactor uitgedrukt als kg NOx per uur
$P_{act.}$ Gemiddeld percentage dat gebruikt wordt van het opgesteld vermogen (P) → inschatting Primo Marine

In tabel 3-2 is per activiteit en deelactiviteit aangegeven wat de berekende emissiefactor is. In Tabel 3-2 is tevens aangegeven welke rekenmethode gebruikt is door (1) of (2).

*Tabel 3-2 overzicht emissiefactoren*

| ***nr.*** | ***Omschrijving activiteit*** | **Emissiefactor [kg NOx/uur]** |
|---|---|---|
| 1 | Pre-engineering geofysisch onderzoek | 6,81 (1) |
| 2 | NGE geofysisch onderzoek | 6,81 (1) |
| 3 | Pre-installatie geofysisch onderzoek | 6,81 (1) |
| 4 | Afgraven mobiele zeebodem | 110,87 (2) |
| 5 | Vrijmaken van route en 'PLGR' | 25,96 (1) |
| 6 | Pre-aanlegfase aanbrengen rotsen t.b.v. bescherming kruisingen | 18,42 (2) |
| 7 | Simultaan aanleggen en begraven kabel incl. lassen verbindingspunten | 13,04 (2) |
| 8 | Begraven van verbindingspunten | 21,49 (1) |
| 9 | Na aanlegfase aanbrengen rotsen t.b.v. bescherming kruisingen | 81,21 (2) |
| 10 | Bescherming van de kabel | 2,02 (2) |

## 3.3 Stikstofoxiden emissie

De stikstofemissievracht is per activiteit berekend aan de hand van de uitgangspunten genoemd in hoofdstuk 3.1 en de berekende emissiefactor. De totale emissievracht voor alle activiteiten t.b.v. het aanleggen van de NeuConnect kabel in de Nederlandse Exclusieve Economische Zone (EEZ) is 162.148 kg NOx. In tabel 3-3 is per activiteit de emissie weergeven. In bijlage D zijn de berekeningen weergeven.

*Tabel 3-3 Totale emissievrachten per activiteit*

| nr. | Omschrijving activiteit | Naam schip | Emissie klasse | Emissie [kg NOx] |
|---|---|---|---|---|
| 1 | Pre-engineering geofysisch onderzoek | Fugro Pionier | TIER II | 3.222 |
| 2 | NGE geofysisch onderzoek | Fugro Pionier | TIER II | 2.405 |
| 3 | Pre-installatie geofysisch onderzoek | Fugro Pionier | TIER II | 2.405 |
| 4 | Afgraven mobiele zeebodem | Boskalis Gateway | TIER II | 51.737 |
| 5 | Vrijmaken van route en 'PLGR' | AHTS Sima | TIER II | 17.261 |
| 6 | Pre-aanlegfase aanbrengen rotsen t.b.v. bescherming kruisingen | JdN Adhémar Saint-Venant | TIER II | 2.210 |
| 7 | Simultaan aanleggen en begraven kabel incl. lassen verbindingspunten | NKT Victoria | TIER III | 27.572 |
| 8 | Begraven van verbindingspunten | Normand Pacific | TIER I | 3.982 |
| 9 | Na aanlegfase aanbrengen rotsen t.b.v. bescherming kruisingen | JdN Simon Stevin | TIER I | 48.725 |
| 10 | Bescherming van de kabel | Asper Malene | Pre TIER I | 2.630 |
| | Totaal | | | **162.148** |

## 3.4 Stikstofoxiden emissie varianten

De stikstofemissievracht is per activiteit berekend voor de varianten 1, variant 1A en variant 1B. Deze varianten zijn niet in AERIUS doorgerekend voor de stikstofdepositie berekeningen. In Tabel 3-4, Tabel 3-5 en Tabel 3-6 zijn de emissievrachten weergeven.

*Tabel 3-4 Totale emissievrachten variant 1*

| nr. | Omschrijving activiteit | Naam schip | Emissie klasse | Emissie [kg NOx] |
|---|---|---|---|---|
| 1 | Pre-engineering geofysisch onderzoek | Fugro Pionier | TIER II | 3.221,8 |
| 2 | NGE geofysisch onderzoek | Fugro Pionier | TIER II | 2.405,0 |
| 3 | Pre-installatie geofysisch onderzoek | Fugro Pionier | TIER II | 2.405,0 |
| 4 | Afgraven mobiele zeebodem | Boskalis Gateway | TIER I | 64.458,9 |
| 5 | Vrijmaken van route en 'PLGR' | AHTS Sima | TIER II | 17.260,7 |
| 6 | Pre-aanlegfase aanbrengen rotsen t.b.v. bescherming kruisingen | JdN Adhémar Saint-Venant | TIER II | 2.210,2 |
| 7 | Simultaan aanleggen en begraven kabel incl. lassen verbindingspunten | NKT Victoria | TIER III | 27.571,6 |
| 8 | Begraven van verbindingspunten | Normand Pacific | TIER I | 3.982,2 |
| 9 | Na aanlegfase aanbrengen rotsen t.b.v. bescherming kruisingen | JdN Simon Stevin | TIER I | 48.724,6 |
| 10 | Bescherming van de kabel | Asper Malene | Pre TIER I | 2.951,3 |
| | Totaal | | | **175.191,3** |

*Tabel 3-5 Totale emissievrachten variant 1A*

| nr. | Omschrijving activiteit | Naam schip | Emissie klasse | Emissie [kg NOx] |
|---|---|---|---|---|
| 1 | Pre-engineering geofysisch onderzoek | Fugro Pionier | TIER II | 3.221,8 |
| 2 | NGE geofysisch onderzoek | Fugro Pionier | TIER II | 2.405,0 |
| 3 | Pre-installatie geofysisch onderzoek | Fugro Pionier | TIER II | 2.405,0 |
| 4 | Afgraven mobiele zeebodem | Boskalis Gateway | TIER II | 51.737,3 |
| 5 | Vrijmaken van route en 'PLGR' | AHTS Sima | TIER II | 17.260,7 |
| 6 | Pre-aanlegfase aanbrengen rotsen t.b.v. bescherming kruisingen | JdN Adhémar Saint-Venant | TIER II | 2.210,2 |
| 7 | Simultaan aanleggen en begraven kabel incl. lassen verbindingspunten | NKT Victoria | TIER III | 27.571,6 |
| 8 | Begraven van verbindingspunten | Normand Pacific | TIER I | 3.982,2 |
| 9 | Na aanlegfase aanbrengen rotsen t.b.v. bescherming kruisingen | JdN Simon Stevin | TIER I | 48.724,6 |
| 10 | Bescherming van de kabel | Asper Malene | Pre TIER I | 2.951,3 |
| | Totaal | | | **162.469,6** |

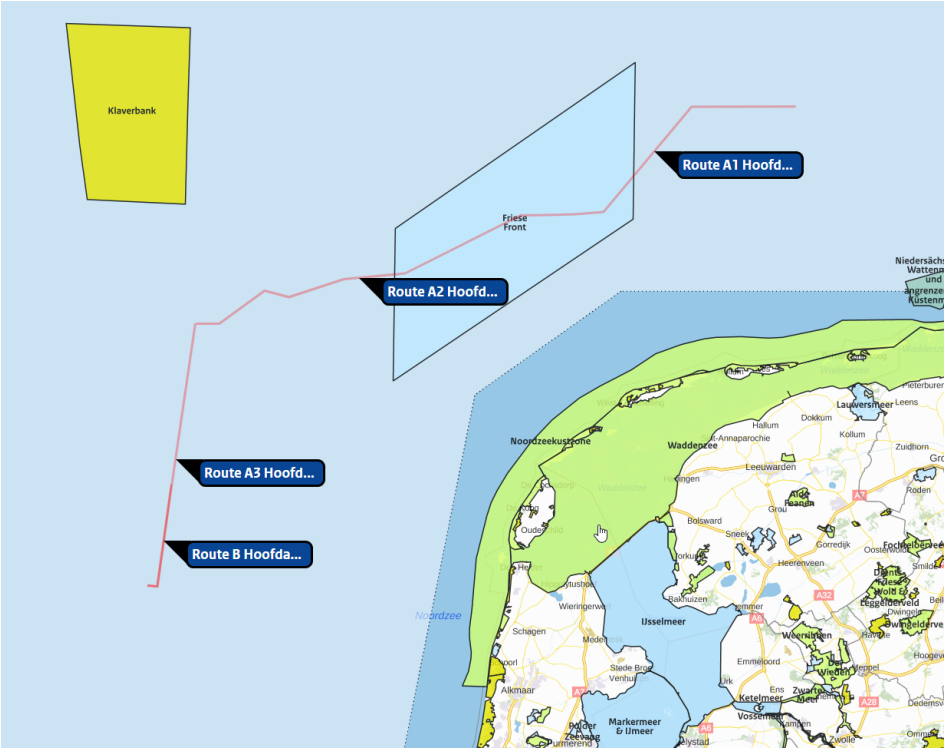
*Tabel 3-6 Totale emissievrachten variant 1B*

| nr. | Omschrijving activiteit | Naam schip | Emissie klasse | Emissie [kg NOx] |
|---|---|---|---|---|
| 1 | Pre-engineering geofysisch onderzoek | Fugro Pionier | TIER II | 3.221,8 |
| 2 | NGE geofysisch onderzoek | Fugro Pionier | TIER II | 2.405,0 |
| 3 | Pre-installatie geofysisch onderzoek | Fugro Pionier | TIER II | 2.405,0 |
| 4 | Afgraven mobiele zeebodem | Boskalis Gateway | TIER I | 64.458,9 |
| 5 | Vrijmaken van route en 'PLGR' | AHTS Sima | TIER II | 17.260,7 |
| 6 | Pre-aanlegfase aanbrengen rotsen t.b.v. bescherming kruisingen | JdN Adhémar Saint-Venant | TIER II | 2.210,2 |
| 7 | Simultaan aanleggen en begraven kabel incl. lassen verbindingspunten | NKT Victoria | TIER III | 27.571,6 |
| 8 | Begraven van verbindingspunten | Normand Pacific | TIER I | 3.982,2 |
| 9 | Na aanlegfase aanbrengen rotsen t.b.v. bescherming kruisingen | JdN Simon Stevin | TIER I | 48.724,6 |
| 10 | Bescherming van de kabel | Asper Malene | Pre TIER I | 2.629,9 |
| | Totaal | | | **174.870,0** |

# 4 Stikstofdepositie berekening

Op basis van de berekende emissie uit hoofdstuk 3 is de extra stikstofdepositie ten gevolge van de voorgenomen activiteiten bepaald met behulp van 'AERIUS versie 2020'. De totaal berekende stikstofemissie van de aanlegfase is 162.148 kg NOx. De extra stikstofdepositie is bepaald voor de Natura 2000 gebieden. De aanlegfase van NeuConnect start in 2022.

Voor iedere activiteit is de locatie vastgesteld. Op basis van de locaties zijn routes gemodelleerd in AERIUS voor de activiteiten op zee. Een route in AERIUS kan dus meerdere activiteiten bevatten. Het AERIUS model is opgebouwd volgens de bronnen uit tabel 4-1. In Figuur 4-1 zijn de gemodelleerde routes weergeven.




*Figuur 4-1 weergave gemodelleerde routes AERIUS*

In AERIUS is het niet mogelijk om langere trajecten (>100 km) in een keer te modelleren als bron. Voor deze bronnen opgesplitst in meerdere deelroutes. De emissie is evenredig verdeeld naar de lengte van de deelroute. Bijvoorbeeld, route A heeft een lengte van 265 km en is vervolgens opgesplitst in deelroutes A1/A2/A3.

De warmteoutput en hoogte van de schoorsteen is onbekend. Hiervoor zijn aannames gedaan door Ingenia op basis van een TNO rapportage[9]:

- Warmteoutput; 25% van het gestookt vermogen komt als warmte vrij uit de schoorsteen.
- Schoorsteenhoogte: 24 m voor het varen. Dit is gebaseerd op werkschepen klasse 4 uitworphoogte

[9] TNO-Rapport TNO 2019 R11040 Kengetallen zeeschepen

*Tabel 4-1 Overzicht bronnen AERIUS scenario 2*

| Bron AERIUS | Omschrijving | Totale emissie [kg NOx] | Activiteiten |
|---|---|---|---|
| Route A | Kabeltracé Nederlandse EEZ | 110.411 | 1 t/m 3; 5 t/m 10 |
| Route B | Deel kabeltracé t.b.v. afgraving mobiele zeebodem | 51.737 | 4 |

Uit de AERIUS berekening volgt dat op meer dan 129 Natura 2000 gebieden een extra stikstofdepositie (>0,00 mol/ha/jaar) optreedt als gevolg van de aanlegwerkzaamheden. De hoogste bijdrage is berekend in het gebied 'Duinen Vlieland', de stikstofdepositie is op twee habitattypen afgerond 0,09 mol/ha/jaar, de hoogste bijdrage is in dat gebied 0,0914 mol/ha/jaar. Dit is op één hexagon berekend. In bijlage E is het rapport van de AERIUS berekening weergeven.

# 5 Conclusie

Bij de aanleg van de NeuConnect kabel in de Nederlandse EEZ wordt $NO_x$ geëmitteerd. De aanlegactiviteiten zijn geïdentificeerd en samengevat om als uitgangspunten te dienen voor de emissieberekeningen. De totaal berekende emissie van de aanlegfase van de NeuConnect kabel bedraagt 162.148 kg $NO_x$.

De extra stikstofdepositie is bepaald met behulp van 'AERIUS versie 2020'. Uit de AERIUS berekening volgt dat op meer dan 150 natura-2000 gebieden een extra stikstofdepositie (>0,00 mol/ha/jaar) optreedt als gevolg van de aanleg. De hoogste bijdrage is berekend in het gebied 'Duinen Vlieland', de stikstofdepositie is maximaal 0,0914 mol/ha/jaar.

*BIJLAGE A Overzicht uitgangspunten Primo Marine*

| Summary | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| nr. | Activity | Sub-Actvity | Location | Typical Vessel | Number of Spreads | Unit | Quantity | Production Speed (incl. maintenance/breakdown allowance) (unit/day) | Waiting on Weather (Estimate as Percent of Operating Days) | Duration [d] | Duration (incl. WoW) | Percent of Total Power (typical daily average) | Included |
| 1 | Pre-Engineering Geophysical Survey | Mobilisation/Demobilisation | IJmuiden | Geophysical Vessel | 1 | day | 4,0 | 1,0 | 0% | 4,0 | 4,0 | 10% | YES |
| 1 | Pre-Engineering Geophysical Survey | Transit to/From Site | N/A | Geophysical Vessel | 1 | day | 1,0 | 1,0 | 0% | 1,0 | 1,0 | 50% | YES |
| 1 | Pre-Engineering Geophysical Survey | Route Survey | Offshore Route | Geophysical Vessel | 1 | km | 265,0 | 15,0 | 30% | 17,7 | 23,0 | 50% | YES |
| 1 | Pre-Engineering Geophysical Survey | Crossing Surveys | Offshore Route | Geophysical Vessel | 1 | crossing | 12,0 | 2,0 | 30% | 6,0 | 7,8 | 50% | YES |
| 2 | UXO Survey | Mobilisation/Demobilisation (same as Geophysical Survey) | IJmuiden | Geophysical Vessel | 1 | day | 1,0 | 1,0 | 0% | 1,0 | 1,0 | 10% | YES |
| 2 | UXO Survey | Transit to/From Site | N/A | Geophysical Vessel | 1 | day | 1,0 | 1,0 | 0% | 1,0 | 1,0 | 50% | YES |
| 2 | UXO Survey | Route Survey | Offshore Route | Geophysical Vessel | 1 | km | 265,0 | 15,0 | 30% | 17,7 | 23,0 | 50% | YES |
| 3 | Pre-Installation Geophysical Survey | Mobilisation/Demobilisation | IJmuiden | Geophysical Vessel | 1 | day | 4,0 | 1,0 | 0% | 4,0 | 4,0 | 10% | YES |
| 3 | Pre-Installation Geophysical Survey | Transit to/From Site | N/A | Geophysical Vessel | 1 | day | 1,0 | 1,0 | 0% | 1,0 | 1,0 | 50% | YES |
| 3 | Pre-Installation Geophysical Survey | Route Survey | Offshore Route | Geophysical Vessel | 1 | km | 265,0 | 15,0 | 30% | 17,7 | 23,0 | 50% | YES |
| 4 | Pre-Sweeping | Mobilisation/Demobilisation | Outside Dutch Territory | Pre-Sweeping Vessel | 1 | day | 4,0 | 1,0 | 0% | 4,0 | 4,0 | 10% | NO |
| 4 | Pre-Sweeping | Transit to/From Site | N/A | Pre-Sweeping Vessel | 1 | day | 0,0 | 1,0 | 0% | 0,0 | 0,0 | 75% | YES |
| 4 | Pre-Sweeping | Offshore Works | Offshore Route | Pre-Sweeping Vessel | 1 | $m^3$ | 175000,0 | 8000,0 | 10% | 21,9 | 24,1 | 75% | YES |
| 5 | PLGR/Route Clearance/OOS Removal | Mobilisation/Demobilisation | IJmuiden | AHT | 1 | day | 2,0 | 1,0 | 0% | 2,0 | 2,0 | 10% | YES |
| 5 | PLGR/Route Clearance/OOS Removal | Transit to/From Site | N/A | AHT | 1 | day | 1,0 | 1,0 | 0% | 1,0 | 1,0 | 50% | YES |
| 5 | PLGR/Route Clearance/OOS Removal | PLGR along route | Offshore Route | AHT | 1 | km | 265,0 | 20,0 | 30% | 13,3 | 17,2 | 75% | YES |
| 5 | PLGR/Route Clearance/OOS Removal | OOS Cable Clearance | Offshore Route | AHT | 1 | locations | 20,0 | 1,0 | 30% | 20,0 | 26,0 | 50% | YES |
| 6 | Pre-Lay Rock Placement at Crossings | Mobilisation/Demobilisation | Outside Dutch Territory | Fall-Pipe Vessel | 1 | day | 0,0 | 1,0 | 0% | 0,0 | 0,0 | 10% | NO |
| 6 | Pre-Lay Rock Placement at Crossings | Transit to/From Site | N/A | Fall-Pipe Vessel | 1 | day | 1,0 | 1,0 | 0% | 1,0 | 1,0 | 75% | YES |
| 6 | Pre-Lay Rock Placement at Crossings | Offshore Works | Offshore Route | Fall-Pipe Vessel | 1 | crossing | 12,0 | 2,0 | 2% | 6,0 | 6,1 | 30% | YES |
| 7 | Cable Lay Activities (In case of predominantly SLB) | Mobilisation/Demobilisation | Outside Dutch Territory | Cable-Lay Vessel | 1 | day | 0,0 | 1,0 | 0% | 0,0 | 0,0 | 10% | NO |
| 7 | Cable Lay Activities (In case of predominantly SLB) | Transit to/From Site | N/A | Cable-Lay Vessel | 1 | day | 1,0 | 1,0 | 0% | 1,0 | 1,0 | 75% | YES |
| 7 | Cable Lay Activities (In case of predominantly SLB) | Pre-Lay Mattress Installation | Offshore Route | Cable-Lay Vessel | 1 | crossing | 12,0 | 4,0 | 25% | 3,0 | 3,8 | 30% | YES |
| 7 | Cable Lay Activities (In case of predominantly SLB) | Trials and Testing | Offshore Route | Cable-Lay Vessel | 1 | day | 6,0 | 1,0 | 10% | 6,0 | 6,6 | 45% | YES |
| 7 | Cable Lay Activities (In case of predominantly SLB) | Cable Laying | Offshore Route | Cable-Lay Vessel | 1 | km | 14,0 | 11,0 | 10% | 1,3 | 1,4 | 45% | YES |
| 7 | Cable Lay Activities (In case of predominantly SLB) | Simultaneous Lay&Burial | Offshore Route | Cable-Lay Vessel | 1 | km | 251,0 | 4,0 | 10% | 62,8 | 69,0 | 45% | YES |
| 7 | Cable Lay Activities (In case of predominantly SLB) | Testing/Sealing/Lay Down Cable End | Offshore Route | Cable-Lay Vessel | 1 | locations | 2,0 | 1,0 | 25% | 2,0 | 2,5 | 30% | YES |
| 7 | Cable Lay Activities (In case of predominantly SLB) | Jointing | Offshore Route | Cable-Lay Vessel | 1 | joints | 2,0 | 0,143 | 25% | 14,0 | 17,5 | 30% | YES |
| 7 | Cable Lay Activities (In case of predominantly SLB) | Post-Lay Survey | Offshore Route | Cable-Lay Vessel | 1 | km | 251,0 | 15,0 | 5% | 16,7 | 17,6 | 30% | YES |
| 7 | Cable Lay Activities (In case of predominantly SLB) | Transit To/From Local Port | N/A | Cable-Lay Vessel | 1 | day | 1,0 | 1,0 | 0% | 1,0 | 1,0 | 75% | YES |
| 7 | Cable Lay Activities (In case of predominantly SLB) | Discharge Scrap/Spare Cable | Outside Dutch Territory | Cable-Lay Vessel | 1 | day | 2,0 | 1,0 | 0% | 2,0 | 2,0 | 10% | NO |
| 8 | Cable Burial (Only joints and crossings) | Mobilisation/Demobilisation | IJmuiden | Post-Lay Burial Vessel | 1 | day | 1,0 | 1,0 | 0% | 1,0 | 1,0 | 10% | YES |
| 8 | Cable Burial (Only joints and crossings) | Transit to/From Site | N/A | Post-Lay Burial Vessel | 1 | day | 1,0 | 1,0 | 0% | 1,0 | 1,0 | 75% | YES |
| 8 | Cable Burial (Only joints and crossings) | Trials and Testing | Offshore Route | Post-Lay Burial Vessel | 1 | day | 6,0 | 1,0 | 10% | 6,0 | 6,6 | 45% | YES |
| 8 | Cable Burial (Only joints and crossings) | Jetting Burial Along Route (incl. joints) | Offshore Route | Post-Lay Burial Vessel | 1 | km | 14,0 | 6,0 | 10% | 2,3 | 2,6 | 45% | YES |
| 8 | Cable Burial (Only joints and crossings) | Hybrid Burial Along Route | Offshore Route | Post-Lay Burial Vessel | 1 | km | 0,0 | 4,0 | 10% | 0,0 | 0,0 | 45% | YES |
| 8 | Cable Burial (Only joints and crossings) | Post-Burial Survey | Offshore Route | Post-Lay Burial Vessel | 1 | km | 14,0 | 15,0 | 5% | 0,9 | 1,0 | 30% | YES |
| 9 | Post-Lay Rock Placement at Crossings | Mobilisation/Demobilisation | Outside Dutch Territory | Fall-Pipe Vessel | 1 | day | 0,0 | 1,0 | 0% | 0,0 | 0,0 | 10% | NO |
| 9 | Post-Lay Rock Placement at Crossings | Transit to/From Site | N/A | Fall-Pipe Vessel | 1 | day | 1,0 | 1,0 | 0% | 1,0 | 1,0 | 75% | YES |
| 9 | Post-Lay Rock Placement at Crossings | Offshore Works | Offshore Route | Fall-Pipe Vessel | 1 | crossing | 12,0 | 0,4 | 2% | 30,0 | 30,6 | 30% | YES |
| 10 | Guardine cable | Offshore Works | Offshore Route | Guard vessel | 4 | day | 16.3 | 1,0 | 0% | 16.3 | 16.3 | 25% | YES |
| 10 | Guarding cable | Transit to/From Site | N/A | Guard vessel | 4 | day | 4,0 | 1,0 | 0% | 4,0 | 4,0 | 25% | YES |
| 11 | Crew transfer | Transit to/From Site | N/A | Crew transfer vessel | 1 | day | 1,0 | 102,5 | 10% | 0,0 | 0,0 | 50% | YES |

*BIJLAGE B datasheets vergelijkbare schepen*

Boskalis
Dredging & Marine Experts

# EQUIPMENT SHEET

**GATEWAY**
TRAILING SUCTION HOPPER DREDGER

## CONSTRUCTION/CLASSIFICATION

| | |
|---|---|
| Built by | Merwede Shipyard B.V. |
| Year of construction | 2010 |
| Classification | I ✠ Hull ✠ Mach. Hopperdredger. Unrestricted Navigation. Dredging within 15 miles from shore or within 20 miles from port; or dredging over 15 miles from shore with a significant wave height restriction to 3.0 m. ✠ AUT-UMS |

## FEATURES

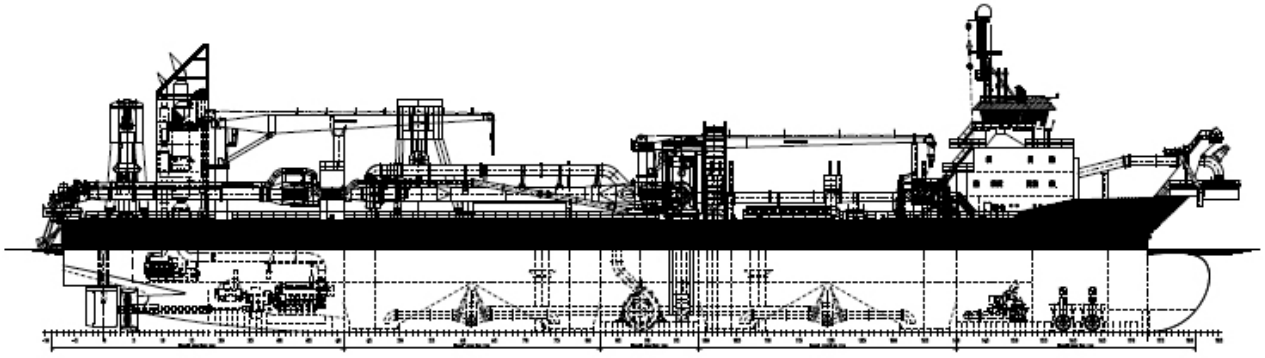
- 2 Separate hoppers with pump room in between.
- Accommodation on fore ship.
- 1 Suction pipe with submersible dredge pump at starboard side.
- 2 Fixed deckcranes.
- Relative small draught.

## MAIN DATA

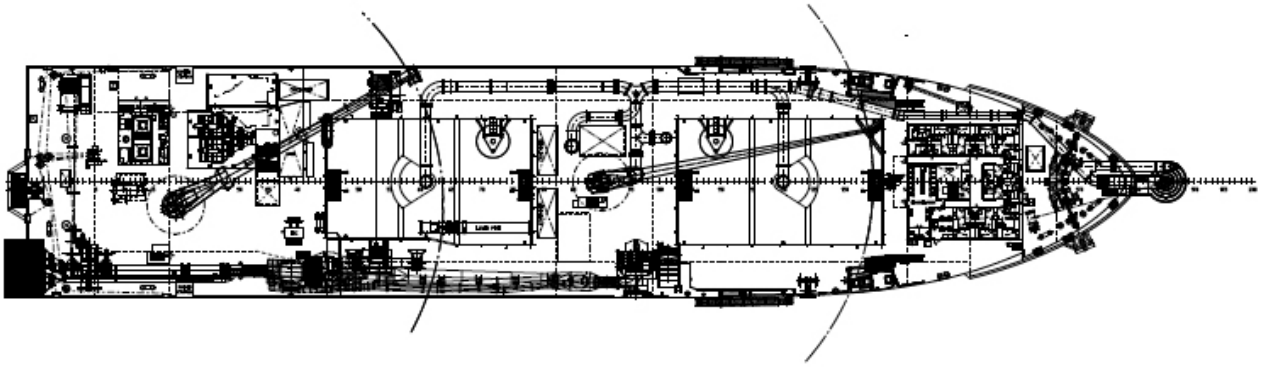
| | |
|---|---|
| Length overall | 143.53 m |
| Breadth | 28.00 m |
| Moulded depth | 13.50 m |
| Max. draught Int. load line | 8.00 m |
| Max. draught dredging load line | 10.00 m |
| Carrying capacity (D.W.) | about 22,000 t |
| Hopper capacity | 12,000 $m^3$ |
| Suction pipe diameter | 1 x 1,200 mm |
| Max. dredging depth | approx. 62.00 m |
| Discharge systems | Dumping through bottom doors (4), shore discharge and rainbow. |
| Sailing speed loaded | 15.4 kn |
| Total installed power | 13,870 kW |
| Sand pump output | Inboard dredge pump: 7,500 kW |
| | Submersible dredge pump: 3,500 kW |
| Jet pump output | 2 x 1,250 kW |
| Pump ashore output | 7,500 kW |
| Propulsion power sailing | 2 x 6,000 kW |
| Bow thruster | 2 x 700 kW |

Boskalis
Dredging & Marine Experts

**GATEWAY**
TRAILING SUCTION HOPPER DREDGER



**SIDE VIEW**



**TOP VIEW DECK LEVEL**

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# NKT VICTORIA

# Next generation cable-laying vessel

NKT Victoria is one of the world´s most advanced and fuel efficient cable-laying vessels with a fully redundant DP3 system and unique onboard DC Grid.

The vessel is capable of simultaneous dual HVDC and fiber optic cable-laying and deep sea HVAC installation with high capacity tensioner system. The two turntables have a combined capacity of massive 9000 ton, plus a 500 ton capacity fiber optic tank below deck.

To enable complete cable-lay capabilities ranging from the deep blue seas to shallow shores, NKT Victoria is designed to be beachable in fully laden condition. The vessel is also fitted with a 6-point mooring system to maneuver where most deep sea cable layer would give up.

For ultra deep waters, the deck is prepared to accommodate a Vertical Lay Tower to enable sufficient high tension hold-back capabilities.

NKT Victoria is designed to the highest safety standard, in full compliance with the most stringent requirements. Her versatility is further strengthened by a fully integrated navigation and survey system.

**SPECIFICATIONS**

LENGTH: 140 m

BREADTH: 29.60 m

DRAUGHT: 7.20 m

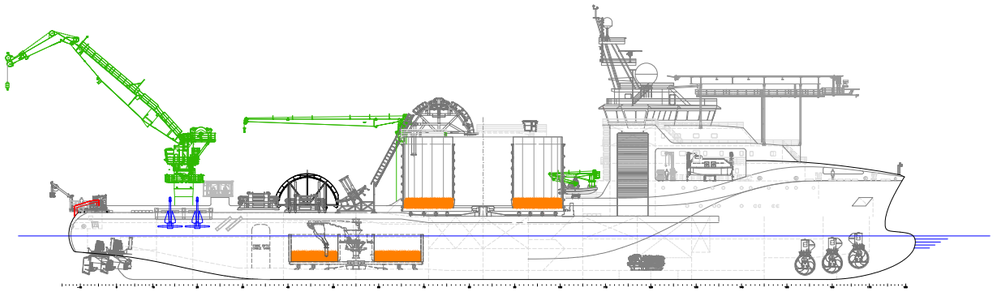
PROPULSION:
Diesel-Electric DC grid
Stern Azipods

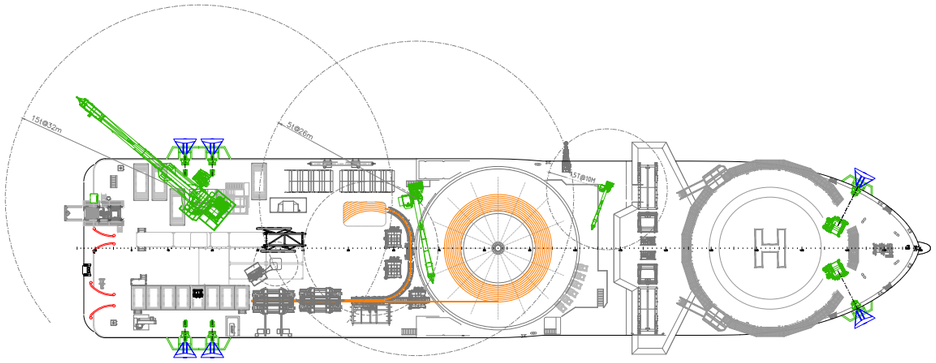
DP CLASS: IMO DPIII

ACCOMMODATION: 100 Pax

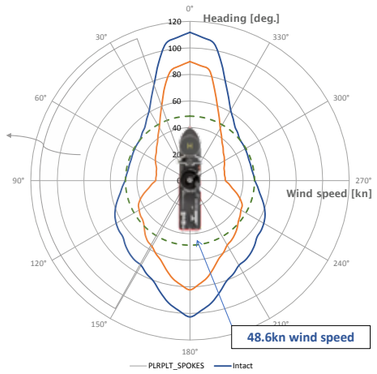
DECK AREA: 1 600 m

TURNTABLES:
7 000 ton on main deck
4 500 ton below deck





| Heading [°] | Wind [knots] Intact | Wind [knots] DP2 SWB C failure |
|---|---|---|
| 20 | 78.4 | 61.7 |
| 25 | 68.9 | 53 |
| 30 | 61.3 | 46.2 |
| 35 | 56.8 | 41.9 |
| 40 | 52.8 | 38 |
| 45 | 50.9 | 35.6 |
| 50 | 48.8 | 33.1 |
| 55 | 48.4 | 31.7 |
| 60 | 48 | 30.1 |
| 65 | 47.6 | 28.3 |
| 70 | 47.1 | 26.8 |
| 75 | 47.2 | 26.3 |
| 80 | 47.3 | 25.7 |
| 85 | 48.1 | 25.8 |
| 90 | 48.9 | 26 |
| 95 | 51.1 | 28.8 |
| 100 | 53.3 | 31.5 |
| 105 | 56.5 | 35.6 |
| 110 | 59.7 | 39.6 |
| 115 | 62.4 | 42.8 |
| 120 | 64.2 | 44.2 |
| 125 | 65.4 | 45.6 |
| 130 | 66 | 46.4 |
| 135 | 68.8 | 48.8 |
| 140 | 71.2 | 52.6 |
| 145 | 72.9 | 55.6 |
| 150 | 73.7 | 57.2 |



# NKT Victoria General specifications

**Classification**
The vessel is built and classified according to DNV GL Rules:
1A1, SF, E0, DYNPOS AUTRO (DP3), COMF C(3), COMF V(3),
Clean Design, BIS, NAUT(OSV) (A), DK(+),HELDK-SH, SPS,
Cable Laying Vessel, Recyclable

**Design**
SALT Shipdesign 306 CLV
Kleven Yards Hull no 372, delivered April 2017
Flag: NIS

**Main dimensions**
Length over all ----------140.00 m
Length between p.p ----------127.10 m
Breadth moulded----------29.60/ 28.60 m
Depth to 1-deck ----------11.00 / 10.40 m
Scantling draught ----------8.00 m
Beaching draught ----------8.25 m
Design draught ----------7.20 m
Gross tonnage ----------16171 GT
Max speed ----------14 kts
Cruising speed ----------12 kts
Endurance Min ----------30 days
Max Deadweight ----------12700 t
Deck Area ----------1600 m2

**Accommodation**
Total 100 persons in 77 cabins:
State Class cabins : 6
Officer Class Cabins: 6
Crew Class Single Cabins: 42
Crew Class Double Cabins: 23

**Dynamic Positioning and Reference**
DNV GL DYNPOS AUTRO (IMO DPIII)
2 x identical DP Operator Stations
1 x DP operator station is provided on emergency bridge.
1 x Dual DP Process Station is provided.
2 x HiPAP, 2 x DGPS, 1 x Cyscan, 1 x RADius
Cable tension, Light Taut Wire
6P mooring system

**Capacities**
Fuel MGO---------- 1 500 m3
Potable water system ---------- 560 m3
Water ballast ---------- 5 000 m3
Lub oil----------25 m3
Urea----------120 m3
Food waste----------4 m3

**Propulsion**
Propulsion Diesel-electric DC Grid
CAT 3516C / ABB variable speed Gensets ---------- 6 x 2 240 kW
Stern Azipods, ABB ---------- 3 x 1 900 kW
Tunnel Thrusters, Brunvoll ---------- 3 x 1 900 kW
Total Installed Power ---------- 13 440 kW

**Environment**
Exhaust gas cleaning by SCR, engines approved according to Tier 3, sulphur free fuel, garbage recycling and sludge/garbage incinerator.

**Offshore cranes**
1 x Main Active Heave Compensated knuckle boom Crane:
Lifting capacity 25 t/15 t at 23 m/32 m radius to 1 000 m
Manriding capabilities
1 x Deck Crane knuckle boom
Lifting capacity : 10 t/4 t at 15 m/26 m radius.
Manriding capabilities
1 x Provision crane knuckle boom
Capacity: 1.5 t @ 10 m

**ROV**
SB side ROV 250 HP Schilling UHD Gen III with 3,000 m depth rating
P side ROV SAAB Panther XTP with 1,500 m depth rating
1 x LARS for WROV on SB side

**Helicopter platform**
Designed & constructed in full compliance with Class Rules
Dimensions 26.1 x 26.1m, designed for Sikorsky S-92 Type, max load15 t

**Cable Lay Equipment**
1 x 7 000 t capacity basket carousel on Main deck
1 x 4 500 t capacity basket carousel below deck
9 000 t total combined cable capacity
2 x wide stern chutes
2 x 45 t four track lay tensioners
3 x 45 t tensioner deck seats
Product pathway for fibre optic cable installation

**Winch package**
3 x 45 t A&R winch with 800 m of wire rope
2 x 6.4 t initiation winch with 160 m of Ø19 mm wire rope
2 x 6.4 t tugger winches with 160 m of Ø19 mm wire rope
Central control system and cable lay distribution system

**Optional Equipment**
25 Te A-frame for jet trencher or ROV launch/recovery
VLS tower for ultra deepwater lay

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SE-37123 Karlskrona
Sweden

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NKT is signatory of the Europacable Industry Charter: A commitment towards superior quality.

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# Adhémar de Saint-Venant.

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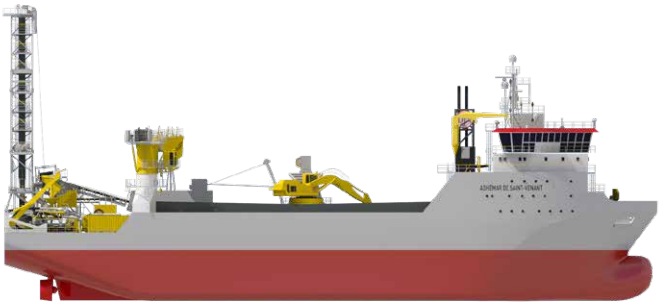
# Adhémar de Saint-Venant.



## DP2 Trenching and Offshore Support Vessel
## Subsea Rock Installation Vessel

### TECHNICAL SPECS

| | |
|---|---|
| Deadweight | 5,950 ton |
| Rock carrying capacity | approx. 4,750 t |
| Lenght o.a. | 95 m |
| Breadth | 22 m |
| Draught loaded | 6.5 m |
| Dynamic positioning | DYNAPOS AM/AT R Class 2 |
| Propulsion power | 2 x 1,250 kW |
| Bow thruster power | 2 x 1,250 kW |
| Total installed diesel power | 7,670 kW |
| Speed | 11.5 kn |
| Accommodation | 60 persons (notation Special Purpose Ship) |
| Built in | 2017 |
| Max fall pipe depth | 600 m |
| Inclined fall pipe diam. | 1,800 mm |
| Offshore crane | AHC Crane 40 t |
| Rock Loading capacity | 1 Liebherr 984 Excavator (1000 ton/h) |
| Optional equipment | ROV Trencher<br>Workclass ROV<br>A-Frame |

In the Subsea Rock Installation mode, the vessel can install approx. 4,750 t of rock in a single load by means of the excavator, conveyor belt and the fall pipe for accurate rock installation at up to 600 m water depth. Alternatively the rock can be handled through an inclined fall pipe, for secure installation against offshore structures such as jacket platforms, gravity bases or monopile foundations.

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Jan De Nul GROUP

14 May 2020 12:21 pm

Photographer: Løtvedt (Bergen)

# Simon Stevin.

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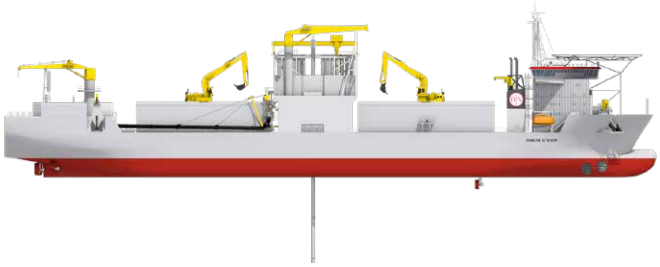
# Simon Stevin.



## DP2 Fall Pipe Rock Installation Vessel

### TECHNICAL SPECS

| | |
|---|---|
| Length o.a. | 191.5 m |
| Breadth | 40.0 m |
| Draught loaded | 9.25 m (at full deadweight) |
| Dynamic positioning | DYNAPOS AM/AT R Class 2 |
| Propulsion power | 4 x 3,350 kW |
| Bow thruster power | 4 x 2,000 kW |
| Total installed diesel power | 24,350 kW |
| Speed | 15.5 kn |
| Accommodation | 70 |
| Rock carrying capacity | 31,500 ton |
| Discharge capacity | 2,000 ton/hour |
| Fall pipe diameter | 1,000 mm |
| Max. discharge depth | 2,000 m |
| Built in | 2010 |

With a rock carrying capacity of 31,500 tonnes, this fallpipe rock installation vessel is together with its sister vessel, Joseph Plateau, the largest of its kind in the world and one of the few vessels equipped for rock installation in waterdepths of 2,000 m. Beside the very large operational depth, a unique feature of the vessel's feeding system to the fall pipe is that it is capable to deal with rock size of 400 mm, which is more than any other fall pipe vessel. For shallow water pipeline sections and scour protection alongside offshore platforms where the stability of the rock is defined by seabed currents, this allows to reduce the rock volume and resulting costs.



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Jan De Nul GROUP

5 May 2020 10:26 am

# **FUGRO**
# M.V. FUGRO PIONEER

**M.V. Fugro Pioneer has been built to the highest standards demanded of a modern internationally operating multi-purpose survey vessel.**

The diesel electric propulsion, specially designed hull, resilient engine mounts and rudder propellers maximize station keeping and navigational control while ensuring acoustically quiet running at survey speeds.

Designed with consideration for safety and environment, Fugro Pioneer is a compact flexible platform supporting a wide range of offshore services with a typical operational profile of geophysical, geotechnical survey operations up to 1000m WD.

It's limited 3m draft adds to its capabilities to operate in shallow water nearshore. The vessel can easily be configured to support light ROV and environmental operations. The 53 metre-long vessel is prepared for dynamic positioning and equipped with state-of-the-art survey equipment.

*State of the Art Kongsberg Dual Head Dual Ping Multibeam in retractable moonpool system.*

*Limited draft makes it specifically suitable for survey nearshore.*

# M.V. FUGRO PIONEER

## Technical specifications

### General info

| | |
|---|---|
| Name | Fugro Pioneer |
| Classification society | DNVGL |
| Flag state / Port | Bahamas Maritime Authority / Nassau |
| Build(er) | September 2014 – Damen Shipyards Galati |
| IMO / Cal sign | 9701645 / C6BH3 |
| Official Number | 7000674 |

### Dimensions

| | |
|---|---|
| LOA. | 53.7m |
| Beam | 12.5m |
| Draught (summer) max. | 3.1m + 0.26m blister |
| Tonnage | 1322T |
| Deck area aft | 250m$^2$ |
| Deck strength | 5T / m$^2$ |
| Deck load | 81,6T |

### Accommodation

| | |
|---|---|
| Cabins | 30+4 Bunks / 10x Single cabins, 10x Double cabins |
| Crew (Typical) | 11x Marine Crew, 20x Survey Crew |
| Recreational | 1x Dayroom, 1x Gym |
| Work Offices | 2x Survey, 1x Meeting room |

### Machinery

| | |
|---|---|
| Propulsion | 2x Azimuth thrusters (electric) |
| Bow thrusters | 1x Tunnel thrusters (electric) |
| Cruising speed | 10 kn |
| Survey speed | Variable as required |
| Maximum speed | 11.2 kn |

### Electrical power

| | |
|---|---|
| Diesel generator sets | 4x 372kW |
| UPS supply survey | 1x 30VA, 220vac |

### Capacities

| | |
|---|---|
| Fuel capacity | 305 m$^3$ |
| Fuel consumption (FOC t/day) | Survey 3t / Stationary ( DP) 4.2t / Transit 6t |
| Potable water capacity | 115 m$^3$ |
| Water making | 6 m$^3$/d |

### Control and navigation

| | |
|---|---|
| DP System | Imtech DP-0 |
| Radar | Hagenuk Bridgemaster FT CAT1/2 S-band and X-band |
| Electronic chart | Imtech ECDIS (Single) |
| DGPS | 1x Koden KGPGZO / 2x Fugro Starpack |
| Magnetic compass | Sperry Jupiter |

### Deck Machinery

| | |
|---|---|
| Deck crane aft | Palfinger PK65002 MD |
| Storage crane forward | Palfinger PK15000 MC |
| Hydraulics Ring Main system | 300bar / 200ltr. |
| A-frame aft (geophysical) | 2x 3/6T SWL |
| A-frame side (geotechnical) | 1x 9T SWL |
| CTD winch/davit | 1x 300 kg / 1000m (environmental sampling) |
| Tugger winch aft deck | 4x 3T SWL |
| Moonpool | Rectangular 1630x883mm (free space) |

### Communications

| | |
|---|---|
| GMDSS | Motorola - 3x VHF Handheld |
| Vsat | 2x Seatel 5009 Ku-band |
| Iridium | Iridium Openport (Fall back) |
| UHF / VHF Radios (Operational coms) | Motorola - 2x VHF Handheld / 3x UHF Mobile / 9x UHF Portable |
| CCTV Camera system | Orlaco |
| TVRO | Intellian t40W |

### Safety

| | |
|---|---|
| MOB boat | RIB |
| Life rafts | 6 x 20 persons |
| Survival suits & Life jackets | 44 pcs |
| Lifeline Pulley System | Yes |
| Personal Locator Beacons (PLB) | SeaMarshall |

### Survey equipment

| | |
|---|---|
| DGPS Positioning | Fugro Starfix Starpacks |
| Navigation package | Fugro Starfix Suite |
| Acoustic positioning | Kongsberg HiPap 501 incl Cymbal |
| Motion Reference Unit | Hydrins + Octans |
| Echosounder | Simrad EA400 |
| Draft monitoring | 2x Rosemount Pressure Sensors |
| Multibeam Echosounder | Kongsberg Maritime EM 2040 (Dual head/ Dual ping) |
| Side Scan Sonar | Edgetech 4200 (100/600) |
| Sub Bottom Profiler | Hullmount Array/ Fugro Glog, Boomer, Sparker |
| Magnetometer | Geometrics G-882 |
| Geophysical tow winch | 2x EMCE (3.5Te/ 4000m/ Rochester) |
| Geotechnical hoisting winch | 1x EMCE (9Te/ 1500m/ 19mm) |
| Seismic Compressor | Wärtsilä Water Systems Ltd Hamworthy 185E MK2 |
| 2D-Seismic gear | as required |
| Geotechnical sampling | as required |
| Environmental sampling | as required |

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# M/V Asper Malene

## Chase Guard Support vessel

**MV Asper Malene is a preferred vessel for guard services offshore. The ship has an eminent history of such missions, and a wide range of good references. On request, the ship can undertake scopes such as towing and also transport of goods in reefer cargo holds.**

**Asper Norway AS has a focus on fully experienced Norwegian Crew members and QA HSE.** The vessel is built and equipped to ensure operation time is kept to a maximum between service intervals.

**The cargo hold is converted in to a large reefer room which contains an area on 203 m³.** Asper Malene has a top speed on 11 knots, making it a good choice for our customers. The vessel is a fully operational Guard Vessel for Operations in European Trade.

ASPER NORWAY AS

# M/V Asper Malene

## TECHNICAL SPECIFICATION

**Main details**
Year of construction: 1971
Refurbished: 1998
Vessel name: Asper Malene
Flag: NOR
IMO Number: 5344695
Call Sign: LJDW
MMSI: 259528000
Homeport: Fosnavaag

**Main Dimensions**
LOA: 37,0 m
WOA: 8,0 m
DPT: 3,9 m

**Tonnage**
GRT: 288
NRT: 136

**Generator(s)**
Main Gen.: 2 x Volvo Penta D6
1 Cummins, 1 x Perkins

**Main Engine**
Stork Werkspoor Callesen 1000 hp

**Propulsion System**
Propeller: Pitch 2,9 m dia

Bow Thruster: 1 x 250 hp
Stern Thruster: 1 x 180 hp

**Accommodation**
6 man
8 berths

**Anchor(s)**
2 x stock

**Crane(s)/Lifting material**
1 x 5 tonnes Palfinger

**Deck Equipment**
1 x Deck crane
3 x Capestanes

**Safety Equipment**
FRC Zodiac

**Communication Equipment**
1 x Furuno GMDSS Station
1 x Furuno SSB Radio
3 x Sailor VHF Radio

3 x ICOM Portable VHF
1 x Furuno Immarsat Sat-C
1 x IRIDIUM Mini-M
1 x Furuno AIS
1 x ICOM E.P.I.R.B.
1 x ICOM S.A.R.T.

E-mail:
bridge.malene@aspernorway.com
Sat. Phone: IRIDIUM
GSM: +47 979 929 45

**Navigation Equipment**
2 x Furuno 10 cm 35 NM Radar
2 x Furuno GP 80 GPS Navigation
1 x Skipper Echo Sounder
1 x Furuno NavTex
1 x JRC Sat. Compass
Robertson AP 50 Automatic Pilot
Tel Chart C map Electronic Charts
Maxsea

**Bunker/Storage capacity**
Fresh water: 20 m3
Fuel oil: 50 m3
Lub oil: 2 m3
Clear deck: 50 m2

**Speed / Fuel Consumtion**
Max speed (12 knots):
2600 ltr / 24 hrs

Eco speed (10 knots):
2300 ltr / 24 hrs

**Watermaker(s)**
FW Maker: N/A

Achilles JQS
empowered by Achilles

**Operator & Owner:** Asper Norway AS

ASPER NORWAY AS

Asper Norway AS • P.O. Box 118 • N-6099 Fosnavåg, Norway • post@aspernorway.com

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VAT DK 16 93 56 97

# AHTS SIMA

SIMA is a versatile DP2 Offshore Installation Vessel that is suited for various offshore installation works. The vessel was in 2013 upgraded with new accommodation, DP2 system, AUX engines and A-frame. In 2018, a new Offshore Sea state 2 Crane was installed.
SIMA can operate anywhere in the world, and due to its design the vessel can quickly be adapted to many different tasks such as cable installation, ROV-work, anchor handling, etc.

| **GENERAL** | | **DIMENSIONS** | | **MACHINERY** | | |
|---|---|---|---|---|---|---|
| Name | Sima | Length | 81.37 m | Main engines | 2X | 2650 kW |
| Call sign | OUXR2 | Breadth | 15.96 m | Bow thruster | 1X | 384 kW |
| IMO number | 8418564 | Depth | 7.2 m | Stern thrusters | 2X | 390 kW |
| Flag | Danish | Draft | 4.9 m | Azimuth thruster retractable | 1X | 1,130 kW |
| Built | 1990 | Draft azimuth | 7.0 m | | | |
| Converted | 2013 | Gross tonnage | 2881 | Aux. engines | 2X<br>1X<br>1X | 832 kW<br>384 kW<br>248 kW |
| Classification | Rina ICE 1B | Cargo deck area 34.8 m x 10.925 m | 380 $m^2$ | | | |
| Certification | AHTS | | | | | |

Revision date 29-01-2019

*All figures and data believed to be correct, but not guaranteed*

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# AHTS SIMA

DP2 Offshore Installation Vessel

## NAVIS NavDP 4000 DP2 SYSTEM

The NAVIS NavDP2 4000 series provides manual, automatic or combined (semi-automatic) ship control.

There are both separate and simultaneous NAVIS NavDP2 4000 series control of ship position (coordinates) and heading.

The system is included ROV follow up and direct link-up with USBL.

## Bridge equipment

SIMA is equipped according to industry standard with radio- and navigation systems (DGPS, echo sounder, gyro, radar etc.).

Furthermore the vessel has:

- NaviPac Online
- Transas ECDIS chart system
- Sonadyne Ranger 2 USBL
- SEAMARCHALL MOB Finder
- Satellite Communication

## Survey/Client office

At the bridge deck next to the vessel office and the meeting room, the vessel have a dedicated survey room/ client office available.

The room is prepared with cabling etc. for easy connection to data streams from both the bridge and specialist equipment on deck. The room has working space for up to 6 persons.

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# AHTS SIMA

DP2 Offshore Installation Vessel

## Conference room

In connection with the bridge and survey rooms there is also a separate conference room fully equipped room with Whiteboard, projector, cabling for data connections etc. for up to 12 people.

## Accommodation

All accommodation was renewed in 2013 and consists of 33 single cabins (with optional upgrade possibility of 4 cabins to double cabins)*. The ship crew takes up 8-14 cabins depending on the work task.

Mess rooms and galley has also been renewed in 2013 and offices, a meeting room and a gym have been added.

## Welfare and fitness

As part of the refurbishing of the accommodation, The vessel had modern welfare facilities installed, including a Gym and TV-rooms.

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# AHTS SIMA

DP2 Offshore Installation Vessel

## Towing & Anchor handling equipment

- Stern roller dimension (ø 1.83 x lg. 3.6 m)
- Towing winch P = 150 mt
- Tugger winch 5 – 10 mt
- Towing wire 1,000 m x ø 57 mm
- Anchor-handling equipment Small Triplex Shark Jaws H350, retractable guide pins Triplex S-200

## Offshore Crane

New Sea state 2 Offshore crane installed in 2018

- Hydramarine HMC 1800 LK 50-30
- Harbour mode: 15t 6-10m & 5t 6-30m
- Offshore mode: 12t 6-16m
- Offshore subsea mode: 5t 6-12m

## A-frame/ROV launching system

A 36 ton A-frame is installed on the vessel, and depending on the task it can be placed either on the port side or at the stern.

As an option, the system can include a 36 ton SWL winch with Kongsberg MRU heave compensation. This enables the vessel to deploy the ROV to seabed in Hs up to 1,5 m.

Consequently, SIMA is able to launch and recover very large ROV's in rough weather conditions with substantial wave and swell.

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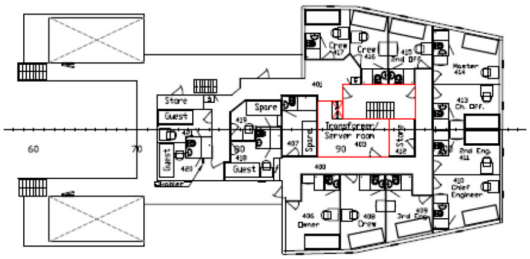
# AHTS SIMA

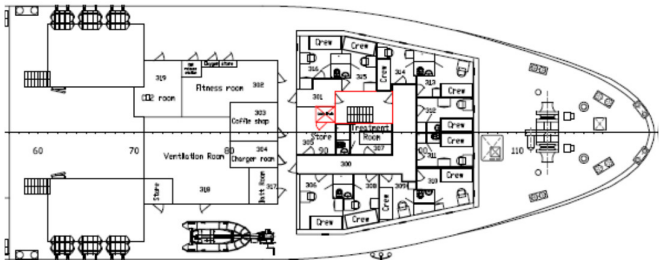
DP2 Offshore Installation Vessel

| Capacity | | | | | Consumption | |
|---|---|---|---|---|---|---|
| Fuel max | $m^3$ | $m^3/h$ | 643 | 68 | Engine consumption 100% | 18 $m^3$ |
| Potable water | $m^3$ | $m^3/h$ | 188 | 100 | Engine consumption DP2 | 13-18 $m^3$ |
| Lubricating oil | $m^3$ | | | 68.7 | Type(s) of fuel used | MGO |
| Deck load | $t/m^2$ | total | | 5 | Endurance (days) | 28 |
| Crane (onshore) | 15t | 6-10m | 5t | 6-30m | Ranges at cruising speed | 8000 nm |
| Crane (offshore/subsea) | 12t | 6-16m | 5t | 6-12m | **Accommodation** | |
| A-Frame | T | | | 36 | | |
| Bollard pull Max | T | | | 86,5 | Crew (min) | 7 |
| A-Frame | T | | | 36 | Passengers (max) | 26 |

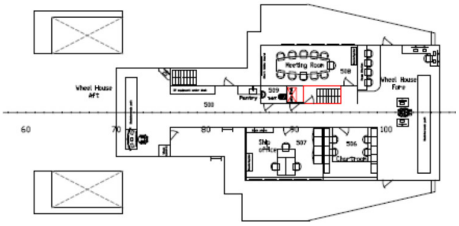
DECK C

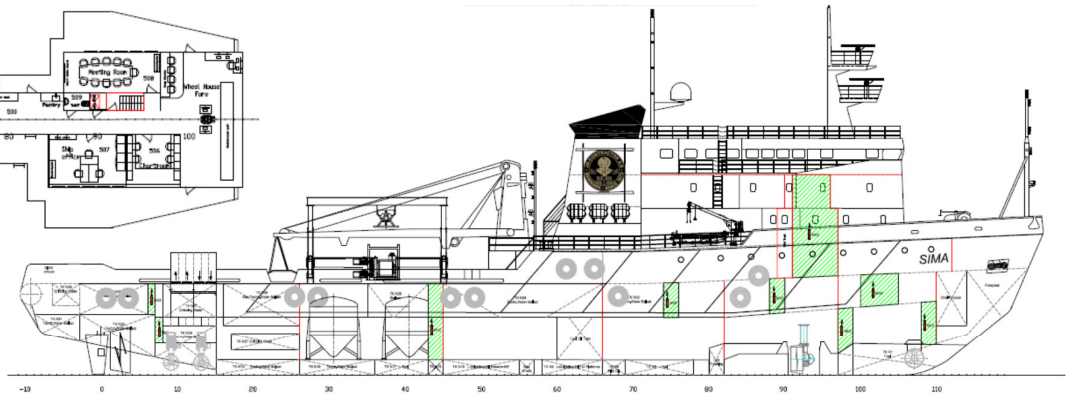


DECK B

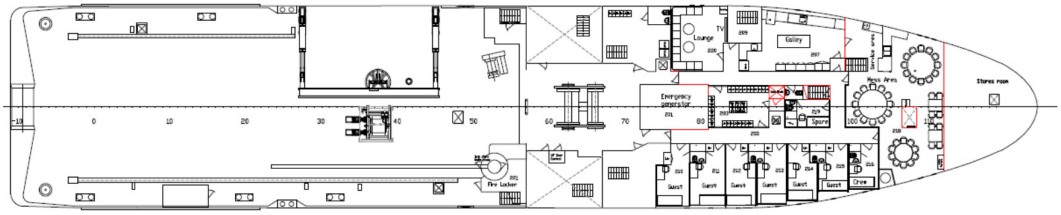


DECK D






DECK A





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Search

# NORMAND PACIFIC

ST 257 L CD

| | |
|---|---|
| Built / Yard | 2010 / Bergen group BMV AS / Yard No. 167 |
| LOA | 122,4m |
| Breadth Moulded | 23m |
| Draft (max) | 7,3m + 0m Skeg/Nozzle |
| Deadweight | 6719mt (d= 7,3m) |
| Gross Register Tonnage | 9778 |
| Cargo Deck Area | 1400m$^2$ |
| Deck Strength | 10mt/m$^2$ |
| Moonpool | 51,84m$^2$ (7,2m x 7,2m) |
| Fuel Oil | 1865m$^3$ / 11731bbls |
| Pot Water | 777m$^3$ / 4887bbls |
| Drill Water / WB | 3721m$^3$ / 23405bbls |

| | |
|---|---|
| Main Crane | 1 x SWL 200mt@ 10m - Single fall - AHC - CT:N/A- Sealift:N/A - Personnel lift: N/A - placed on N/A - Wire lenght: TBCm - Wire diameter: TBCmm |
| Deck Cranes | 2 x SWL 5mt@15m - Fixed with No manipulators |
| Main Engines | 4 x 3690KW |
| Total BHP | 22073 BHP |
| Catalytic Converters | Fitted |
| Bow Thrusters | 2 x 2682BHP |
| Stern Thrusters | 1 x 2682BHP |
| Azimuth Thrusters (Bow) | 1 x 2950BHP |
| Consumption at Economy Speed | $36m^3$ / 24hrs @ 10Knots |
| Consumption at Service Speed | $40m^3$ / 24hrs @ 12Knots |
| Helideck | Diameter20,88m, 12,8mt Sikorsky S92 |
| Total Accommodation | 120 Persons |

## *BIJLAGE C Brandstofverbruiksgegevens*

| Vessel | Activity / Location | Consumption [m3/day] | Notes |
|---|---|---|---|
| Fugro Pioneer | Survey activity | 3,4 | |
| Fugro Pioneer | Transit | 6,8 | 10 kn cruising speed |
| AHTS SIMA | Route clearance | 13,0 | Proposed values |
| Normand Pacific | In Port (Mobilisation/Demobilisation, Cable Loading, etc) | 5,3 | |
| Normand Pacific | Transit | 36,0 | 24 hours à 10 knots |
| Normand Pacific | Transit | 40,0 | 24 hours à 12 knots |
| Normand Pacific | Post-Lay Burial | 9,2 | |
| Asper Malene | Transit | 2,3 | 10 kn cruising speed |
| Asper Malene | Transit | 2,6 | 12 kn cruising speed |
| Dalby Esk | Crew Transfer | 1,4 | 22 tot 29 kn |

## *BIJLAGE D uitgangspunten en resultaten emissie berekening*

### Emissieberekeningen o.b.v. brandstofverbruik

| | NeuConnect aanlegfase | | Hourly power usage per activity | Power percentage based on fuel consumption | Total power used activity incl. WoW | Emission activity |
|---|---|---|---|---|---|---|
| *Activiteit nr.* | *Omschrijving activiteit* | *Naam schip* | *kWh per uur* | *%* | kWh | *[kg NOx]* |
| 1 | Pre engineering geofysisch onderzoek | Fugro Pionier | 667,2 | 45% | 410.543 | 3.221,8 |
| 2 | UXO geofysisch onderzoek | Fugro Pionier | 667,2 | 45% | 306.461 | 2.405,0 |
| 3 | Pre installatie geofysisch onderzoek | Fugro Pionier | 667,2 | 45% | 306.461 | 2.405,0 |
| 4 | Afgraven mobiel zeebodem | Boskalis Gatewat | - | - | - | - |
| 5 | Vrijmaken van route en 'PLGR' | AHTS Sima | 2544,2 | 48% | 2.199.468 | 17.260,7 |
| 6 | pre-aanlegfase aanbrengen rotsen t.b.v. be | JdN Adhémar Saint-Venant | - | - | - | - |
| 7 | Simultaan aanleggen en begraven kabel in | NKT Victoria | - | - | - | - |
| 8 | Begraven van verbindingspunten | Normand Pacific | 1800,5 | 12% | 365.385 | 3.982,2 |
| 9 | Na aanlegfase aanbrengen rotsen t.b.v. be | JdN Simon Stevin | - | - | - | - |
| 10 | Bescherming van de kabel | Asper Malene | - | - | - | - |
| | | | | | | 29.275 |

### Emissieberekeningen o.b.v. gemiddeld motor verbruik

| | NeuConnect aanlegfase | | EF | Year of build | RPM | P | Pact. | EF'' | Used power per day activity | Operational hours | % waiting on weather | Emission activity |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Activiteit nr.* | *Omschrijving activiteit* | *Naam schip* | *[g/kWh]* | *[-]* | *[rpm]* | *[kW]* | *[%]* | *[kg/hour]* | *kWh per uur* | *[hours]* | *[%]* | *[kg NOx]* |
| 1 | Pre engineering geofysisch onderzoek | Fugro Pionier | 7,8 | 2014 | 1.800 | 1.488 | 50% | | 14.880 | 473 | 30% | - |
| 2 | UXO geofysisch onderzoek | Fugro Pionier | 7,8 | 2014 | 1.800 | 1.488 | 50% | | 14.880 | 353 | 30% | - |
| 3 | Pre installatie geofysisch onderzoek | Fugro Pionier | 7,8 | 2014 | 1.800 | 1.488 | 50% | | 14.880 | 353 | 30% | - |
| 4 | Afgraven mobiel zeebodem | Boskalis Gatewat | 9,7 | 2010 | 720 | 13.870 | 75% | 100,8 | 208.050 | 467 | 10% | 51.737 |
| 5 | Vrijmaken van route en 'PLGR' | AHTS Sima | 7,8 | 2013 | 1.800 | 5.300 | 60% | | 63.560 | 665 | 30% | - |
| 6 | pre-aanlegfase aanbrengen rotsen t.b.v. bescherming knooppunten | JdN Adhémar Saint-Venant | 7,8 | 2017 | 1.800 | 7.670 | 30% | 18,1 | 46.020 | 120 | 2% | 2.210 |
| 7 | Simultaan aanleggen en begraven kabel incl. lassen verbindingspunten | NKT Victoria | 2,2 | 2017 | 1.200 | 13.440 | 40% | 11,6 | 106.882 | 2.115 | 12% | 27.572 |
| 8 | Begraven van verbindingspunten | Normand Pacific | 10,9 | 2010 | 1.200 | 14.760 | 44% | | 128.563 | 185 | 9% | - |
| 9 | Na aanlegfase aanbrengen rotsen t.b.v. bescherming knooppunten | JdN Simon Stevin | 10,9 | 2010 | 1.200 | 24.350 | 30% | 79,6 | 146.100 | 600 | 2% | 48.725 |
| 10 | Bescherming van de kabel | Asper Malene | 11,0 | 1998 | >2.000 | 736 | 25% | 2,0 | 3.678 | 1.300 | 0% | 2.630 |

*BIJLAGE E AERIUS berekening aanlegfase NeuConnect kabel Dutch EEZ*

AERIUS CALCULATOR

*Dit document bevat rekenresultaten van AERIUS Calculator. Het betreft de hoogst berekende stikstofbijdragen per stikstofgevoelig Natura 2000-gebied, op basis van rekenpunten die overlappen met habitattypen en/of leefgebieden die aangewezen zijn in het kader van de Wet natuurbescherming, gekoppeld aan een aangewezen soort, of nog onbekend maar mogelijk wel relevant.*

*De berekening op basis van stikstofemissies gaat uit van de componenten ammoniak (NH3) en/of stikstofoxide (NOx).*

*Wilt u verder rekenen of gegevens wijzigen? Importeer de pdf dan in Calculator. Voor meer toelichting verwijzen wij u naar de website www.aerius.nl.*

Berekening Aanlegfase NeuConnect Kabel Dutch EEZ

- Kenmerken
- Samenvatting emissies
- Depositieresultaten
- Gedetailleerde emissiegegevens

Verdere toelichting over deze PDF kunt u vinden in een bijbehorende leeswijzer. Deze leeswijzer en overige documentatie is te raadplegen via: https://www.aerius.nl/handleidingen-en-leeswijzers.

# AERIUS CALCULATOR

## Contact

| Rechtspersoon | Inrichtingslocatie |
|---|---|
| Ingenia Consultants & Engineers | Esp, 5633AA Eindhoven |

## Activiteit

| Omschrijving | AERIUS kenmerk |
|---|---|
| NeuConnect kabel | RVp33sxdWF9A |

| Datum berekening | Rekenjaar | Rekenconfiguratie |
|---|---|---|
| 09 maart 2021, 18:24 | 2022 | Berekend voor natuurgebieden |

## Totale emissie

| | Situatie 1 |
|---|---|
| NOx | 162,15 ton/j |
| NH3 | - |

## Resultaten

Hectare met hoogste bijdrage (mol/ha/j)

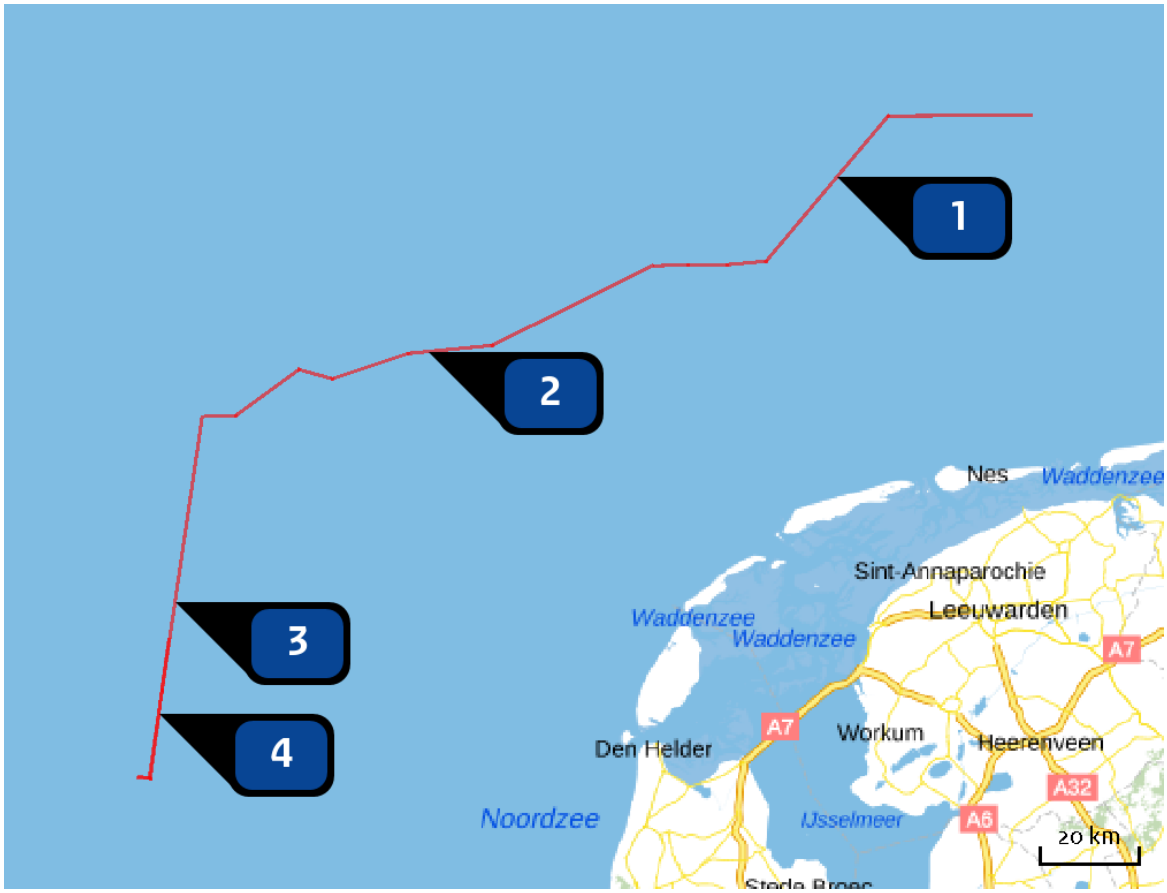
| Natuurgebied | Bijdrage |
|---|---|
| Duinen Vlieland | 0,09 |

## Toelichting

Aanlegfase NeuConnect kabel Nederlandse EEZ

## Locatie

Aanlegfase
NeuConnect Kabel
Dutch EEZ




## Emissie

Aanlegfase
NeuConnect Kabel
Dutch EEZ

| Bron Sector | | Emissie NH3 | Emissie NOx |
|---|---|---|---|
| 1 | Route A1 Hoofdactiviteiten 1t/m 3 en 5 t/m 10<br>Anders... \| Anders... | - | 37,50 ton/j |
| 2 | Route A2 Hoofdactiviteiten 1 t/m 3 en 5 t/m 10<br>Anders... \| Anders... | - | 41,25 ton/j |
| 3 | Route A3 Hoofdactiviteiten 1 t/m 3 en 5 t/m 10<br>Anders... \| Anders... | - | 31,66 ton/j |
| 4 | Route B Hoofdactiviteit 4<br>Anders... \| Anders... | - | 51,74 ton/j |

## Resultaten stikstof gevoelige Natura 2000 gebieden (mol/ha/j)

| Natuurgebied | Hoogste bijdrage | Bijdrage op (bijna) overbelaste hexagonen* |
|---|---|---|
| Duinen Vlieland | 0,09 | |
| Duinen en Lage Land Texel | 0,09 | |
| Duinen Terschelling | 0,09 | |
| Duinen Den Helder-Callantsoog | 0,08 | |
| Waddenzee | 0,08 | |
| Duinen Ameland | 0,07 | |
| Zwanenwater & Pettemerduinen | 0,07 | 0,06 |
| Schoorlse Duinen | 0,06 | |
| Noordhollands Duinreservaat | 0,06 | |
| Duinen Schiermonnikoog | 0,06 | |
| Noordzeekustzone | 0,05 | |
| Alde Feanen | 0,05 | |
| Kennemerland-Zuid | 0,05 | |
| IJsselmeer | 0,04 | - |
| Wijnjeterper Schar | 0,04 | |
| Weerribben | 0,04 | |
| Drents-Friese Wold & Leggelderveld | 0,04 | |
| Fochteloërveen | 0,04 | |
| Norgerholt | 0,04 | |
| Bakkeveense Duinen | 0,04 | |

| Natuurgebied | Hoogste bijdrage | Bijdrage op (bijna) overbelaste hexagonen* |
|---|---|---|
| Groote Wielen | 0,04 | - |
| Rottige Meenthe & Brandemeer | 0,04 | |
| Drentsche Aa-gebied | 0,04 | |
| Meijendel & Berkheide | 0,04 | |
| Holtingerveld | 0,04 | |
| De Wieden | 0,04 | |
| Dwingelderveld | 0,04 | |
| Van Oordt's Mersken | 0,04 | |
| Polder Westzaan | 0,03 | |
| Witterveld | 0,03 | |
| Westduinpark & Wapendal | 0,03 | |
| Drouwenerzand | 0,03 | |
| Ilperveld, Varkensland, Oostzanerveld & Twiske | 0,03 | |
| Oudegaasterbrekken, Fluessen en omgeving | 0,03 | - |
| Naardermeer | 0,03 | |
| Solleveld & Kapittelduinen | 0,03 | |
| Mantingerbos | 0,03 | |
| Mantingerzand | 0,03 | |
| Veluwe | 0,03 | |
| Lieftinghsbroek | 0,03 | |

| Natuurgebied | Hoogste bijdrage | Bijdrage op (bijna) overbelaste hexagonen* |
|---|---|---|
| Oostelijke Vechtplassen | 0,03 | |
| Coepelduynen | 0,03 | |
| Elperstroomgebied | 0,03 | |
| Voornes Duin | 0,03 | |
| Wormer- en Jisperveld & Kalverpolder | 0,03 | |
| Rijntakken | 0,03 | |
| Vecht- en Beneden-Reggegebied | 0,03 | |
| Grevelingen | 0,03 | |
| Duinen Goeree & Kwade Hoek | 0,03 | |
| Kop van Schouwen | 0,03 | |
| Bargerveen | 0,03 | |
| Sallandse Heuvelrug | 0,03 | |
| Boetelerveld | 0,03 | |
| Botshol | 0,03 | |
| Nieuwkoopse Plassen & De Haeck | 0,03 | |
| Engbertsdijksvenen | 0,03 | |
| Eilandspolder | 0,03 | |
| Olde Maten & Veerslootslanden | 0,02 | |
| Wierdense Veld | 0,02 | |
| Uiterwaarden Zwarte Water en Vecht | 0,02 | |

| Natuurgebied | Hoogste bijdrage | Bijdrage op (bijna) overbelaste hexagonen* |
|---|---|---|
| Kolland & Overlangbroek | 0,02 | |
| Springendal & Dal van de Mosbeek | 0,02 | |
| Borkeld | 0,02 | |
| Lingegebied & Diefdijk-Zuid | 0,02 | |
| Manteling van Walcheren | 0,02 | |
| Achter de Voort, Agelerbroek & Voltherbroek | 0,02 | |
| Biesbosch | 0,02 | |
| Krammer-Volkerak | 0,02 | |
| Landgoederen Brummen | 0,02 | |
| Bergvennen & Brecklenkampse Veld | 0,02 | |
| Lemselermaten | 0,02 | |
| Landgoederen Oldenzaal | 0,02 | |
| Dinkelland | 0,02 | |
| Zwarte Meer | 0,02 | - |
| Loonse en Drunense Duinen & Leemkuilen | 0,02 | |
| Lonnekermeer | 0,02 | |
| Langstraat | 0,02 | |
| Buurserzand & Haaksbergerveen | 0,02 | |
| Voordelta | 0,02 | |
| Brabantse Wal | 0,02 | |

| Natuurgebied | Hoogste bijdrage | Bijdrage op (bijna) overbelaste hexagonen* |
|---|---|---|
| Stelkampsveld | 0,02 | |
| Witte Veen | 0,02 | |
| Ulvenhoutse Bos | 0,02 | |
| Kampina & Oisterwijkse Vennen | 0,02 | |
| Aamsveen | 0,02 | |
| Vlijmens Ven, Moerputten & Bossche Broek | 0,02 | |
| Sint Jansberg | 0,02 | |
| Korenburgerveen | 0,02 | |
| Loevestein, Pompveld & Kornsche Boezem | 0,02 | |
| Bekendelle | 0,02 | |
| Regte Heide & Riels Laag | 0,02 | |
| Binnenveld | 0,02 | |
| Kempenland-West | 0,02 | |
| Oosterschelde | 0,02 | |
| Willinks Weust | 0,02 | |
| Maasduinen | 0,02 | |
| Zeldersche Driessen | 0,02 | |
| Zouweboezem | 0,02 | |
| Uiterwaarden Lek | 0,02 | |
| Boschhuizerbergen | 0,02 | |

| Natuurgebied | Hoogste bijdrage | Bijdrage op (bijna) overbelaste hexagonen* |
|---|---|---|
| Leenderbos, Groote Heide & De Plateaux | 0,02 | |
| Strabrechtse Heide & Beuven | 0,02 | |
| Deurnsche Peel & Mariapeel | 0,02 | |
| De Bruuk | 0,02 | |
| Wooldse Veen | 0,02 | |
| Weerter- en Budelerbergen & Ringselven | 0,02 | |
| Groote Peel | 0,02 | |
| Leudal | 0,02 | |
| Westerschelde & Saeftinghe | 0,02 | |
| Swalmdal | 0,01 | |
| Meinweg | 0,01 | |
| Zwin & Kievittepolder | 0,01 | |
| Roerdal | 0,01 | |
| Yerseke en Kapelse Moer | 0,01 | |
| Brunssummerheide | 0,01 | |
| Oeffelter Meent | 0,01 | |
| Geleenbeekdal | 0,01 | |
| Bunder- en Elslooërbos | 0,01 | |
| Sarsven en De Banen | 0,01 | |
| Geuldal | 0,01 | |

| Natuurgebied | Hoogste bijdrage | Bijdrage op (bijna) overbelaste hexagonen* |
|---|---|---|
| Savelsbos | 0,01 | |
| Bemelerberg & Schiepersberg | 0,01 | |
| Sint Pietersberg & Jekerdal | 0,01 | |
| Kunderberg | 0,01 | |
| Vogelkreek | 0,01 | - |
| Groote Gat | 0,01 | |
| Noorbeemden & Hoogbos | 0,01 | |
| Canisvliet | 0,01 | |
| Maas bij Eijsden | 0,01 | - |

* Als de hoogste depositietoename plaatsvindt op een hexagoon waar géén sprake is van een (naderende) stikstofoverbelasting, dan is de hoogste toename op een hexagoon met wel een (naderende) stikstofoverbelasting in deze kolom weergegeven.

Resultaten per habitattype (mol/ha/j)

voor de 10 stikstofgevoelige Natura 2000-gebieden met het hoogste resultaat

## Duinen Vlieland

| Habitattype | Hoogste bijdrage | Bijdrage op (bijna) overbelaste hexagonen* |
|---|---|---|
| ZGH2180Abe Duinbossen (droog), berken-eikenbos | 0,09 | |
| H2180Abe Duinbossen (droog), berken-eikenbos | 0,09 | |
| ZGH2180B Duinbossen (vochtig) | 0,09 | |
| H2120 Witte duinen | 0,09 | |
| H2140B Duinheiden met kraaihei (droog) | 0,09 | |
| H2130B Grijze duinen (kalkarm) | 0,09 | |
| H2140A Duinheiden met kraaihei (vochtig) | 0,09 | |
| H2190C Vochtige duinvalleien (ontkalkt) | 0,09 | |
| H2150 Duinheiden met struikhei | 0,08 | |
| H2180B Duinbossen (vochtig) | 0,08 | |
| H2190Aom Vochtige duinvalleien (open water), oligo- tot mesotrofe vormen | 0,08 | |
| H2130C Grijze duinen (heischraal) | 0,07 | |
| H2190B Vochtige duinvalleien (kalkrijk) | 0,06 | |
| H1330A Schorren en zilte graslanden (buitendijks) | 0,06 | |
| H2160 Duindoornstruwelen | 0,06 | |
| H2130A Grijze duinen (kalkrijk) | 0,06 | |
| H2170 Kruipwilgstruwelen | 0,06 | - |
| H1310A Zilte pionierbegroeiingen (zeekraal) | 0,05 | - |

## Duinen en Lage Land Texel

| Habitattype | Hoogste bijdrage | Bijdrage op (bijna) overbelaste hexagonen* |
|---|---|---|
| H2180Abe Duinbossen (droog), berken-eikenbos | 0,09 | |
| H2130B Grijze duinen (kalkarm) | 0,09 | |
| H2180B Duinbossen (vochtig) | 0,09 | |
| H2180C Duinbossen (binnenduinrand) | 0,09 | |
| H2140B Duinheiden met kraaihei (droog) | 0,09 | |
| H2150 Duinheiden met struikhei | 0,09 | |
| H2160 Duindoornstruwelen | 0,08 | |
| H2190B Vochtige duinvalleien (kalkrijk) | 0,08 | |
| ZGH2180B Duinbossen (vochtig) | 0,08 | |
| H2130C Grijze duinen (heischraal) | 0,08 | |
| ZGH2180C Duinbossen (binnenduinrand) | 0,08 | |
| ZGH2180Abe Duinbossen (droog), berken-eikenbos | 0,08 | |
| H2190Aom Vochtige duinvalleien (open water), oligo- tot mesotrofe vormen | 0,08 | |
| H9999:2 Habitattype onbekend/onzeker KDW op basis meest kritische relevante type (H2130B;H2130C). | 0,08 | |
| H2120 Witte duinen | 0,07 | |
| H2130A Grijze duinen (kalkrijk) | 0,07 | |
| H2190C Vochtige duinvalleien (ontkalkt) | 0,07 | |
| H7210 Galigaanmoerassen | 0,07 | |
| H2140A Duinheiden met kraaihei (vochtig) | 0,07 | |

## Duinen en Lage Land Texel

| Habitattype | Hoogste bijdrage | Bijdrage op (bijna) overbelaste hexagonen* |
|---|---|---|
| H1330A Schorren en zilte graslanden (buitendijks) | 0,07 | |
| H1310B Zilte pionierbegroeiingen (zeevetmuur) | 0,06 | 0,05 |
| H2170 Kruipwilgstruwelen | 0,06 | |
| H2110 Embryonale duinen | 0,06 | |
| H1310A Zilte pionierbegroeiingen (zeekraal) | 0,05 | |
| H1330B Schorren en zilte graslanden (binnendijks) | 0,05 | 0,04 |

## Duinen Terschelling

| Habitattype | Hoogste bijdrage | Bijdrage op (bijna) overbelaste hexagonen* |
|---|---|---|
| H2180Abe Duinbossen (droog), berken-eikenbos | 0,09 | |
| H2180B Duinbossen (vochtig) | 0,09 | |
| ZGH2180B Duinbossen (vochtig) | 0,08 | |
| H2140B Duinheiden met kraaihei (droog) | 0,08 | |
| ZGH2180Abe Duinbossen (droog), berken-eikenbos | 0,08 | |
| H2130B Grijze duinen (kalkarm) | 0,08 | |
| H2150 Duinheiden met struikhei | 0,08 | |
| H2140A Duinheiden met kraaihei (vochtig) | 0,08 | |
| H6410 Blauwgraslanden | 0,08 | |
| H2170 Kruipwilgstruwelen | 0,08 | |
| H2190C Vochtige duinvalleien (ontkalkt) | 0,08 | |
| H2160 Duindoornstruwelen | 0,08 | |
| H2130A Grijze duinen (kalkrijk) | 0,08 | |
| ZGH2190C Vochtige duinvalleien (ontkalkt) | 0,07 | |
| H2120 Witte duinen | 0,07 | |
| H2190Aom Vochtige duinvalleien (open water), oligo- tot mesotrofe vormen | 0,07 | |
| H2190B Vochtige duinvalleien (kalkrijk) | 0,07 | |
| H1330A Schorren en zilte graslanden (buitendijks) | 0,06 | |
| H1310A Zilte pionierbegroeiingen (zeekraal) | 0,06 | |

## Duinen Terschelling

| Habitattype | Hoogste bijdrage | Bijdrage op (bijna) overbelaste hexagonen* |
|---|---|---|
| H1310B Zilte pionierbegroeiingen (zeevetmuur) | 0,06 | |
| H6230vka Heischrale graslanden, vochtig kalkarm | 0,06 | |
| ZGH2120 Witte duinen | 0,05 | |
| ZGH2160 Duindoornstruwelen | 0,05 | - |
| Lg07 Dotterbloemgrasland van veen en klei | 0,05 | |
| H2110 Embryonale duinen | 0,05 | |
| ZGH2190B Vochtige duinvalleien (kalkrijk) | 0,05 | |
| ZGH2130C Grijze duinen (heischraal) | 0,05 | |
| ZGH2110 Embryonale duinen | 0,05 | |
| H1320 Slijkgrasvelden | 0,04 | - |

## Duinen Den Helder-Callantsoog

| Habitattype | Hoogste bijdrage | Bijdrage op (bijna) overbelaste hexagonen* |
|---|---|---|
| H2180Abe Duinbossen (droog), berken-eikenbos | 0,08 | |
| H2130B Grijze duinen (kalkarm) | 0,07 | |
| H6410 Blauwgraslanden | 0,07 | |
| H2180C Duinbossen (binnenduinrand) | 0,06 | |
| H2120 Witte duinen | 0,06 | |
| H2140B Duinheiden met kraaihei (droog) | 0,06 | |
| H2190C Vochtige duinvalleien (ontkalkt) | 0,06 | |
| H2190Aom Vochtige duinvalleien (open water), oligo- tot mesotrofe vormen | 0,06 | |
| H2170 Kruipwilgstruwelen | 0,05 | |
| H2160 Duindoornstruwelen | 0,05 | |

## Waddenzee

| Habitattype | Hoogste bijdrage | Bijdrage op (bijna) overbelaste hexagonen* |
|---|---|---|
| ZGH2120 Witte duinen | 0,08 | |
| ZGH2130A Grijze duinen (kalkrijk) | 0,08 | |
| H1310B Zilte pionierbegroeiingen (zeevetmuur) | 0,08 | |
| H1330A Schorren en zilte graslanden (buitendijks) | 0,08 | |
| ZGH2190B Vochtige duinvalleien (kalkrijk) | 0,08 | |
| ZGH2160 Duindoornstruwelen | 0,07 | 0,06 |
| H1310A Zilte pionierbegroeiingen (zeekraal) | 0,06 | |
| H1320 Slijkgrasvelden | 0,06 | |
| H2130B Grijze duinen (kalkarm) | 0,06 | |
| H2160 Duindoornstruwelen | 0,05 | |
| H2190B Vochtige duinvalleien (kalkrijk) | 0,05 | 0,03 |
| ZGH2110 Embryonale duinen | 0,05 | |
| H2110 Embryonale duinen | 0,05 | |
| H2120 Witte duinen | 0,04 | |
| ZGH1330B Schorren en zilte graslanden (binnendijks) | 0,02 | - |
| ZGH1310A Zilte pionierbegroeiingen (zeekraal) | 0,02 | - |

## Duinen Ameland

| Habitattype | Hoogste bijdrage | Bijdrage op (bijna) overbelaste hexagonen* |
|---|---|---|
| H2180Abe Duinbossen (droog), berken-eikenbos | 0,07 | |
| H2180B Duinbossen (vochtig) | 0,07 | |
| ZGH2180B Duinbossen (vochtig) | 0,07 | |
| H2130B Grijze duinen (kalkarm) | 0,07 | |
| ZGH2130B Grijze duinen (kalkarm) | 0,06 | |
| H2130A Grijze duinen (kalkrijk) | 0,06 | |
| ZGH2170 Kruipwilgstruwelen | 0,06 | |
| H9999:5 Habitattype onbekend/onzeker KDW op basis meest kritische relevante type (H2130B;H2130C;H6230). | 0,06 | |
| H2180C Duinbossen (binnenduinrand) | 0,06 | |
| ZGH2120 Witte duinen | 0,06 | |
| H2170 Kruipwilgstruwelen | 0,06 | |
| H2190Aom Vochtige duinvalleien (open water), oligo- tot mesotrofe vormen | 0,05 | |
| H2150 Duinheiden met struikhei | 0,05 | |
| H2160 Duindoornstruwelen | 0,05 | |
| H2140A Duinheiden met kraaihei (vochtig) | 0,05 | |
| H2130C Grijze duinen (heischraal) | 0,05 | |
| ZGH2160 Duindoornstruwelen | 0,05 | |
| H2120 Witte duinen | 0,05 | |
| ZGH2130A Grijze duinen (kalkrijk) | 0,05 | |

## Duinen Ameland

| Habitattype | Hoogste bijdrage | Bijdrage op (bijna) overbelaste hexagonen* |
|---|---|---|
| H2190C Vochtige duinvalleien (ontkalkt) | 0,05 | |
| H2190B Vochtige duinvalleien (kalkrijk) | 0,05 | 0,04 |
| ZGH2190C Vochtige duinvalleien (ontkalkt) | 0,05 | |
| H2140B Duinheiden met kraaihei (droog) | 0,05 | |
| ZGH2190B Vochtige duinvalleien (kalkrijk) | 0,04 | |
| ZGH2180Abe Duinbossen (droog), berken-eikenbos | 0,04 | |
| ZGH6230vka Heischrale graslanden, vochtig kalkarm | 0,04 | |

## Zwanenwater & Pettemerduinen

| Habitattype | Hoogste bijdrage | Bijdrage op (bijna) overbelaste hexagonen* |
|---|---|---|
| H2180B Duinbossen (vochtig) | 0,07 | 0,06 |
| H2130B Grijze duinen (kalkarm) | 0,06 | |
| H2140B Duinheiden met kraaihei (droog) | 0,06 | |
| H2150 Duinheiden met struikhei | 0,06 | |
| H2180Abe Duinbossen (droog), berken-eikenbos | 0,06 | |
| ZGH2170 Kruipwilgstruwelen | 0,06 | |
| H2190C Vochtige duinvalleien (ontkalkt) | 0,06 | |
| H7210 Galigaanmoerassen | 0,06 | |
| H2140A Duinheiden met kraaihei (vochtig) | 0,06 | |
| H2120 Witte duinen | 0,06 | |
| H6230vka Heischrale graslanden, vochtig kalkarm | 0,06 | |
| H2190Aom Vochtige duinvalleien (open water), oligo- tot mesotrofe vormen | 0,06 | |
| H2170 Kruipwilgstruwelen | 0,05 | |
| H2190B Vochtige duinvalleien (kalkrijk) | 0,05 | |
| H2130A Grijze duinen (kalkrijk) | 0,05 | |
| H6410 Blauwgraslanden | 0,05 | |
| ZGH2120 Witte duinen | 0,05 | |
| H9999:85 Habitattype onbekend/onzeker KDW op basis meest kritische relevante type (H2130B;H6230). | 0,05 | |
| ZGH2130B Grijze duinen (kalkarm) | 0,05 | |

## Zwanenwater & Pettemerduinen

| Habitattype | Hoogste bijdrage | Bijdrage op (bijna) overbelaste hexagonen* |
|---|---|---|
| H2110 Embryonale duinen | 0,04 | |
| ZGH2130A Grijze duinen (kalkrijk) | 0,04 | |

## Schoorlse Duinen

| Habitattype | Hoogste bijdrage | Bijdrage op (bijna) overbelaste hexagonen* |
|---|---|---|
| H2180Abe Duinbossen (droog), berken-eikenbos | 0,06 | |
| H2150 Duinheiden met struikhei | 0,06 | |
| H2130B Grijze duinen (kalkarm) | 0,06 | |
| H2140B Duinheiden met kraaihei (droog) | 0,06 | |
| H2140A Duinheiden met kraaihei (vochtig) | 0,06 | |
| H2170 Kruipwilgstruwelen | 0,06 | |
| H2190Aom Vochtige duinvalleien (open water), oligo- tot mesotrofe vormen | 0,06 | |
| H2190C Vochtige duinvalleien (ontkalkt) | 0,06 | |
| H2120 Witte duinen | 0,06 | |
| H2180C Duinbossen (binnenduinrand) | 0,06 | |
| H2130A Grijze duinen (kalkrijk) | 0,05 | |
| H2180B Duinbossen (vochtig) | 0,05 | |
| ZGH2130B Grijze duinen (kalkarm) | 0,05 | |
| H2160 Duindoornstruwelen | 0,04 | |
| H2110 Embryonale duinen | 0,04 | |

## Noordhollands Duinreservaat

| Habitattype | Hoogste bijdrage | Bijdrage op (bijna) overbelaste hexagonen* |
|---|---|---|
| H2180A Duinbossen (droog), berken-eikenbos | 0,06 | |
| H2190A Vochtige duinvalleien (open water) | 0,06 | |
| H2130B Grijze duinen (kalkarm) | 0,06 | |
| H2140B Duinheiden met kraaihei (droog) | 0,06 | |
| H2180B Duinbossen (vochtig) | 0,06 | |
| H2180C Duinbossen (binnenduinrand) | 0,06 | |
| H2140A Duinheiden met kraaihei (vochtig) | 0,06 | |
| H2130A Grijze duinen (kalkrijk) | 0,06 | |
| H2150 Duinheiden met struikhei | 0,06 | |
| H2190B Vochtige duinvalleien (kalkrijk) | 0,06 | |
| H2120 Witte duinen | 0,06 | |
| Lg12 Zoom, mantel en droog struweel van de duinen | 0,06 | |
| H2130C Grijze duinen (heischraal) | 0,06 | |
| H2160 Duindoornstruwelen | 0,06 | |
| H2170 Kruipwilgstruwelen | 0,06 | |
| ZGH2180C Duinbossen (binnenduinrand) | 0,05 | |
| ZGH2180A Duinbossen (droog), berken-eikenbos | 0,05 | |
| H2190C Vochtige duinvalleien (ontkalkt) | 0,05 | |
| H7210 Galigaanmoerassen | 0,05 | |

## Noordhollands Duinreservaat

| Habitattype | Hoogste bijdrage | Bijdrage op (bijna) overbelaste hexagonen* |
|---|---|---|
| H6410 Blauwgraslanden | 0,05 | |

## Duinen Schiermonnikoog

| Habitattype | Hoogste bijdrage | Bijdrage op (bijna) overbelaste hexagonen* |
|---|---|---|
| H2180B Duinbossen (vochtig) | 0,06 | |
| ZGH2180Abe Duinbossen (droog), berken-eikenbos | 0,06 | |
| ZGH2160 Duindoornstruwelen | 0,06 | |
| H2170 Kruipwilgstruwelen | 0,06 | |
| H9999:6 Habitattype onbekend/onzeker KDW op basis meest kritische relevante type (H2130B;H2130C). | 0,06 | |
| ZGH2130B Grijze duinen (kalkarm) | 0,06 | |
| H2190B Vochtige duinvalleien (kalkrijk) | 0,06 | |
| H2190C Vochtige duinvalleien (ontkalkt) | 0,06 | |
| ZGH2180B Duinbossen (vochtig) | 0,06 | |
| ZGH2120 Witte duinen | 0,05 | |
| H2190Aom Vochtige duinvalleien (open water), oligo- tot mesotrofe vormen | 0,05 | |
| H2130C Grijze duinen (heischraal) | 0,05 | |
| ZGH2190C Vochtige duinvalleien (ontkalkt) | 0,05 | |
| ZGH2170 Kruipwilgstruwelen | 0,05 | |
| H6410 Blauwgraslanden | 0,05 | |
| ZGH2180C Duinbossen (binnenduinrand) | 0,05 | |
| H1330A Schorren en zilte graslanden (buitendijks) | 0,05 | |
| ZGH2130A Grijze duinen (kalkrijk) | 0,04 | |
| ZGH2190B Vochtige duinvalleien (kalkrijk) | 0,04 | |

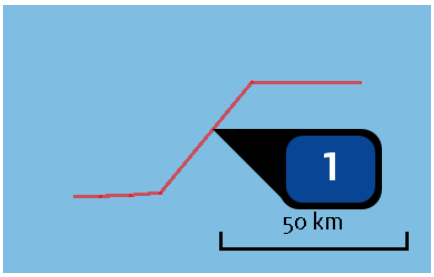
## Duinen Schiermonnikoog

| Habitattype | Hoogste bijdrage | Bijdrage op (bijna) overbelaste hexagonen* |
|---|---|---|
| H1310B Zilte pionierbegroeiingen (zeevetmuur) | 0,04 | 0,03 |

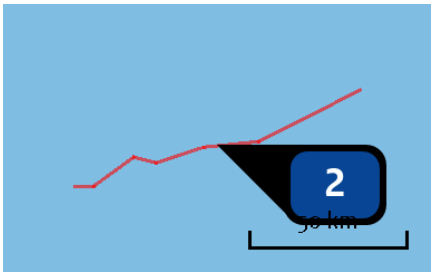
* Als de hoogste depositietoename plaatsvindt op een hexagoon waar géén sprake is van een (naderende) stikstofoverbelasting, dan is de hoogste toename op een hexagoon met wel een (naderende) stikstofoverbelasting in deze kolom weergegeven.

## Emissie (per bron)

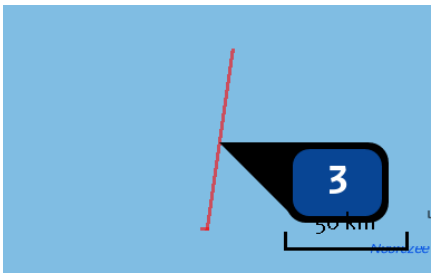
Aanlegfase NeuConnect Kabel Dutch EEZ



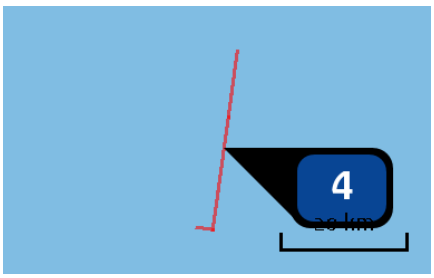

| | |
|---|---|
| Naam | Route A1 Hoofdactiviteiten 1t/m 3 en 5 t/m 10 |
| Locatie (X,Y) | 150370, 668214 |
| Uitstoothoogte | 24,0 m |
| Warmteinhoud | 0,950 MW |
| Temporele variatie | Transport |
| NOx | 37,50 ton/j |




| | |
|---|---|
| Naam | Route A2 Hoofdactiviteiten 1 t/m 3 en 5 t/m 10 |
| Locatie (X,Y) | 67405, 632788 |
| Uitstoothoogte | 24,0 m |
| Warmteinhoud | 0,950 MW |
| Temporele variatie | Transport |
| NOx | 41,25 ton/j |




| | |
|---|---|
| Naam | Route A3 Hoofdactiviteiten 1 t/m 3 en 5 t/m 10 |
| Locatie (X,Y) | 16005, 581873 |
| Uitstoothoogte | 24,0 m |
| Warmteinhoud | 0,950 MW |
| Temporele variatie | Transport |
| NOx | 31,66 ton/j |




| | |
|---|---|
| Naam | Route B Hoofdactiviteit 4 |
| Locatie (X,Y) | 12732, 559194 |
| Uitstoothoogte | 24,0 m |
| Warmteinhoud | 0,950 MW |
| Temporele variatie | Continue emissie |
| NOx | 51,74 ton/j |

## Disclaimer

Hoewel verstrekte gegevens kunnen dienen ter onderbouwing van een vergunningaanvraag, kunnen er geen rechten aan worden ontleend. De eigenaar van AERIUS aanvaardt geen aansprakelijkheid voor de inhoud van de door de gebruiker aangeboden informatie. Bovenstaande gegevens zijn enkel bruikbaar tot er een nieuwe versie van AERIUS beschikbaar is. AERIUS is een geregistreerd handelsmerk in Europa. Alle rechten die niet expliciet worden verleend, zijn voorbehouden.

## Rekenbasis

Deze berekening is tot stand gekomen op basis van:

| | |
|---|---|
| AERIUS | versie 2020_20210209_2f032ce1a2 |
| Database | versie 2020_20210209_2f032ce1a2 |

Voor meer informatie over de gebruikte methodiek en data zie:
https://www.aerius.nl/nl/factsheets/release/aerius-calculator-2020

# Bijlage 6b: Stikstofdepositie onderzoek tbv de exploitatiefase NeuConnect kabel,

# Ingenia, 17 maart 2021

# Stikstofdepositie onderzoek t.b.v. de exploitatiefase NeuConnect kabel in Nederlandse EEZ

## Verantwoording

| | |
|---|---|
| **Titel** | Stikstofdepositie onderzoek t.b.v. de exploitatiefase NeuConnect kabel in Nederlandse EEZ |
| **Opdrachtgever** | NeuConnect |
| **Projectnummer** | 1958639 |
| **Documentidentificatie** | 1958639-RAP-0004-05.docx |
| **Auteur(s)** | ing. N. Voets |
| **Aantal pagina's** | 20 |

| | |
|---|---|
| **Autorisatie** | drs.ing R. Verberne MBA |
| **Datum** | 17 maart 2021 |

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# 1 Inleiding

## 1.1 Achtergrond en doel

NeuConnect wordt ontwikkeld door een consortium van investeerders: Meridiam SAS, Allianz Capital Partners, Kansai Electric Power Company en Greenage Power. Voor de ontwikkeling van het project hebben zij NeuConnect Great Britain Limited (NCGBL, verder NeuConnect genoemd) opgericht. De voorgestelde NeuConnect kabel is een 1.400 megawatt (MW) interconnector tussen de hoogspanning elektriciteitsnetwerken van Groot-Brittannië en Duitsland met een geschatte lengte van in totaal circa 720 km tussen de twee converterstations. In Groot-Brittannië loopt dit via de Isle of Grain te Medway en in Duitsland via Fedderwarden te Wilhelmshaven. De route van de kabel doorkruist de Nederlandse Exclusieve Economische Zone (EEZ) over een lengte van circa 265 km. AECOM heeft in opdracht van NeuConnect een milieueffect-rapport (MER) opgesteld. De mogelijke effecten die de aanleg, het gebruik en de ontmanteling van de kabel in de Nederlandse EEZ kunnen hebben op het milieu zijn omschreven in dat MER. De aanleg van de kabel en vervolgens de exploitatiefase leiden tot stikstofemissies en mogelijk tot stikstofdepositie in Natura-2000 gebieden. Voor de aanleg en de exploitatiefase zijn meerdere en verschillende soorten schepen nodig, die op- en afvaren gedurende beide fases. Eventuele stikstofdepositie wordt veroorzaakt door de stikstofoxide emissie die schepen emitteren.

AECOM heeft Ingenia opdracht gegeven om de stikstofemissie voor zowel de aanlegfase van de kabel in de Nederlandse EEZ als de exploitatiefase van de kabel in de Nederlandse EEZ te berekenen om vervolgens aan de hand daarvan de stikstofdepositie te berekenen. In dit rapport is de stikstofdepositie berekend voor de exploitatiefase van de kabel.

In een separaat rapport is de stikstofdepositie ten gevolge van de aanlegfase vastgesteld, dit betreft rapport *“Stikstofdepositie onderzoek t.b.v. de aanleg van de NeuConnect kabel in Nederlandse EEZ (1958639-RAP-0003-06)”.*

## 1.2 Leeswijzer

In hoofdstuk 2 zijn de uitgangspunten beschreven. De uitgangspunten bestaan uit de technische gegevens van de benodigde schepen, snelheid van het proces, duur van het project en het kabeltracé. In hoofdstuk 3 zijn de stikstof emitterende activiteiten en onderbouwing van de berekeningen beschreven. De stikstofdepositie berekening inclusief de resultaten zijn weergeven in hoofdstuk 4. In hoofdstuk 5 is de conclusie beschreven.

# 2 Uitgangspunten

NeuConnect wordt ontwikkeld door een consortium van investeerders: Meridiam SAS, Allianz Capital Partners, Kansai Electric Power Company en Greenage Power. Voor de ontwikkeling van het project hebben zij NeuConnect Great Britain Limited (NCGBL, verder NeuConnect genoemd) opgericht. De voorgestelde NeuConnect kabel is een 1.400 megawatt (MW) interconnector tussen de hoogspanning elektriciteitsnetwerken van Groot-Brittannië en Duitsland met een geschatte lengte van in totaal circa 720 km tussen de twee converterstations. In Groot-Brittannië loopt dit via de Isle of Grain te Medway en in Duitsland via Fedderwarden te Wilhelmshaven. De route van de kabel doorkruist de Nederlandse Exclusieve Economische Zone (EEZ) over een lengte van circa 265 km.

In dit hoofdstuk zijn de uitgangspunten gegeven voor de activiteiten die naar verwachting uitgevoerd dienen te worden in de exploitatiefase .

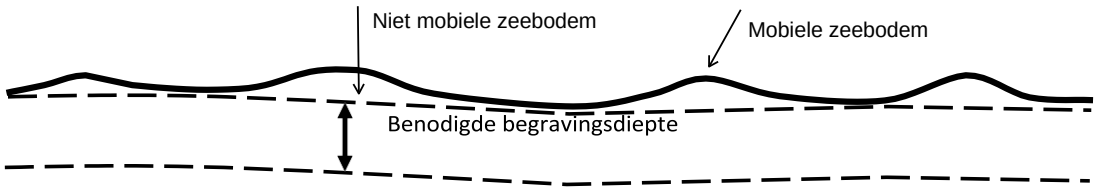
## 2.1 Exploitatiefase

Nadat de kabel in gebruik is genomen, start de exploitatiefase. De exploitatie bestaat uit het meten van de diepte van kabel onder de zeebodem en de hoogte van de zeebodem (bathymetrie). De diepte van de kabel of de hoogte van de zeebodem kunnen veranderen door de volgende oorzaken:

1. De mobiele zeebodem(zandgolven) kan zich door de stroming verplaatsen
2. Een flinke storm kan ervoor zorgen dat de toplaag van de zeebodem wordt weggespoeld.

Wanneer de diepte van de kabel of de hoogte van de zeebodem wijzigt, kan dit er in beginsel toe leiden dat de kabel ‘bloot’ komt te liggen. In het geval de kabel bloot zou komen te liggen zorgt dit voor een verhoogd risico dat er schade aan de kabel kan worden veroorzaakt door bijvoorbeeld een anker of vissersschepen die over de bodem van de zee gaan met het vissersgerei.

Echter, bij het ontwerp en de aanleg van de kabel is met beide mogelijke oorzaken (verplaatsing mobiele zeebodems en wijziging toplaag rekening gehouden door (i) een benodigde begravingsdiepte van tenminste 1,5 tot 2 m aan te houden, afhankelijk van de aard van de zeebodem en de mogelijke plaatselijke risico’s (zoals eventuele ankerplaatsen) en (ii) door ter plaatse van mobiele zeebodem pre-sweeping toe te passen waardoor de kabel wordt aangelegd onder de onderliggende niet-mobiele zeebodem. Dit is weergeven in Figuur 2-1. Als gevolg hiervan is het risico dat de kabel komt bloot te liggen verwaarloosbaar. Er worden daarom geen herbegraafwerkzaamheden voorzien tijdens de exploitatiefase.




*Figuur 2-1 schematische weergave benodigde begravingsdiepte*

Primo Marine, expert op het gebied van onderwaterinfrastructuur, heeft op basis van de vergelijkbare projecten een overzicht opgesteld met de benodigde activiteiten voor de exploitatie aan de kabel. Deze activiteiten zijn vastgelegd in

Tabel 2-1. In BIJLAGE B zijn de datasheets per schip weergeven. De activiteiten uit Tabel 2-1 zijn nader beschreven in het MER en de vergunningaanvragen. De activiteiten zijn doorgenummerd van de stikstofdepositie rapportage voor de aanlegfase van de NeuConnect kabel (1958639-RAP-0003-06).

*Tabel 2-1 Overzicht bronnen incl. benodigde schepen t.b.v. exploitatiefase*

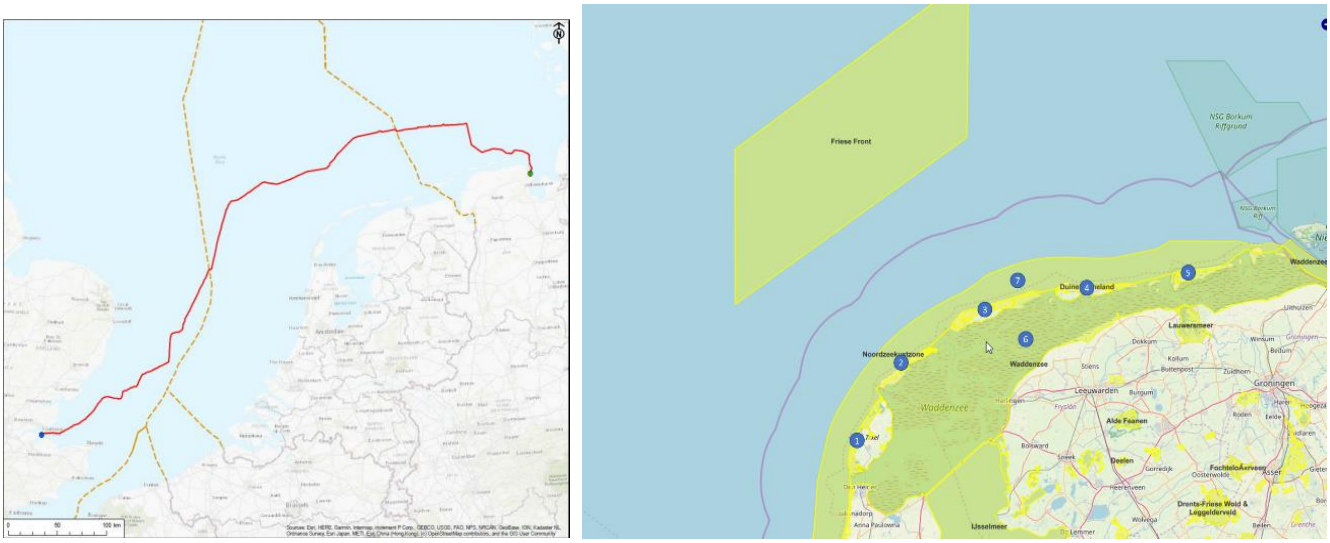
| nr. | Activiteit | Geschikt schip of soortgelijk | IMO emissie klasse |
|---|---|---|---|
| 12 | Onderzoek naar diepte kabel met een robot (ROV[1]) | Edda Sun | TIER I |
| 13 | Onderzoek naar hoogte van de zeebodem (bathymetrie) | MW Fugro Venturer | TIER I |

In hoofdstuk 3 worden de emissie gerelateerde uitgangspunten van deze activiteiten beschreven.

## 2.2 Beschrijving kabeltracé

De NeuConnect kabel heeft een lengte van circa 265 km in de Nederlandse EEZ. De kabel wordt gelegd in Noordzee. In figuur 2-2 is het tracé van de kabel weergeven. Het aan te vragen NeuConnect kabeltracé kruist in Nederlandse wateren het volgende Natura 2000 gebied:

- Friese Front over een lengte van circa 78 km;
    - Voor het Friese Front zijn geen instandhoudingsdoelstellingen vastgesteld voor soorten met stikstof-gevoelig leefgebied, zodat voor stikstofeffecten van het project op het Friese Front geen vergunning op grond van de Wet natuurbescherming nodig is.[2]




*Figuur 2-2 Kabeltracé NeuConnect (rechts) kaart met Natura 2000 gebieden(links)[2]*

Ten zuiden van het kabeltracé liggen de volgende Natura 2000 gebieden[3]:

[1] Remote Operated Vehicle

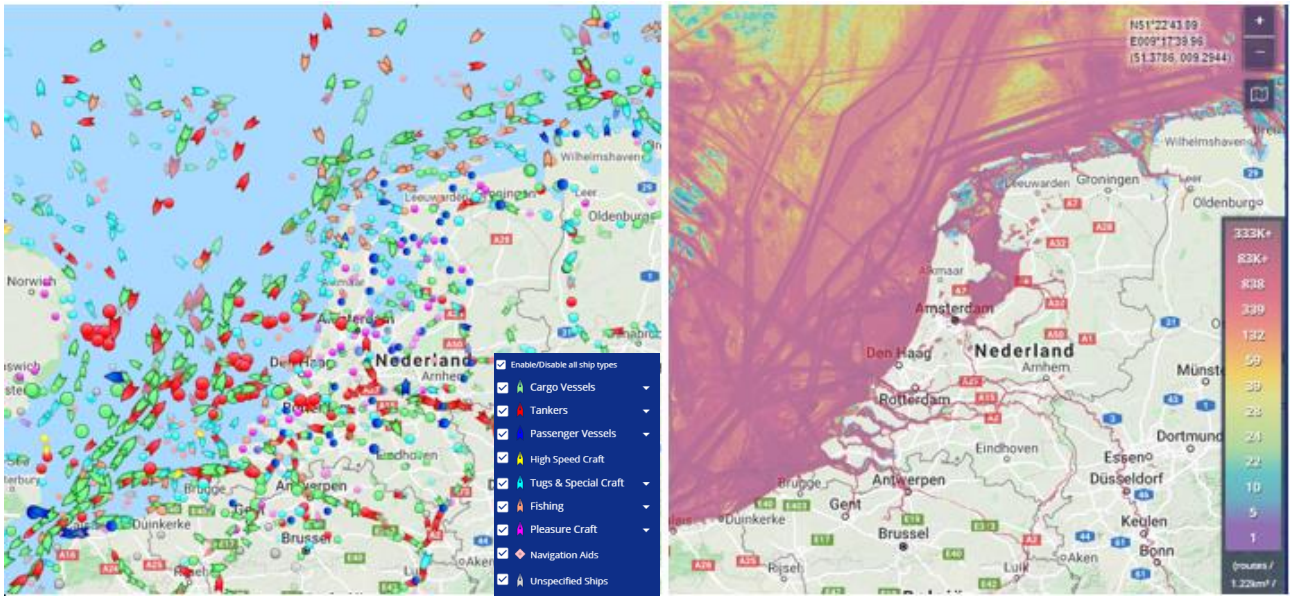
[2] Bron: https://zoek.officielebekendmakingen.nl/stcrt-2017-70696.html#d17e7416

[3] Bron: https://www.synbiosys.alterra.nl/natura2000/googlemapszoek2.aspx

1. Duinen en lage land Texel
2. Duinen Vlieland
3. Duinen Terschelling
4. Duinen Ameland
5. Duinen Schiermonnikoog
6. Waddenzee
7. Noordzeekustzone

De hierboven genoemde Natura 2000 gebieden zijn stikstofgevoelige natuurgebieden, behalve het gebied Noordzee-kustzone[1]. Voor de Noordzeekustzone geldt hetzelfde als voor de Friese Front, hier geldt dus geen vergunningsverplichting ter behoeve van de stikstofdepositie. Voor de Natura 2000 gebieden 1 t/m 6 geldt dat de stikstofdepositie in deze gebieden vastgesteld moet worden. Vanuit het kabeltracé is Duinen Terschelling het dichtstbijzijnde Natura 2000 gebied dat getoetst moet worden op de stikstofdepositie. Op het dichtstbijzijnde punt is de afstand ongeveer 45 km tussen het tracé en het Natura 2000 gebied.

De Noordzee is een druk bevaren gebied. Iedere dag leggen tientallen tot honderden schepen ongeveer dezelfde route af als het kabeltracé. Dit wordt vastgelegd door MarineTraffic. Op het linkse deel van Figuur 2-2 zijn de schepen te zien die op 10-12-2020 varen in de Noordzee, ieder pijltje is een schip. In het rechterdeel van Figuur 2-2 is de vaarintensiteit weergeven. De kleur geeft de intensiteit aan. Op basis van de bordeaux-rode vaarlijnen is te zien dat vaarintensiteit hoog is in de EEZ, die kunnen oplopen tot meer dan 300.000 vaarbewegingen[4] per 1,22 km² per jaar.




*Figuur 2-3 Weergave van scheepvaart op 10-12-2020[4]*

[4] Bron: https://www.marinetraffic.com/en/ais/home/centerx:4.8/centery:53.3/zoom:8

# 3 Beschrijving emissieberekening

## 3.1 Uitgangspunten activiteiten exploitatie fase

Primo Marine heeft op basis van de aangeleverde tenderdocumenten een overzicht opgesteld van de benodigde activiteiten voor de exploitatie. Hierbij zijn per activiteit de volgende punten beschreven:

- Locatie per activiteit
- Aantal benodigde schepen
- Tijdsduur van activiteit
- Gemiddeld gebruik vermogen per activiteit
- Wachttijd t.b.v. veranderende weersomstandigheden (WoW – Waiting on Weather)
    - Geldt voor hoofdactiviteit en transit. Heeft geen invloed op schip gereedmaken in haven
- Aantal dagen dat een schip op zee kan blijven

Het door Primo Marine opgestelde overzicht is weergeven in BIJLAGE A.

Om de hoofdactiviteiten te kunnen realiseren is het nodig om het schip gereed te maken in de haven en de vervoerbeweging van en/ naar het kabeltracé.

- Benodigde deelactiviteiten
    - Schip gereedmaken in haven
    - Vervoersbeweging van en/ of naar kabeltracé

Onafhankelijk van dit project wordt ieder schip ingezet en dus voorbereid in de haven. Dit is dan ook opgenomen in activiteiten van de desbetreffende havens. De emissies die vrijkomen bij de voorbereiding van het schip in de haven zijn onderdeel van de emissies die bij die haven horen en zijn al betrokken in het AERIUS model. Dit betekent dus dat het niet nodig is om deze emissie te berekenen voor de activiteiten van NeuConnect omdat het anders dubbel in AERIUS gemodelleerd wordt. De emissie van de vaarbewegingen vanuit de haven naar de dichtstbijzijnde hoofdvaarweg is ook reeds opgenomen in het AERIUS model.

De schepen varen vanuit de havens, IJmuiden of de Eemshaven, direct de zeevaartroutes op tot dat ze het kabeltracé bereiken. Dit betekent dat ze direct worden opgenomen in het heersende vaarbeeld, wat reeds is verwerkt in de achtergronddepositie. Conform het document “Instructie gegevensinvoer voor AERIUS Calculator 2020” opgesteld door Expertiseteam Stikstof en Natura 2000 is het daarom niet nodig deze activiteiten op te nemen in de AERIUS calculatie.

De emissie van voornoemde deelactiviteiten worden niet opgenomen in de AERIUS berekeningen.

In dit hoofdstuk zijn de uitgangspunten per activiteit beschreven voor de exploitatiefase. Dit dient als de basis van de emissieberekeningen. Per activiteit is de emissie berekend. Er worden 2 verschillende activiteiten onderscheiden die hieronder nader worden toegelicht.

**Activiteit 11: Onderzoek naar diepte kabel met een op afstand bedienbare robot (ROV)**
Jaarlijks dient de hoogte van de zeebodem in kaart gebracht te worden. Dit wordt over het algemeen uitgevoerd met een 'side scan sonar'. De hoogte van de zeebodem dient te worden vastgesteld voor het gehele Nederlandse kabeltracé, dit is ca. 265 km. De snelheid van het onderzoek ligt op ca. 2 knopen per uur[5]. Indien blijkt dat de diepte van de kabel of de hoogte van de zeebodem de eerste jaren constant is, dan zal aan de waterbeheerder toestemming worden gevraagd om het betreffende onderzoek niet jaarlijks, maar bijvoorbeeld een keer per drie jaar uit te mogen voeren.

Voor de emissieberekening is uitgegaan dat het onderzoek naar de diepte van de kabel wordt uitgevoerd door een soortgelijk schip als bijvoorbeeld 'Edda Sun'. De datasheet van het schip is weergeven in BIJLAGE B.

**Activiteit 12: Onderzoek naar hoogte van de zeebodem (bathymetrie)**
Jaarlijks dient de hoogte van de zeebodem in kaart gebracht te worden. Dit wordt over het algemeen uitgevoerd met een 'side scan sonar'. De hoogte van de zeebodem dient te worden vastgesteld voor het gehele Nederlandse kabeltracé, dit is ca. 265 km. De snelheid van het onderzoek ligt op ca. 7,5 km per uur.

Voor de emissieberekening is uitgegaan dat het bathymetrisch onderzoek wordt uitgevoerd door een soortgelijk schip als bijvoorbeeld 'MW Fugro Venturer'. De datasheet van het schip is weergeven in BIJLAGE B.

In tabel 3-1 is een overzicht weergeven van uitgangspunten per (deel)activiteit. Dit dient als basis voor de emissie-berekeningen van de exploitatiefase.

*Tabel 3-1 overzicht uitgangspunten per activiteit exploitatiefase*

| ***Nr.*** | ***Omschrijving activiteit*** | ***Naam schip*** | **Aantal schepen** | **Uren activiteit [uren]** | **WoW [%]** |
|---|---|---|---|---|---|
| 11 | Onderzoek naar diepte kabel met een robot (ROV[6]) | Edda Sun | 1 | 75 | 30% |
| 12 | Onderzoek naar hoogte van de zeebodem (bathymetrie) | MW Fugro Venturer | 1 | 35 | 30% |

## 3.2 Onderbouwing berekening

De emissieberekening wijkt af van de standaardmethode van AERIUS om de emissie van schepen te berekenen. Dit is gedaan omdat de standaard AERIUS berekenmethode gebaseerd is op enkel het varen van A naar B of het laden en lossen in de haven. De activiteiten maken op een andere manier en intensiteit gebruik van het desbetreffende opgesteld vermogen. De gehanteerde berekenmethodes voor dit rapport komen overeen met de achterliggende berekeningen van AERIUS.

[5] 1 knoop staat gelijk aan 1,852 km.
[6] Remote Operated Vehicle

### 3.2.1 Emissiekengetal schepen (IMO emissie klasse)

Voor de emissieberekening is gebruik gemaakt van de emissiekengetallen afkomstig uit IMO emissie klassen[7][8]. De emissiekengetallen zijn gegeven in g $NO_x$ per kWh. Om de emissiekengetallen te kunnen gebruiken, dient de nuttige gebruikte energie berekend te worden. De nuttig gebruikte energie is uitgedrukt op kWh/km en kWh per uur.

De nuttig gebruikte energie is volgens de volgende twee rekenmethodes berekend:

- Rekenmethode 1: Op basis van het brandstofverbruik;
- Rekenmethode 2: Op basis van het opgestelde vermogen in combinatie met gemiddeld gebruik van het vermogen.

Rekenmethode 1 is de meest nauwkeurige methode om de nuttig gebruikte energie te berekenen. Het brandstofverbruik is gebaseerd op de praktijk, waarbij er onderscheid wordt gemaakt tussen de verschillende activiteiten van een schip. Rekenmethode 2 is gebaseerd op het opgestelde vermogen en een inschatting gemiddeld percentage dat gebruikt wordt van het opgesteld vermogen. Rekenmethode 2 leidt tot een hogere emissie in vergelijking met rekenmethode 1. Dat betekent indien er gebruik wordt gemaakt van rekenmethode 2 de nuttig gebruikte energie wordt overschat ten opzichte van de praktijk. Dit leidt dus tot een hogere $NO_x$ emissie.

Voor het berekenen van de emissie is in eerste instantie gebruik gemaakt van rekenmethode 1. Indien de benodigde gegevens niet (volledig) beschikbaar zijn, is gebruik gemaakt van rekenmethode 2.

**Rekenmethode 1: Op basis van het brandstofverbruik (schepen)**

Primo Marine beschikt over gegevens van het brandstofverbruik van diverse schepen en activiteiten. Deze zijn weergeven in BIJLAGE C. Het brandstofverbruik is gegeven in m³/dag. Om op basis van het brandstofverbruik de nuttig gebruikte energie te berekenen zijn de volgende formules gebruikt:

$$Nuttige\ gebruikte\ energie\ [kWh/uur] = \frac{Brandstofverbruik * \rho * LHV * \eta_{motor}}{24\ {}^{uur}/_{dag}} \qquad \text{(formule 3-1)}$$

$$Nuttige\ gebruikte\ energie\ [kWh/km] = \frac{Brandstofverbruik\ * \rho * LHV * \eta_{motor}}{V\ \ *1{,}852 * 24\ uur/dag} \qquad \text{(formule 3-2)}$$

Brandstofverbruik in m³/dag afkomstig uit gegevens Primo Marine (afhankelijk per activiteit en of vaarsnelheid)

ρ : dichtheid (MDO[9] = 0,88 ton/m³)

LHV : stookwaarde (MDO = 42.700 MJ/ton)

ηmotor : motorefficiency (45%)

V: snelheid in km/uur (afhankelijk per schip)

**Rekenmethode 2: Op basis van het opgestelde vermogen (schepen)**

De emissiefactoren zijn met behulp van twee verschillende formules berekend. De eerste is voor de berekening van de emissiefactor uitgedrukt in kg NOx per km. Om de emissiefactor te kunnen bepalen is gebruik gemaakt van formule 3-3. Deze formule is afkomstig uit rapport “Marin report no. 29555-1-MSCN-rev.2”[1]. Voor elke activiteit is op basis van deze formule een emissiefactor berekend.

---

[7] https://dieselnet.com/standards/inter/imo.php

[8] Marin report no. 29555-1-MSCN-rev.2; sea shipping emissions 2015: netherlands continental Shelf, 12-mile zone and port areas; juni 2017

[9] Marine Diesel Oil

$$EF' = EF \times \frac{P \times fMCR}{V}$$ (Formule 3-3)

EF' Emissiefactor uitgedrukt als kg NOx per km

EF standaard motor emissiefactor als kg/kWh → Tier I/Tier II/Tier III afhankelijk van bouwjaar.

P Opgesteld vermogen in kW → data komt uit datasheets per schip

fMCR Gemiddeld percentage dat gebruikt wordt van het opgesteld vermogen P → inschatting Primo

V Actuele snelheid in km/uur → Inschatting Primo Marine of datasheet schip

De tweede emissiefactor is uitgedrukt in kg NOx per uur. Voor deze emissiefactorberekening is gebruik gemaakt van formule 3-4. Formule 3-4 is afgeleid van formule 3-3. In formule 3-4 is de vaarsnelheid uit de formule gehaald, dit resulteert in een formule gebaseerd op tijdsbasis.

$$EF'' = EF \times P \times P_{act.}$$ (Formule 3-4)

EF'' Emissiefactor uitgedrukt als kg NOx per uur

$P_{act.}$ Gemiddeld percentage dat gebruikt wordt van het opgesteld vermogen (P) → inschatting Primo Marine

### 3.2.2 Overzicht emissiefactoren

In tabel 3-2 is per activiteit aangegeven wat de berekende emissiefactor is. In deze tabel is tevens aangegeven welke rekenmethode gebruikt is door (1) of (2).

*Tabel 3-2 overzicht emissiefactoren exploitatiefase*

| ***nr.*** | ***Omschrijving activiteit*** | **Emissiefactor activiteit [kg NOx/uur]** |
|---|---|---|
| 11 | Onderzoek naar diepte kabel met een robot (ROV[10]) | 27,1 (1) |
| 12 | Onderzoek naar hoogte van de zeebodem (bathymetrie) | 28,1 (2) |

## 3.3 Stikstofoxiden emissie

De stikstofemissievracht is per activiteit en deelactiviteit berekend aan de hand van de uitgangspunten genoemd in hoofdstuk 3.1 en de berekende emissiefactor. De emissievracht is weergeven in tabel 3-3. In bijlage D zijn de berekeningen weergeven.

*Tabel 3-3 Totale emissievrachten per activiteit exploitatiefase*

| **nr.** | **Omschrijving activiteit** | **Naam schip (of soortgelijk)** | **Emissie klasse** | **Emissie [kg NOx per jaar]** |
|---|---|---|---|---|
| 11 | Onderzoek naar diepte kabel met een robot (ROV) | Edda Sun | TIER I | 1.940 |
| 12 | Onderzoek naar hoogte van de zeebodem (bathymetrie) | MW Fugro Venturer | TIER I | 993 |
| | **Totaal** | | | **2.933** |

[10] Remote Operated Vehicle

# 4 Stikstofdepositie berekeningsresultaten

Op basis van de berekende emissie uit hoofdstuk 3 is de extra stikstofdepositie ten gevolge van de voorgenomen activiteiten in de exploitatiefase bepaald met behulp van 'AERIUS versie 2020'. De totaal berekende stikstofemissie van de exploitatiefase is 2.933 kg NOx per jaar. De extra stikstofdepositie is bepaald voor de Natura 2000 gebieden. De exploitatiefase van de NeuConnect kabel start tot 1 jaar na de volledige realisatie. Dit is naar verwachting in 2023.

Voor iedere activiteit is de locatie vastgesteld. Op basis van de locaties zijn routes gemodelleerd in AERIUS voor de activiteiten op zee. Een route in AERIUS kan dus meerdere activiteiten bevatten. Het AERIUS model is opgebouwd volgens de bronnen uit Tabel 4-1. In Figuur 4-1 zijn de gemodelleerde routes weergeven.

*Figuur 4-1 weergave gemodelleerde routes AERIUS beheer- en onderhoudsfase*

In AERIUS is het niet mogelijk om langere trajecten (>100 km) in een keer te modelleren als bron. Daarom is de route opgesplitst in meerdere deelroutes, die vervolgens ieder als bron zijn gemodelleerd. De emissie is evenredig verdeeld naar de lengte van de deelroute. Bijvoorbeeld, route A heeft een lengte van 265 km en is vervolgens opgesplitst in deelroutes A1/A2/A3.

De warmteoutput en hoogte van de schoorsteen zijn in AERIUS ingevoerd op basis van de TNO rapportage kengetallen zeeschepen[11]:

- Warmteoutput; 25% van het gestookt vermogen komt als warmte vrij uit de schoorsteen.
- Schoorsteenhoogte: 24 m voor het varen en 20 m voor stilliggen in de haven. Dit is gebaseerd op werkschepen klasse 4 uitworphoogte

[11] TNO-Rapport TNO 2019 R11040 Kengetallen zeeschepen

*Tabel 4-1 Overzicht bronnen AERIUS exploitatiefase*

| Bron AERIUS | Omschrijving | Totale emissie [kg NOx per jaar] | Activiteiten |
|---|---|---|---|
| Route A | Kabeltracé Nederlandse EEZ | 2.933 | 11 & 12 |

Uit de AERIUS berekening volgt dat er geen stikstofdepositie (<0,00 mol/ha/jaar) optreedt als gevolg van de exploitatie. In bijlage E is het rapport van de AERIUS berekening weergeven.

# 5 Conclusie

**Exploitatiefase**

Er dient jaarlijks regulier beheer gepleegd te worden aan de NeuConnect kabel, dit wordt de exploitatiefase genoemd. Het beheer aan de kabel bestaat uit het jaarlijks monitoren van de diepte van de kabel en de hoogte van de zeebodem. In het geval dat jaarlijks blijkt dat diepte van de kabel gelijk blijft of dat de hoogte van de zeebodem gelijk blijft kan de frequentie van de onderzoeken lager worden. Bij de exploitatie van de NeuConnect kabel in de Nederlandse EEZ wordt $NO_x$ geëmitteerd. De activiteiten van exploitatiefase zijn geïdentificeerd en samengevat om als uitgangspunten te dienen voor de emissieberekeningen. De totaal berekende extra emissie ten gevolge van de exploitatiefase van de NeuConnect kabel bedraagt 2.933 kg $NO_x$ per jaar.

De extra stikstofdepositie is bepaald met behulp van ‘AERIUS versie 2020’. Uit de AERIUS berekening volgt dat er geen stikstofdepositie (<0,00 mol/ha/jaar) optreedt als gevolg van de exploitatiefase.

## *BIJLAGE A Overzicht uitgangspunten Primo Marine*

| Summary | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| nr. | Activity | Sub-Actvity | Location | Typical Vessel | Number of Spreads | Unit | Quantity | Production Speed (incl. maintenance/breakdown allowance) [unit/day] | Waiting on Weather (Estimate as Percent of Operating Days) | Duration [d] | Duration (incl. WoW) | Percent of Total Power (typical daily average) |
| 11 | Cable depth (maintance) | Mobilisation/Demobilisation | Outside Dutch Territory | ROV | 1 | days | 0 | 0 | 0% | - | - | - |
| 11 | Cable depth (maintance) | Transit to/From Site | N/A | ROV | 1 | km | 0 | 0 | 0% | - | - | - |
| 11 | Cable depth (maintance) | Offshore Works | Offshore Route | ROV | 1 | km | 265 | 74,08 | 30% | 3,6 | 4,7 | 50% |
| 12 | Bathometry (height of seabed) | Mobilisation/Demobilisation | Outside Dutch Territory | MBES | 1 | days | 0 | - | 0% | - | - | - |
| 12 | Bathometry (height of seabed) | Transit to/From Site | N/A | MBES | 1 | km | 0 | 0 | 0% | | | - |
| 12 | Bathometry (height of seabed) | Offshore Works | Offshore Route | MBES | 1 | km | 265 | 150 | 30% | 1,8 | 2,3 | 50% |

*BIJLAGE B datasheets vergelijkbare schepen*

# FUGRO
# EDDA SUN

**Edda Sun is a multipurpose ROV support vessel, capable of a broad range of IRM, construction and decommissioning support activities. Built in 2009 to the highest Norwegian standards, the vessel is extremely versatile with a high weather capability. The Edda Sun can accommodate up to 72 personnel, is equipped with a Sikorsky S-92-compatible helideck, a 70T/11m heave compensated knuckle boom deck crane and large deck space.**

*Edda Sun*

One of the key features of the vessel is its 625m$^2$ of free deck space for project use - one of the largest in its class. This coupled with the powerful deck crane and large bed space, enables Fugro to offer a broad range of bundled services.

The Edda Sun has two crane-deployed Seaeye Lynx inspection class ROV systems and one hangar-deployed FCV 3000 work class ROV system permanently installed.

The vessel also has integrated ROV control, online inspection, survey and offline processing/review offices and client offices.

This means the Edda Sun is ideally configured to carry out the inspection of platforms, pipelines and subsea structures in water depths of up to 3,000 msw and a whole variety of maintenance and repair tasks.

The Edda Sun will also be integrated to Fugro's European Remote Operations Centre, enabling further inspection, processing and ROV operation efficiencies and HSSE benefits.

# EDDA SUN

## Technical Specifications

### General

| | |
|---|---|
| Vessel Name | Edda Sun |
| Classification | DNV +1A1, SF, Comfort-C(3)-V(3), HELDK-SH, E0 |
| | DYNPOS AUTR, CLEAN, ICE-C, NAUTOSV (A), DK(+) |
| Owner | Østensjø Rederi AS |
| Operator | Fugro |
| Year Built | 2009 |
| Built by | Baatbygg AS |
| Port of registry | Bergen |
| Tonnage | Gross: 4,398 t; Net: 1,320 t |
| Call sign | LARF 7 |
| IMO | 9489651 |
| Helicopter Deck | Suitable for Sikorsky S-92 |

### Dimensions

| | |
|---|---|
| Length | LOA: 85.30 m; LBP: 75.0 m |
| Breadth | 18.0 m |
| Draft | 6.8 m |

### Accommodation

| | |
|---|---|
| Total complement | 72 persons |
| Cabins | 20 single, 26 double |
| Hospital | 1 berth + treatment table |
| Offices/workspaces | Online survey / ROV control room |
| | Offline survey room |
| | 1 x client office |
| | Conference room |
| | OVM office |
| | Inspection Coordinator office |
| | ROV office |
| | Inspection review room |
| Recreation | 2 x recreation rooms c/w satellite |
| | TV & video |
| | Messroom |
| | Gymnasium |
| | Sauna |

### Safety Equipment

| | |
|---|---|
| Lifeboats | 2 x 40 person Harding type MCB24 |
| Liferafts | 8 x 25 person Viking D625 inflateable |
| MOB boat | Springer MP-741 |

### Machinery & Performance

| | |
|---|---|
| Main engine | 4 x CAT 3516B, 1,800 kW |
| Main generator | 4 x 1,901 kW |
| Harbour generator | 1 x Set CAT C18 |
| Emergency generator | 1 x Set CAT C90I |
| Bow thrusters | 2 x 1,150 kW Ulstein Tunnel |
| Bow azimuth thruster | 1 x 1,400 kW UL 2001 CP Azi drop down |
| Speed | Full speed: 15 knots; Service: 10 knots |

### Deck Machinery

| | |
|---|---|
| Free project deck area | 625m² |
| Total deck area | 650m² |
| Deck crane TTS | 70 t / 11 m; 25 t / 25 m |
| | Main lift: 2,200 m |
| | Whip: 10 t / 29.5 m; 540 m x 28 mm |
| Deck crane (x 2) | 1.5 t, 10.3 m |

### Capacities

| | |
|---|---|
| Fresh water | 430 m³ |
| Water maker | Alfa Laval Evaporator |
| Ballast water | 2,200 m³ |
| Fuel oil | 1,052 m³ |

### Control and Navigation

| | |
|---|---|
| DP system | Rolls-Royce ICON Dynamic Positioning System (DP2) |
| DP reference systems | 2 x HiPAP 501, 2 x DGPS Seapath 200, Cyscan |

### Communication

| | |
|---|---|
| General | GMDSS Installation in accordance with IMO |
| | regulations for vessels operating within Sea Area A3 |
| GMDSS Radio MF/HF Transceivers & DSC | Sailor System 5000 |
| GMDSS VHF with DSC | 4 x Sailor RT5022, 1 x Sailor 6022 |
| GMDSS VHF portable | 3 x Sailor SP3520 |
| VHF | 4 x GP 340 Handheld |
| GMDSS EPIRB | 1 x Tron 60S Free Float. 1 x Tron 60S Manual |
| GMDSS SART | 2 x Jotron Tron |
| GMDSS Inmarsat C | 2 x Sailor TT-3606E |
| UHF | 15 x Motorola GP 340 Handheld, 3 x GM 360 Stationary |
| Satellite system | 1 x V-sat. 1 x Fleet 77 |
| Mobile telephone | GSM |
| Telefax | N/A |
| Sat TV system | Marlink |
| Helicopter Communication | 2 x Fixed and 3 x portable VHF |

### Work class ROV (WROV) Systems

| | |
|---|---|
| Number and type | 1 x FCV 3000 150 HP ROV systems |
| Deployment locations | 1 x vessel hanger (A-Frame) launch |
| TMS | 9.3 t SWL, 600 m tether capacity |
| System depth rating | 3,000 msw |
| Vehicle dimensions | 3 m x 1.7 m x 1.7 m |
| Vehicle power rating | 150 HP |

### Inspection ROV (OBSROV) System

| | |
|---|---|
| Number and type | 2 x Seaeye Lynx |
| System depth rating | 1,500 msw |
| TMS | Seaeye Type 8, side entry |
| | extendable height, 200 m tether capacity |
| LARS | Integrated crane, winch & HPU on |
| | 4.8 m x 2.8 m skid, 3 m outreach @ 3G |

© FUGRO 01 2019

# FUGRO
# M.V. FUGRO VENTURER

**New generation geophysical & hydrographic survey vessel designed for performance, safety and efficiency. Fugro Venturer, is the newest evolution of Fugro's Standard Survey Vessels (FSSV series) built specifically to meet multi-role geophysical survey standards.**

The suite of survey equipment includes analogue sensors comprising of hull-mounted single and multibeam echo sounders, state of the art sub-bottom profilers, a hull mounted Edgetech CHIRP profiler and 2 x 12 cubic inch mini-airgun array and an Edgetech dual frequency 4200 FS digital sidescan sonar.

In complement to this, the vessel is also mobilised with a Hydroscience SeaMUX digital recorder, comprised of a 1200m HTI digital streamer and seismic source of 152 cubic inches, although additional sources and streamers may be mobilised as an HR3D offering subject to client requirements.

Precise subsea positioning of survey equipment is achieved via a hull-mounted HiPAP 502 USBL system. Dual Rx / Dual Swath EM2040 and a Deep Water EM302 MBES systems are fitted to an acoustically efficient gondola. A 20t traction winch is fitted below decks that offers sampling in up to 3500m water depth.

The design of the vessel permits simultaneous analogue/digital survey operations and the capability to also conduct AUV, ROV, Environmental and Shallow Geotechnical surveys.

*Fugro Venturer on launch day.*

*M.V. Fugro Venturer interior.*

# M.V. FUGRO VENTURER

## Technical Specifications

### General

| | |
|---|---|
| Name | M.V. Fugro Venturer |
| Classification | GL+100 A5 E1 BWM(D2) Special Purpose Ship, Research Vessel, GL+MC E1 AUT DP 1 EP-D |
| Owner | Fugro |
| Built | Q2 2017 |
| Port / Flag | Nassau, Bahamas |
| MMSI No. | 311 000 463 |
| Call Sign | C6CG3 |
| IMO No. | 9769051 |

### Dimensions

| | |
|---|---|
| LOA | 71.5m |
| Beam | 15.4m |
| Draught | 5.6m |
| Tonnage | GT 2455 |

### Accommodation

| | |
|---|---|
| Cabins | 34 single ensuite, 4 double ensuite |
| Sick Bay | 1 single berth |
| Offices | 2 x offices |
| Recreation | 2 x lounge / video, 1 x gym, 1 x cinema |

### Machnery

| | |
|---|---|
| Bow Thruster | 1 x 600 kW (electric) |
| Cruising Speed | 10 knots |
| Maximum Speed | 12 knots |

### Electrical Power

| | |
|---|---|
| Auxiliary Generators | N/A |
| Generators | 2 x 1175 KVA, 2 x 972 KVA CAT Leroy Somer |

### Capacities

| | |
|---|---|
| Fuel Capacity | 464 $m^3$ (35 operational days at sea) |
| Fuel Consumption | 211 g/KWh at 100% load (pending sea trial measurements) |
| Water Capacity | 185 $m^3$ |
| Water Making | 10 $m^3$/day |
| Provisions | 90 days |

### Control and Navigation

| | |
|---|---|
| Autopilot | Schottel Co-pilot Simrad AP80 |
| DP System | Kongsberg KPOS and cJoy |
| 2 x Radars | Sperry S-Band & Sperry X-Band |
| 2 x Electronic Chart | Transas NS 4000 |
| 2 x DGPS | Saab R5 |
| 1 x Gyro | Sperry Navigat X MK1 |

### Deck Machinery

| | |
|---|---|
| Deck Crane | 2 x SWL 5.0 t /12 m crane |
| Hydraulic A Frame | 1 x SWL 20t, 1 x SWL 7.5t, 1 x SWL 2.5t |
| Launch Boom | 1 x SWL 2.5t and 1 x SWL 1t traversing |
| Deepwater Sampling lift/log | 3,500m 20t lift and 1,400m winch (PCPT) |

### Communications

| | |
|---|---|
| MF / HF (2x) | Sailor 6000 series |
| Inmarsat C (2x) | Sailor 6110 mini |
| VHF (4x) | Sailor 6222 |
| UHF(4x) | Motorola DM2600 |
| V-SAT | 1 x KU band Sea Tel 6012 |
| CCTV | Hernis |

### Safety

| | |
|---|---|
| Rescue / MOB Boat | 6.1m 6 pers rescue boat |
| Life Rafts (200%) | 4 x 25 person |
| Survival Suits (100%) | 42 pcs |
| Lift Jackets (200%) | 100 pcs |
| Work Vest | 12 pcs |
| Fire Detection | Funa MD9800 |

### Survey Equipment

| | |
|---|---|
| DGNSS Positioning | Starfix G2+ / Starfix XP2 and Starfix HP |
| Acoustic Positioning | Kongsberg HiPAP 502, 2 Poles available |
| Motion Reference Unit | Seapath 300, MRU5+, MGC R3 INS |
| Echo Sounder | Kongsberg EA600 |
| Multibeam Echo Sounder | Kongsberg EM302 and EM2040 Dual Rx |
| Sound Velocity Probe | 2 x Valeport Midas SVX2 |
| Sidescan Sonar | Edgetech 4200 FS |
| Sub-Bottom Profiler | Hull-mounted Edgetech CHIRP Profiler, 2 x 12 cu inch mini guns |
| Single Channel Streamer | SES 24 Element Mini Streamer |
| Magnetometer | Geometrics G-882 Magnetometer |
| Digital Logging | GLOG / GPLOT |
| Seabed Sampling | 3 / 6m Gravity Corer, Grab Sampler, 3 / 6m Piston Coring |
| Digital Seismic Recording | Hydroscience Technologies NTRS2 240 ch |
| Streamer | HTI Seamux gel filled 6.25m / 12.5m |
| Gun Controller | RTS Hotshot |
| Depth Controller | Digicourse 5010 & 5011 |
| Source Arrays | 6 x Sercel Mini G Guns, 152 cu inch array |
| Network | Several 10G Bass T |
| Compressor | 4 x Hamworthy compressors |
| Geotechnical Capability | Roson CPT, Coiled rod CPTs, Vibrocorer |
| Environmental Capability | Box corer - several options can be mobilised<br>Corers - several options can be mobilised |
| ROV Capability | Several ROV options can be mobilised |

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*BIJLAGE C Brandstofverbruiksgegevens*

| Vessel | Activity / Location | Consumption [m3/day] | Notes |
|---|---|---|---|
| Edda Sun | Transit | 22 | Service speed |
| Edda Sun | DP heavy | 10 | |
| Edda Sun | DP mid | 6 | |

## *BIJLAGE D uitgangspunten en resultaten emissie berekening*

### Uitgangspunten emissieberekeningen

| NeuConnect beheer en onderhoud | | | EF | Year of build | RPM | CEF | P | Pact. |
|---|---|---|---|---|---|---|---|---|
| *Activiteit nr.* | *Omschrijving activiteit* | *Naam schip* | *[g/kWh]* | *[-]* | *[rpm]* | *[-]* | *[kW]* | *[%]* |
| 11 | Onderzoek naar diepte kabel met robot | Edda Sun | 10,4 | 2009 | 1.500 | 1 | 7.200 | 50% |
| 12 | Onderzoek naar hoogte van de zeebodem | MW Fugro Venturer | 10,0 | 2008 | 1.800 | 1 | 4.300 | 50% |

### Emissieberekeningen o.b.v. brandstofverbruik

| NeuConnect beheer en onderhoud | | | Hourly power usage per activity | Power percentage based on fuel consumption | Total power used activity incl. WoW | Emission activity |
|---|---|---|---|---|---|---|
| *Activiteit nr.* | *Omschrijving activiteit* | *Naam schip* | *kWh per uur* | *%* | kWh | *[kg NOx]* |
| 11 | Onderzoek naar diepte kabel met robot | Edda Sun | 2001,6 | 28% | 186.160 | 1.940,4 |
| 12 | Onderzoek naar hoogte van de zeebodem | MW Fugro Venturer | 0,0 | 0% | - | - |

### Emissieberekeningen o.b.v. gemiddeld motor verbruik

| v | | | EF'' | Used power per day activity | Operational hours | % waiting on weather | Emission activity |
|---|---|---|---|---|---|---|---|
| *Activiteit nr.* | *Omschrijving activiteit* | *Naam schip* | *[kg/hour]* | *kWh per uur* | *[hours]* | *[%]* | *[kg NOx]* |
| 11 | Onderzoek naar diepte kabel met robot | Edda Sun | | 72.000 | 72 | 30% | |
| 12 | Onderzoek naar hoogte van de zeebodem | MW Fugro Venturer | 21,6 | 43.000 | 35 | 30% | 992 |

*BIJLAGE E AERIUS berekening exploitatiefase NeuConnect kabel Dutch EEZ*

AERIUS CALCULATOR

*Dit document bevat rekenresultaten van AERIUS Calculator. Het betreft de hoogst berekende stikstofbijdragen per stikstofgevoelig Natura 2000-gebied, op basis van rekenpunten die overlappen met habitattypen en/of leefgebieden die aangewezen zijn in het kader van de Wet natuurbescherming, gekoppeld aan een aangewezen soort, of nog onbekend maar mogelijk wel relevant.*

*De berekening op basis van stikstofemissies gaat uit van de componenten ammoniak (NH3) en/of stikstofoxide (NOx).*

*Wilt u verder rekenen of gegevens wijzigen? Importeer de pdf dan in Calculator. Voor meer toelichting verwijzen wij u naar de website www.aerius.nl.*

Berekening O&M fase Neuconnect (2022)

- Kenmerken
- Samenvatting emissies
- Depositieresultaten
- Gedetailleerde emissiegegevens

Verdere toelichting over deze PDF kunt u vinden in een bijbehorende leeswijzer. Deze leeswijzer en overige documentatie is te raadplegen via: https://www.aerius.nl/handleidingen-en-leeswijzers.

# AERIUS CALCULATOR

## Contact

| Rechtspersoon | Inrichtingslocatie |
|---|---|
| Nick Voets | Esp, 5633AA Eindhoven |

## Activiteit

| Omschrijving | AERIUS kenmerk |
|---|---|
| NeuConnect exploitatiefase | RY44eCJ4h2Mj |

| Datum berekening | Rekenjaar | Rekenconfiguratie |
|---|---|---|
| 16 maart 2021, 14:34 | 2023 | Berekend voor natuurgebieden |

## Totale emissie

| | Situatie 1 |
|---|---|
| NOx | 2.932,90 kg/j |
| NH3 | - |

## Resultaten

Hectare met hoogste bijdrage (mol/ha/j)

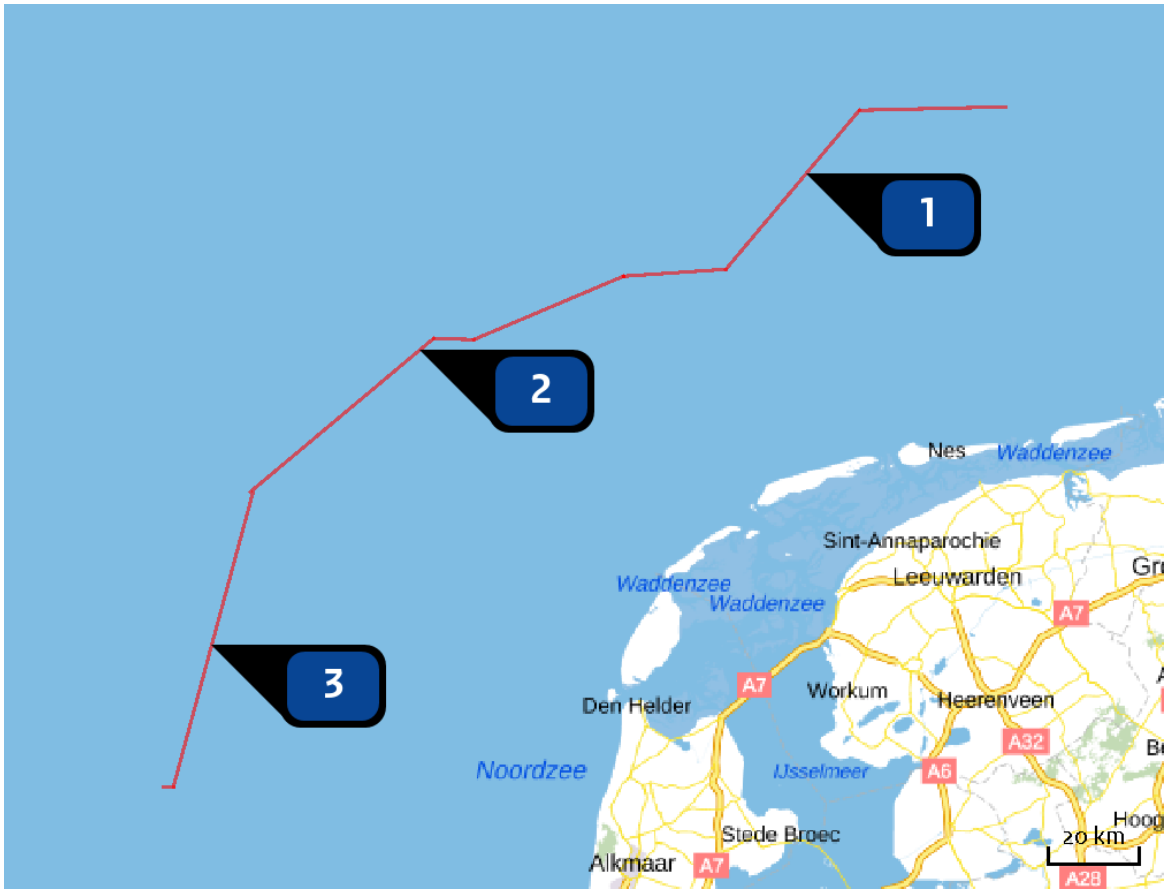
| Natuurgebied |
|---|
| Uw berekening heeft geen depositieresultaten opgeleverd boven 0,00 mol/ha/jr. |

## Toelichting

Exploitatiefase NeuConnect kabel

## Locatie

O&M fase
Neuconnect (2022)



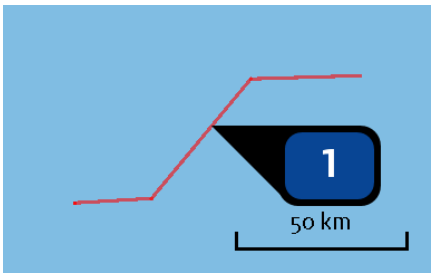

## Emissie

O&M fase
Neuconnect (2022)

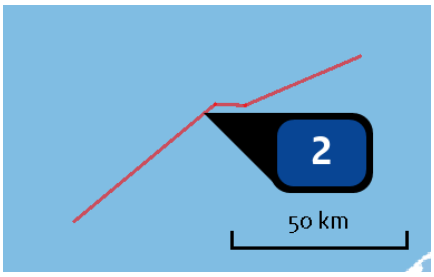
| Bron<br>Sector | | | Emissie NH3 | Emissie NOx |
|---|---|---|---|---|
| 1 | ••• | Route A1 bron 11&12<br>Anders... \| Anders... | - | 996,10 kg/j |
| 2 | ••• | Route A2 bron 11&12<br>Anders... \| Anders... | - | 1.095,70 kg/j |
| 3 | ••• | Route A3 bron 11&12<br>Anders... \| Anders... | - | 841,10 kg/j |

## Emissie (per bron)

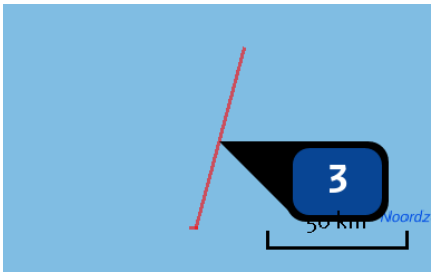
O&M fase Neuconnect (2022)




| | |
|---|---|
| Naam | Route A1 bron 11&12 |
| Locatie (X,Y) | 150265, 668315 |
| Uitstoothoogte | 24,0 m |
| Warmteinhoud | 0,350 MW |
| Temporele variatie | Transport |
| NOx | 996,10 kg/j |




| | |
|---|---|
| Naam | Route A2 bron 11&12 |
| Locatie (X,Y) | 65773, 629830 |
| Uitstoothoogte | 24,0 m |
| Warmteinhoud | 0,350 MW |
| Temporele variatie | Transport |
| NOx | 1.095,70 kg/j |




| | |
|---|---|
| Naam | Route A3 bron 11&12 |
| Locatie (X,Y) | 20290, 565451 |
| Uitstoothoogte | 24,0 m |
| Warmteinhoud | 0,350 MW |
| Temporele variatie | Transport |
| NOx | 841,10 kg/j |

## Disclaimer

Hoewel verstrekte gegevens kunnen dienen ter onderbouwing van een vergunningaanvraag, kunnen er geen rechten aan worden ontleend. De eigenaar van AERIUS aanvaardt geen aansprakelijkheid voor de inhoud van de door de gebruiker aangeboden informatie. Bovenstaande gegevens zijn enkel bruikbaar tot er een nieuwe versie van AERIUS beschikbaar is. AERIUS is een geregistreerd handelsmerk in Europa. Alle rechten die niet expliciet worden verleend, zijn voorbehouden.

## Rekenbasis

Deze berekening is tot stand gekomen op basis van:

| | |
|---|---|
| AERIUS | versie 2020_20210209_2f032ce1a2 |
| Database | versie 2020_20210209_2f032ce1a2 |

Voor meer informatie over de gebruikte methodiek en data zie:
https://www.aerius.nl/nl/factsheets/release/aerius-calculator-2020

# Bijlage 6c: Aerius berekening aanlegfase NeuConnect

AERIUS CALCULATOR

*Dit document bevat rekenresultaten van AERIUS Calculator. Het betreft de hoogst berekende stikstofbijdragen per stikstofgevoelig Natura 2000-gebied, op basis van rekenpunten die overlappen met habitattypen en/of leefgebieden die aangewezen zijn in het kader van de Wet natuurbescherming, gekoppeld aan een aangewezen soort, of nog onbekend maar mogelijk wel relevant.*

*De berekening op basis van stikstofemissies gaat uit van de componenten ammoniak (NH3) en/of stikstofoxide (NOx).*

*Wilt u verder rekenen of gegevens wijzigen? Importeer de pdf dan in Calculator. Voor meer toelichting verwijzen wij u naar de website www.aerius.nl.*

Berekening Aanlegfase NeuConnect Kabel Dutch EEZ

- Kenmerken
- Samenvatting emissies
- Depositieresultaten
- Gedetailleerde emissiegegevens

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# AERIUS CALCULATOR

## Contact

| Rechtspersoon | Inrichtingslocatie |
|---|---|
| Ingenia Consultants & Engineers | Esp, 5633AA Eindhoven |

## Activiteit

| Omschrijving | AERIUS kenmerk |
|---|---|
| NeuConnect kabel | RVp33sxdWF9A |

| Datum berekening | Rekenjaar | Rekenconfiguratie |
|---|---|---|
| 09 maart 2021, 18:24 | 2022 | Berekend voor natuurgebieden |

## Totale emissie

| | Situatie 1 |
|---|---|
| NOx | 162,15 ton/j |
| NH3 | - |

## Resultaten

Hectare met hoogste bijdrage (mol/ha/j)

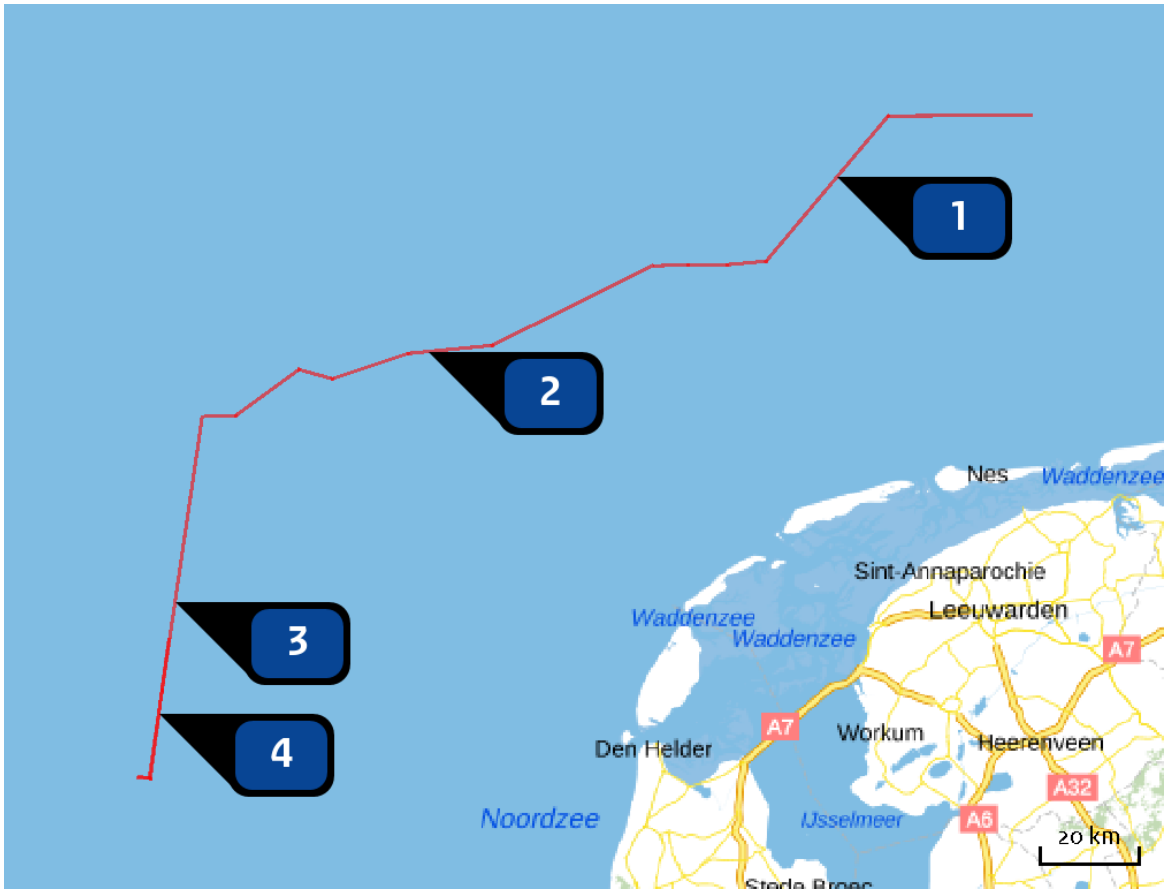
| Natuurgebied | Bijdrage |
|---|---|
| Duinen Vlieland | 0,09 |

## Toelichting

Aanlegfase NeuConnect kabel Nederlandse EEZ

## Locatie

Aanlegfase
NeuConnect Kabel
Dutch EEZ




## Emissie

Aanlegfase
NeuConnect Kabel
Dutch EEZ

| Bron Sector | | Emissie NH3 | Emissie NOx |
|---|---|---|---|
| 1 | Route A1 Hoofdactiviteiten 1t/m 3 en 5 t/m 10<br>Anders... \| Anders... | - | 37,50 ton/j |
| 2 | Route A2 Hoofdactiviteiten 1 t/m 3 en 5 t/m 10<br>Anders... \| Anders... | - | 41,25 ton/j |
| 3 | Route A3 Hoofdactiviteiten 1 t/m 3 en 5 t/m 10<br>Anders... \| Anders... | - | 31,66 ton/j |
| 4 | Route B Hoofdactiviteit 4<br>Anders... \| Anders... | - | 51,74 ton/j |

## Resultaten stikstof gevoelige Natura 2000 gebieden (mol/ha/j)

| Natuurgebied | Hoogste bijdrage | Bijdrage op (bijna) overbelaste hexagonen* |
|---|---|---|
| Duinen Vlieland | 0,09 | |
| Duinen en Lage Land Texel | 0,09 | |
| Duinen Terschelling | 0,09 | |
| Duinen Den Helder-Callantsoog | 0,08 | |
| Waddenzee | 0,08 | |
| Duinen Ameland | 0,07 | |
| Zwanenwater & Pettemerduinen | 0,07 | 0,06 |
| Schoorlse Duinen | 0,06 | |
| Noordhollands Duinreservaat | 0,06 | |
| Duinen Schiermonnikoog | 0,06 | |
| Noordzeekustzone | 0,05 | |
| Alde Feanen | 0,05 | |
| Kennemerland-Zuid | 0,05 | |
| IJsselmeer | 0,04 | - |
| Wijnjeterper Schar | 0,04 | |
| Weerribben | 0,04 | |
| Drents-Friese Wold & Leggelderveld | 0,04 | |
| Fochteloërveen | 0,04 | |
| Norgerholt | 0,04 | |
| Bakkeveense Duinen | 0,04 | |

| Natuurgebied | Hoogste bijdrage | Bijdrage op (bijna) overbelaste hexagonen* |
|---|---|---|
| Groote Wielen | 0,04 | - |
| Rottige Meenthe & Brandemeer | 0,04 | |
| Drentsche Aa-gebied | 0,04 | |
| Meijendel & Berkheide | 0,04 | |
| Holtingerveld | 0,04 | |
| De Wieden | 0,04 | |
| Dwingelderveld | 0,04 | |
| Van Oordt's Mersken | 0,04 | |
| Polder Westzaan | 0,03 | |
| Witterveld | 0,03 | |
| Westduinpark & Wapendal | 0,03 | |
| Drouwenerzand | 0,03 | |
| Ilperveld, Varkensland, Oostzanerveld & Twiske | 0,03 | |
| Oudegaasterbrekken, Fluessen en omgeving | 0,03 | - |
| Naardermeer | 0,03 | |
| Solleveld & Kapittelduinen | 0,03 | |
| Mantingerbos | 0,03 | |
| Mantingerzand | 0,03 | |
| Veluwe | 0,03 | |
| Lieftinghsbroek | 0,03 | |

| Natuurgebied | Hoogste bijdrage | Bijdrage op (bijna) overbelaste hexagonen* |
|---|---|---|
| Oostelijke Vechtplassen | 0,03 | |
| Coepelduynen | 0,03 | |
| Elperstroomgebied | 0,03 | |
| Voornes Duin | 0,03 | |
| Wormer- en Jisperveld & Kalverpolder | 0,03 | |
| Rijntakken | 0,03 | |
| Vecht- en Beneden-Reggegebied | 0,03 | |
| Grevelingen | 0,03 | |
| Duinen Goeree & Kwade Hoek | 0,03 | |
| Kop van Schouwen | 0,03 | |
| Bargerveen | 0,03 | |
| Sallandse Heuvelrug | 0,03 | |
| Boetelerveld | 0,03 | |
| Botshol | 0,03 | |
| Nieuwkoopse Plassen & De Haeck | 0,03 | |
| Engbertsdijksvenen | 0,03 | |
| Eilandspolder | 0,03 | |
| Olde Maten & Veerslootslanden | 0,02 | |
| Wierdense Veld | 0,02 | |
| Uiterwaarden Zwarte Water en Vecht | 0,02 | |

| Natuurgebied | Hoogste bijdrage | Bijdrage op (bijna) overbelaste hexagonen* |
|---|---|---|
| Kolland & Overlangbroek | 0,02 | |
| Springendal & Dal van de Mosbeek | 0,02 | |
| Borkeld | 0,02 | |
| Lingegebied & Diefdijk-Zuid | 0,02 | |
| Manteling van Walcheren | 0,02 | |
| Achter de Voort, Agelerbroek & Voltherbroek | 0,02 | |
| Biesbosch | 0,02 | |
| Krammer-Volkerak | 0,02 | |
| Landgoederen Brummen | 0,02 | |
| Bergvennen & Brecklenkampse Veld | 0,02 | |
| Lemselermaten | 0,02 | |
| Landgoederen Oldenzaal | 0,02 | |
| Dinkelland | 0,02 | |
| Zwarte Meer | 0,02 | - |
| Loonse en Drunense Duinen & Leemkuilen | 0,02 | |
| Lonnekermeer | 0,02 | |
| Langstraat | 0,02 | |
| Buurserzand & Haaksbergerveen | 0,02 | |
| Voordelta | 0,02 | |
| Brabantse Wal | 0,02 | |

| Natuurgebied | Hoogste bijdrage | Bijdrage op (bijna) overbelaste hexagonen* |
|---|---|---|
| Stelkampsveld | 0,02 | |
| Witte Veen | 0,02 | |
| Ulvenhoutse Bos | 0,02 | |
| Kampina & Oisterwijkse Vennen | 0,02 | |
| Aamsveen | 0,02 | |
| Vlijmens Ven, Moerputten & Bossche Broek | 0,02 | |
| Sint Jansberg | 0,02 | |
| Korenburgerveen | 0,02 | |
| Loevestein, Pompveld & Kornsche Boezem | 0,02 | |
| Bekendelle | 0,02 | |
| Regte Heide & Riels Laag | 0,02 | |
| Binnenveld | 0,02 | |
| Kempenland-West | 0,02 | |
| Oosterschelde | 0,02 | |
| Willinks Weust | 0,02 | |
| Maasduinen | 0,02 | |
| Zeldersche Driessen | 0,02 | |
| Zouweboezem | 0,02 | |
| Uiterwaarden Lek | 0,02 | |
| Boschhuizerbergen | 0,02 | |

| Natuurgebied | Hoogste bijdrage | Bijdrage op (bijna) overbelaste hexagonen* |
|---|---|---|
| Leenderbos, Groote Heide & De Plateaux | 0,02 | |
| Strabrechtse Heide & Beuven | 0,02 | |
| Deurnsche Peel & Mariapeel | 0,02 | |
| De Bruuk | 0,02 | |
| Wooldse Veen | 0,02 | |
| Weerter- en Budelerbergen & Ringselven | 0,02 | |
| Groote Peel | 0,02 | |
| Leudal | 0,02 | |
| Westerschelde & Saeftinghe | 0,02 | |
| Swalmdal | 0,01 | |
| Meinweg | 0,01 | |
| Zwin & Kievittepolder | 0,01 | |
| Roerdal | 0,01 | |
| Yerseke en Kapelse Moer | 0,01 | |
| Brunssummerheide | 0,01 | |
| Oeffelter Meent | 0,01 | |
| Geleenbeekdal | 0,01 | |
| Bunder- en Elslooërbos | 0,01 | |
| Sarsven en De Banen | 0,01 | |
| Geuldal | 0,01 | |

| Natuurgebied | Hoogste bijdrage | Bijdrage op (bijna) overbelaste hexagonen* |
|---|---|---|
| Savelsbos | 0,01 | |
| Bemelerberg & Schiepersberg | 0,01 | |
| Sint Pietersberg & Jekerdal | 0,01 | |
| Kunderberg | 0,01 | |
| Vogelkreek | 0,01 | - |
| Groote Gat | 0,01 | |
| Noorbeemden & Hoogbos | 0,01 | |
| Canisvliet | 0,01 | |
| Maas bij Eijsden | 0,01 | - |

* Als de hoogste depositietoename plaatsvindt op een hexagoon waar géén sprake is van een (naderende) stikstofoverbelasting, dan is de hoogste toename op een hexagoon met wel een (naderende) stikstofoverbelasting in deze kolom weergegeven.

Resultaten per habitattype (mol/ha/j)

voor de 10 stikstofgevoelige Natura 2000-gebieden met het hoogste resultaat

## Duinen Vlieland

| Habitattype | Hoogste bijdrage | Bijdrage op (bijna) overbelaste hexagonen* |
|---|---|---|
| ZGH2180Abe Duinbossen (droog), berken-eikenbos | 0,09 | |
| H2180Abe Duinbossen (droog), berken-eikenbos | 0,09 | |
| ZGH2180B Duinbossen (vochtig) | 0,09 | |
| H2120 Witte duinen | 0,09 | |
| H2140B Duinheiden met kraaihei (droog) | 0,09 | |
| H2130B Grijze duinen (kalkarm) | 0,09 | |
| H2140A Duinheiden met kraaihei (vochtig) | 0,09 | |
| H2190C Vochtige duinvalleien (ontkalkt) | 0,09 | |
| H2150 Duinheiden met struikhei | 0,08 | |
| H2180B Duinbossen (vochtig) | 0,08 | |
| H2190Aom Vochtige duinvalleien (open water), oligo- tot mesotrofe vormen | 0,08 | |
| H2130C Grijze duinen (heischraal) | 0,07 | |
| H2190B Vochtige duinvalleien (kalkrijk) | 0,06 | |
| H1330A Schorren en zilte graslanden (buitendijks) | 0,06 | |
| H2160 Duindoornstruwelen | 0,06 | |
| H2130A Grijze duinen (kalkrijk) | 0,06 | |
| H2170 Kruipwilgstruwelen | 0,06 | - |
| H1310A Zilte pionierbegroeiingen (zeekraal) | 0,05 | - |

## Duinen en Lage Land Texel

| Habitattype | Hoogste bijdrage | Bijdrage op (bijna) overbelaste hexagonen* |
|---|---|---|
| H2180Abe Duinbossen (droog), berken-eikenbos | 0,09 | |
| H2130B Grijze duinen (kalkarm) | 0,09 | |
| H2180B Duinbossen (vochtig) | 0,09 | |
| H2180C Duinbossen (binnenduinrand) | 0,09 | |
| H2140B Duinheiden met kraaihei (droog) | 0,09 | |
| H2150 Duinheiden met struikhei | 0,09 | |
| H2160 Duindoornstruwelen | 0,08 | |
| H2190B Vochtige duinvalleien (kalkrijk) | 0,08 | |
| ZGH2180B Duinbossen (vochtig) | 0,08 | |
| H2130C Grijze duinen (heischraal) | 0,08 | |
| ZGH2180C Duinbossen (binnenduinrand) | 0,08 | |
| ZGH2180Abe Duinbossen (droog), berken-eikenbos | 0,08 | |
| H2190Aom Vochtige duinvalleien (open water), oligo- tot mesotrofe vormen | 0,08 | |
| H9999:2 Habitattype onbekend/onzeker KDW op basis meest kritische relevante type (H2130B;H2130C). | 0,08 | |
| H2120 Witte duinen | 0,07 | |
| H2130A Grijze duinen (kalkrijk) | 0,07 | |
| H2190C Vochtige duinvalleien (ontkalkt) | 0,07 | |
| H7210 Galigaanmoerassen | 0,07 | |
| H2140A Duinheiden met kraaihei (vochtig) | 0,07 | |

## Duinen en Lage Land Texel

| Habitattype | Hoogste bijdrage | Bijdrage op (bijna) overbelaste hexagonen* |
|---|---|---|
| H1330A Schorren en zilte graslanden (buitendijks) | 0,07 | |
| H1310B Zilte pionierbegroeiingen (zeevetmuur) | 0,06 | 0,05 |
| H2170 Kruipwilgstruwelen | 0,06 | |
| H2110 Embryonale duinen | 0,06 | |
| H1310A Zilte pionierbegroeiingen (zeekraal) | 0,05 | |
| H1330B Schorren en zilte graslanden (binnendijks) | 0,05 | 0,04 |

## Duinen Terschelling

| Habitattype | Hoogste bijdrage | Bijdrage op (bijna) overbelaste hexagonen* |
|---|---|---|
| H2180Abe Duinbossen (droog), berken-eikenbos | 0,09 | |
| H2180B Duinbossen (vochtig) | 0,09 | |
| ZGH2180B Duinbossen (vochtig) | 0,08 | |
| H2140B Duinheiden met kraaihei (droog) | 0,08 | |
| ZGH2180Abe Duinbossen (droog), berken-eikenbos | 0,08 | |
| H2130B Grijze duinen (kalkarm) | 0,08 | |
| H2150 Duinheiden met struikhei | 0,08 | |
| H2140A Duinheiden met kraaihei (vochtig) | 0,08 | |
| H6410 Blauwgraslanden | 0,08 | |
| H2170 Kruipwilgstruwelen | 0,08 | |
| H2190C Vochtige duinvalleien (ontkalkt) | 0,08 | |
| H2160 Duindoornstruwelen | 0,08 | |
| H2130A Grijze duinen (kalkrijk) | 0,08 | |
| ZGH2190C Vochtige duinvalleien (ontkalkt) | 0,07 | |
| H2120 Witte duinen | 0,07 | |
| H2190Aom Vochtige duinvalleien (open water), oligo- tot mesotrofe vormen | 0,07 | |
| H2190B Vochtige duinvalleien (kalkrijk) | 0,07 | |
| H1330A Schorren en zilte graslanden (buitendijks) | 0,06 | |
| H1310A Zilte pionierbegroeiingen (zeekraal) | 0,06 | |

## Duinen Terschelling

| Habitattype | Hoogste bijdrage | Bijdrage op (bijna) overbelaste hexagonen* |
|---|---|---|
| H1310B Zilte pionierbegroeiingen (zeevetmuur) | 0,06 | |
| H6230vka Heischrale graslanden, vochtig kalkarm | 0,06 | |
| ZGH2120 Witte duinen | 0,05 | |
| ZGH2160 Duindoornstruwelen | 0,05 | - |
| Lg07 Dotterbloemgrasland van veen en klei | 0,05 | |
| H2110 Embryonale duinen | 0,05 | |
| ZGH2190B Vochtige duinvalleien (kalkrijk) | 0,05 | |
| ZGH2130C Grijze duinen (heischraal) | 0,05 | |
| ZGH2110 Embryonale duinen | 0,05 | |
| H1320 Slijkgrasvelden | 0,04 | - |

## Duinen Den Helder-Callantsoog

| Habitattype | Hoogste bijdrage | Bijdrage op (bijna) overbelaste hexagonen* |
|---|---|---|
| H2180Abe Duinbossen (droog), berken-eikenbos | 0,08 | |
| H2130B Grijze duinen (kalkarm) | 0,07 | |
| H6410 Blauwgraslanden | 0,07 | |
| H2180C Duinbossen (binnenduinrand) | 0,06 | |
| H2120 Witte duinen | 0,06 | |
| H2140B Duinheiden met kraaihei (droog) | 0,06 | |
| H2190C Vochtige duinvalleien (ontkalkt) | 0,06 | |
| H2190Aom Vochtige duinvalleien (open water), oligo- tot mesotrofe vormen | 0,06 | |
| H2170 Kruipwilgstruwelen | 0,05 | |
| H2160 Duindoornstruwelen | 0,05 | |

## Waddenzee

| Habitattype | Hoogste bijdrage | Bijdrage op (bijna) overbelaste hexagonen* |
|---|---|---|
| ZGH2120 Witte duinen | 0,08 | |
| ZGH2130A Grijze duinen (kalkrijk) | 0,08 | |
| H1310B Zilte pionierbegroeiingen (zeevetmuur) | 0,08 | |
| H1330A Schorren en zilte graslanden (buitendijks) | 0,08 | |
| ZGH2190B Vochtige duinvalleien (kalkrijk) | 0,08 | |
| ZGH2160 Duindoornstruwelen | 0,07 | 0,06 |
| H1310A Zilte pionierbegroeiingen (zeekraal) | 0,06 | |
| H1320 Slijkgrasvelden | 0,06 | |
| H2130B Grijze duinen (kalkarm) | 0,06 | |
| H2160 Duindoornstruwelen | 0,05 | |
| H2190B Vochtige duinvalleien (kalkrijk) | 0,05 | 0,03 |
| ZGH2110 Embryonale duinen | 0,05 | |
| H2110 Embryonale duinen | 0,05 | |
| H2120 Witte duinen | 0,04 | |
| ZGH1330B Schorren en zilte graslanden (binnendijks) | 0,02 | - |
| ZGH1310A Zilte pionierbegroeiingen (zeekraal) | 0,02 | - |

## Duinen Ameland

| Habitattype | Hoogste bijdrage | Bijdrage op (bijna) overbelaste hexagonen* |
|---|---|---|
| H2180Abe Duinbossen (droog), berken-eikenbos | 0,07 | |
| H2180B Duinbossen (vochtig) | 0,07 | |
| ZGH2180B Duinbossen (vochtig) | 0,07 | |
| H2130B Grijze duinen (kalkarm) | 0,07 | |
| ZGH2130B Grijze duinen (kalkarm) | 0,06 | |
| H2130A Grijze duinen (kalkrijk) | 0,06 | |
| ZGH2170 Kruipwilgstruwelen | 0,06 | |
| H9999:5 Habitattype onbekend/onzeker KDW op basis meest kritische relevante type (H2130B;H2130C;H6230). | 0,06 | |
| H2180C Duinbossen (binnenduinrand) | 0,06 | |
| ZGH2120 Witte duinen | 0,06 | |
| H2170 Kruipwilgstruwelen | 0,06 | |
| H2190Aom Vochtige duinvalleien (open water), oligo- tot mesotrofe vormen | 0,05 | |
| H2150 Duinheiden met struikhei | 0,05 | |
| H2160 Duindoornstruwelen | 0,05 | |
| H2140A Duinheiden met kraaihei (vochtig) | 0,05 | |
| H2130C Grijze duinen (heischraal) | 0,05 | |
| ZGH2160 Duindoornstruwelen | 0,05 | |
| H2120 Witte duinen | 0,05 | |
| ZGH2130A Grijze duinen (kalkrijk) | 0,05 | |

## Duinen Ameland

| Habitattype | Hoogste bijdrage | Bijdrage op (bijna) overbelaste hexagonen* |
|---|---|---|
| H2190C Vochtige duinvalleien (ontkalkt) | 0,05 | |
| H2190B Vochtige duinvalleien (kalkrijk) | 0,05 | 0,04 |
| ZGH2190C Vochtige duinvalleien (ontkalkt) | 0,05 | |
| H2140B Duinheiden met kraaihei (droog) | 0,05 | |
| ZGH2190B Vochtige duinvalleien (kalkrijk) | 0,04 | |
| ZGH2180Abe Duinbossen (droog), berken-eikenbos | 0,04 | |
| ZGH6230vka Heischrale graslanden, vochtig kalkarm | 0,04 | |

## Zwanenwater & Pettemerduinen

| Habitattype | Hoogste bijdrage | Bijdrage op (bijna) overbelaste hexagonen* |
|---|---|---|
| H2180B Duinbossen (vochtig) | 0,07 | 0,06 |
| H2130B Grijze duinen (kalkarm) | 0,06 | |
| H2140B Duinheiden met kraaihei (droog) | 0,06 | |
| H2150 Duinheiden met struikhei | 0,06 | |
| H2180Abe Duinbossen (droog), berken-eikenbos | 0,06 | |
| ZGH2170 Kruipwilgstruwelen | 0,06 | |
| H2190C Vochtige duinvalleien (ontkalkt) | 0,06 | |
| H7210 Galigaanmoerassen | 0,06 | |
| H2140A Duinheiden met kraaihei (vochtig) | 0,06 | |
| H2120 Witte duinen | 0,06 | |
| H6230vka Heischrale graslanden, vochtig kalkarm | 0,06 | |
| H2190Aom Vochtige duinvalleien (open water), oligo- tot mesotrofe vormen | 0,06 | |
| H2170 Kruipwilgstruwelen | 0,05 | |
| H2190B Vochtige duinvalleien (kalkrijk) | 0,05 | |
| H2130A Grijze duinen (kalkrijk) | 0,05 | |
| H6410 Blauwgraslanden | 0,05 | |
| ZGH2120 Witte duinen | 0,05 | |
| H9999:85 Habitattype onbekend/onzeker KDW op basis meest kritische relevante type (H2130B;H6230). | 0,05 | |
| ZGH2130B Grijze duinen (kalkarm) | 0,05 | |

## Zwanenwater & Pettemerduinen

| Habitattype | Hoogste bijdrage | Bijdrage op (bijna) overbelaste hexagonen* |
|---|---|---|
| H2110 Embryonale duinen | 0,04 | |
| ZGH2130A Grijze duinen (kalkrijk) | 0,04 | |

## Schoorlse Duinen

| Habitattype | Hoogste bijdrage | Bijdrage op (bijna) overbelaste hexagonen* |
|---|---|---|
| H2180Abe Duinbossen (droog), berken-eikenbos | 0,06 | |
| H2150 Duinheiden met struikhei | 0,06 | |
| H2130B Grijze duinen (kalkarm) | 0,06 | |
| H2140B Duinheiden met kraaihei (droog) | 0,06 | |
| H2140A Duinheiden met kraaihei (vochtig) | 0,06 | |
| H2170 Kruipwilgstruwelen | 0,06 | |
| H2190Aom Vochtige duinvalleien (open water), oligo- tot mesotrofe vormen | 0,06 | |
| H2190C Vochtige duinvalleien (ontkalkt) | 0,06 | |
| H2120 Witte duinen | 0,06 | |
| H2180C Duinbossen (binnenduinrand) | 0,06 | |
| H2130A Grijze duinen (kalkrijk) | 0,05 | |
| H2180B Duinbossen (vochtig) | 0,05 | |
| ZGH2130B Grijze duinen (kalkarm) | 0,05 | |
| H2160 Duindoornstruwelen | 0,04 | |
| H2110 Embryonale duinen | 0,04 | |

## Noordhollands Duinreservaat

| Habitattype | Hoogste bijdrage | Bijdrage op (bijna) overbelaste hexagonen* |
|---|---|---|
| H2180A Duinbossen (droog), berken-eikenbos | 0,06 | |
| H2190A Vochtige duinvalleien (open water) | 0,06 | |
| H2130B Grijze duinen (kalkarm) | 0,06 | |
| H2140B Duinheiden met kraaihei (droog) | 0,06 | |
| H2180B Duinbossen (vochtig) | 0,06 | |
| H2180C Duinbossen (binnenduinrand) | 0,06 | |
| H2140A Duinheiden met kraaihei (vochtig) | 0,06 | |
| H2130A Grijze duinen (kalkrijk) | 0,06 | |
| H2150 Duinheiden met struikhei | 0,06 | |
| H2190B Vochtige duinvalleien (kalkrijk) | 0,06 | |
| H2120 Witte duinen | 0,06 | |
| Lg12 Zoom, mantel en droog struweel van de duinen | 0,06 | |
| H2130C Grijze duinen (heischraal) | 0,06 | |
| H2160 Duindoornstruwelen | 0,06 | |
| H2170 Kruipwilgstruwelen | 0,06 | |
| ZGH2180C Duinbossen (binnenduinrand) | 0,05 | |
| ZGH2180A Duinbossen (droog), berken-eikenbos | 0,05 | |
| H2190C Vochtige duinvalleien (ontkalkt) | 0,05 | |
| H7210 Galigaanmoerassen | 0,05 | |

## Noordhollands Duinreservaat

| Habitattype | Hoogste bijdrage | Bijdrage op (bijna) overbelaste hexagonen* |
|---|---|---|
| H6410 Blauwgraslanden | 0,05 | |

## Duinen Schiermonnikoog

| Habitattype | Hoogste bijdrage | Bijdrage op (bijna) overbelaste hexagonen* |
|---|---|---|
| H2180B Duinbossen (vochtig) | 0,06 | |
| ZGH2180Abe Duinbossen (droog), berken-eikenbos | 0,06 | |
| ZGH2160 Duindoornstruwelen | 0,06 | |
| H2170 Kruipwilgstruwelen | 0,06 | |
| H9999:6 Habitattype onbekend/onzeker KDW op basis meest kritische relevante type (H2130B;H2130C). | 0,06 | |
| ZGH2130B Grijze duinen (kalkarm) | 0,06 | |
| H2190B Vochtige duinvalleien (kalkrijk) | 0,06 | |
| H2190C Vochtige duinvalleien (ontkalkt) | 0,06 | |
| ZGH2180B Duinbossen (vochtig) | 0,06 | |
| ZGH2120 Witte duinen | 0,05 | |
| H2190Aom Vochtige duinvalleien (open water), oligo- tot mesotrofe vormen | 0,05 | |
| H2130C Grijze duinen (heischraal) | 0,05 | |
| ZGH2190C Vochtige duinvalleien (ontkalkt) | 0,05 | |
| ZGH2170 Kruipwilgstruwelen | 0,05 | |
| H6410 Blauwgraslanden | 0,05 | |
| ZGH2180C Duinbossen (binnenduinrand) | 0,05 | |
| H1330A Schorren en zilte graslanden (buitendijks) | 0,05 | |
| ZGH2130A Grijze duinen (kalkrijk) | 0,04 | |
| ZGH2190B Vochtige duinvalleien (kalkrijk) | 0,04 | |

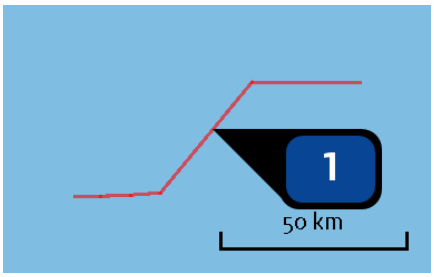
## Duinen Schiermonnikoog

| Habitattype | Hoogste bijdrage | Bijdrage op (bijna) overbelaste hexagonen* |
|---|---|---|
| H1310B Zilte pionierbegroeiingen (zeevetmuur) | 0,04 | 0,03 |

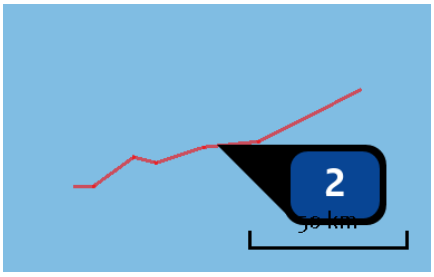
* Als de hoogste depositietoename plaatsvindt op een hexagoon waar géén sprake is van een (naderende) stikstofoverbelasting, dan is de hoogste toename op een hexagoon met wel een (naderende) stikstofoverbelasting in deze kolom weergegeven.

## Emissie (per bron)

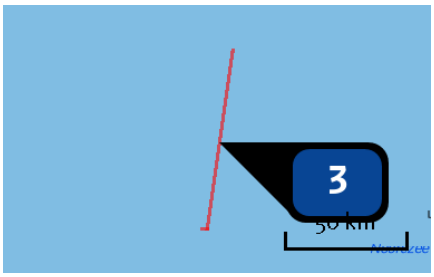
Aanlegfase NeuConnect Kabel Dutch EEZ



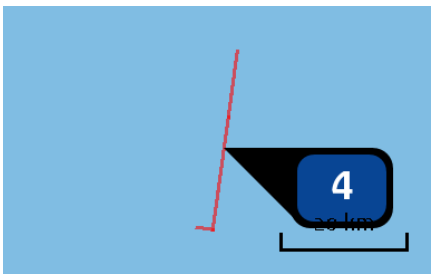

| | |
|---|---|
| Naam | Route A1 Hoofdactiviteiten 1t/m 3 en 5 t/m 10 |
| Locatie (X,Y) | 150370, 668214 |
| Uitstoothoogte | 24,0 m |
| Warmteinhoud | 0,950 MW |
| Temporele variatie | Transport |
| NOx | 37,50 ton/j |




| | |
|---|---|
| Naam | Route A2 Hoofdactiviteiten 1 t/m 3 en 5 t/m 10 |
| Locatie (X,Y) | 67405, 632788 |
| Uitstoothoogte | 24,0 m |
| Warmteinhoud | 0,950 MW |
| Temporele variatie | Transport |
| NOx | 41,25 ton/j |




| | |
|---|---|
| Naam | Route A3 Hoofdactiviteiten 1 t/m 3 en 5 t/m 10 |
| Locatie (X,Y) | 16005, 581873 |
| Uitstoothoogte | 24,0 m |
| Warmteinhoud | 0,950 MW |
| Temporele variatie | Transport |
| NOx | 31,66 ton/j |




| | |
|---|---|
| Naam | Route B Hoofdactiviteit 4 |
| Locatie (X,Y) | 12732, 559194 |
| Uitstoothoogte | 24,0 m |
| Warmteinhoud | 0,950 MW |
| Temporele variatie | Continue emissie |
| NOx | 51,74 ton/j |

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| | |
|---|---|
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| Database | versie 2020_20210209_2f032ce1a2 |

Voor meer informatie over de gebruikte methodiek en data zie:
https://www.aerius.nl/nl/factsheets/release/aerius-calculator-2020

# Bijlage 6d: Aerius berekening exploitatiefase NeuConnect

AERIUS CALCULATOR

*Dit document bevat rekenresultaten van AERIUS Calculator. Het betreft de hoogst berekende stikstofbijdragen per stikstofgevoelig Natura 2000-gebied, op basis van rekenpunten die overlappen met habitattypen en/of leefgebieden die aangewezen zijn in het kader van de Wet natuurbescherming, gekoppeld aan een aangewezen soort, of nog onbekend maar mogelijk wel relevant.*

*De berekening op basis van stikstofemissies gaat uit van de componenten ammoniak (NH3) en/of stikstofoxide (NOx).*

*Wilt u verder rekenen of gegevens wijzigen? Importeer de pdf dan in Calculator. Voor meer toelichting verwijzen wij u naar de website www.aerius.nl.*

Berekening O&M fase Neuconnect (2022)

- Kenmerken
- Samenvatting emissies
- Depositieresultaten
- Gedetailleerde emissiegegevens

Verdere toelichting over deze PDF kunt u vinden in een bijbehorende leeswijzer. Deze leeswijzer en overige documentatie is te raadplegen via: https://www.aerius.nl/handleidingen-en-leeswijzers.

# AERIUS CALCULATOR

## Contact

| Rechtspersoon | Inrichtingslocatie |
|---|---|
| Nick Voets | Esp, 5633AA Eindhoven |

## Activiteit

| Omschrijving | AERIUS kenmerk |
|---|---|
| NeuConnect exploitatiefase | RY44eCJ4h2Mj |

| Datum berekening | Rekenjaar | Rekenconfiguratie |
|---|---|---|
| 16 maart 2021, 14:34 | 2023 | Berekend voor natuurgebieden |

## Totale emissie

| | Situatie 1 |
|---|---|
| NOx | 2.932,90 kg/j |
| NH3 | - |

## Resultaten

Hectare met hoogste bijdrage (mol/ha/j)

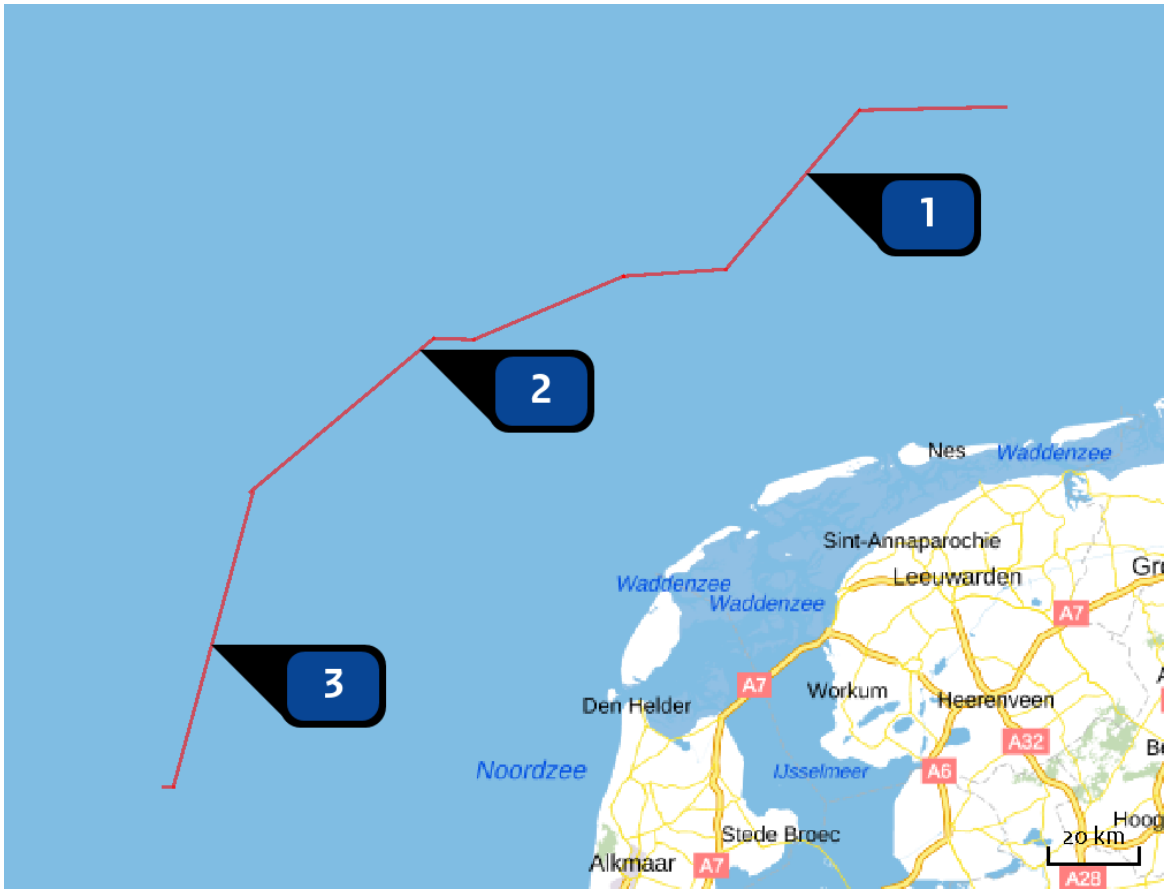
| Natuurgebied |
|---|
| Uw berekening heeft geen depositieresultaten opgeleverd boven 0,00 mol/ha/jr. |

## Toelichting

Exploitatiefase NeuConnect kabel

## Locatie

O&M fase
Neuconnect (2022)



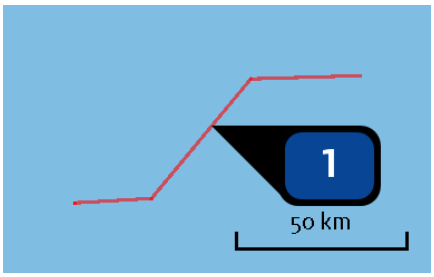

## Emissie

O&M fase
Neuconnect (2022)

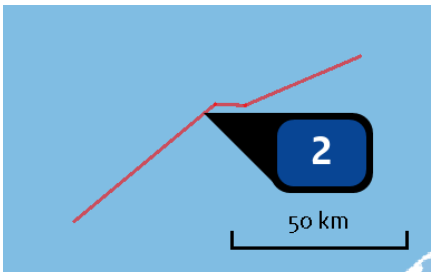
| Bron<br>Sector | | | Emissie NH3 | Emissie NOx |
|---|---|---|---|---|
| 1 | ••• | Route A1 bron 11&12<br>Anders... \| Anders... | - | 996,10 kg/j |
| 2 | ••• | Route A2 bron 11&12<br>Anders... \| Anders... | - | 1.095,70 kg/j |
| 3 | ••• | Route A3 bron 11&12<br>Anders... \| Anders... | - | 841,10 kg/j |

## Emissie (per bron)

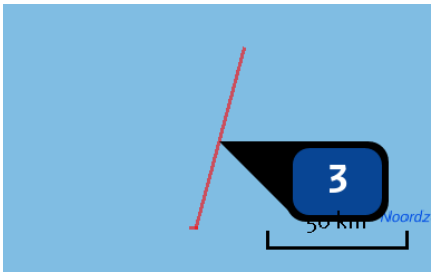
O&M fase Neuconnect (2022)




| | |
|---|---|
| Naam | Route A1 bron 11&12 |
| Locatie (X,Y) | 150265, 668315 |
| Uitstoothoogte | 24,0 m |
| Warmteinhoud | 0,350 MW |
| Temporele variatie | Transport |
| NOx | 996,10 kg/j |




| | |
|---|---|
| Naam | Route A2 bron 11&12 |
| Locatie (X,Y) | 65773, 629830 |
| Uitstoothoogte | 24,0 m |
| Warmteinhoud | 0,350 MW |
| Temporele variatie | Transport |
| NOx | 1.095,70 kg/j |




| | |
|---|---|
| Naam | Route A3 bron 11&12 |
| Locatie (X,Y) | 20290, 565451 |
| Uitstoothoogte | 24,0 m |
| Warmteinhoud | 0,350 MW |
| Temporele variatie | Transport |
| NOx | 841,10 kg/j |

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## Rekenbasis

Deze berekening is tot stand gekomen op basis van:

| | |
|---|---|
| AERIUS | versie 2020_20210209_2f032ce1a2 |
| Database | versie 2020_20210209_2f032ce1a2 |

Voor meer informatie over de gebruikte methodiek en data zie:
https://www.aerius.nl/nl/factsheets/release/aerius-calculator-2020

# Bijlage 7: Bureau Studie Maritieme Archeologie, Wessex Archeology, mei 2021

# NeuConnect – Dutch Offshore Scheme

Marine Archaeological Desk-Based Assessment

Ref: 201272.01
April 2021

wessexarchaeology

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| Document subtitle | Marine Archaeological Desk-Based Assessment |
| Document reference | 201272.01 |
| | |
| Client name | AECOM |
| Address | 1 Tanfield<br>Edinburgh<br>EH3 5DA |
| | |
| Site location | Dutch Territorial Waters |
| County | n/a |
| National grid reference | n/a |
| Statutory designations | |
| Planning authority | n/a |
| Planning reference | n/a |
| Museum name | n/a |
| Museum accession code | n/a |
| | |
| WA project name | Neuconnect Interconnector |
| WA project codes | 201270; 201272; 201273 |
| Project management by | Andrew Bicket |
| Document compiled by | Natalia Bain, Stephanie Said |
| Contributions from | Megan Metcalfe, Sophie Thorogood |
| Graphics by | Kitty Foster |

**Quality Assurance**

| Version & issue date | | Status | Author | Approved by |
|---|---|---|---|---|
| V1 | 17/03/21 | | NB, SS | AB |
| V2 | 23/04/2021 | RCE comments addressed; report is now being submitted as a desk research (*bureauonderzoek*) | MM, SS | AB |


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**Summary**

Wessex Archaeology was commissioned to prepare a marine archaeological baseline desk-based assessment including an Environmental Appraisal (EA) for part of the marine cable corridor of the NeuConnect Interconnector; a proposed 1400MW High Velocity Direct Current (HVDC) electricity interconnector cable extending both underwater and underground with on-shore converter stations linking into the existing electricity grids in Great Britain and Germany. The Project is being developed by an international consortium, NeuConnect Britain Limited.

The NeuConnect marine cable corridor will extend within Dutch Offshore Waters from the median line between UK and Dutch Offshore Waters in the west through the Dutch Exclusive Economic Zone (EEZ) to the median line between Dutch and German Offshore Waters to the east.

The desk-based assessment comprises:

- Relevant legislation and guidance;
- Methodology;
- An archaeological baseline study informed by an archaeological assessment of geophysical data, geotechnical samples and relevant documentary archives;
- A high-level Environmental Appraisal informed by the desk-based assessment, which includes an assessment of value and sensitivity of the assets identified within the assessed Study Area.

The archaeological resource within the Study Area are summarised as follows:

- A total of 191 features of palaeogeographic potential, including 29 palaeochannels and 25 further palaeogeographic features;
- Potential for discovery of sites and artefacts from the Palaeolithic to the Mesolithic periods across the marine cable corridor;
- A total of 120 individual anomalies of possible archaeological potential within the marine cable corridor, three of which are considered to be of high archaeological potential (A1). Of these, one was classified as a wreck, and the other two are likely associated items of debris. A 100 m Archaeological Exclusion Zone is to be placed around the extents of these features;
- Potential for the discovery of further shipwreck material from the late Mesolithic to the present;
- No known aircraft crash sites; however, there is the potential for the discovery of 20th century aircraft material, particularly from the Second World War.

**Acknowledgements**

This project was commissioned by AECOM, and Wessex Archaeology is grateful to David Ritchie and Natascha Schuttinga in this regard.

Wessex Archaeology would like to thank the Rijkswaterstaat Sea and Delta for supplying the terrestrial and marine sites and monuments data and the United Kingdom Hydrographic Office for supplying known wreck and obstruction data. Geophysical data was provided by MMT who are gratefully acknowledged.

The report was compiled by Natalia Bain and Stephanie Said, with contributions from Megan Metcalfe and Sophie Thorogood. The figures were prepared by Kitty Foster. Dr Andrew Bicket managed the project on behalf of Wessex Archaeology.

# NeuConnect – Dutch Offshore Scheme

## Marine Archaeological Desk-Based Assessment

## 1 INTRODUCTION

### 1.1 Project background

1.1.1 Wessex Archaeology was commissioned to prepare a marine archaeological baseline report including an Environmental Appraisal (EA) for part of the marine cable corridor of the NeuConnect Interconnector; a proposed 1400MW High Velocity Direct Current (HVDC) electricity interconnector cable extending both underwater and underground with on-shore converter stations linking into the existing electricity grids in Great Britain and Germany. The Project is being developed by an international consortium, NeuConnect Britain Limited.

1.1.2 This report comprises a marine archaeological baseline study of the Proposed Development, based on an archaeological assessment of geophysical and geotechnical data, gathered as part of the planning stage of the development, together with a review of records held by national and local inventories and secondary sources relating to the marine historic environment of the region.

1.1.3 The NeuConnect marine cable corridor will extend within Dutch Offshore Waters from the median line between UK and Dutch Offshore Waters in the west through the Dutch Exclusive Economic Zone (EEZ) to the median line between Dutch and German Offshore Waters to the east.

1.1.4 This Technical Report focuses on the element of the marine cable corridor within the Dutch EEZ, otherwise referred to as the NED Offshore Scheme. This report will refer to one section:

1. Dutch Offshore Waters: an approximate 265 km section of subsea DC cables in the Project Route Corridor between the UK/Netherlands median line and the Netherlands/Germany median line, estimated as KP 50 to KP 270.

### 1.2 Development proposal

1.2.1 NeuConnect is a 1400 megawatt (MW) interconnector between Great Britain (GB) and Germany, creating a connection for electricity to be passed in either direction. NeuConnect will be formed by a pair of subsea and underground High Voltage Direct Current (HVDC) cable system over a distance of approximately 720 km, with onshore converter stations linking into the existing electricity grids in Germany and GB.

1.2.2 The installation, operation (including maintenance and repair) and decommissioning phases of the project are described in terms of the likely component options. The following provides a summary of the development activities that likely to be undertaken, subject to a licence being awarded.

*Project Installation (Overview)*

1.2.3 The main installation phase activities are expected to comprise:

- **Pre-installation activities** including engineering surveys immediately prior to installation will be carried out to reconfirm existing geotechnical and geophysical information about seabed conditions, bathymetry and other seabed features. These may include swathe bathymetry; multi-beam echo sounder (MBES); side-scan sonar surveys etc. In additional visual inspection may also be made using a remote operate vehicle (ROV). Pre-installation activities may also include additional specialist studies, including geotechnical investigations, Unexploded Ordnance (UXO) studies etc. if considered necessary.

- **Route preparation** involving clearance activities to ensure the installation area is clear of boulders, dropped object debris, and other obstacles. This is likely to require a seabed plough to be towed across the surface. Any specialist clearance activities (e.g. UXO clearance) will also be carried out at this point.

  Pre-sweeping dredging may also be required through areas of sandwaves currently identified along the Project Route Corridor. A pre-lay grapnel run will also be completed involving towing a heavy grapnel with a series of specially designed hooks (grapnels) along the centre line of the route, to confirm the installation site is clear of obstructions.

  In certain places along the route, including locations where the Project crosses other cables and/or pipeline infrastructure, crossing agreements will be made with other parties owning these pipelines and cables. In these locations protection features potentially including rock placement, mattresses etc. may be required to be installed, prior to the cable installation.

- **Cable installation.** It is not yet confirmed what trenching techniques will be used to install the cables however it is anticipated that mechanical ploughing or cutting and/or water jetting will be used at different points along the Project Route Corridor, in response to the seabed sediment conditions. Installation of the cables into soft sediments will seek to achieve a target burial depth of at least 1.5 and 2 m and below the depth of mobile sediments depending on the nature of the seabed and potential hazards (e.g. anchorage areas and/or specific legislative requirements).

- **Cable Protection.** Rock placement may also be required in specific locations where the target burial depth cannot be achieved, to protect subsea cables by covering them in a continuous, profiled berm of graded rock. No rock placement will be installed within protected sensitive habitats.

*Operation and Maintenance (Overview)*

1.2.4 Normal operations will involve the transmission of up to 1400 MW of DC electricity between the two countries.

1.2.5 Once installed, the subsea cables are designed to require minimal maintenance during their operational lifetime. Maintenance activities may include inspection surveys to monitor cable burial, re-burial if sections become exposed through natural hydrodynamic process; maintenance and reinstatement of any protection features such as cable crossings etc.

1.2.6 In the unlikely event of a cable fault, cable repair is anticipated to involve gaining access to the cable(s) (removal of any protection structure and de-trenching); cutting out of damaged section and replacement with a new section of cable and return to the seabed for re-burial. Additional or replacement cable protection may also be required. The operations involved will be similar to those during construction but on a lesser scale.

1.2.7 For the purposes of this report, repair and maintenance has been collectively referred to as 'maintenance'.

*Decommissioning (Overview)*

1.2.8 Decommissioning details will be confirmed at the appropriate time in accordance with prevailing industry standards and regulatory requirement. At this stage it has been assumed that the cables will be recovered and removed to shore for recycling.

## 1.3 Previous impact

1.3.1 It is expected that there will be minor isolated impacts from dredging and fishing along the study area however these will mostly be superficial due to shifting sediments.

1.3.2 A number of pipelines and cable trenches are present within the study area (**Table 1**), based on the information provided by Primo Marine (MMT 2009a). These have been further discussed in **section 5.2.20** and shown in **Figures 8a-e.**

**Table 1** Pipelines and cables crossing the route

| NC_ID | Name | Owner | Status | Type |
|---|---|---|---|---|
| 035 | Zeepipe 1 | GASCO | Active | Pipeline |
| 036 | Franpipe | GASCO | Active | Pipeline |
| 037 | SEA-ME-WE3 seg 10.4 | Deutsche Telekom/BT | Inactive | Cable |
| 038 | BT North Sea | BT | Planned | Cable |
| 039 | BBL Balgzand-Bacton | BBL | Active | Pipeline |
| 040 | UK-Germany 3 | BT/German | Inactive | Cable |
| 041 | K13AP-Callantsoog | Wintershall | Active | Pipeline |
| 042 | UK-Germany 2 | BT/German | Inactive | Cable |
| 043 | UK-Denmark 3 | BT/Danish | Inactive | Cable |
| 044 | Bacton-Borkum No 1 | BT/German | Inactive | Cable |
| 045 | Bacton-Borkum No 2 | BT/German | Inactive | Cable |
| 046 | PL007 – K8-FA-1 to K14-FA-1P | NAM | Active | Pipeline |
| 047 | PL142 -D15-FA-1 to L 10-AC | Noordgastranspoort BV | Active | Pipeline |
| 048 | Fano-Oye No 1 | Great Northern Tel co. | Inactive | Cable |
| 049 | PL064 – K9c-A to L10-AR | Gaz de France(engie) | Active | Pipeline |
| 050 | PL047 – L4-B to L7-A | Total Fina Elf Netherland BV | Abandoned | Pipeline |
| 051 | PL048 | Total Fina Elf Netherland BV | Abandoned | Pipeline |
| 052 | UK-Denmark 3 | BT/Danish | Inactive | Cable |
| 053 | PL022 -L4A to L7-P | Total Fina Elf Netherland BV | Abandoned | Pipeline |
| 054 | PL021 – L4A to L7-P | Total Fina Elf Netherland BV | Abandoned | Pipeline |
| 055 | Bacton-Borkkum No 2 | BT/German | Inactive | Cable |
| 056 | UK-Germany 2 | BT/German | Inactive | Cable |
| 058 | PL091 – L2-FA-1 to Callantsoog | Noordgastranspoort BV | Active | Pipeline |
| 059 | Fano-Oye No 2 | Great Northern Tel Co | Inactive | Cable |
| 060 | Uk-Germany 2 Winterton-Borkum 1 | - | Inactive | Cable |
| 061 | SEA-ME-WE3 | Deutsche Telekom/BT | Inactive | Cable |
| 062 | UK-Germany 5 | BT/German | Inactive | Cable |

| NC_ID | Name | Owner | Status | Type |
|---|---|---|---|---|
| 063 | PL154 – G17d-A to NGT-Leiding | Noordgastranspoort BV | Active | Pipeline |
| 064 | Bacton-Norkum No 3 | BT/German | Inactive | Cable |
| 065 | Mundesley-Norderney | BT/German | Inactive | Cable |
| 066 | TGN North Europe Cable | euNetworks | Active | Cable |
| 067 | ODIN 1 seg 1 | TDC | Inactive | Cable |
| 068 | Atlantic Crossing 1 seg B2 | Century Link | Active | Cable |
| 069 | Fano-West Terschelling | Dutch | Inactive | Cable |

## 1.4 Scope of document

1.4.1 This assessment has been produced in order to determine, as far as is possible from existing information and bespoke survey data, the nature and extent of the known and potential marine archaeological resource within the Study Area and its environs.

1.4.2 This document has been prepared for the area of the extent of the marine cable corridor (500 m) that lies within the Dutch EEZ.

## 1.5 Aims

1.5.1 The specific aim of this marine assessment is to summarise the known and potential archaeological baseline within the study area.

1.5.2 The objectives of the assessment are as follows:

- to provide details of relevant legislation, national and local planning policy and best practice guidance for the Netherlands;
- to outline the known and potential marine archaeological resource based on a review of existing information within a defined study area;
- to assess the geophysical survey data comprising topographic and bathymetric data, side scan sonar data and magnetometer data in order to identify any material of archaeological and cultural heritage significance present within the study area;
- to review geotechnical logs to identify sediments of potential archaeological interest and assess alongside the sub-bottom (SBP) data;
- to compare the geophysical and geotechnical interpretation with desk-based assessments (DBA), historical data, known archaeological sites and previous investigations in the vicinity of the defined study area to outline the known and potential marine archaeological resource;
- to recommend mitigation measures for any potential archaeological or cultural heritage assets newly identified within the study area, including the addition of new Archaeological Exclusion Zones where necessary within the study area.

## 1.6 Copyright

1.6.1 This report may contain material that is non-Wessex Archaeology copyright (e.g. Ordnance Survey, BGS, Crown Copyright), or the intellectual property of third parties, which Wessex Archaeology are able to provide for limited reproduction under the terms of our own

copyright licences, but for which copyright itself is non-transferable by Wessex Archaeology. Users remain bound by the conditions of the Copyright, Designs and Patents Act 1988 with regard to multiple copying and electronic dissemination of the report.

# 2 LEGISLATION, GUIDANCE AND POLICY

## 2.1 Introduction

2.1.1 The marine cable corridor falls within several different jurisdictions, each covered by separate legislation and guidance, and is under the responsibility of different curators and heritage agencies.

2.1.2 A summary of legislation and guidance relevant to the marine archaeological environment within the Dutch jurisdiction is outlined below.

## 2.2 Marine legislation

2.2.1 The Cultural Heritage Agency (Rijksdienst voor het Cultureel Erfgoed), part of the Ministry of Education, Culture and Science (Ministerie van Onderwijs, Cultuur en Wetenschappen-MT-OCW) is responsible for the protected archaeological resource within the Netherlands, and act as advisors to Rijkswaterstaat (Directorate General for Public Works and Water Management) as the licensing body for marine development.

*Heritage Act 2016 (Erfgoedwet 2016; issued by the Ministry of Education, Culture and Science)*

2.2.2 The above legislation provides protection for cultural heritage assets, including wrecks, aircraft crash sites and submerged prehistory.

2.2.3 It also “prohibits without a certificate for that purpose, to carry out actions involving the detection, investigation, or acquisition of cultural heritage, or parts thereof, which results in disturbance of the soil or disruption or total or partial displacement or removal of an archaeological monument or of underwater cultural heritage” (Section 5.1). Certificates are issued on application to the Minister for Education, Culture and Science.

2.2.4 The *Heritage Act* is in accordance with the *Valletta Convention* of 1992 (European Convention for the Protection of the Archaeological Heritage (revised)), in which the preservation and improvement of archaeological heritage is designated as one of the objectives of spatial planning authorities.

2.2.5 The *Heritage Act* established the AMZ cycle (Archeologische Monumenten Zorg), which is a defined series of steps and decisions through which archaeological works, mitigation and research are structured within the Dutch planning system. The procedure is embedded in the Dutch Quality Standard for Archaeology (KNA Waterbodems 4.1) as the mandatory workflow for archaeologists. This marine archaeological desk-based assessment forms the first step within this process (bureauonderzoek).

## 2.3 International conventions

2.3.1 The UNESCO Convention on the Protection of Underwater Cultural Heritage was concluded in 2001 and is a comprehensive attempt to codify the law internationally, with regards to underwater cultural heritage. The Netherlands has not yet ratified the Convention, however it has adopted the Annex of the Convention, which governs the conduct of archaeological investigations, as best practice for archaeology. Although the Netherlands is not a signatory, the Convention entered into force on 2nd January 2009, having been signed or ratified by 20 member states. It has since been ratified or accepted by an additional 40 states.

## 2.4 Marine policy

2.4.1 The National Water Plan gives a policy framework for the Maritime Spatial Plan and as an appendix, includes the Policy Document for the North Sea 2016-2021. The Policy Document is revised every 6 years and includes the Maritime Spatial Plan and emulates the Dutch government's policy decisions for the North Sea. The Netherlands are currently preparing the Policy Document for the North Sea 2022-2027.

## 2.5 Dutch guidance

2.5.1 This assessment was carried out in a manner consistent with following national guidance:

- Stichting Infrastructuur Kwaliteitsborging Bodembeheer (SIKB) Protocol 4002 Bureauonderzoek (Desk Research) (Versie 4.1 2018).

2.5.2 The following best practice guidance were also consulted:

- Identifying and Protecting Palaeolithic Remains: Archaeological Guidance for Planning Authorities and Developers (English Heritage (now Historic England), 1998);
- Managing Lithic Scatters: Archaeological Guidance for Planning Authorities and Developers (English Heritage (now Historic England), 2000);
- Military Aircraft Crash Sites: Guidance on their Significance and Future Management (English Heritage (now Historic England), 2002);
- The Code of Practice for Seabed Developers (Joint Nautical Archaeology Policy Committee and The Crown Estate, 2006);
- Conservation Principles, Policies and Guidance for the Sustainable Management of the Historic Environment (English Heritage (now Historic England), 2008);
- Ships and Boats: Prehistory to Present: Designation Selection Guide (English Heritage (now Historic England), 2012);
- Herkennen van archaeologische vondsten uit waterbodems en hoe daar mee om te gaan (Recognition of archaeological finds from waterbeds and how to deal with them) (Caspers and Houkes, 2013);
- Marine Geophysics Data Acquisition, Processing and Interpretation Guidance Notes (Bates *et al.* 2013);
- Guidelines to the process of underwater archaeological research: SASMAP Guideline Manual 1 (Gregory and Manders, 2015a);
- Best practices for locating, surveying, assessing, monitoring, and preserving underwater archaeological sites: SASMAP Guideline Manual 2 (Gregory and Manders, 2015b);
- North Sea Prehistory Research and Management Framework (NSPRMF): Retuning the research and management agenda for prehistoric landscapes and archaeology in the Dutch sector of the continental shelf (Peeters *et al.* 2019).

# 3 METHODOLOGY

## 3.1 Study Area

*Extent*

3.1.1 For the purposes of this report, the Study Area is defined by the extent of the marine cable corridor which is approximately 500 m wide across the length concerned here. This is based on the geophysical data coverage, which is centred on the originally proposed cable route. The portion of the marine cable corridor assessed here lies within Dutch EEZ, approximately 265 km. The location of the marine cable corridor is illustrated in **Figure 1**.

*Search area*

3.1.2 A wider 2 km buffer area to either side of the marine cable corridor was used as the search area for obtaining records from relevant archive databases. The larger buffer allows for a greater understanding of the wider archaeological baseline environment, with the dual purpose of enabling any archaeological trends within the area to be recognised and to allow any assets within the marine cable corridor to be represented in a broader archaeological context.

## 3.2 Archaeological desk-based assessment

*Key themes*

3.2.1 The methodology follows the best practice professional guidance outlined by the Chartered Institute for Archaeologists' (CIfA) Standard and Guidance for Historic Environment Desk-Based Assessment (2014, updated 2017, updated 2020) and was conducted in accordance with the Dutch Quality Standard for Archaeology (KNA Waterbodems 4.1, Protocol 4002).

3.2.2 The marine themes relevant to marine archaeological baseline as assessed in this report are:

- Seabed prehistory (for example, palaeochannels and other features that contain prehistoric sediment, and derived Palaeolithic artefacts e.g. handaxes); and
- Seabed features, including maritime sites (such as shipwrecks and associated material including cargo, obstructions and fishermen's fasteners) and aviation sites (aircraft crash sites and associated debris).

3.2.3 The results of the study are summarised in Chapters 4 and 5. Based on this, the assessment concludes with potential impacts and recommendations for future research.

*Data sources*

3.2.4 A number of sources of primary and synthesised information were consulted in order to compile this assessment. Data generated from marine geophysical survey was also a main component of the data (**Section 3.3**).

3.2.5 The following data sources were consulted for this assessment:

- the United Kingdom Hydrographic Office (UKHO) data for charted wrecks and obstructions;
- the *Nationaal Contactnummer Nederland* (NCN) database maintained by Rijkswaterstaat Sea and Delta, comprising data for terrestrial and marine

archaeological sites, find spots and archaeological events from the following sources:

- 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 III database (official archaeological database of the Ministry of Cultural Heritage).

- Admiralty Charts; and
- relevant primary and secondary documentary sources and grey literature held by Wessex Archaeology, and those available through the Archaeology Data Service and other websites, both published and unpublished archaeological reports relating to excavations and observations in the area around the Study Area were reviewed.

3.2.6 For clarity, duplicate entries (i.e. heritage assets or archaeological events that had been listed in more than one dataset) have been removed, with only a single, grouped listing for each heritage asset remaining.

3.2.7 This report also refers to the results of an earlier DBA for an earlier routing version completed by Periplus Archeomare (2018) which looked at a larger study area with a buffer of 10 nautical miles (nm) around the cable route.

3.2.8 A bibliography of documentary sources consulted is presented in the References section of this report.

*Data structure*

3.2.9 This report is based on a Geographic Information System (GIS) using ArcGIS 10.6, incorporating the positional information of the various data sources listed in above, allowing the data to be spatially analysed. The data were subsequently compiled into gazetteers of the prehistoric, maritime and aviation resources within Dutch Waters located within the Study Area; these were used to inform the assessment of geophysical data.

3.2.10 Within this assessment, the gazetteers of datasets are compiled and illustrated in Universal Transverse Mercator (UTM) zone 31 North projected from a WGS84 datum.

*Chronology*

3.2.11 Archaeological material is generally studied within a framework of ‘periods’ or ‘ages’ that reflect the activities and cultural changes taking place over time. Due to the geographical and cultural differences across the international route of NeuConnect, the defined chronologies vary slightly for each neighbouring country. A list of the main archaeological periods referred to in the text, along with their broadly defined dates are presented in **Appendix 1** to facilitate local comparisons with terrestrial chronologies**.**

3.2.12 All dates are referred to as BC (before Christ), BP (before present) or AD (anno domini) within the text. BC refers to calibrated radiocarbon chronology that can be considered equivalent to calendar years. BP dates are used for periods of time older than c. 10,000 years ago.

*Seabed prehistory*

3.2.13 The baseline summary of Seabed Prehistory was based on a range of secondary sources, including academic papers, geological information (e.g. BGS mapping), previous work undertaken by Wessex Archaeology and Periplus Archaeomare (2018) and assessment of sub-bottom profiler data. The baseline for seabed prehistory is further discussed in the Marine Archaeological Assessment: Paleogeography below (**Section 4**, **Appendix 3**).

3.2.14 The Study Area crosses through the southern North Sea. The recent geological history of the southern North Sea is directly linked to glacial / interglacial cycles experienced by the area during the Pleistocene (2.5 million – 10 ka), which resulted in large areas of the southern North Sea being periodically exposed as a terrestrial environment. This is represented in the geological record, with distinct terrestrial landscape features being present, interspersed with deposits of marine and glacially derived sediments. Due to these fluctuations of glaciations, the corresponding rises and falls in eustatic sea level, and major reconfigurations of the landscape during the last million years, the archaeological record is phased between periods of occupation and long periods of hiatus (**Figure 2**). These changes in relative sea level are recorded as Marine Isotope Stages (MIS) (**Appendix 1**).

3.2.15 The southern North Sea is known to contain relatively well preserved palaeolandscape features such as fluvial palaeochannels, created during periods of sea level lowstand but while the landscape was still free of ice. The remains of this terrestrial landscape are frequently recovered by marine aggregates dredging and fishing in numerous areas around the southern North Sea, generally in the form of the remains of extinct megafauna (e.g. mammoths, bison, horse etc.). The presence of palaeolandscape features and peat deposits may indicate a former, now-submerged terrestrial landscape and, as such, the sediments and geomorphology associated with these palaeolandscape features are deemed to be of high archaeological potential as they could contain both *in situ* or derived anthropogenic artefacts and preserved palaeoenvironmental material from Holocene and Pleistocene early prehistoric archaeology.

3.2.16 The discovery of actual human artefacts, such as hand axes and worked bone, is a rarer occurrence, but substantial numbers of artefacts have been recovered from the southern North Sea and neighbouring coastlines. Reported finds from offshore activity have, to date, produced a range of early prehistoric lithic artefacts indicating early prehistoric activity in submerged palaeolandscapes from Lower, Middle, and Upper Palaeolithic periods (Tizzard *et al*. 2014; 2015; Wessex Archaeology 2011; 2013), with notable collections of more recent Mesolithic artefacts from submerged palaeolandscape contexts (Momber *et a*l. 2011; Wessex Archaeology 2013).

3.2.17 The geology of the area is thought to be predominantly Pleistocene deposits, namely the Eem, Brown Bank and Boxtel Formations (Periplus Archaeomare, 2018), overlain by Holocene deposits.

3.2.18 As a marine deposit, the archaeological potential of the Eem Formation is considered relatively low, although the unit may cover and protect earlier land surfaces. The potential of the Brown Bank Formation is interpreted to be higher, with the possibility of derived and *in situ* artefacts and intact organic material of palaeoenvironmental interest. The potential of the Boxtel Formation is also considered to be relatively high however it should be noted that, where the formation is not protected by overlying peat, the top of the feature may have been subjected to erosion and therefore it is possible that only derived artefact may be present (Periplus Archaeomare, 2018).

3.2.19 Pre-transgression Holocene deposits may also be of higher archaeological potential. These can comprise fluvial, estuarine and terrestrial (including peat) deposits. Areas of peat are expected to be present throughout the study area (Periplus Archaeomare, 2018), likely located beneath the modern marine Holocene deposits. Seabed features: maritime and aviation sites.

*Maritime and Aviation History*

3.2.20 Various sources of data for maritime and aviation history have been collated and summarised in order to develop a baseline of archaeological and cultural heritage for the Study Area, and the potential for encountering unknown shipwreck and aircraft crash site (**Section 5.4**).

3.2.21 The data obtained were reviewed and those within the Study Area were extracted and compiled to form a gazetteer as part of the known maritime and aviation baseline. These records were each given a unique identifier. The research for maritime and aviation history was then combined with the archaeological assessment of geophysical survey data (**Appendix 4**).

3.2.22 Records relating to Recorded Losses were also researched from the data sources. Recorded Losses are records for ships or aircraft that are known to have wrecked or crashed offshore, but for which the exact locations are not known. The positional data of these records is unreliable and serve only to provide an indication of the types of vessels that passed through the Study Area and the wrecking incidents that are known to have occurred in the general area. Whilst the remains of these vessels are expected to exist somewhere on the seafloor, their location is unknown. As such, they support a greater understanding of the potential maritime and aviation resource.

3.2.23 The baseline assessment of maritime and aviation archaeology was further supplemented by a review of relevant primary and secondary source material in order to provide an indication on the nature of maritime and aviation activity across the Study Area. As well as summarising the known archaeological resource, the baseline assessment underlines the potential for encountering unknown shipwreck and aircraft crash sites within the Study Area (Historic England, 2002; Wessex Archaeology, 2008b). A summary of key areas of maritime and aviation potential are presented in **Table 2** and **Table 3**.

**Table 2** Summary of key areas of maritime potential

| Period | Summary |
|---|---|
| Pre-1500 AD | Low potential for material associated with prehistoric maritime activities. Prehistoric maritime activities include coastal travel, fishing and the exploitation of other marine and coastal resources. Vessels of this period include rafts, hide covered watercraft and log boats. |
| | Low potential for material associated with later prehistoric maritime activities, including seaworthy watercraft suitable for overseas voyages to facilitate trade and the exploitation of deep water resources. Such remains are likely to comprise larger boat types, including those representing new technologies such as the Bronze Age sewn plank boats which are associated with a growing scale of seafaring activities. |
| | Low potential for material of Romano-British date, associated with the expansion and diversification of trade with the Continent. Watercraft of this period, where present, may be representative of a distinct shipbuilding tradition known as 'Romano-Celtic' shipbuilding, often considered to represent a fusion of Roman and northern European methods. |

| Period | Summary |
|---|---|
| | Low potential for material associated with coastal and seafaring activity in the 'Dark Ages', associated with the renewed expansion of trade routes and Germanic and Norse invasion and migration. Vessels of this period may be representative of new shipbuilding traditions such as the technique. |
| | Low potential for material associated with medieval maritime activity, including that associated with increasing trade between the UK and Europe, the development of established ports around the southern North Sea and the expansion of fishing fleets and the herring industry. Vessels of this period are representative of a shipbuilding industry which encompassed a wide range of vessel types (comprising both larger ships and vernacular boats). Such wrecks may also be representative of new technologies (e.g. the use of flush-laid strakes in construction), developments in propulsion, the development of reliable navigation techniques and the use of ordnance. |
| 1500 to 1815 | Medium potential for post-medieval shipwrecks representative of continuing technological advances in the construction, fitting and arming of ships, and in navigation, sailing and steering techniques. Vessels of this period continued to variously represent both the clinker techniques and construction utilising the flush-laid strakes technique. |
| | Medium potential for post-medieval shipwrecks associated with continuing local trade and marine exploitation including the transport of goods associated with the agricultural revolution. |
| 1816 to 1913 | Higher potential for the discovery of shipwrecks associated with the introduction of iron and later steel in shipbuilding techniques. Such vessels may also be representative of other fundamental changes associated with the industrial revolution, particularly with regards to propulsion and the emergence of steam propulsion and the increasing use of paddle and screw propelled vessels. |
| | Higher potential for the discovery of shipwrecks demonstrating a diverse array of vernacular boat types evolved for use in specific environments. |
| | Higher potential for wrecks associated with large scale worldwide trade, the fishing industry or coastal maritime activity including marine exploitation. |
| 1914 to 1945 | Higher potential for the discovery of shipwrecks associated with the two world wars including both naval vessels and merchant ships. Wrecks of this period may also be associated with the increased shipping responding to the demand to fulfil military requirements. A large number of vessels dating to this period were lost as a result of enemy action. |
| Post-1946 | Potential for wrecks associated with a wide range of maritime activities, including military, commerce, fishing and leisure. Although ships and boats of this period are more numerous, loses decline due to increased safety coupled with the absence of any major hostilities. Vessels dating to this period are predominantly lost as a result of any number of isolated or interrelated factors including human error, adverse weather conditions, collision with other vessels or navigational hazards or mechanical faults. |

**Table 3** Summary of key areas of aviation potential

| Period | Summary |
|---|---|
| Pre- 1939 | Minimum potential for material associated with the early development of aircraft. Aircraft of this period may represent early construction techniques (e.g. those constructed of canvas covered wooden frames) or may be associated with the mass-production of fixed wing aircraft in large numbers during WWI. |
| | Minimum potential for material associated with the development of civil aviation during the 1920s and 1930s, associated with the expansion of civilian flight from the UK to a number of European and worldwide destinations. |
| 1939 to 1945 | Very high potential for WWII aviation remains. Aircraft of this period are likely to be representative of technological innovations propelled by the necessities of war which extended the reliability and range of aircraft. |
| Post- 1945 | Potential for aviation remains associated with military activities dominated by the Cold War, the evolution of commercial travel and recreational flying and the intensification of offshore industry (including helicopter remains). Aircraft of this period may be representative of advances in aerospace engineering and the development of the jet engine |

## 3.3 Geophysical and geotechnical methodology

*Data sources*

3.3.1 A number of data sources were consulted during this assessment, including:

- Geophysical survey data sets acquired by MMT in 2019;
- Previous assessments of the survey area (Wessex Archaeology 2019) and Periplus Archeomare 2018);
- Geophysical survey and operations reports provided by MMT (MMT 2019a; 2019c);
- Geotechnical survey reports provided by MMT (MMT 2019b);
- Client-supplied information on known pipelines and cable crossings in the area;
- Relevant geological mapping from the area (British Geological Survey (BGS) 1984; 1986), admiralty charts received from MarineFind; and
- Recorded wreck and obstructions data acquired via the UKHO and BHS.

*Technical specifications*

3.3.2 The geophysical data were acquired by MMT between 23 March and 21 July 2018 (MMT 2019) onboard the *M/V Franklin*.

3.3.3 The data consisted of sub-bottom profiler (SBP) (surface towed Sparker), multibeam echosounder (MBES), sidescan sonar (SSS) and magnetometer (Mag.) data sets (MMT 2019c). The survey lines were run at 75 m line spacing and cross lines run every 5 km. A SSS range of 100 m per channel was used. Further details on equipment specifications are listed in **Table 4**.

**Table 4** Summary of planned survey equipment

| Survey Company | Survey Vessel | Data Type | Equipment | Data Format |
|---|---|---|---|---|
| MMT | *M/V Franklin* | SBP | GeoSpark 1000 (surface towed) | *.sgy* |
| | | MBES | Hull mounted Kongsberg EM 2040D (200, 300, 400 kHz) | *.xyz* |
| | | SSS | EdgeTech 2200 (300/600 kHz, 100 m range), mounted on a remotely operated towed vehicle (ROTV) | *.xtf* |
| | | Mag. | Geometrics G-882 | *.xls* |
| | | Positioning | Applanix POS MV 320 with C-Nav 3050 using C2 corrections | N/A |

*Co-ordinate system*

3.3.4 The survey data were acquired predominantly in WGS84 UTM31N, with a small amount of data acquired in WGS84 UTM32N where the Study Area overlaps with the German sector. Any features identified in the WGS84 UTM32N data sets have had their coordinates converted so all results are presented in WGS84 UTM31N.

*Data quality*

3.3.5 Once processed, the geophysical data sets were individually assessed for quality and their suitability for archaeological purposes and rated using the following criteria (**Table 5**).

**Table 5** Criteria for assigning data quality rating

| Data quality | Description |
|---|---|
| Good | Data which are clear and unaffected or only slightly affected by weather conditions, sea state, background noise or data artefacts. Seabed datasets are suitable for the interpretation of upstanding and partially buried wrecks, debris fields, and small individual anomalies. The structure of wrecks is clear, allowing assessments on wreck condition to be made. Subtle reflectors are clear within SBP data. These data provide the highest probability that anomalies of archaeological potential will be identified. |
| Average | Data which are moderately affected by weather conditions, sea state and noise. Seabed datasets are suitable for the identification of upstanding and partially buried wrecks, the larger elements of debris fields and dispersed sites, and larger individual anomalies. Dispersed and/or partially buried wrecks may be difficult to identify. Interpretation of continuous reflectors in SBP data is problematic. These data are not considered to be detrimentally affected to a significant degree. |
| Below Average | Data which are affected by weather conditions, sea state and noise to a significant degree. Seabed datasets are suitable for the identification of relatively intact, upstanding wrecks and large individual anomalies. Dispersed and/or partially buried wrecks, or small isolated anomalies may not be clearly resolved. Small palaeogeographic features, or internal structure may not be resolved in SBP data. |
| Variable | This category contains datasets where the individual lines range in quality. Confidence of interpretation is subsequently likely to vary within the Study Area. |

3.3.6 The quality of the SBP (sparker) data has been rated as ‘Variable’ using the above criteria. Generally, the data were of good quality; possible engine noise and occasional weather effects (e.g. cavitation) could be seen in some of lines. However, in general it was possible to identify and trace the different horizons and, as such, the data were considered suitable for archaeological assessment.

3.3.7 The MBES data quality has been rated as 'Variable' using the above criteria table. The data quality and resolution of 1 m was found to be of a good standard and suitable for archaeological assessment of objects and debris over 1 m in size. However, in some of the block the tidal reductions had resulted in 'stepping' being seen in the data, which may make it hard to identify small features of possible interest.

3.3.8 The SSS data have been rated as 'Average' using the above criteria table. During the initial data audit, it was found that the high-frequency (HF) data was not imaging the full range. As such, it was necessary to use the low-frequency (LF) SSS data rather than the higher resolution, HF data. Using the LF data may mean that some of the detail on larger features is lost compared to the HF data, and smaller features may be harder to detect. However, the LF data were deemed of good quality and larger features were identifiable within the data. There were some very small data gaps around the edges of the study area in Block 11; therefore, some small anomalies may not have been imaged in these areas.

3.3.9 The Mag. data have been rated as 'Average' using the above criteria table. Occasional interference and background variation was identified throughout the data files which may obscure smaller anomalies. There are also some occasional data gaps in the Mag. lines, although these are largely covered by the other data sets. The relatively wide (75 m) line spacing, and the towed height of the magnetometer above the seafloor (approximately 8 m (MMT 2019c), may mean that features with a lower ferrous content that are situated between survey lines or at the edges of the Study Area may not be identified in the Mag. data, or may appear as lower amplitude features. As such, it is possible for some ferrous debris that are either buried or without surface expression to be present within the study area that have not been identified during this assessment. However, larger ferrous features (such as steel wrecks) are still likely to be identifiable in the data even where not directly covered by a survey line.

3.3.10 Although these data set are considered suitable for identifying large and distinct features such as wrecks within the data, after discussion with the Dutch authorities (Rijksdienst voor het Cultureel Erfgoed and Rijkswaterstaat), it was concluded that, due to the fact smaller objects of potential archaeological interest may not be identified, the resolution of the geophysical data are not considered high enough for a detailed archaeological assessment. As such, the geophysical interpretation reported on here should be considered supplementary to the desk-based assessment rather than a full geophysical technical report as per Protocol 4103 (*Inventariserend Veldonderzoek (waterbodems*), version 4.1 2018).

*Processing*

3.3.11 A number of datasets were assessed over the study area, each dataset was processed separately using the following software (**Table 6**).

**Table 6** Software used for geophysical assessment

| Dataset | Processing Software | Interpretation and rationalisation |
|---|---|---|
| SBP | CodaOctopus Survey Engine v5.11 | ArcMap v10.6 |
| MBES | QPS Fledermaus v7.7.5 | |
| SSS | CodaOctopus Survey Engine v5.11 | |
| Mag. | Geometrics MagPick and proprietary software | |

3.3.12 The SBP and MBES data were used as the primary datasets for the palaeographic assessment and SSS, MBES and Mag. datasets were used for the seabed features assessment.

3.3.13 The SBP data were processed using CodaOctopus Survey Engine Seismic+ software. This software allows the data to be visualised with user selected filters and gain settings in order to optimise the appearance of the data for interpretation. The software then allows an interpretation to be applied to the data by identifying and selecting sedimentary boundaries and shallow geological features that might be of archaeological interest.

3.3.14 The SBP data were interpreted with a two-way travel time (TWTT) along the z-axis. In order to convert from TWTT to depth, the velocity of the seismic waves was estimated to be 1,600 ms-1. This is a standard estimate for shallow, unconsolidated sediments.

3.3.15 The SBP data can also be used to identify small reflectors, which may indicate buried material such as a wreck site covered by sediment. The position and dimensions of any such objects are noted in a gazetteer, and an image acquired of each anomaly for future reference. It should be noted that anomalies of this type are rare, as the sensors must pass directly over such an object in order to detect an anomaly.

3.3.16 For the SBP assessment, 25% of the lines were initially assessed. Where features of interest were identified, additional lines were then interpreted in order to more accurately map the extents of these features.

3.3.17 The MBES data were analysed to identify any unusual seabed structures that could be shipwrecks or other anthropogenic debris. The data were gridded at 1 m and analysed using QPS Fledermaus software, which enables a 3-D visualisation of the acquired data and geo-picking of seabed anomalies. The MBES data were also used in the palaeogeographic assessment.

3.3.18 The low frequency .jsf SSS data files were converted to .cod format and processed using CodaOctopus Survey Engine Sidescan+ software. This allowed the data to be replayed with various gain settings in order to optimise the quality of the images. The data were interpreted for any objects of possible anthropogenic origin. This involves creating a database of anomalies within Coda by tagging individual features of possible archaeological potential, recording their positions and dimensions, and acquiring an image of each anomaly for future reference. Due to the SSS range, the low frequency files were deemed more suitable and used for the interpretation, with high frequency files used to infill where necessary.

3.3.19 A mosaic of the SSS is produced during this process to assess the quality of the sonar towfish positioning. This process allows the position of anomalies to be checked between different survey lines and for the positioning to be further refined if necessary.

3.3.20 The form, size and/or extent of an anomaly is a guide to its potential to be an anthropogenic feature and therefore of archaeological interest. A single small but prominent anomaly may be part of a much more extensive feature that is largely buried. Similarly, a scatter of minor anomalies may be unrelated individual features, define the edges of a buried but intact feature, or may be all that remains as a result of past impacts from, for example, dredging or fishing. Assessment is made of such groups of anomalies during data interpretation to determine which of these alternatives is the most likely.

3.3.21 The Mag. data were processed and interpreted using Geometrics MagPick and proprietary software in order to identify any discrete magnetic contacts which could represent buried metallic debris or structures such as wrecks (**Figures 8a-e**).

3.3.22 The software enables both the visualisation of individual lines of data and gridding of data to produce a magnetic anomaly map. The data were first smoothed to try and eliminate any spiking. A trend was then fitted to the resulting data, and the trend values subtracted from the smoothed values. This was carried out to remove natural variations in the data (such as diurnal variation in magnetic field strength and changes in geology). The processed data were then gridded to produce a map of magnetic anomalies, and individual anomalies tagged based on the grid and individual profile lines. Images are taken in a similar process to that of the SSS data.

3.3.23 For the purposes of this assessment, any identified magnetic anomalies have been classified depending on their amplitude as small (5 nT to 49 nT), medium (50 nT to 99 nT), or large (>100 nT).

3.3.24 For the seabed features, anomalies are classified by interpreted type as per **Table 7**.

**Table 7** Types of anomaly identified

| Anomaly classification | Definition |
|---|---|
| Wreck | Areas of coherent structure including wrecks of ships, submarines and some aircraft (where coherent structure survives) |
| Debris field | A discrete area containing numerous individual debris items that are potentially anthropogenic, and can include dispersed wreck sites for which no coherent structure remains |
| Debris | Distinct objects on the seabed, generally exhibiting height or with evidence of structure, that are potentially anthropogenic in origin |
| Seabed disturbance | An area of disturbance without individual, distinct objects. Potentially indicates wreck debris or other anthropogenic features buried just below the seabed. |
| Rope/chain | Curvilinear dark reflectors, often with a small amount of height, indicating rope or chain (if ferrous). |
| Bright reflector | Individual objects or areas of low reflectivity, characteristic of materials that absorb acoustic energy, such as waterlogged wood or synthetic materials. Precise nature is uncertain |
| Dark reflector | Individual objects or areas of high reflectivity, displaying some anthropogenic characteristics. Precise nature is uncertain |
| Mound | A mounded feature with height not considered to be natural. Mounds may form over wreck sites or other debris. |
| Depression | An area of disturbed seabed with depth. Potentially indicates scour around a buried feature or where a feature has been cleared. |
| Buried object | A possible buried object identified in the SBP data as a parabola or other disturbance, thought to be caused by a buried anthropogenic feature. |
| Magnetic | No associated seabed surface expression, and have the potential to represent possible buried ferrous debris or buried wreck sites |
| Recorded Wreck | Position of a recorded wreck at which previous surveys have identified definite seabed anomalies, but for which no associated feature has been identified within the current geophysical data set. |
| Recorded obstruction | Position of a recorded obstruction (e.g. foul ground, fisherman's fastener recorded by the UKHO), but for which no associated feature has been identified within the current data set. |

*Anomaly grouping and discrimination*

3.3.25 The previous section describes the initial interpretation of all available geophysical datasets which were conducted independently of one another. This inevitably leads to the possibility of any one object being the cause of numerous anomalies in different datasets and apparently overstating the number of archaeological features in the exploration area.

3.3.26 To address this fact the anomalies were grouped together; allowing one ID number to be assigned to a single object for which there may be, for example, a UKHO record, a MBES anomaly, and multiple SSS anomalies.

3.3.27 Once all the geophysical anomalies and desk-based information have been grouped, a discrimination flag is added to the record in order to discriminate against those which are not thought to be of an archaeological concern. For anomalies located on the seabed, these flags are ascribed as follows (**Table 8**).

**Table 8** Criteria discriminating relevance of identified features to proposed scheme

| Overview classification | Discrimination | Criteria | Data type |
|---|---|---|---|
| Archaeological | P1 | Feature of probable archaeological interest, either because of its palaeogeography or likelihood for producing palaeoenvironmental material | SBP, MBES |
| Archaeological | P2 | Feature of possible archaeological interest | SBP, MBES |
| | | | |
| Archaeological | A1 | Anthropogenic origin of archaeological interest | MBES, SSS, Mag. |
| Archaeological | A2 | Uncertain origin of possible archaeological interest | MBES, SSS, Mag. |
| Archaeological | A3 | Historic record of possible archaeological interest with no corresponding geophysical anomaly | MBES, SSS, Mag. |
| | | | |
| Non-archaeological | U1 | Not of anthropogenic origin | MBES, SSS, Mag. |
| Non-archaeological | U2 | Known non-archaeological feature / Feature of non-archaeological interest | MBES, SSS, Mag., SBP |
| Non-archaeological | U3 | Recorded loss | MBES, SSS, Mag. |
| | | | |
| Non-impact | O1 | Outside horizontal footprint of study area | MBES, SSS, Mag., SBP |
| Non-impact | O2 | Outside vertical footprint of proposed impact | SBP |
| Non-impact | O3 | Area subsequently cleared after data acquired, anomaly/object recovered | MBES, SSS, Mag., SBP |

3.3.28 The grouping and discrimination of information at this stage is based on all available information and is not definitive. It allows for all features of potential archaeological interest to be highlighted, while retaining all the information produced during the course of the geophysical interpretation and desk-based assessment for further evaluation should more information become available.

3.3.29 Any anomalies located outside of the defined study areas, either previously recorded in known databases (e.g. UKHO) or identified during this geophysical assessment, are deemed beyond the scope of the current assessment and are subsequently not included in this report.

*Geoarchaeological framework*

3.3.30 Vibrocore logs were supplied by MMT along the length of the study area (MMT 2019b). Where a vibrocore correlated with a palaeogeographic feature of interest identified in the SBP data, the core log was looked at in order to confirm the sediments and help determine the origin of the feature. Associated core logs are noted in the palaeogeographic gazetteer (**Appendix 3**).

## 3.4 Assumptions and limitations

*Archaeological data*

3.4.1 Data used to compile this report consists of primary geophysical and geotechnical survey data and secondary information derived from a variety of sources, only some of which have been directly examined for the purposes of this assessment. The assumption is made that the secondary data, as well as that derived from other secondary sources, is reasonably accurate.

3.4.2 Vibrocore logs were assessed where corresponding with a feature of palaeoenvironmental interest were identified in the SBP data to groundtruth the interpretation of the geophysical dataset. A geoarchaeological assessment of the remaining isolated logs could be undertaken if it is necessary to refine the interpretation and the wider geological context at later stages of the project.

3.4.3 Is should be noted that there is a small section of the route where the cable has been re-routed approximately 300 m south as it enters the German EEZ. In this section the route partially extends outside of the geophysical data coverage and, as such, it is not possible to comment of the presence of archaeological features in the geophysical data within this area.

3.4.4 The records held by the UKHO, NCN and the other sources used in this assessment are not a record of all surviving cultural heritage assets, rather a record of the discovery of a wide range of archaeological and historical components of the marine historic environment. The information held within these datasets is not complete and does not preclude the subsequent discovery of further elements of the historic environment that are, at present, unknown. In particular, this relates to buried archaeological features.

# 4 MARINE ARCHAEOLOGICAL ASSESSMENT: PALAEOGEOGRAPHY

## 4.1 Geological baseline

4.1.1 The following is an overview of the geological and archaeological history of the wider region from the Pleistocene to the Holocene marine transgression.

4.1.2 The Study Area crosses through the southern North Sea. The recent geological history of the southern North Sea is directly linked to glacial / interglacial cycles experienced by the area during the Pleistocene (2.5 million – 10 ka), which resulted in large areas of the southern North Sea being periodically exposed as a terrestrial environment. This is represented in the geological record, with distinct terrestrial landscape features being present, interspersed with deposits of marine and glacially derived sediments. Due to these fluctuations of glaciations, the corresponding rises and falls in eustatic sea level, and major reconfigurations of the landscape during the last million years, the archaeological record is phased between periods of occupation and long periods of hiatus (**Figure 2**). These changes in relative sea level are recorded as Marine Isotope Stages (MIS).

4.1.3 The geology of the area is thought to be predominantly Pleistocene deposits, namely the Eem, Brown Bank and Boxtel Formations (Periplus Archaeomare, 2018), overlain by Holocene deposits. The oldest of these, the Eem Formation, was deposited during the Eemian interglacial period, and is thought to comprise a shallow marine / intertidal deposit of shelly and muddy sands. The Brown Bank Formation is generally thought to be a lagoon deposit of Lower Weichselian age (Cameron *et al*., 1992). However, based on previous geophysical and geotechnical assessments of areas of Brown bank Formation, it may have a much longer, more complex history, including changes of sediment input and potential periods of drying out/exposure (Wessex Archaeology, 2018a; 2018b). The Boxtel formation, thought to comprise aeolian sands and fluvial periglacial sands and is also Weichselian in age (Periplus Archaeomare, 2018).

4.1.4 The southern North Sea is known to contain relatively well preserved palaeolandscape features such as fluvial channels, created during periods of sea level lowstand but while the landscape was still free of ice. The remains of this terrestrial landscape are frequently recovered by dredging and fishing in numerous areas around the southern North Sea, generally in the form of the remains of extinct megafauna (e.g. mammoths, bison, horse etc.). The discovery of actual human artefacts, such as hand axes and worked bone, is a rarer occurrence, but artefacts have been recovered. Reported finds from offshore activity have, to date, produced a range of early prehistoric lithic artefacts indicating early prehistoric activity in submerged palaeolandscapes from Lower, Middle, and Upper Palaeolithic periods (Tizzard *et al.* 2014; Wessex Archaeology 2011; 2013), with notable collections of more recent Mesolithic artefacts from submerged palaeolandscape contexts (Momber *et a*l. 2011; Wessex Archaeology 2013b; Peeters and Amkreutz 2020).

*Pre-Elsterian (>478 ka; >MIS 12)*

4.1.5 Prior to the Elsterian glaciation, an extensive estuarine/deltaic landscape existed at the location of the current North Sea basin. This landscape, the Ur-Frisia delta (Cameron *et al*. 1992), drained many major European rivers, including the palaeo-Thames-Medway system, which drained northwards through Essex and East Anglia (Bridgland 1994), the Rhine (Hijma *et al*. 2012) and the 'Baltic River System' which deposited a large delta in the North Sea (Elhers *et al.* 2011).

4.1.6 At this time a chalk ridge along the axis of the Weald-Artois high, between southeast England and northern France, separated the North Sea and the English Channel into two

distinct basins. Any river systems northeast of the ridge flowed northwards across the North Sea basin to the Ur-Frisia delta, whilst those southwest of the ridge flowed along the English Channel towards the Atlantic.

4.1.7 In the UK, the earliest direct evidence for hominin activity has been identified at the Lower Palaeolithic sites of Happisburgh, on the Norfolk coast, and Pakefield, on the Suffolk coast, which date from c. 900,000 and 700,000 BP respectively (Parfitt *et al*. 2005; 2010). These sites would have been situated on the edge of an extensive landscape of low-lying estuaries, major river systems, plains and rolling hills. Whilst the archaeology at Pakefield was created during a more Mediterranean climate, around MIS 17 (**Figure 2**), the remains at Happisburgh Site 3 are indicative of colder-than-present conditions at the edge the boreal zone (Candy *et al*. 2011), indicating that earlier hominins were capable of surviving in conditions previously thought to be too harsh for habitation (Parfitt *et al*. 2010).

4.1.8 The importance of these sites is international, as they are currently unique at this latitude for this early date (Wessex Archaeology 2013). Cohen *et al*. (2012) have highlighted the North Sea basin as a key region for understanding Pleistocene hominins within a northerly, coastal environment.

*Elsterian to Eemian (c. 478 ka – 115 ka; MIS 12 – 5e)*

4.1.9 The Elsterian glacial period was the most extensive glaciation of the Pleistocene and saw ice sheets extending further south than at any time in the past 2.5 million years (**Figure 2**), although during the coldest phase of the Saalian major part of the Dutch Shelf and the northern part of the Netherlands was covered by an ice sheet (Periplus Archaeomare, 2018). The advancing ice sheets drastically remodelled the drainage systems. The historically south-east to north-west drainage system of the Rhine and Meuse were blocked by the ice advance and were forced to alter their courses to a proglacial lake in the southern North Sea. (Verpoorte *et al*. 2015). The lake was fed with melt water of the retreating glaciers and the Rhine which developed a northerly course via the Vecht Valley.

4.1.10 During deglaciation and retreat of the ice sheet at the end of the Elsterian, it is thought that the emptying of an ice-dammed lake within the North Sea may have created a volume of water large enough to breach the chalk ridge along the Weald-Artois high. This connected the North Sea to the English Channel, incising the Lobourg Channel off the Kent coast and some of the English Channel palaeovalleys in the process (Gupta *et al*., 2017; Hamblin *et al*., 1992). This initial catastrophic breaching of the Weald-Artois ridge is thought to have been followed by further erosive events leading to the permanent breaching of the English Channel approximately 150 kya (Hijma *et al.,* 2012). However, the precise timing and mechanism of breaching is still under debate. After the breaching of Weald-Artois ridge, the Lobourg Channel is likely to have formed the main drainage route of the major northern European rivers flowing into the dry North Sea Basin (Cameron et al., 1992).

4.1.11 During the periods of glaciation, vast tunnel valleys formed due to the transport of melt water beneath the ice sheets. It is possible that the edges of these valleys may have been attractive locations for hunting, as reindeer are thought to have used them as their migration routes. Evidence from later Ahrensburg sites suggest that where the reindeer were more confined by the narrow lengths of the valleys, they were relatively easier to hunt. (Periplus Archaeomare, 2018).

4.1.12 During the interglacial periods between the Elsterian and Weichselian glaciations (Holsteinian and Eemian), warmer climate conditions meant the area was more hospitable to hominin communities. The Middle Pleistocene is the time when there starts to be major archaeological evidence for the presence of humans in central Europe. This evidence post-

dates the Elsterian glaciation, however it is uncertain as to whether this is due to traces of earlier occupation being eroded by the glaciation or by actual human absence (Ehlers *et al*., 2011). The transition from the Saalian to Eemian resulted in a further inundation of the North Sea basin and a coherent transgressive infill of glacial basins. (Periplus Archaeomare, 2018).

4.1.13 The Netherlands is thought to be located at the northern limits of the Neanderthal range, with one of the earliest traces of occupation being a collection of flint tools found in the Belvédère quarry, thought to date to the intra-Saalian interglacial as well as the Early Weichselian (Verpoorte *et al*. 2015). It has been suggested that the flint finds may demonstrate the presence of children practising their flint knapping skills (Stapert 2007). Further evidence from the Early Middle Palaeolithic comes from the site of Kesselt - Op deSchans, where four clusters of lithic artifacts were discovered on an ancient land surface dated to MIS-9 / MIS-8 (Van Baelen *et al.* 2008), although it is thought that these artefacts may have been eroded out of their original context (Meijs *et al.* 2014). Well-preserved sites in stratigraphic context are extremely rare in the Netherlands and limited to the loess region of southern Limburg.

4.1.14 Other evidence of the Middle palaeolithic in the Netherlands comes from the 'Rhenen industry' artefacts, including collections characterised by Levallois production and scraper-dominated tool assemblages. These were identified in fluvial sediments dated to early MIS 6 and are thought to have been made, used and discarded ahead of the Late Saalian glaciation (Verpoorte *et al.* 2015).

4.1.15 The international importance of Early Middle Palaeolithic archaeology in the southern North Sea is highlighted by the numerous sites preserved around the south-east of the UK (White., 2006; Scott and Ashton, 2011) and, in particular, by the submerged prehistoric Levallois lithic assemblage from marine aggregates licence Area 240 in the palaeo-Yare catchment. Over 120 artefacts have now been recovered from this locale, some of which are identifiable as Levallois, with many recovered from *in situ* or near *in situ* contexts (Tizzard *et al*., 2014; Wessex Archaeology 2013).

4.1.16 The substantial, mixed assemblage of handaxes also recovered from Area 240 may be of older Lower Palaeolithic origin (e.g. >MIS 9, **Figure 2**), or may date to the Later Middle Palaeolithic when technologically similar artefacts were made (c. MIS 3, **Figure 2**) (Boismier *et al*., 2012). However, based on palaeoenvironmental and sedimentological evidence an Early Middle Palaeolithic date is most likely (Tizzard *et al.,* 2014).

4.1.17 Palaeogeographically, Area 240 is one of the most northerly Neanderthal sites in northwest Europe and of primary archaeological importance for defining Middle Palaeolithic potential and the contemporary palaeogeography across the southern North Sea basin (Tizzard *et a*l., 2014). The site highlights the archaeological potential of preserved Pleistocene fluvial deposits within the southern North Sea.

4.1.18 During the Eemian interglacial (MIS 5e) which saw warm and humid climatic conditions in Europe, the archaeological record in the Netherlands is unknown, with no sites or artefacts dated to the Eemian (Verpoorte *et al*. 2017).

*Weichselian to Late Glacial Maximum (c. 115 ka – 18 ka; MIS 5d – 2)*

4.1.19 Deterioration of the climate during the Late Pleistocene resulted in the most recent glaciation of the North Sea during the Weichselian period. During the Weichselian, the British ice sheet is thought to have reached into the Dutch sector of the North Sea (Laban and Jaap 2011), although it is not thought to have extended as far as into the Study Area.

During this period, the prograding Rhine and Meuse delta entered a lower deltaic flood basin referred to as the Brown Bank delta plain, which extended into the south-west section of the Study Area (Periplus Archaeomare, 2018).

4.1.20 Within the context of early prehistory and submerged palaeogeography, substantial areas of the southern North Sea basin would have been dry land during the warming and cooling limbs of the various sub-stages (MIS 5a to 5e, **Figure 2**). Therefore, the potential exists for human activity to have occurred in the area of exposed terrestrial environment within the southern North Sea basin, during and after the Weichselian glaciation.

4.1.21 The North Sea was characterised by an open subarctic landscape during the cold periods of the Early Weichselien. This changed during the relative warm Brørup interstadial 100,000 years ago and Odderade interstadial 80,000 years ago, when the area became characterised by forested landscape with meandering rivers and bogs (Periplus Archaeomare, 2018). Locally, in low lying areas, wet conditions resulted in the development of peat. However, the colder periods at the end of the Weichselian major, much of the North Sea would have been a polar desert. During this period, aeolian sands, part of the Boxtel Formation, were being eroded from the North Sea landscape and deposited over vast areas of the Netherlands (Periplus Archaeomare, 2018).

4.1.22 Climatically, MIS 3 was significantly colder than now but did not attain the glacial conditions of later or earlier glacial periods (e.g. MIS 6 or 2, **Figure 2**) (Pettitt and White 2012). It is likely that humans hunted for large mammals throughout glacial periods, even under very cold conditions (Periplus Archaeomare, 2018). For the Neanderthals that may have occupied the region at this time, surviving during this period may have been subject to a variety of technological and cultural adaptations (White 2006).

4.1.23 During the Late Glacial Maximum, sea level dropped drastically, up to 120 meters, and a major part of the North Sea area became a terrestrial environment. During this period, it's thought that the glacial landscape was occupied by Late Palaeolithic and Early Mesolithic hunters-gatherers. (Periplus Archaeomare, 2018). A skull fragment, thought to have belonged to a young adult male Neanderthal was discovered in Middle Weichselian sediments extracted from the so-called Zeeland Ridges area, a complex of south-west to north-east oriented sandy ridges situated parallel to the Dutch coast, which have become known as a Palaeolithic 'treasure trove' (Verpoorte *et al*. 2017; Peeters and Amkreutz 2020). A number of finds have been found in the waste heaps from the dredging of these ridges which consist of sediment, which is often re-worked, dating to the Early Pleistocene, Eemian, Weichselian and Holocene (Peeters and Amkreutz 2020).

4.1.24 Closer inshore, a number of Middle Palaeolithic flint implements, including two hand-axes and several Levallois flakes have been dredged from the Middeldiep area. A recent geological study allowed the correlation of the offshore stratigraphic units in the Middeldiep area with onshore deposits dated between 50,000 and 30,000 BP, which would data these tools and the skull fragment to the Middle Palaeolithic (Peeters and Amkreutz 2020). These finds highlight the importance of potential of the Pleistocene and Holocene archaeological archive in the Southern North Sea.

*Post-Late Glacial Maximum and early Holocene (18,000 – 6000 BP; MIS 2 – 1)*

4.1.25 Following the Weichselian glacial maximum, ice sheet retreat once again left significant areas of the southern North Sea exposed as a terrestrial environment. In the Early Upper Palaeolithic, at the end of the Late Pleistocene, there was a transition period for hominins. Neanderthals died out around 40,000 BP, and modern humans then colonised Doggerland. Archaeological evidence for this period is relatively sparse, but submerged

palaeolandscapes provide key contextual evidence for recovered artefacts and provides a background landscape within which to place these human communities.

4.1.26 During the Last Glacial Maximum, the environment within the southern North Sea was relatively poor for human colonisation, and was situated at the north-western extents of possible habitation. However, there was increasing human exploitation after 15,000 BP. Humans at this time were hunting game, such as mammoth and deer, and evidence of these animals has been reported through marine aggregate dredging within the southern North Sea, and the associated reporting requirements (Bicket and Tizzard, 2015).

4.1.27 The onshore archaeological record of Upper Palaeolithic activity is relatively sparse, and offshore locations may provide unique and important context for coastal and lowland human activity during this period (Wessex Archaeology 2013). For example, a Maglemosian harpoon artefact from trawled peat in the early 20th century was subsequently radiocarbon dated to around 12,000 years ago (Housely 1991), and archaeological and palaeoenvironmental material has been reported from North Sea contexts for over a century (Reid, 1913; Godwin and Godwin, 1933).

4.1.28 The Mesolithic period began in the early Holocene. Around 10,000 BP, sea levels were still more than 60 m below current levels, and during this period, an extremely large area of the southern North Sea and English Channel was dry land, suitable for human occupation. In the UK, evidence of this environment has been identified from the foreshore at Jaywick, Essex, where layers of peat dating from the Early Holocene are present along with a preserved land surface from which Mesolithic artefacts have been recovered (Wilkinson and Murphy, 1995).

4.1.29 Considerable attention has been paid to Mesolithic Doggerland in the last decade (Gaffney *et al*. 2007; Tappin *et al*., 2011) and the geoarchaeology (Boomer *et al*. 2007), submerged forests (Hazell 2008), and palaeo-river systems around the current North Sea coast of the UK (Wessex Archaeology 2013; Limpenny *et a*l. 2011; EMU 2009). Increasingly, a maritime perspective has developed for understanding the early prehistoric archaeological record, where coasts, estuaries and wetlands are key landscape elements (Ransley *et al*. 2013).

4.1.30 It is clear from numerous research and development-led investigations that postglacial marine transgression has not destroyed Pleistocene and Holocene palaeogeography by default (Wessex Archaeology, 2013). Areas of preserved palaeogeographic features do remain, and detailed reconstructions of palaeoenvironments and palaeogeography can be achieved for large parts of the North Sea basin (Tappin *et al*., 2011; Limpenny 2011; Dix and Sturt 2011). By the early Holocene, Mesolithic hunter-fisher-gatherers in Doggerland were active in a familiar ecosystem of mixed deciduous woodland with oak, elm, alder and lime populated by deer and a wide variety of other mammals (Tappin *et al*., 2011).

4.1.31 Since the last ice age, the sedimentation rates along the southern North Sea coast have been enormous (Karle and Goldhammer 2017). Before the Middle Ages large parts of the western and northern Netherlands were covered with an extensive peat bed that, in many places has been drowned or almost completely disappeared. Although Intertidal flat environments would have been unfit for habitation due to tides, dwelling mounds on highly silted-up salt marshes would have made certain areas of these marsh lands a desirable place to live due to the high biological productivity of the area. Geoarchaeological evidence suggests that salt marshes were inhabited only if the cover of salt-marsh clay had reached a minimum thickness of about 80 cm (Vos & Knol, 2015).

4.1.32 The presence of fluvial features and peat deposits may indicate a former terrestrial landscape and, as such, the sediments associated with these features are deemed to be of high archaeological potential as they could contain both *in situ* or derived anthropogenic artefacts and preserved palaeoenvironmental material.

4.1.33 Adjacent to the Flevoland area of the Netherlands, palaeogeographic modelling of in-filled channels has aided in the interpretation of the Mesolithic-Neolithic landscape. Evidence from the back-barrier, intertidal and coastal peats show how archaeological material can survive beneath land that is now covered by subsequent deposits, and in some cases, by the sea. One such submerged example was found at the mouth of an estuary, which lead to the discovery of the Yangzte Harbour Mesolithic site in Rotterdam Harbour. (Momber & Peeters, 2017).

4.1.34 Available sea level curves indicate that the Pleistocene landscape drowned between 8000 and 7000 BC (Periplus Archaeomare, 2018). Much of the land was inundated by eustatically driven sea level change (Bicket and Tizzard 2015), and by 6,000 BP sea level was only approximately 7 m below the present level (Cameron *et a*l. 1992). Settlements at the time were often transitory and seasonal, and therefore leave little trace in the archaeological record, however, new types of stone tools were introduced during this period. It is possible that the now submerged environment of which the Study Area was was occupied up until the final marine transgression.

4.1.35 It should be noted that a number of Neolithic finds have been found offshore in the Netherlands within the Brown bank area, including several Neolithic axe blades. During this period, sea level is thought to have been at roughly its present level and, as such, the topographic highs of the Dogger Bank and the Brown Bank are thought to have been fully submerged, although the highest parts of the Brown Bank may have been exposed as shallow islands or banks at low tide. It is therefore possible that the Neolithic finds represent a ritual deposition or lost cargo (Peeters and Amkreutz 2020).

4.1.36 Post the Holocene marine transgression, the archaeological potential of the southern North Sea, including the Study Area, shifts to the maritime history, which is presented in **Appendix 4** and summarised in **Section 4.2**.

## 4.2 Geophysical and geotechnical palaeogeographic assessment

4.2.1 A number of palaeogeographic features of archaeological potential have been identified within the Study Area. These features are discussed below, individually described in gazetteer format in **Appendix 3**, and their distribution is illustrated in **Figures 3a-h** with examples shown in **Figures 4** and **5**.

4.2.2 The identified geology within the Study Area has been divided into 8 Units, as described below (**Table 9**):

**Table 9** Shallow stratigraphy of the Study Area

| Unit | Unit Name | Geophysical Characteristics (1) | Sediment Type (2) | Archaeological Potential |
|---|---|---|---|---|
| 8 | Holocene Seabed Sediments (post-transgression) (Marine Isotope Stage (MIS) 1) | Generally observed as a veneer in the east, thickening towards the west. Boundary between surficial sediments and underlying units not always discernible. | Gravelly sand with shell fragments, sand waves and ripples indicate sediment is mobile. | Considered of low potential in itself, but possibly contains re-worked artefacts and can cover wreck sites and other cultural heritage. |
| 7 | Holocene Sediments (Pre-transgression) (MIS 2 to 1) | Small shallow infilled channels with either seismically transparent fill, or fill characterised by sub-parallel internal reflectors. Also comprises a basal high amplitude reflector peat layer. | Fluvial, estuarine and terrestrial (including peat) deposits | Potential to contain *in situ* and derived archaeological material, and palaeoenvironmental material. |
| 6 | Boxtel Formation (Upper Weichselian) (MIS 3 to 2) | Complex units which can comprise acoustically unstructured units, occasional possible cross bedding, high amplitude reflectors and some possible channelling of infilled depressions at its base. | Fluvioglacial or aeolian periglacial sand, fluvio-periglacial, floodbasin and bog deposits. | Potential to contain *in situ* and derived archaeological and palaeoenvironmental material, and to protect underlying surfaces. |
| 5 | Brown Bank Formation (Late Eemian to Lower Weichselian) (MIS 5d to 3) | Observed as a blanket deposit across much of the area, either acoustically transparent or characterised by sub-horizontal layered reflectors. | Clayey silty sand infilling channels or hollows and deposited in an intertidal / lagoon environment. | *In situ* Palaeolithic artefacts may be protected, particularly where protected by overlying peat. Middle Palaeolithic *in situ* and derived artefacts may be associated particularly with channel edges dependent on the age of the fill. Palaeoenvironmental information. Basal contact may cover old land surfaces. |

| Unit | Unit Name | Geophysical Characteristics (1) | Sediment Type (2) | Archaeological Potential |
|---|---|---|---|---|
| 4 | Lower Brown Bank / Eem Formation (Eemian or Lower Weichselian) (MIS 5e to 5d) | Broad, blanket deposit. Generally characterised by low relief basal and either an acoustically transparent or well-layered fill. | Silty sand and sandy silt, possible intertidal or shallow marine deposits. | *In situ* Lower Palaeolithic artefacts may be protected. Middle Palaeolithic *in situ* and derived artefacts may be associated particularly with channel edges dependent on the age of the fill. Palaeoenvironmental information. Basal contact may cover old land surfaces. |
| 3 | Cleaver Bank/ Drente Formation<br><br>(Saalian 6-10 MS) | Not definitively identified within the geophysical data however may be characterised by thick unit either seismically unstructured or containing numerous areas of channel complexes characterised by layered sub-parallel internal reflectors. Top of unit generally a well-defined regional erosion surface. | Proglacial and Glacimarine Silty clays with silt and sand lamiae | Low likelihood of *In situ* artefacts however the basal contact may cover old land surfaces of archaeological and palaeoenvironmental interest. |
| 2 | Peelo Formation (Elsterian) (MIS 12) | Not definitively identified within the geophysical data | Sub-glacial channel fill, comprising a basal reworked till with upper glaciolacustrine / glaciomarine sediment. | Unlikely to contain archaeological material. |
| 1 | Yarmouth Roads Formation (Lower to Middle Pleistocene) (MIS 62 to 13) | Not definitively identified within the geophysical data however may be characterised by thick unit either seismically unstructured or containing numerous areas of channel complexes characterised by layered sub-parallel internal reflectors. Top of unit generally a well-defined regional erosion surface. | Silty sand with occasional shell fragments with occasional layers of clay. Generally becoming silty with depth. Sediments deposited as part of delta complex. | Possibility of *in situ* finds in later part of formation if not eroded. Contemporaneous with terrestrial Cromer Forest Bed Formation (Pakefield and Happisburgh). Has been found to contain plant debris, wood and peat in some areas of possible palaeoenvironmental importance. Potential greatest where associated with river valleys. |

| Unit | Unit Name | Geophysical Characteristics (1) | Sediment Type (2) | Archaeological Potential |
|---|---|---|---|---|
| (1) Based on geophysical data<br>(2) Based on borehole data and Cameron *et al.,* (1992), Perplus Archeomare (2018) and Vibrocore logs (MMT 2019b) | | | | |

4.2.3 Throughout the majority of the Study Area, a broad, blanket deposit of a relatively acoustically unstructured unit, with very few internal reflectors, has been identified. Locally, some large, slightly complex channelling observed, characterised by faint, sub-parallel internal reflectors. The geological formation of this unit is uncertain; based on its seismic similarities in relation to other sites in the southern North Sea, it is possible that this unit represents the Yarmouth Roads formation (Unit 1). The Yarmouth Roads formation is thought to be an extensive delta top deposit covering a large section of the southern North Sea, deposited during the Cromerian prior to the Elsterian Glaciation (Cameron *et al.* 1992). The upper layers of the Yarmouth Roads formation are interpreted as being contemporaneous with the Cromer Forest Bed Formation of East Anglia, within which the Lower Palaeolithic sites at Happisburgh and Pakefield have been discovered (Parfitt et al., 2010; Parfitt *et al.*, 2005). As such, there is the potential for both *in situ* and reworked archaeological and palaeoenvironmental material to be present within Unit 2.

4.2.4 However, it is also possible that this unit represents Unit 3, which is interpreted as a partly marine, proglacial diamicton of eastern provenance (Cameron *et al*. 1992). Sediments are expected to comprise of stratified laminae of clay, silt and fine sand, with the laminated sequence marking the evolution from shallow freshwater lakes into brackish lagoons into an open marine environment (Periplus Archaeomare, 2018). Based on its depositional environment, it is considered of low archaeological potential.

4.2.5 Unit 2 is reported as filling tunnel valleys up to 400 m deep, which were incised by melt water transport underneath the ice sheets during the Elsterian, and has not been definitively identified within the study area. It is possibly present directly below Unit 4, infilling channel features **79138**, **79139** and **79183**. However, these channel features are identified cutting into the top of broad blanket deposit interpreted as either Unit 1 or Unit 3. If these features are cutting into Unit 3, then stratigraphically it would not be possible for their fill to comprise Unit 2.

4.2.6 In the SBP data, these channel features appear to be relatively small in relation to Unit 2 channels identified in other sites in the southern North Sea, and therefore they cannot be definitively correlated to Unit 2. It is possible that channels **79138**, **79139** and **79183** may instead represent internal channelling within Unit 1, or possible pre-Eemian fluvial channelling. Due to the uncertainty in the age of these features, they have been mapped and retained as of potential interest, but discriminated as P2 features of lower potential.

4.2.7 Unit 4 and Unit 5 are thought to represent different members of the same formation, with Unit 4 representing the Eem or Lower Brown Bank formation, which is described as a shallow marine / intertidal deposit of shelly and muddy sands (Cameron *et al.* 1992), and Unit 5 which is the Brown Bank formation which is thought to be a lagoon deposit of Lower Weichselian Age (Cameron *et al.,* 1992). Although, evidence from other sites within the UK have suggested that Unit 5 may have a much more complex history, including changes of sediment input and potential periods of drying out/exposure (Wessex Archaeology, 2018a; 2018b).

4.2.8 The archaeological potential of these features depends on their age. As a marine deposit, the archaeological potential of Unit 4 is considered relatively low, with the exception of areas where overlying peat are present, (Periplus Archaeomare, 2018). It is also possible that the unit may cover and protect earlier land surfaces. The potential of Unit 5 is interpreted to be higher, with the possibility of derived artefacts and intact organic material of palaeoenvironmental interest. In areas where peat is seen to be overlying Unit 5, there is the possibility of finding Palaeolithic or possibly later Mesolithic artefacts where deposited on the surface (Periplus Archaeomare, 2018).

4.2.9 Unit 4 is expected throughout the Study Area, whereas Unit 5 is only expected to the south-west, and possibly in sporadic areas throughout the rest of the Study Area. Above Unit 4 and Unit 5, a significant number of high-amplitude reflectors have been identified which are interpreted as being peat deposits (**Appendix 3**, **Figures 3a-h, 4** and **5**). Towards the south-west of the Study Area, these are generally seen below a relatively thick overlying unit of marine sands (Unit 8), and were therefore below the sample depth of the vibrocores. However, moving towards the east where the overlying Unit 8 thins, it was possible for a number of these features to be sampled and confirmed to correlate with peat in the vibrocore logs, for example high amplitude reflectors **79072** and **79089.** It is possible that this peat represents the Woudenberg formation (Periplus Archaeomare, 2018), although further analysis would be needed to confirm this.

4.2.10 These high amplitude reflectors are seen intermittently throughout the Study Area and may suggest preservation of an extensive terrestrial landscape. The age of these peat deposits is uncertain. It is possible that the peat indicates periods of drying of the Brown Bank lagoon, which lasted long enough for land surfaces to form making them late Eemian or early Weichselian in age; however, they may be late Pleistocene peats of the Woudenberg formation (Periplus Archaeomare, 2018), or possibly pre-transgression deposits (Unit 7). Further analysis and dating of the sediments would be needed in order to confirm the age of these features. However, as these features could contain in situ archaeological artefacts and preserved organic material, they are considered of high archaeological and palaeoenvironmental potential.

4.2.11 Throughout the Study Area, some slightly higher amplitude reflectors can be seen. These are less distinct and appear lower amplitude in comparison to the high amplitude reflectors mentioned above, but are still relatively defined and otherwise similar in form. Based on their similarities with the high-amplitude reflectors, it is possible that they represent the same former terrestrial landscape but with a lower peat content; however, this is not certain. Where the features appear less distinct in the SBP data or have been found by vibrocores to not contain peat, they have been retained as a precaution but discriminated as P2 based on the uncertainty around their formation (Appendix 3). Distinct, high amplitude reflectors were also identified at the base of the interpreted Unit 4 (**79063-4, 79071, 79080, 79084, 79140, 79150-1, 79162** and **79190**). These were often seen to be irregular and undulating, occasionally over extensive areas. It is noted by the Geological Survey of the Netherlands on their website providing data and information on the Dutch Subsurface (DINOloket) that the lower boundary of the Eem formation has localised areas of *Gyttja* at its base. It is therefore possible that these high amplitude reflectors represent that although, as the Eem formation was deposited in a maritime setting, the sediments associated with it are unlikely to be of archaeological interest. As this cannot be confirmed without further investigation, they have been retained as a precaution and discriminated as P2 features.

4.2.12 A number of channel features were identified cutting into the surface of Units 4 and 5 (**79006, 79014, 79028, 79048, 79049, 79056, 79082, 79104-5, 79109, 79111, 79113-4**). These were generally seen to have distinct basal reflectors and fill characterised by

numerous sub-horizontal reflectors. A number of these features were sampled by vibrocores (**79006, 79104-5, 79113, 79124**) and were generally found to comprise low-strength clay, often with laminations of silt or sand. A number of these channel features were also found to contain peat. The exact age of these features is uncertain. It may be that they represent Weichselian channels (Unit 5 or 6) or Holocene pre-transgression channelling (Unit 7).

4.2.13 These features represent former terrestrial landscapes and, as such, the sediments associated with these features are deemed to be of high archaeological potential. This is due to the fact they could contain *in situ* or derived anthropogenic artefacts and preserved palaeoenvironmental material.

4.2.14 Unit 6 is identified in large areas from the centre to the east of the Study Area. Unit 6 is thought to comprise several different members including the Weirden member (aeolian sands) and the Singraven Member (fluvioperiglacial sand and loam with subordinate peat and gyettja) (Periplus Archaeomare, 2018; DINOloket), related to their different depositional environments. This is reflected in the SBP data, with the acoustic characteristics of the unit ranging from acoustically quiet to acoustically chaotic, with some areas displaying distinct, horizontal reflectors and possible well-layered sediments and channelling.

4.2.15 Unit 6 is considered of high archaeological potential, particularly in areas where the unit has been overlain by pre-transgression Holocene peat deposits (Unit 7), which is likely to have protected the surface from erosion (Periplus Archaeomare, 2018). However, even in areas where the unit is not overlain by peat, there is still the potential for *in situ* archaeological remains to be present. Evidence from the UK and continental Europe suggest that within low-lying, predominantly wetland, areas, topographic highs, such as ridges formed by the aeolian sands, can provide an area of high ground which would be favourable for habitation. Sites such as Peacock's Farm in Cambridgeshire and the Great Coversand Ridge in northern Belgium show that prehistoric communities were using such features (Crombé *et al.,* 2012).

4.2.16 A number of high amplitude reflectors were identified both within and at the top of Unit 6 (**Appendix 3**, **Figures 3a-h, 4** and **5**). A number of these were sampled by vibrocores and found to comprise peat. It is possible these peat horizons and other high-amplitude reflectors represent Weichselian peats related to the Boxtel formation (Unit 6) or overlying pre-transgression Holocene peats associated with Unit 7. As with the peat deposits identified overlying Units 4 and 5, geoarchaeological dating would be necessary to undertake further geoarchaeological analysis to accurately date these features.

4.2.17 A number of interpreted channel features were identified in areas where the Boxtel formation were interpreted as being present (**79122, 79124, 79148, 79132, 79135, 79141, 79145, 79161, 79165, 79171, 79178, 79185-6**). These are seen to either be cutting into the interpreted Boxtel formation or at the base. A number of these were found by vibrocores to contain peat (**79124, 79128, 79145, 79171, 79185**). Based on their association with the Boxtel, these features are likely to be Weichselian (Unit 6) or Holocene pre-transgression features (Unit 7). As with the other channel features, these are considered of high archaeological potential.

4.2.18 Several possible coarse-grained deposits were interpreted throughout the Study Area (**79026**, **79027**, **79142**, **79147**, **79149**, **79152** and **79156**). These were generally seen to be acoustically chaotic, or unstructured sediments, with no clearly defined basal reflector. It is possible that these represent areas of re-worked sediments or may be poorly defined cut and fill features. Three of these were sampled by vibrocores (**79142**, **79149** and **79152**) and

were found to comprise gravely sand, with **79149** and **79152** having occasional laminae of clay or organic matter.

4.2.19 A number of cut and fills were identified throughout the area and are thought to likely be either Weichselian or Holocene in age (Appendix 3). However, as they could not be traced any distance as coherent palaeochannels, they are interpreted as cut and fill features. It is possible that they are the remnants of eroded palaeochannel systems but, as their nature is less certain, they are considered of lower archaeological potential, with the exception of (**79090**, **79129**, **79133**, **79137**) which have been discriminated as P1 based on the fact they were sampled by vibrocores and found to contain peat.

4.2.20 Unit 8 is a modern marine sediment deposited since the Holocene marine transgression. The unit is likely present as a thin veneer across much of the site, deepening to a thicker unit towards the west of the Study Area. Due to its age and depositional environment, Unit 8 is not considered of archaeological potential in itself. However, it has the potential to contain re-worked sediments or to periodically bury seabed archaeological sites such as shipwrecks and associated debris where the sediments are more mobile.

# 5 MARINE ARCHAEOLOGICAL ASSESSMENT: MARITIME AND AVIATION SITES

## 5.1 Introduction

5.1.1 The geophysical data were assessed to identify features of archaeological potential relating to maritime and aviation activity.

5.1.2 Where features were identified during the previous geophysical assessment of target areas within the Study Area (Wessex Archaeology 2019), their original interpretation and anomaly numbers have been retained, unless it has been deemed necessary to update based on new information (e.g. from the UKHO record) or based on the wider context of the geophysical data.

5.1.3 Any sites located outside of the defined Study Area (the 500 m corridor centred on the originally proposed cable route), either previously recorded in known databases (e.g. UKHO) or identified during this or previous geophysical assessments, are deemed beyond the scope of the current project and are subsequently not included as part of the assessment.

## 5.2 Geophysical seabed features assessment

5.2.1 The results of this assessment are collated in gazetteer format detailed in **Appendix 4** and illustrated in **Figures 6a-e** and **7**.

5.2.2 A total of 120 features have been identified as being of possible archaeological potential within the Study Area and are discriminated as shown in **Table 10**.

**Table 10** Anomalies of archaeological potential within the Study Area

| Archaeological discrimination | Quantity | Interpretation |
|---|---|---|
| A1 | 3 | Anthropogenic origin of archaeological interest |
| A2 | 109 | Uncertain origin of possible archaeological interest |
| A3 | 8 | Historic record of possible archaeological interest with no corresponding geophysical anomaly |
| **Total** | **120** | |

5.2.3 Furthermore, these anomalies can be classified by probable type, which can further aid in assigning archaeological potential and importance (**Table 11**).

**Table 11** Types of anomaly identified

| Anomaly classification | Definition | Number of anomalies |
|---|---|---|
| Wreck | Areas of coherent structure including wrecks of ships, submarines and some aircraft (where coherent structure survives) | 1 |
| Debris field | A discrete area containing numerous individual debris items that are potentially anthropogenic, and can include dispersed wreck sites for which no coherent structure remains | 1 |
| Debris | Distinct objects on the seabed, generally exhibiting height or with evidence of structure, that are potentially anthropogenic in origin | 10 |
| Seabed disturbance | An area of disturbance without individual, distinct objects. Potentially indicates wreck debris or other anthropogenic features buried just below the seabed. | 4 |
| Bright reflector | Individual objects or areas of low reflectivity, characteristic of materials that absorb acoustic energy, such as waterlogged wood or synthetic materials. Precise nature is uncertain | 2 |
| Dark reflector | Individual objects or areas of high reflectivity, displaying some anthropogenic characteristics. Precise nature is uncertain | 39 |
| Mound | A mounded feature with height not considered to be natural. Mounds may form over wreck sites or other debris. | 5 |
| Buried object | A possible buried object identified in the SBP data as a parabola or other disturbance, thought to be caused by a buried anthropogenic feature. | 1 |
| Magnetic | No associated seabed surface expression, and have the potential to represent possible buried ferrous debris or buried wreck sites | 49 |
| Recorded Wreck | Position of a recorded wreck at which previous surveys have identified definite seabed anomalies, but for which no associated feature has been identified within the current geophysical data sets. | 8 |
| **Total** | | **120** |

5.2.4 Full details of these anomalies are available in **Appendix 4**.

5.2.5 It should be noted that the features identified here include only the features identified in the geophysical data within the 500 m Study Area which are considered to be of archaeological potential. Any features deemed to be natural, such as boulders, or modern anthropogenic, such as cables and pipelines (see **section 5.2.20**) have not been reported on here.

*Archaeological Discrimination: A1*

5.2.6 One wreck, **7477**, has been identified in the geophysical data within the study area (**Wreck Sheet 1; Figure 6b**). This corresponds with the UKHO record 28296 and *Nationaal Contactnummer Nederland* (NCN) record 2238 and was identified in the previous assessment of priority areas (Wessex Archaeology 2019). In the SSS data this is visible as a large wreck that appears to be relatively intact and possibly lying upright on the seabed, with dimensions of 37.0 x 9.9 x 0.9 m. One edge of the hull appears to be partially degraded or buried by sediment. There are some slightly slatted features visible within the vessel which could represent internal structure. The wreck is situated on a sandy and featureless area of the seabed, within a depression, with possible associated debris in the vicinity. In the MBES data this is visible as a distinct mound, measuring 1.7 m high, orientated on an approximate north-west to south-east alignment. Scour up to -0.5 m deep is visible around

the wreck and extending approximately 22 m to the north-east. In the MBES data, the wreck is seen orientated north-west to south-east on the seabed, in three main segments which may suggest there is some deterioration in its centre. There is a small magnetic anomaly associated with this feature indicating the presence of some ferrous material; however, as the nearest magnetometer line is situated 50 m from the wreck, it is likely that the true amplitude would be larger if the wreck were directly covered by the magnetometer data. This is recorded in the UKHO database as the wreck of a fishing vessel.

5.2.7 Two likely associated items of debris (**7475** and **7476**) are identified in the vicinity of wreck **7477** and have been assigned an A1 archaeological potential rating. Anomaly **7476** is a small dark reflector which does not cast a shadow. This is located 2m from the bow or stern of the wreck and is possibly an associated item of wreck debris. Debris item **7475** is a curved dark reflector, again which does not cast a shadow. This is located 12m from the wreck and is possibly an associated item of debris. Both were reported on in the previous assessment of priority areas (Wessex Archaeology 2019).

*Archaeological Discrimination: A2*

5.2.8 There are 109 anomalies ascribed an archaeological potential rating of A2. For a full list of anomalies, please refer to **Appendix 4**.

5.2.9 Of these, one feature has been classified as a debris field (**7482**). It is visible in the SSS data as a curved dark reflector, measuring 4.2 x 2.3 x 1.1 m, identified within a slight depression, directly next to a very small and rounded dark reflector measuring 1.3 x 1.3 x 0.6 m. Some very slight dark reflectors were seen surrounding the main objects, however it is not possible to discern whether these are associated debris items or natural features. In total, the debris field measures 10.0 x 10.0 x 1.1 m. The feature corresponds with a large magnetic anomaly of 237 nT, indicating ferrous material is present.

5.2.10 A total of eight A2 anomalies have been classified as items of debris. These are generally identified in the SSS data as dark reflectors with shadows, ranging in size from 3.6 x 1.0 x 0.2 m (**7545**) to 8.5 x 3.9 x 0.2 m (**7484**). None of the possible items of debris have associated magnetic anomalies; however, it should be noted that due to the magnetometer line spacing, this may be reflective of their distance from the closest line of magnetometer data rather than their ferrous content. Of these possible debris items, two have been reported on in the previous assessment on priority areas (**7472** and **7484**) (Wessex Archaeology 2019).

5.2.11 A total of four seabed disturbances are noted in the Study Area, all newly identified during the latest phase of assessment. These are generally irregular in plan and somewhat indistinct, although they may contain more distinct dark reflectors. These range in size from 7.8 x 3.2 m (**7606**) to 24.5 x 18.9 m (**7515**). No associated magnetic anomalies are present, indicating feature comprise non-ferrous material. These may represent collections of partially buried, non-ferrous debris; however they may also be natural in origin.

5.2.12 In total two anomalies have been classified as bright reflectors, both were newly identified in this assessment. Anomaly **7523** measures 5.7 x 4.9 m and is a slightly elongate ‘L’ shape in plan. Anomaly **7576** measures 4.9 x 1.7 m and is distinct, curved and elongate in plan. These anomalies potentially represent pieces of debris that absorb rather than reflect acoustic waves, such as waterlogged wood or synthetic material, or seabed scars.

5.2.13 A total of 39 dark reflectors were identified in the Study Area. The anomalies range in size from 1.1 x 0.3 x 0.1 m (**7601**) to 27.9 x 0.9 m (**7481**). None of the dark reflectors were associated with magnetic anomalies and are therefore likely to be non-ferrous; although

some features were present in the areas between magnetometer survey lines and therefore the possibility of some ferrous material being present remains. Dark reflectors could either be individual pieces of debris or natural features; ground truthing would be needed to further determine their archaeological potential.

5.2.14 A number of dark reflectors identified in the SSS data correspond with an area of natural seabed undulations identified in the MBES data (**7571-4** and **7577-83**). It is possible that these dark reflectors are therefore related to these natural formations. However, as they appeared anomalous in the SSS data, and covered a smaller area than that seen in the MBES data, they have been retained as a precaution.

5.2.15 In total five anomalies have been classified as mounds, all are newly identified and were seen in the MBES data only. These are mostly angular and range in size between 5.0 x 4.0 x 0.2 m (**7543**) to 19.0 x 5.1 x 0.1 m (**7603**). All five mounds are of uncertain origin, and could represent debris partially covered by seabed sediment or be natural features.

5.2.16 A total of 49 magnetic anomalies have been noted in the study area, all of which are newly identified and without associated SSS or MBES anomalies. These range from 5 nT (**7514** and **7556**) to 182 nT (**7532**) in amplitude. These indicate potential ferrous debris that is either buried or without surface expression.

5.2.17 A number of magnetic anomalies were seen to be in a roughly linear orientation (**7528-30**, **7547** and **7548-50**); although were not seen on all the lines. Given the length of the features, it is unlikely that these are of archaeological potential. However, none of these features were charted on the relevant admiralty chart or in the client supplied pipeline and cable shapefiles, and therefore their exact origin is not certain. It is likely that they may represent modern, uncharted lengths of cable; however, as there is the potential for them to represent lengths of chain, or to be individual features in a linear orientation such as wartime mine fields, they have been retained as a precaution.

5.2.18 It should be noted that the magnetic anomalies reported on here are only the features deemed to be of archaeological potential, and does not include known modern anthropogenic features such as pipelines and cables. As discussed in **section 3.3**, the line spacing of the magnetometer data is such that objects with a smaller ferrous content, or ferrous objects positioned between lines, may not have been identified in the geophysical data.

*Archaeological Discrimination: A3*

5.2.19 The remaining eight anomalies have all been ascribed an archaeological potential rating of A3. These are recorded wreck locations for which no remains were visible in any of the geophysical data sets. Of these, four were covered by the geophysical data but not identified in any of the geophysical data sets (**7474**, **7487**, **7489**, **7591**). The remaining four recorded wreck locations (**7486**, **7488, 7607** and **7492**) were outside of the geophysical data coverage and therefore no comment can be made on whether the wrecks, or wreck material, are present on the seabed. However, they have been included here due to their proximity (within 100 m) of the Study Area. For a description of these receptors, please refer to **Appendix 4**.

*Pipeline and Cable crossings in the Geophysical data*

5.2.20 A number of cables and pipelines are charted as crossing the Study Area (**see Section 1.3**). Although not considered of archaeological potential in themselves, the installation of these pipelines and cables are may have impacted any features of archaeological potential which were present on the seabed prior to their installation. As such, any features identified

within the immediate vicinity of the pipelines or cables are likely to be either modern features or out of their original context.

5.2.21 The client-supplied shapefiles of all cable crossings, which includes the RWS database and the MMT background database, were compared against the marine magnetometer data to confirm whether they were identified. The results are listed in **Table 12**.

**Table 12** Pipelines and cables identified in the geophysical data

| NC_ID | Name | Owner | Status | Type | Observed in geophysical data |
|---|---|---|---|---|---|
| 035 | Zeepipe 1 | GASCO | Active | Pipeline | Yes |
| 036 | Franpipe | GASCO | Active | Pipeline | Yes |
| 037 | SEA-ME-WE3 seg 10.4 | Deutsche Telekom/BT | Inactive | Cable | Yes |
| 038 | BT North Sea | BT | Planned | Cable | Information from Primo Marine is that this has not yet been built. The latest information is that this will be built in the UK sector. |
| 039 | BBL Balgzand-Bacton | BBL | Active | Pipeline | Yes |
| 040 | UK-Germany 3 | BT/German | Inactive | Cable | Not definitively identified; however, it should be noted that magnetic anomalies **7505** – **7507** are approximately 150 m north and therefore it is possible they may represent this cable crossing |
| 041 | K13AP-Callantsoog | Wintershall | Active | Pipeline | Yes |
| 042 | UK-Germany 2 | BT/German | Inactive | Cable | Not definitively identified; however, a linear magnetic trend is identified approximately 1.7 km south of the RWS charted position. See paragraph 5.2.22. |
| 043 | UK-Denmark 3 | BT/Danish | Inactive | Cable | A linear magnetic trend is identified approximately 85 m north-west of RWS charted position |
| 044 | Bacton-Borkum No 1 | BT/German | Inactive | Cable | A linear magnetic trend is identified approximately 370 m north of MMT supplied background charts |
| 045 | Bacton-Borkum No 2 | BT/German | Inactive | Cable | Not identified in any of the geophysical data sets |
| 046 | PL007 – K8-FA-1 to K14-FA-1P | NAM | Active | Pipeline | Yes |
| 047 | PL142 -D15-FA-1 to L 10-AC | Noordgastranspoort BV | Active | Pipeline | Yes |
| 048 | Fano-Oye No 1 | Great Northern Tel co. | Inactive | Cable | Not identified in any of the geophysical datasets |
| 049 | PL064 – K9c-A to L10-AR | Gaz de France(engie) | Active | Pipeline | Yes |
| 050 | PL047 – L4-B to L7-A | Total Fina Elf Netherland BV | Abandoned | Pipeline | Yes |

| NC_ID | Name | Owner | Status | Type | Observed in geophysical data |
|---|---|---|---|---|---|
| 051 | PL048 | Total Fina Elf Netherland BV | Abandoned | Pipeline | Yes |
| 052 | UK-Denmark 3 | BT/Danish | Inactive | Cable | Not identified in any of the geophysical datasets |
| 053 | PL022 -L4A to L7-P | Total Fina Elf Netherland BV | Abandoned | Pipeline | Yes, although proximity to PL021 -L4A to L7-P makes it hard to definitively differentiate between the two pipelines. |
| 054 | PL021 – L4A to L7-P | Total Fina Elf Netherland BV | Abandoned | Pipeline | Yes, although proximity to PL022 -L4A to L7-P makes it hard to definitively differentiate between the two pipelines. |
| 055 | Bacton-Borkkum No 2 | BT/German | Inactive | Cable | Not identified in any of the geophysical datasets |
| 056 | UK-Germany 2 | BT/German | Inactive | Cable | Linear magnetic trend observed approximately 300 m south-east |
| 058 | PL091 – L2-FA-1 to Callantsoog | Noordgastranspoort BV | Active | Pipeline | Yes |
| 059 | Fano-Oye No 2 | Great Northern Tel Co | Inactive | Cable | Not identified in any of the geophysical datasets |
| 060 | Uk-Germany 2 Winterton-Borkum 1 | - | Inactive | Cable | Yes |
| 061 | SEA-ME-WE3 | Deutsche Telekom/BT | Inactive | Cable | Yes |
| 062 | UK-Germany 5 | BT/German | Inactive | Cable | Weak linear magnetic trend identified approximately 30 m north of RWS charted position |
| 063 | PL154 – G17d-A to NGT-Leiding | Noordgastranspoort BV | Active | Pipeline | Yes |
| 064 | Bacton-Norkum No 3 | BT/German | Inactive | Cable | Not identified in any of the geophysical datasets |
| 065 | Mundesley-Norderney | BT/German | Inactive | Cable | Not identified in any of the geophysical datasets |
| 066 | Tata (VSNL) North Europe | Zayo | Active | Cable | Yes |
| 067 | ODIN 1 seg 1 | TDC | Inactive | Cable | Yes |
| 068 | Atlantic Crossing 1 seg B2 | Century Link | Active | Cable | Yes |
| 069 | Fano-West Terschelling | Dutch | Inactive | Cable | Not identified in any of the geophysical datasets |

5.2.22 A linear magnetic feature has been identified within the magnetic data, orientated north-east to south west across the Study Area (centred on 523438 mE, 5903796 mN. This does not appear to correspond with any charted pipeline or cable routes; however, MMT have noted it as being the UK - Germany 2 cable route which is located approximately 1.7 km to the north. Based on its form in the data, it is interpreted as being likely modern infrastructure and not of archaeological interest. Its presence within the Study Area should be noted; however, as it is not considered of archaeological potential, it will not be discussed further in this report.

5.2.23 For more detail on cable crossings within the area, please refer to MMT 2019a.

## 5.3 Maritime archaeological potential

5.3.1 The assessment of potential for the discovery of shipwreck and shipwreck-derived material within the Study Area draws on the results of the geophysical survey and desk-based research combined with further research of the wider area. A list of receptors found within the wider search area, out-with the Study Area are presented in **Appendix 5**.

*Recorded Losses*

5.3.2 Recorded Losses can be considered as an indication of the potential for archaeological maritime remains to exist within the Study Area and the type and number of wrecks that could be present. These records relate to vessels reportedly lost or for which no physical wreck remains have ever been identified.

5.3.3 Eight recorded wrecks, which will impact the Study Area, have been identified for which no remains were visible in the geophysical data (**7474**, **7486**, **7487**, **7488**, **7489**, **7591, 7492** and **7607**). Details regarding these losses are presented in **Appendix 4**.

5.3.4 The Netherlands has been a seafaring nation for over five centuries and has developed a close commercial connection to its rivers and seas. As a major naval power during the 17th century a majority of the trade was undertaken by the Dutch merchant fleet (United East India Company) with the Dutch navy protecting shipping lanes all over the world. Although their naval power declined during the second half of the 18th century their presence within East Asia was still very much at large. During the First World War the Royal Netherlands Navy saw the introduction of submarines, light cruisers and destroyers, whilst during the Second World War, the Dutch navy was based in Allied countries, with submarines based in the Dutch East Indies. Although during both wars the Netherlands declared neutrality, a number of Dutch ships were lost at sea. After the wars the Dutch fleet expanded. The port of Rotterdam embraced the industrial revolution of the 19th century and developed its port facility, later on becoming one of the largest container-handling ports in Europe. (North Sea 2050 Spatial Agenda).

5.3.5 There is the potential for the presence of archaeological material of maritime nature spanning from the Mesolithic to the present day within the Study Area. The key areas of potential are summarised in **Table 2**.

## 5.4 Aviation archaeological baseline and potential

5.4.1 The assessment of potential for the discovery of aircraft crash sites and aircraft derived material within the Study Area draws on the results of the geophysical survey and desk-based research combined with further research of the wider area.

5.4.2 There are no known aircraft crash sites or Recorded Losses within the Study Area, nonetheless there is potential for aircraft or aircraft-related debris to exist on the seafloor within the Proposed Development. During the Second World War ('WWII') the Netherlands was to become the main area for the Luftwaffe from which to attack the UK. A number of military air bases were constructed, including Deelen Air Base, north of Arnhem, of which is now a national monument, and the adjacent central air control bunker for Belgium and the Netherlands, Diogenes. The Netherlands later turned into the first line of western air defence for Germany and its industrial heartland of the Ruhrgebiet, complete with extensive flak, sound detection installations and later radar.

5.4.3 Given the identified potential of the area for military aircraft crashes, particularly relating to the Second World War, the likelihood would be for any aircraft crash to be of military origin. This would include both Allied and Axis aircraft and would relate to both complete aircraft wrecks and debris scatters. A summary of key areas of aviation potential is presented in **Table 3**.

# 6 ENVIRONMENTAL APPRAISAL AND RECOMMENDATIONS

## 6.1 Potential Impacts

6.1.1 Offshore developments can affect heritage assets in two ways:

- from the direct effect of the physical siting of the project; and
- from indirect changes to the physical marine environment.

*Damage to known and unknown assets from direct impacts of construction*

6.1.2 All seabed receptors have the potential to be damaged or destroyed if they are directly impacted during seabed preparation or construction activities. Furthermore, all damage to archaeological sites or material is permanent and recovery is limited to stabilisation or re-burial, aimed at preventing further impacts. There is no potential for the recoverability of any seabed receptors if they are affected following a direct physical impact. As such, all wrecks, aircraft, associated material and debris and seabed prehistory should be regarded as having high sensitivity to physical impacts.

6.1.3 Direct physical impacts to marine archaeology are most likely to occur during the construction phase of the Proposed Development upon the archaeological receptors that have been identified above and any potential archaeology within the marine cable corridor. Impacts resulting in negative effects upon archaeological receptors as part of construction works are those involving contact with the seabed and/or the removal of seabed sediments. Marine archaeological receptors with height, such as shipwrecks, may also be impacted by activities that occur within the water column. Construction activities that may lead to direct physical impacts include:

- Route preparation prior to cable laying, including clearance of obstacles and/or seabed features, and construction of crossing structures over in-service cables;
- Pre-sweeping dredging required through areas of sandwaves identified along the Project Route Corridor;
- The use of a pre-lay grapnel run involving towing a heavy grapnel with a series of specially designed hooks (grapnels) along the centre line of the route, to confirm the installation site is clear of obstructions;
- Laying marine cables using the following options dependent on type of seabed – plough, jet trenching, and/or mechanical trenching;
- Backfilling of cable trench and stabilisation of unburied marine cables;
- Placement of non-burial protection on the seabed; and,
- Use of anchors or jack-up legs on vessels associated with the installation, maintenance and decommissioning phases of the project.

6.1.4 Activities considered here refer to direct physical impacts associated with seabed preparation and construction, but some may also occur during operational and decommissioning activities undertaken within the area of the Proposed Development. Direct physical impacts associated with construction works are considered to arise as a result of

seabed preparation, cable installation/ protection and seabed contact by construction vessels through jack-ups or anchors.

*Damage to known and unknown assets from indirect impacts of construction*

6.1.5 The indirect effects upon the known and potential marine archaeological assets considered here are those which occur as a result of changes to hydrodynamic and sediment transport regimes, where these changes have occurred as a consequence of activities and structures associated with the construction activities. These impacts may occur from the clearance of areas of sandwaves and large ripples during route preparation but may also occur through sediment deposition or the placement of cable protection on the seabed. Construction activities that may create indirect physical impacts include:

- Dredging in areas where sandwaves and ripples are present; and,
- Scour associated with the disturbance from construction activities and structures.

6.1.6 Indirect impacts may affect marine archaeological baseline conditions where they result in the increased exposure of burial of marine archaeological assets. The increased exposure of marine archaeological receptors has the potential to cause erosion and deterioration to the receptors. Conversely, should receptors be subject to increased sedimentation and burial, they may, in turn benefit from conditions which afford higher levels of preservation.

*Operation (including maintenance and repairs)*

6.1.7 Operational effects will be limited to those arising from repair, maintenance or any monitoring that may be required. Potential effects on marine heritage assets during the operation of the Proposed Development could include direct effects such as re-burial of cables, repair / replacement of cables, placement of additional cable protection, anchors or jack-ups being used for any maintenance activities (although these are likely to be minimal), and indirect effects such as changes in local scouring and sedimentation patterns. The heritage asset receptors most at risk of direct effects are those closest to the final cable route.

*Decommissioning*

6.1.8 As with construction activities, decommissioning activities have the potential to affect archaeological assets either directly or indirectly. However, what infrastructure will be decommissioned and the methodology for doing so is not currently fully known but will be agreed prior to the commencement of decommissioning works.

6.1.9 If the cables are left buried however, likely significant effects from decommissioning will be avoided. If the cables are to be removed at decommissioning this assessment assumes that impacts from decommissioning activities are of a similar nature to operation activities and would be of a similar or lesser scale.

## 6.2 Recommendations

*Avoidance*

6.2.1 The primary mitigation for the protection of known archaeological assets is avoidance. This is achieved through the implementation and monitoring of Archaeological Exclusion Zones (AEZs), which are proposed for identified high value seabed features of anthropogenic origin (i.e. A1 classified geophysical anomalies).

6.2.2 The mitigation strategy will establish 100 m AEZs around receptors which have been considered to be of high archaeological potential, in consultation with the Archaeological

Curator (Directorate-General for Public Works and Water Management (Rijkswaterstaat) and the National Agency for the Protection of Cultural Heritage (Rijksdienst voor het Cultureel Erfgoed).

6.2.3 These areas would be out of bounds to construction activities and to anchoring. Monitoring of any AEZs to ensure there is no disturbance to them will be part of this mitigation.

6.2.4 As features of high archaeological potential, it is recommended that AEZs are implemented around the three A1 anomalies (**7477**, **7475**, **7476**).

6.2.5 For the wreck (**7477**), an AEZ of 100 m around the wreck's extents is recommended. For the two debris items (**7475** and **7476**), a smaller AEZ of 25 m has been recommended. Due to their proximity to wreck **7477** these features will be covered by the recommended 100 m AEZ for wreck **7477** (**Figure 6b**).

6.2.6 For features assigned A2 archaeological discrimination rating, no AEZs are recommended at this time. However, avoidance is recommended with further mitigation to be implemented (e.g. visual inspection (divers or ROV)) if they are proposed to be directly impacted by development.

6.2.7 For the four features assigned an A3 archaeological discrimination that were not fully covered by the geophysical survey data extents (**7486**, **7488, 7492** and **7607**), a precautionary 100 m exclusion zone is recommended (**Figure 6**).

6.2.8 As noted in **section 3.3.10**, after discussions with the Dutch authorities, it was decided that the resolution of the geophysical data are not considered suitable for archaeological assessment. It is therefore recommended that higher resolution geophysical survey data is acquired, and archaeologically assessed, over the Study Area ahead of any construction. This will be undertaken in accordance with the Dutch AMZ cycle (archaeological heritage) to conduct a field investigation (*Inventariserend veldonderzoek opwaterfase*).

*Reduction*

6.2.9 Reduction of impact can be achieved by means of appropriate mitigation identified through potential opportunities for further investigation of assets (e.g. during UXO survey and clearance works). Further investigations mean that these anomalies can either have their archaeological value removed, if they prove to be of non-anthropogenic nature or modern, or their value as archaeological assets confirmed. If their value is confirmed, mitigation in the form of either avoidance (which may be enacted by the implementation of an AEZ) or through remedying or offsetting measures as identified through an Archaeological Project Design, implemented by a qualified Retained Archaeologist and in consultation with the Archaeological Curators.

*Remedying and offsetting*

6.2.10 In cases where avoidance is either inappropriate or impossible, the damage to archaeological assets should be offset. In the case of seabed prehistoric features, this can be achieved by undertaking a palaeoenvironmental assessment of deposits with high geoarchaeological potential, principally peat deposits and other sedimentary deposits of palaeoenvironmental potential. Pollen and macrofossil assessment, supported by radiocarbon dating, will provide information on age and vegetation history of the submerged terrestrial environment, providing a landscape context to any prehistoric activity within the area. Recovery of artefacts and/or other archaeological receptors should be a final resort, when all other mitigation has failed. Any recovery should be completed under the supervision of an appropriately qualified and experienced marine archaeologist. Recovery

methods will be identified in the Archaeological Project Design, with specific Method Statements covering those specific activities and agreed in consultation with the Archaeological Curator.

6.2.11 As terrestrial features interpreted as being deposited during periods of likely human occupation, those features given a P1 archaeological rating are considered of high archaeological potential. Those features with a P2 discrimination are considered of medium archaeological potential, partly due to the uncertainty of features formation and fill. Further geoarchaeological work, such as a stage one assessment of all the core logs or sampling and dating work, would aid in refining the interpretation and therefore help determine the archaeological potential of the area.

6.2.12 Should further ground investigation work be undertaken within the Study Area, it is recommended that the archaeological contractor be consulted to advise on potential samples to be acquired for archaeological purposes and other identified units of archaeological interest identified within the data. It is also recommended that any future additional geotechnical logs from within the study area be made available for geoarchaeological assessment.

6.2.13 Furthermore, it is recommended that any samples acquired containing material of archaeological potential, particularly those within the interpreted Pleistocene/early Holocene features, be made available for geoarchaeological assessment.

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# APPENDICES

## Appendix 1: Terminology

### Glossary

The terminology used in this assessment follows definitions contained within the UK's *National Planning Policy Framework* (Department for Communities and Local Government, 2012: 50-57):

| | |
|---|---|
| **Archaeological interest** | There will be archaeological interest in a heritage asset if it holds, or potentially may hold, evidence of past human activity worthy of expert investigation at some point. Heritage assets with archaeological interest are the primary source of evidence about the substance and evolution of places, and of the people and cultures that made them. |
| **Conservation (for heritage policy)** | The process of maintaining and managing change to a heritage asset in a way that sustains and, where appropriate, enhances its significance. |
| **Designated heritage asset** | A World Heritage Site, Scheduled Monument, Listed Building, Protected Wreck Site, Registered Park and Garden, Registered Battlefield or Conservation Area designated under the relevant legislation. |
| **Development Plan** | This includes adopted Local Plans, neighbourhood plans and the London Plan, and is defined in section 38 of the Planning and Compulsory Purchase Act 2004. |
| **Environmental Impact Assessment** | A procedure to be followed for certain types of projects to ensure that decisions are made in full knowledge of any likely significant effects on the environment. |
| **Heritage asset** | A building, monument, site, place, area or landscape identified as having a degree of significance meriting consideration in planning decisions, because of its heritage interest. Heritage asset includes designated heritage assets and assets identified by the local planning authority (including local listing). |
| **Heritage coast** | Areas of undeveloped coastline which are managed to conserve their natural beauty and, where appropriate, to improve accessibility for visitors. |
| **Historic environment** | All aspects of the environment resulting from the interaction between people and places through time, including all surviving physical remains of past human activity, whether visible, buried or submerged, and landscaped and planted or managed flora. |
| **Historic environment record** | Information services that seek to provide access to comprehensive and dynamic resources relating to the historic environment of a defined geographic area for public benefit and use. |
| **Setting of a heritage asset** | The surroundings in which a heritage asset is experienced. Its extent is not fixed and may change as the asset and its surroundings evolve. Elements of a setting may make a positive or negative contribution to the significance of an asset, may affect the ability to appreciate that significance or may be neutral. |

| | |
|---|---|
| **Significance (for heritage policy)** | The value of a heritage asset to this and future generations because of its heritage interest. That interest may be archaeological, architectural, artistic or historic. Significance derives not only from a heritage asset's physical presence, but also from its setting. |

**Chronology**

Where referred to in the text, the main archaeological periods are broadly defined by the following date ranges (adopted from SIKB, Code table 3 – period, 2015):

| Period | Date Range |
|---|---|
| Palaeolithic | *c.* 900,000 BP– 8800 BC |
| Mesolithic | 8800 – 5300 BC |
| Neolithic | 5300 – 2000 BC |
| Bronze Age | 2000 – 800 BC |
| Iron Age | 800 – 12 BC |
| Roman | BC 12 – AD 450 |
| Early Medieval | 450 – 1050 |
| Medieval | 1050 – 1500 |
| Post-medieval | 1500 – 1800 |
| 19th century | 1800 – 1899 |
| Modern | 1900 – present day |

The geological periods and associated Marine Isotope Stages are defined by the following date ranges:

| Period | Date Range | MIS |
|---|---|---|
| Holocene | 11,700 – present day | 1 |
| Devensian | 115,000 – 11,700 BP | 5d – 2 |
| Ipswichian | 130,000 – 115,000 BP | 5e |
| Saalian | 374,000 – 130,000 BP | 10 – 6 |
| Hoxnian | 424,000 – 374,000 BP | 11 |
| Anglian | 478,000 – 424,000 BP | 12 |
| Pre-Anglian | >478,000 BP | >12 |

## Appendix 2: Legislative, policy and guidance

### Global Policy and Legislation

| Legislation/Policy | Summary |
|---|---|
| **The World Heritage Convention 1972** | The Convention provides for the identification, protection, conservation and presentation of cultural and natural sites of 'outstanding universal value' for inscription on the World Heritage List. The Convention sets out the duties of States Parties in identifying potential sites and their role in protecting and preserving them. By signing the Convention, each country pledges to conserve not only the World Heritage sites situated on its territory, but also to protect its national heritage. The 1972 UNESCO World Heritage Convention was ratified by the UK in 1984 and the UK currently has 29 World Heritage Sites. |
| **The United Nations Convention on the Law of the Sea 1982** | UNCLOS 1982 was ratified by the UK in 1997. Article 149 applies only to those archaeological and historical objects that lie outside national jurisdiction and stipulates that 'all objects of an archaeological and historical nature found in the Area shall be preserved or disposed of for the benefit of mankind as a whole, particular regard being paid to the preferential rights of the State or country of origin, or the State of cultural origin, or the State of historical and archaeological origin'. Article 303 stipulates that 'states have the duty to protect objects of an archaeological and historical nature found at sea and shall co-operate for this purpose'. Article 303 also provides for coastal states to exert a degree of control over the archaeological heritage to 24 nm, though the UK has not introduced any measures to implement this right. |
| **International Council of Monuments and Sites Charter on the Protection and Management of Underwater Cultural Heritage 1996 (the Sofia Charter)** | The Charter upon which the Annex of the UNESCO Convention is largely based includes a series of statements regarding best practice, intending 'to ensure that all investigations are explicit in their aims, methodology and anticipated results so that the intention of each project is transparent to all'. The UK is a member of the International Council of Monuments and Sites. |
| **UNESCO Convention on the Protection of the Underwater Cultural Heritage (2001)** | The UNESCO Convention was concluded in 2001, and is a comprehensive attempt to codify the law internationally with regards to underwater archaeological heritage. The UK abstained in the vote on the final draft of the Convention, however, it has stated that it has adopted the Annex of the Convention, which governs the conduct of archaeological investigations, as best practice for archaeology. Although the UK is not a signatory, the convention entered into force on 2nd January 2009 having been signed or ratified by 20 member states. |

## European Policy and Legislation

| Legislation/Policy | Summary |
|---|---|
| **The European Convention on the Protection of the Archaeological Heritage (Revised) 1992 (The Valletta Convention)** | The Articles of the Valletta Convention tackle various aspects. Article 1 deals with the inventorying and protection of sites and areas; Article 2 deals with the mandatory reporting of chance finds and providing for 'archaeological reserves' on land or underwater; Article 3 promotes high standards for all archaeological work undertaken by suitably qualified people; Article 4 requires the conservation of excavated sites and the safe-keeping of finds; and Article 5 is concerned with consultation that should take place between planning authorities and developers to avoid damage to archaeological remains.<br>The Valletta Convention was ratified by the UK Government in 2000 and came into force in 2001. The convention binds the UK to implement protective measures for the archaeological heritage within the jurisdiction of each party, including sea areas. Insofar as the UK exerts jurisdiction over the Continental Shelf, then it would appear that the provisions of the Valletta Convention apply to that jurisdiction. |
| **The European Landscape Convention 2000** | The European Landscape Convention became binding on the UK from 1 March 2007. Its principal clauses require the Government to protect and manage landscapes and to integrate landscape into regional and town planning policies including its cultural, environmental, agricultural, social and economic policies. The Convention applies to the entire territory of the UK and includes land, inland water and marine areas. It is not regarded as applying to sea areas regulated by the UK that lie beyond territorial waters. |
| **European Directives for Environmental Impact Assessments (2014/52/EU)** | The EIA Directive entered into force on 15 May 2014 to simplify the rules for assessing the potential effects of projects on the environment. The newly amended directive replaces former directives (85/337/EEC; 97/11/EC; 2003/35/EC; 2009/31/EC; 2011/92/EU) and Member States must apply these from 16 May 2017 at the latest. |

## Dutch Policy and Legislation

| | |
|---|---|
| **Heritage Act 2016 (Erfgoedwet 2016; issued by the Ministry of Education, Culture and Science)** | This provides protection for cultural heritage assets, including wrecks, aircraft crash sites and submerged prehistory. It also "prohibits without a certificate for that purpose, to carry out actions involving the detection, investigation, or acquisition of cultural heritage, or parts thereof, which results in disturbance of the soil or disruption or total or partial displacement or removal of an archaeological monument or of underwater cultural heritage" (Section 5.1). Certificates are issued on application to the Minister for Education, Culture and Science.<br>The Heritage Act established the AMZ cycle (Archeologische Monumenten Zorg), which is a defined series of steps and decisions through which archaeological works, mitigation and research are structured within the Dutch planning system. The procedure is embedded in the Dutch Quality Standard for Archaeology (KNA Waterbodems 4.1) as the mandatory workflow for archaeologists. |

## Guidance

| | |
|---|---|
| **Code of Practice for Seabed Developers, Joint Nautical Archaeology Policy Committee (Joint Nautical Archaeology Policy Committee 2006)** | This voluntary Code provides a framework for seabed developers similar to the principles found in current policy and practice on land. The aim of the Code is to ensure a best practice model for seabed development. The Code offers guidance to developers on issues such as risk management and legislative implications. |
| **Standard and guidance for historic environment desk-based assessment (Chartered Institute for Archaeologists 2014)** | This guidance seeks to define good practice for the execution and reporting of desk-based assessment, in line with the by-laws of the Chartered Institute for Archaeologists. The standard and guidance was formally adopted as approved practice at the Annual General Meeting of the Institute held on 14 October 1994. This revision recognises the new Chartered status of the Institute. |
| **Guidelines to the process of underwater archaeological research: SASMAP Guideline Manual 1 & Best practices for locating, surveying, assessing, monitoring and preserving underwater archaeological sites: SASMAP Guideline Manual 2 (2015)** | As part of the European Collaborative Research Project, SASMAP (development of tools and techniques to survey, assess, stabilise, monitor and preserve underwater archaeological sites), two sets of best practice guidelines have been established for stakeholders and managers of underwater cultural heritage. Guideline Manual 1 offers a thorough overview of the process of (underwater) cultural heritage management within development-led archaeology (Treaty of Valletta), using a question-based approach. Guideline Manual 2 illustrates, using best practice examples, a practical approach for implementing the different steps in the process. These are divided into accepted methods that have already been applied in multiple projects around the world, and newly developed research processes, such as the methods and techniques developed within the SASMAP project. The two guideline manuals are intrinsically linked. |

## Appendix 3: Palaeogeographic features of archaeological potential

| ID | Classification | Archaeological Discrimination | Depth Range (mBSB) | | Description |
|---|---|---|---|---|---|
| | | | From | To | |
| 79000 | High amplitude reflector | P2 | 11.7 | 12.5 | Small high amplitude reflector identified towards the base of a unit characterised by horizontal reflectors, interpreted as the BNB formation. Slightly chaotic. May be thin layer of peat or possibly just reworked sediments |
| 79001 | High amplitude reflector | P2 | 13.6 | 14.2 | Small high amplitude reflector identified towards the base of a unit characterised by horizontal reflectors, interpreted as the BNB formation. Slightly chaotic. May be thin layer of peat or possibly just reworked sediments |
| 79002 | High amplitude reflector | P1 | 3 | 4 | A high amplitude reflector identified at the top of the interpreted BNB formation, beneath a unit of modern marine sands. Possible peat horizon. |
| 79003 | High amplitude reflector | P1 | 3.4 | 5.4 | A high amplitude reflector identified at the top of the interpreted BNB formation, beneath a unit of modern marine sands. Possible peat horizon. |
| 79004 | High amplitude reflector | P1 | 3.6 | 4.3 | A high amplitude reflector identified at the top of the interpreted BNB formation, beneath a unit of modern marine sands. Possible peat horizon. |
| 79005 | High amplitude reflector | P1 | 1.2 | 5.9 | A high amplitude reflector identified at the top of the interpreted BNB formation, beneath a unit of modern marine sands. Located on one side of a possible channel feature (**79006**). Possible peat horizon. Feature was sampled by Vibrocore 553-VC-B06-284 and found to comprise peat. |
| 79006 | Channel | P1 | 4 | 10.4 | A small channel identified beneath a unit of modern marine sand, cutting into the interpreted BNB formation. Feature has a relatively faint basal reflector and fill characterised by faint, draping reflectors, which was found by 553-VC-B06-285 to comprise silty sand with occasional laminae of clay with gravel sized pockets of brown organic matter. |
| 79007 | High amplitude reflector | P1 | 2.5 | 4.4 | A high amplitude reflector identified at the top of the interpreted BNB formation, beneath a unit of modern marine sands. Located on one side of a possible channel feature (**79006**). Possible peat horizon. |
| 79008 | High amplitude reflector | P1 | 2.2 | 6.3 | A distinct, flat, high amplitude reflector identified at the top of the interpreted BNB formation, beneath a unit of modern marine sands. Possible peat horizon. |

| | | | | | |
|---|---|---|---|---|---|
| 79009 | High amplitude reflector | P1 | 3.5 | 3.6 | A distinct, flat, high amplitude reflector identified at the top of the interpreted BNB formation, beneath a unit of modern marine sands. Possible peat horizon. |
| 79010 | High amplitude reflector | P1 | 3.6 | 7.5 | A distinct, flat, high amplitude reflector identified at the top of the interpreted BNB formation, beneath a unit of modern marine sands. Possible peat horizon. |
| 79011 | High amplitude reflector | P1 | 5.4 | 7.3 | A distinct, flat, high amplitude reflector identified at the top of the interpreted BNB formation, beneath a unit of modern marine sands. Possible peat horizon. |
| 79012 | High amplitude reflector | P1 | 4.3 | 7.2 | A distinct, flat, high amplitude reflector identified at the top of the interpreted BNB formation, beneath a unit of modern marine sands. Possible peat horizon. |
| 79013 | High amplitude reflector | P1 | 4.9 | 5.9 | A high amplitude reflector identified at the top of the interpreted BNB formation, beneath a unit of modern marine sands. Located on one side of a possible channel feature (**79014**). Possible peat horizon. |
| 79014 | Channel | P1 | 5.3 | 11.3 | A small channel identified beneath a unit of modern marine sand, cutting into the interpreted BNB formation. Feature has a relatively distinct basal reflector and quiet fill, possibly with some very faint, draping reflectors which may indicate some well-layered sediments. Feature is flanked in some areas by a high amplitude reflector, possibly indicating associated peat or overbank deposits. |
| 79015 | High amplitude reflector | P1 | 5.5 | 6.2 | A high amplitude reflector identified at the top of the interpreted BNB formation, beneath a unit of modern marine sands. Located on one side of a possible channel feature (**79014**). Possible peat horizon. |
| 79016 | High amplitude reflector | P1 | 5.2 | 5.6 | A distinct, flat, high amplitude reflector identified at the top of the interpreted BNB formation, beneath a unit of modern marine sands. Possible peat horizon. |
| 79017 | High amplitude reflector | P1 | 5.5 | 8.2 | A distinct, high amplitude reflector identified at the top of the interpreted BNB formation, beneath a unit of modern marine sands. Feature is largely horizontal, although appears to dip down slightly in places, possibly where the sediments are infilling a depression in the surface of the underlying unit. |
| 79018 | High amplitude reflector | P1 | 6.3 | 6.7 | A distinct, flat, high amplitude reflector identified at the top of the interpreted BNB formation, beneath a unit of modern marine sands. Possible peat horizon. |
| 79019 | High amplitude reflector | P1 | 6 | 9.2 | A distinct, high amplitude reflector identified at the top of the interpreted BNB formation, beneath a unit of modern marine sands. Feature is largely horizontal, although appears to dip down slightly in places, possibly where the sediments are infilling a depression in the surface of the underlying unit. |

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| 79020 | High amplitude reflector | P1 | 6.3 | 10.2 | A distinct, high amplitude reflector identified at the top of the interpreted BNB formation, beneath a unit of modern marine sands. Feature is largely horizontal, although appears to dip down slightly in places, possibly where the sediments are infilling a depression in the surface of the underlying unit. |
| 79021 | High amplitude reflector | P1 | 6.7 | 13.1 | A distinct, high amplitude reflector identified at the top of the interpreted BNB formation, beneath a unit of modern marine sands. Feature is largely horizontal, although appears to dip down slightly in places, possibly where the sediments are infilling a depression in the surface of the underlying unit. |
| 79022 | High amplitude reflector | P1 | 7.9 | 8.2 | A small, higher amplitude reflector identified on one survey line at the top of the interpreted BNB formation, beneath a unit of modern marine sands. Possible peat, but appears less distinct and therefore less certain. |
| 79023 | High amplitude reflector | P1 | 7.4 | 8.3 | A small, distinct, high amplitude reflector identified at the top of the interpreted BNB formation, beneath a unit of modern marine sands. Possible peat horizon. |
| 79024 | High amplitude reflector | P1 | 7.8 | 8.2 | A small, higher amplitude reflector identified on one survey line at the top of the interpreted BNB formation, beneath a unit of modern marine sands. Possible peat, but appears less distinct and therefore less certain. |
| 79025 | High amplitude reflector | P1 | 8.2 | 8.9 | A small, distinct, high amplitude reflector identified at the top of the interpreted BNB formation, beneath a unit of modern marine sands. Possible peat horizon. |
| 79026 | Coarse-grained deposit | P2 | 10.4 | 15.8 | A small disturbance with chaotic fill and no discernible basal reflector identified beneath a unit of modern marine sands, cutting into the interpreted BNB formation. Possible re-worked sediments, however has the potential of being a poorly-defined channel feature. |
| 79027 | Coarse-grained deposit | P2 | 10.5 | 14.9 | A small disturbance with chaotic fill and no discernible basal reflector identified beneath a unit of modern marine sands, cutting into the interpreted BNB formation. Possible re-worked sediments, however has the potential of being a poorly-defined channel feature. |
| 79028 | Channel | P1 | 11.1 | 17.7 | A small channel identified beneath a unit of modern marine sand, cutting into the interpreted Eem formation. Feature has a faint basal reflector and quiet fill, possible with some very faint, draping reflectors which may indicate some well-layered sediments. |
| 79029 | High amplitude reflector | P2 | 10.5 | 11 | A small, slightly higher amplitude reflector identified at the top of the interpreted Eem formation, beneath a unit of modern marine sands. Feature appears to cause parabolas, which may indicate buried objects although these are likely to be geological in origin. Possible coarse-grained deposits or peat horizon. |

| | | | | | |
|---|---|---|---|---|---|
| 79030 | High amplitude reflector | P2 | 10.8 | 11.3 | A small, slightly higher amplitude reflector identified at the top of the interpreted Eem formation, beneath a unit of modern marine sands. Feature appears to cause parabolas, which may indicate buried objects although these are likely to be geological in origin. Possible coarse-grained deposits or peat horizon. |
| 79031 | High amplitude reflector | P2 | 10.2 | 10.9 | A small, slightly higher amplitude reflector identified at the top of the interpreted Eem formation, beneath a unit of modern marine sands. Feature appears to cause parabolas, which may indicate buried objects although these are likely to be geological in origin. Possible coarse-grained deposits or peat horizon. |
| 79032 | High amplitude reflector | P1 | 11 | 11.5 | A small, distinct, high amplitude reflector identified at the top of the interpreted Eem formation, beneath a unit of modern marine sands. Possible peat horizon. |
| 79033 | High amplitude reflector | P1 | 10.3 | 11.9 | A small, distinct, high amplitude reflector identified at the top of the interpreted Eem formation, beneath a unit of modern marine sands. Possible peat horizon. |
| 79034 | High amplitude reflector | P1 | 10.6 | 10.9 | A small, distinct, high amplitude reflector identified at the top of the interpreted Eem formation, beneath a unit of modern marine sands. Possible peat horizon. |
| 79035 | High amplitude reflector | P1 | 11.1 | 11.4 | A small, distinct, high amplitude reflector identified at the top of the interpreted Eem formation, beneath a unit of modern marine sands. Possible peat horizon. |
| 79036 | High amplitude reflector | P1 | 11.1 | 11.6 | A small, distinct, high amplitude reflector identified at the top of the interpreted Eem formation, beneath a unit of modern marine sands. Possible peat horizon. |
| 79037 | High amplitude reflector | P2 | 10.2 | 11.4 | A small, higher amplitude reflector identified on one survey line at the top of the interpreted BNB formation, beneath a unit of modern marine sands. Possible peat, but appears less distinct and therefore less certain. |
| 79038 | High amplitude reflector | P1 | 10.5 | 10.8 | A small, distinct, high amplitude reflector identified at the top of the interpreted Eem formation, beneath a unit of modern marine sands. Possible peat horizon. |
| 79039 | High amplitude reflector | P1 | 11 | 12.6 | A small, distinct, high amplitude reflector identified at the top of the interpreted Eem formation, beneath a unit of modern marine sands. Possible peat horizon. |
| 79040 | High amplitude reflector | P1 | 10.7 | 11.3 | A distinct, high amplitude reflector identified at the top of the interpreted Eem formation, beneath a unit of modern marine sands. Feature appears to dip down slightly into the underlying unit , possibly indicating an infilled depression or shallow cut and fill containing peat. |

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| 79041 | High amplitude reflector | P1 | 10.6 | 11.5 | A distinct, high amplitude reflector identified at the top of the interpreted Eem formation, beneath a unit of modern marine sands. Feature appears to dip down slightly into the underlying unit , possibly indicating an infilled depression or shallow cut and fill containing peat. |
| 79042 | High amplitude reflector | P1 | 10.5 | 13.2 | A distinct, high amplitude reflector identified at the top of the interpreted Eem formation, beneath a unit of modern marine sands. Feature appears to be slightly inset , possible infilled depression or shallow channel containing peat. |
| 79043 | High amplitude reflector | P1 | 11 | 14.8 | A distinct, high amplitude reflector identified at the top of the interpreted Eem formation, beneath a unit of modern marine sands. Feature appears to be slightly inset , possible infilled depression or shallow channel feature containing peat. |
| 79044 | High amplitude reflector | P2 | 11.8 | 14.7 | A distinct, high amplitude reflector identified close to the top but slightly within the interpreted Eem formation. Feature appears to be slightly inset. Possible infilled depression or shallow channel containing peat, but appears less distinct and therefore less certain. |
| 79045 | High amplitude reflector | P2 | 10.1 | 10.9 | A small, higher amplitude reflector identified on one survey line at the top of the interpreted Eem formation, beneath a unit of modern marine sands. Possible peat, but appears less distinct and therefore less certain. |
| 79046 | Cut and fill | P2 | 8.3 | 12.3 | A small simple cut and fill identified beneath a unit of modern marine sediments, cutting into the interpreted Eem formation. Feature has a relatively well-defined basal reflector and fill characterised by sub-horizontal reflectors, possibly indicating well-layered fill. Possible remnants of a buried fluvial feature. |
| 79047 | High amplitude reflector | P1 | 7.4 | 8.1 | A distinct, high amplitude reflector identified at the top of the interpreted Eem formation, beneath a unit of modern marine sands. Feature appears to dip down into underlying sediment, possible peat infilling slight depression. |
| 79048 | Channel | P1 | 8.4 | 17.4 | A small channel identified beneath a unit of modern marine sand, cutting into the interpreted BNB formation. Feature has a relatively distinct basal reflector and fill characterised by faint, horizontal reflectors which may indicate some well-layered sediments. Some slight blanking of underlying horizons which may indicate the presence of gas caused by the microbial breakdown of organic matter. Located close to channel feature **79049** and possibly related. |

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| 79049 | Channel | P1 | 8.1 | 14.8 | A small channel identified beneath a unit of modern marine sand, cutting into the interpreted BNB formation. Feature has a relatively distinct basal reflector and fill characterised by faint, horizontal reflectors which may indicate some well-layered sediments. Some slight blanking of underlying horizons which may indicate the presence of gas caused by the microbial breakdown of organic matter. Located close to channel feature **79048** and possibly related. |
| 79050 | High amplitude reflector | P1 | 7.8 | 8.2 | A high amplitude reflector identified at the top of the interpreted Eem formation, beneath a unit of modern marine sands. Located on one side of a possible channel feature (**79049**) and possibly represents associated deposits. Possible peat. |
| 79051 | High amplitude reflector | P1 | 7.8 | 9.9 | A distinct, high amplitude reflector identified at the top of the interpreted Eem formation, beneath a unit of modern marine sands. Feature appears to dip down slightly into the underlying unit , possibly indicating an infilled depression or shallow cut and fill containing peat. |
| 79052 | High amplitude reflector | P1 | 7.6 | 8 | A small, distinct, high amplitude reflector identified at the top of the interpreted Eem formation, beneath a unit of modern marine sands. Possible peat horizon. |
| 79053 | High amplitude reflector | P1 | 7.4 | 7.9 | A small, distinct, high amplitude reflector identified at the top of the interpreted Eem formation, beneath a unit of modern marine sands. Possible peat horizon. |
| 79054 | High amplitude reflector | P1 | 7.1 | 7.7 | A small, distinct, high amplitude reflector identified at the top of the interpreted Eem formation, beneath a unit of modern marine sands. Possible peat horizon. |
| 79055 | Cut and fill | P2 | 7.8 | 13.4 | A small simple cut and fill identified beneath a unit of modern marine sediments, cutting into the interpreted Eem formation. Feature has a relatively well-defined basal reflector and fill characterised by sub-horizontal reflectors, possibly indicating well-layered fill. Possible remnants of a buried fluvial feature related to nearby channel feature **79056**. |
| 79056 | Channel | P1 | 7.1 | 14.5 | A small channel identified beneath a unit of modern marine sand, cutting into the interpreted BNB formation. Feature has a relatively distinct basal reflector and fill characterised by faint, horizontal reflectors which may indicate some well-layered sediments. Located close to simple cut and fill **79055** and possibly related. |

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| 79057 | High amplitude reflector | P2 | 6.7 | 7.2 | A high amplitude reflector identified at the top of the interpreted Eem formation, beneath a unit of modern marine sands. Located on one side of a possible channel feature (**79056**) and possibly represents associated deposits. Possible peat, but appears less distinct and therefore less certain. |
| 79058 | High amplitude reflector | P1 | 5.6 | 6.1 | A small, distinct, high amplitude reflector identified at the top of the interpreted Eem formation, beneath a unit of modern marine sands. Possible peat horizon. |
| 79059 | High amplitude reflector | P1 | 5.3 | 6 | A distinct, high amplitude reflector identified at the top of the interpreted Eem formation, beneath a unit of modern marine sands. Feature appears to dip down slightly into the underlying unit , possibly indicating an infilled depression or shallow cut and fill containing peat. |
| 79060 | High amplitude reflector | P1 | 5.4 | 8.4 | A distinct, high amplitude reflector identified at the top of the interpreted Eem formation, beneath a unit of modern marine sands. Feature appears to dip down slightly into the underlying unit , possibly indicating an infilled depression or shallow cut and fill containing peat. |
| 79061 | High amplitude reflector | P1 | 5.8 | 8.5 | A distinct, high amplitude reflector identified at the top of the interpreted Eem formation, beneath a unit of modern marine sands. Feature appears to dip down slightly into the underlying unit , possibly indicating an infilled depression or shallow cut and fill containing peat. |
| 79062 | High amplitude reflector | P1 | 4.1 | 4.6 | A distinct, high amplitude reflector identified at the top of the interpreted Eem formation, beneath a unit of modern marine sands. Feature appears to dip down slightly into the underlying unit , possibly indicating an infilled depression or shallow cut and fill containing peat. |
| 79063 | High amplitude reflector | P2 | 9.7 | 13.4 | A distinct, fairly extensive and slightly undulating high amplitude reflector identified at the base of an acoustically quiet unit, interpreted as the possible Eem formation. It is noted in DINOloket that the lower boundary of the Eem formation has localised areas of Gyttja at its base, and therefore it is possible that the high amplitude reflector mapped here represents that. As the Eem formation was deposited in a maritime setting, the sediments associated with it are unlikely to be of archaeological interest. However, as the unit is not definitively the Eem formation, the feature has been retained here as of possible interest. |

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| 79064 | High amplitude reflector | P2 | 4.6 | 10.1 | A distinct, fairly extensive and slightly undulating high amplitude reflector identified at the base of an acoustically quiet unit, interpreted as the possible Eem formation. It is noted in DINOloket that the lower boundary of the Eem formation has localised areas of Gyttja at its base, and therefore it is possible that the high amplitude reflector mapped here represents that. As the Eem formation was deposited in a maritime setting, the sediments associated with it are unlikely to be of archaeological interest. However, as the unit is not definitively the Eem formation, the feature has been retained here as of possible interest. |
| 79065 | High amplitude reflector | P2 | 3.1 | 4.2 | A high amplitude reflector identified at the top of the interpreted Eem formation, beneath a unit of modern marine sands. Possible peat, but appears less distinct and therefore less certain. |
| 79066 | High amplitude reflector | P2 | 3.5 | 5.4 | A high amplitude reflector identified at the top of the interpreted Eem formation, beneath a unit of modern marine sands. Possible peat, but appears less distinct and therefore less certain. |
| 79067 | High amplitude reflector | P2 | 3.9 | 4.3 | A high amplitude reflector identified at the top of the interpreted Eem formation, beneath a unit of modern marine sands. Possible peat, but appears less distinct and therefore less certain. |
| 79068 | High amplitude reflector | P1 | 3.4 | 4.9 | A distinct, high amplitude reflector identified at the top of the interpreted Eem formation, beneath a unit of modern marine sands. Feature appears to dip down slightly into the underlying unit , possibly indicating an infilled depression or shallow cut and fill containing peat. |
| 79069 | High amplitude reflector | P1 | 4.1 | 4.3 | A distinct, high amplitude reflector identified at the top of the interpreted Eem formation, beneath a unit of modern marine sands. Feature appears to dip down slightly into the underlying unit , possibly indicating an infilled depression or shallow cut and fill containing peat. Possible related to nearby feature **79068**. |
| 79070 | Cut and fill | P2 | 3.6 | 8.8 | A small simple cut and fill identified beneath a unit of modern marine sediments, cutting into the interpreted Eem formation. Feature has a distinct basal reflector and fill characterised by sub-horizontal reflectors, possibly indicating well-layered fill. Possible remnants of a buried fluvial feature. |

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| 79071 | High amplitude reflector | P2 | 4.6 | 14.7 | A distinct, fairly extensive and slightly undulating high amplitude reflector identified at the base of an acoustically quiet unit, interpreted as the possible Eem formation. It is noted in DINOloket that the lower boundary of the Eem formation has localised areas of Gyttja at its base, and therefore it is possible that the high amplitude reflector mapped here represents that. As the Eem formation was deposited in a maritime setting, the sediments associated with it are unlikely to be of archaeological interest. However, as the unit is not definitively the Eem formation, the feature has been retained here as of possible interest. |
| 79072 | High amplitude reflector | P1 | 3.3 | 7.8 | A distinct, high amplitude reflector identified at the top of the interpreted Eem formation, beneath a unit of modern marine sands. Feature appears to be dip down slightly in places, possible where it is infilling slight depressions in the top of the underlying sediment. Feature corresponds with a layer of peat identified in vibrocore 553-VC-B08-353. |
| 79073 | High amplitude reflector | P2 | 3.1 | 3.9 | Area of occasionally intermittent high amplitude reflectors identified at the top of the interpreted Eem formation, beneath a unit of modern marine sands. Appears similar in acoustic characteristics to **79072**, however not identified within vibrocore 553-VC-B08-354 and therefore less certain. |
| 79074 | Cut and fill | P2 | 4.3 | 7.2 | A small simple cut and fill identified beneath a possible unit of peat, overlain by a unit of modern marine sediments, cutting into the interpreted Eem formation. Feature has a distinct basal reflector and fill characterised by sub-horizontal reflectors, possibly indicating well-layered fill. Possible remnants of a buried fluvial feature. |
| 79075 | High amplitude reflector | P1 | 2.7 | 7.8 | Area of occasionally intermittent, high amplitude reflectors identified at the top of the interpreted Eem formation beneath a unit of modern marine sands. Occasionally appears to be infilling slight depressions. Possible peat. |
| 79076 | High amplitude reflector | P2 | 2.4 | 2.9 | A high amplitude reflector identified at the top of the interpreted Eem formation, beneath a unit of modern marine sands. Possible peat, but appears less distinct and therefore less certain. |
| 79077 | High amplitude reflector | P2 | 2.5 | 3.1 | A high amplitude reflector identified at the top of the interpreted Eem formation, beneath a unit of modern marine sands. Possible peat, but appears less distinct and therefore less certain. |
| 79078 | Cut and fill | P2 | 3.4 | 6 | A small simple cut and fill identified beneath a possible unit of peat, overlain by a unit of modern marine sediments, cutting into the interpreted Eem formation. Feature has a distinct basal reflector and fill characterised by sub-horizontal reflectors, possibly indicating well-layered fill. Possible remnants of a buried fluvial feature. |

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|---|---|---|---|---|---|
| 79079 | High amplitude reflector | P2 | 2.4 | 3.1 | A high amplitude reflector identified at the top of the interpreted Eem formation, beneath a unit of modern marine sands. Possible peat, but appears less distinct and therefore less certain. |
| 79080 | High amplitude reflector | P2 | 10.2 | 13.4 | A distinct, intermittent and slightly undulating, high amplitude reflector identified as a relatively extensive horizon at the base of an acoustically quiet unit, interpreted as the possible Eem formation. It is noted in DINOloket that the lower boundary of the Eem formation has localised areas of Gyttja at its base, and therefore it is possible that the high amplitude reflector mapped here represents that. As the Eem formation was deposited in a maritime setting, the sediments associated with it are unlikely to be of archaeological interest. However, as the unit is not definitively the Eem formation, the feature has been retained here as of possible interest. |
| 79081 | High amplitude reflector | P2 | 2.2 | 2.9 | A high amplitude reflector identified at the top of the interpreted Eem formation, beneath a unit of modern marine sands. Possible peat, but appears less distinct and therefore less certain. Identified at the edge of a n interpreted channel feature. |
| 79082 | Channel | P1 | 2.7 | 10.6 | A channel identified beneath a thin unit of modern marine sand, cutting into the interpreted Eem formation. Feature has a distinct basal reflector and fill characterised by faint, horizontal reflectors which may indicate some well-layered sediments. |
| 79083 | High amplitude reflector | P1 | 2.1 | 6.2 | A distinct, high amplitude reflector identified at the top of the interpreted Eem formation, beneath a unit of modern marine sands. Feature appears to be dip down slightly in places, possible where it is infilling slight depressions in the top of the underlying sediment. Possible peat. |
| 79084 | High amplitude reflector | P2 | 11 | 15.3 | A distinct, intermittent and slightly undulating, high amplitude reflector identified as a relatively extensive horizon at the base of an acoustically quiet unit, interpreted as the possible Eem formation. It is noted in DINOloket that the lower boundary of the Eem formation has localised areas of Gyttja at its base, and therefore it is possible that the high amplitude reflector mapped here represents that. As the Eem formation was deposited in a maritime setting, the sediments associated with it are unlikely to be of archaeological interest. However, as the unit is not definitively the Eem formation, the feature has been retained here as of possible interest. |
| 79085 | High amplitude reflector | P1 | 2.3 | 3.4 | A distinct, high amplitude reflector identified at the top of the interpreted Eem formation, beneath a unit of modern marine sands. Feature appears to be dip down slightly in places, possible where it is infilling slight depressions in the top of the underlying sediment. Possible peat. |

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| 79086 | High amplitude reflector | P2 | 2.2 | 3.1 | A distinct, high amplitude reflector identified at the top of the interpreted Eem formation, beneath a unit of modern marine sands. Feature appears to be dip down slightly in places, possible where it is infilling slight depressions in the top of the underlying sediment. Corresponds with a layer of clay with frequent organic matter identified in 553-VC-B08-360, which may indicate a former terrestrial surface however its origins are less certain. |
| 79087 | High amplitude reflector | P2 | 11.7 | 12.8 | A distinct, intermittent and slightly undulating, high amplitude reflector identified at the base of an acoustically quiet unit, interpreted as the possible Eem formation. It is noted in DINOloket that the lower boundary of the Eem formation has localised areas of Gyttja at its base, and therefore it is possible that the high amplitude reflector mapped here represents that. As the Eem formation was deposited in a maritime setting, the sediments associated with it are unlikely to be of archaeological interest. However, as the unit is not definitively the Eem formation, the feature has been retained here as of possible interest. Possibly related to nearby feature **79088**. |
| 79088 | High amplitude reflector | P2 | 11.4 | 13.5 | A distinct, intermittent and slightly undulating, high amplitude reflector identified at the base of an acoustically quiet unit, interpreted as the possible Eem formation. It is noted in DINOloket that the lower boundary of the Eem formation has localised areas of Gyttja at its base, and therefore it is possible that the high amplitude reflector mapped here represents that. As the Eem formation was deposited in a maritime setting, the sediments associated with it are unlikely to be of archaeological interest. However, as the unit is not definitively the Eem formation, the feature has been retained here as of possible interest. Possibly related to nearby feature **79087**. |
| 79089 | High amplitude reflector | P1 | 2.1 | 4.3 | A distinct, high amplitude reflector identified at the top of the interpreted Eem formation, beneath a unit of modern marine sands. Feature appears to be dip down slightly in places, possible where it is infilling slight depressions in the top of the underlying sediment. Feature corresponds with a layer of peat identified in vibrocore 553-VC-B08-362. |
| 79090 | Cut and fill | P1 | 2.1 | 6.6 | A small simple cut and fill identified beneath a unit of modern marine sediments, cutting into the interpreted Eem formation. Feature has a distinct basal reflector and is seen to be flanked towards the south-east by a high amplitude reflector, possibly peat. Unit fill was found by vibrocore 553-VC-B08-363 to comprise a unit of low-strength clay, interlaminated in places with sand, with peat at the base. Possible remnants of a buried fluvial feature. |

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| 79091 | High amplitude reflector | P1 | 1.6 | 4.7 | A distinct, high amplitude reflector identified at the top of the interpreted Eem formation, beneath a unit of modern marine sands. Feature appears to be dip down slightly in places, possible where it is infilling slight depressions in the top of the underlying sediment. Feature is located south-east of cut and fill **79090** and is possibly related. Possible peat. |
| 79092 | High amplitude reflector | P1 | 1.8 | 6.6 | A distinct, high amplitude reflector identified at the top of the interpreted Eem formation, beneath a unit of modern marine sands. Feature appears to be dip down slightly in places, possible where it is infilling slight depressions in the top of the underlying sediment. Feature corresponds with a thin band of brown clayey peat identified in vibrocore 553-VC-B08-364. |
| 79093 | High amplitude reflector | P1 | 1.6 | 2.4 | A distinct, high amplitude reflector identified at the top of the interpreted Eem formation, beneath a unit of modern marine sands. Feature appears to be dip down slightly in places, possible where it is infilling slight depressions in the top of the underlying sediment. Possible peat. |
| 79094 | High amplitude reflector | P2 | 1.8 | 3.1 | A distinct, high amplitude reflector identified at the top of the interpreted Eem formation, beneath a unit of modern marine sands. Close to simple cut and fill and possible associated. |
| 79095 | Cut and fill | P2 | 2.2 | 5.9 | A shallow simple cut and fill identified beneath a veneer of seabed sediments, cutting into the interpreted Eem formation. |
| 79096 | High amplitude reflector | P2 | 1.6 | 2.1 | A high amplitude reflector identified at the top of the interpreted Eem formation, beneath a unit of modern marine sands. Possible peat, but appears less distinct and therefore less certain. |
| 79097 | High amplitude reflector | P2 | 1.6 | 2.2 | A high amplitude reflector identified at the top of the interpreted Eem formation, beneath a unit of modern marine sands. Possible peat, but appears less distinct and therefore less certain. |
| 79098 | Cut and fill | P2 | 3.4 | 6 | A small simple cut and fill identified beneath a possible unit of peat, overlain by a unit of modern marine sediments, cutting into the interpreted Eem formation. Feature has a distinct basal reflector and fill characterised by sub-horizontal reflectors, possibly indicating well-layered fill. Possible remnants of a buried fluvial feature. |
| 79099 | High amplitude reflector | P2 | 1.3 | 2 | A high amplitude reflector identified at the top of the interpreted Eem formation, beneath a unit of modern marine sands. Feature appears to be dip down slightly in the top of the underlying sediment. Possible peat infilling depression or shallow cut and fill. |

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| 79100 | High amplitude reflector | P2 | 2 | 4.2 | A high amplitude reflector identified at the top of the interpreted Eem formation, beneath a unit of modern marine sands. Feature appears to be dip down slightly in the top of the underlying sediment. Possible peat infilling depression or shallow cut and fill. |
| 79101 | High amplitude reflector | P1 | 1.8 | 6.6 | A distinct, high amplitude reflector identified at the top of the interpreted Eem formation, beneath a unit of modern marine sands. Feature appears to be dip down slightly in places, possible where it is infilling slight depressions in the top of the underlying sediment. Feature may correspond with a thin band with pockets of clayey peat identified between 0.66-0.72 m in vibrocore 553-VC-B08-370, although this appears to be shallower than identified in the geophysical data and therefore is less certain. Feature possibly represents a former terrestrial landscape. |
| 79102 | High amplitude reflector | P2 | 1.4 | 5.1 | A high amplitude reflector identified beneath a veneer of modern marine sands. Feature appears to be overlaying a unit with faint, dipping reflectors, possibly a poorly defined cut and fill although this isn't clear. Possible peat, but appears less distinct and therefore less certain. |
| 79103 | High amplitude reflector | P1 | 1.5 | 1.9 | A high amplitude reflector identified at the top of the interpreted Eem formation, beneath a unit of modern marine sands. Appears slightly inset. Possible peat infilling a slight depression but less certain. |
| 79104 | Channel | P1 | 2 | 8.8 | A channel feature identified beneath a veneer of modern marine sediments. Feature had a well defined basal reflector and fill characterised by numerous dipping reflectors. Unit fill was found by vibrocore 553-VC-B08-372 to comprise a unit of low-strength clay with peat at the base. |
| 79105 | Channel | P1 | 1.5 | 18.1 | A complex, multiphase channel feature identified cutting into the interpreted Eem formation, overlain by a distinct, high-amplitude reflector. Feature has a poorly-defined basal reflector and multiple phases of cut and fill, some of which are characterised by numerous dipping reflectors. Unit fill was found by vibrocore 553-VC-B08-373 to comprise clay and sand with band of clay, overlain with clay with pockets of peat. |
| 79106 | High amplitude reflector | P2 | 1.3 | 1.9 | A high amplitude reflector identified at the top of the interpreted Eem formation, beneath a unit of modern marine sands. Possible peat, but appears less distinct and therefore less certain. |

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| 79107 | High amplitude reflector | P1 | 1.3 | 5.5 | A high amplitude reflector identified at the top of the interpreted Eem, or possibly Boxtel formation, beneath a unit of modern marine sands. Appears slightly inset in places. Feature sampled by vibrocores 553-VC-B08-376 to 381 which indicate clay overlying sand, with some occasional areas of organic matter, including a band of dark brown black fibrous peat with wood fragments in core, which may indicate a former terrestrial land surface. |
| 79108 | Cut and fill | P2 | 2.9 | 7.7 | A shallow, simple cut and fill identified below a veneer of marine sediment, cutting through a possible peat horizon. Feature had a distinct basal reflector and slightly chaotic fill. Possible remnants of a buried fluvial feature. |
| 79109 | Channel | P1 | 2.7 | 10.5 | A complex, multi-phase channel identified beneath a thin unit of modern marine sand, cutting into the interpreted Eem formation. Feature has a distinct basal reflector and an acoustically quiet lower fill and fill characterised by faint, horizontal reflectors which may indicate some well-layered sediments. Feature is flanked by a high amplitude horizon which may represent a former land surface or peat horizon. |
| 79110 | High amplitude reflector | P1 | 2 | 7.1 | A high amplitude reflector identified at the top of the interpreted Eem, or possibly Boxtel formation, beneath thin unit of modern marine sands. Appears slightly inset in places. Feature sampled by vibrocores 553-VC-B08-383 to 385 which indicate clay overlying sand, with some occasional areas of organic matter, including a band laminated peat in 553-VC-B08-383, which indicates a former terrestrial land surface. |
| 79111 | Channel | P1 | 3.4 | 8.3 | A shallow channel feature identified either beneath a veneer of modern marine sediments or a thin peat later. Feature had a well defined basal reflector and quiet fill with occasional horizontal reflectors, which may indicate sediments deposited in a low-energy environment. |
| 79112 | High amplitude reflector | P2 | 2.6 | 3.1 | A high amplitude reflector identified at the top of the interpreted Eem formation, beneath a veneer of modern marine sands. Located between two interpreted channel features. Possible peat, but less distinct and therefore less certain. |
| 79113 | Channel | P1 | 3.4 | 12.3 | A complex channel feature identified beneath a veneer of modern marine sediments. Feature had a well defined basal reflector and fill characterised by numerous horizontal reflectors, with a lower, older, acoustically quiet phase. Unit fill was found by vibrocore 553-VC-B08-386 to comprise sandy silt with thin laminations of organic matter. Close to and possibly related to channel **79114**. |

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| 79114 | Channel | P1 | 3.3 | 10.3 | A small channel feature identified beneath a thin unit of acoustically quiet sediments, possibly the Boxtel formation. Feature had a well defined basal reflector and fill characterised by numerous dipping reflectors, with a lower, older, acoustically quiet phase. Close to and possibly related to channel **79113**. |
| 79115 | High amplitude reflector | P2 | 2.4 | 7.2 | A high amplitude reflector identified at the top of the interpreted Eem formation, beneath a veneer of modern marine sands. Appears inset in places. Possible peat, but less distinct and therefore less certain. |
| 79116 | High amplitude reflector | P1 | 2.1 | 6.2 | A high amplitude reflector identified at the top of the interpreted Eem, or possibly Boxtel formation, beneath thin unit of modern marine sands. Appears slightly inset in places. Feature sampled by vibrocores 553-VC-B08-390 to 392 which indicate peat overlying sand, suggesting a former terrestrial land surface. |
| 79117 | High amplitude reflector | P2 | 2.7 | 3 | A high amplitude reflector identified at the top of the interpreted Eem formation, beneath a unit of modern marine sands. Possible peat, but appears less distinct and therefore less certain. |
| 79118 | High amplitude reflector | P2 | 2.7 | 4 | A high amplitude reflector identified at the top of the interpreted Eem formation, beneath a unit of modern marine sands. Possible peat, but appears less distinct and therefore less certain. |
| 79119 | High amplitude reflector | P2 | 3.2 | 3.3 | A high amplitude reflector identified at the top of the interpreted Eem formation, beneath a unit of modern marine sands. Possible peat, but appears less distinct and therefore less certain. |
| 79120 | High amplitude reflector | P1 | 2.6 | 3.5 | A high amplitude reflector identified at the top of the interpreted Eem formation, beneath a unit of modern marine sands. Possible peat, but appears less distinct and therefore less certain. Not definitively identified in Vibrocore 553-VC-B08-395, although a gravel sized pocket of peat was identified at 3.17 - 3.21 m. |
| 79121 | High amplitude reflector | P1 | 2.4 | 5.1 | A high amplitude reflector identified at the top of the interpreted Eem, or possibly Boxtel formation, beneath an acoustically quiet unit. Appears slightly inset in places. Feature sampled by vibrocores 553-VC-B08-396 to 553-VC-B09-401, which indicate clay with frequent pockets of dark brown fibrous peat overlying sand, with a thicker bands of peat being identified in 53-VC-B08-400 and 553-VC-B09-401, suggesting a former terrestrial land surface. |
| 79122 | Channel | P1 | 3.7 | 14.8 | A shallow channel feature identified either beneath an acoustically quiet unit which may be modern sands or potentially a member of the Boxtel formation. Feature has an undulating, occasionally poorly-defined defined basal reflector and acoustically quiet fill with, which may indicate fine-grained sediments deposited in a low-energy environment. |

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| 79123 | High amplitude reflector | P1 | 3.3 | 6.4 | A distinct, undulating high-amplitude reflector identified beneath an acoustically quiet unit which was found by Vibrocores 553-VC-B09-402 to 403 to comprise sandy silt and silty sandy clay. The base of the feature corresponds with a layer of peat, identified in both vibrocores, indicating a former terrestrial landscape. |
| 79124 | Channel | P1 | 3.7 | 11.3 | A broad, shallow channel or infilled depression identified beneath an acoustically quiet unit. Feature has an undulating, occasionally poorly-defined defined basal reflector and acoustically quiet fill, with occasional horizontal reflectors, which was found by Vibrocores 553-VC-B09-404 to 407 to comprise low-strength clay with laminations of sand and organic matter with a layer of peat corresponding with the base of the feature. |
| 79125 | Cut and fill | P2 | 2.9 | 9.1 | A shallow, simple cut and fill identified below an acoustically quiet unit, cutting through a distinct horizontal reflector, possibly representing a peat horizon although appears less distinct on this line. Feature had a faint basal reflector and acoustically quiet fill. Possible remnants of a buried fluvial feature, possibly related to **79126**. |
| 79126 | Cut and fill | P2 | 3.1 | 7 | A shallow, simple cut and fill identified below an acoustically quiet unit, cutting through a distinct horizontal reflector, possibly representing a peat horizon. Feature had a faint basal reflector and acoustically quiet fill. Possible remnants of a buried fluvial feature, possibly related to **79125**. |
| 79127 | High amplitude reflector | P1 | 2.7 | 3.7 | A distinct, high-amplitude reflector identified beneath an acoustically quiet unit which was found by Vibrocores 553-VC-B09-402 to 409 to comprise silt and clay, overlying a unit characterised by numerous horizontal reflectors, found by both vibrocores to contain peat. The base of the feature corresponds with a layer of peat, identified in both vibrocores, indicating a former terrestrial landscape. |
| 79128 | Channel | P1 | 3.4 | 10.1 | A broad, shallow channel or infilled depression identified either beneath an acoustically quiet unit. Feature has an undulating, occasionally poorly-defined defined basal reflector and acoustically quiet fill, with occasional horizontal reflectors, which was found by Vibrocores 553-VC-B09-410 to comprise lew-strength clay with laminations of sand and organic matter. A layer of peat corresponds with the base of the feature. |
| 79129 | Cut and fill | P1 | 3.6 | 15.8 | A small simple cut and fill identified beneath an acoustically quiet unit, cutting into the interpreted Eem formation. Feature has a poorly-defined basal reflector and acoustically chaotic fill. Unit fill was found by vibrocore 553-VC-B09-411 to comprise clay overlying peat. Possible remnants of a buried fluvial feature. |
| 79130 | High amplitude reflector | P2 | 3.5 | 4.1 | A high amplitude reflector identified at the top of the interpreted Eem formation, beneath unit of interpreted marine sands. Possible peat, but appears less distinct and therefore less certain. |

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| 79131 | High amplitude reflector | P2 | 3 | 3.4 | A high amplitude reflector identified at the top of the interpreted Eem formation, beneath an acoustically quiet unit. Possible peat, but appears less distinct and therefore less certain. |
| 79132 | Channel | P1 | 2.9 | 8.3 | A small channel feature identified beneath a thin unit of acoustically quiet sediments. Feature had a well defined basal reflector and appears to have slightly chaotic fill which may indicate coarse-grained sediments. |
| 79133 | Cut and fill | P1 | 3.2 | 6.7 | A small simple cut and fill identified beneath a unit an acoustically quiet unit, cutting into the interpreted Eem, or possibly Boxtel formation. Feature has a relatively distinct basal reflector and slightly acoustically chaotic fill. Unit fill was found by vibrocore 553-VC-B09-411 to comprise gravelly, sandy clay overlying sand with frequent pockets of peat. Possible remnants of a buried fluvial feature. |
| 79134 | High amplitude reflector | P1 | 2.4 | 3.7 | A distinct, high-amplitude reflector identified beneath an acoustically quiet unit which was found by Vibrocores 553-VC-B09-402 to 409 to comprise low to extremely low-strength clay. High amplitude reflector corresponds with a layer of peat, indicating a former terrestrial landscape. Located adjacent to channel feature **79135** and possibly related. |
| 79135 | Channel | P1 | 2.9 | 11 | A shallow channel feature identified either beneath an acoustically quiet unit. Feature has an undulating, occasionally poorly-defined defined basal reflector and acoustically chaotic fill, with occasional horizontal reflectors. Unit fill was found by Vibrocores 553-VC-B09-428 to comprise low-strength clay with laminations of sandy silty clay and organic material. A number of gravel-sized fragments of wood were noted at 4.76 - 4.85 m. |
| 79136 | High amplitude reflector | P2 | 1.9 | 6.7 | A high amplitude reflector identified within an upper, slightly acoustically chaotic unit interpreted as the Boxtel formation. Feature appears to be slightly inset in places. Possible shallow channel or peat, but appears less distinct and therefore less certain. |
| 79137 | Cut and fill | P1 | 0.6 | 11 | A distinct simple cut and fill identified either directly at the seabed or beneath a veneer of seabed sediments. The feature is seen to cut through a slightly acoustically chaotic unit, which may represent the Boxtel formation, into an acoustically quiet formation (possible Eem). The feature has a distinct basal reflector and some draping horizons indicating layered fill. The feature is causing blanking of lower horizons, possibly indicating the presence of gas caused by the microbial breakdown of organic matter. Vibrocore 553-VC-B09-435 found the feature fill comprises sand with pockets of peat over a thick layer of slightly clayey peat. Possible remnants of a buried fluvial feature. |

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| 79138 | Channel | P2 | 12.9 | 37.6 | A broad channel feature identified below an acoustically quiet unit interpreted as the possible Eem formation, cutting into a more acoustically chaotic unit. Feature has a relatively defined basal reflector, although this is not always clearly discernible due to the blanking caused by the overlying simple cut and fill **79137**. The feature has some faint sub horizontal reflectors, which may indicate layered sediments. Due to the uncertain age of the feature it has been discriminated as P2. |
| 79139 | Channel | P2 | 7.8 | 43.4 | A broad channel feature identified below an acoustically quiet unit interpreted as the possible Eem formation, cutting into a more acoustically chaotic unit. Feature has a relatively defined basal reflector, although this is not always clearly discernible due to depth of the feature extending beyond the SBP penetration. The feature fill is acoustically quiet with some undulating internal horizons. Due to the uncertain age of the feature it has been discriminated as P2. |
| 79140 | High amplitude reflector | P2 | 8.2 | 9.6 | A distinct, fairly extensive and slightly undulating high amplitude reflector identified at the base of an acoustically quiet unit, interpreted as the possible Eem formation. It is noted in DINOloket that the lower boundary of the Eem formation has localised areas of Gyttja at its base, and therefore it is possible that the high amplitude reflector mapped here represents that. As the Eem formation was deposited in a maritime setting, the sediments associated with it are unlikely to be of archaeological interest. However, as the unit is not definitively the Eem formation, the feature has been retained here as of possible interest. |
| 79141 | Channel | P1 | 0.8 | 8.1 | A small channel feature identified either directly at the seabed or beneath a veneer of seabed sediments. Feature had a well defined basal reflector and appears to have slightly chaotic fill which may indicate coarse-grained sediments. The feature is causing blanking of lower horizons, possibly indicating the presence of gas caused by the microbial breakdown of organic matter. Feature is cutting through an acoustically chaotic unit found by vibrocores to comprise gravelly sand. |
| 79142 | Coarse-grained deposit | P2 | 1.3 | 7.3 | An acoustically chaotic feature identified either directly at the seabed or below a veneer of seabed sediments. Feature has no clearly discernible basal reflector but is characterised by slightly chaotic fill, with occasional draping reflectors. Vibrocore 553-VC-B10-445 found the feature comprises gravelly sand. Possible channel feature or area of re-worked sediments. |
| 79143 | High amplitude reflector | P2 | 1.3 | 2.3 | A high amplitude reflector identified at the top of an acoustically chaotic unit, possibly the Boxtel formation, beneath a veneer of marine sands. Possible peat, but appears less distinct and therefore less certain. |

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| 79144 | High amplitude reflector | P2 | 1.1 | 2 | A high amplitude reflector identified at the top of an acoustically chaotic unit, possibly the Boxtel formation, beneath a veneer of marine sands. Possible peat, but appears less distinct and therefore less certain. |
| 79145 | Channel | P1 | 1.6 | 4.9 | A small channel feature identified either directly at the seabed or beneath a veneer of seabed sediments. Feature had a distinct basal reflector and possibly layered fill, although due to the shallow nature of the feature this is hard to discern. Unit fill was found by Vibrocore 553-553-VC-B10-449 to comprise low strength clay overlying a layer of peat with frequent plant fibres. |
| 79146 | High amplitude reflector | P2 | 1.4 | 1.8 | A high amplitude reflector identified at the top of an acoustically chaotic unit, possibly the Boxtel formation, beneath a veneer of marine sands. Possible peat, but appears less distinct and therefore less certain. |
| 79147 | Coarse-grained deposit | P2 | 1.3 | 8 | An acoustically chaotic feature identified either directly at the seabed or below a veneer of seabed sediments. Feature has no clearly discernible basal reflector but is characterised by slightly chaotic fill, with occasional draping reflectors. Possible channel feature or area of re-worked sediments. |
| 79148 | Cut and fill | P2 | 9.1 | 32.3 | A broad simple cut and fille identified below an occasionally acoustically chaotic unit, found by vibrocore 553-VC-B10-455 to comprise brown sand overlying grey sand with shell fragments, interpreted as the possible Boxtel formation, although this is uncertain. Feature has a relatively defined basal reflector, although this is not always clearly discernible due to depth of the feature. The feature fill is acoustically quiet with some undulating internal horizons. Possible remnants of a buried fluvial feature although may be an internal channelling feature. |
| 79149 | Coarse-grained deposit | P2 | 1.2 | 7.5 | An acoustically chaotic feature identified either directly at the seabed or below a veneer of seabed sediments. Feature has no clearly discernible basal reflector but is characterised by slightly chaotic fill, with occasional draping reflectors. Vibrocore 553-VC-B10-458 found the feature comprises gravelly sand with occasional laminae of clay and pockets of silt. Possible channel feature or area of re-worked sediments. |
| 79150 | High amplitude reflector | P2 | 11.5 | 19.5 | A distinct, high amplitude reflector identified at the base of an acoustically quiet unit, possibly infilling depressions, interpreted as the possible Eem formation. It is noted in DINOloket that the lower boundary of the Eem formation has localised areas of Gyttja at its base, and therefore it is possible that the high amplitude reflector mapped here represents that, although it may also represent internal channelling within a unit. Due to the uncertainty of the features formation and depositional environment, the feature has been retained here as of possible interest. |

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| 79151 | High amplitude reflector | P2 | 11.4 | 12.6 | A distinct, high amplitude reflector identified at the base of an acoustically quiet unit, possibly infilling depressions, interpreted as the possible Eem formation. It is noted in DINOloket that the lower boundary of the Eem formation has localised areas of Gyttja at its base, and therefore it is possible that the high amplitude reflector mapped here represents that. As the Eem formation was deposited in a maritime setting, the sediments associated with it are unlikely to be of archaeological interest. However, as the unit is not definitively the Eem formation, the feature has been retained here as of possible interest. |
| 79152 | Coarse-grained deposit | P2 | 1.2 | 11.1 | An acoustically chaotic feature identified either directly at the seabed or below a veneer of seabed sediments. Feature has no clearly discernible basal reflector but is characterised by slightly chaotic fill which appear to cut through into the underlying acoustically quiet unit. Vibrocore 553-VC-B10-463 found the feature comprises gravelly sand with laminae of dark brown silty organic material between 3.58 and 3.61 m. Possible channel feature or area of re-worked sediments. |
| 79153 | Cut and fill | P2 | 5.3 | 6.5 | A small simple cut and fill identified beneath an acoustically chaotic unit interpreted as the possible Boxtel formation. Feature had a distinct basal reflector and acoustically chaotic fill similar to the overlying unit. Possible remnants of a buried fluvial feature or shallow infilled depression. |
| 79154 | Cut and fill | P2 | 4.9 | 9.2 | A small simple cut and fill identified beneath an acoustically chaotic unit interpreted as the possible Boxtel formation. Feature had a distinct basal reflector and acoustically chaotic fill similar to the overlying unit. Possible remnants of a buried fluvial feature or shallow infilled depression. |
| 79155 | Cut and fill | P2 | 4.3 | 8.1 | A small simple cut and fill identified beneath an acoustically chaotic unit interpreted as the possible Boxtel formation. Feature had a distinct basal reflector and acoustically chaotic fill similar to the overlying unit. Possible remnants of a buried fluvial feature or shallow infilled depression. |
| 79156 | Coarse-grained deposit | P2 | 3.3 | 11.9 | A possible coarse-grained deposit identified beneath, or possibly truncated by, an overlying acoustically quiet unit. Feature has a distinct basal reflector and slightly acoustically chaotic fill. Possible re-worked sediments or may be gravelly sediments related to the overlying feature. |
| 79157 | High amplitude reflector | P1 | 3.3 | 4.4 | A distinct, high-amplitude reflector identified beneath an acoustically quiet unit which was found by Vibrocores 553-VC-B10-465 to comprise slightly gravelly sand with shell fragments. The feature corresponds with a layer of peat, indicating a former terrestrial landscape. |

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| 79158 | Cut and fill | P2 | 1.5 | 10.7 | A small possible channel feature identified either directly BSB or beneath a veneer of seabed sediments. Feature doesn't have a clearly definable basal reflector, however fill is characterised by acoustically chaotic fill. |
| 79159 | Cut and fill | P2 | 7.5 | 15.3 | A possible infilled depression or simple cut and fill identified beneath a slightly acoustically chaotic upper unit found by vibrocore 553-VC-B10-472 to comprise slightly gravelly silty sand. Feature fill is characterised by numerous sub-horizontal reflectors, possibly indicating cross-bedding. |
| 79160 | High amplitude reflector | P1 | 1.8 | 4.6 | A distinct, high amplitude reflector identified at the top of a unit of sand, beneath thin unit characterised by numerous horizontal reflector, possibly indicating well-layered sediments. Appears slightly inset in places. Feature sampled by vibrocore 553-VC-B10-476 which indicates thinly laminated clay overlying gravelly sand. The feature is identified to one side of a channel feature, and may represent associated fine-grained deposits such as overbank deposits. |
| 79161 | Channel | P1 | 2.7 | 10.6 | A distinct , complex channel feature identified beneath a thin acoustically quiet unis, cutting into a more acoustically chaotic unit. Feature has a relatively distinct basal reflector and fill characterised by at least two separate phases of fill, the upper if which is characterised by numerous sub-horizontal reflectors indicating layered sediments. |
| 79162 | High amplitude reflector | P2 | 9.7 | 13.3 | A distinct, high amplitude reflector identified beneath a channel feature. Feature may represent an internal reflector within the underlying sediment, however it has the potential of representing the basal reflector of an earlier phase of cut and fill related to overlying channel **79161**; and, as such, has been retained as a precaution. |
| 79163 | High amplitude reflector | P1 | 2.3 | 4.2 | A distinct, high amplitude reflector identified at the top of a unit of sand, beneath thin unit characterised by numerous horizontal reflector, possibly indicating well-layered sediments. Appears slightly inset in places. Feature sampled by vibrocore 553-VC-B10-477 which indicates sandy silt with thick laminations of clay overlying sand. The feature is identified to one side of a channel feature, and may represent associated fine-grained deposits such as overbank deposits. |
| 79164 | High amplitude reflector | P2 | 2.1 | 2.5 | A distinct, high amplitude reflector identified at the edge of an interpreted channel feature (**79165**), beneath a thin acoustically quiet unit of possible marine sands. The feature may represent associated fine-grained deposits such as overbank deposits. |

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| 79165 | Channel | P1 | 2.2 | 11.5 | A distinct, complex channel feature identified beneath a thin unit of marine sands, cutting into a generally acoustically quiet unit, possibly representing the Eem formation. Feature has a distinct basal reflector and at least 2 phases of cut and fill, with unit fill characterised by numerous sup-horizonal reflectors. Unit fill was found by vibrocore 553-VC-B10-479 to comprise slightly sandy silt with frequent thin laminae of brown organic matter. |
| 79166 | High amplitude reflector | P2 | 2.3 | 2.7 | A high amplitude reflector identified at the top of a slightly acoustically chaotic unit, possibly the Boxtel formation, beneath a veneer of marine sands. Possible peat, but appears less distinct and therefore less certain. |
| 79167 | High amplitude reflector | P2 | 1.5 | 1.6 | A high amplitude reflector identified at the top of a slightly acoustically chaotic unit, found by nearby vibrocore 553-VC-B10-484 to comprise sand, beneath a veneer of marine sands. Possible peat, but appears less distinct and therefore less certain. |
| 79168 | High amplitude reflector | P2 | 1.5 | 2 | A high amplitude reflector identified at the top of a slightly acoustically chaotic unit, found by nearby vibrocore 553-VC-B10-483 to comprise sand, beneath a veneer of marine sands. Possible peat, but appears less distinct and therefore less certain. |
| 79169 | High amplitude reflector | P2 | 1.3 | 2 | A high amplitude reflector identified at the top of a slightly acoustically chaotic unit beneath a veneer of marine sands. Feature possibly corresponds with a sand unit with pockets of brown organic matter and gravelly sand identified by vibrocore 553-VC-B10-484 although these appear to be slightly shallower than identified in the geophysical data. Possible former terrestrial surface, but appears less distinct and therefore less certain. |
| 79170 | High amplitude reflector | P2 | 1.4 | 2 | A high amplitude reflector identified at the top of a slightly acoustically chaotic unit, beneath a veneer of marine sands. Close to channel feature **79171** and possibly related. Possible peat, but appears less distinct and therefore less certain. |
| 79171 | Channel | P1 | 1 | 8.8 | A distinct channel feature identified either directly at the seabed or beneath a veneer of marine sediments. Feature has a distinct basal reflector and acoustically chaotic fill which appears to cause blanking of lower horizons, possibly indicating the presence of gas caused by the microbial breakdown of organic matter. Feature was sampled by vibrocore 553-VC-B10-486 and found to comprise extremely low-strength clay overlying peat with occasional thin laminae of clay. |

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| 79172 | High amplitude reflector | P2 | 6.4 | 7.5 | A high amplitude reflector identified at the top of a slightly acoustically chaotic unit, beneath a veneer of marine sands. Possibly an internal reflector; however, as there is the possibility of the feature representing peat it has been retained as a precaution. |
| 79173 | High amplitude reflector | P2 | 7 | 7.2 | A high amplitude reflector identified at the top of a slightly acoustically chaotic unit, beneath a veneer of marine sands. Possibly an internal reflector; however, as there is the possibility of the feature representing peat it has been retained as a precaution. |
| 79174 | High amplitude reflector | P2 | 7 | 7.3 | A high amplitude reflector identified at the top of a slightly acoustically chaotic unit, beneath a veneer of marine sands. Possibly an internal reflector; however, as there is the possibility of the feature representing peat it has been retained as a precaution. |
| 79175 | High amplitude reflector | P2 | 7.1 | 7.2 | A high amplitude reflector identified at the top of a slightly acoustically chaotic unit, beneath a veneer of marine sands. Possibly an internal reflector; however, as there is the possibility of the feature representing peat it has been retained as a precaution. |
| 79176 | High amplitude reflector | P2 | 6.9 | 7.2 | A high amplitude reflector identified at the top of a slightly acoustically chaotic unit, beneath a veneer of marine sands. Possibly an internal reflector; however, as there is the possibility of the feature representing peat it has been retained as a precaution. |
| 79177 | High amplitude reflector | P2 | 5.8 | 6.7 | A high amplitude reflector identified at the top of a slightly acoustically chaotic unit, beneath a veneer of marine sands. Possibly an internal reflector or base of the upper sand unit; however, as there is the possibility of the feature representing peat it has been retained as a precaution. |
| 79178 | Channel | P1 | 6.8 | 12.7 | A small possible channel feature identified below the upper unit, found by nearby vibrocore 553-VC-B10-493 to comprise gravelly sand with shell fragments. Feature has a distinct basal reflector and acoustically chaotic fill, with occasional faint draping reflectors. |
| 79179 | High amplitude reflector | P2 | 6 | 6.8 | A high amplitude reflector identified at the top of a slightly acoustically chaotic unit, beneath a veneer of sands. Vibrocore 553-VC-B10-494 notes a thick laminae of organic matter at 5.30 - 5.31 m which may be associated, although this is shallower than identified in the geophysical data and may therefore be unrelated. Possibly an internal reflector or base of the upper sand unit; however, as there is the possibility of the feature representing peat it has been retained as a precaution. |

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| 79180 | Cut and fill | P2 | 1.3 | 12.8 | A possible complex cut and fill identified cutting through the upper sand unit. Basal reflector hard to discern however may extend to the seabed. Unit fill appears to be slightly chaotic with at least two phases of fill. Possible cut and fill however may also be re-worked sediments. |
| 79181 | High amplitude reflector | P2 | 0.9 | 1.6 | A distinct high amplitude reflector identified close to the seabed, beneath a possible veneer of modern marine sediments. Feature is overlying an acoustically chaotic unit, possibly the Boxtel formation. Possible peat, but appears less distinct and therefore less certain. |
| 79182 | High amplitude reflector | P2 | 1.2 | 1.6 | A distinct high amplitude reflector identified close to the seabed, beneath a possible veneer of modern marine sediments. Feature is overlying an acoustically chaotic unit, possibly the Boxtel formation. Possible peat, but appears less distinct and therefore less certain. |
| 79183 | Channel | P2 | 5.7 | 32.7 | A distinct channel feature identified beneath an upper acoustically chaotic unit found by vibrocore 553-VC-B10-499 as gravelly sand with some layers containing shell fragments. Feature has a distinct basal reflector and acoustically quiet fill and some faint, draping reflectors which may have just been sampled by vibrocore 553-VC-B10-499 and found to comprise  firm to stiff silty clay. |
| 79184 | Cut and fill | P2 | 5.7 | 13.2 | A simple cut and fill identified on one line beneath an upper acoustically chaotic unit, possibly the Boxtel formation. Feature has a relatively defined basal reflector and acoustically quiet fill indicating fine-grained deposits. Possible remnants of a buried fluvial feature or may be an internal reflector. |
| 79185 | Channel | P1 | 0.8 | 6.5 | A distinct channel feature identified either directly at the seabed or beneath a veneer of seabed sediments, upper acoustically chaotic unit interpreted as the possible Boxtel formation. Feature has a distinct basal reflector and fill characterised by numerous sub-horizontal reflectors indicating well-layered sediments. Unit fill was found by vibrocore 553-VC-B10-501 to comprise silt with frequent thin laminae of brown organic matter overlying peat. |
| 79186 | Channel | P1 | 4.4 | 16.9 | A distinct channel feature identified beneath an upper acoustically chaotic unit interpreted as the possible Boxtel formation. Feature has a distinct basal reflector and acoustically quiet fill and some faint, draping reflectors. Possibly related to nearby feature **79187**. |
| 79187 | Cut and fill | P2 | 3.8 | 8.3 | A simple cut and fill identified beneath an upper acoustically chaotic unit interpreted as the possible Boxtel formation. Feature has a distinct basal reflector and acoustically quiet fill and some faint, draping reflectors. Possible remnants of a buried fluvial feature related to nearby feature **79186**. |

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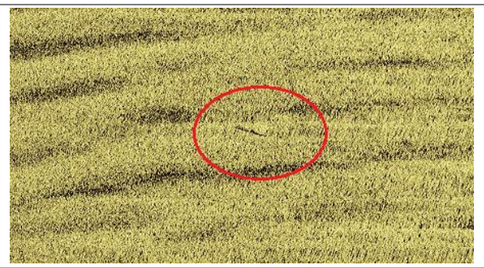
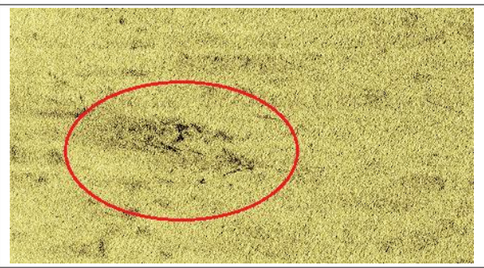
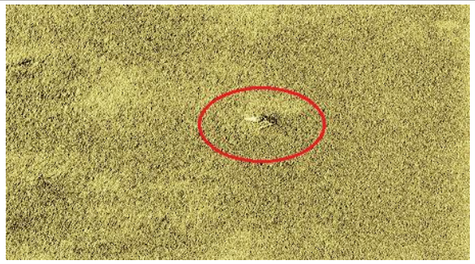
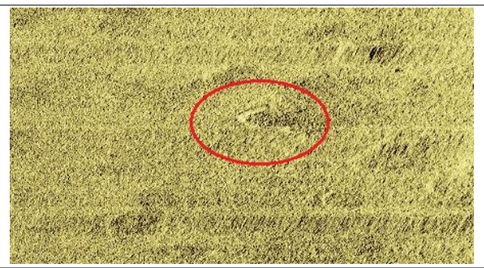
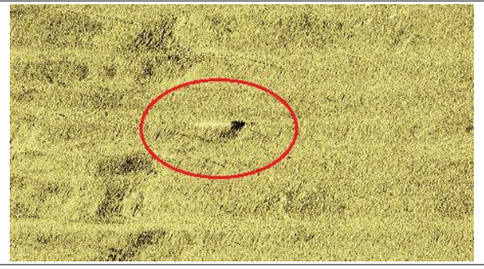
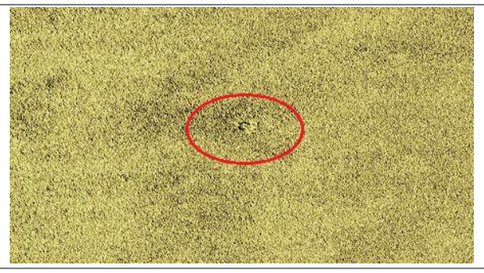
| 79188 | Cut and fill | P2 | 2.2 | 11.6 | A small, simple cut and fill identified beneath the upper acoustically quiet unit. Feature has a relatively distinct basal reflector and acoustically quiet fill, indicating fine-grained sediments. Possible remnants of a buried fluvial feature. |
| 79189 | Cut and fill | P2 | 3 | 8.6 | A simple cut and fill feature identified beneath the upper acoustically quiet unit, with a relatively defined basal reflector and fill characterised by numerous draping reflectors indicating layered fill. Feature was found by vibrocore 553-VC-B12-520 to comprise sandy silt with thin to thick bands of sand. Possible remnants of a buried fluvial feature. |
| 79190 | High amplitude reflector | P2 | 10.6 | 12.8 | A distinct, high amplitude reflector identified slightly to the south-west of the base of channel feature **79165**. Feature may represent an internal reflector within the underlying sediment, however it has the potential of representing the basal reflector of an earlier phase of cut related to overlying channel **79165**; and, as such, has been retained as a precaution. |

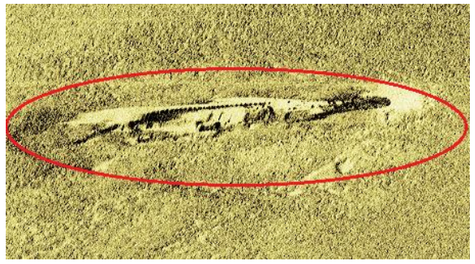
## Appendix 4: Seabed features of archaeological potential

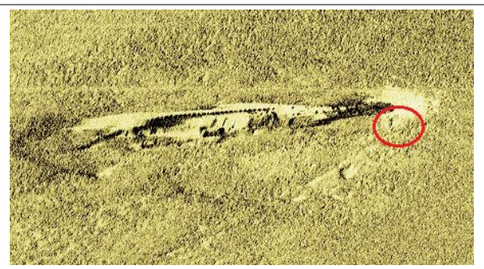
| ID | Classification | Easting | Northing | Archaeological discrimination | Length (m) | Width (m) | Height (m) | Depth below seabed (m) | Magnetic amplitude (nT) | Description | Images of possible archaeological features with surface expression | Anomaly type | External references |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **7472** | Debris | 512057 | 5862960 | A2 | 5.9 | 5.6 | - | - | - | Originally identified during the 2019 assessment of priority areas as a medium sized, distinct, rectangular dark reflector with no discernible shadow that is situated in an area of sand ripples. The feature is possibly slightly broken up or partially buried. Possible item of debris. | | SSS | - |
| **7500** | Magnetic | 516415 | 5877111 | A2 | - | - | - | - | 14 | Identified in the Mag. data as a small, broad dipole with peak and trough on one survey line. No corresponding SSS or MBES contact. May represent possible ferrous debris with no surface expression. | | Mag. | - |
| **7501** | Magnetic | 517527 | 5882038 | A2 | - | - | - | - | 36 | Identified in the Mag. data as a small dipole with peak and trough on one survey line. No corresponding SSS or MBES contact. May represent possible ferrous debris with no surface expression. | | Mag. | - |
| **7502** | Magnetic | 517803 | 5882229 | A2 | - | - | - | - | 17 | Identified in the Mag. data as a small, broad dipole with peak and trough over two survey lines. No corresponding SSS or MBES contact. May represent possible ferrous debris with no surface expression. | | Mag. | - |
| **7503** | Magnetic | 517998 | 5884113 | A2 | - | - | - | - | 17 | Identified in the Mag. data as a small, broad dipole with peak and trough on one survey line. No corresponding SSS or MBES contact. May represent possible ferrous debris with no surface expression. | | Mag. | - |
| **7504** | Magnetic | 519195 | 5888047 | A2 | - | - | - | - | 15 | Identified in the Mag. data as a small positive monopole with peak and trough on one survey line. No corresponding SSS or MBES contact. May represent possible ferrous debris with no surface expression or a natural feature. | | Mag. | - |
| **7505** | Magnetic | 519381 | 5890167 | A2 | - | - | - | - | 11 | Identified in the Mag. data as a small positive monopole with peak and trough on one survey line. Possibly part of a linear trend with 7506 and 7507. No corresponding SSS or MBES contact. May represent possible ferrous debris with no surface expression or a modern anthropogenic feature. It should be noted that the feature is located approximately 150 m north-east of the UK-Germany 3 cable, and may therefore represent that. However, as this cannot be confirmed without further investigation, the feature has been retained as a precaution. | | Mag. | - |
| **7506** | Magnetic | 519479 | 5890232 | A2 | - | - | - | - | 20 | Identified in the Mag. data as a small positive monopole with peak and trough on one survey line. Possibly part of a linear trend with 7505 and 7507. No corresponding SSS or MBES contact. May represent possible ferrous debris with no surface expression or a modern anthropogenic feature. It should be noted that the feature is located approximately 150 m north-east of the UK-Germany 3 cable, and may therefore represent that. | | Mag. | - |

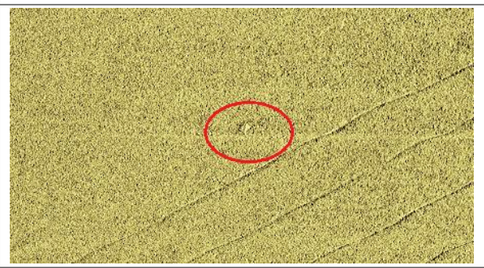
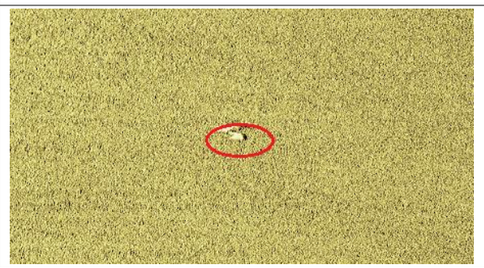
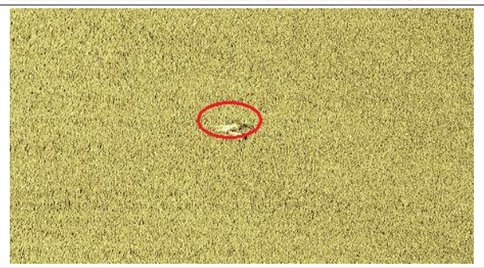
| ID | Classification | Easting | Northing | Archaeological discrimination | Length (m) | Width (m) | Height (m) | Depth below seabed (m) | Magnetic amplitude (nT) | Description | Images of possible archaeological features with surface expression | Anomaly type | External references |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | However, as this cannot be confirmed without further investigation, the feature has been retained as a precaution. | | | |
| **7507** | Magnetic | 519736 | 5890316 | A2 | - | - | - | - | 14 | Identified in the Mag. data as a small positive monopole with peak and trough on one survey line. Possibly part of a linear trend with 7505 and 7506. No corresponding SSS or MBES contact. May represent possible ferrous debris with no surface expression or a modern anthropogenic feature. It should be noted that the feature is located approximately 150 m north-east of the UK-Germany 3 cable, and may therefore represent that. However, as this cannot be confirmed without further investigation, the feature has been retained as a precaution. | | Mag. | - |
| **7508** | Dark reflector | 521532 | 5897505 | A2 | 4.5 | 0.3 | - | - | - | Identified in the SSS data as a short, straight, elongate dark reflector with no clearly discernible height. No corresponding MBES or Mag. contact. Possible non-ferrous debris or a natural feature. |  | SSS | - |
| **7509** | Magnetic | 522863 | 5901510 | A2 | - | - | - | - | 7 | Identified in the Mag. data as a small negative monopole with peak and trough on one survey line. Broad, but distinct. No corresponding SSS or MBES contact. May represent possible ferrous debris with no surface expression. | | Mag. | - |
| **7510** | Magnetic | 523555 | 5904479 | A2 | - | - | - | - | 9 | Identified in the Mag. data as a small, broad dipole with peak and trough on one survey line. No corresponding SSS or MBES contact. May represent possible ferrous debris with no surface expression. | | Mag. | - |
| **7511** | Magnetic | 524275 | 5906445 | A2 | - | - | - | - | 33 | Identified in the Mag. data as a small negative monopole with peak and trough on one survey line. Broad, but distinct along the line of data. No corresponding SSS or MBES contact. May represent possible ferrous debris with no surface expression. | | Mag. | - |
| **7513** | Magnetic | 525525 | 5911357 | A2 | - | - | - | - | 15 | Identified in the Mag. data as a small, broad dipole with peak and trough over two survey lines. No corresponding SSS or MBES contact. May represent possible ferrous debris with no surface expression. | | Mag. | - |
| **7514** | Magnetic | 525879 | 5912325 | A2 | - | - | - | - | 5 | Identified in the Mag. data as a small negative monopole with peak and trough on one survey line. No corresponding SSS or MBES contact. May represent possible ferrous debris with no surface expression. | | Mag. | - |

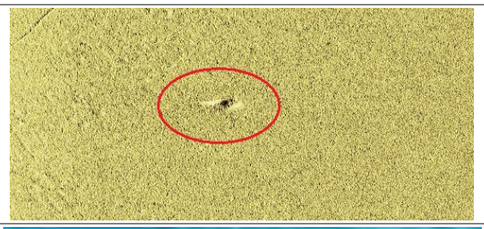
| ID | Classification | Easting | Northing | Archaeological discrimination | Length (m) | Width (m) | Height (m) | Depth below seabed (m) | Magnetic amplitude (nT) | Description | Images of possible archaeological features with surface expression | Anomaly type | External references |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **7515** | Seabed disturbance | 527204 | 5917445 | A2 | 24.5 | 18.9 | - | - | - | Identified in the SSS data as an irregular area of seabed with patches of high reflectivity. No corresponding MBES or Mag. contact. Possible non-ferrous debris or a natural feature. |  | SSS | - |
| **7516** | Magnetic | 527776 | 5918851 | A2 | - | - | - | - | 11 | Identified in the Mag. data as a small negative monopole with peak and trough over two survey lines. No corresponding SSS or MBES contact. May represent possible ferrous debris with no surface expression. | | Mag. | - |
| **7517** | Buried object | 528669 | 5920182 | A2 | - | - | - | 2.0 | - | A buried feature identified in the SBP data as a parabola, with a disturbance to the surrounding sediment extending approximately 100 m to the south-west. Feature is seen to cause blanking of the lower horizons. As the feature is within the interpreted modern Holocene sediments, it is unlikely to be of palaeoenvironmental interest, however it has the potential of being a buried anthropogenic feature. Feature may represent an object, and associated area of dredging, related to modern infrastructure, although there is nothing identified at this location on the admiralty charts. Possible buried debris item of natural feature. | | SBP | - |
| **7518** | Magnetic | 530008 | 5923592 | A2 | - | - | - | - | 17 | Identified in the Mag. data as a small negative monopole with peak and trough on one survey line. No corresponding SSS or MBES contact. May represent possible ferrous debris with no surface expression. | | Mag. | - |
| **7519** | Magnetic | 530106 | 5923839 | A2 | - | - | - | - | 11 | Identified in the Mag. data as a small negative monopole with peak and trough on one survey line. No corresponding SSS or MBES contact. May represent possible ferrous debris with no surface expression. | | Mag. | - |
| **7474** | Recorded Wreck | 530737 | 5925181 | A3 | - | - | - | - | - | Position of a recorded wreck in the UKHO record. The position is for a steel wreck and was first reported in 1971. The record has since been amended to dead. During the 2019 assessment of priority areas, a very faint and straight dark reflector measuring 4.7 x 0.8 m was identified 57.0 m east of a recorded wreck position; however, this was deemed to be natural and of no relation to the recorded wreck position. No evidence of the wreck was identified in the geophysical data. | | SSS | 28293 (UKHO) |
| **7520** | Magnetic | 530776 | 5925585 | A2 | - | - | - | - | 14 | Identified in the Mag. data as a distinct, small negative monopole with peak and trough over two survey lines. No corresponding SSS or MBES contact. May represent possible ferrous debris with no surface expression. | | Mag. | - |

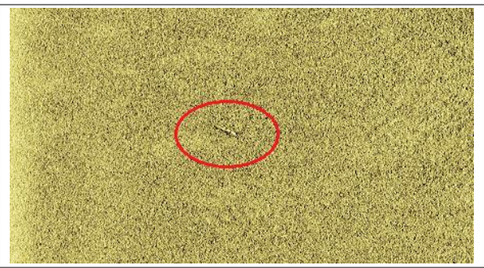
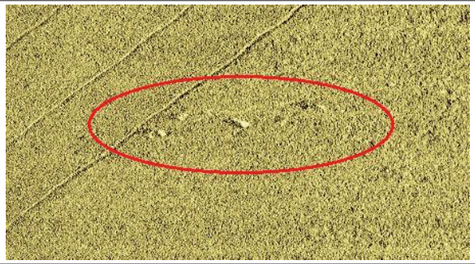
| ID | Classification | Easting | Northing | Archaeological discrimination | Length (m) | Width (m) | Height (m) | Depth below seabed (m) | Magnetic amplitude (nT) | Description | Images of possible archaeological features with surface expression | Anomaly type | External references |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **7521** | Dark reflector | 531060 | 5925962 | A2 | 4.0 | 2.9 | 0.5 | - | - | Identified in the SSS data as a curved, elongate dark reflector, with a faint shadow. Appears isolated on the seabed. In the MBES data, this was seen as a small, distinct mound, squared in plan, with gently sloped sides. This appears anomalous for the area. No corresponding Mag. contact. Possible non-ferrous debris or a natural feature. |  | SSS, MBES | - |
| **7522** | Magnetic | 532964 | 5927977 | A2 | - | - | - | - | 7 | Identified in the Mag. data as a small, broad dipole with peak and trough on one survey line. No corresponding SSS or MBES contact. May represent possible ferrous debris with no surface expression. | | Mag. | - |
| **7523** | Bright reflector | 536049 | 5928981 | A2 | 5.7 | 4.9 | - | - | - | Identified in the SSS data as a small, slightly elongate bright reflector, which possibly extends out on one side to form an 'L' shape. Possibly a shadow of a poorly defined dark reflector although this is not clear. No corresponding MBES or Mag. contact. Possible non-ferrous debris or a natural feature. |  | SSS | - |
| **7524** | Dark reflector | 536662 | 5929287 | A2 | 2.3 | 2.0 | 0.6 | - | - | Identified in the SSS data as a small but distinct dark reflector with height. In the MBES data, this was seen as a small distinct mound, with a slightly squared plan. Appears anomalous. No corresponding Mag. contact. Possible non-ferrous debris or a natural feature. |  | SSS, MBES | - |
| **7525** | Magnetic | 538234 | 5929501 | A2 | - | - | - | - | 6 | Identified in the Mag. data as a small negative monopole with peak and trough on one survey line. No corresponding SSS or MBES contact. May represent possible ferrous debris with no surface expression. | | Mag. | - |
| **7526** | Dark reflector | 539154 | 5929422 | A2 | 3.1 | 1.7 | - | - | - | Identified in the SSS data as a small, narrow, elongate dark reflector that appears to curve round in a 'C' shape. Identified within a small patch of disturbed sediment. Feature appears isolated on the seabed. No corresponding MBES or Mag. contact. Possible non-ferrous debris or a natural feature. |  | SSS | - |

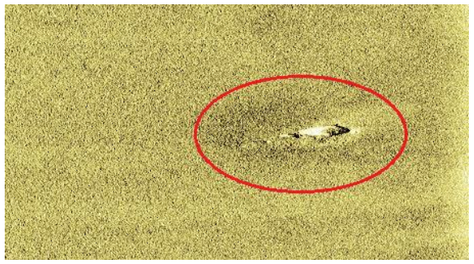
| ID | Classification | Easting | Northing | Archaeological discrimination | Length (m) | Width (m) | Height (m) | Depth below seabed (m) | Magnetic amplitude (nT) | Description | Images of possible archaeological features with surface expression | Anomaly type | External references |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **7527** | Magnetic | 539724 | 5929553 | A2 | - | - | - | - | 6 | Identified in the Mag. data as a small, broad dipole with peak and trough over two survey lines. No corresponding SSS or MBES contact. May represent possible ferrous debris with no surface expression. | | Mag. | - |
| **7528** | Magnetic | 540700 | 5930059 | A2 | - | - | - | - | 11 | Identified in the Mag. data as a small, broad dipole with peak and trough on one survey line. Possibly part of a linear formation with **7529** and **7530**, however no features are recorded on the Admiralty Chart. No corresponding SSS or MBES contact. Features likely represent a modern anthropogenic feature however, as this cannot be proven without further investigation, they have been retained here as a precaution. Possible ferrous debris with no surface expression. | | Mag. | - |
| **7529** | Magnetic | 540846 | 5930066 | A2 | - | - | - | - | 15 | Identified in the Mag. data as a small, broad dipole with peak and trough on one survey line. Possibly part of a linear formation with **7528** and **7530**, however no features are recorded on the Admiralty Chart. No corresponding SSS or MBES contact. Features likely represent a modern anthropogenic feature however, as this cannot be proven without further investigation, they have been retained here as a precaution. Possible ferrous debris with no surface expression. | | Mag. | - |
| **7530** | Magnetic | 540984 | 5930069 | A2 | - | - | - | - | 29 | Identified in the Mag. data as a small negative monopole with peak and trough on one survey line. Possibly part of a linear formation with **7528** and **7529**, however no features are recorded on the Admiralty Chart. No corresponding SSS or MBES contact. Features likely represent a modern anthropogenic feature however, as this cannot be proven without further investigation, they have been retained here as a precaution. Possible ferrous debris with no surface expression. | | Mag. | - |
| **7477** | Wreck | 545026 | 5932601 | A1 | 37.0 | 9.9 | 1.7 | - | 11 | Originally identified during the 2019 assessment of priority areas as a large wreck that appears to be relatively intact and possibly upright, with some internal structure visible in the SSS data. One edge of the hull appears to be partially degraded or buried by sediment. There are some slightly slatted features visible within the vessel which could be structural. The wreck is situated on a sandy and featureless area of the seabed, within a depression, with possible associated debris in the vicinity. In the MBES data this is visible as a distinct mound, orientated on an approximate north-west to south-east alignment. Scour up to -0.5 m deep is visible around the wreck and extending approximately 22.0 m to the north-east. The wreck appears on the MBES data to be in three main segments. There is a small magnetic anomaly associated with this feature indicating the presence of some ferrous material however, as the nearest magnetometer line is situated 50.0 m from the wreck, it is likely that is the true amplitude would be larger if the wreck was directly covered by the magnetometer data. This is recorded in the UKHO database as the wreck of a Fishing vessel. |  | SSS, MBES, Mag. | 2238 (RWS), 28296 (UKHO), NL_NCN_2238 (RCE), NCN 2238, DHY2449 |

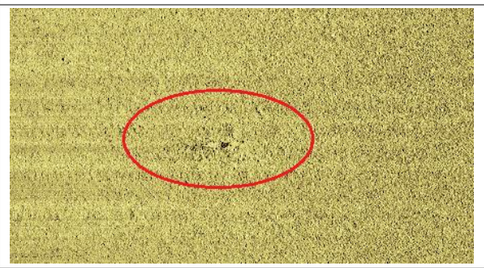
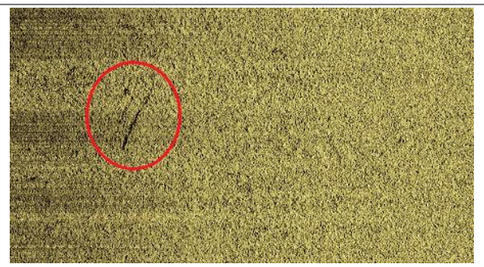
| ID | Classification | Easting | Northing | Archaeological discrimination | Length (m) | Width (m) | Height (m) | Depth below seabed (m) | Magnetic amplitude (nT) | Description | Images of possible archaeological features with surface expression | Anomaly type | External references |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **7476** | Debris | 545019 | 5932616 | A1 | 1.7 | 0.9 | - | - | - | Originally identified during the 2019 assessment of priority areas as a small dark reflector with no shadow close to the stern or bow section of wreck (**7477**). This object is situated on a sandy and featureless area of the seabed and is possibly an associated item of wreck debris. |  | SSS | 28296 (UKHO) |
| **7475** | Debris | 545032 | 5932618 | A1 | 4.3 | 0.7 | - | - | - | Originally identified during the 2019 assessment of priority areas as a curved dark reflector object with no shadow situated in a slight depression on a featureless and sandy area of the seabed. This is possibly an item of debris associated with wreck **7477**. | | SSS | 28296 (UKHO) |
| **7487** | Recorded wreck | 546919 | 5934236 | A3 | - | - | - | - | - | A recorded wreck position from the RCE database. Location was covered by the geophysical data but no remains were identified by Wessex Archaeology at this location. | | - | RWS_RCE 942 |
| **7486** | Recorded Wreck | 546713 | 5934355 | A3 | - | - | - | - | - | A recorded wreck positioned outside of the geophysical survey data extents. This is recorded in the UKHO record as dangerous wreck. Although the feature is outside of the study area, its recommended AEZ will impact the scheme and therefore the feature has been retained here. | | - | 28297 (UKHO), 943 (RWS), NL_NCN_943 (RCE) |
| **7531** | Magnetic | 548725 | 5935241 | A2 | - | - | - | - | 8 | Identified in the Mag. data as a small, broad positive monopole with peak and trough on one survey line, superimposed on an area of background noise. No corresponding SSS or MBES contact. May represent possible ferrous debris with no surface expression. | | Mag. | - |
| **7532** | Magnetic | 552948 | 5937973 | A2 | - | - | - | - | 182 | Identified in the Mag. data as a large dipole with peak and trough on one survey line. Slightly complex with a possible secondary peak to the southwest. No corresponding SSS or MBES contact. There is a UKHO position for a recorded wreck located approximately 280 m SSW of the anomaly, outside of the study area (**7607**). Due to the distance from the UKHO position, and the fact the wreck is reported as being dead in the UKHO record, this mag anomaly is not considered to be associated. However; the possibility of this representing an related feature should be noted. May represent possible ferrous debris with no surface expression. | | Mag. | - |
| **7533** | Magnetic | 553159 | 5938385 | A2 | - | - | - | - | 51 | Identified in the Mag. data as a medium dipole with peak and trough on one survey line. No corresponding SSS or MBES contact. May represent possible ferrous debris with no surface expression. | | Mag. | - |

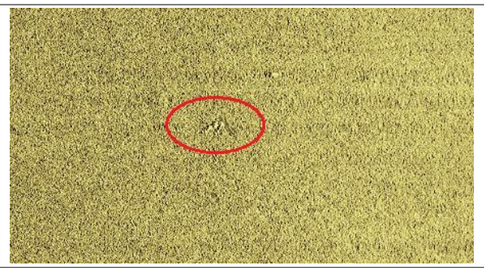
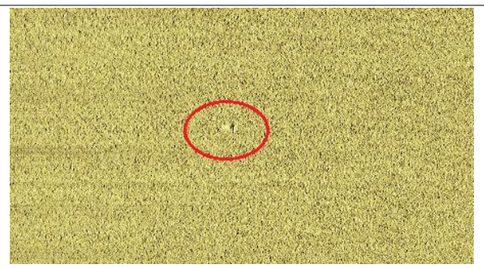
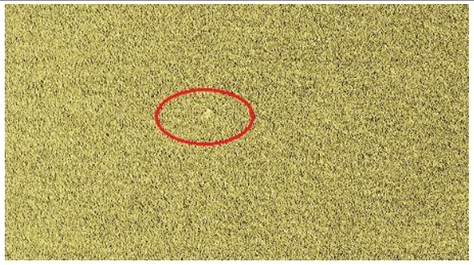
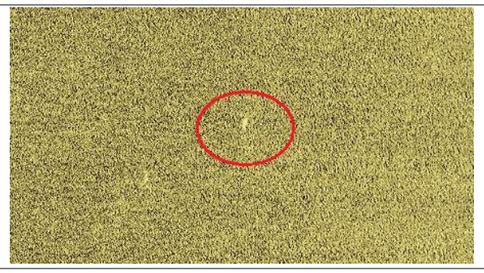
| ID | Classification | Easting | Northing | Archaeological discrimination | Length (m) | Width (m) | Height (m) | Depth below seabed (m) | Magnetic amplitude (nT) | Description | Images of possible archaeological features with surface expression | Anomaly type | External references |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **7534** | Dark reflector | 557409 | 5941028 | A2 | 5.0 | 2.2 | 0.1 | - | - | Identified in the SSS data as a faint, slightly elongate dark reflector with height. No corresponding MBES or Mag. contact. Possible non-ferrous debris or a natural feature. |  | SSS | - |
| **7535** | Magnetic | 557858 | 5941344 | A2 | - | - | - | - | 28 | Identified in the Mag. data as a small, broad dipole with peak and trough on one survey line. No corresponding SSS or MBES contact. May represent possible ferrous debris with no surface expression. | | Mag. | - |
| **7536** | Magnetic | 565340 | 5946256 | A2 | - | - | - | - | 16 | Identified in the Mag. data as a small positive monopole with peak and trough on one survey line. No corresponding SSS or MBES contact. May represent possible ferrous debris with no surface expression. | | Mag. | - |
| **7537** | Magnetic | 566391 | 5946641 | A2 | - | - | - | - | 17 | Identified in the Mag. data as a small negative monopole with peak and trough on one survey line. No corresponding SSS or MBES contact. May represent possible ferrous debris with no surface expression. | | Mag. | - |
| **7538** | Dark reflector | 567803 | 5946355 | A2 | 3.3 | 0.4 | 0.4 | - | - | Identified in the SSS data as a small, distinct dark reflector with a bright, irregular shadow. Located very close to another irregular dark reflector with height (**7539**) but otherwise in a relatively featureless area of seabed. No corresponding MBES or Mag. contact. Possible non-ferrous debris or a natural feature. |  | SSS | - |
| **7539** | Dark reflector | 567800 | 5946355 | A2 | 2.9 | 1.0 | 0.6 | - | - | Identified in the SSS data as a faint, poorly defined dark reflector with a bright, irregular shadow indicating varying height. Close to a similar feature (**7538**). No corresponding MBES or Mag. contact. Possible non-ferrous debris or a natural feature. |  | SSS | - |

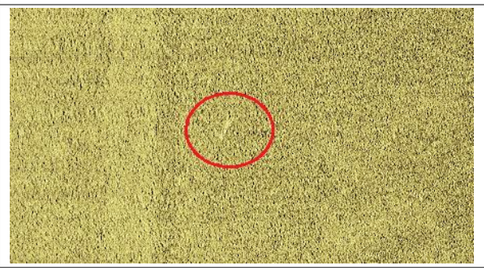
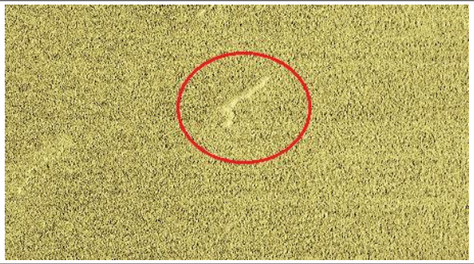
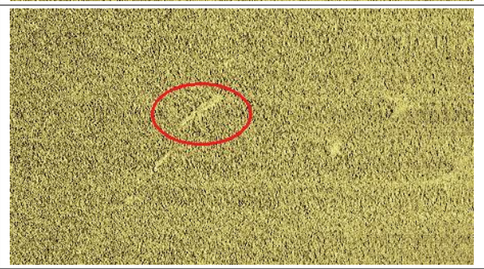
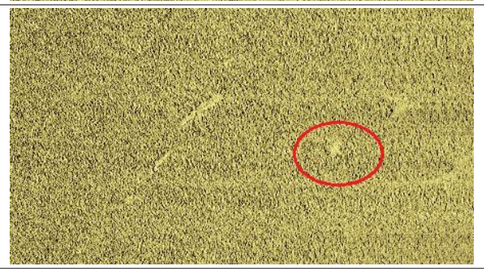
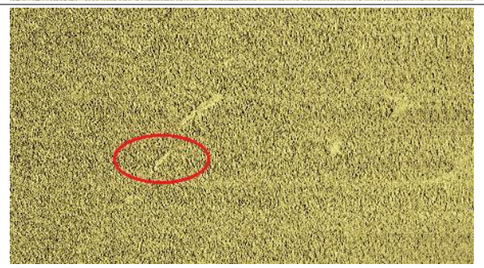
| ID | Classification | Easting | Northing | Archaeological discrimination | Length (m) | Width (m) | Height (m) | Depth below seabed (m) | Magnetic amplitude (nT) | Description | Images of possible archaeological features with surface expression | Anomaly type | External references |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **7540** | Dark reflector | 571279 | 5946129 | A2 | 4.8 | 3.5 | 0.5 | - | - | Identified in the SSS data as a distinct, poorly defined dark reflector with height. Possibly within a slight depression, or associated scour. No corresponding MBES or Mag. contact. Possible non-ferrous debris or a natural feature. |  | SSS | - |
| **7541** | Mound | 584239 | 5946750 | A2 | 9.1 | 3.0 | 0.1 | - | - | Identified in the MBES data as a distinct mound, slightly elongated and oriented north-south. The northern extent slopes more gently than the south, which has a flattened top. Profiles are steep and the feature is anomalous. No corresponding SSS or Mag. contact. Possible non-ferrous debris or a natural feature. | | MBES | - |
| **7542** | Magnetic | 586610 | 5947530 | A2 | - | - | - | - | 34 | Identified in the Mag. data as a small, broad dipole with peak and trough on one survey line. No corresponding SSS or MBES contact. May represent possible ferrous debris with no surface expression. | | Mag. | - |
| **7543** | Mound | 588747 | 5947917 | A2 | 5.0 | 4.0 | 0.2 | - | - | Identified in the MBES data as a squared mound with a flattened ridge along the top. This is distinct and anomalous for the area. A similar mound (**7544**) is located 173.0 m to the ENE. No corresponding SSS or Mag. contact. Possible non-ferrous debris or a natural feature. | | MBES | - |
| **7544** | Mound | 588915 | 5947978 | A2 | 6.0 | 4.2 | 0.2 | - | - | Identified in the MBES data as a mound, almost triangular in plan, with a flattened top. This is distinct and anomalous for the area. A similar mound (**7543**) is located 173.0 m to the WSW. No corresponding SSS or Mag. contact. Possible non-ferrous debris or a natural feature. | | MBES | - |

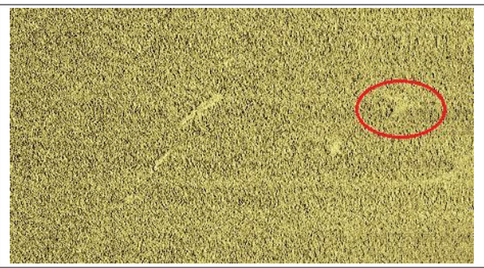
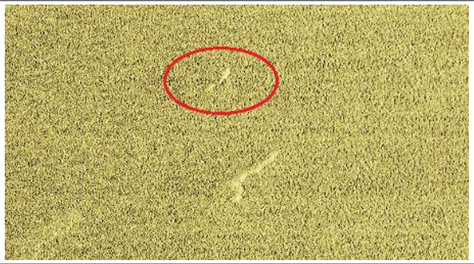
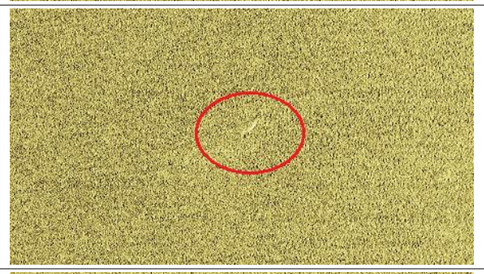
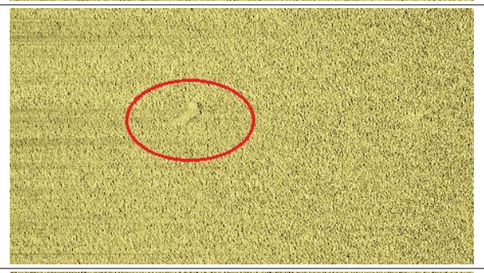
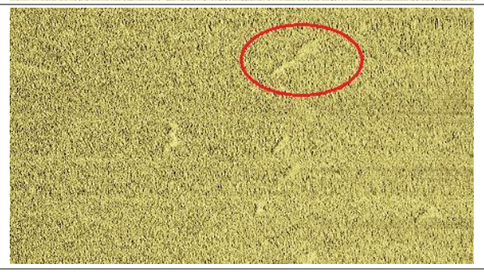
| ID | Classification | Easting | Northing | Archaeological discrimination | Length (m) | Width (m) | Height (m) | Depth below seabed (m) | Magnetic amplitude (nT) | Description | Images of possible archaeological features with surface expression | Anomaly type | External references |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **7545** | Debris | 591465 | 5948986 | A2 | 3.6 | 1.0 | 0.2 | - | - | Identified in the SSS data as a straight, elongate dark reflector with a slight shadow. No corresponding MBES or Mag. contact. Possible item of debris. |  | SSS | - |
| **7546** | Seabed disturbance | 591842 | 5949469 | A2 | 22.0 | 10.2 | 0.2 | - | - | Identified in the SSS data as a slightly elongate patch of disturbed seabed comprising several dark reflectors with height. Located close to an area of trawl scares and may therefore be disturbed by, or related to, trawling activity. No corresponding MBES or Mag. contact. Possible non-ferrous debris or a natural feature. |  | SSS | - |
| **7547** | Magnetic | 593298 | 5949805 | A2 | - | - | - | - | 48 | Identified in the Mag. data as small dipoles across several lines of Mag. data. These appear to be part of a short linear WNW to ESE trend measuring 390.0 m, narrower than the study area. No corresponding SSS or MBES contact. No features are recorded on the Admiralty Chart. Feature likely represents a modern anthropogenic feature however, as this cannot be proven without further investigation, it has been retained here as a precaution. Possible ferrous debris with no surface expression. | | Mag. | - |
| **7548** | Magnetic | 594090 | 5950051 | A2 | - | - | - | - | 23 | Identified in the Mag. data as two small, broad dipoles in close proximity. No corresponding SSS or MBES contacts. This may be part of a linear trend on a north-east to south-west alignment with **7549** and **7550**. However, no features are recorded at this location on the Admiralty Chart and the anomalies are not definitively associated. Likely represents a modern anthropogenic feature however, as this cannot be proven without further investigation, it has been retained here as a precaution. Possible ferrous debris with no surface expression. | | Mag. | - |
| **7549** | Magnetic | 594519 | 5950312 | A2 | - | - | - | - | 29 | Identified in the Mag. data as two small, broad dipoles in close proximity. No corresponding SSS or MBES contacts. This may be part of a linear trend on a north-east to south-west alignment with **7548** and **7550**. However, no features are recorded at this location on the Admiralty Chart and the anomalies are not definitively associated. Likely represents a modern anthropogenic feature however, as this cannot be proven without further investigation, it has been retained here as a precaution. Possible ferrous debris with no surface expression. | | Mag. | - |

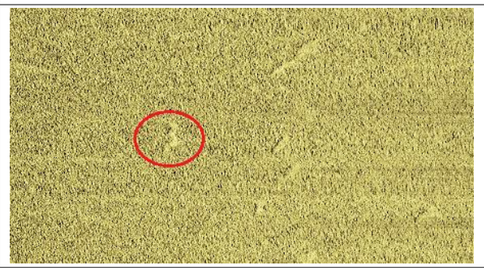
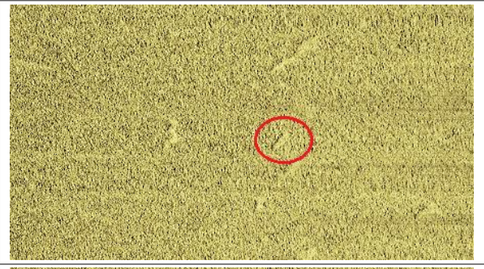
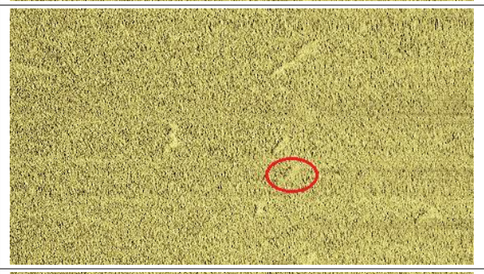
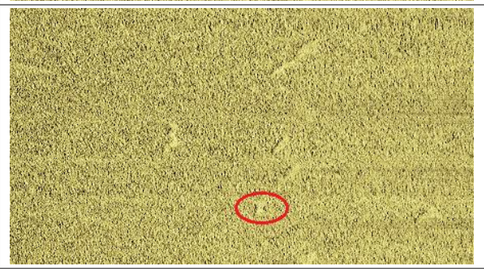
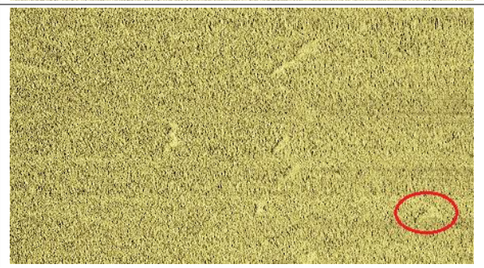
| ID | Classification | Easting | Northing | Archaeological discrimination | Length (m) | Width (m) | Height (m) | Depth below seabed (m) | Magnetic amplitude (nT) | Description | Images of possible archaeological features with surface expression | Anomaly type | External references |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **7550** | Magnetic | 594791 | 5950508 | A2 | - | - | - | - | 68 | Identified in the Mag. data as one medium dipole and two small, broad dipoles in close proximity. No corresponding SSS or MBES contacts. This may be part of a linear trend on a north-east to south-west alignment with **7548** and **7549**. However, no features are recorded at this location on the Admiralty Chart and the anomalies are not definitively associated. Likely represents a modern anthropogenic feature however, as this cannot be proven without further investigation, it has been retained here as a precaution. Possible ferrous debris with no surface expression. | | Mag. | - |
| **7551** | Magnetic | 597920 | 5951512 | A2 | - | - | - | - | 36 | Identified in the Mag. data as small, broad dipole. No corresponding SSS or MBES contacts. May represent possible ferrous debris with no surface expression. | | Mag. | - |
| **7482** | Debris field | 598394 | 5952067 | A2 | 10.0 | 10.0 | 1.1 | - | 237 | Originally identified during the 2019 assessment of priority areas as a possible debris field comprising a large, distinct, slightly curved dark reflector with a bright, tapered shadow (4.2 x 2.3 x 1.1 m), in a slight depression directly next to a very small and rounded dark reflector object with a bright, small shadow (1.3 x 1.3 x 0.6 m). Some very slight dark reflectors were seen surrounding the main objects, however it is not possible to discern whether these are associated debris items or natural features. There is a large magnetic anomaly associated with this feature indicating ferrous material is present. In the MBES data this is visible as a round mound with a large depression to the north-west, there are three smaller, shallower depressions visible, one to the north-west and two to the south-west. Scour is visible extending approximately 20.0 m to the north-east of the feature. Possible ferrous item of debris |  | SSS, MBES, Mag | - |
| **7552** | Magnetic | 602594 | 5953888 | A2 | - | - | - | - | 26 | Identified in the Mag. data as small, positive monopole. No corresponding SSS or MBES contacts. May represent possible ferrous debris with no surface expression. | | Mag. | - |
| **7553** | Magnetic | 604597 | 5954349 | A2 | - | - | - | - | 12 | Identified in the Mag. data as small, broad dipole. No corresponding SSS or MBES contacts. May represent possible ferrous debris with no surface expression. | | Mag. | - |
| **7554** | Magnetic | 614095 | 5957695 | A2 | - | - | - | - | 21 | Identified in the Mag. data as small, negative monopole. No corresponding SSS or MBES contacts. May represent possible ferrous debris with no surface expression. | | Mag. | - |
| **7555** | Magnetic | 614594 | 5957925 | A2 | - | - | - | - | 9 | Identified in the Mag. data as small, broad dipole. No corresponding SSS or MBES contacts. May represent possible ferrous debris with no surface expression. | | Mag. | - |
| **7556** | Magnetic | 615764 | 5957951 | A2 | - | - | - | - | 5 | Identified in the Mag. data as small, negative monopole. No corresponding SSS or MBES contacts. May represent possible ferrous debris with no surface expression. | | Mag. | - |
| **7557** | Magnetic | 617313 | 5958344 | A2 | - | - | - | - | 15 | Identified in the Mag. data as small, broad dipole. No corresponding SSS or MBES contacts. May represent possible ferrous debris with no surface expression. | | Mag. | - |

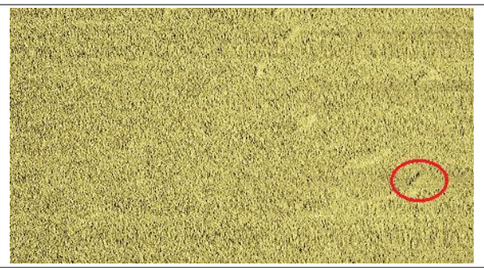
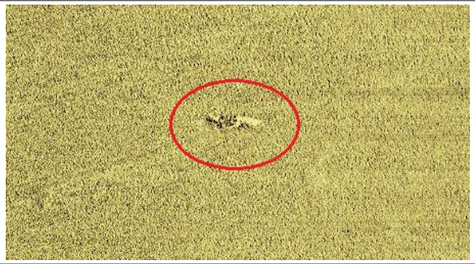
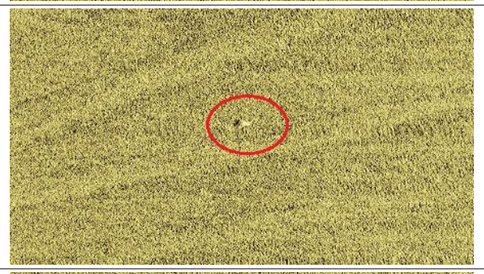
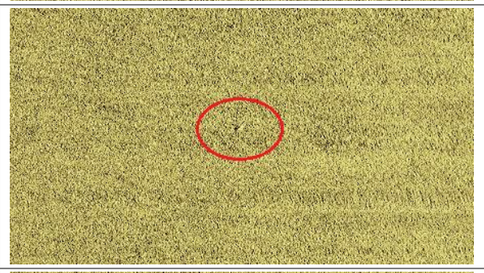
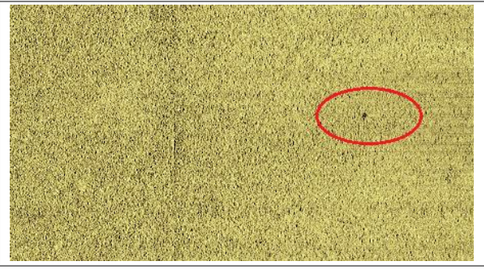
| ID | Classification | Easting | Northing | Archaeological discrimination | Length (m) | Width (m) | Height (m) | Depth below seabed (m) | Magnetic amplitude (nT) | Description | Images of possible archaeological features with surface expression | Anomaly type | External references |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **7558** | Magnetic | 618710 | 5958408 | A2 | - | - | - | - | 20 | Identified in the Mag. data as small, broad dipole. No corresponding SSS or MBES contacts. May represent possible ferrous debris with no surface expression. | | Mag. | - |
| **7559** | Magnetic | 619528 | 5958460 | A2 | - | - | - | - | 26 | Identified in the Mag. data as small dipole. No corresponding SSS or MBES contacts. May represent possible ferrous debris with no surface expression. | | Mag. | - |
| **7560** | Magnetic | 619729 | 5958718 | A2 | - | - | - | - | 7 | Identified in the Mag. data as small, negative monopole. No corresponding SSS or MBES contacts. May represent possible ferrous debris with no surface expression. | | Mag. | - |
| **7561** | Dark reflector | 619805 | 5958800 | A2 | 3.7 | 2.0 | 0.3 | - | - | Identified in the SSS data as an angular dark reflector with a small shadow. Visible in the MBES as a small mound within an area of scour which extends for a maximum of 12.2 m and is 0.2 m deep. No corresponding Mag. contact. Possible item of debris or a natural feature. |  | SSS, MBES | - |
| **7481** | Dark reflector | 619963 | 5958840 | A2 | 27.9 | 0.9 | - | - | - | Originally identified in the 2019 assessment of priority areas as a long dark reflector that is slightly wider at one end than the other, with no shadow. This feature is situated on a sandy and featureless area of the seabed. This feature is located 116.0 m south of a UKHO record position (**7492**) which is located outside of the study area. This feature was identified at the edge of the geophysical survey area, and is only seen in the outer ranges on one SSS line. As such, it cannot be confirmed whether this is debris or a natural feature. However, the feature was retained as a precaution based on proximity to UKHO position. |  | - | - |
| **7489** | Recorded Wreck | 621305 | 5958935 | A3 | - | - | - | - | - | Originally identified during the 2019 assessment as a recorded wreck position. The feature was covered by the geophysical data however no remains were identified by Wessex Archaeology at this location. Based on the record information, it is possible that this wreck has been lifted, although this is not definitive. As such, the recorded location of the wreck has been retained here as a precaution. It should be noted that, even if the wreck has been lifted, there is still the possibility of associated debris items being present on the seabed. | | - | 67311 (UKHO) |
| **7562** | Magnetic | 623434 | 5959289 | A2 | - | - | - | - | 9 | Identified in the Mag. data as small, broad asymmetric dipole. No corresponding SSS or MBES contacts. May represent possible ferrous debris with no surface expression. | | Mag. | - |

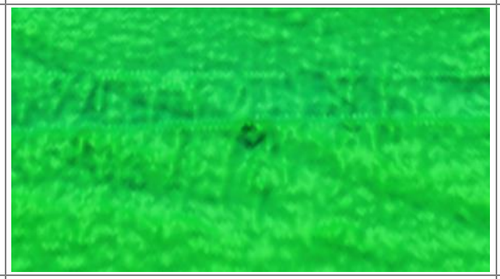
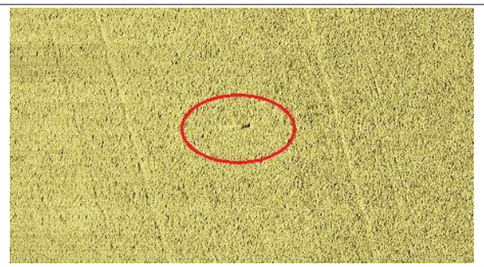
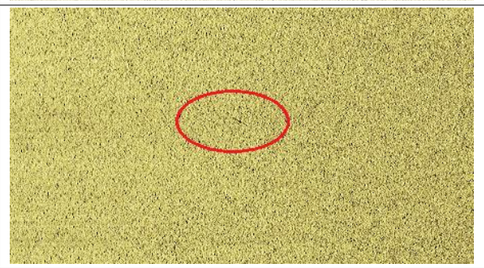
| ID | Classification | Easting | Northing | Archaeological discrimination | Length (m) | Width (m) | Height (m) | Depth below seabed (m) | Magnetic amplitude (nT) | Description | Images of possible archaeological features with surface expression | Anomaly type | External references |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **7563** | Debris | 625510 | 5959556 | A2 | 3.6 | 2.9 | 0.1 | - | - | Identified in the SSS data as an area of seabed disturbance with three distinct dark reflectors with bright shadows. No corresponding Mag. or MBES contact. Possible item of non-ferrous partially buried debris. |  | SSS | - |
| **7564** | Magnetic | 630674 | 5960569 | A2 | - | - | - | - | 10 | Identified in the Mag. data as a small, broad dipole. No corresponding SSS or MBES contacts. May represent possible ferrous debris with no surface expression. | | Mag. | - |
| **7566** | Dark reflector | 633548 | 5965294 | A2 | 1.5 | 0.6 | 0.2 | - | - | Identified in the SSS data as a slightly indistinct dark reflector with a straight sided shadow. No corresponding Mag. or MBES contact. Possible non-ferrous debris or a natural feature. |  | SSS | - |
| **7567** | Dark reflector | 634209 | 5965649 | A2 | 3.5 | 1.2 | 0.2 | - | - | Identified in the SSS data as an angular dark reflector with a small shadow. Observed in MBES data as an indistinct mound. No corresponding Mag. contact. Possible non-ferrous debris or a natural feature. |  | SSS | - |
| **7568** | Dark reflector | 634920 | 5966110 | A2 | 4.2 | 0.5 | 0.1 | - | - | Identified in the SSS data as an indistinct dark reflector with a bright shadow. Observed in MBES data as an indistinct mound. No corresponding Mag. contact. Possible non-ferrous debris or a natural feature. |  | SSS | - |

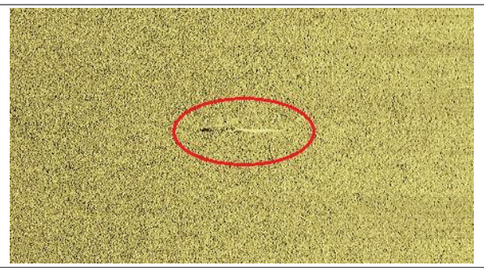
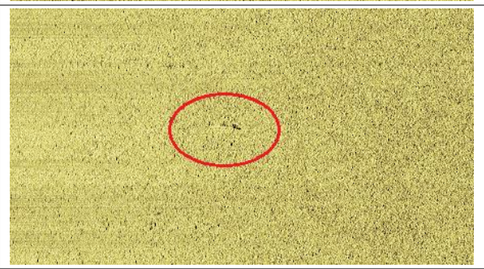
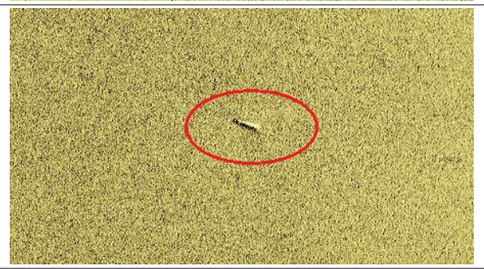
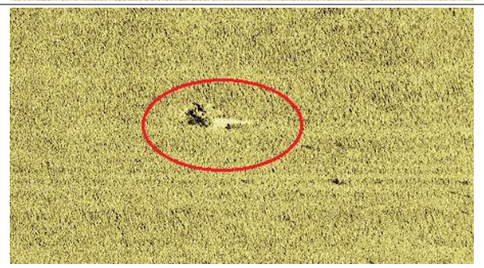
| ID | Classification | Easting | Northing | Archaeological discrimination | Length (m) | Width (m) | Height (m) | Depth below seabed (m) | Magnetic amplitude (nT) | Description | Images of possible archaeological features with surface expression | Anomaly type | External references |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **7569** | Dark reflector | 635151 | 5966200 | A2 | 6.0 | 0.8 | 0.1 | - | - | Identified in the SSS data as a curvilinear dark reflector with a bright shadow. Observed in MBES data as an indistinct mound. No corresponding Mag. contact. Possible non-ferrous debris or a natural feature. |  | SSS | - |
| **7570** | Dark reflector | 635061 | 5966432 | A2 | 16.4 | 1.0 | 0.3 | - | - | Identified in the SSS data as an irregular curvilinear dark reflector with a flared shadow. Possibly associated with **7575** and **7576**. Observed in MBES data as an elongate mound. No corresponding Mag. contact. Possible non-ferrous debris or a natural feature. |  | SSS | - |
| **7571** | Dark reflector | 635148 | 5966383 | A2 | 10.9 | 0.6 | 0.2 | - | - | Identified in the SSS data as an elongate dark reflector with a long shadow. Possibly associated with **7572**, **7573**, and **7574**. Observed in MBES data as an indistinct mound. No corresponding Mag. contact. Possible non-ferrous debris or a natural feature. |  | SSS | - |
| **7572** | Dark reflector | 635150 | 5966405 | A2 | 3.3 | 0.7 | 0.2 | - | - | Identified in the SSS data as an indistinct dark reflector with a flared shadow. Possible associated with **7571**, **7573**, and **7574**. Observed in MBES data as an indistinct mound. No corresponding Mag. contact. Possible non-ferrous debris or a natural feature. |  | SSS | - |
| **7573** | Dark reflector | 635166 | 5966393 | A2 | 6.8 | 0.5 | - | - | - | Identified in the SSS data as an elongate dark reflector with a curved end a distinct shadow. Possibly associated with **7572**, **7571**, and **7574**. Observed in MBES data as an indistinct mound. No corresponding Mag. contact. Possible non-ferrous debris or a natural feature. |  | SSS | - |

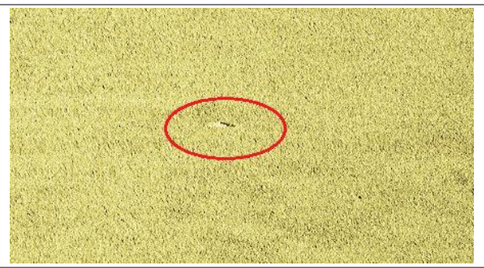
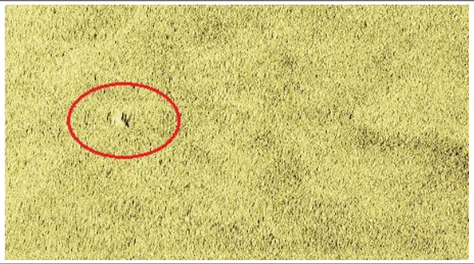
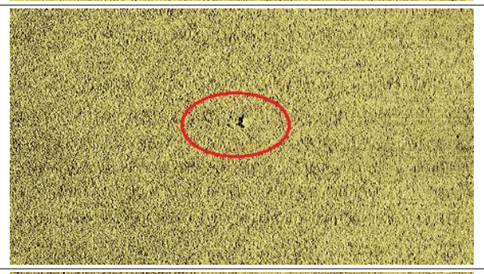
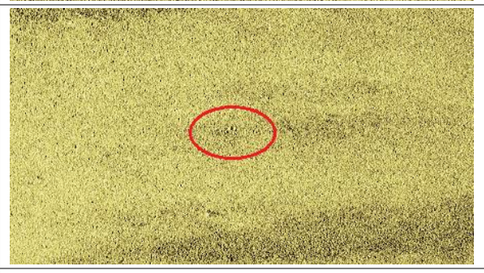
| ID | Classification | Easting | Northing | Archaeological discrimination | Length (m) | Width (m) | Height (m) | Depth below seabed (m) | Magnetic amplitude (nT) | Description | Images of possible archaeological features with surface expression | Anomaly type | External references |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **7574** | Dark reflector | 635137 | 5966402 | A2 | 4.2 | 0.5 | 0.2 | - | - | Identified in the SSS data as an curved dark reflector with an indistinct shadow. Possibly associated with **7572**, **7571**, and **7573**. Observed in MBES data as an indistinct mound. No corresponding Mag. contact. Possible non-ferrous debris or a natural feature. |  | SSS | - |
| **7575** | Dark reflector | 635087 | 5966458 | A2 | 7.3 | 1.5 | 0.2 | - | - | Identified in the SSS data as a narrow curved dark reflector with a rounded shadow. Possibly associated with **7570** and **7576**. Observed in MBES data as a rounded mound. No corresponding Mag. contact. Possible non-ferrous debris or a natural feature. |  | SSS | - |
| **7576** | Bright reflector | 635150 | 5966526 | A2 | 4.9 | 1.7 | - | - | - | Identified in the SSS data as a distinct bright reflector, which may be the shadow of a poorly imaged dark reflector. Possibly associated with **7570** and **7575**. A rounded mound is visible in the MBES data at this location. No corresponding Mag. contact. Possible non-ferrous debris or a natural feature. |  | SSS | - |
| **7484** | Debris | 635354 | 5966674 | A2 | 8.5 | 3.9 | 0.2 | - | - | Originally identified during the 2019 assessment of priority areas as a thin and angular dark reflector at a right angle with faint shadow. This is a possible linear item of debris, or a partially buried object situated on an otherwise featureless area of the seabed. In the MBES data this is visible as a rectangular mound on an approximate north-east to south-west alignment. |  | SSS, MBES | - |
| **7577** | Dark reflector | 635525 | 5966726 | A2 | 12.4 | 0.4 | 0.2 | - | - | Identified in the SSS data as an indistinct curvilinear dark reflector with a shadow of varying lengths. Possibly associated with **7578**, **7579**, **7580**, **7581**, **7582** and **7583**. Observed in MBES data as an indistinct mound. No corresponding Mag. contact. Possible non-ferrous debris or a natural feature. |  | SSS | - |

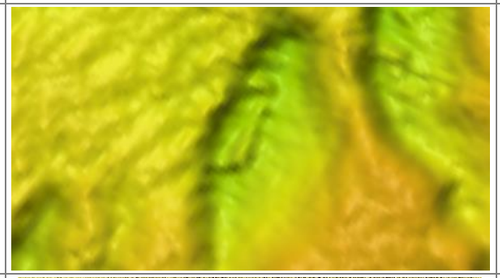
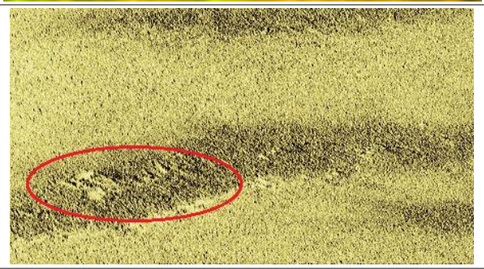
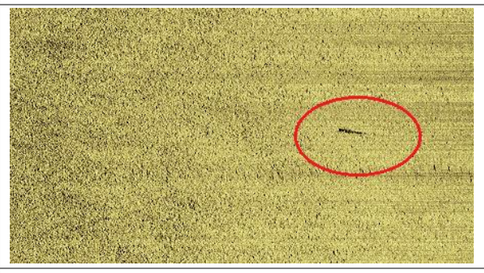
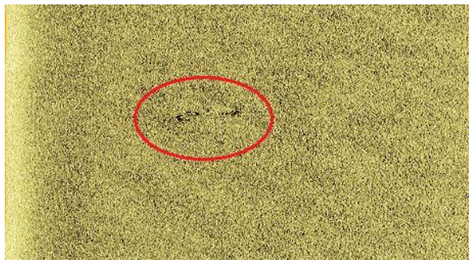
| ID | Classification | Easting | Northing | Archaeological discrimination | Length (m) | Width (m) | Height (m) | Depth below seabed (m) | Magnetic amplitude (nT) | Description | Images of possible archaeological features with surface expression | Anomaly type | External references |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **7578** | Dark reflector | 635553 | 5966732 | A2 | 9.4 | 0.7 | 0.1 | - | - | Identified in the SSS data as an indistinct curvilinear dark reflector with a bright shadow. Possibly associated with **7577**, **7579**, **7580**, **7581**, **7582** and **7583**. Observed in MBES data as an indistinct mound. No corresponding Mag. contact. Possible non-ferrous debris or a natural feature. |  | SSS | - |
| **7579** | Dark reflector | 635548 | 5966744 | A2 | 5.0 | 0.3 | 0.1 | - | - | Identified in the SSS data as an elongate dark reflector with a bright shadow. Possibly associated with **7577**, **7578**, **7580**, **7581**, **7582** and **7583**. Observed in MBES data as an indistinct mound. No corresponding Mag. contact. Possible non-ferrous debris or a natural feature. |  | SSS | - |
| **7580** | Dark reflector | 635554 | 5966751 | A2 | 4.1 | 1.4 | 0.1 | - | - | Identified in the SSS data as an indistinct dark reflector with a shadow. Possibly associated with **7577**, **7578**, **7579**, **7581**, **7582** and **7583**. Observed in MBES data as an indistinct mound. No corresponding Mag. contact. Possible non-ferrous debris or a natural feature. |  | SSS | - |
| **7581** | Dark reflector | 635566 | 5966756 | A2 | 4.2 | 0.6 | 0.1 | - | - | Identified in the SSS data as a curved elongate dark reflector with an indistinct shadow. Possibly associated with **7577**, **7578**, **7579**, **7580**, **7582** and **7583**. Observed in MBES data as an indistinct mound. No corresponding Mag. contact. Possible non-ferrous debris or a natural feature. |  | SSS | - |
| **7582** | Dark reflector | 635556 | 5966772 | A2 | 6.0 | 0.8 | 0.2 | - | - | Identified in the SSS data as an indistinct elongate dark reflector with a shadow. Possibly associated with **7577**, **7578**, **7579**, **7580**, **7581** and **7583**. Observed in MBES data as an indistinct mound. No corresponding Mag. contact. Possible non-ferrous debris or a natural feature. |  | SSS | - |

| ID | Classification | Easting | Northing | Archaeological discrimination | Length (m) | Width (m) | Height (m) | Depth below seabed (m) | Magnetic amplitude (nT) | Description | Images of possible archaeological features with surface expression | Anomaly type | External references |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **7583** | Dark reflector | 635580 | 5966792 | A2 | 4.9 | 0.7 | 0.1 | - | - | Identified in the SSS data as an elongate dark reflector with an indistinct shadow. Possibly associated with **7577**, **7578**, **7579**, **7580**, **7581** and **7582**. Observed in MBES data as an elongate mound. No corresponding Mag. contact. Possible non-ferrous debris or a natural feature. |  | SSS | - |
| **7584** | Debris | 635768 | 5966834 | A2 | 5.7 | 5.1 | 0.4 | - | - | Identified in the SSS data as an area of disturbed seabed with multiple dark reflectors. Visible in the MBES data as an irregularly shaped mound of varying height located within some encircling scour extending for 3.9 m and 0.1 m deep. No corresponding Mag. anomaly. Possible non-ferrous debris. |  | SSS, MBES | - |
| **7585** | Dark reflector | 635878 | 5967189 | A2 | 3.0 | 1.1 | 0.3 | - | - | Identified in the SSS data as a rounded dark reflector with a bright shadow. No corresponding Mag. or MBES contact. Possible non-ferrous debris or a natural feature. |  | SSS | - |
| **7586** | Dark reflector | 637345 | 5968474 | A2 | 4.2 | 1.0 | 0.1 | - | - | Identified in the SSS data as an elongated dark reflector with a bright shadow. There is some visible scour. No corresponding Mag. or MBES contact. Possible non-ferrous debris or a natural feature. |  | SSS | - |
| **7587** | Dark reflector | 637570 | 5968514 | A2 | 1.3 | 0.6 | 0.1 | - | - | Identified in the SSS data as a rounded dark reflector with a bright shadow. No corresponding MBES or Mag. contact. Possible item of debris or a natural feature. |  | SSS | - |

| ID | Classification | Easting | Northing | Archaeological discrimination | Length (m) | Width (m) | Height (m) | Depth below seabed (m) | Magnetic amplitude (nT) | Description | Images of possible archaeological features with surface expression | Anomaly type | External references |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **7588** | Magnetic | 637772 | 5968973 | A2 | - | - | - | - | 33 | Identified in the Mag. data as a small dipole. No corresponding SSS or MBES contacts. May represent possible ferrous debris with no surface expression. | | Mag. | - |
| **7589** | Magnetic | 638337 | 5969448 | A2 | - | - | - | - | 18 | Identified in the Mag. data as a small, broad dipole. No corresponding SSS or MBES contacts. May represent possible ferrous debris with no surface expression. | | Mag. | - |
| **7590** | Mound | 643124 | 5975121 | A2 | 9.2 | 8.2 | 0.1 | - | - | Identified in the MBES data as an angular mound with a secondar pointed section at the north-west corner, possibly truncated due to trawling. No corresponding SSS or Mag. contact. Possible item of non-ferrous debris. |  | MBES | - |
| **7591** | Recorded Wreck | 644401 | 5976415 | A3 | - | - | - | - | - | Originally identified in the 2019 assessment of priority areas as recorded wreck position. This was covered by the geophysical data, but no remains were identified by Wessex Archaeology at this location. This is described in the UKHO record as an unknown shipwreck and is recorded as dead. | | - | 28768 (UKHO); RWS_RCE_666 |
| **7592** | Dark reflector | 649590 | 5981292 | A2 | 1.6 | 0.5 | 0.4 | - | - | Identified in the SSS data as a distinct angular dark reflector with a bright narrow shadow. No corresponding MBES or Mag. contact. Possible item of debris or a natural feature. |  | SSS | - |
| **7593** | Dark reflector | 664149 | 5990985 | A2 | 4.0 | 0.8 | - | - | - | Identified in the SSS data as a faint, elongate dark reflector. No corresponding MBES or Mag. contact. Possible non-ferrous debris or a natural feature. |  | SSS | - |

| ID | Classification | Easting | Northing | Archaeological discrimination | Length (m) | Width (m) | Height (m) | Depth below seabed (m) | Magnetic amplitude (nT) | Description | Images of possible archaeological features with surface expression | Anomaly type | External references |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **7594** | Debris | 672158 | 5992512 | A2 | 7.3 | 4.3 | 0.8 | - | - | Identified in the SSS data as an elongate dark reflector measuring 4.1 x 1.9 x 0.8 m with a bright narrow shadow. It was observed in the MBES data as a sub-rounded mound measuring 7.3 x 4.3 x 0.2 m. No corresponding Mag. contact. Possible item of debris. |  | SSS, MBES | - |
| **7595** | Dark reflector | 675119 | 5993014 | A2 | 1.9 | 0.2 | 0.3 | - | - | Identified in the SSS data as a distinct elongate dark reflector with a bright shadow. Identified towards the edge of the data and therefore height should be considered a minimum. No corresponding MBES or Mag. contact. Possible non-ferrous debris or a natural feature. | | SSS | - |
| **7596** | Dark reflector | 681289 | 5994621 | A2 | 2.4 | 1.8 | 0.4 | - | - | Identified in the SSS data as a distinct elongate dark reflector with a bright narrow shadow. No corresponding MBES or Mag. contact. Possible non-ferrous debris or a natural feature. |  | SSS | - |
| **7597** | Debris | 683718 | 5995479 | A2 | 5.2 | 1.3 | 0.5 | - | - | Identified in the SSS data as a short elongate dark reflector with a bright shadow. No corresponding MBES or Mag. contact. Possible item of non-ferrous debris. |  | SSS | - |
| **7483** | Dark reflector | 684500 | 5995487 | A2 | 9.9 | 4.0 | 0.7 | - | - | Originally identified during the 2019 assessment of priority areas as a slightly irregular dark reflector, or possibly a collection of numerous small dark reflectors, with a faint, tapered shadow. In the MBES data this is visible as an isolated rounded mound, measuring 4.2 x 5.2 x 0.2 m, in an area of gently sloping seabed. The feature has scour that extends approximately 2.0 m to the south-west. Possible non-ferrous debris or a natural feature. |  | SSS, MBES | - |

| ID | Classification | Easting | Northing | Archaeological discrimination | Length (m) | Width (m) | Height (m) | Depth below seabed (m) | Magnetic amplitude (nT) | Description | Images of possible archaeological features with surface expression | Anomaly type | External references |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **7598** | Dark reflector | 684775 | 5995514 | A2 | 3.0 | 1.8 | 0.3 | - | - | Identified in the SSS data as a small, distinct elongate dark reflector with a bright shadow. No corresponding Mag. or MBES contact. Possible non-ferrous debris or a natural feature. |  | SSS | - |
| **7599** | Dark reflector | 686620 | 5994762 | A2 | 4.3 | 0.5 | 0.2 | - | - | Identified in the SSS data as a distinct elongate dark reflector with a slightly indistinct shadow. No corresponding Mag. or MBES contact. Possible non-ferrous debris or a natural feature. |  | SSS | - |
| **7600** | Dark reflector | 689389 | 5995498 | A2 | 4.8 | 0.7 | 0.2 | - | - | Identified in the SSS data as a distinct, irregularly shaped dark reflector with a bright shadow. No corresponding Mag. or MBES contact. Possible non-ferrous debris or a natural feature. |  | SSS | - |
| **7601** | Dark reflector | 692925 | 5996240 | A2 | 1.1 | 0.3 | 0.1 | - | - | Identified in the SSS data as a distinct, small dark reflector which casts a bright shadow. Appears to be within a small area of scour. There is no corresponding Mag. contact, however it is not directly covered by magnetometer survey lines and therefore the possibility of some ferrous material being present remains. Possible item of debris or a natural feature. |  | SSS | - |
| **7602** | Magnetic | 694252 | 5996434 | A2 | - | - | - | - | 10 | Identified in the Mag. data as a small, slightly broad dipole. No corresponding SSS or MBES contacts. May represent possible ferrous debris with no surface expression. | | Mag. | - |

| ID | Classification | Easting | Northing | Archaeological discrimination | Length (m) | Width (m) | Height (m) | Depth below seabed (m) | Magnetic amplitude (nT) | Description | Images of possible archaeological features with surface expression | Anomaly type | External references |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **7603** | Mound | 695713 | 5996568 | A2 | 19.0 | 5.1 | 0.1 | - | - | Identified in the MBES as an elongate mound which is more prominent to the south and slopes down to the north. The sides are evenly sloped and the top is pointed. Possible secondary feature to the immediate north but unclear. In the MBES data, the feature appears similar in form to **7604**. No corresponding SSS or Mag. contact. Possible item of debris or a natural feature. |  | MBES | - |
| **7604** | Seabed disturbance | 695711 | 5996626 | A2 | 11.9 | 11.9 | 0.2 | - | - | Identified in the SSS data as a series of indistinct, irregular, elongate dark reflectors with bright shadows. Visible in the MBES as a distinct irregular mound with four clear sections, with the largest at the north-east measuring 8.9 x 4.7 x 0.2 m. Feature appears to have variable height which may suggest one irregular object or multiple anomalies. No corresponding Mag. contact. Possible collection of non-ferrous debris or a natural feature. |  | SSS, MBES | - |
| **7488** | Recorded Wreck | 696144 | 5996878 | A3 | - | - | - | - | - | This is the position of a recorded wreck, *Sparkling Wave,* which sank in a collision with *Citonia* of Grimsby, in 1895. The wreck is positioned outside of the geophysical study area and was only partially covered by MBES data. No remains were identified at the location or within the vicinity on any of the datasets; however, as it was only partially covered, the possibility of material being present remains. Although the feature is outside the study area, any associated exclusion zone would be impacted and therefore it has been retained here as a precaution. | | - | 29890 (UKHO) |
| **7605** | Dark reflector | 696834 | 5996980 | A2 | 3.7 | 1.7 | - | - | - | Identified in the SSS data as a distinct elongate dark reflector with no clear shadow. No corresponding Mag. or MBES contact. Possible non-ferrous debris or a natural feature. |  | SSS | - |
| **7606** | Seabed disturbance | 698140 | 5997156 | A2 | 7.8 | 3.2 | - | - | - | Identified in the SSS data as an area of seabed disturbance visible as multiple distinct dark reflectors which form a poorly defined feature with no clear shadow. Observed in the MBES as an indistinct mound. No corresponding Mag. contact. Possible partially buried debris or a natural feature. |  | SSS | - |

| ID | Classification | Easting | Northing | Archaeological discrimination | Length (m) | Width (m) | Height (m) | Depth below seabed (m) | Magnetic amplitude (nT) | Description | Images of possible archaeological features with surface expression | Anomaly type | External references |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 7607 | Recorded Wreck | 552844 | 5937711 | A3 | - | - | - | - | - | A recorded wreck positioned outside of the geophysical survey data extents. This is recorded in the UKHO record as non-dangerous and has been marked as dead. Although the feature is outside of the study area, its recommended AEZ will impact the scheme and therefore the feature has been retained here. | | - | 28327 (UKHO), 869 (RWS), NL_NCN_869 (RCE) |
| 7492 | Recorded Wreck | 619955 | 5958957 | A3 | - | - | - | - | - | A recorded wreck positioned outside of the geophysical survey data extents. This is recorded in the UKHO record as dangerous wreck. Although the feature is outside of the study area, its recommended AEZ will impact the scheme and therefore the feature has been retained here. | | - | 28397 (UKHO), 604 (RWS), NL_NCN_604 (RCE) |

1. Co-ordinates are in WGS84 UTM31N
2. Positional accuracy estimated ±10 m
3. SSS images produced using the LF data, clipped with an across-track range of approximately 50 m
4. MBES images at 1X vertical exaggeration

**Appendix 5: List of known receptors within the wider search area**

| Reference | Type | Area Name | Description | Easting | Northing |
|---|---|---|---|---|---|
| NCN_527 | Unknown | L07 | Shipwreck; Small wreck. | 578793.06 | 5943612.9 |
| NCN_602 | Unknown | L06 | Shipwreck | 619187.56 | 5959407.68 |
| NCN_603 | Unknown | L06 | Shipwreck | 619140.18 | 5959124.48 |
| NCN_648 | Kirona | M01 | Shipwreck | 640188.34 | 5970712.62 |
| NCN_688 | Unknown | M01 | Shipwreck | 649948.46 | 5983787.83 |
| NCN_696 | Unknown | G17 | Shipwreck | 656552.62 | 5989061.14 |
| NCN_697 | Unknown | G17 | Shipwreck | 658721.3 | 5990224.08 |
| NCN_703 | Unknown | G17 | Shipwreck | 671157.23 | 5993283.09 |
| NCN_914 | Unknown | K09 | Shipwreck | 546803.83 | 5936034.97 |
| NCN_980 | U-97 | K11 | Shipwreck; DE; German, type submarine. | 531514.12 | 5924607.24 |
| NCN_1211 | Unknown | K16 | Shipwreck | 518976.59 | 5881629.76 |
| NCN_1527 | Unknown | K06 | Obstruction | 564657.78 | 5947158.89 |
| NCN_2229 | Unknown | K08 | Shipwreck | 542610.31 | 5930238.19 |
| NCN_2380 | Unknown | K16 | Shipwreck; shipwreck; iron/steel; Sank 06-08-1990. | 515551.07 | 5880091.94 |
| NCN_2756 | Unknown | L06 | Obstruction | 630526.63 | 5963251.53 |
| NCN_3458 | Anchor with chain | K09 | Obstruction; 243 m long | 550231 | 5934649 |
| NCN_14369 | Anchor | L06 | Obstruction; Anchor | 631624 | 5963282 |
| NCN_14611 | Unknown | M01 | Shipwreck | 647134.41 | 5981028.9 |
| NCN_18756 | Unknown | P01 | Shipwreck | 513273 | 5866589 |
| NCN_19300 | Unknown | L05 | Obstruction | 593655 | 5950911 |
| NCN_19301 | Unknown | L05 | Obstruction | 596463 | 5949899 |
| NCN_19303 | Unknown | L04 | Obstruction | 566131 | 5947975 |
| NCN_19414 | Unknown | G17 | Obstruction | 659633 | 5991721 |
| NCN_19437 | Unknown | M01 | Obstruction | 637467 | 5969399 |
| NCN_19591 | Unknown | M01 | Obstruction | 637004 | 5969419 |
| NCN_20136 | Unknown | G18 | Shipwreck; Location Lelystad; wood; Discovered during construction of wind farm park Gemini. | 686860.04 | 5994518.71 |

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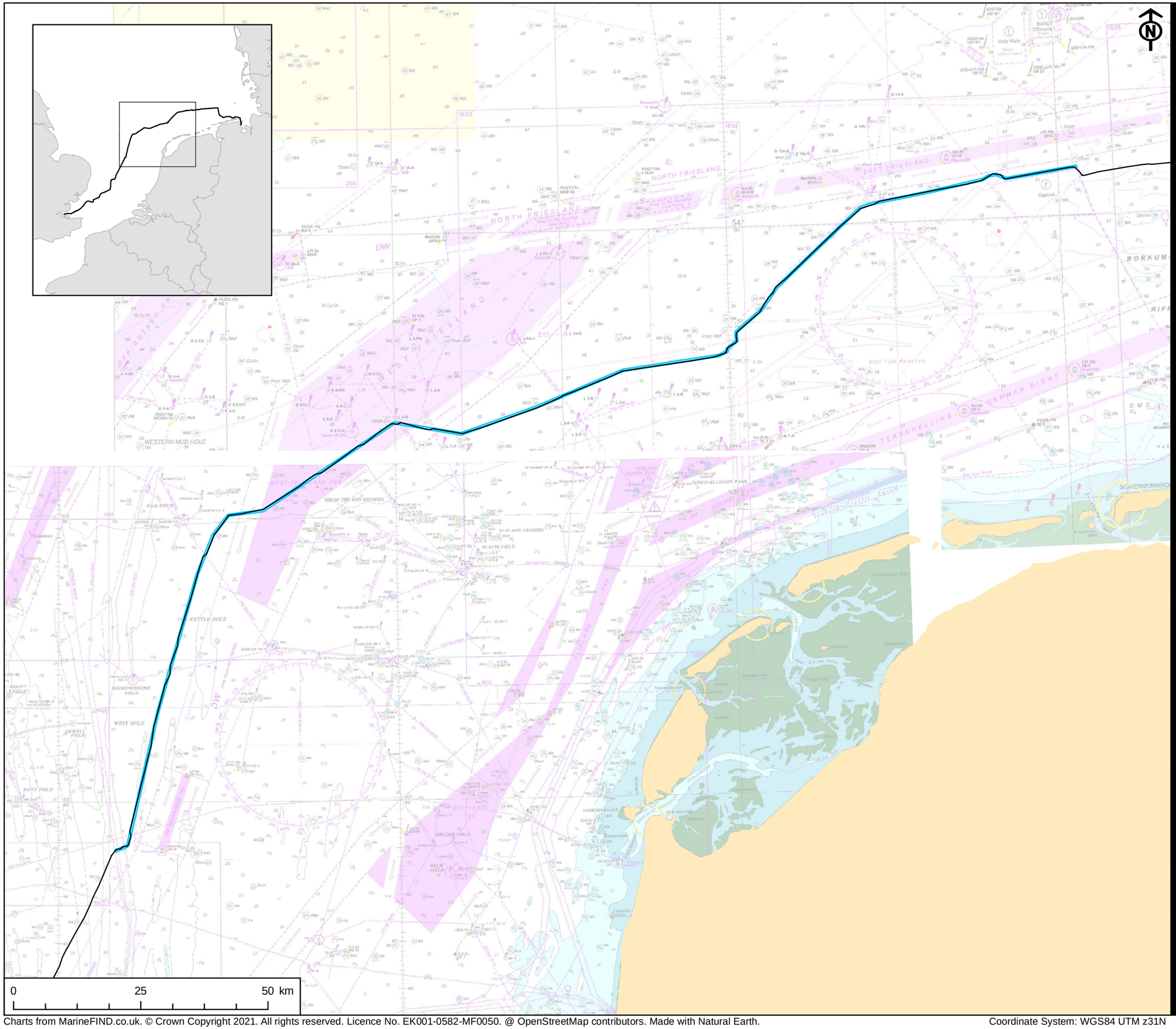


Scale @ A3 1:700,000

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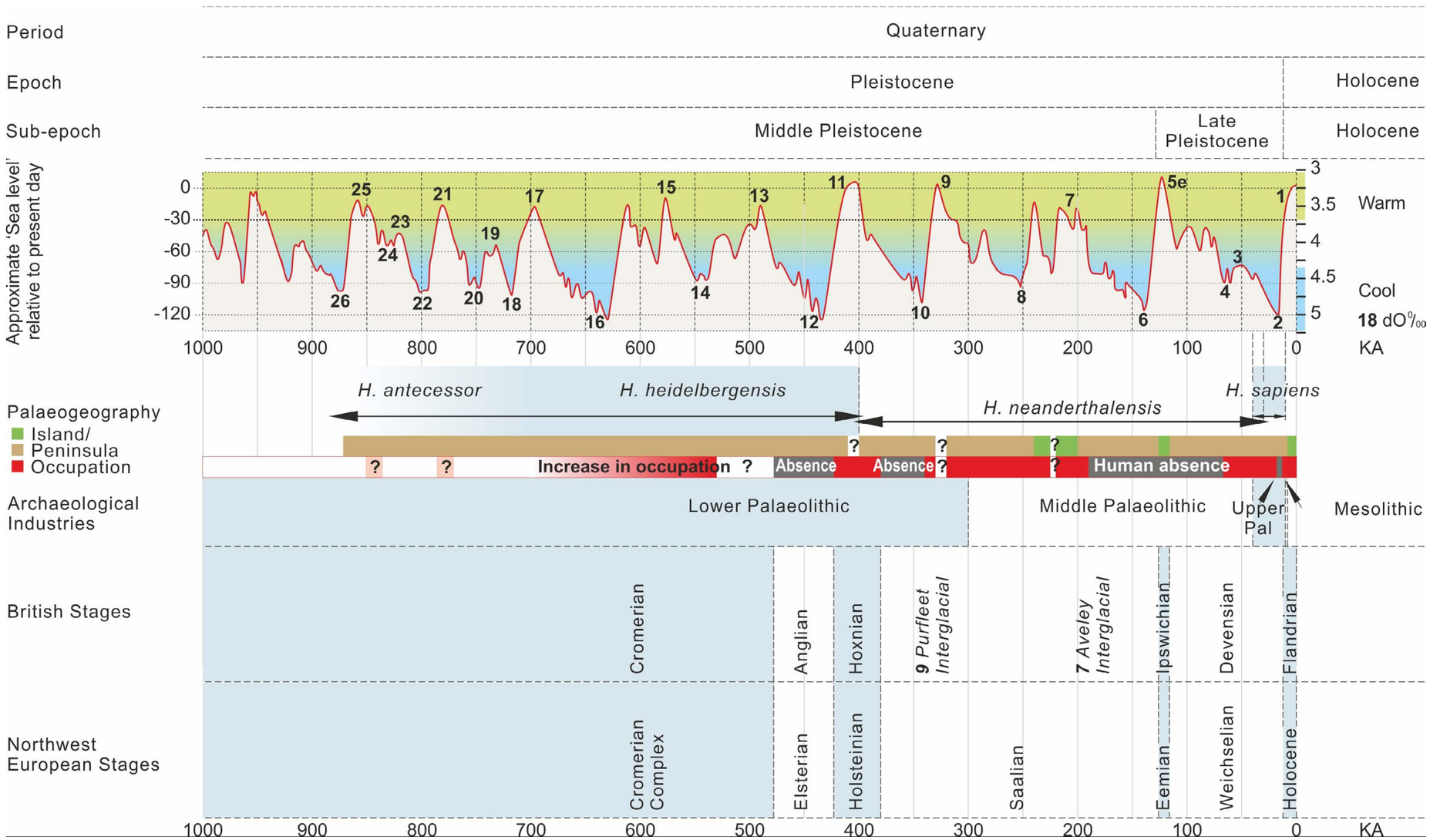
KEY
Proposed cable route
Geophysical study area

TITLE
FIGURE 1
LOCATION OF NEUCONNECT
CABLE CORRIDOR (DUTCH SECTOR)

REFERENCE
NC_210312_Tech_Dutch_Fig01

| SHEET NUMBER | DATE |
|---|---|
| 1 of 1 | 12/03/21 |

Project Management Initials: AB Designer: KJF Checked: ## Approved: ##

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The figure presents information derived from several references: the global sea-level curve is from Lisiecki and Raymo (2005) and Jelgersma (1979). Details on the geology and archaeology were provided by Dix and Westley (2004); Funnel (1995); Gibbard and van Kolfschoten (2004); Kukla et al. (2002); Lee et al. (2006); Lowe and Walker (1997) and Wymer (1999).

TITLE
FIGURE 2
SEA LEVEL CURVE AND CHRONOLOGY
OF THE SOUTHERN NORTH SEA LANDSCAPE

REFERENCE
NC_210312_GeophysDutch_Fig02

SHEET NUMBER
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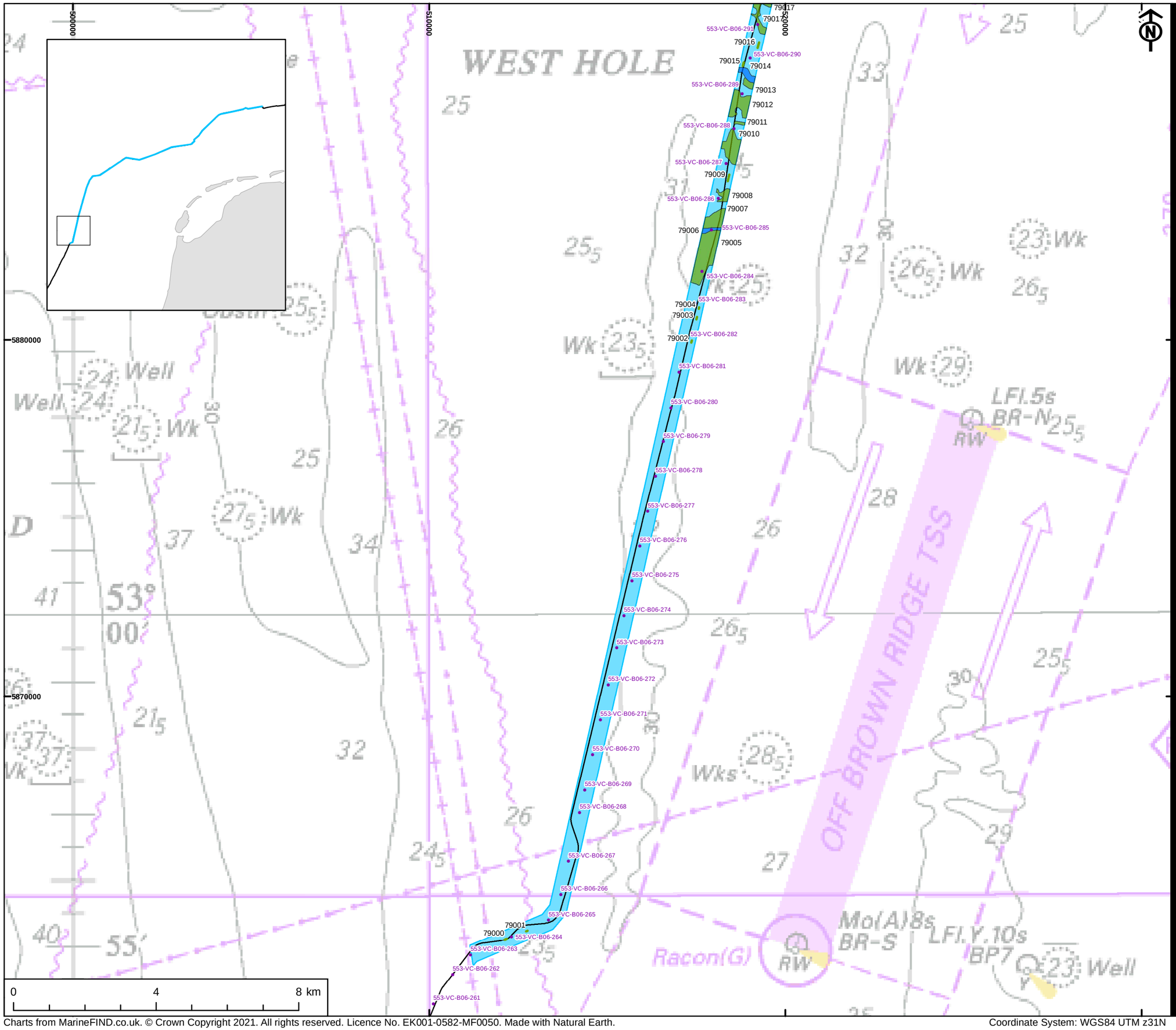


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- Vibrocore locations
- Data example location
- Channel
- Older channel
- Coarse-grained deposit
- Cut and fill
- High amplitude reflector
- Older high amplitude reflector

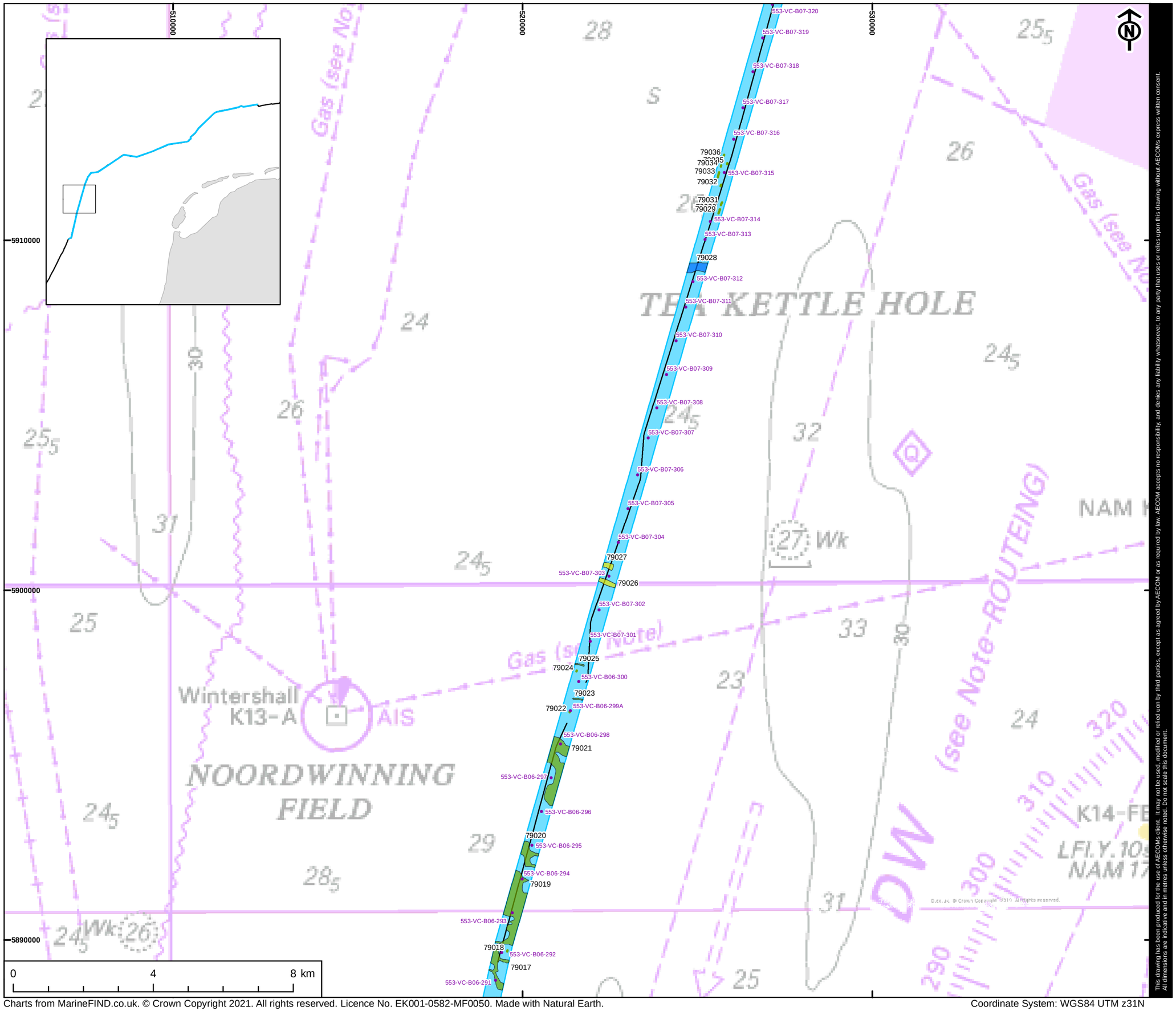
TITLE
FIGURE 3A
PALAEOGEOGRAPHIC FEATURES OF ARCHAEOLOGICAL POTENTIAL

REFERENCE
NC_210312_GeophysDutch_Fig03a

SHEET NUMBER
1 of 8

DATE
12/03/21

Project Management Initials: AB Designer: KJF Checked: ## Approved: ##

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TITLE
FIGURE 3B
PALAEOGEOGRAPHIC FEATURES OF ARCHAEOLOGICAL POTENTIAL

REFERENCE
NC_210312_GeophysDutch_Fig03b

SHEET NUMBER
2 of 8

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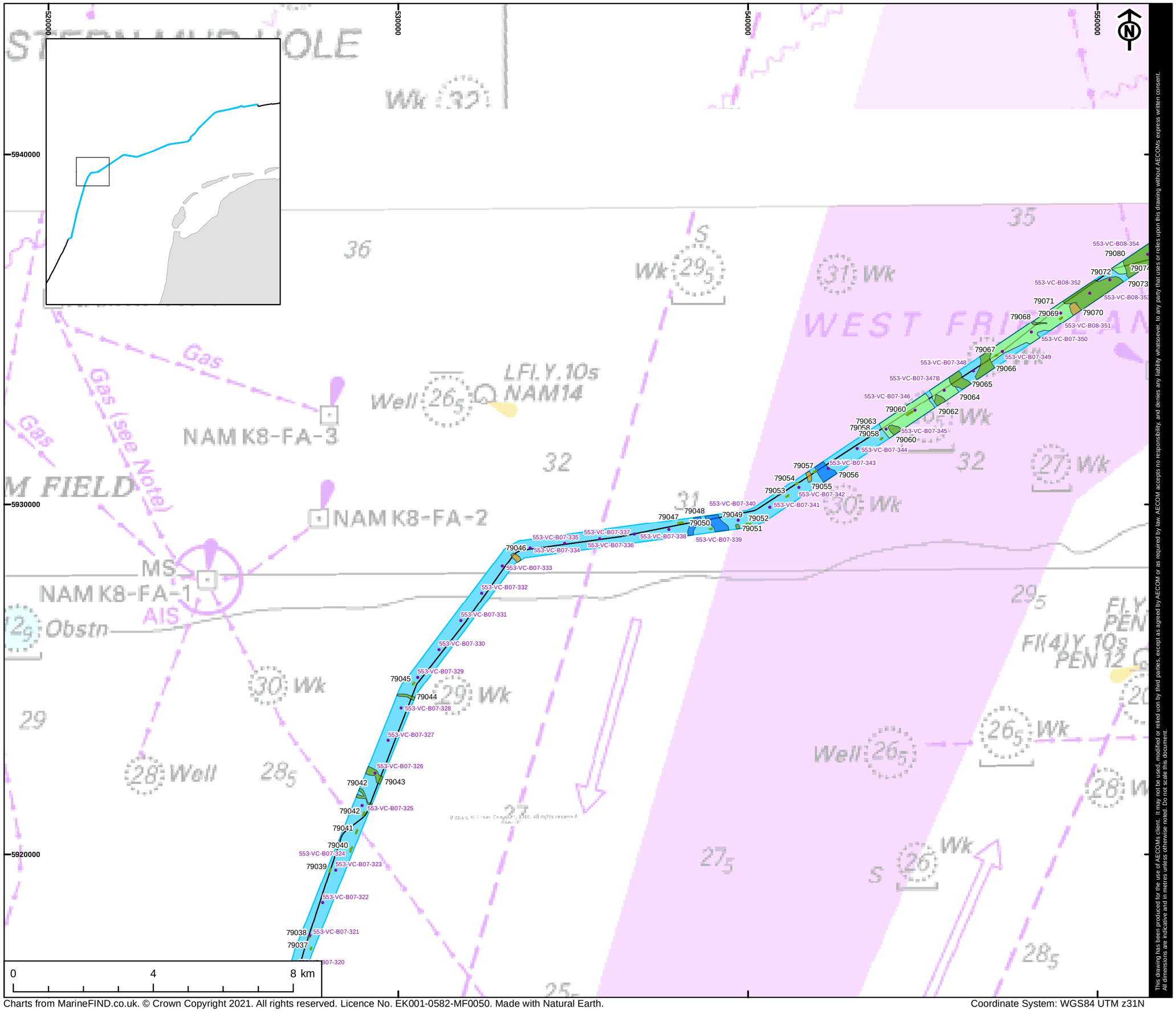


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- Older high amplitude reflector

TITLE
FIGURE 3C
PALAEOGEOGRAPHIC FEATURES OF ARCHAEOLOGICAL POTENTIAL

REFERENCE
NC_210312_GeophysDutch_Fig03c

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3 of 8

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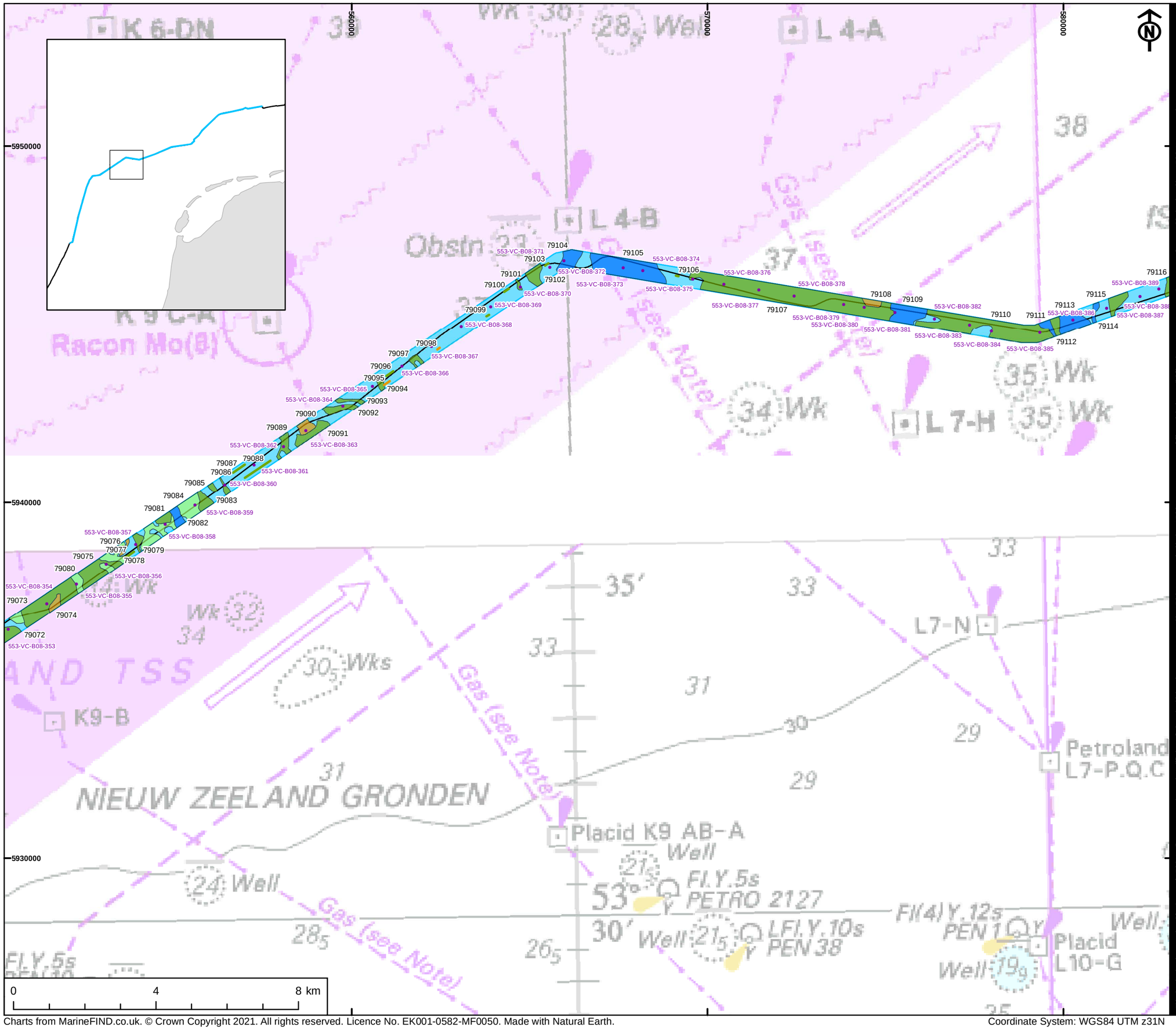


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TITLE
FIGURE 3D
PALAEOGEOGRAPHIC FEATURES OF ARCHAEOLOGICAL POTENTIAL

REFERENCE
NC_210312_GeophysDutch_Fig03d

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4 of 8

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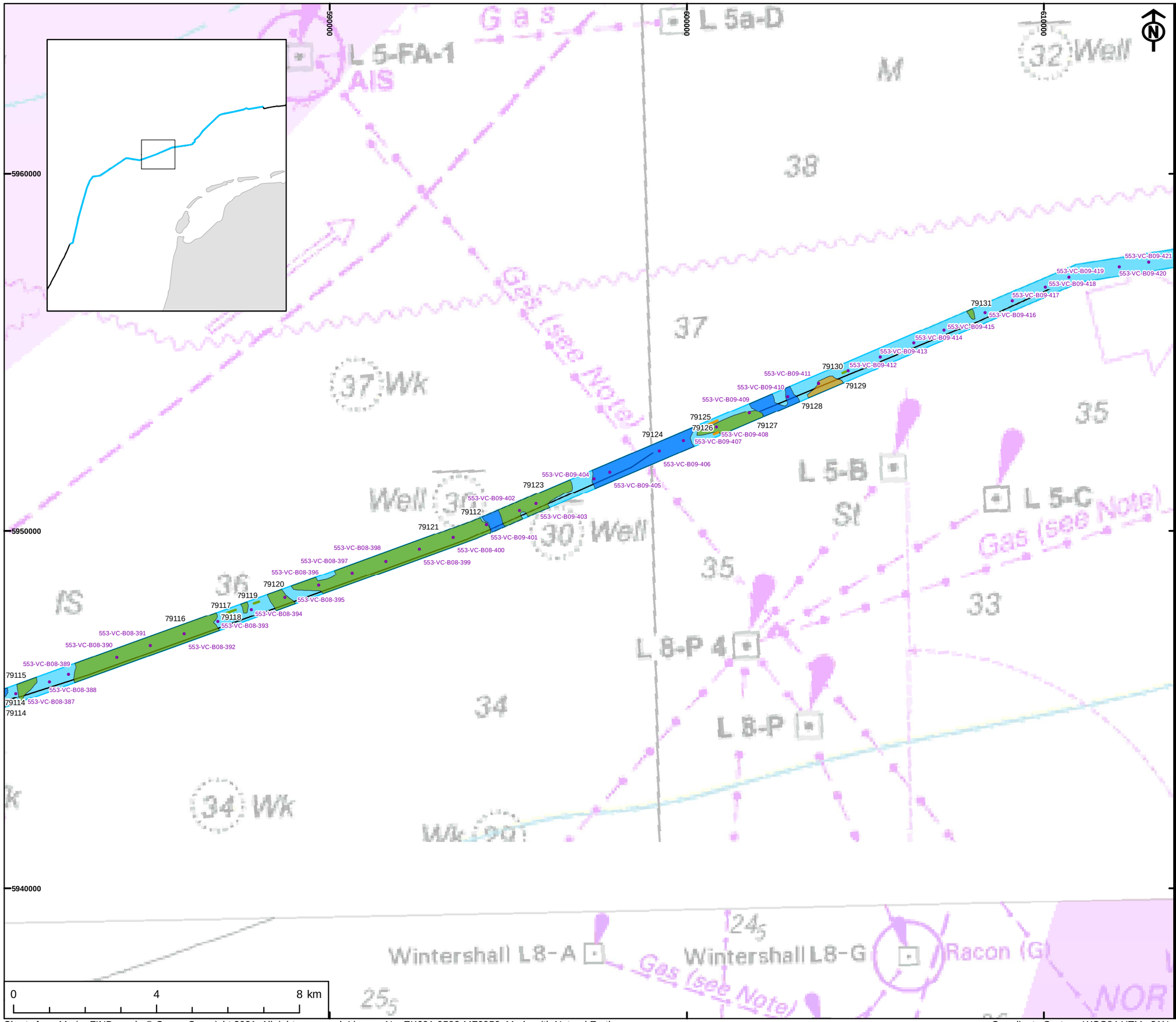


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TITLE
FIGURE 3E
PALAEOGEOGRAPHIC FEATURES OF ARCHAEOLOGICAL POTENTIAL

REFERENCE
NC_210312_GeophysDutch_Fig03e

SHEET NUMBER
5 of 8

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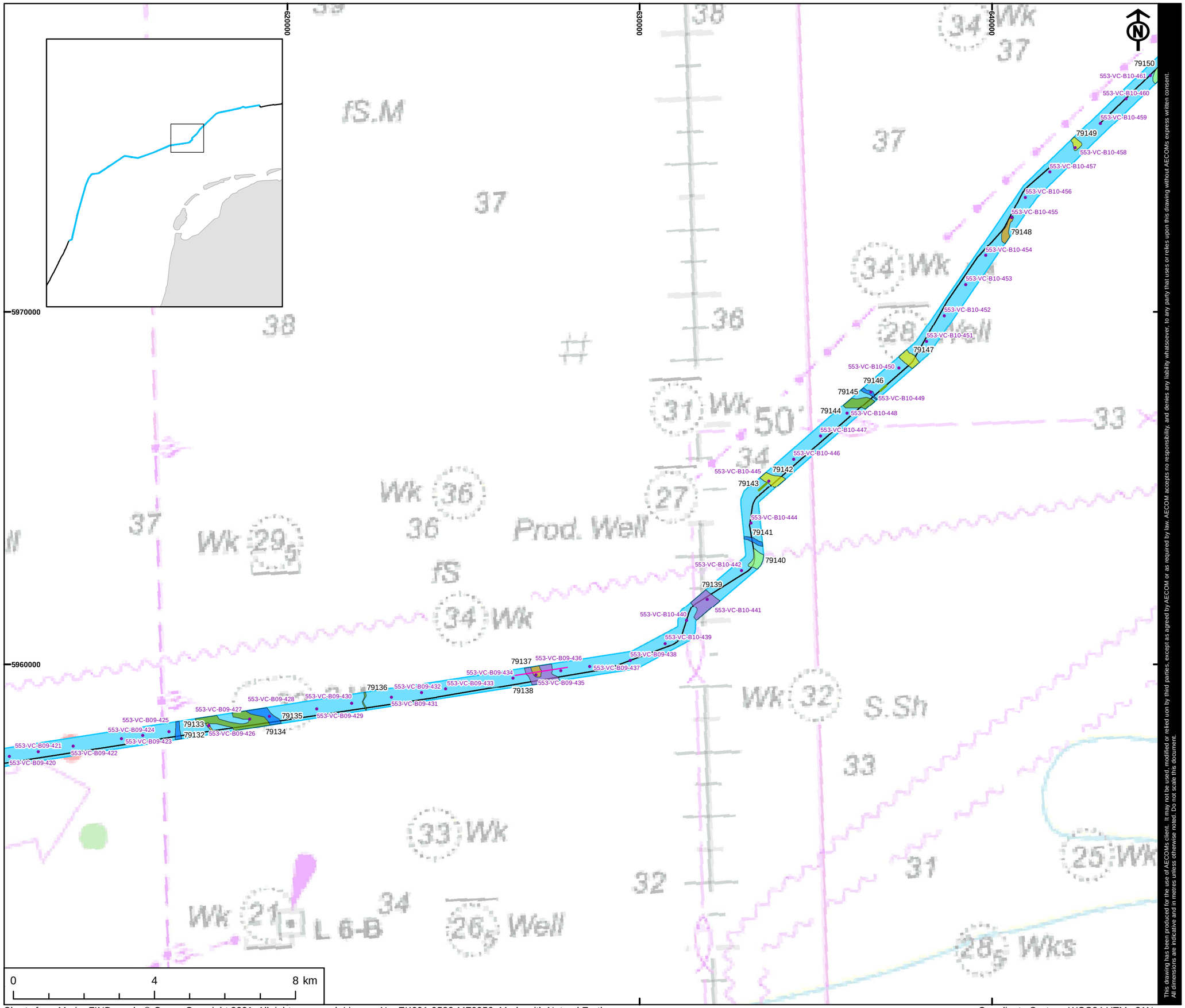


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TITLE
FIGURE 3F
PALAEOGEOGRAPHIC FEATURES OF ARCHAEOLOGICAL POTENTIAL

REFERENCE
NC_210312_GeophysDutch_Fig03f

SHEET NUMBER
6 of 8

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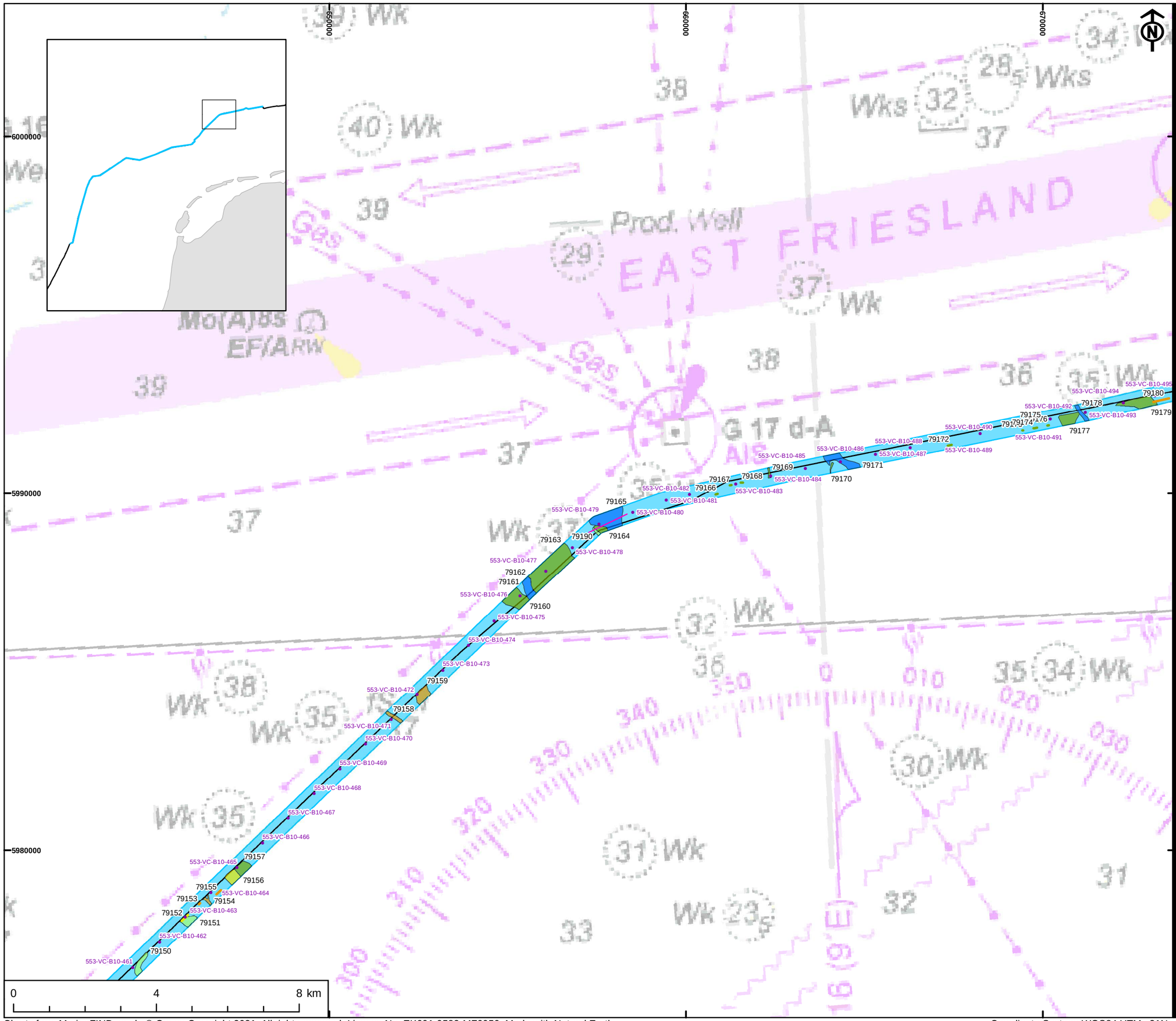


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TITLE
FIGURE 3G
PALAEOGEOGRAPHIC FEATURES OF ARCHAEOLOGICAL POTENTIAL

REFERENCE
NC_210312_GeophysDutch_Fig03g

SHEET NUMBER
7 of 8

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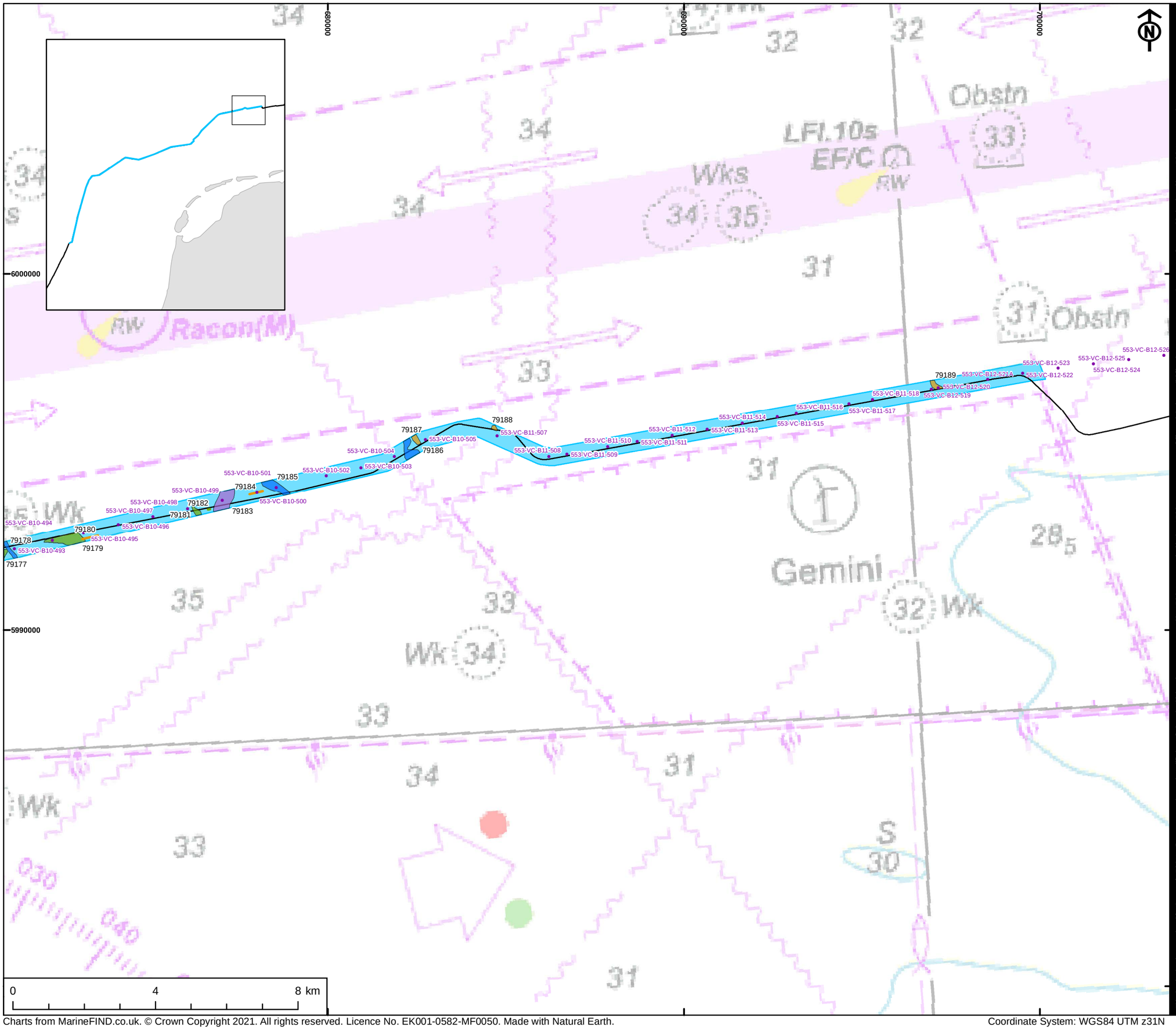


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TITLE
FIGURE 3H
PALAEOGEOGRAPHIC FEATURES OF ARCHAEOLOGICAL POTENTIAL

REFERENCE
NC_210312_GeophysDutch_Fig03h

SHEET NUMBER
8 of 8

DATE
12/03/21

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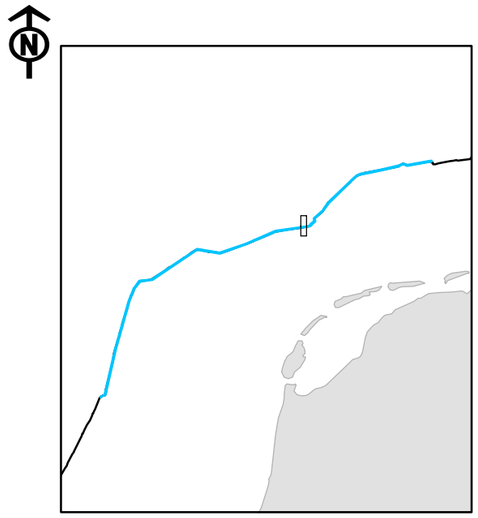

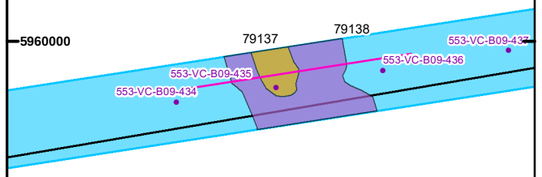


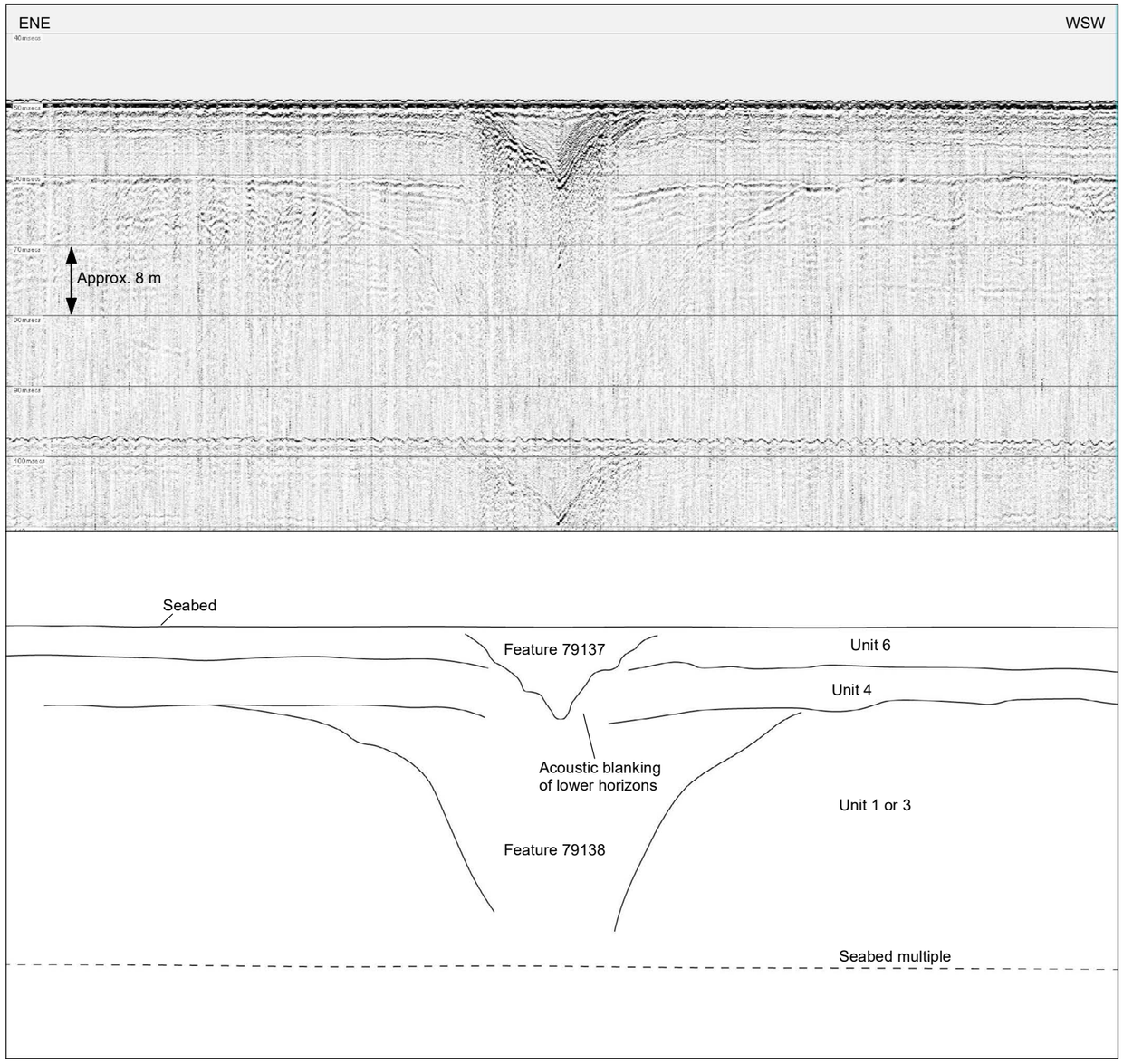


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0 1.5 3 km

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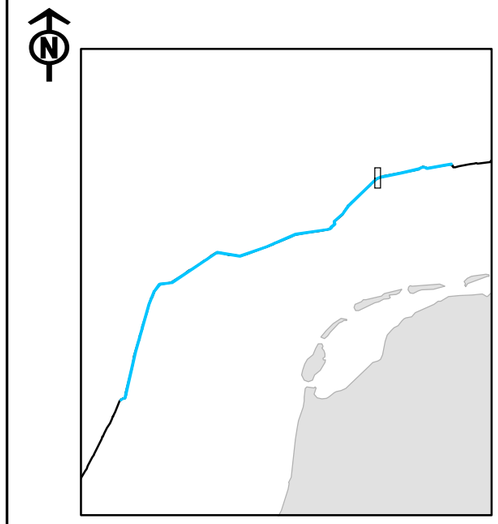
- Geophysical study area
- Vibrocore locations
- Data example location
- Older channel
- Cut and fill

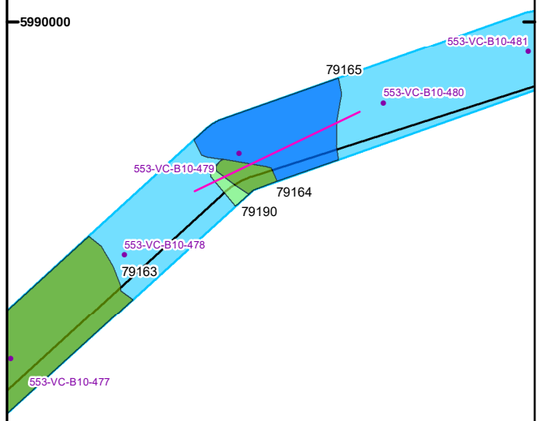
TITLE
FIGURE 4
PALAEOGEOGRAPHIC FEATURE
DATA EXAMPLE – 79138

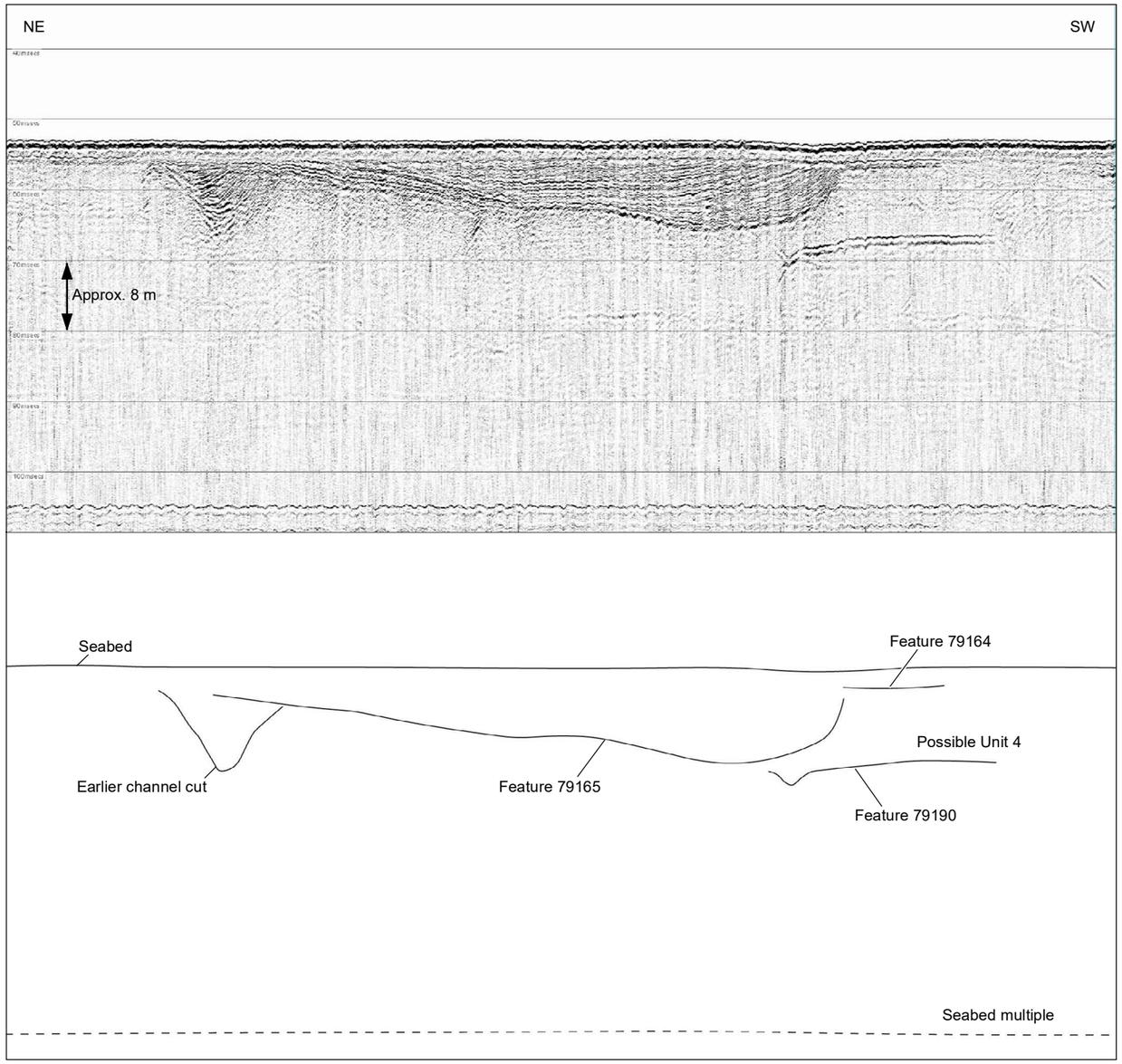
REFERENCE
NC_210312_GeophysDutch_Fig04

| SHEET NUMBER | DATE |
|---|---|
| 1 of 1 | 12/03/21 |

Project Management Initials: AB Designer: KJF Checked: ## Approved: ##






Scale @ A3 1:40,000

0 1.5 3 km

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Coordinate System: WGS84 UTM z31N

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PROJECT
NEUCONNECT

CLIENT
NeuConnect Britain Ltd.

KEY
- Proposed cable route
- Geophysical study area
- Vibrocore locations
- Data example location
- Channel
- High amplitude reflector
- Older high amplitude reflector

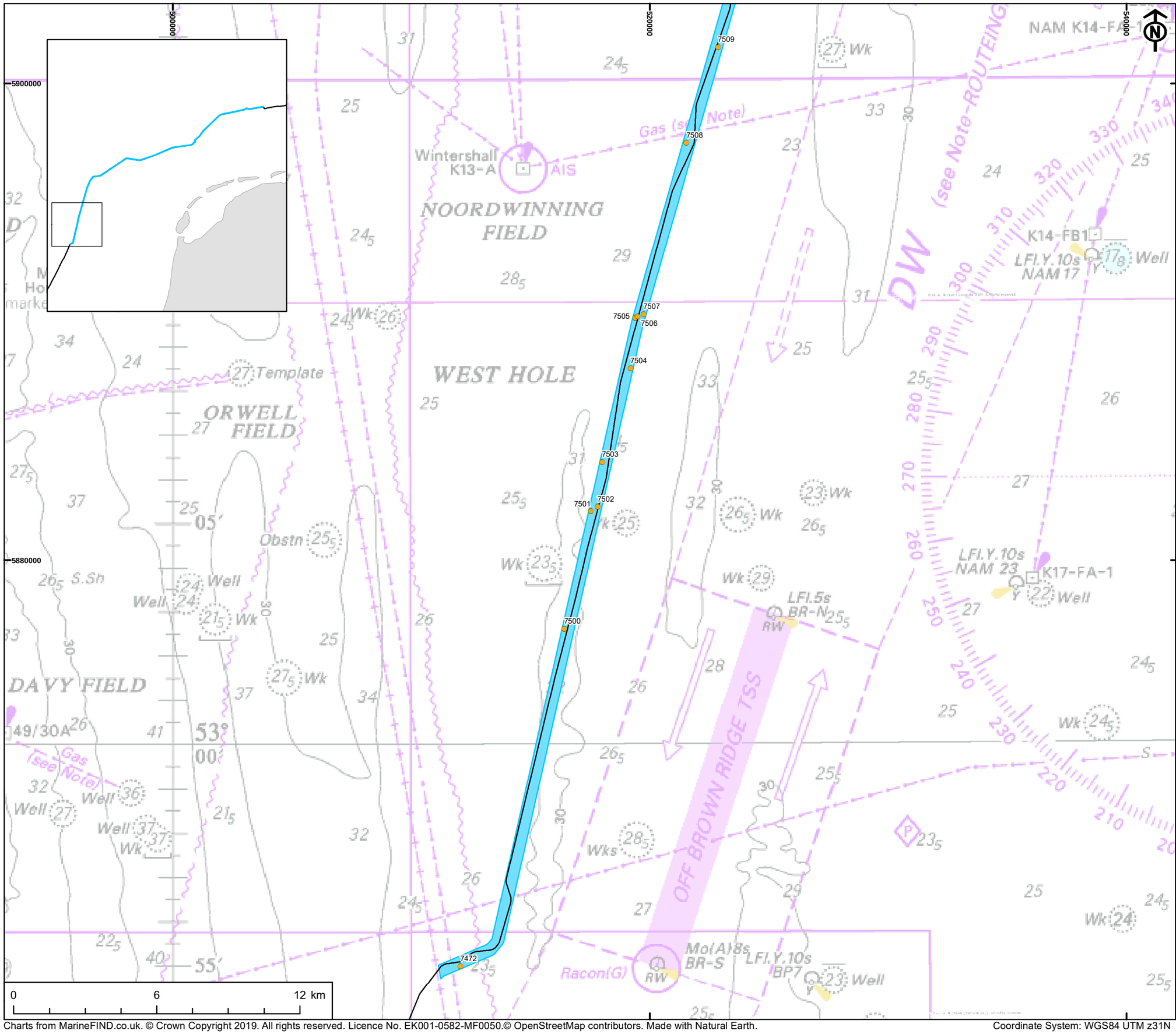
TITLE
FIGURE 5
PALAEOGEOGRAPHIC FEATURE
DATA EXAMPLE – 79165

REFERENCE
NC_210312_GeophysDutch_Fig05

SHEET NUMBER 1 of 1

DATE 12/03/21

Project Management Initials: AB Designer: KJF Checked: ## Approved: ##




Scale @ A3 1:150,000

0 6 12 km

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PROJECT
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KEY

- Proposed cable route
- Geophysical study area
- Recommended Archaeological Exclusion Zone (AEZ)
- Seabed feature extents
- Linear seabed features

**Seabed features of archaeological potential**

- A1 – Anthropogenic origin of archaeological interest
- A2 – Uncertain origin of possible archaeological interest
- A3 – Historic record of possible archaeological interest

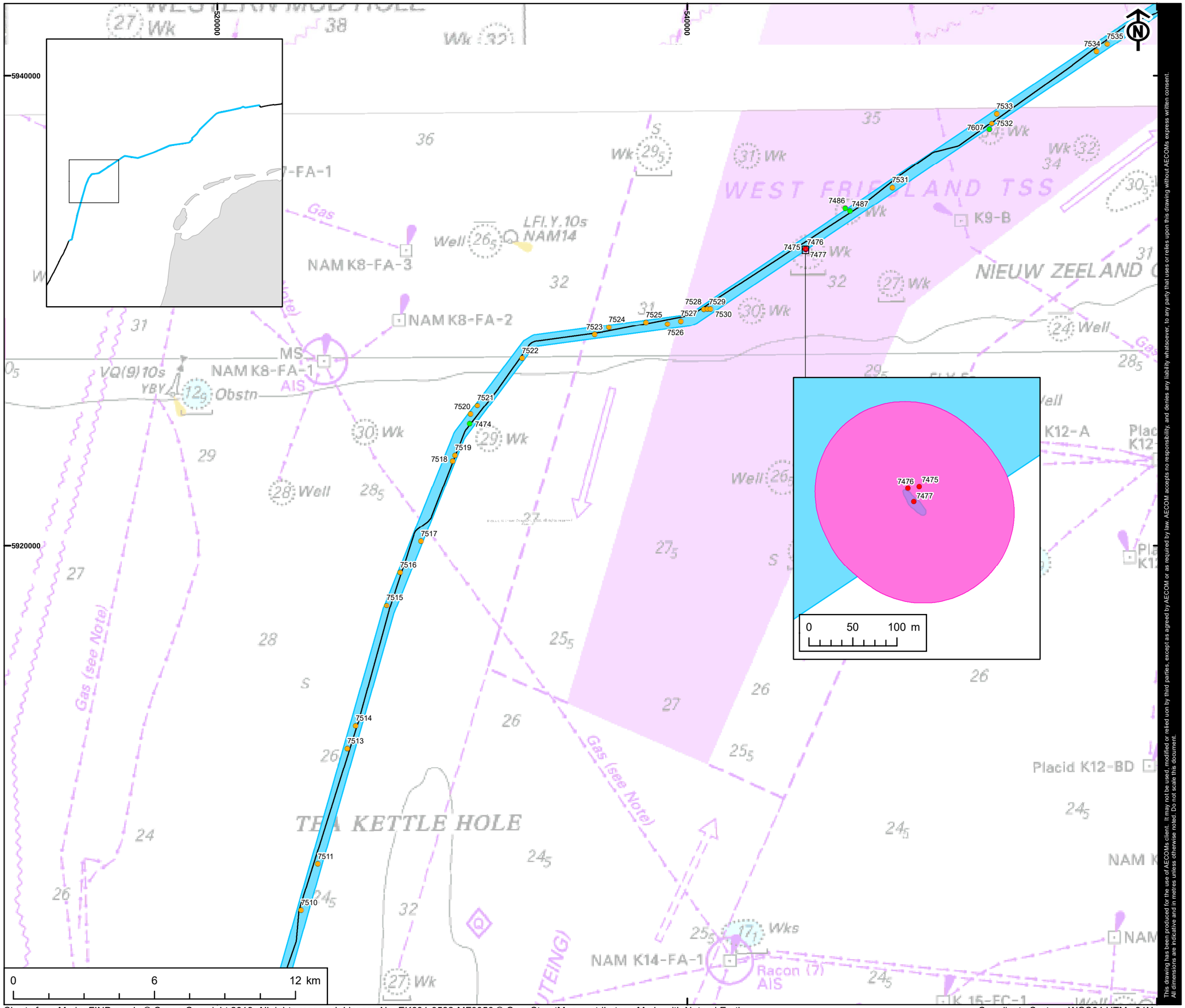
TITLE
FIGURE 6A
SEABED FEATURES OF
ARCHAEOLOGICAL POTENTIAL

REFERENCE
NC_210423_GeophysDutch_Fig06a

SHEET NUMBER
1 of 5

DATE
23/04/21

Project Management Initials: AB Designer: KJF Checked: ## Approved: ##

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PROJECT
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KEY
- Proposed cable route
- Geophysical study area
- Recommended Archaeological Exclusion Zone (AEZ)
- Seabed feature extents
- Linear seabed features

**Seabed features of archaeological potential**
- A1 – Anthropogenic origin of archaeological interest
- A2 – Uncertain origin of possible archaeological interest
- A3 – Historic record of possible archaeological interest

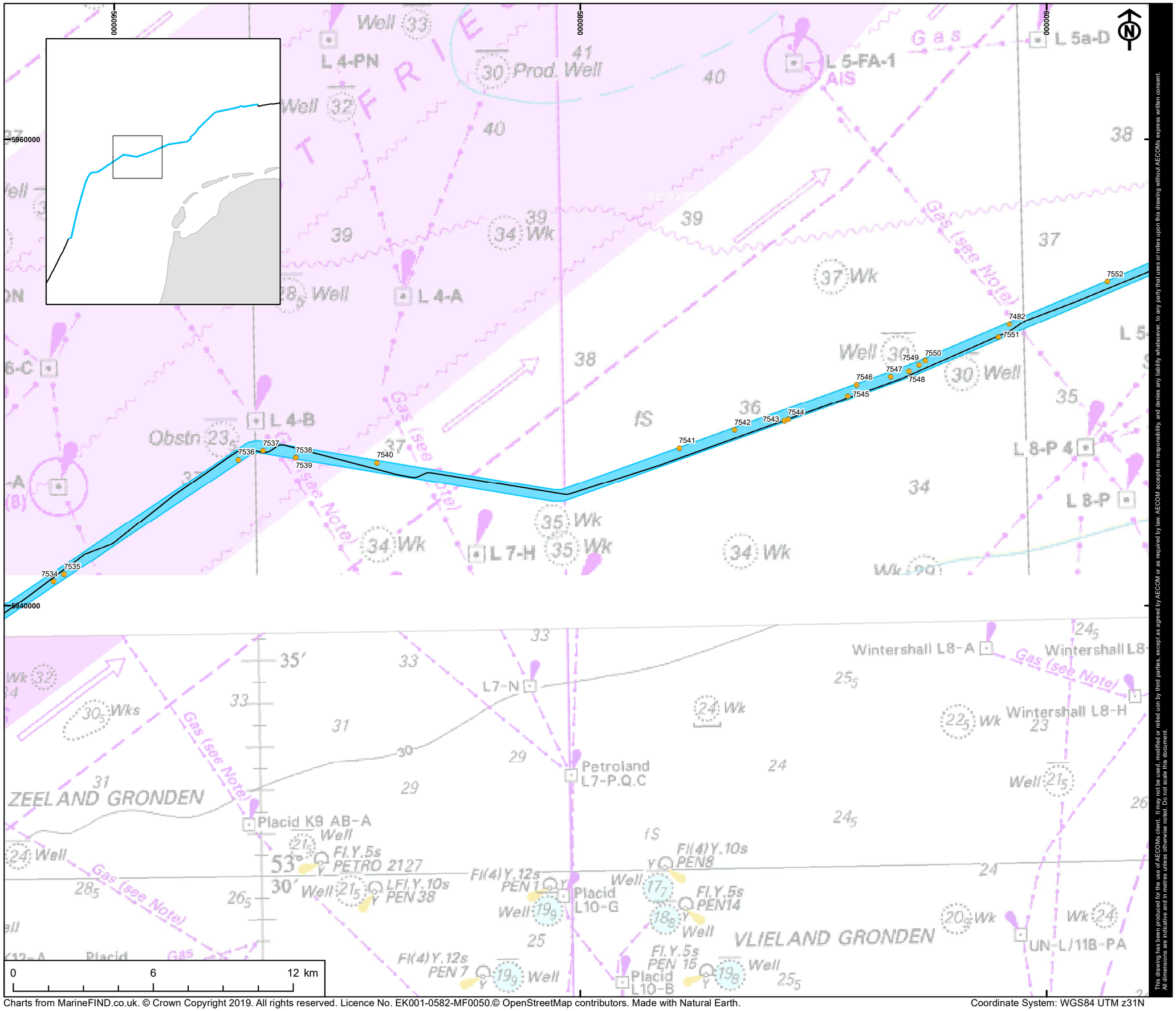
TITLE
FIGURE 6B
SEABED FEATURES OF ARCHAEOLOGICAL POTENTIAL

REFERENCE
NC_210423_GeophysDutch_Fig06b

SHEET NUMBER
2 of 5

DATE
23/04/21

Project Management Initials: AB Designer: KJF Checked: ## Approved: ##

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PROJECT
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NeuConnect Britain Ltd.

KEY

- Proposed cable route
- Geophysical study area
- Recommended Archaeological Exclusion Zone (AEZ)
- Seabed feature extents
- Linear seabed features

**Seabed features of archaeological potential**

- A1 – Anthropogenic origin of archaeological interest
- A2 – Uncertain origin of possible archaeological interest
- A3 – Historic record of possible archaeological interest

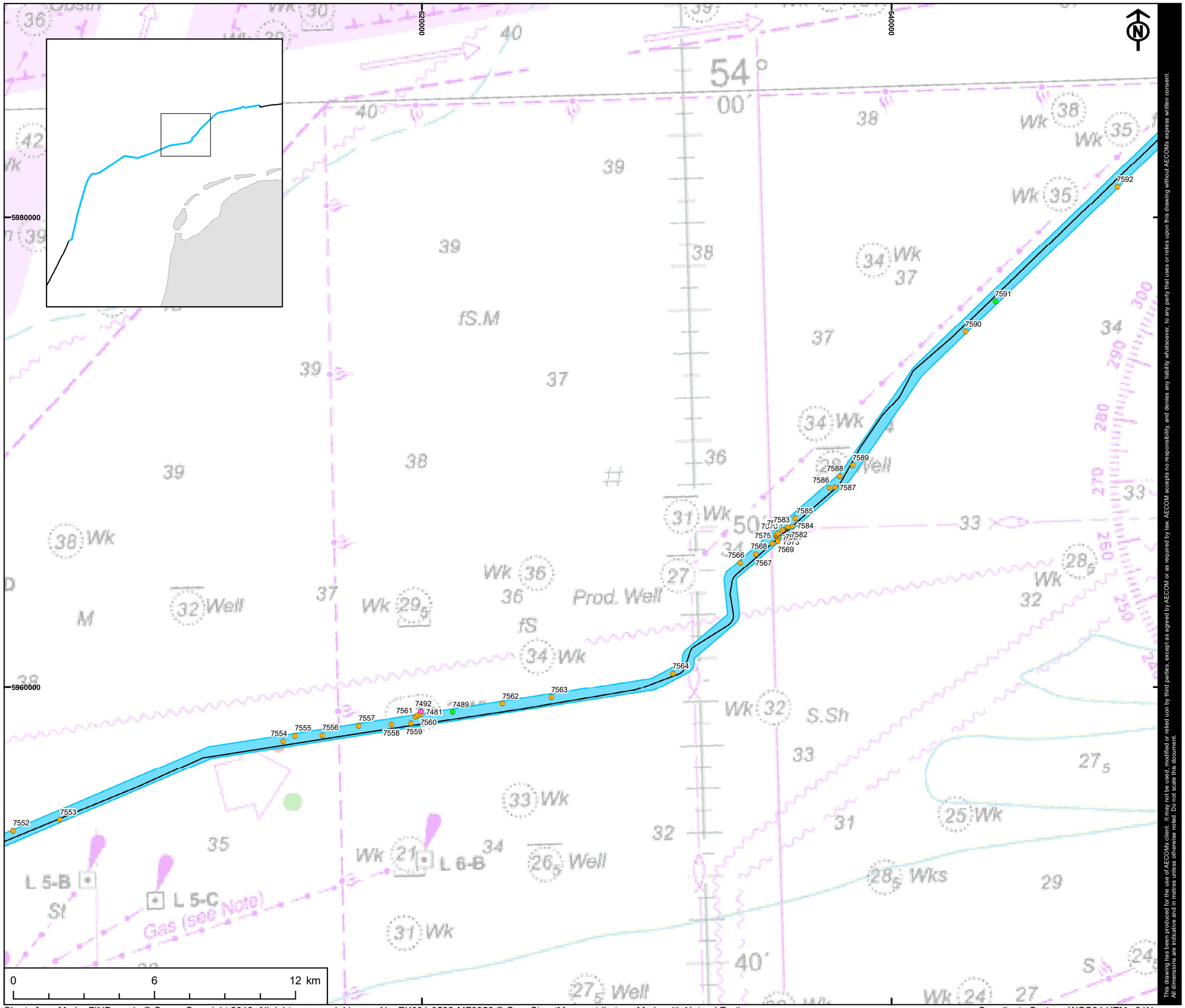
TITLE
FIGURE 6C
SEABED FEATURES OF ARCHAEOLOGICAL POTENTIAL

REFERENCE
NC_210423_GeophysDutch_Fig06c

SHEET NUMBER
3 of 5

DATE
23/04/21

Project Management Initials: AB Designer: KJF Checked: ## Approved: ##

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PROJECT
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KEY

- Proposed cable route
- Geophysical study area
- Recommended Archaeological Exclusion Zone (AEZ)
- Seabed feature extents
- Linear seabed features

**Seabed features of archaeological potential**

- A1 – Anthropogenic origin of archaeological interest
- A2 – Uncertain origin of possible archaeological interest
- A3 – Historic record of possible archaeological interest

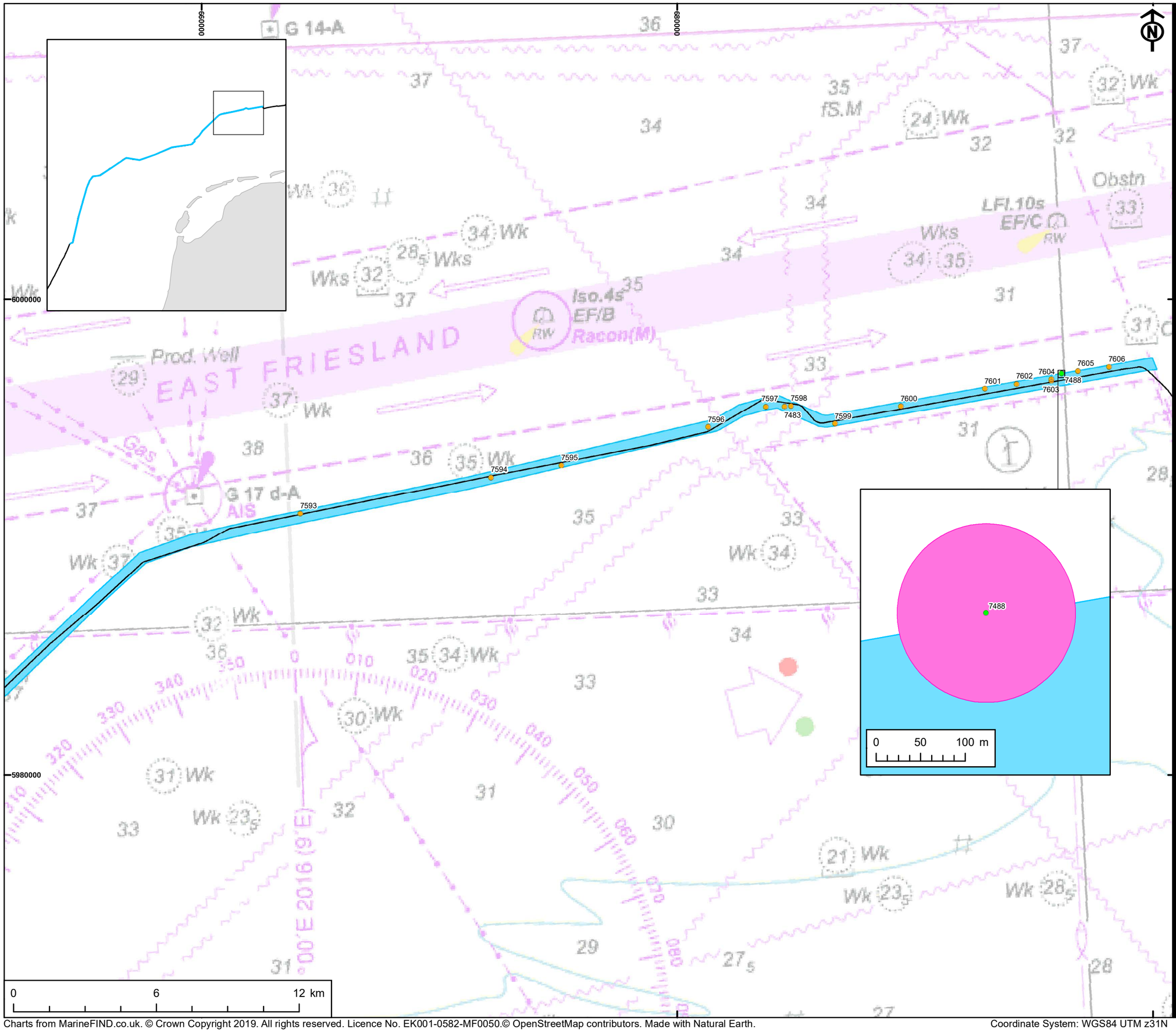
TITLE
FIGURE 6D
SEABED FEATURES OF ARCHAEOLOGICAL POTENTIAL

REFERENCE
NC_210423_GeophysDutch_Fig06d

SHEET NUMBER
4 of 5

DATE
23/04/21

Project Management Initials: AB Designer: KJF Checked: ## Approved: ##




Scale @ A3 1:4,000

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PROJECT
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NeuConnect Britain Ltd.

KEY

- Proposed cable route
- Geophysical study area
- Recommended Archaeological Exclusion Zone (AEZ)
- Seabed feature extents
- Linear seabed features

**Seabed features of archaeological potential**

- A1 – Anthropogenic origin of archaeological interest
- A2 – Uncertain origin of possible archaeological interest
- A3 – Historic record of possible archaeological interest

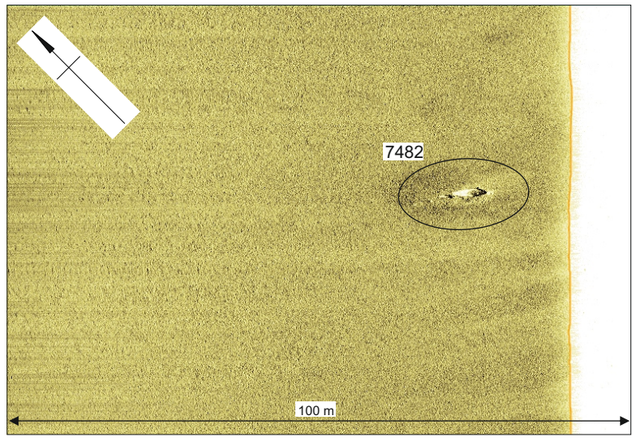
TITLE
FIGURE 6E
SEABED FEATURES OF ARCHAEOLOGICAL POTENTIAL

REFERENCE
NC_210423_GeophysDutch_Fig06e

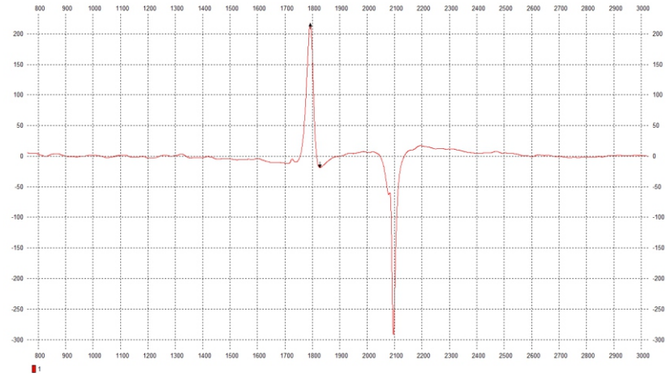
SHEET NUMBER
5 of 5

DATE
23/04/21

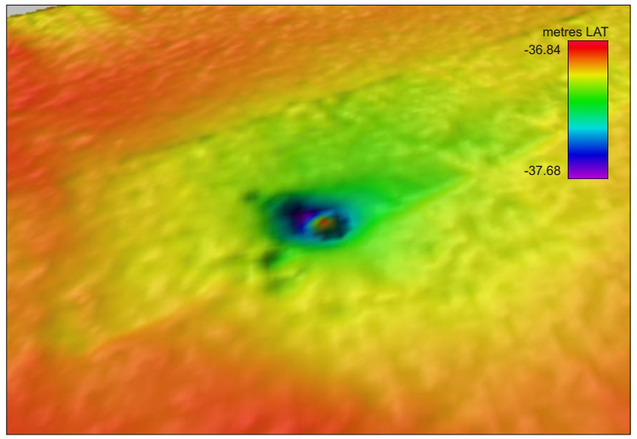
Project Management Initials: ## Designer: ## Checked: ## Approved: ##



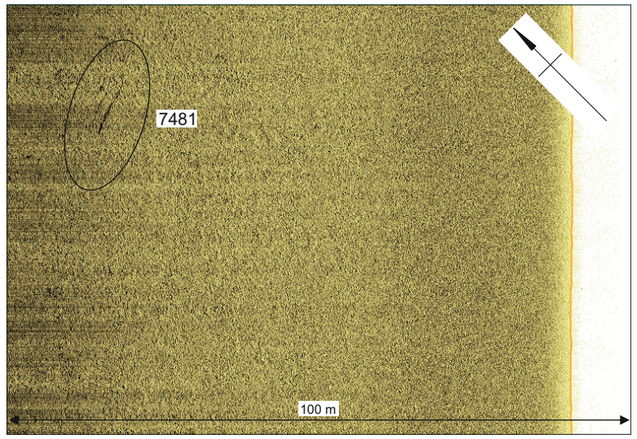

Sidescan sonar waterfall image of ferrous debris field **7482**, 10.0 x 10.0 x 1.1 m



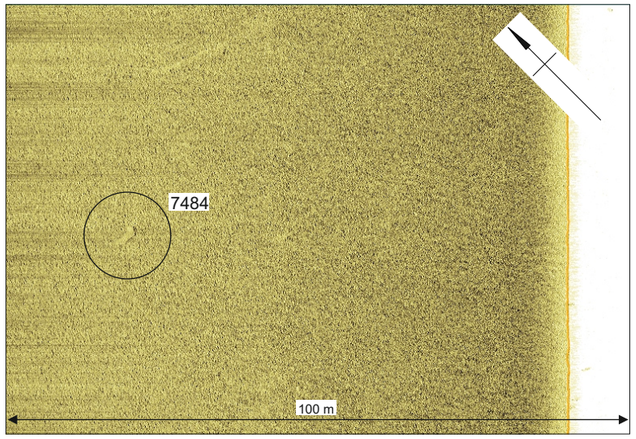
Magnetic profile of ferrous debris field **7482**, measuring 237 nT



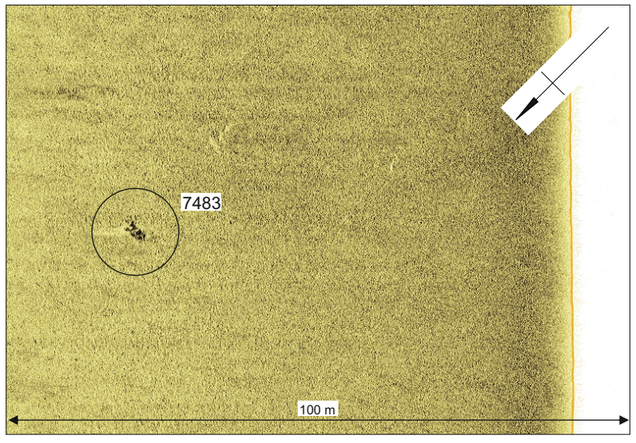

Multibeam echosounder image of ferrous debris field **7482**, looking north (x1 vertical exaggeration)




Sidescan sonar waterfall image of dark reflector **7481**, 27.9 x 0.9 m




Sidescan sonar waterfall image of debris **7484**, 13.1 x 3.9 x 0.2 m




Sidescan sonar waterfall image of dark reflector **7483**, 9.9 x 4.0 x 0.7 m

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KEY

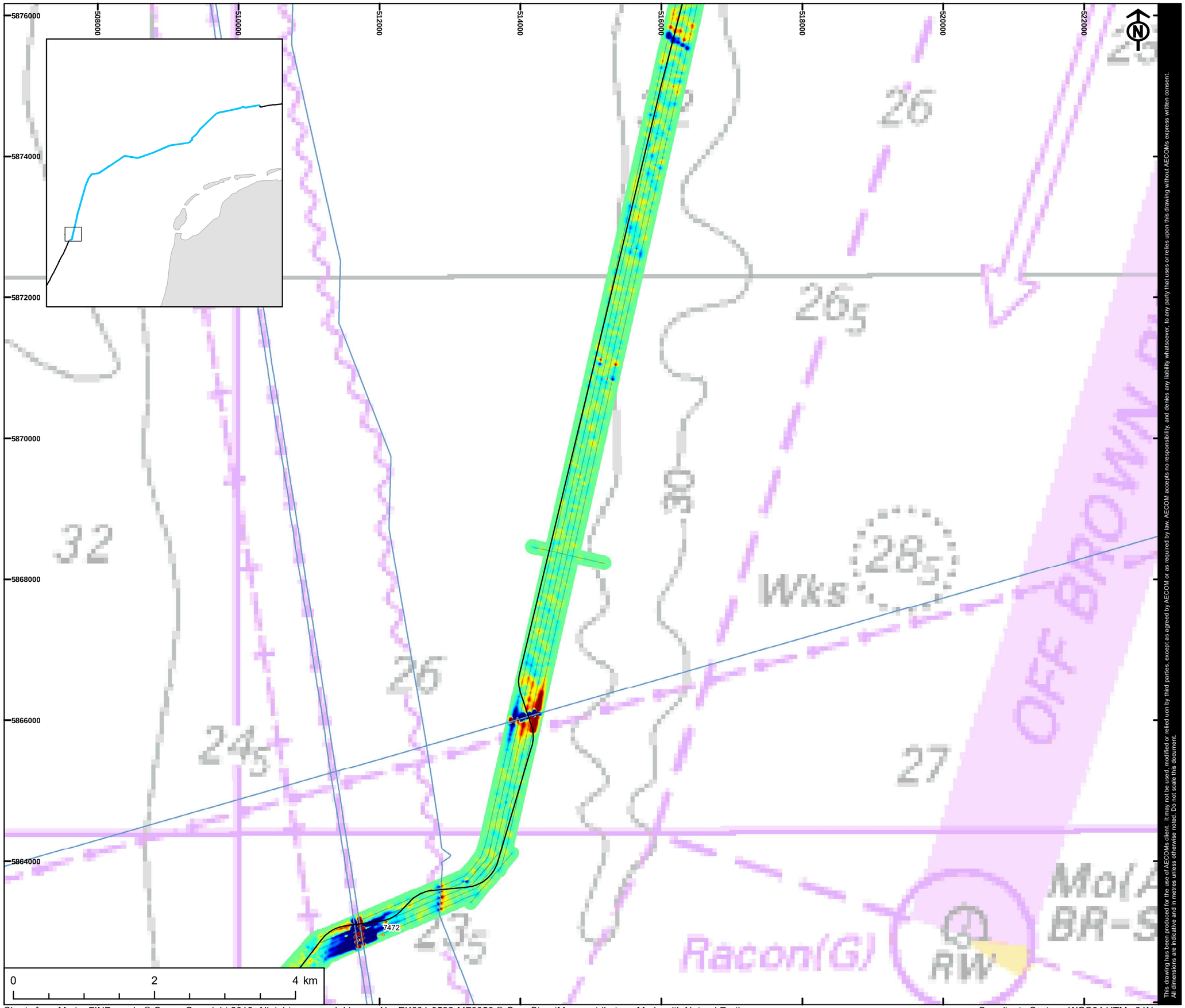
TITLE
FIGURE 7
SEABED FEATURES DATA EXAMPLES

REFERENCE
NC_190702_GeophysDutch_Fig07

SHEET NUMBER
1 of 1

DATE
28/02/19

Project Management Initials: AB Designer: KJF Checked: ## Approved: ##




Scale @ A3 1:50,000

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AECOM

PROJECT
NEUCONNECT

CLIENT
NeuConnect Britain Ltd.

KEY

- Proposed cable route
- RWS pipelines and cables
- MMT produced magnetometer trackplot

**Seabed features of archaeological potential**

- A1 – Anthropogenic origin of archaeological interest
- A2 – Uncertain origin of possible archaeological interest
- A3 – Historic record of possible archaeological interest

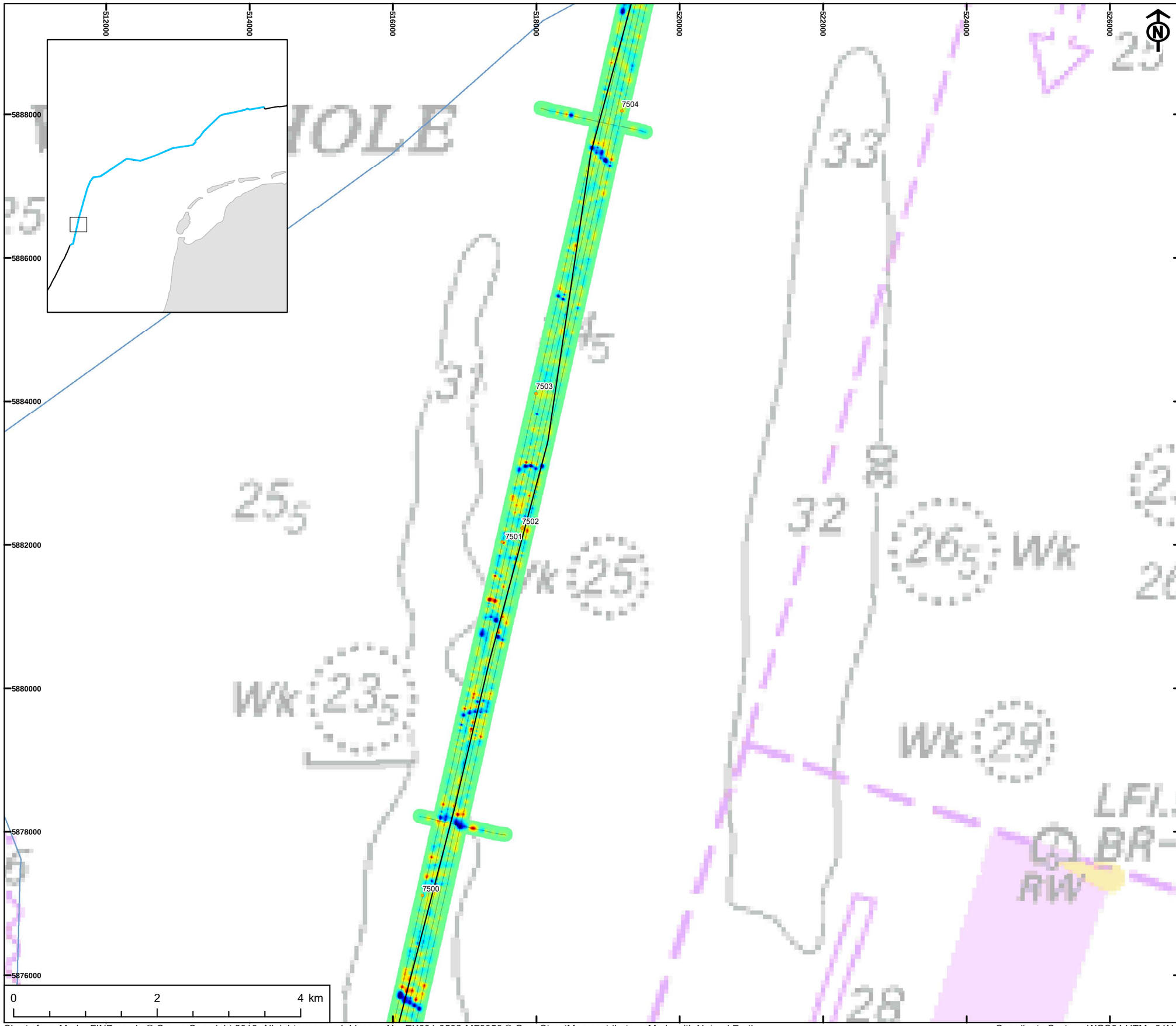
TITLE
FIGURE 8A
SEABED FEATURES OF ARCHAEOLOGICAL POTENTIAL IN RELATION TO THE MAGNETOMETER DATA

REFERENCE
NC_210423_GeophysDutch_Fig08

SHEET NUMBER
1 of 16

DATE
23/04/21

Project Management Initials: AB Designer: KJF Checked: ## Approved: ##

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PROJECT
NEUCONNECT

CLIENT
NeuConnect Britain Ltd.

KEY

- Proposed cable route
- RWS pipelines and cables
- MMT produced magnetometer trackplot

**Seabed features of archaeological potential**

- A1 – Anthropogenic origin of archaeological interest
- A2 – Uncertain origin of possible archaeological interest
- A3 – Historic record of possible archaeological interest

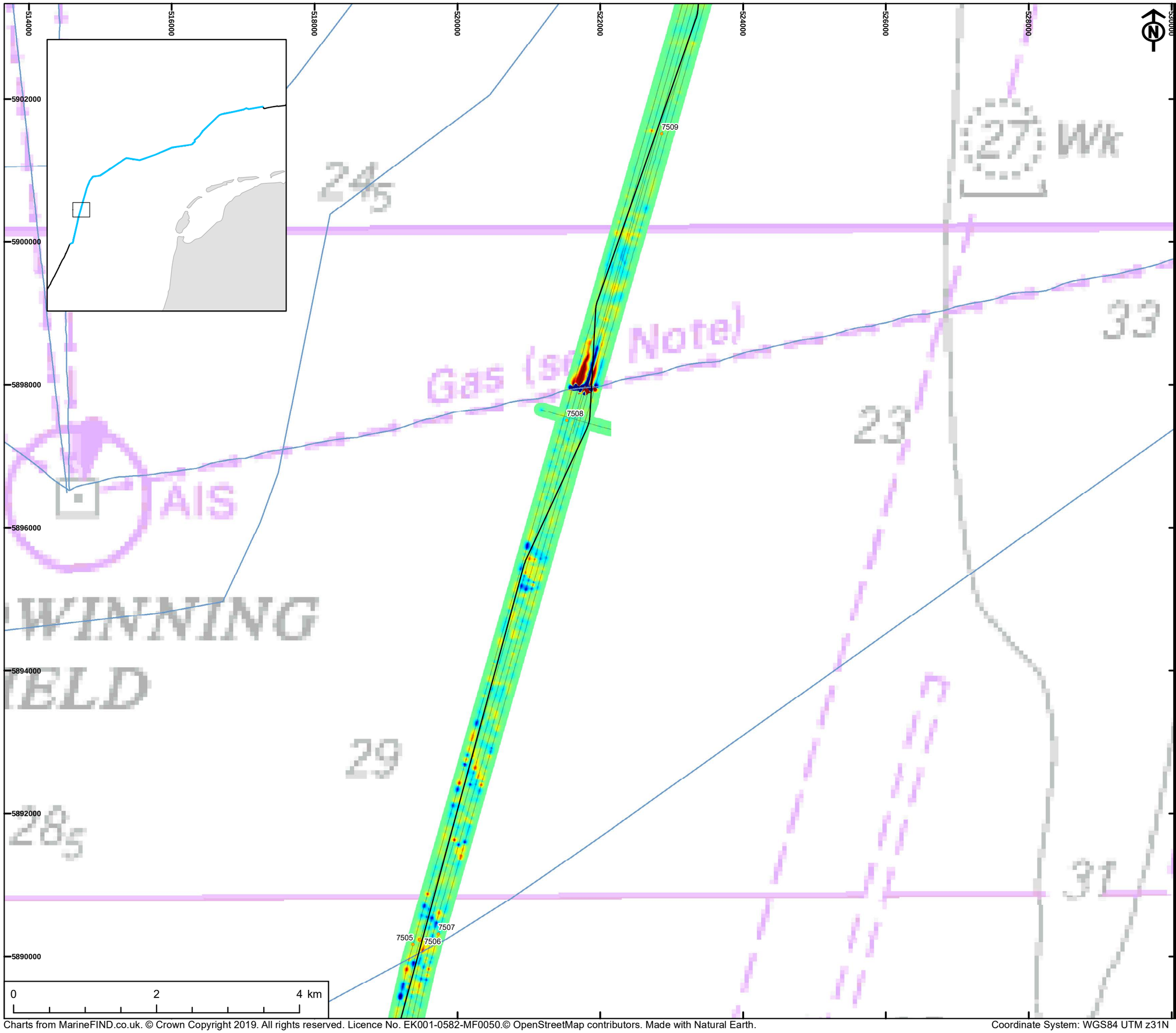
TITLE
FIGURE 8B
SEABED FEATURES OF ARCHAEOLOGICAL POTENTIAL IN RELATION TO THE MAGNETOMETER DATA

REFERENCE
NC_210423_GeophysDutch_Fig08

SHEET NUMBER
2 of 16

DATE
23/04/21

Project Management Initials: AB Designer: KJF Checked: ## Approved: ##

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PROJECT
NEUCONNECT

CLIENT
NeuConnect Britain Ltd.

KEY

- Proposed cable route
- RWS pipelines and cables
- MMT produced magnetometer trackplot

**Seabed features of archaeological potential**

- A1 – Anthropogenic origin of archaeological interest
- A2 – Uncertain origin of possible archaeological interest
- A3 – Historic record of possible archaeological interest

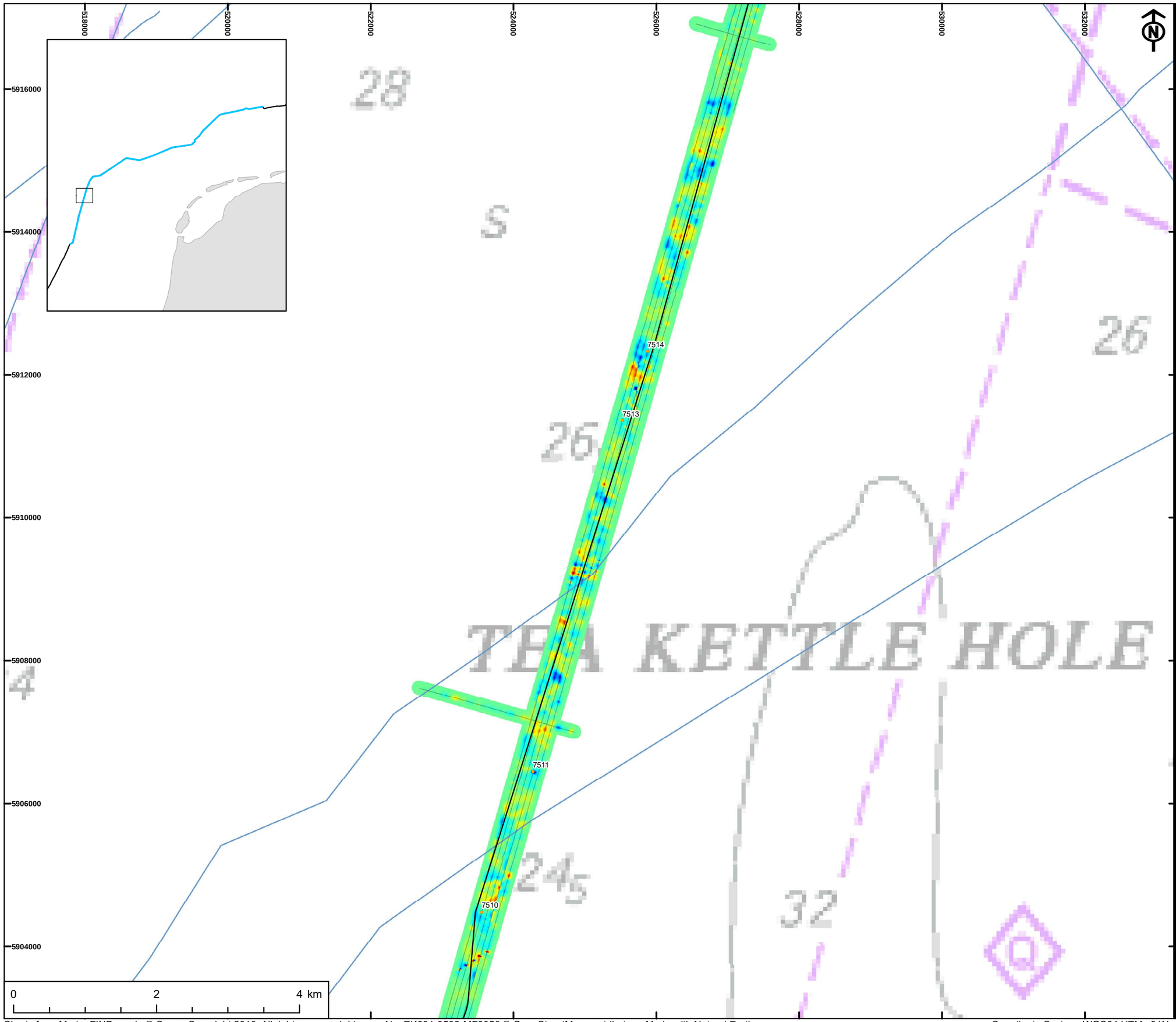
TITLE
FIGURE 8C
SEABED FEATURES OF ARCHAEOLOGICAL POTENTIAL IN RELATION TO THE MAGNETOMETER DATA

REFERENCE
NC_210423_GeophysDutch_Fig08

SHEET NUMBER
3 of 16

DATE
23/04/21

Project Management Initials: AB Designer: KJF Checked: ## Approved: ##

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PROJECT
NEUCONNECT

CLIENT
NeuConnect Britain Ltd.

KEY

- Proposed cable route
- RWS pipelines and cables
- MMT produced magnetometer trackplot

**Seabed features of archaeological potential**

- A1 – Anthropogenic origin of archaeological interest
- A2 – Uncertain origin of possible archaeological interest
- A3 – Historic record of possible archaeological interest

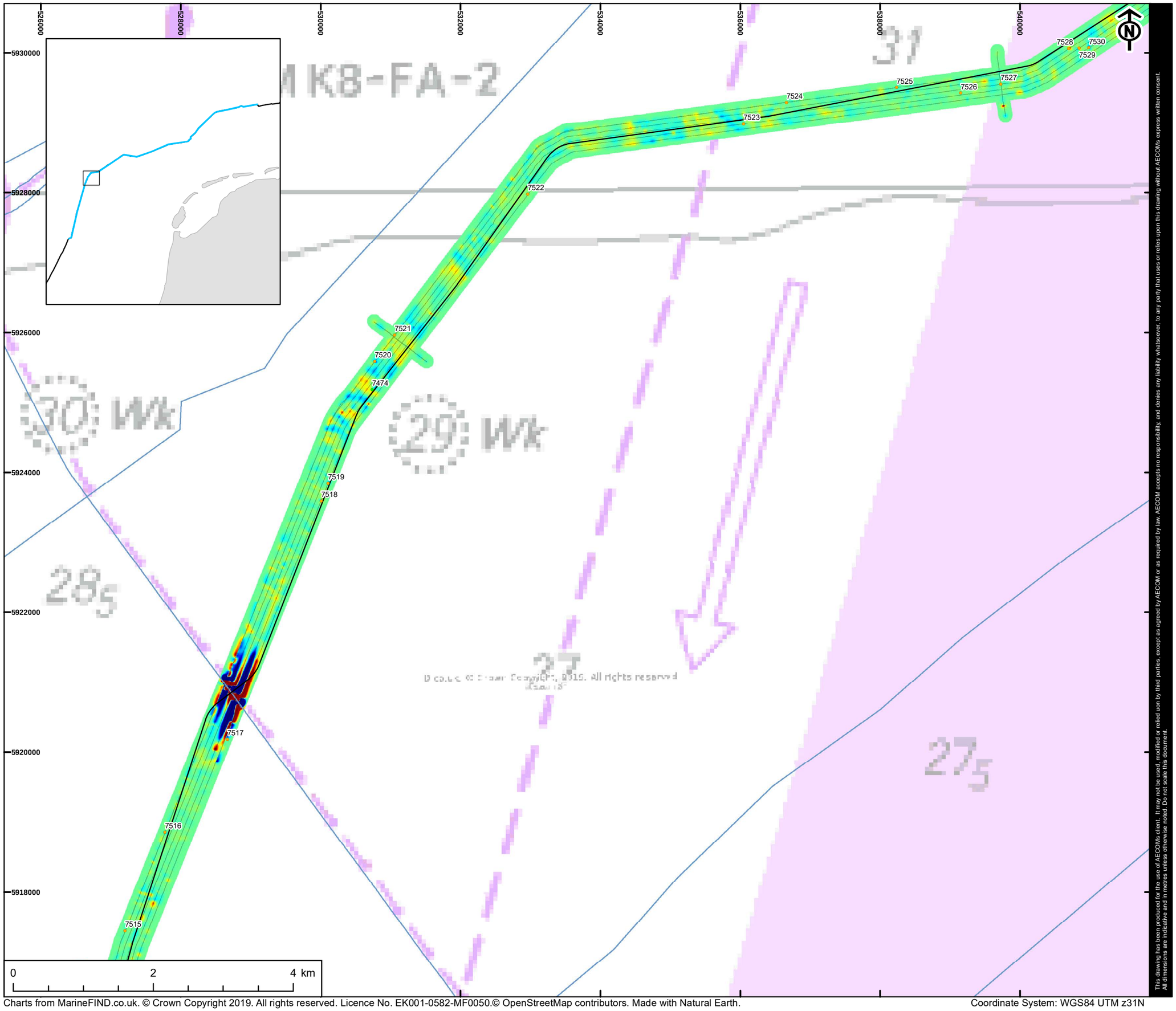
TITLE
FIGURE 8D
SEABED FEATURES OF ARCHAEOLOGICAL POTENTIAL IN RELATION TO THE MAGNETOMETER DATA

REFERENCE
NC_210423_GeophysDutch_Fig08

SHEET NUMBER
4 of 16

DATE
23/04/21

Project Management Initials: AB Designer: KJF Checked: ## Approved: ##

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Coordinate System: WGS84 UTM z31N

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PROJECT
NEUCONNECT

CLIENT
NeuConnect Britain Ltd.

KEY

- Proposed cable route
- RWS pipelines and cables
- MMT produced magnetometer trackplot

**Seabed features of archaeological potential**

- A1 – Anthropogenic origin of archaeological interest
- A2 – Uncertain origin of possible archaeological interest
- A3 – Historic record of possible archaeological interest

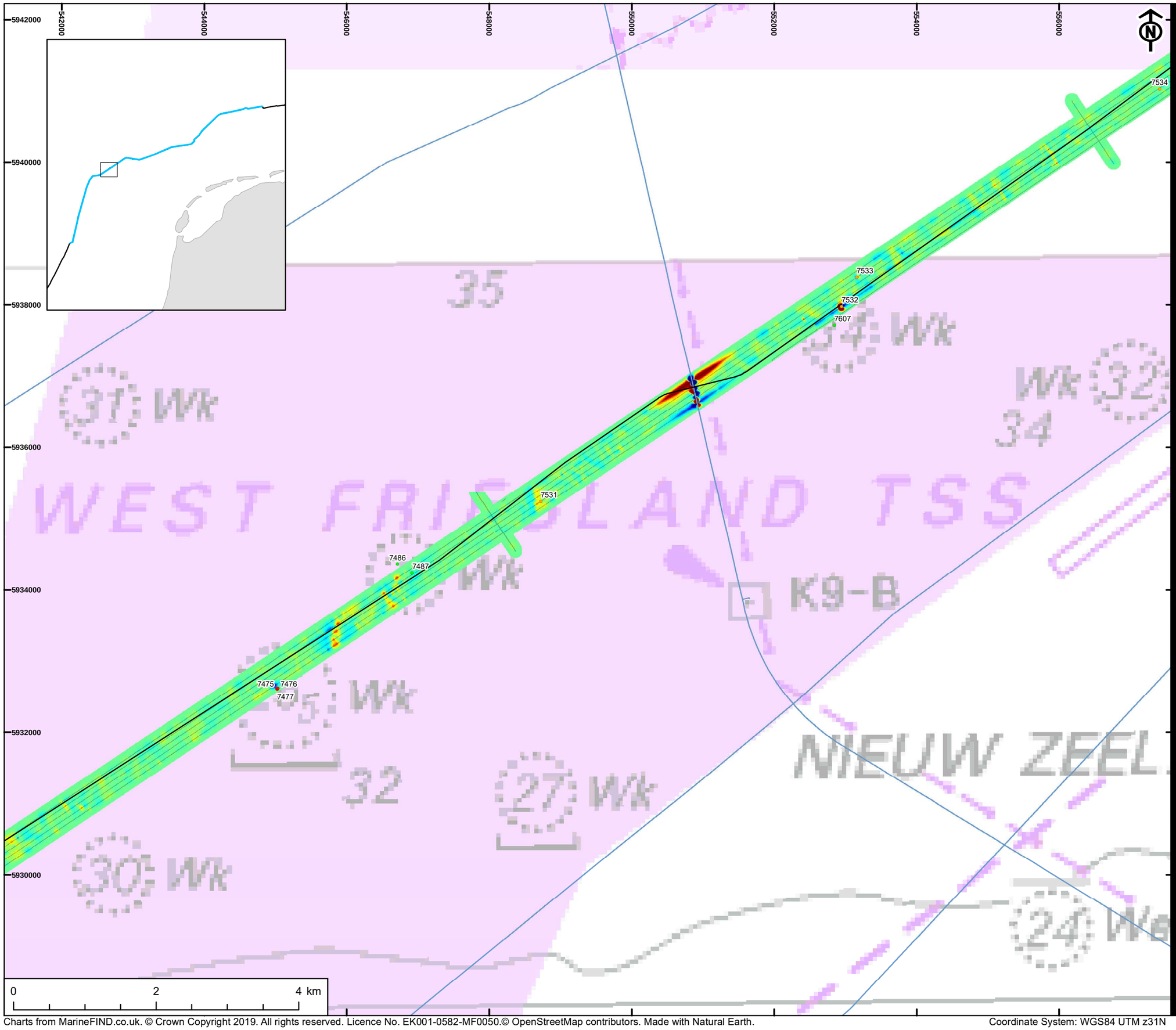
TITLE
FIGURE 8E
SEABED FEATURES OF ARCHAEOLOGICAL POTENTIAL IN RELATION TO THE MAGNETOMETER DATA

REFERENCE
NC_210423_GeophysDutch_Fig08

SHEET NUMBER
5 of 16

DATE
23/04/21

Project Management Initials: AB Designer: KJF Checked: ## Approved: ##

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PROJECT
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NeuConnect Britain Ltd.

KEY

- Proposed cable route
- RWS pipelines and cables
- MMT produced magnetometer trackplot

**Seabed features of archaeological potential**

- A1 – Anthropogenic origin of archaeological interest
- A2 – Uncertain origin of possible archaeological interest
- A3 – Historic record of possible archaeological interest

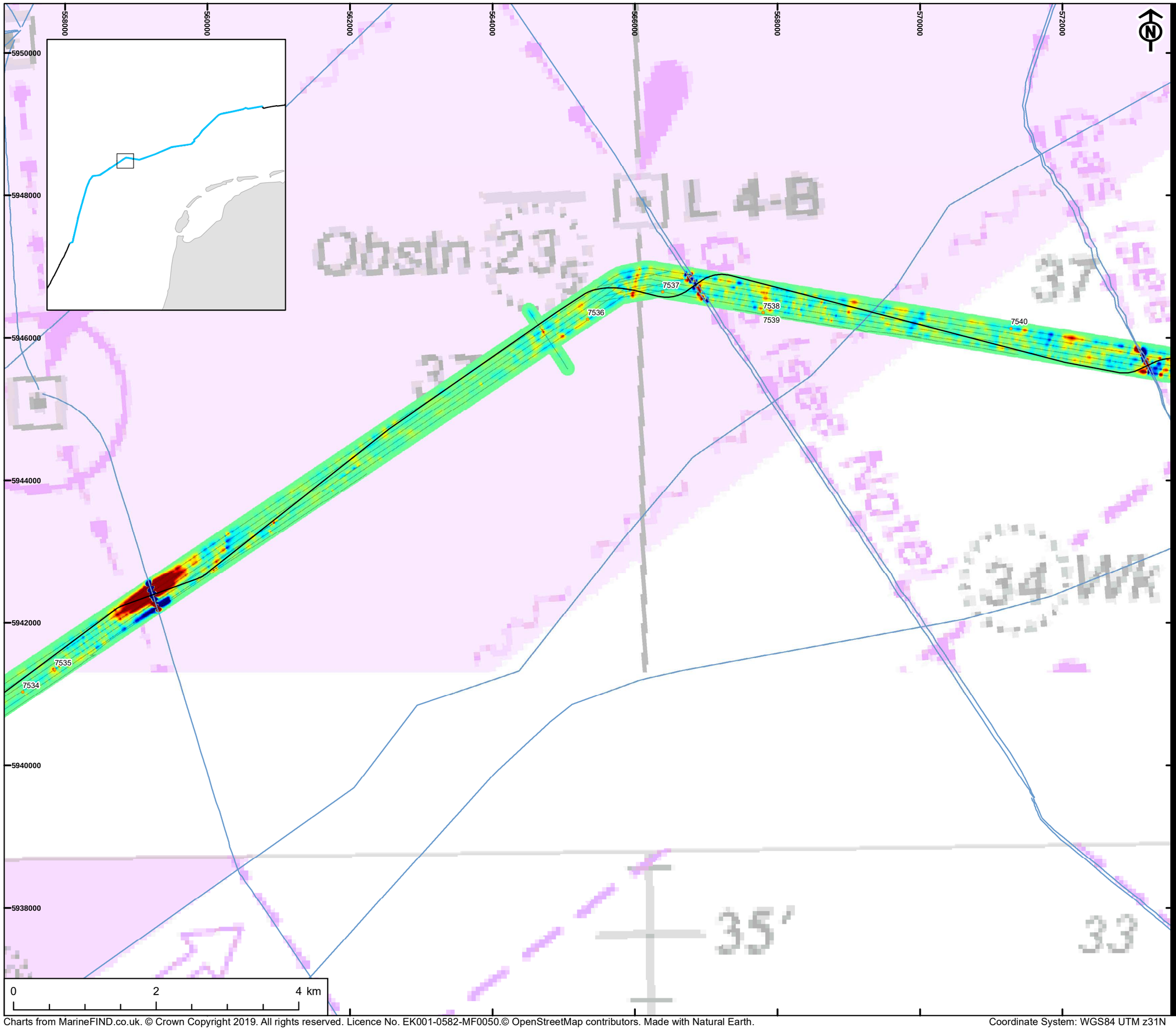
TITLE
FIGURE 8F
SEABED FEATURES OF ARCHAEOLOGICAL POTENTIAL IN RELATION TO THE MAGNETOMETER DATA

REFERENCE
NC_210423_GeophysDutch_Fig08

SHEET NUMBER
6 of 16

DATE
23/04/21

Project Management Initials: AB Designer: KJF Checked: ## Approved: ##




Scale @ A3 1:50,000

0 2 4 km

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PROJECT
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NeuConnect Britain Ltd.

KEY

- Proposed cable route
- RWS pipelines and cables
- MMT produced magnetometer trackplot

**Seabed features of archaeological potential**

- A1 – Anthropogenic origin of archaeological interest
- A2 – Uncertain origin of possible archaeological interest
- A3 – Historic record of possible archaeological interest

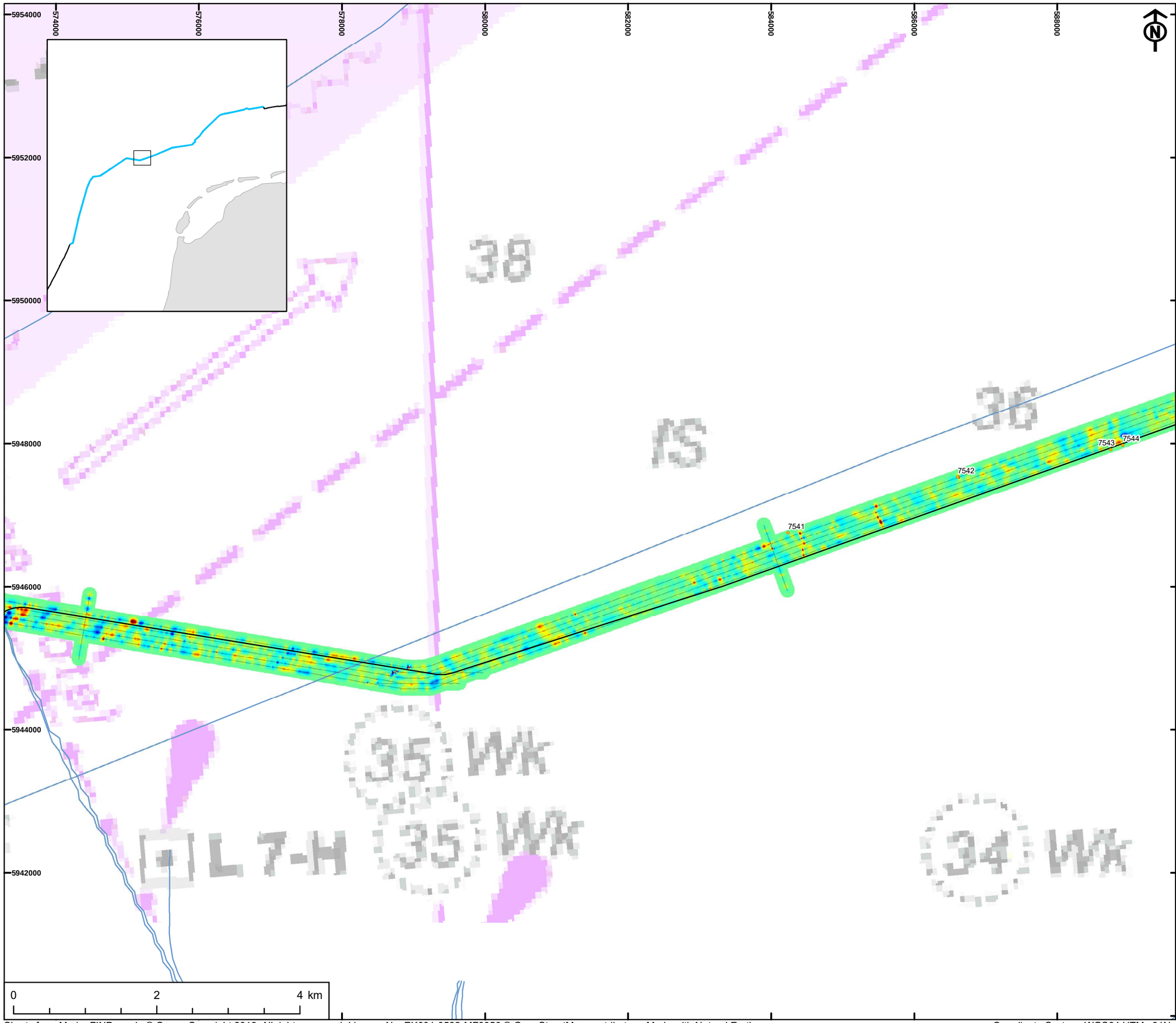
TITLE
FIGURE 8G
SEABED FEATURES OF ARCHAEOLOGICAL POTENTIAL IN RELATION TO THE MAGNETOMETER DATA

REFERENCE
NC_210423_GeophysDutch_Fig08

SHEET NUMBER
7 of 16

DATE
23/04/21

Project Management Initials: AB Designer: KJF Checked: ## Approved: ##

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AECOM

PROJECT
NEUCONNECT

CLIENT
NeuConnect Britain Ltd.

KEY

- Proposed cable route
- RWS pipelines and cables
- MMT produced magnetometer trackplot

**Seabed features of archaeological potential**

- A1 – Anthropogenic origin of archaeological interest
- A2 – Uncertain origin of possible archaeological interest
- A3 – Historic record of possible archaeological interest

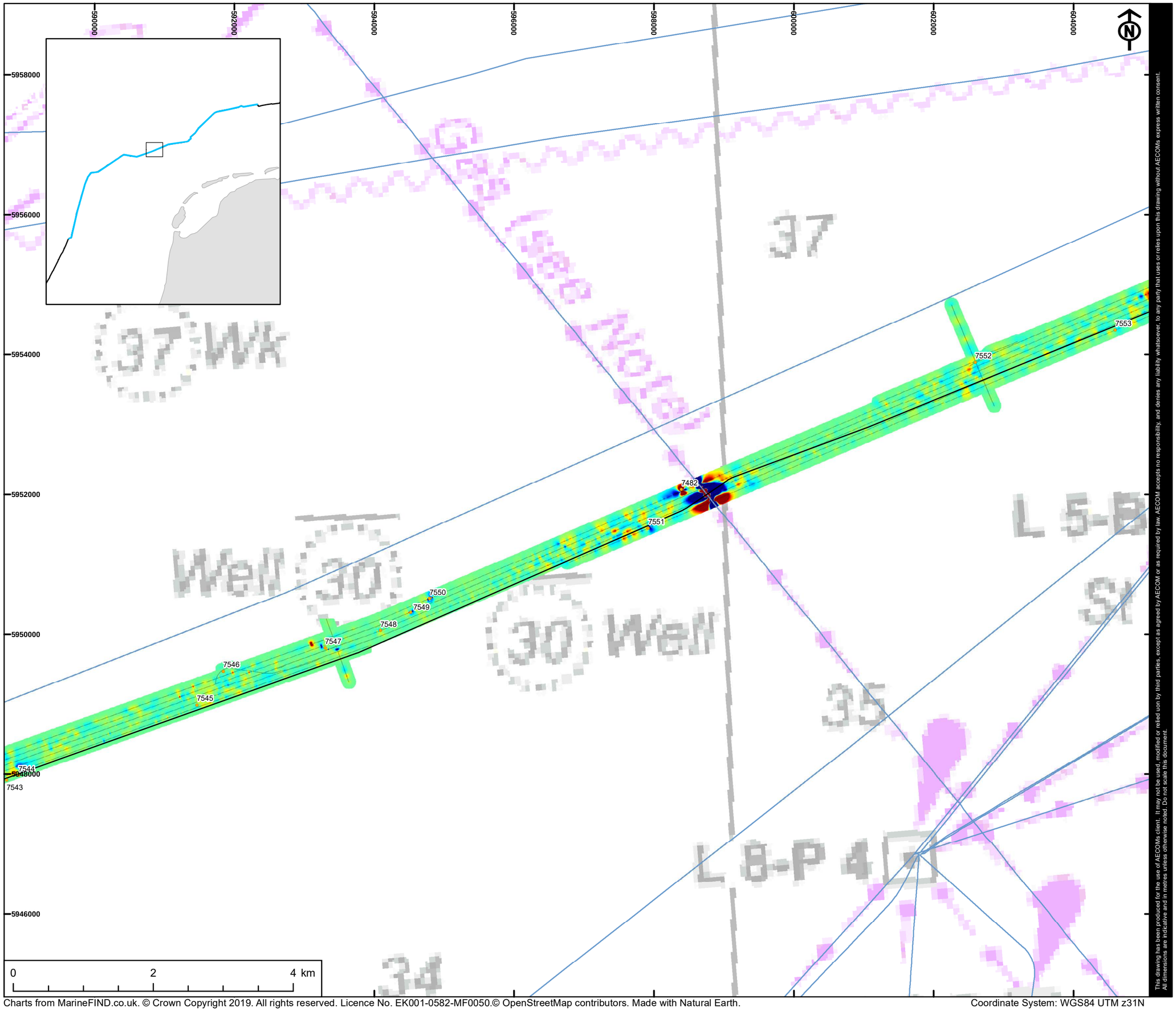
TITLE
FIGURE 8H
SEABED FEATURES OF ARCHAEOLOGICAL POTENTIAL IN RELATION TO THE MAGNETOMETER DATA

REFERENCE
NC_210423_GeophysDutch_Fig08

SHEET NUMBER
8 of 16

DATE
23/04/21

Project Management Initials: AB Designer: KJF Checked: ## Approved: ##

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KEY
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**Seabed features of archaeological potential**
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TITLE
FIGURE 8I
SEABED FEATURES OF ARCHAEOLOGICAL POTENTIAL IN RELATION TO THE MAGNETOMETER DATA

REFERENCE
NC_210423_GeophysDutch_Fig08

SHEET NUMBER
9 of 16

DATE
23/04/21

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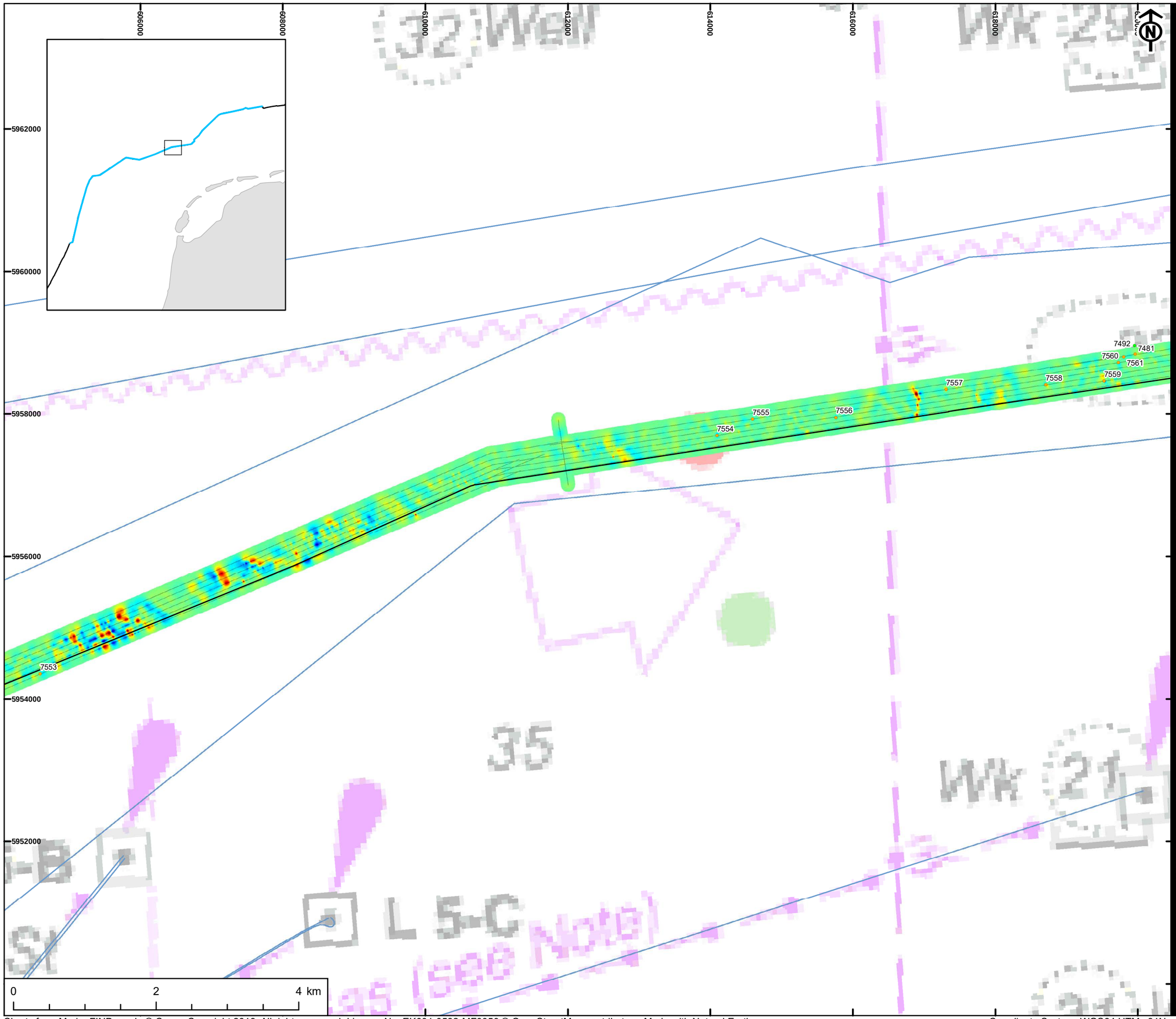


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PROJECT
NEUCONNECT

CLIENT
NeuConnect Britain Ltd.

KEY
- Proposed cable route
- RWS pipelines and cables
- MMT produced magnetometer trackplot

**Seabed features of archaeological potential**
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- A3 – Historic record of possible archaeological interest

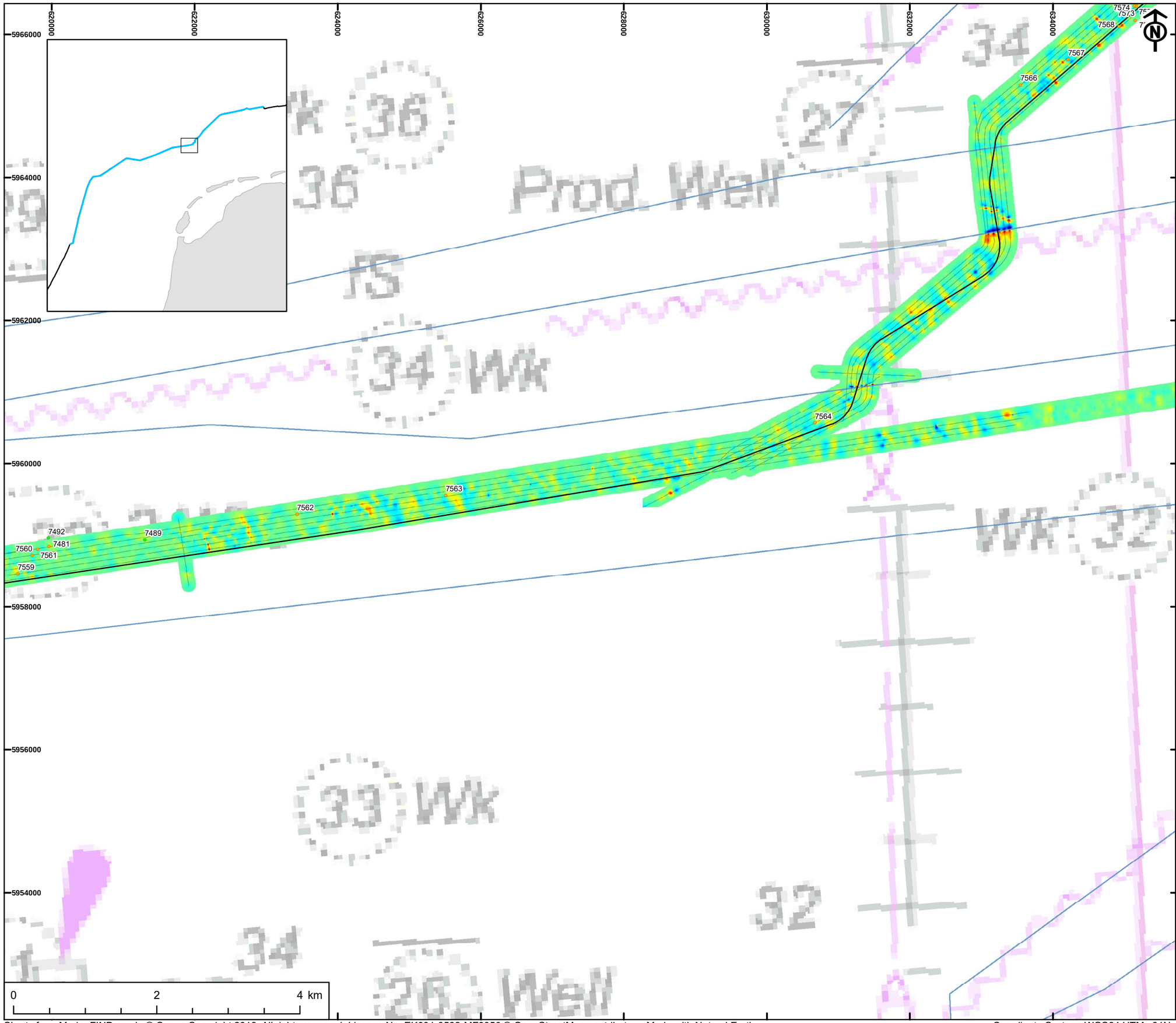
TITLE
FIGURE 8J
SEABED FEATURES OF ARCHAEOLOGICAL POTENTIAL IN RELATION TO THE MAGNETOMETER DATA

REFERENCE
NC_210423_GeophysDutch_Fig08

SHEET NUMBER
10 of 16

DATE
23/04/21

Project Management Initials: AB Designer: KJF Checked: ## Approved: ##

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PROJECT
NEUCONNECT

CLIENT
NeuConnect Britain Ltd.

KEY

- Proposed cable route
- RWS pipelines and cables
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**Seabed features of archaeological potential**

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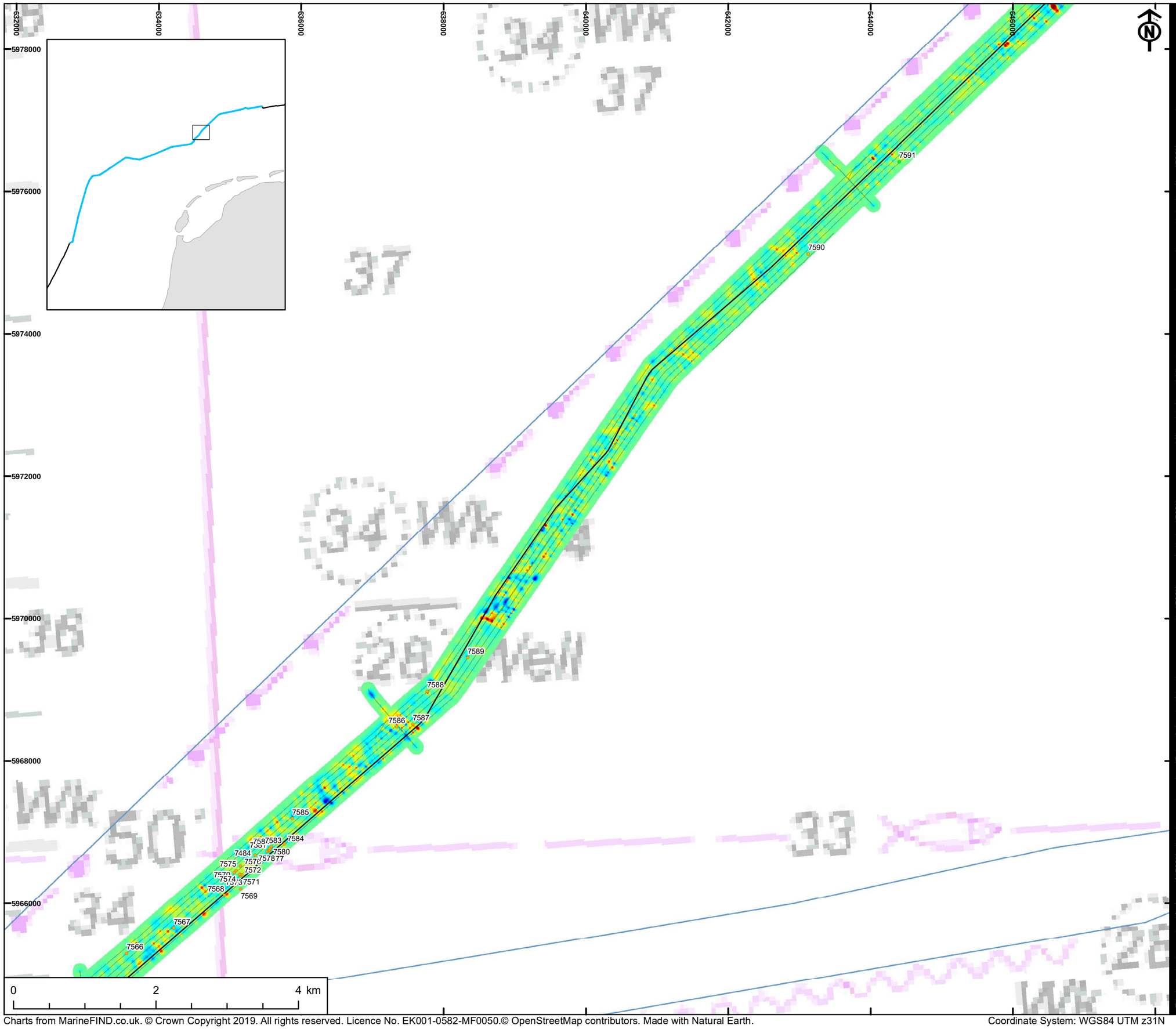
TITLE
FIGURE 8K
SEABED FEATURES OF ARCHAEOLOGICAL POTENTIAL IN RELATION TO THE MAGNETOMETER DATA

REFERENCE
NC_210423_GeophysDutch_Fig08

SHEET NUMBER
11 of 16

DATE
23/04/21

Project Management Initials: AB Designer: KJF Checked: ## Approved: ##

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PROJECT
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CLIENT
NeuConnect Britain Ltd.

KEY

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- RWS pipelines and cables
- MMT produced magnetometer trackplot

**Seabed features of archaeological potential**

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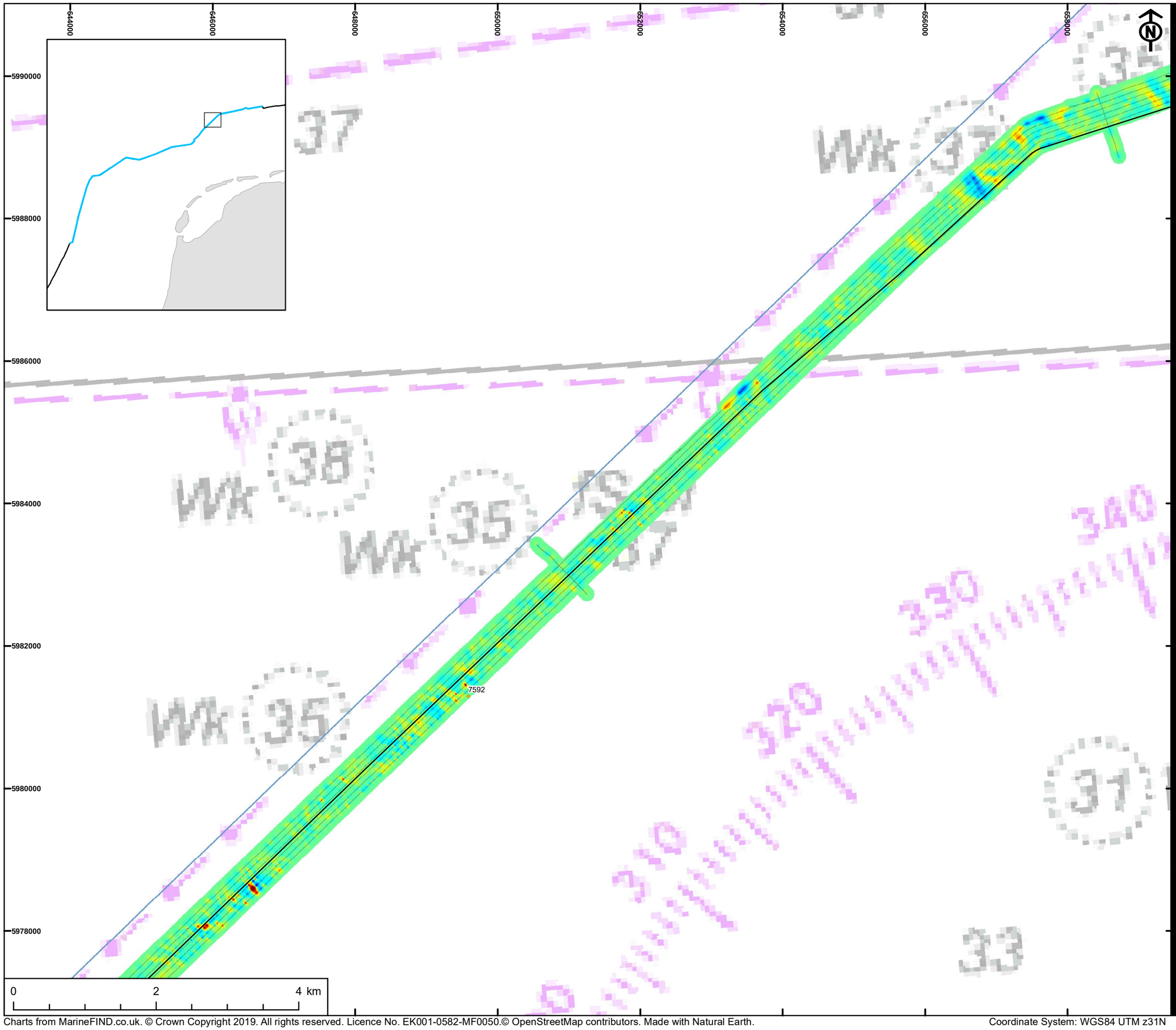
TITLE
FIGURE 8L
SEABED FEATURES OF ARCHAEOLOGICAL POTENTIAL IN RELATION TO THE MAGNETOMETER DATA

REFERENCE
NC_210423_GeophysDutch_Fig08

SHEET NUMBER
12 of 16

DATE
23/04/21

Project Management Initials: AB Designer: KJF Checked: ## Approved: ##

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PROJECT
NEUCONNECT

CLIENT
NeuConnect Britain Ltd.

KEY
- Proposed cable route
- RWS pipelines and cables
- MMT produced magnetometer trackplot

**Seabed features of archaeological potential**
- A1 – Anthropogenic origin of archaeological interest
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- A3 – Historic record of possible archaeological interest

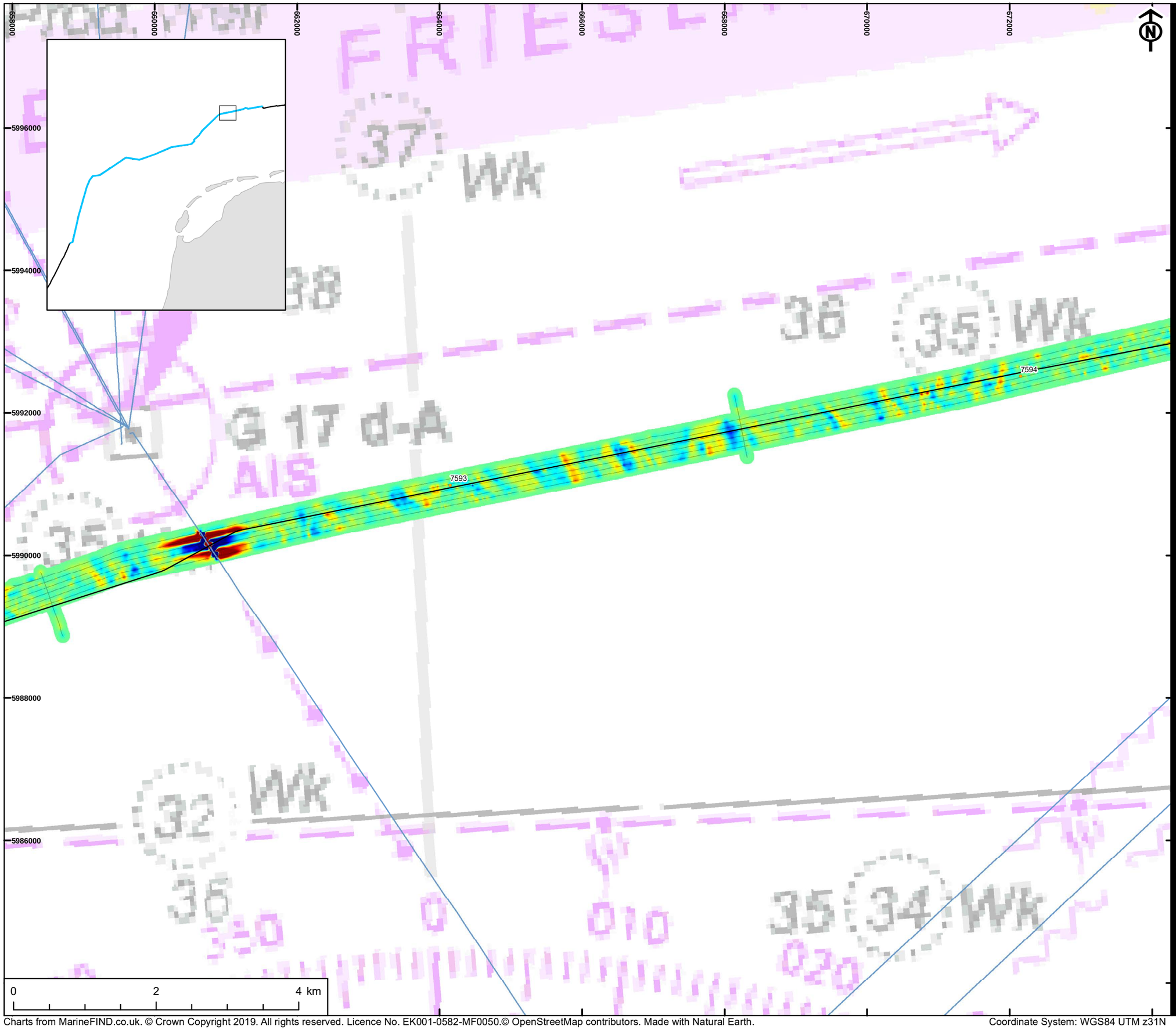
TITLE
FIGURE 8M
SEABED FEATURES OF ARCHAEOLOGICAL POTENTIAL IN RELATION TO THE MAGNETOMETER DATA

REFERENCE
NC_210423_GeophysDutch_Fig08

SHEET NUMBER
13 of 16

DATE
23/04/21

Project Management Initials: AB Designer: KJF Checked: ## Approved: ##

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PROJECT
NEUCONNECT

CLIENT
NeuConnect Britain Ltd.

KEY

- Proposed cable route
- RWS pipelines and cables
- MMT produced magnetometer trackplot

**Seabed features of archaeological potential**

- A1 – Anthropogenic origin of archaeological interest
- A2 – Uncertain origin of possible archaeological interest
- A3 – Historic record of possible archaeological interest

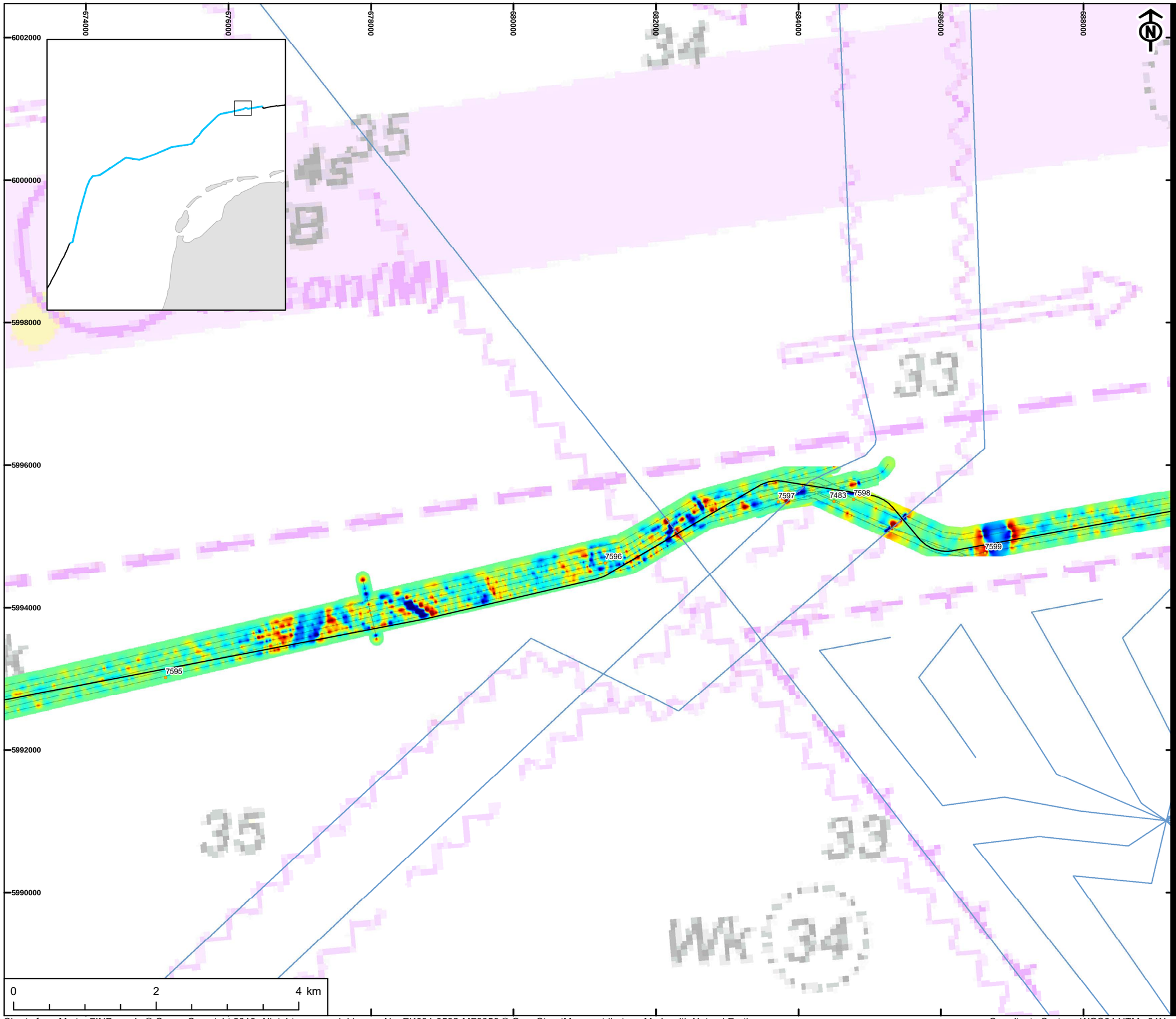
TITLE
FIGURE 8N
SEABED FEATURES OF ARCHAEOLOGICAL POTENTIAL IN RELATION TO THE MAGNETOMETER DATA

REFERENCE
NC_210423_GeophysDutch_Fig08

SHEET NUMBER
14 of 16

DATE
23/04/21

Project Management Initials: AB Designer: KJF Checked: ## Approved: ##

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AECOM

PROJECT
NEUCONNECT

CLIENT
NeuConnect Britain Ltd.

KEY

- Proposed cable route
- RWS pipelines and cables
- MMT produced magnetometer trackplot

**Seabed features of archaeological potential**

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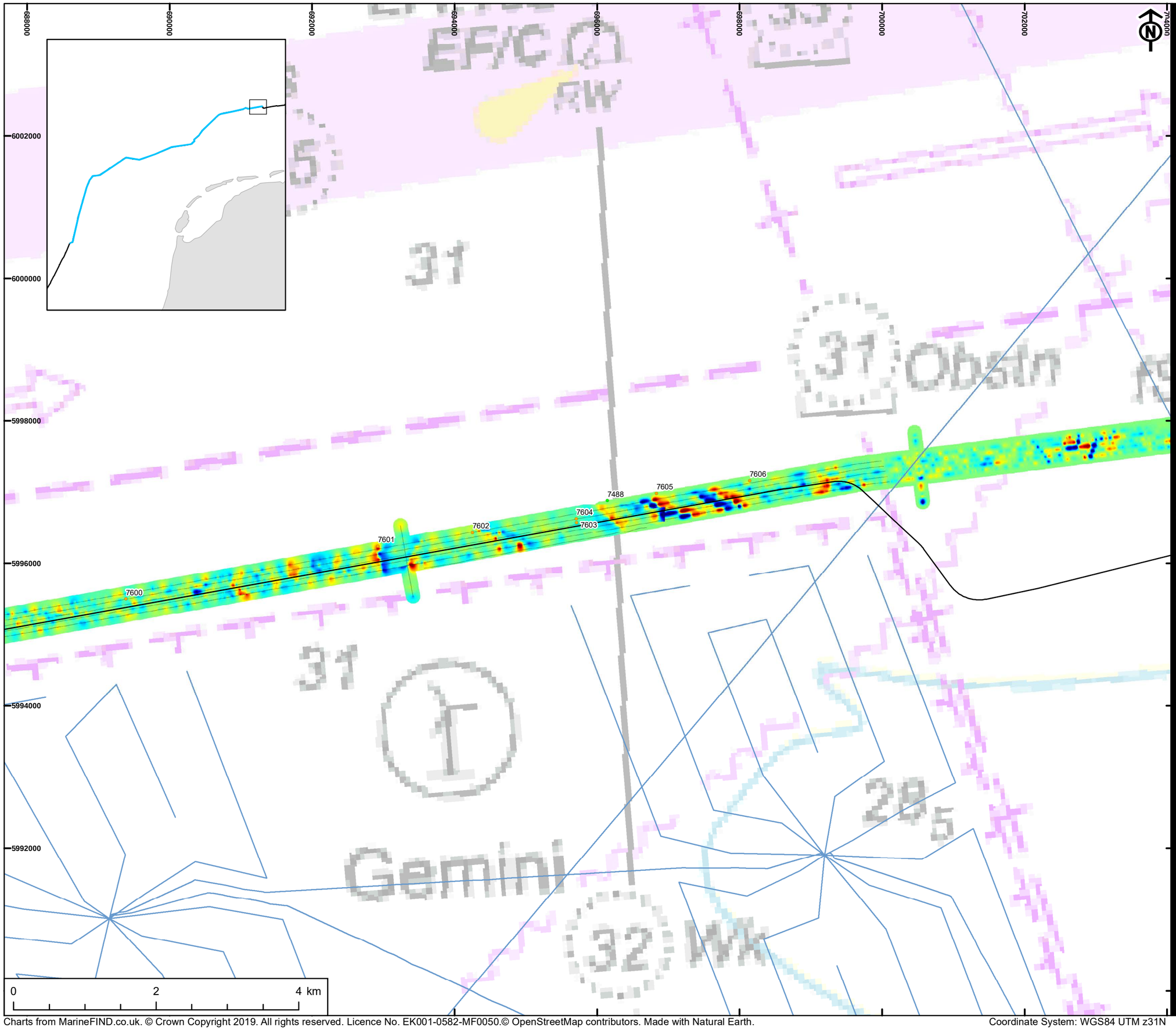
TITLE
FIGURE 8O
SEABED FEATURES OF ARCHAEOLOGICAL POTENTIAL IN RELATION TO THE MAGNETOMETER DATA

REFERENCE
NC_210423_GeophysDutch_Fig08

SHEET NUMBER
15 of 16

DATE
23/04/21

Project Management Initials: AB Designer: KJF Checked: ## Approved: ##

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AECOM

PROJECT
NEUCONNECT

CLIENT
NeuConnect Britain Ltd.

KEY

- Proposed cable route
- RWS pipelines and cables
- MMT produced magnetometer trackplot

**Seabed features of archaeological potential**

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TITLE
FIGURE 8P
SEABED FEATURES OF ARCHAEOLOGICAL POTENTIAL IN RELATION TO THE MAGNETOMETER DATA

REFERENCE
NC_210423_GeophysDutch_Fig08

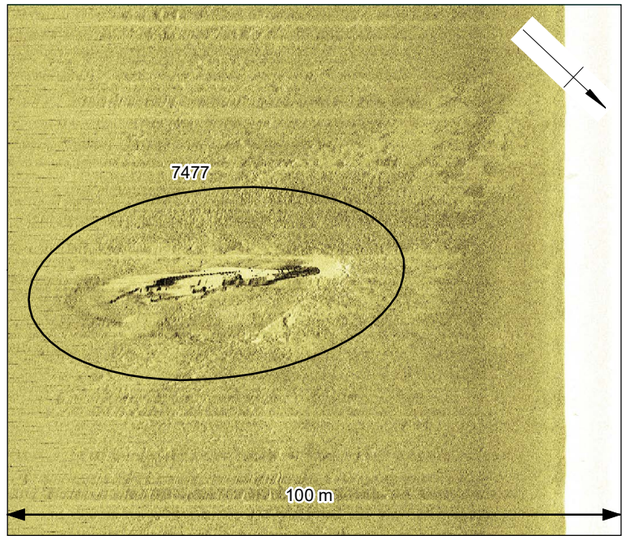
SHEET NUMBER
16 of 16

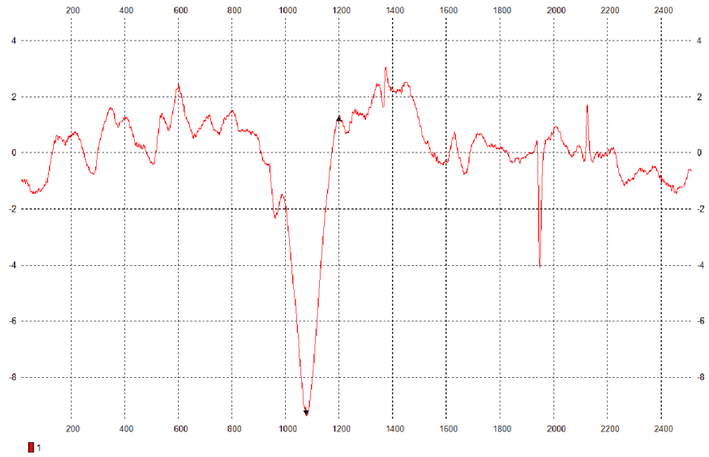
DATE
23/04/21

Project Management Initials: AB Designer: KJF Checked: ## Approved: ##

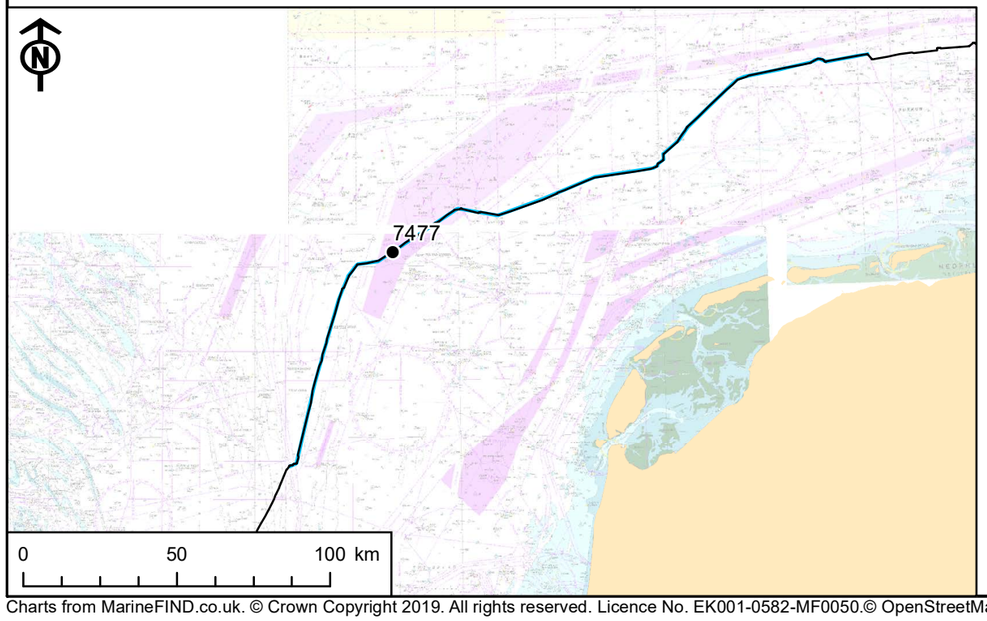
# ID 7477 – Unknown

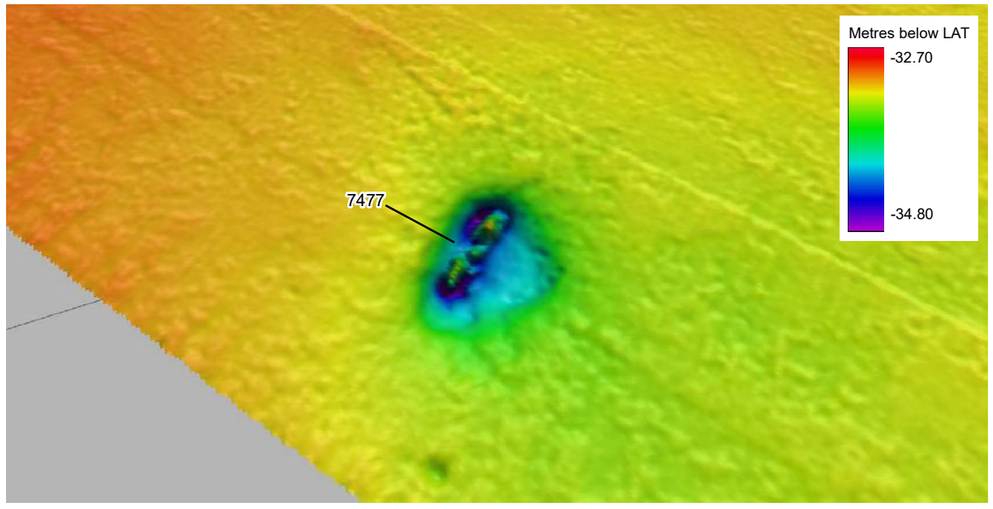
| | | | |
|---|---|---|---|
| **Location** | | 545026 E 5932601 N | **Area** Dutch Sector |
| **Archaeological Importance** | | High | |
| **Geophysical survey dimensions and notes** | | **7477** is a wreck situated in the Dutch Sector of the NeuConnect study area, orientated north west to south east on the seabed. The wreck is recorded in the UKHO database (UKHO 28296).<br><br>In the SSS data this is a large wreck that appears to be relatively intact and possibly lying upright on the seabed with dimensions of 37 x 9.9 x 0.9 m. One edge of the hull appears to be partially degraded or buried by sediment, while the other edge seems complete. There are some slightly slatted features visible within the vessel which could be surviving structural remains. The wreck is situated on a sandy and featureless area of the seabed, within a depression, with possible associated debris items in the vicinity.<br><br>There is a small magnetic anomaly measuring 11 nT associated with this wreck indicating the presence of some ferrous material however, as the nearest magnetometer line is situated 40 m from the wreck, it is likely that the true amplitude would be larger if the wreck was directly covered by the magnetometer data.<br><br>In the MBES data this is visible as a distinct mound 1.7 m high, orientated on an approximate north-west to south-east alignment. Scour up to -0.5 m deep is visible around the wreck and extending approximately 22 m to the north east. The wreck appears in the MBES data to be in three main segments which suggests there is some deterioration in its centre. | |
| **Build** | **Type** | Unknown | |
| | **Construction** | Unknown | |
| | **Dimensions (m)** | Unknown | |
| | **Shipyard** | Unknown | |
| **Loss** | **Cause** | Unknown | |
| **Extent of Survival** | | This is recorded in the UKHO database as the remains of an unknown fishing vessel.<br><br>In the geophysical data the wreck appears to be mostly intact, with some internal possible structural objects still standing and discernible. There is possibly some deterioration to the central area of the wreck visible in the MBES data. | |




Magnetic profile of wreck **7477**, measuring 11 nT




Multibeam echosounder image of wreck 7477, looking north west (x1 vertical exaggeration

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PROJECT
NEUCONNECT

CLIENT
NeuConnect Britain Ltd.

KEY
Proposed cable route
Geophysical study area

TITLE
SHEET 1
ID 7477 – UNKNOWN

REFERENCE
NC_210312_WreckSheet01

| SHEET NUMBER | DATE |
|---|---|
| 1 of 1 | 12/03/21 |

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Tel: 01722 326867 Fax: 01722 337562 info@wessexarch.co.uk www. wessexarch.co.uk

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# Bijlage 8: CBRA (Cable Burial Risk Assessment), Intertek, 20 maart 2019

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# NEUCONNECT BRITAIN LTD

## NeuConnect Interconnetor

**Cable Burial Risk Assessment**

P2131_R4592_Rev1 | 20 March 2019

**Intertek Energy & Water Consultancy Services**
Exchange House, Station Road, Liphook, Hampshire GU30 7DW, United Kingdom

# DOCUMENT RELEASE FORM

## NeuConnect Britain Ltd

**P2131_R4592_Rev1**

NeuConnect Interconnetor

Cable Burial Risk Assessment

Author/s

Louis Duménil, Christopher Carroll, Alan Redman

Project Manager

Stephane Theurich

Authoriser

Dr. Andrew Page

| Rev No | Date | Reason | Author | Checker | Authoriser |
|---|---|---|---|---|---|
| Rev 0 | 21/12/2018 | Draft | LDU/CCA | ATR/SLT | APA |
| Rev 1 | 20/03/2019 | Revised | ATR/CCA | APA | APA |

Intertek Energy & Water Consultancy Services is the trading name of Metoc Ltd, a member of the Intertek group of companies.

# SUMMARY

Intertek Energy & Water Consultancy Services (Intertek) has been appointed by NeuConnect Britani Ltd to conduct a Cable Burial Risk Assessment (CBRA) study for the marine sections of the NeuConnect Interconnector cable route. The proposed Project is a High Voltage Direct Current (HVDC) electrical interconnector with an approximate capacity of 1400MW, which will allow transfer of power between the electricity transmission systems of Germany and Great Britain, crossing the Exclusive Economic Zones (EEZ) of UK, the Netherlands and Germany.

The Cable Burial Risk Assessment (CBRA) has shown that the following key hazards are present along the Greenlink Cable Route:

- sediment mobility
- anchoring; and
- fishing.

The process to calculate the Target DOL is as follows:

1. Analysis of survey results to categorise the seabed into individual zones of similar seabed sediment type, water depth range and vessel traffic density
2. Analysis of external threats to determine depths of penetration of each external aggressor (fishing gear and various anchors sizes) in identified seabed soils in each zone of the route, according to industry research;
3. Addition of a 20% Factor of Safety (FoS) to each of the respective maximum penetration depths;
4. Analysis of external threats (fishing gear and anchors) to calculate (where data allows) the probability of an aggressor-cable interaction in each zone of the route;
5. Determination of which threats must be protected against through burial in order to reduce risk from external aggressors down to ALARP;
6. Determine Recommended Minimum Depth of Lowering (RMDOL) for each zone of the route by selection of the greatest penetration depth value calculated (including the 20% FoS) for identified aggressors which must be protected against in each zone of the route in order that the overall risk to the cable over the project lifetime is reduced to ALARP or, where applicable, the legislative DOL if greater;
7. Target DOL (TDOL) is then determined as what can reasonably be added to RMDOL without incurring a step change in costs and which represents a practical target for burial tools on the market

The key hazards are explained below:

**Sediment Mobility**
Sediment mobility in itself does not pose a threat to a submarine cable but it can lead to issues with the thermal conductivity of cables (over burial), and exposure of cables (scour); burial under excess sand can change the thermal properties of the soil and cause hotspots along the cable, while exposure increases the risk of damage due to external aggressors such as trawling and anchoring and potentially mechanical damage from free spans.

There are a number of areas within the NeuConnect 500m corridor where there are bedforms present which could be mobile.

The first indication of mobile bedforms can be observed at KP11. These have been interpreted by the route survey contractor, MMT, as ripples and have a wave length of <15m and height <1.0 m. Ripples are observed intermittently throughout the route where they terminate at KP304 and do not appear again until KP620 from

which they then extend to the end of the route at KP700. While these may indicate some levels of sediment movement it is not thought that these minor bedforms will have an impact on the cable installation or operability.

Mega Ripples are also observed intermittently throughout the corridor, between KP108 & KP190 and then between KP669 and KP700. These are slightly larger than ripples and have a wave length of 15-50m and height 1-3m so may pose a risk to an installed cable within its lifetime.

Sandwaves present within the route corridor and are first observed between KP78 and KP 80. These have been interpreted by MMT to have a wave length 50-200m and height of >3 m. Sandwaves are next present at KP 106 and remain as intermittent features until KP294. They do not appear again until between KP673 and KP700.

For the purposes of burial targets (RMDOL & TDOL) all depths are to be measured against trough depth and after any required route engineering has been undertaken to flatten mobile sediments.

**Fishing Risk**

The entire route is within water depth range in which mobile gear fishing could take place, thus we recommend the cable is given sufficient protection from potential fishing gear interaction along the entire route.

The Carbon Trust' guidance (ref 12) indicates that penetration of fishing gear into the seabed is limited to a maximum of 0.3 m penetration even in soft sediment based on previous literature research. Adding a 20% Factor of Safety (FoS) to account for measurement errors and deformation of soil beneath fishing gear gives a RMDOL of 0.36m for fishing risk alone.

In practice a DOL < 0.5m is not advisable due to the instability of some trenching tools at these depths. Therefore, TDOL would be >0.5m if based on fishing risk only.

**Anchoring Risk**

Vessel Automatic Identification System (AIS) data has been used to determine the size and quantity of vessels which operate in the vicinity of the cable route. Vessels are grouped into size categories based on their deadweight tonnage (DWT) from Band A (0-100 DWT) to Band K (325K-460K DWT) and an appropriate associated anchor size is assigned to each band. Analysis of this data determines the probability of anchor-cable interactions for each vessel banding and thus the size of anchor which must be protected against in order to reduce risk to the cable to ALARP.

Assessment of the anchor risk strike for a surface laid cable demonstrated an unacceptable level of risk to the cable (failure probability of 97.75% over the lifetime of the cable) and thus there is a requirement to protect the cable against anchors interaction.

Anchoring risk exceeds fishing risk in in all zones of the route and thus determines RMDOL (except for zones in Germany where the legislative DOL requirements exceed the minimum DOL calculated by the probabilistic assessment). DOL has been calculated for protection against the anchor size associated with each vessel band in each cable route zone. Following this, the RMDOL has been selected for each individual zone in order that the overall risk to the cable over the project lifetime is reduced to ALARP. This varies from 0.55-2.00m. The full results by zone are provided in **Appendix E**. As can be seen if RMDOL is achieved during installation (and maintained throughout the project life) then the NeuConnect cable would have an annual failure probability of 9.00E-04. This equates to a return period of 1111.27 years and a failure probability over the (40 year) lifetime of 3.54%.

**Conclusions and recommendations**

TDOL is determined as what can reasonably be added to RMDOL without incurring a step change in costs and which represents a practical target for burial tools on the market.

TDOL has been set at 1.5m for the vast majority of the route and varies up to a maximum TDOL of 2m in some zones due either to anchor risk or legislative requirements. The DOL specification by cable route zone are provided in **Appendix E**. As can be seen if TDOL is achieved during installation (and maintained throughout the

project life) then the NeuConnect cable would have an annual failure probability of 5.37E-04. This equates to a return period of 1863.84 years and a failure probability over the (40 year) lifetime of 2.12%.

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# GLOSSARY

**AIS**
Automatic Identification System

**CBRA**
Cable Burial Risk Assessment

**CPT**
Cone Penetration Test

**DoL**
Depth of Lowering

**DoC**
Depth of Cover

**EU**
European Union

**Greenlink**
Greenlink Interconnector Limited

**HVAC**
High-Voltage Alternating Current

**HVDC**
High-Voltage Direct Current

**ICES**
International Council for the Exploration of the Sea

**IMO**
International Maritime Organisation

**Intertek**
Intertek Energy and Water Consultancy Services

**MAIB**
Marine Accident Investigation Branch

**MBES**
Multi-Beam Echo Sounder

**MMO**
Marine Management Organisation

**PCI**
Project of Common Interest

**RMDOL**
Recommended Minimum Depth of Lowering

**SI**
Seabed Index

**SSS**
Side-Scan Sonar

**TDOL**
Target Depth of Lowering

**VC**
Vibro-Core

# 1. INTRODUCTION

**Intertek Energy & Water Consultancy Services (Intertek) has been appointed by NeuConnect Britain Ltd to conduct a Cable Burial Risk Assessment (CBRA) study for the marine sections of the NeuConnect Interconnector cable route.**

## 1.1 Project background

The proposed Project is a High Voltage Direct Current (HVDC) electrical interconnector with an approximate capacity of 1400MW, which will allow transfer of power between the electricity transmission systems of Germany and Great Britain, crossing the Exclusive Economic Zones (EEZ) of UK, the Netherlands and Germany.

A Geophysical and Geotechnical campaign has been carried out over a 500m corridor along the entirety of the route, with the exception of the last remaining 50km (survey block 15) where no Geotechnical sampling has been carried out. At this time, acquisition of Geotech samples within the last 50km of the route is thought to be undertaken in Q2 of 2019. This CBRA has been completed for the first 650km only. It is recommended this is revised following the completion of the remaining 50km of the cable route.

For an overview of the route see **Figure 2-1**.

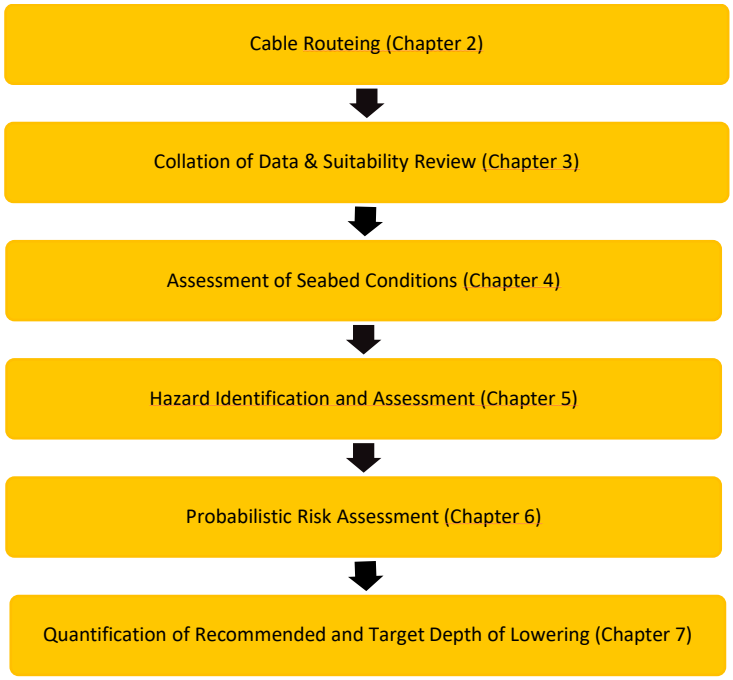
## 1.2 Scope of Work

The Scope of Work is as follows:

- Characterisation of the predominant hazards which could pose a risk to the cable system.
- Assessment of the risks posed to the cable system by the identified hazards.
- Assessment of the geophysical and geotechnical data along the cable route.
- Probabilistic assessment of the anchoring threat to the cable system using historical vessel AIS (Automatic Identification System) data.
- Provision of recommended Minimum Depth of Lowering (RMDOL) and Target DOL (TDOL) along the route which if achieved would reduce risk to the submarine cable to levels acceptable to the project.

The CBRA study presented in this report has been undertaken following the Carbon Trust's proposed methodology (ref 22) and steps (see **Figure 1-1**).

**Figure 1-1 Burial Risk Assessment method flowchart in line with Carbon Trust CTC835 guideline**




## 1.3 Purpose of report

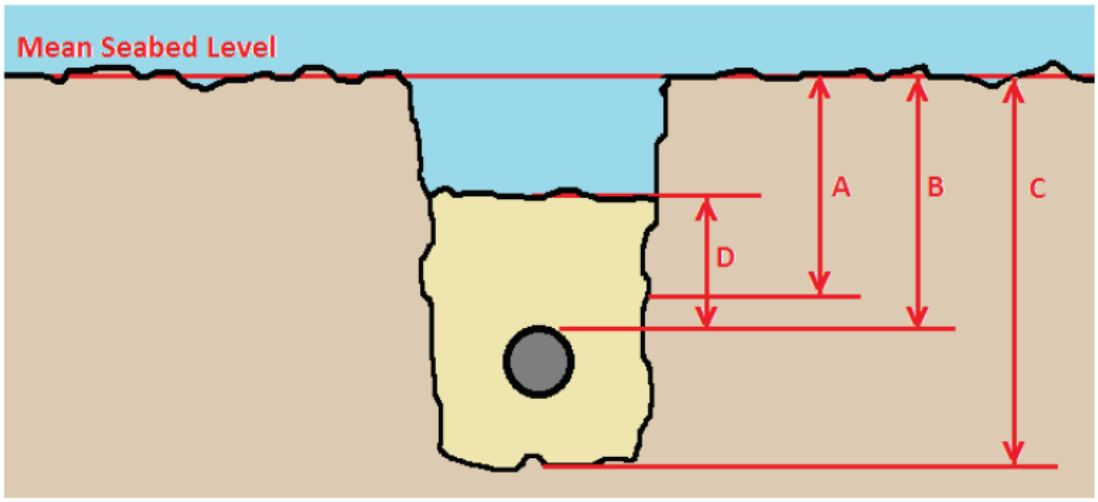
The purpose of this report is to identify any potential areas where activities, such as shipping and fishing, may pose a risk to the integrity of the installed cable. In the probabilistic risk assessment of anchoring risk, probability is measured as a ratio of the favourable cases to the whole number of cases possible. An event that would occur with certainty has a probability of 1.

Assumptions used are considered conservative and 'realistic worst case' which produces higher probabilities than would likely be the case. This enables the route and installation methods to be considered with a higher margin of safety.

## 1.4 Definition of trenching parameter

Intertek has used the Carbon Trust's definition of DOL for this study. This is illustrated in **Figure 1-2.**

**Figure 1-2 Definition of Burial Terms used in Report**




**A** Recommended Minimum Depth of Lowering
**B** Target Depth of Lowering
**C** Target Trench Depth
**D** Depth of Cover

**Recommended Minimum Depth of Lowering (RMDOL)**
This is the minimum DOL recommended for protection from the external threats, it is the direct output of the populistic risk assessment and includes a factor of safety (FoS).

**Target Depth of Lowering (TDOL)**
This is the depth that will be specified as the target depth to the cable installation contractor. TDOL is a depth which makes best use of what is achievable by industry standard burial tools to gain additional depth beyond RMDOL without incurring a step change in costs. Target DOL is also a practical application of depth which considers the effect burial depth has on tool stability.

**Target Trench Depth**
This is the trench depth cable installation contractors determine is required to meet TDOL. This is driven by cable properties and the selected trenching tool and is usually the diameter of the cable plus between 0.1 m and 0.4 m beyond the TDOL.

**Depth of Cover**
The thickness of material on top of the cable after trenching. It is not normally required for cable protection; however, it may be required by some consenting authorities.

## 1.5 Relevant Data

Data obtained from the Geophysical & Geotechnical campaigns and other relevant data sources are presented in **Table 1-1** below.

**Table 1-1 Provided Survey Data**

| Data Type | Name | Information |
|---|---|---|
| Survey Bathymetry (Ref1) | MMT_553_NEU_WGS84_UTM31_DTU10_LAT_DTM_1m_DTM | 1m resolution bathymetry over a 500m survey corridor in UTM31 |
| | MMT_553_NEU_WGS84_UTM32_DTU10_LAT_DTM_1m_DTM | 1m resolution bathymetry over a 500m survey corridor in UTM32 |

| Data Type | Name | Information |
|---|---|---|
| | MMT_553_NEU_WGS84_UTM31_DTU10_LAT_DTM_1m_DTM_Slope | Slope in degrees of the seafloor over a 500m survey corridor in UTM31 |
| | MMT_553_NEU_WGS84_UTM32_DTU10_LAT_DTM_1m_DTM_Slope | Slope in degrees of the seafloor over a 500m survey corridor in UTM31 |
| | Bathymetry Contours obtained from Geophysical survey | 1m and 5m bathymetry contours over the extent of the survey corrido |
| Open Source Bathymetry | BSH Aurfmod Bathymetry (Ref 2) | German nearshore bathymetry available annually from 1982 to 2016. 50m resolution from coastline to a depth of 20m |
| | EMODnet Bathymetry (Ref 3 | EMODnet Digital Terrain Model (DTM) is generated for European sea regions from selected bathy survey data sets (1975 to 2013 using SBES & MBES) and composite DTMs, while gaps with no data coverage are completed by integrating the GEBCO Digital Bathymetry. 200m Resolution |
| AIS Data (Ref 4) | Intertek_Area_of_Interest_201708_to_201807 | 5-minute time series data of shipping activities in 2017 (12 months of data) +/- 30km either side of the Issue 5 NeuConnect cable route provided by Oceaneering International Inc (ref 5) |
| Crossings (ref 5) | As found Pipeline/Cable data | As found XY locations and depth of burial for cables and pipelines along the cable route +/- 250m of the centreline |
| Contacts (Ref 6) | SSS contacts & Mag contacts | Seafloor Contacts and Magnetometer anomalies found within the 500m survey corridor |
| Seabed Sediments (Ref 7) | Seabed Classification | Seabed surficial polygon of classified geology interpreted from SSS and correlated with MBES/SBP |
| Geology (Ref 8) | Shallow Geological Isopach | Shallow geological isopach interpreted from sub-bottom profiler data and correlated with side scan sonar imagery and bathymetric digital terrain model data |
| Geotechnical Samples (Ref 8) | Vibrocore, Cone Penetrometer Tests and grab sample logs | Geotechnical sample logs from Vibrocore (VC), Cone Penetration Test (CPT) and Grab Sample (GS) |
| Geotechnical Results report (Ref 9) | 102553-NEU-MMT-SUR-REP-GEOTECH-02 | Results of the Geotechnical campaign |
| Geophysical Results reports (Ref 10) | 102553-NEU-MMT-SUR-REP-OPERFR-02 | Results of the Geophysical campaign |
| Admiralty Charts (Ref 11) | MarineFind | Navigation charts over the study area obtained from http://wmsgateway.findmaps.co.uk/wms/IntertecMetocCharts |

**Limitations**

This document uses the information obtained from the geophysical and geotechnical campaigns carried out by MMT in 2018 and AIS data purchased from Oceaneering. Please note that no geotechnical operations were carried out in the last 50km of the route in German waters (Block 15) due to permitting issues therefore no VC's or CPT's were acquired in this area. This CBRA is based on MMT's survey results highlighted in **Table 1-1** and the geophysical and geotechnical reports (ref 10).

# 2. CABLE ROUTEING

## 2.1 Route development background

An initial route centreline was put forward for survey from 4C offshore after a desktop study was carried out. The route centreline was reviewed by Fichtner in German Waters and Intertek in Dutch & UK waters. Minor amendments were made, and a final centreline route was created, named:

- Neuconnect_Issue_03_180212_R03_Route_Z31

The results of the Geophysical survey revealed areas in which dynamic re-routing during the survey campaign was required to avoid major offshore constraints such as:

a. avoiding shallows around Long Sand Head

b. further avoid the BritNed cable nearshore

c. avoid windfarm licence block area

d. avoid the Nordegrunde export cable in German waters

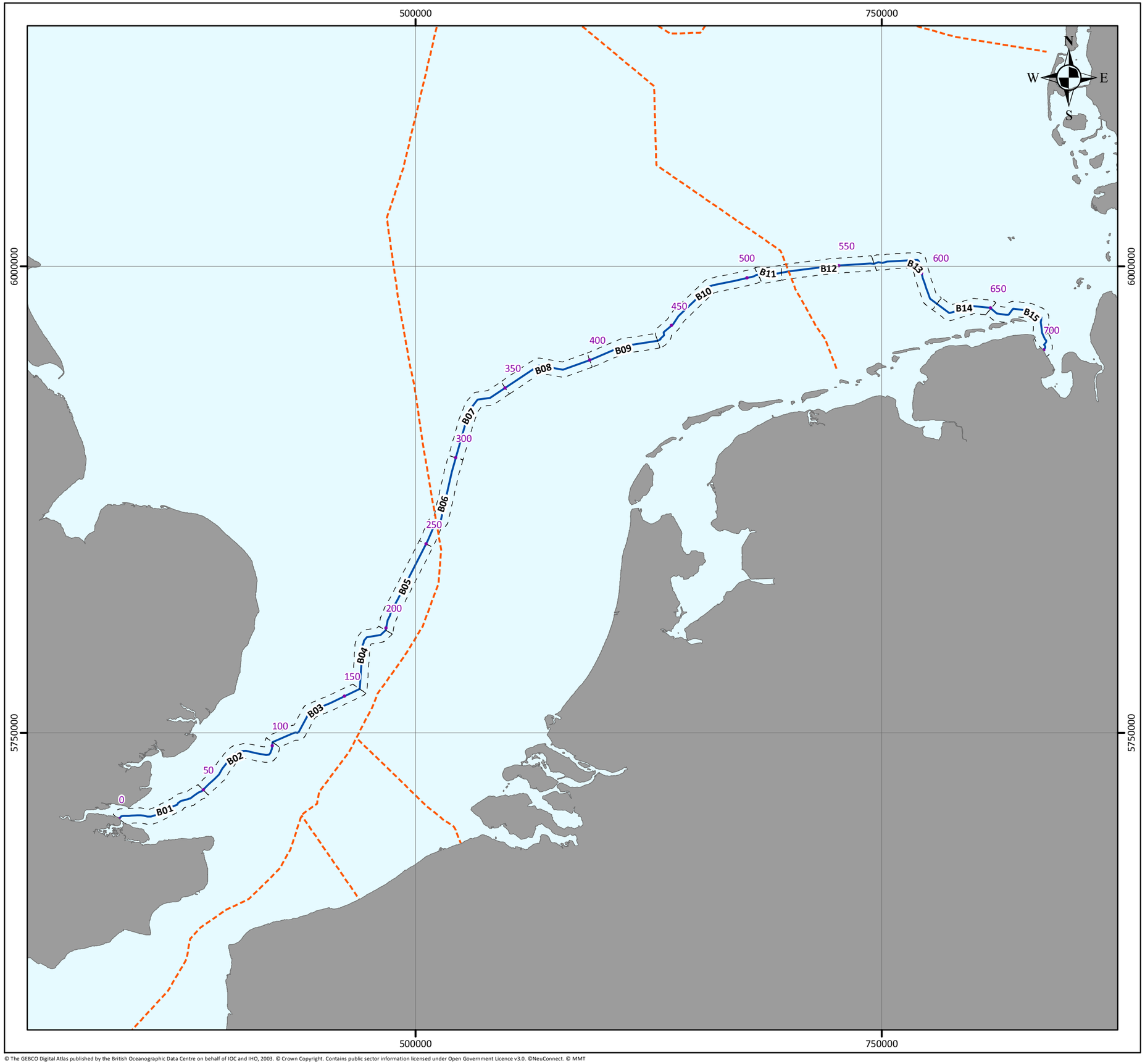
After the re-routeing was confirmed a final centreline route was created:

- **20180726_NeuConnect_Issue_5_RPL**

KP 0 is located on the UK landfall, Isle of Grain and increases toward Germany. KP 700.580 is located near Hooksiel, on the German landfall.

## 2.2 Route overview

The route assessed in this report is presented in **Figure 2-1** below. The route was divided into 15 Blocks to optimise survey efficiency. The Blocks were approximately 50 km long, but the boundaries were adjusted to coincide with turns in the cable route.

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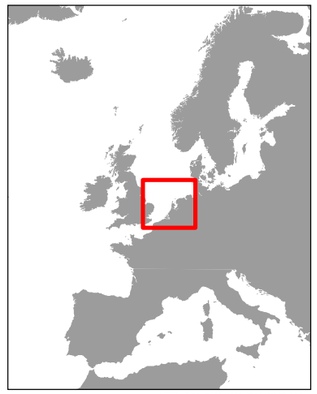
# NeuConnect CBRA

## Figure 2-1: Route Overview

**Legend**

- KP's
- Median Line
- NeuConnect Route
- Survey Block



NOTE: Not to be used for Navigation

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| **Created By** | Chris Carroll |
| **Reviewed By** | Chris Goode |
| **Approved By** | Louis Dumenil |

NeuConnect intertek

0 10 20 30 40 km

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# 3. COLLATION OF DATA AND SUITABILITY REVIEW

This section provides an overview of the bathymetrical and geological data along the surveyed corridor, based on the interpretation of the geophysical and geotechnical data. All data obtained from the geophysical and geotechnical survey has been correlated with each other, and the output from this has been compared to the existing data sources.

## 3.1 Bathymetric data

The seabed topography along the route is characterised by the presence of numerous mounds, areas of mobile sediments, outcrop of bedrock, trenches, ridges, boulders, linear features such as furrows or striations of coarser sediment and varying relief. The knowledge of these features is critical to any cable installation feasibility study. This section describes the existing bathymetry data in the study area and the resolution and quality of each dataset.

Sources for the bathymetry datasets can be found in Section 1.5 and is summarised below:

- EMODnet Bathymetry – 100m resolution
- BSH Aufmod Bathymetry – 50m
- MMT Survey Data – 1m resolution bathymetric soundings
- MMT Survey Data – 1m resolution slope in degrees

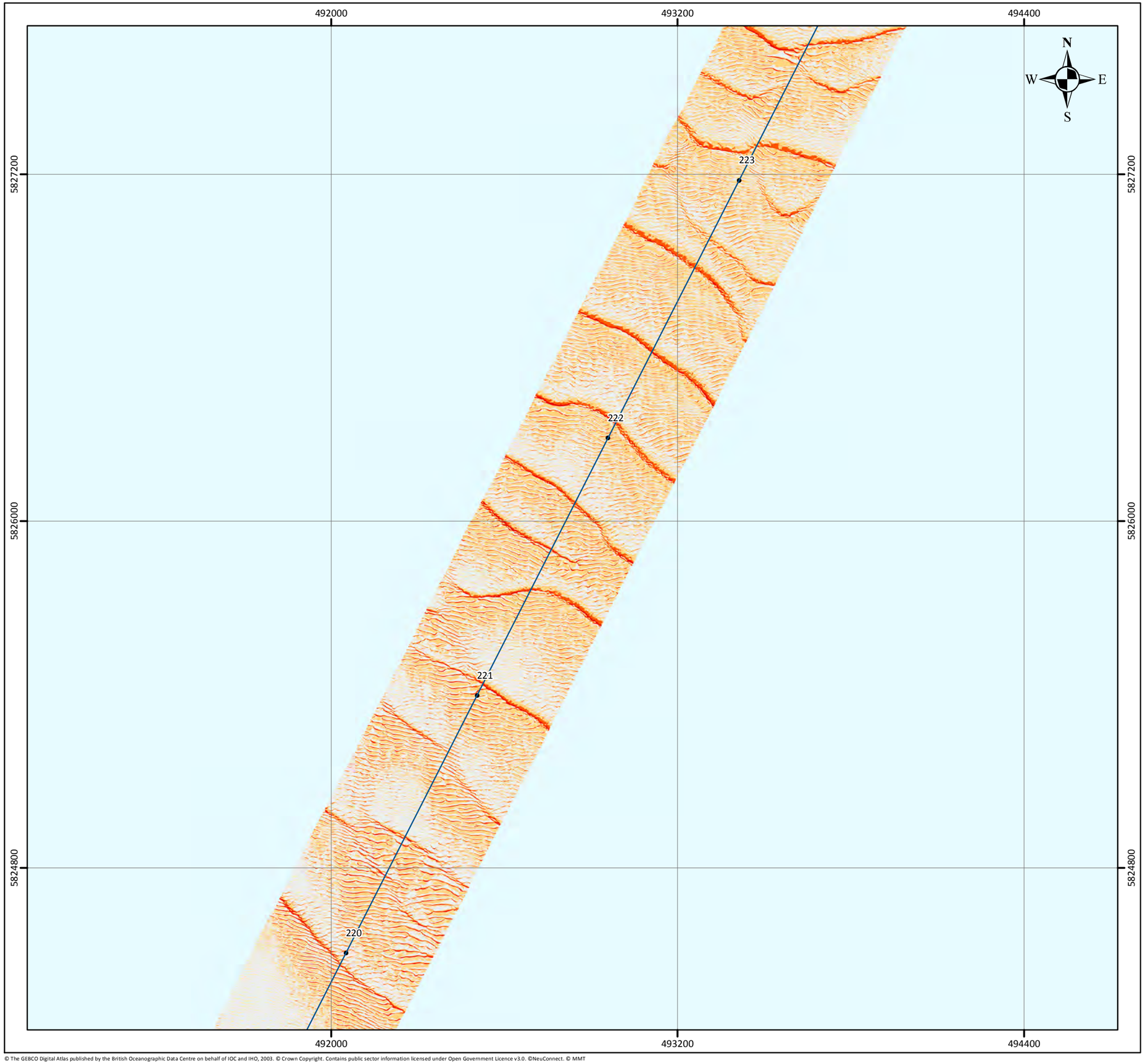
The open source data was used to define the route centreline for survey. These sources provide a good overview of the surrounding area and highlight large features such as sandwaves. There is good overall correlation between the open source data and the acquired high resolution survey data. The open source dataset, however, does not provide the high resolution required to carry out a cable burial risk assessment. This resolution is provided by the data acquired along the route during the survey.

### 3.1.1 Suitability of data

The bathymetric soundings obtained for this study is of very high quality and processed to a resolution (1m). It has highlighted areas of shoaling, potential areas of sediment mobility, areas of outcrop and in some cases confirmed the presence of wrecks and obstructions.

The offshore dataset provided by EMODnet and the BSH are good robust datasets suitable to show water depths, areas of shoaling and bathymetric lows. The low-resolution dataset confirms the presence of larger features in the study area, but its resolution is too low to determine any migration rate of mobile bedforms. The acquires bathymetric data provides this insight.

An example of the typical slopes encountered within the survey corridor has been provided by MMT and shown in **Figure 3-1**, while bathymetry of the cable route is displayed in **Figure 3-2** and **Figure 3-3.**




# NeuConnect CBRA

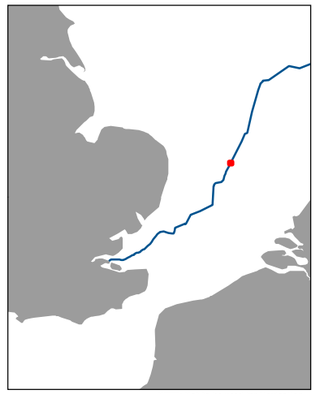
## Figure 3-1: Typical Slopes Encountered within Block 5

**Legend**

- KP's
- NeuConnect Route

**Slope (Degrees)**

- 0 - 1
- 2 - 5
- 6 - 10
- 11 - 15
- 16 - 90



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| **Created By** | Chris Carroll |
| **Reviewed By** | Chris Goode |
| **Approved By** | Louis Dumenil |

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0 0.1 0.2 0.3 0.4 km

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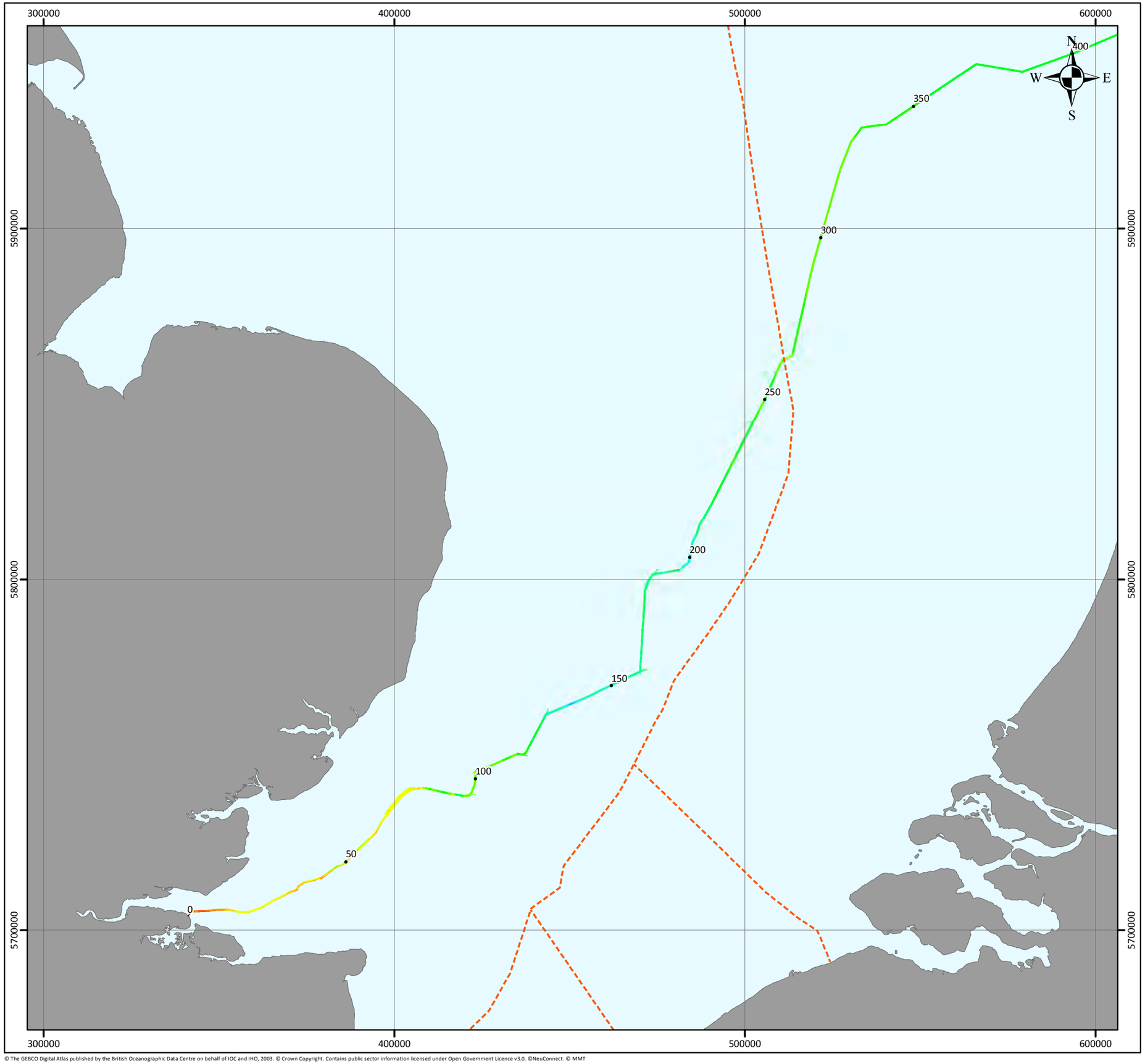


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## NeuConnect CBRA

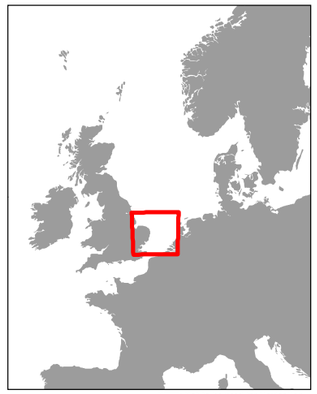
### Figure 3-2: Bathymetry Overview KP0-KP350

**Legend**

- Median Line

**Bathymetry (m below LAT)**

- -68
- -67 - -65
- -64 - -60
- -59 - -55
- -54 - -50
- -49 - -45
- -44 - -40
- -39 - -35
- -34 - -30
- -29 - -25
- -24 - -20
- -19 - -15
- -14 - -10
- -9 - -5
- -4 - 0
- 1 - 5



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| **Created By** | Chris Carroll |
| **Reviewed By** | Chris Goode |
| **Approved By** | Louis Dumenil |

NeuConnect intertek

0 8 16 24 32 km

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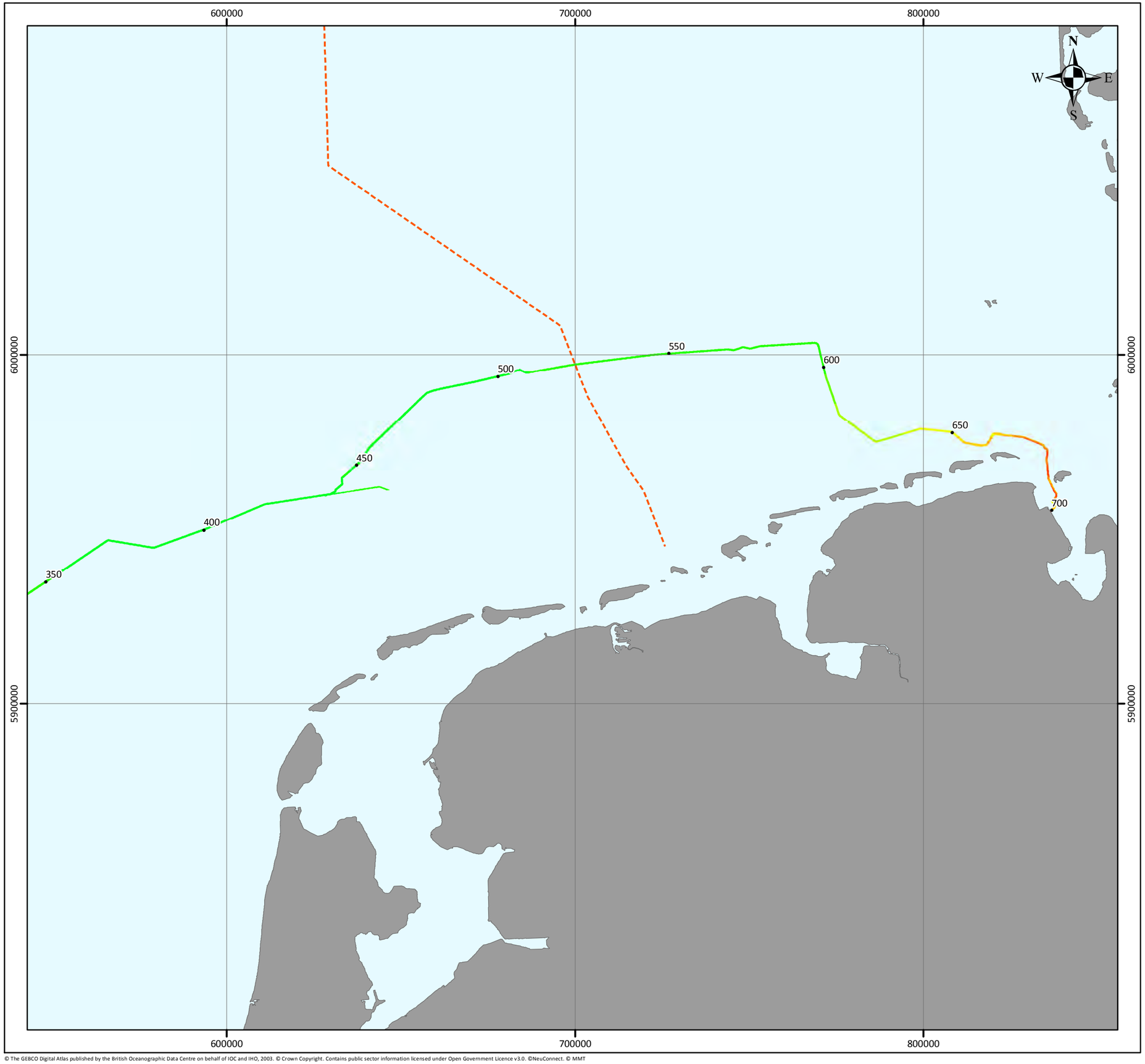


# NeuConnect CBRA

**Figure 3-3: Bathymetry Overview KP350-KP700.58**

**Legend**

- Median Line

**Bathymetry (m below LAT)**

- -68
- -67 - -65
- -64 - -60
- -59 - -55
- -54 - -50
- -49 - -45
- -44 - -40
- -39 - -35
- -34 - -30
- -29 - -25
- -24 - -20
- -19 - -15
- -14 - -10
- -9 - -5
- -4 - 0
- 1 - 5

NOTE: Not to be used for Navigation

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| **Reviewed By** | Chris Goode |
| **Approved By** | Louis Dumenil |

NeuConnect intertek

0 8 16 24 32 km

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## 3.2 Geophysical data

Side scan sonar (SSS) data has been used for interpretation of surficial geology, identification of seabed features, and to select contacts. Sediment classes distinguished from SSS imagery are correlated with grab sample, vibrocore (VC) and cone penetration test (CPT) results. Topographical features identified from SSS records have been correlated with bathymetric digital terrain models processed from the bathymetric sounds acquired using the multibeam echo sounder (MBES). Shallow geology interpretations are based on sub-bottom profiler (SBP) data correlated with the geotechnical sampling results. SSS and MBES data is also used to corroborate the SBP interpretation in the uppermost layers.

Magnetometer records collected during the survey are used to identify cables/pipelines and ferrous objects on the seafloor within the survey corridor. Note that due to line spacing this does not constitute an unexploded ordnance (UXO) survey.

### 3.2.1 Geophysical Survey (Blocks 1-15)

Bathymetric soundings were of a good quality throughout. Halocline and sound velocity artefacts were present on occasion in Blocks 8, 9 and 10 and infill lines were acquired where necessary.

Side scan sonar imagery proved to be fit for purpose, yielding detection of objects as small as 0.5 m in the outer ranges of the low frequency (LF) data. Shallow depths and strong tidal currents resulted in data of reduced quality over the shallower banks in Block 02. In Blocks 7, 9 and 10 environmental noise, caused by thermocline/halocline, was observed on some of the acquired lines. Appropriate infill was acquired in order to achieve 200 % coverage, excluding the outermost survey lines. Some reruns were required due to weather and environmentally affected data in Block 13.

The overall quality of the sub bottom profiler (SBP) data were good. Penetration on the Chirp varied from 10 m to 16 m. Penetration on the Sparker varied from 18 m to 30 m in places. Greater signal attenuation was observed when thick layers of surficial sand were present. Where sediments were more granular in nature the Sparker data was used for interpretation to ensure sufficient penetration.

Magnetometer data were of good quality throughout.

### 3.2.2 Seabed Sediment Classification

The interpretation of surficial sediment types was derived from the acoustic character of the high frequency SSS data, and the interpretations aided by MBES bathymetric 3D surfaces and SBP data. During the review of the SSS survey data, higher intensity sonar returns (darker grey to black colours) were interpreted as relatively coarser grained sediments, and lower intensity sonar returns (lighter grey colours) were interpreted as relatively finer grained sediments. Bathymetric data was used to correct the interpretation for the effects of seabed slope on sonar returns. In addition, drop down video (DDV) images from the benthic sampling and video transects together with logs from the geotechnical sampling were used to verify any interpretations made.

Seabed Sediment Classifications are as follows:

**Table 3-1 Seabed Sediment Classification**

| Acoustic description | Interpretation |
|---|---|
| Low acoustic reflectivity.<br>No texture. | CLAY<br>May contain silt, sand and/or gravel. |
| Low to medium acoustic reflectivity. Slightly grainy texture. | Sandy CLAY |
| Medium acoustic reflectivity. Grainy texture. | Gravelly CLAY |

| Acoustic description | Interpretation |
|---|---|
| Low to medium acoustic reflectivity. Slightly grainy to grainy texture with point source reflectors. | SILT<br>Predominantly silt, may have minor fractions of clay, sand and/or gravel. |
| Medium acoustic reflectivity, slightly grainy texture. | SAND<br>Predominantly sand, may have minor fractions of clay, silt and/or gravel. |
| Medium acoustic reflectivity, slightly grainy texture. | Clayey SAND |
| Medium to high acoustic reflectivity. Slightly grainy to grainy texture, coarse texture in places. | Gravelly SAND to sandy GRAVEL<br>The ratio between SAND and GRAVEL can vary within this sediment type. |
| High acoustic reflectivity.<br>Grainy to coarse texture. | Clayey GRAVEL |
| High acoustic reflectivity.<br>Grainy to coarse texture. | GRAVEL<br>Predominantly gravel, may have minor fractions of clay, silt and/or sand. |

Seabed Feature Classifications are as follows:

### Table 3-2 Seabed Feature Classification

| Interpreted Seabed Feature | Criteria[1] |
|---|---|
| Ripples | Wave length <15 m<br>Height <1.0 m |
| Megaripples | Wave length 15-50 m<br>Height 1-3 m |
| Sandwaves | Wave length 50-200 m, Height >3 m |
| Boulder Field<br>Occasional boulders<br>All >0.5 m | Concentration of 5 to 20 boulders within a maximum area of 100 x 100 m |
| Boulder Field<br>Numerous boulders<br>All >0.5 m | Concentration of >20 boulders within a maximum area of 100 x 100 m |
| Trawl Mark Area | Concentration of numerous trawl marks |
| Current Lineation | Current lineation |
| Marine growth | Marine Growth (Potential Annex 1 habitat) |
| Relict gas/fluid seepage features | Relict gas/fluid seepage features |
| Eroded Depressions | Eroded Depressions |
| Anthropogenic | Man-made |
| Dredging activity | Dredging activity |

[1] Note, there is no standard for bedform descriptions. Criteria presented in Table 3-2 are as defined by route survey contractor MMT. Alternative criteria are also common.

### 3.2.3 Shallow Geology

The classifications of the shallow geology have been derived through a combination of analysis and interpretation of the acoustic character of the SBP data and geotechnical results. A comparison with available background information was made and broken down into major sediment types along the route.

| Sediment Type | Acoustic Characteristics | Lithological Variations | Blocks |
|---|---|---|---|
| CLAY | Homogeneous to layered, transparent to high amplitude recent sediments lying from at or near the seabed to base of record and/or filling paleo-channels. | Very soft to very stiff, slightly silty to very silty, slightly sandy to very sandy, slightly gravelly to very gravelly CLAY.<br>Massive to layered to pockets. May locally contain shells, pebbles, cobbles and pockets of SILT, SAND and GRAVEL. | Blocks 1 - 15 |
| SILT | Acoustically layered, low to medium amplitude recent sediments lying from at or near the seabed to base of record and/or filling paleo-channels. | Slightly sandy to very sandy, slightly clayey to very clayey SILT. Generally, present as laminations and pockets and occasionally as a coherent unit. | Blocks 1 - 15 |
| SAND | Acoustically homogeneous to layered, low to medium amplitude recent sediments lying from at or near the seabed to base of record and/or filling paleo-channels. | Slightly clayey to very clayey, slightly silty to very silty, slightly gravelly to very gravelly SAND. Laminations of CLAY and SILT.<br>May locally contain shells, pebbles, cobbles and pockets of SILT, CLAY and GRAVEL. Commonly forming mobile sediment. | Blocks 1 - 15 |
| GRAVEL | Medium to high amplitude recent sediments lying from at or near the seabed to base of record and/or filling paleo-channels. | Slightly clayey to very clayey, slightly silty to very silty, slightly sandy to very sandy GRAVEL. Predominantly comprising shell fragments, Generally present as pockets and internal layers and commonly a surface veneer. Locally mobile. May locally contain pebbles, cobbles. | Blocks 1 - 15 |
| PEAT | High amplitude layers/bands and/or filling paleo-channels. | Soft to firm PEAT. Present as either a thin layer/band, pockets or reworked. | Blocks 5, 6, 8, 9, 10, 12, 13 &14 |
| SAND, SILT and CHALK | Weathered and structureless | Locally present as a mobile sediment overlying CLAY | Block 03 |

### 3.2.4 Contacts and Anomalies

The contacts or objects interpreted from the side scan sonar imagery were selected according to the following criteria:

- Wreck

- Boulder
- Debris
- Wire/rope
- Mound
- Buoy
- Fishing gear
- Other

During seabed interpretation, boulder occurrence at surface has been grouped based on the frequency and content of boulder >0.5 m per 100 x 100 m. Contacts less than 0.5 m were not picked.

Magnetic anomalies, if identified, are classified according to the following criteria:

- Dipole, monopole or complex shape
- Single anomaly or anomalies creating a linear trend relating to possible or identified cable/pipeline crossings.

## 3.3 Geotechnical data

The geotechnical investigations consisted of vibrocore samples (VC) and cone penetration tests (CPT).

The initial program was for approximately seven hundred (700) VC to be carried out, i.e. one every kilometre. CPT locations were to be carried out every 2km, such that correlation could be made between the two investigation methods. In total, three hundred and twenty (320) CPT locations were carried out, with multiple re-attempts required at eight locations, resulting in a total number of tests as three hundred and twenty-nine (329). Six hundred and fifty-five (655) VC locations were carried out.

### 3.3.1 Vibrocores

The vibrocores were recovered using an electrically powered VKG-6 vibrocore unit, owned and operated by MMT, fitted with a 6m long core barrel and using clear PVC 100mm OD liner. During VC operations, there were instances of re-attempts being required due to initial poor recovery. Poor penetration and subsequent low material recovery were generally a function of dense to very dense coarse granular material or high strength cohesive material being encountered.

Following an acceptable recovery of a vibrocore sample to the vessel deck, each liner was successively cut into 1.0m sections. Offshore processing comprised the production of a field log from the visual inspection of the cut liner ends. Upon completion of the offshore processing, the complete vibrocore samples were then appropriately labelled, sealed and placed into secure storage crates. Each vibrocore liner in turn was removed from storage, split longitudinally, photographed and logged.

Shear strength measurements were taken on any suitable cohesive strata using a torvane. In-situ thermal measurements were also carried out during logging

### 3.3.2 Cone Penetration Testing

CPTs were carried out to a maximum depth of 5.50m using 10cm2 electric piezocones operated from a ROSON seabed CPT unit, ballasted to eleven tonnes in air weight. The aim at each CPT location was to reach the target penetration depth of 5.00m. Re-attempts were required at eight locations due to either initial failure to reach the required depth, concern with the overall test application class, or due to electrical power and/or communication issues with the seabed CPT unit.

Measured cone end resistance, sleeve friction and dynamic porewater pressure was recorded at 2cm intervals of penetration.

### 3.3.3 Suitability of data

Each VC and CPT log are clearly presented in an annex to the Geotechnical report (Ref 9) and provided the relevant geological information at each location.

Within the Geotechnical report (Ref 9) a scale has been derived for the seabed conditions. We have used this to define 'route sections', based on similarities between the CPT/VC results. The scale is called the Seabed Index (SI) and can be viewed as a semi-quantitative scale in respect of the encountered ground conditions, and to some respect, the likely difficulties for engineering activities in the investigated depth below seabed level. The Seabed Index values provided are based on the geological and geotechnical characteristics of the encountered material at a depth of 1.50m. The seabed index is not, however, a suitable categorisation for a CBRA. This is because it only provides a classification at one specific depth (i.e. 1.5m) and review of the VC and CPT show that the soil type and properties vary significantly above and below this single point. As a result we have re-assessed the seabed classification using the CPTs and VC information directly – see Section 4.

## 3.4 AIS shipping data

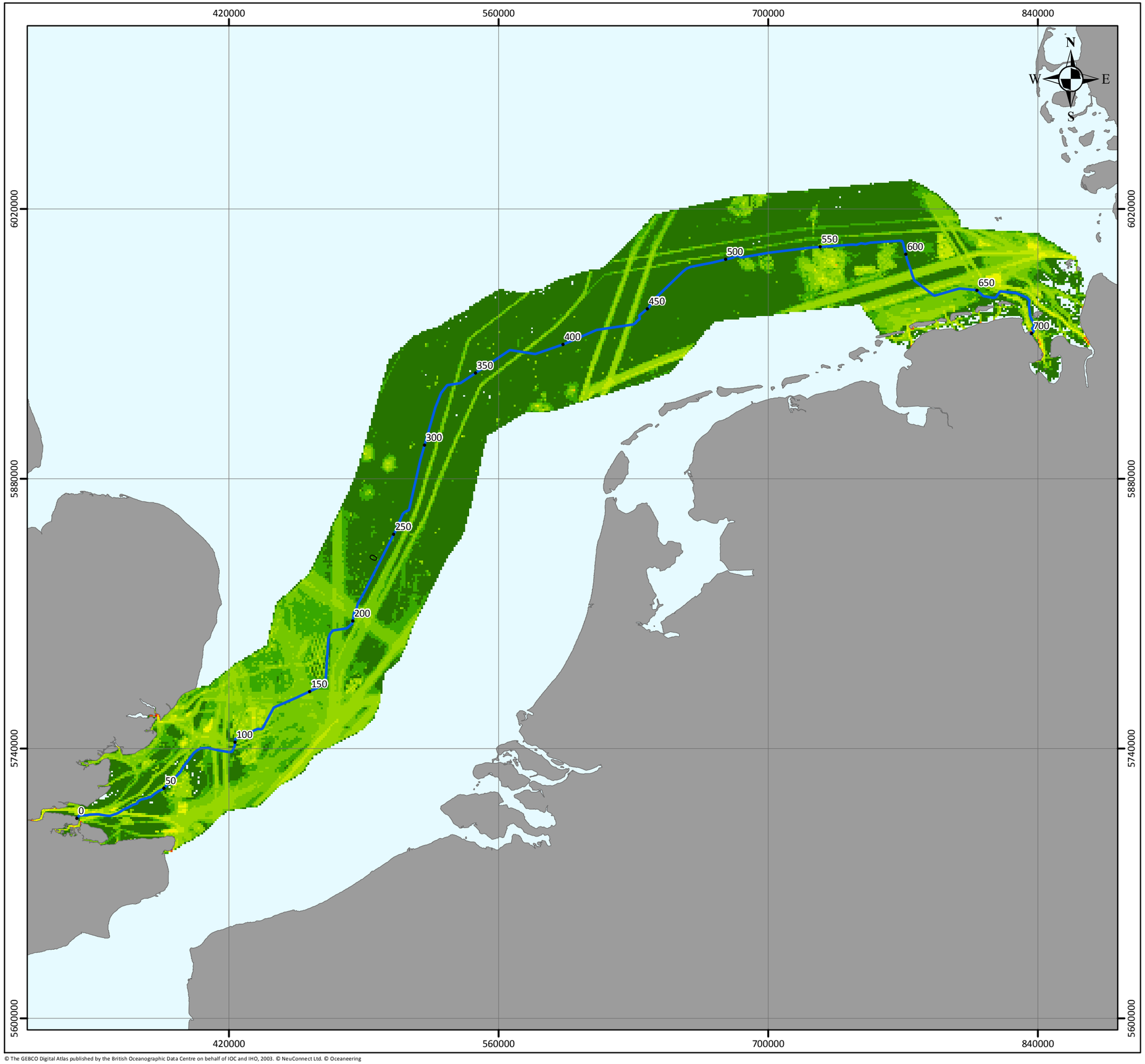
AIS (Automatic Identification System) is an automatic tracking system used on ships for identifying and locating vessels by electronically exchanging data with other nearby ships and AIS base stations and satellites. The International Maritime Organisation (IMO) requires AIS to be fitted aboard international voyaging ships with gross tonnage of 300 or more tons, and all passenger ships regardless of size. This would cover almost all commercial vessels and most private vessels that would be of risk to the cable; however, some smaller fishing vessels could be missing from the AIS dataset.

Information provided by the AIS equipment usually consists of unique identification number for each vessel, vessel name, vessel type, vessel position, course and speed. Other attributes like vessel deadweight tonnage and draught may be completed by the AIS supplier.

To quantify the anchoring risk to the cable, Intertek procured historical AIS data along the NeuConnect cable route for the period of August 2017 to July 2018 (inclusive) (ref 4) from Oceaneering for a study area of approximatively 30km wide either side of the cable route. This wide study area allows a clear insight into vessel movements by vessel type/size in the surrounding geography.

The NeuConnect route crosses several areas of high vessel traffic which are associated with shipping lanes. Where possible, the cable crosses perpendicular to these lanes, minimising the risks of encountering traffic during survey, installation and any operations and maintenance campaigns. These lanes are at approximately the following KPs: KP86; KP190; KP205; KP338, KP378; KP424; KP436; KP611; KP622 and KP 698. These are highlighted on **Figures 3-4** to **3-7.**

Vessel density increased closer to land as shipping routes condense to ports and harbours. In the UK nearshore area, between KP0 and KP20 the route travels in a westerly direction and is constrained between a shipping channel associated with the port of London and the BritNed Cable. This can clearly be seen on the AIS data before the route turns into a North Easterly direction. There are a number of additional areas separate from the linear shipping lanes with increased vessel density which can be correlated with offshore windfarms and the associated windfarm maintenance vessels. This can be seen again in German waters, where there is a clear correlation between the windfarms and vessel density. Vessel density increases again in the approach to the German landfall.

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# NeuConnect CBRA

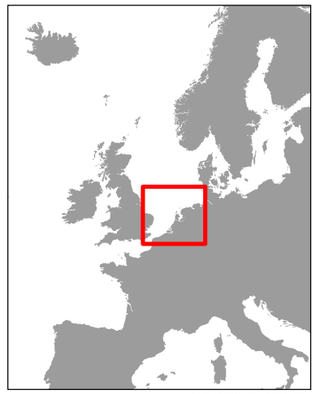
## Figure 3-4: Vessel Density August 2016 to July 2017

**Legend**

- NeuConnect Route

**Vessel Hours Per Year (1km x 1km grid)**

- 0 - 10
- 10 - 20
- 20 - 50
- 50 - 200
- 200 - 1000
- 1000 - 3000
- 3000 - 5500
- 5500 - 9000
- 9000 - 13000
- 13000 - 30000
- 30000 - 55000
- 55000 - 120000



NOTE: Not to be used for Navigation

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| **Data Source** | GEBCO, NEUCONNECT, OCEANEERING |
| **File Reference** | J:\P2131\Mxd\CBRA\ Fig_3_4_AIS_Data.mxd |
| **Created By** | Chris Carroll |
| **Reviewed By** | Chris Goode |
| **Approved By** | Louis Dumenil |

NeuConnect intertek

0 10 20 30 40 km

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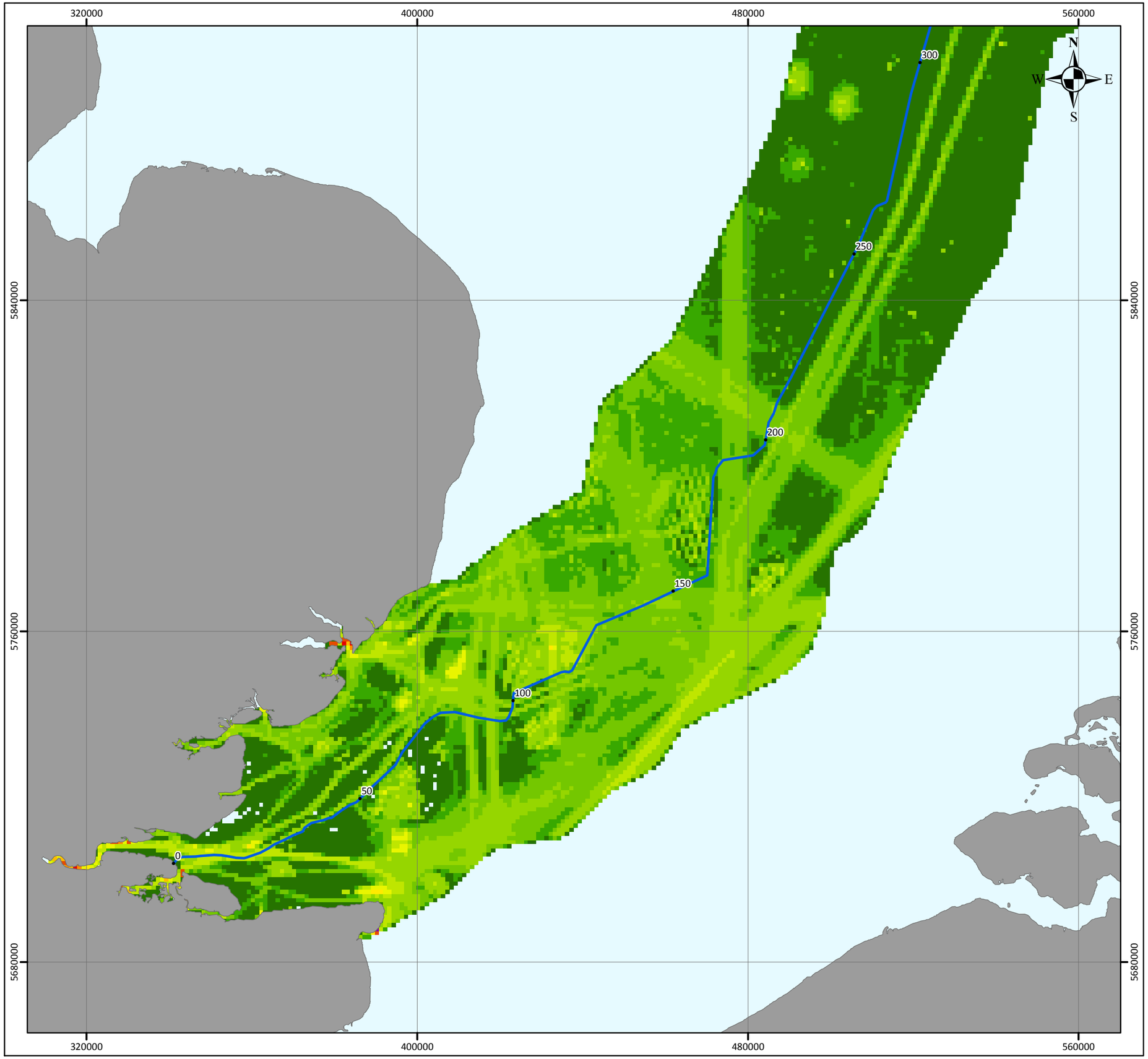



# NeuConnect CBRA

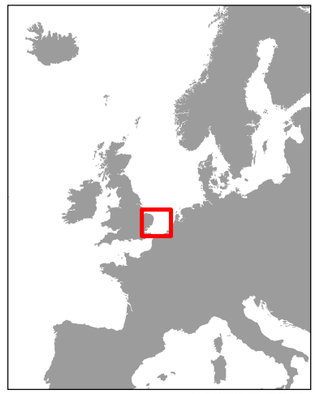
## Vessel Density August 2016 to July 2017
## KP0 to KP250

**Legend**

- KP's
- NeuConnect Route

**Vessel Hours Per Year (1km x 1km grid)**

- 0 - 10
- 10 - 20
- 20 - 50
- 50 - 200
- 200 - 1000
- 1000 - 3000
- 3000 - 5500
- 5500 - 9000
- 9000 - 13000
- 13000 - 30000
- 30000 - 55000
- 55000 - 120000



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| **Created By** | Chris Carroll |
| **Reviewed By** | Chris Goode |
| **Approved By** | Louis Dumenil |

NeuConnect intertek

0 5 10 15 20 km

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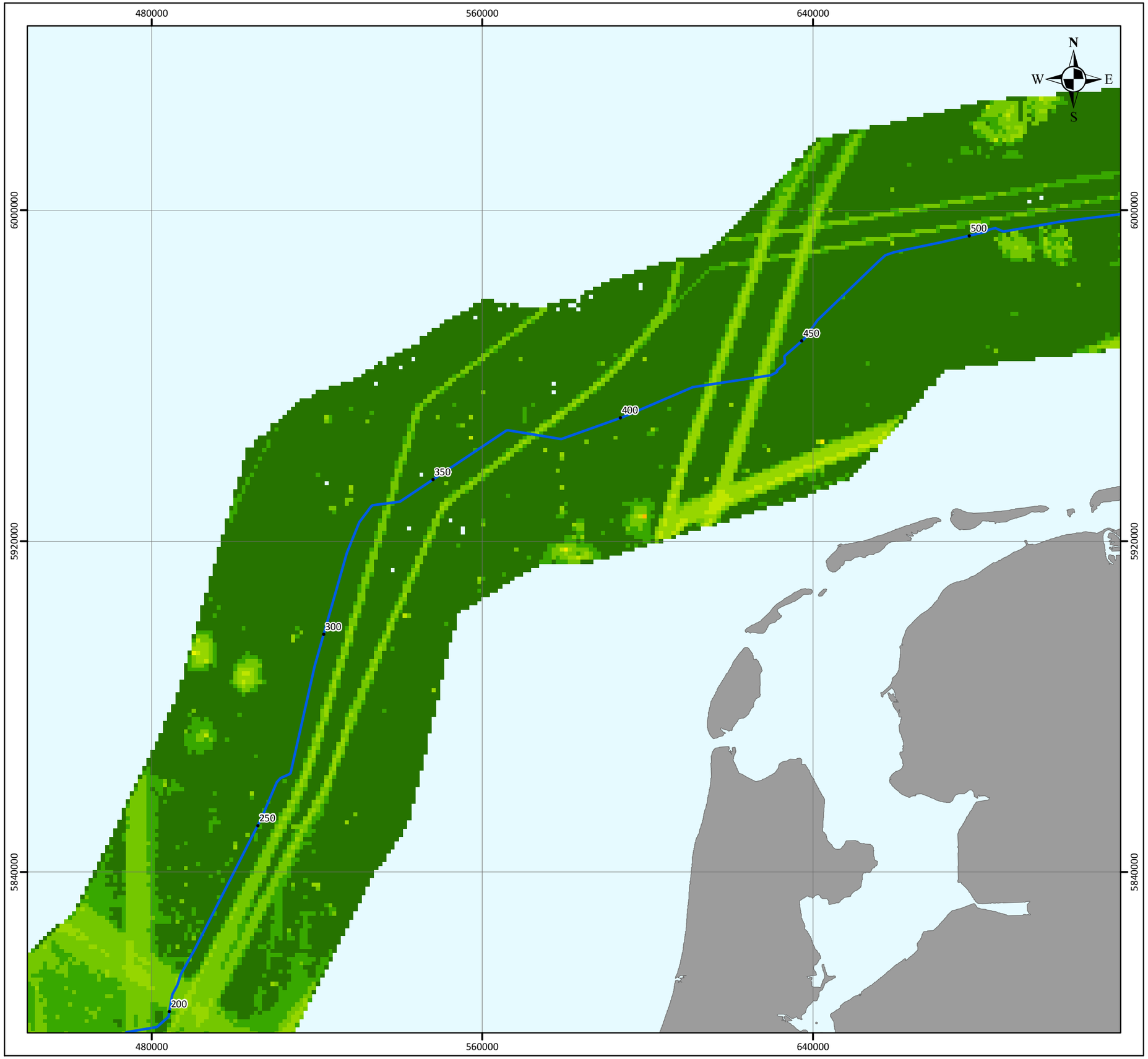


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# NeuConnect CBRA

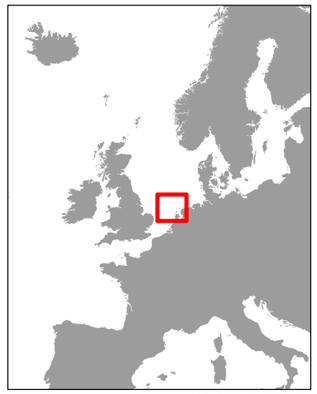
## Vessel Density August 2016 to July 2017
## KP250 to KP500

**Legend**

- KP's
- NeuConnect Route

**Vessel Hours Per Year (1km x 1km grid)**

- 0 - 10
- 10 - 20
- 20 - 50
- 50 - 200
- 200 - 1000
- 1000 - 3000
- 3000 - 5500
- 5500 - 9000
- 9000 - 13000
- 13000 - 30000
- 30000 - 55000
- 55000 - 120000



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| **Created By** | Chris Carroll |
| **Reviewed By** | Chris Goode |
| **Approved By** | Louis Dumenil |

NeuConnect intertek

km
0 5 10 15 20

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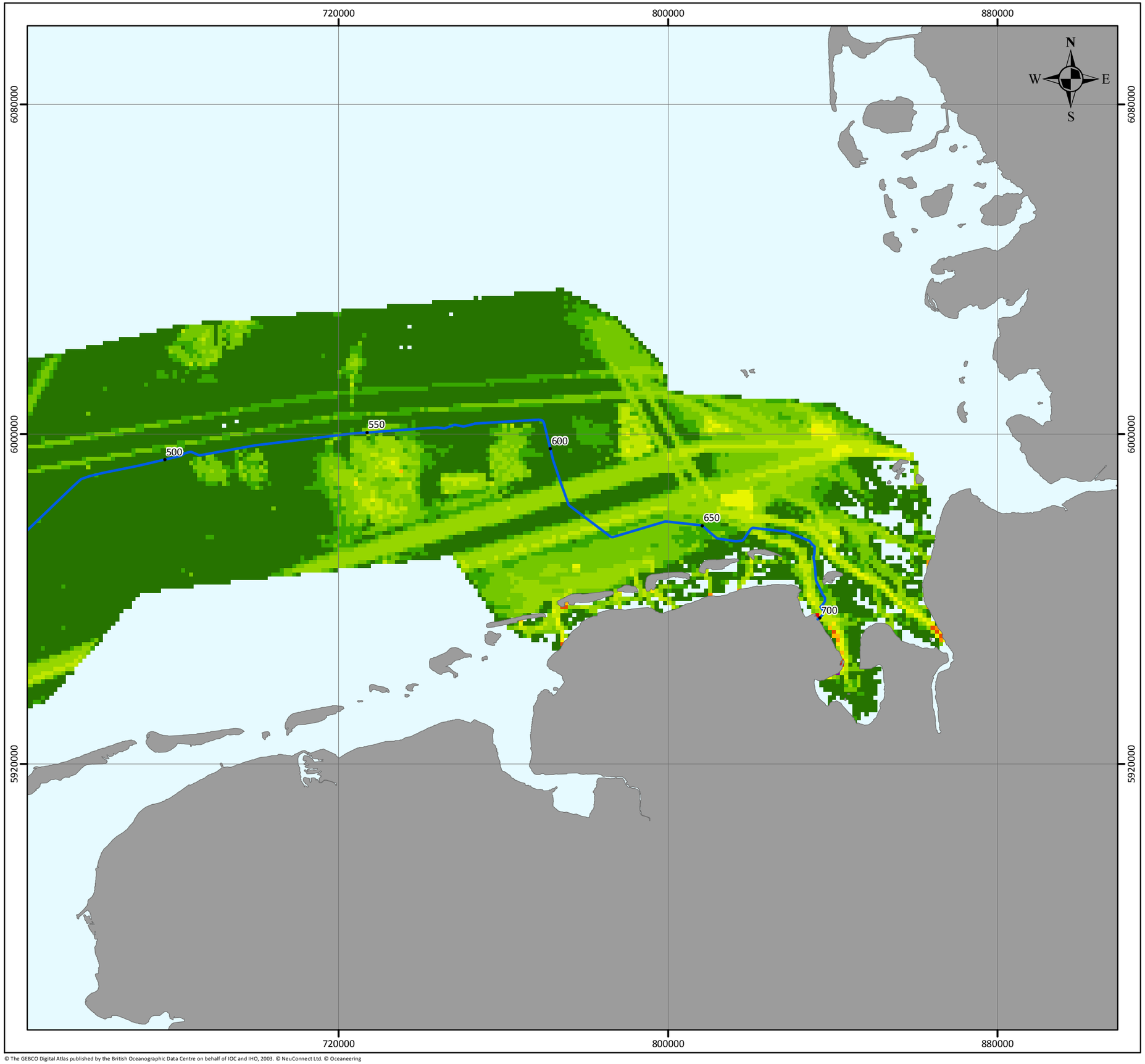



# NeuConnect CBRA

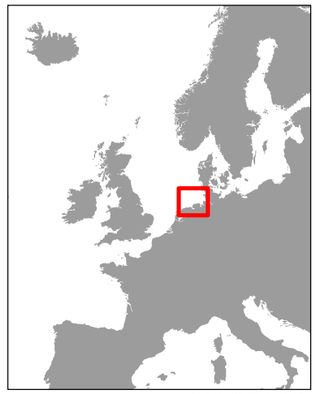
**Vessel Density August 2016 to July 2017**
**KP500 to KP700.58**

**Legend**

- KP's
- NeuConnect Route

**Vessel Hours Per Year (1km x 1km grid)**

- 0 - 10
- 10 - 20
- 20 - 50
- 50 - 200
- 200 - 1000
- 1000 - 3000
- 3000 - 5500
- 5500 - 9000
- 9000 - 13000
- 13000 - 30000
- 30000 - 55000
- 55000 - 120000



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| **Created By** | Chris Carroll |
| **Reviewed By** | Chris Goode |
| **Approved By** | Louis Dumenil |

NeuConnect intertek

0 5 10 15 20 km

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## 3.5 Territorial Regulatory Burial Requirements

For the purpose of this CBRA we have complied with the following regulatory burial requirements:

- In Germany the DOL should be minimal 1.5 m as standard (i.e. regardless of threats and soil conditions – see Zones 76-81 and 84-87) and minimum 2.0m in the traffic separation lanes (Zones 82-83);
- In the very nearshore landfall area in Germany the presence of dredging activities requires the burial depth to be minimal 5 m regardless of threats and soil conditions however this section (Zone 88) is outside the scope of this CBRA.
- In the United Kingdom and the Netherlands the burial depth should follow from a risk based approach.

# 4. ASSESSMENT OF SEABED CONDITIONS

This section presents the breakdown of the NeuConnect cable routes based on distinct seabed conditions based on our review of the available geotechnical and regional geological data.

In the MMT geotechnical report (ref. 9), complete descriptions of CPT and VC samples at each location are provided. A further level of description is provided by applying a "Seabed Index" classification to each complete sample, reproduced from the MMT report in **Table 4-1** below. This classification is applied at 1.5m depth.

As discussed in Section 3.3, the seabed index is not a suitable categorisation for a CBRA because it only provides a classification at one specific depth (i.e. 1.5m) and review of the VC and CPT show that the soil type and properties vary significantly above and below this single point. As a result, we have re-assessed the seabed classification using the CPTs and VC information directly. The results of this analysis are provided in **Appendix A**.

### Table 4-1 Summary of the Seabed Index (SI) scale

| SI | Typical Seabed Sediment |
|---|---|
| 1 | Shallow Bedrock (<1.00m) |
| 2 | Bedrock / Obstruction (>1.00m) |
| 3 | Very dense granular, very to extremely high strength cohesive |
| 4 | Medium to high strength cohesive |
| 5 | Dense granular |
| 6 | Medium dense granular |
| 7 | Loose granular, low to medium strength cohesive |
| 8 | Very loose granular, low strength cohesive |
| 9 | Very low strength sandy cohesive |
| 10 | Extremely low strength cohesive |

### Table 4-2 Interpreted Undrained Shear Strength Parameter and classification

| Descriptive term | Shear Strength Range (kPa) |
|---|---|
| extremely low | <10 |
| very low | 10 to 20 |
| low | 20 to 40 |
| medium | 40 to 75 |
| high | 75 to 150 |
| very high | 150 to 300 |

### Table 4-3 Interpreted Relative Density Parameter and classification

| Descriptive Term (Relative Density) | Cone Resistance Range (MPa) |
|---|---|
| very loose | <2.5 |
| loose | 2.5 to 5 |
| medium dense | 5 to 10 |
| dense | 10 to 20 |
| very dense | >20 |

# 5. RISK IDENTIFICATION AND ASSESSMENT

To specify an appropriate DOL for the Greenlink cable, Intertek conducted a risk identification and assessment considering both the likelihood and severity of all external threat to the cable.

Risks that pose a threat to installed marine cables can be classified as either Natural or Anthropogenic risks. The following sections describe the most common risks affecting marine cables.

The completed Risk Register is provided in **Appendix B**.

## 5.1 Natural hazards

### 5.1.1 Sediment Mobility

Sediment mobility in itself does not pose a threat to a submarine cable but it can lead to issues with the thermal conductivity of cables (over burial), and exposure of cables (scour); burial under excess sand can change the thermal properties of the soil and cause hotspots along the cable, while exposure increases the risk of damage due to external aggressors such as trawling and anchoring and potentially mechanical damage from free spans.

There are several areas within the NeuConnect 500m corridor where there are bedforms present which could be mobile.

The first indication of mobile bedforms can be observed at KP11. These have been interpreted by MMT as ripples and have a wave length of <15m and height <1.0 m. Ripples are observed intermittently throughout the route where they terminate at KP304 and do not appear again until KP620 and extent to the end of the route at KP700. While these may indicate some levels of sediment movement it is not thought that these minor bedforms will have an impact on the cable installation or operability.

Mega Ripples are also observed intermittently throughout the corridor, between KP108 & KP190 and then between KP669 and KP700. These are slightly larger than ripples and have a wavelength of 15-50m and height 1-3m so may pose a risk to an installed cable within its lifetime.

Sandwaves are present within the route corridor and are first observed between KP78 and KP 80. These have been interpreted by MMT to have a wavelength 50-200m and height of >3 m. Sandwaves are next present at KP 106 and remain as intermittent features until KP294. They do not appear again until between KP673 and KP700.

For further details of mobile features interpreted along the NeuConnect corridor please see MMT's Geophysical Report (Ref 10).

For the purposes of burial targets (RMDOL & TDOL) all depths are to be measured against trough depth and after any required route engineering has been undertaken to flatten mobile sediments.

### 5.1.2 Other geohazards

Earthquakes, volcanic eruptions, landslides, slumps and turbidity flows, could have a devastating effect on a subsea cable within its operational lifespan. Generally, these hazards are associated with areas that are tectonically active or are located on or near a continental slope or rise. The NeuConnect route resides in an area that is tectonically stable and away from a continental shelf/plate boundary; therefore, is it not expected that any significant hazards of this nature present on the route. No areas of unstable sediment were encountered along the NeuConnect route.

### 5.1.3 Outcropping bedrock

Bedrock and hard sediment are considered an issue when the seabed proves to have properties that affect, and effectively inhibit, the use of the common trenching methods.

Bedrock and hard sediment may cause problems with reaching the required burial depth. In addition, topographical irregularities in bedrock or hard sediment may cause freespan, point load, and abrasion. Methods to avoid problems with bedrock or hard sediment include appropriate micro-routing, deployment of heavier trenching machines, or the installation of additional cable protection.

MMT's Geophysical results report (Ref 10) details in full the exact locations of hard ground. There are no areas of outcrop as such within the NeuConnect route. There is however, a lighthouse (Mellumplate lighthouse) that is located on an isolated rock outcrop offset 139 m east from KP 683.709.

### 5.1.4 Waves and currents

Waves and currents may cause abrasion and stress to an exposed cable where it crosses over rock or rough terrain. Sufficient burial and protection of a subsea cable will reduce the risk of waves and currents to a negligible level.

### 5.1.5 Extreme weather

Extreme weather is unexpected, unusual, unpredictable, severe or unseasonal weather and involves weather at the extremes of the historical distribution. While the NeuConnect cable is geographically in a relatively weather-stable area, sufficient depth of lowering and protection will be required to deal with the effects of extreme weather such as excessive scour and extensive movement of mobile sediments.

## 5.2 Anthropogenic hazards

### 5.2.1 Shipping

Shipping represents an anchoring hazard to a cable on or in the seabed. Vessels that drop their anchors have the potential to interact with the cables if the anchor is dragged along the cable route or dropped directly on the cable. Ships in transit do not typically anchor under normal conditions and planned anchoring normally takes place within a designated area. Contact with an anchor is often catastrophic for the cable as the forces applied by a moving anchor can be extremely large. The anchoring hazard may result from:

- Insufficient protection
- Negligent anchoring
- Emergency anchoring (where an anchor is deployed to prevent collision or grounding)
- Accidental anchoring (where an anchor falls unexpectedly from a vessel due to equipment impact or operator error). Accidental anchoring is accentuated by proximity to a port where, for navigational reasons such as the traffic density, proximity of obstructions, shallow waters and other vessels, anchors are more likely to be readied for deployment.
- A vessel being anchored inadequately (where an anchor is deployed but drags along the seabed prior to embedment)

### 5.2.2 Fishing gear interaction

Noting that vessels of less than 300 deadweight tonnage (DWT) tonnes are not presently required to carry AIS transponders, fishing data obtained from the Marine Management Organisation (MMO) has

been analysed to determine areas fished using mobile methods (dredging, trawling, netting etc). It is difficult to determine the specific type of gear used but the specified DOL must consider the maximum depth of penetration from fishing.

### 5.2.3 Dredging/aggregate extraction/subsea mining/dumping

Within UK, Dutch and German waters, all active and historical dredging and aggregation areas are known and have detailed surveys undertaken to ascertain sediment levels. All disposal and dumping sites are also known and are contaminated with material such as heavy metals and in some extreme cases radioactive waste. Aggregation, dredging and dumping ground have all been avoided with the exception on the very nearshore landfall area in Germany. The route has no option but to cross a known dredging area between approximately KP 696 and 697. Within this area the water depth is constantly maintained at 17.6m, as stated on the admiralty chart (ref 11) The Nordergründe Export Cable is also observed to cross this area. The as laid data indicates that the export cable is buried to between 5 and 6m crossing the dredged area.

The NeuConnect Interconnector will cross a total of 89 existing subsea linear assets.

- 29 in-service cables, 45 out-of-service cables and;
- 13 in-service pipelines, 2 abandoned pipelines

MMT surveyed 30 known in-service assets. Details of this survey can be found in MMT's crossing survey report (Ref 18). Each live asset will require a third-party crossing agreement and each disused asset will need permission to remove the existing asset prior to installation. Before each crossing location burial depth will be steadily decreased to allow crossing of the asset and then will be steady increased after the crossing down to the specified burial depth again. The point at which the burial depth starts to decrease will be determined by assessment of how close to the crossed asset the burial tool can be safely operated.

## 5.3 Risk assessment and evaluation criteria

In this section, the risk acceptance criteria are discussed to allow implementation of the results of the probability of failure and consequence of failure assessment. The key output of this Risk register being a probabilistic assessment of the risk to the cable after burial options are completed to a specified depth.

**Figure 5-1** shows the risk matrix that we developed for this project. The generic meaning of the colour code is indicated in the legend below the figure. The principle works as follows: an event, such as a cable failure, has a probability of happening, and has a severity. The combination gives a location in the risk matrix and from that follows required next steps.

**Figure 5-1 Risk matrix**

| | | Likelihood | | | | |
|---|---|---|---|---|---|---|
| | | Rare (1) | Unlikely (2) | Possible (3) | Likely (4) | Almost cer |
| Severity | Insignificant (1) | 1 | 2 | 3 | 4 | 5 |
| | Minor (2) | 2 | 4 | 6 | 8 | 10 |
| | Moderate (3) | 3 | 6 | 9 | 12 | 15 |
| | Major (4) | 4 | 8 | 12 | 16 | 20 |
| | Severe (5) | 5 | 10 | 15 | 20 | 25 |

| | |
|---|---|
| | Broadly acceptable |
| | ALARP low |
| | ALARP medium |
| | ALARP high |
| | Intolerable |

The severities are defined for two different categories, cost and performance, as shown in **Figure 5-2**, while the definition of the likelihood is shown in **Figure 5-3**.

### Figure 5-2 Severity definition

| | | | Severity | | | | |
|---|---|---|---|---|---|---|---|
| | | | Insignificant (1) | Minor (2) | Moderate (3) | Major (4) | Severe (5) |
| Category | Cost | | Less than £50K | £50K - £500K | £500K - £10M | £10M - £200M | 10% CAPEX (>£200M) |
| | Performance | Availibility | Increased surveillance | Increased maintenance<br><br>Occasional duration limits (days) at peak capacity | One substantial outage + major intervention<br><br>Regular duration limits (hours) at peak capacity | Between one and eight 6-month outages.<br><br>Between 1 and 10% capacity loss | 10% availability drop through project lifetime (eg > eight 6 month outages in 40 years)<br><br>> 10% max capacity loss |
| | | Derating | Rare minor derating in a short period of time. | Routine minor derating for short period of time. | Minor derating for extended period. | Substantial derating for significant period of time. | Significant permanent derating. |

### Figure 5-3 Likelihood definition

| | Description | Probability of event in the lifetime (40 Years) | Probability of event per year range |
|---|---|---|---|
| Rare (1) | Although they are conceivable, not expected to occur. "Plausible but no known occurrences in industry." | 0% - 2% | 0.00% - 0.05% |
| Unlikely (2) | Incidents of this nature are uncommon but there is a chance that they may occur. | 2% - 10% | 0.05% - 0.26% |
| Possible (3) | This may happen. | 10% - 25% | 0.26% - 0.72% |
| Likely (4) | Likely to experience in the near-future. | 25% - 75% | 0.72% - 3.41% |
| Almost certain (5) | Will occur or is already occurring. "Probably within the life time of the project (i.e. several known occurrences per year)." | 75% - 100% | 3.41% - 100.00% |

## 5.4 Risk mitigation

There are several remedial methods of protection that can be considered to reduce the risk to the cable. The principal method of protection for most modern cable systems is burial into the seabed. In general, an activity must penetrate through the material above the burial to interact with the cable.

It may be noted that there are instances in which utility crossings or extremely hard soil conditions (e.g., bedrock) preclude burial or reduce the depth achievable. In such instances, there are three primary means of remedial protection which can be used:

- Concrete mattresses
- Rock placement
- Articulated shells

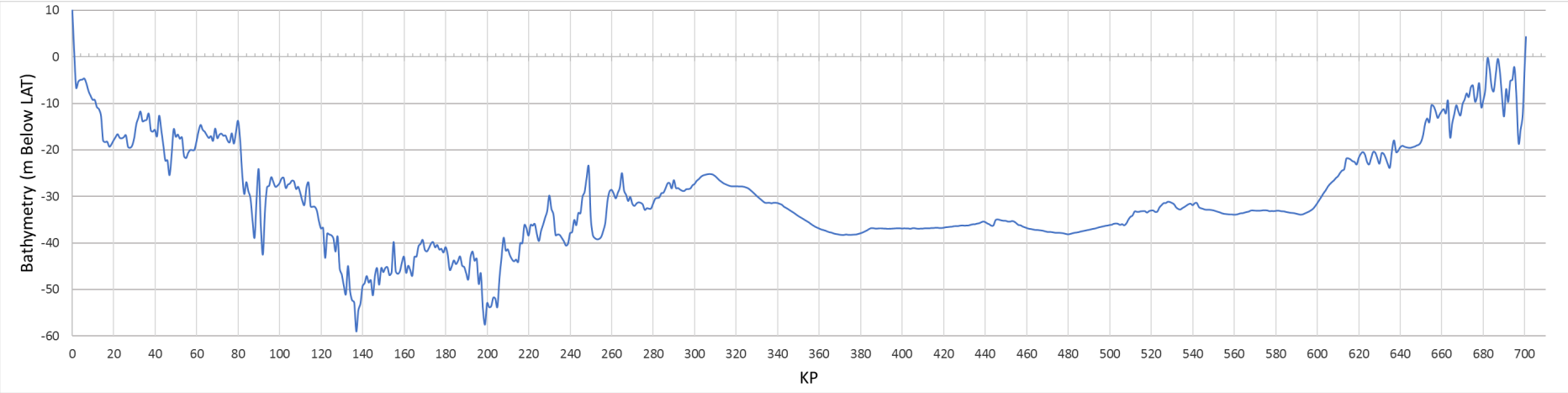
## 5.5 Final route segmentation

The final route segmentation used for the probabilistic assessment was divided according to changes in risk profile resulting from changes to:

- Anchoring risk (as determined by water depth and vessel traffic density)
- Fishing risk
- Changes in soil type or coastal process feature (e.g. presence of mobile sediment)

Bathymetric profile for the cable route is illustrated in **Figure 5-4** and the final cable segmentation for the NeuConnect cable route is presented in the Cable Burial Risk Assessment (CBRA) Summary Table (**Section 7**).

## Figure 5-4 Bathymetry profile overview – NeuConnect cable route



# 6. PROBABILISTIC RISK ASSESSMENT

This section describes the methodology and results used to assess the fishing and anchoring risk to the NeuConnect cable system.

All relevant factors are assessed for a cable route on a section by section basis.

## 6.1 Fishing risk assessment methodology

The entire route is within a water depth range in which mobile gear fishing could take place, thus we recommend the cable is given sufficient protection from potential fishing gear interaction along the entire route.

The Carbon Trust' guidance (ref 12) indicates that penetration of fishing gear into the seabed is limited to a maximum of 0.3 m penetration even in soft sediment based on previous literature research. Adding a 20% Factor of Safety (FoS) to account for measurement errors and deformation of soil beneath fishing gear gives a Recommended Minimum DOL of 0.36m for fishing risk alone.

In practice a DOL < 0.5m is not advisable due to the instability of some trenching tools at these depths. Therefore, TDOL would be ≥0.5m if based on fishing risk only.

## 6.2 Vessel and anchors bands

To facilitate easier analysis of vessel traffic the vessels were grouped into 11 deadweight tonnage bands. This allowed a set range of anchor sizes to be used to characterise those carried by shipping fleets in the tonnage bands. This is shown below in **Table 6-1**.

The vessels' DWT were calculated from the vessel length data supplied in the AIS data. The methodology to calculate the vessels' DWT is as follows:

1. Create a list of all unique vessels present in the AIS data set
2. For each vessel category (Cargo, Tanker, Passenger, etc..) research the DWT information online (https://www.marinetraffic.com/, ref 14) using vessel MMSI number for a sufficient set of vessels per category (30 to 50 vessels' DWT were researched online per vessel category).
3. For each vessel category, plot the DWT vs Length and derive a power trendline that fits the distribution of data points.

Based on the above process, the following empirical formulas were derived by Intertek and used to calculate the vessels' DWT:

$$DWT_{cargo} = 0.0322 \times L^{2.6119}$$

$$DWT_{Tanker} = 0.0008 \times L^{3.3662}$$

$$DWT_{Passenger}{}^{2} = 0.0834 \times L^{2.0656}$$

$$DWT_{Vessel<70m} = 0.0042 \times L^{2.9328}$$

Where:

DWT = Vessel deadweight tonnage (tonnes)

L = Vessel length (m)

[2] The relationship between DWT and vessel length would normally be expected to be closer to the cube of the length than the square. However, as demonstrated in **Appendix D**, the formula is a good fit to the data set obtained from research.

The plots from which the above empirical formulas have been derived are provided in Appendix D.

Once the vessel deadweight tonnage is known, the theoretical anchor mass can be estimated by the following empirical formula proposed by Luger as referenced in the Submarine Power Cables book by Worzyk, 2009 (this is recognised as an acceptable approach by the Carbon Trust's CTC-835):

$$y = 7 \times 10^{-13}x^3 - 6 \times 10^{-7}x^2 + 0.1635x + 2162.2$$

Where:

y = Anchor mass (kg)

x = Vessel deadweight tonnage (upper DWT boundary of each band) (tonnes)

The Carbon Trust's guidance (ref. 13) shows the Luger formula to be a good fit with the International Association of Classification Societies (IACS) rules for vessel DWT between 10,000 Tonnes and at least up to 100,000 tonnes. However, the Luger formula does not give a range of applicability for vessel DWT below 10,000 Tonnes. Thus, for the vessel Band with a DWT up to 10,000 (Bands A-D), Intertek has used the estimated anchor size from Table 9 of ref.13 and for Bands H-K Intertek has used a chart from a presentation given by Luger.

We then used an anchor catalogue (http://www.sotra.net/catalogue/2016/index.html, ref.16) to select realistic stockless anchor dimensions based on the theoretical anchor mass calculated. The "Hall" pattern anchor is used for Bands A-F and "Spek" is used for Bands G-K as these are typical stockless anchors in common use, especially on older vessels. These type of anchors have a relatively long fluke length for its unit mass and a large opening angle, which equates to more penetration for a given fluke length.

**Table 6-1 Vessel and anchor size bands**

| Band Name | Vessel DWT [Tonnes] | Estimated Anchor Mass [kg] | Selected Anchor Mass [kg] |
|---|---|---|---|
| Band A | 0 – 100 | 335* | 300 |
| Band B | 100 – 1,000 | 524 | 570 |
| Band C | 1,000 – 3,500 | 1,302 | 1,290 |
| Band D | 3,500 – 10,000 | 2,388 | 2,460 |
| Band E | 10,000 – 30,000 | 6,546 | 6,900 |
| Band F | 30,000 – 60,000 | 9,963 | 9,900 |
| Band G | 60,000 – 100,000 | 13,212 | 13,500 |
| Band H | 100,000 – 150,000 | 16,917 | 17,800 |
| Band I | 150,000 – 200,000 | 18,583 | 20,000 |
| Band J | 200,000 – 325,000 | 22,167 | 20,000 |
| Band K | 325,000 – 460,000 | 31,667 | 29,000 |

* The Carbon Trust Guideline (ref.13) specifies an estimated anchor size of 335kg for vessels of 500 Tonnes. As such, the selected anchor mass represents a conservative approach.

## 6.3 Probabilistic model

Intertek have developed a robust probabilistic assessment to determine the probability of interaction between an anchor and an installed cable based on local data for shipping traffic intensities, derived from historical AIS data. The model predicts the probability of a buried cable being struck because of

anchoring. The probability of cable-anchor interaction decreases as DOL increases below the maximum penetration limit of each individual class of external aggressor (i.e. fishing gear and anchors of various sizes)

The method takes account of:

- shipping traffic intensity by vessel size;
- probability of engine failure;
- probability of an emergency anchor deployment;
- dragging distance of an anchor; and
- protection factor provided by soils.

The assessment provides the annual probability of a failure, which can in turn be used to calculate the mean time to failure (MTTF) for anchoring. It should be recognised that it does not predict a failure time and that failure in Year 1 is equally as likely as in any subsequent year.

The probabilities are calculated for a range of vessel and anchor sizes. The anchor size for the upper end of the vessel tonnage band is used, as indicated in **Table 6-1**.

The probability of failure of the cable because of damage caused by emergency anchoring is calculated using the following equation:

$$P_{anchor\ damage\ per\ km} = K \times P_{loss} \times P_{deploy} \times P_{fa}$$

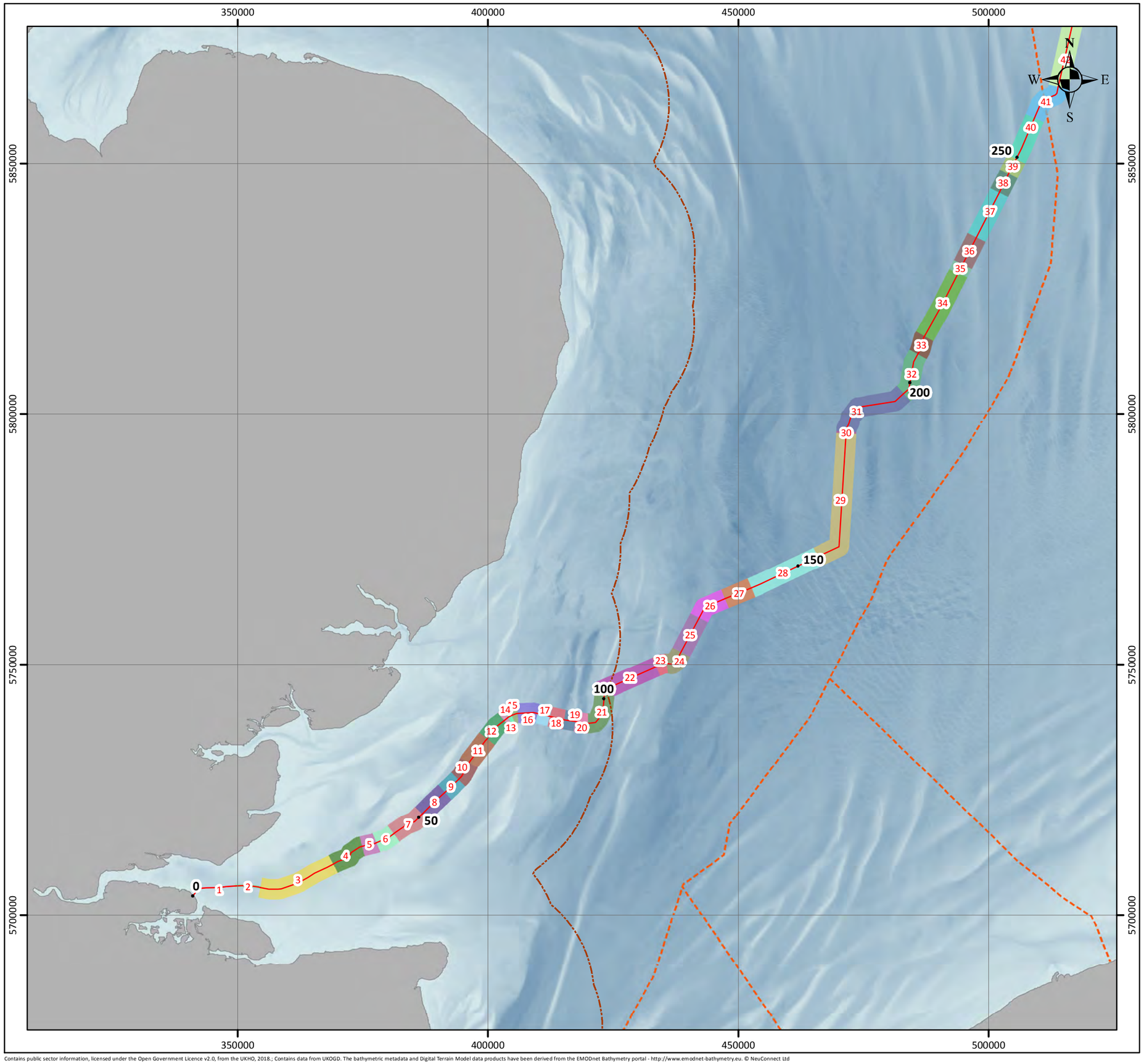
Where:

| | |
|---|---|
| $P_{anchor\ damage\ per\ km}$ | = probability of anchor damage on cable (-/year.km$^{-1}$) |
| K | = total number of ship hours in sample box (hr/year.km$^{-2}$) |
| $P_{loss}$ | = probability of engine failure (-/engine hour) |
| $P_{deploy}$ | = probability of anchor operation (-) |
| $P_{fa}$ | = protection factor (-) |

**Buffer Zones**

A vessel does not immediately drop an anchor when it encounters engine problems. It drifts for a period while trying to recover from the engine problem. If unrecoverable, it slows down to below approximately 1 knot before dropping an anchor. Anchoring at speeds above 1 knot will most likely lead to vessel structural damage. Defining a buffer which is greater than just directly adjacent to the cable route allows for a potential period spent drifting while trying to recover the engine and/or slow down sufficiently to allow anchoring to take place. This means that the Neuconnect cables will not just be affected by vessels that are directly above it.

The buffer for the cable route for each individual cable segments are defined as a 2km around each zone in open water and 100m and 200m for Zone 1 and Zone 2 respectively as these areas are severely constrained nearshore areas which are under the Port of London Authority's pilotage scheme (and thus highly controlled areas). **Figure 6-1** below show the cable route zones and associated buffers used.

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## NeuConnect CBRA

**Figure 6-1: Route Zones - KP 0 to 250**

**Legend**

- KP's
- NeuConnect Route
- UK 12nm Territorial Sea Limit
- Median Line

**ZONE**

1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42

**Bathymetry (Below LAT m)**

High : 100

NOTE: Not to be used for Navigation

| | |
|---|---|
| Date | Tuesday, March 19, 2019 17:02:54 |
| Projection | WGS_1984_UTM_Zone_31N |
| Spheroid | WGS_1984 |
| Datum | D_WGS_1984 |
| Data Source | UKHO, CDA, GEBCO, EMODNET, NEUCONNECT |
| File Reference | J:\P2131\Mxd\CBRA\ Fig_6_1_Route_Zones_KP0-250.mxd |
| Created By | Chris Goode |
| Reviewed By | Chris Carroll |
| Approved By | Alan Redman |

NeuConnect intertek

0 10 20 30 40 km

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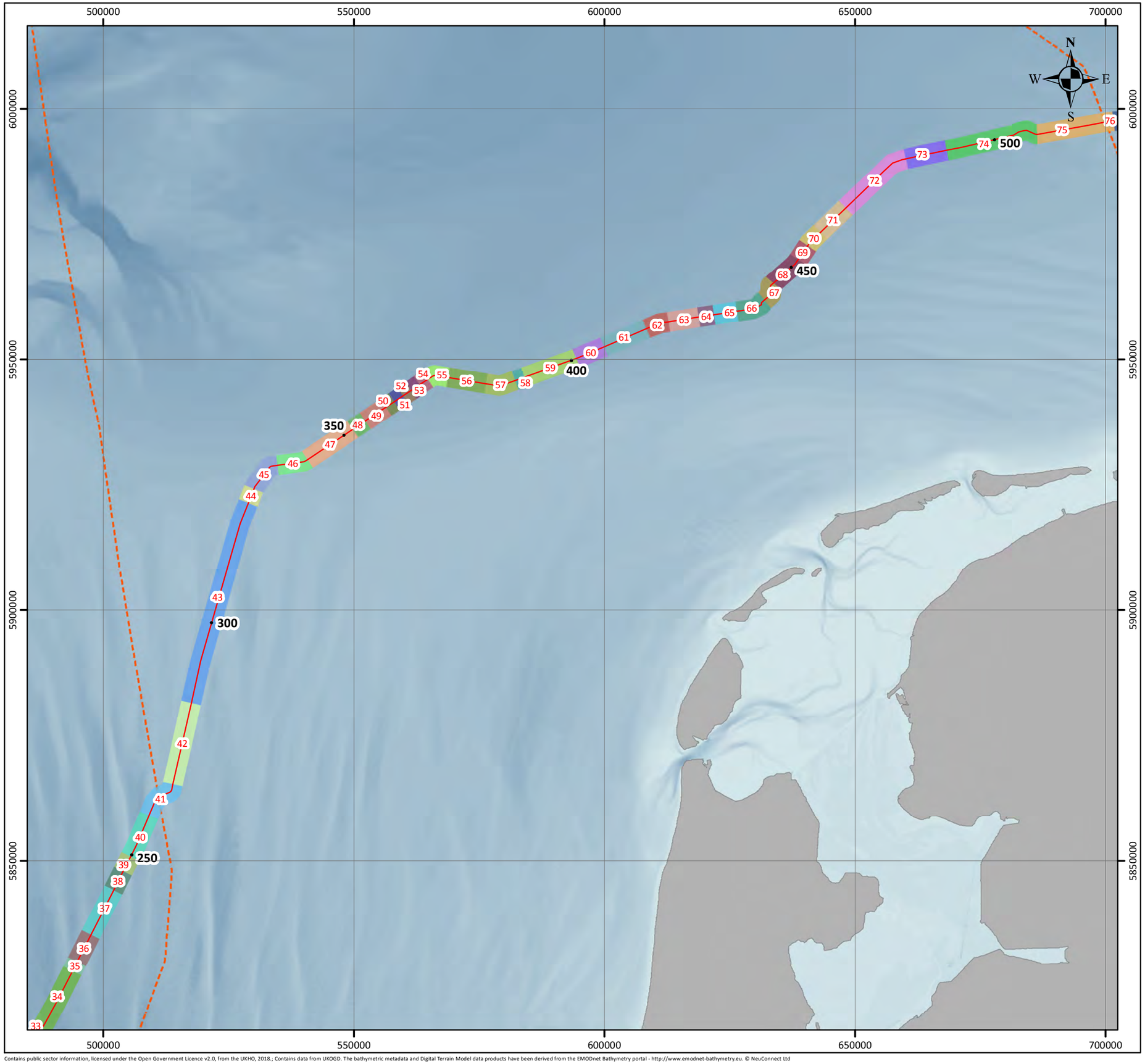


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## NeuConnect CBRA

**Figure 6-2: Route Zones - KP 250 to 500**

**Legend**

- KP's
- NeuConnect Route
- Median Line

**ZONE**

33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76

**Bathymetry (Below LAT m)**

High : 100

Low : 0

NOTE: Not to be used for Navigation

| | |
|---|---|
| Date | Tuesday, March 19, 2019 16:53:40 |
| Projection | WGS_1984_UTM_Zone_31N |
| Spheroid | WGS_1984 |
| Datum | D_WGS_1984 |
| Data Source | UKHO, CDA, GEBCO, EMODNET, NEUCONNECT |
| File Reference | J:\P2131\Mxd\CBRA\ Fig_6_3_Route_Zones_KP500-700.mxd |
| Created By | Chris Goode |
| Reviewed By | Chris Carroll |
| Approved By | Alan Redman |

NeuConnect intertek

0 10 20 30 40 km

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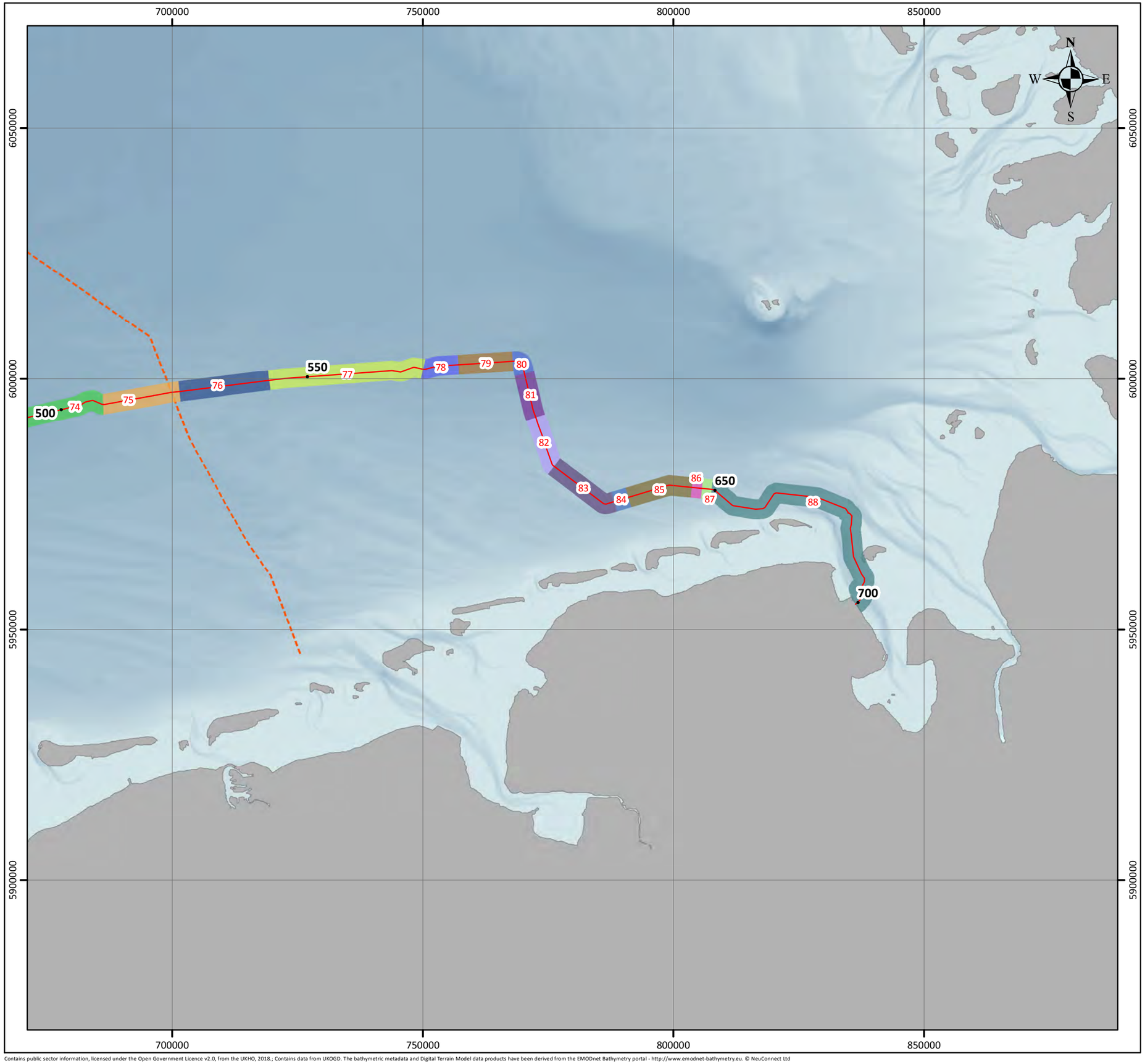


# NeuConnect CBRA

**Figure 6-3: Route Zones - KP 500 to 700.58**

**Legend**

- KP's
- NeuConnect Route

**ZONE**

- 74
- 75
- 76
- 77
- 78
- 79
- 80
- 81
- 82
- 83
- 84
- 85
- 86
- 87
- 88
- Median Line

**Bathymetry (Below LAT m)**

High : 100

Low : 0

NOTE: Not to be used for Navigation

| | |
|---|---|
| Date | Tuesday, March 19, 2019 17:01:18 |
| Projection | WGS_1984_UTM_Zone_31N |
| Spheroid | WGS_1984 |
| Datum | D_WGS_1984 |
| Data Source | UKHO, CDA, GEBCO, EMODNET, NEUCONNECT |
| File Reference | J:\P2131\Mxd\CBRA\ Fig_6_3_Route_Zones_KP500-700.mxd |
| Created By | Chris Goode |
| Reviewed By | Chris Carroll |
| Approved By | Alan Redman |

NeuConnect intertek

0 10 20 30 40 km

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**K - Total number of ship hours in sample box**

This can be obtained by interrogating the historical AIS data. The AIS data has readings every 5 minutes.

Each Zone of Interest is split into a grid of 1km square boxes and the vessel intensities for each vessel class is calculated for each 1km square box from the AIS data.

The cable route length is then divided into sample boxes. A sample box is defined as a 1 km long box, parallel with the route of width equal to the anchor drag distance (assumed to be 60m).

The vessel intensities used for each sample box are defined as the P90 vessel intensity for each vessel/anchor bands from the buffer (i.e. the vessel intensities for which 90% of the 1km square boxes have lower intensity per band) multiplied by the drag distance(m)/1000m.

**$P_{loss}$ - Probability of engine failure**

This is taken from a report compiled by DNV (Det Norske Veritas) for the Marine & Coastguard Agency (ref 26) for coastal waters around the UK. The value used in the calculations is 0.00015 / hr (equivalent to an average of 1.3 / yr of continuous vessel operation). In general, this figure is probably somewhat conservative.

**$P_{deploy}$ - Probability of anchor operation:**

The anchor will not be dropped in every emergency situation. This depends on the local geography, local bathymetry and the Vessel Master's knowledge.

**Table 6-2** provides the $P_{deploy}$ factors which have been applied in this CBRA.

## Table 6-2 Definition of $P_{deploy}$

| Scenario | $P_{deploy}$ | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Band A | Band B | Band C | Band D | Band E | Band F | Band G | Band H | Band I | Band J | Band K |
| Water depth between 0 and 30m (under pilotage[3]) | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 |
| Water depth between 0 and 30m | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 |
| Water depth between 30 and 50m | 0.05 | 0.05 | 0.05 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 |
| Water depth between 50 and 75m | 0 | 0 | 0.025 | 0.025 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 |

**$P_{fa}$ - Protection factor**

This considers the protection offered by soil cover. $P_{fa}$ is a combination between the anchor penetration depth in different soil condition and the actual cable DOL and is either 0 or 1. If the cable DOL is equal to or greater than the maximum anchor penetration depth (including Factor of Safety) for a given anchor size then $P_{fa}$ equals to 0 for that anchor size. Conversely, if cable DOL is less than

[3] Zone 1 and Zone 2 are defined as under pilotage.

the anchor penetration depth (including the Factor of Safety) for a given anchor size then $P_{fa}$ equals to 1 for that anchor size.

Anchor penetration depths for SANDS and CLAYS (or SAND/CLAY mixes) are typically calculated by taking the sine of the fluke opening angle and multiplying by the fluke length (for Hall anchors this is 45°). This is due to observations that anchor shanks are typically supported by the soil as they are dragged over it. However, EXTREMELY LOW STRENGTH SILTS and CLAYS (i.e. with shear strength <10kPa) are unable to support the shank and as such penetration can be significantly deeper – 3 times the sine 45° of fluke length is typically used in the industry and is accepted for this study as well. In addition, industry understanding is that HIGH STRENGTH CLAYS (≥100kPa) prevent flukes penetrating at all so it would be valid to only specify a nominal penetration depth in high strength clays present on the NeuConnect route. However, taking a conservative approach and in recognition that MMT has defined high strength clay as 75kPa (rather than 100kPa), we have defined anchor penetration depths as 0.5 times sine 45° of fluke length for areas designated as HIGH STRENGTH CLAY.

As above, the industry typically applies Sin 45° of fluke length to calculate anchor penetration in SANDS. However, trials in the German Bight in 2013 (ref 23) suggest that in SANDS anchor penetration are less than previously thought. This report concluded that a 11.5t Hall anchor would have a maximum depth of penetration of 1m in VERY LOOSE SAND, 0.79m in LOOSE SAND and 0.40m in a MEDIUM DENSE SAND which are less than the theoretical value of 1.17m calculated by Sin 45° of fluke length. In addition, the report indicates extrapolation of results to anchors of different size using a scaling factor is valid.

Thus, for each anchor size defined in **Table 6-1**, Intertek calculated the theoretical anchor penetration depth and used the results outlined in the German Bight Anchor Penetration Trials report (ref 23) to scale these anchor penetration depths to more realistic values for areas of SAND sediment type. Areas of SAND sediment type which were dense or very dense were considered as medium dense for the purposes of calculating anchor penetration depths.

A Factor of Safety of 20% has been applied on the anchor penetration depths to consider:

- uncertainty in anchor sizing;
- uncertainty of soil type; and
- deformation of the soil beneath the maximum penetration depth.

In addition, all final maximum penetration depths have been rounded up to the closet 5cm to avoid implying a level of accuracy which is not justified. Results of anchor penetration calculations by soil category, without and with the Factor of Safety are provided in Table 6-3 and 6-4 respectively.

In addition (and as can be expected), there are a number of zones in which there is a surficial sediment layer which has soil properties which vary significantly from the underlying layers. To account for this, we have assigned the zone to the categorisation associated with the underlying layer and added an offset value representative of the thickness of the surficial sediment layer. The offset layers are then added onto the calculated anchor penetration depths to give augmented anchor penetration depths for the zone. This is a conservative approach as it assumes the surficial layer provides zero protection. While conservative, this method is justified as there are zones which have surficial sediment layers composed of EXTREMELY LOW STRENGTH SILTS and CLAYS which do not support the shank of an anchor.

### Table 6-3 Anchor Penetration Depths by Soil Category

| Band Name | Selected Anchor mass | Theoretical value for 100% anchor penetration | Anchor Penetration by Soil Category | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Very Loose Sand | Loose Sand | Medium Dense Sand | Extremely Low Strength Clay (<10 kPa) | Sand and Clay (≥10 to <100 kPa) & Clay (≥10 to <100 kPa) | High Strength Clay (≥100 kPa) |
| [-] | [kg] | [m] | [m] | [m] | [m] | [m] | [m] | [m] |
| Ref. Anchor (German Bight Trials) | 11,500 | 1.17 | 1.00 | 0.79 | 0.40 | 3.52 | 1.17 | 0.59 |
| Band A | 300 | 0.35 | 0.30 | 0.24 | 0.12 | 1.05 | 0.35 | 0.18 |
| Band B | 570 | 0.44 | 0.38 | 0.30 | 0.15 | 1.33 | 0.44 | 0.22 |
| Band C | 1,290 | 0.57 | 0.49 | 0.39 | 0.20 | 1.72 | 0.57 | 0.29 |
| Band D | 2,460 | 0.71 | 0.61 | 0.48 | 0.24 | 2.14 | 0.71 | 0.36 |
| Band E | 6,900 | 1.00 | 0.85 | 0.68 | 0.34 | 3.01 | 1.00 | 0.50 |
| Band F | 10,500 | 1.03 | 0.88 | 0.69 | 0.35 | 3.10 | 1.03 | 0.52 |
| Band G | 13,500 | 1.12 | 0.95 | 0.75 | 0.38 | 3.35 | 1.12 | 0.56 |
| Band H | 17,800 | 1.25 | 1.06 | 0.84 | 0.43 | 3.75 | 1.25 | 0.63 |
| Band I | 20,000 | 1.28 | 1.09 | 0.86 | 0.44 | 3.84 | 1.28 | 0.64 |
| Band J | 20,000 | 1.28 | 1.09 | 0.86 | 0.44 | 3.84 | 1.28 | 0.64 |
| Band K | 29,000 | 1.46 | 1.24 | 0.98 | 0.50 | 4.37 | 1.46 | 0.73 |

### Table 6-4 Anchor Penetration Depths by Soil Category incl. Factor of Safety (FoS)

| Band Name | Selected Anchor mass | Theoretical value for 100% anchor penetration | Anchor Penetration by Soil Category incl. 20% FoS & Rounded up to nearest 5cm | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Very Loose Sand | Loose Sand | Medium Dense Sand | Extremely Low Strength Clay (<10 kPa) | Sand and Clay (≥10 to <100 kPa) & Clay (≥10 to <100 kPa) | High Strength Clay (≥100 kPa) |
| [-] | [kg] | [m] | [m] | [m] | [m] | [m] | [m] | [m] |
| Ref. Anchor (German Bight Trials) | 11,500 | 1.17 | 1.20 | 0.95 | 0.50 | 4.25 | 1.45 | 0.75 |
| Band A | 300 | 0.35 | 0.40 | 0.30 | 0.15 | 1.30 | 0.45 | 0.25 |
| Band B | 570 | 0.44 | 0.50 | 0.40 | 0.20 | 1.60 | 0.55 | 0.30 |
| Band C | 1,290 | 0.57 | 0.60 | 0.50 | 0.25 | 2.10 | 0.70 | 0.35 |
| Band D | 2,460 | 0.71 | 0.75 | 0.60 | 0.30 | 2.60 | 0.90 | 0.45 |
| Band E | 6,900 | 1.00 | 1.05 | 0.85 | 0.45 | 3.65 | 1.25 | 0.65 |
| Band F | 10,500 | 1.03 | 1.10 | 0.85 | 0.45 | 3.75 | 1.25 | 0.65 |
| Band G | 13,500 | 1.12 | 1.15 | 0.95 | 0.50 | 4.05 | 1.35 | 0.70 |
| Band H | 17,800 | 1.25 | 1.30 | 1.05 | 0.55 | 4.55 | 1.55 | 0.80 |
| Band I | 20,000 | 1.28 | 1.35 | 1.05 | 0.55 | 4.65 | 1.55 | 0.80 |
| Band J | 20,000 | 1.28 | 1.35 | 1.05 | 0.55 | 4.65 | 1.55 | 0.80 |
| Band K | 29,000 | 1.46 | 1.50 | 1.20 | 0.60 | 5.25 | 1.75 | 0.90 |

## 6.4 Identification of the acceptable risk

The calculation for probability of a cable strike for the entire cable system is given by:

$$P_{anchor\ damage,total\ system} = \sum P_{anchor\ damage\ per\ km}$$

Where:

$P_{anchor\ damage,total\ system}$ = probability of anchor damage for the entire cable route (-/year)

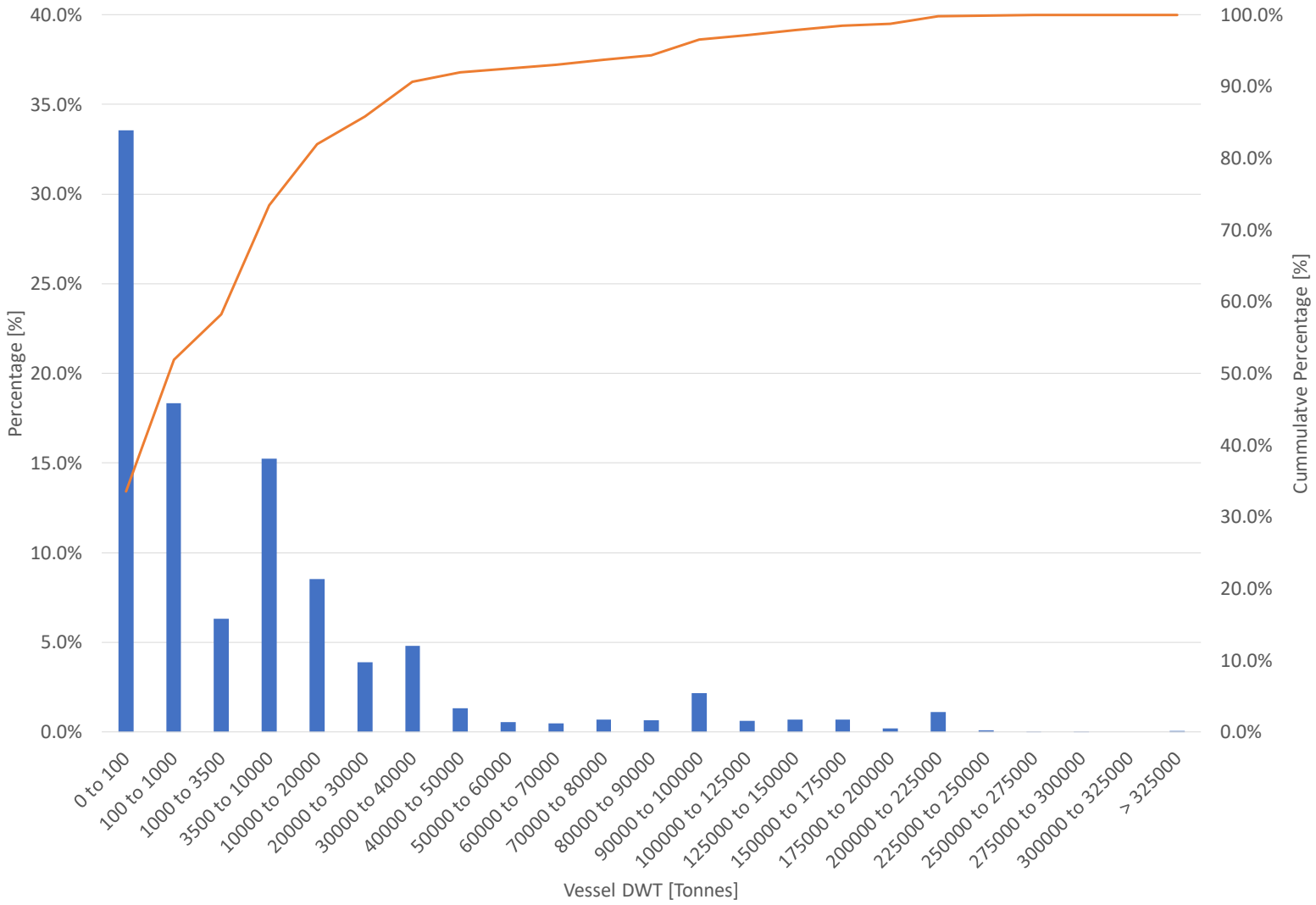
As recommended by the Carbon Trust's guideline (ref 22), Intertek used an iterative approach to identify a burial depth which results in a "target" residual risk to overall cable system.

The iterative step can be described as follows:

1. Calculate the value of $P_{anchor\ damage,total\ system}$ for all vessels with a surface-laid cable
2. Identify the value of $P_{anchor\ damage,total\ system}$ that would be acceptable to the stakeholders
3. Goal-seek RMDOL which achieves this tolerable level
4. If the RMDOL is considered impractical the acceptable level of risk should be re-considered.

The probabilistic assessment calculates the annual failure probability of 9% for the entire NeuConnect route (based on anchor risk alone) if surface laid. This value equates to a return period of 11 years and a failure probability over the (40 year) lifetime of 97.75%. This is clearly not an acceptable level of risk. **Figure 6.4.1** shows vessel size distribution by DWT. Naturally, vessel densities are overwhelmingly composed of smaller vessels, so risk reduces significantly as DOL increases over and above the penetration depths of anchor sizes associated smaller vessels.

### 6.4.1 Vessel size distribution



### 6.4.2 Results for Recommended Minimum DOL

A RMDOL was derived on a zone basis to remove the risk from anchoring from the selected vessel band in order to achieve an overall acceptable risk. The tables below present the RMDOL and associated annual failure probability for the following 6 scenarios:

1. Scenario 1: Protection against vessels in Band A
2. Scenario 2: Protection against vessels in Bands A to B
3. Scenario 3: Protection against vessels in Bands A to C
4. Scenario 4: Protection against vessels in Bands A to D
5. Scenario 5: Protection against vessels in Bands A to E
6. Scenario 6: Protection against vessels in Bands A to F
7. Scenario 7: Protection against vessels in Bands A to G
8. Scenario 8: Protection against vessels in Band A to H
9. Scenario 9: Protection against vessels in Bands A to I
10. Scenario 10: Protection against vessels in Bands A to J
11. Scenario 11: Protection against vessels in Bands A to K
12. Scenario 12: Selected Protection Section by Section (RMDOL)

Anchoring risk exceeds fishing risk in in all zones of the route and thus determines RMDOL (except for zones in Germany where the legislative DOL requirements exceed the minimum DOL calculated by the probabilistic assessment). RMDOL has been selected for each individual zone in order that the overall risk to the cable over the project lifetime is reduced to ALARP. RMODOL varies from 0.55-2.00m along the length of the route.

The full results of the above assessment by zone are provided in **Appendix E**[4]. As can be seen if RMDOL is achieved during installation (and maintained throughout the project life) then the NeuConnect cable would have an annual failure probability of 9.00E-04. This equates to a return period of 1111.27 years and a failure probability over the (40 year) lifetime of 3.54%.

### 6.4.3 Results for Target DoL

TDOL is determined as what can reasonably be added to RMDOL without incurring a step change in costs and which represents a practical target for burial tools on the market.

TDOL has been set at 1.5m for the vast majority of the route and varies up to a maximum TDOL of 2m in some zones due either to anchor risk or legislative requirements. The DOL specification by cable route zone are provided in **Appendix E**. As can be seen if TDOL is achieved during installation (and maintained throughout the project life) then the NeuConnect cable would have an annual failure probability of 5.37E-04. This equates to a return period of 1863.84 years and a failure probability over the (40 year) lifetime of 2.12% .

[4] Note, the failure probability is as calculated for identified hazards only and is based on the assumptions detailed in this report. It does not account for manufacturing defects or latent damage to the asset incurred during installation. Furthermore, the values provided are predicated on DOL being maintained throughout the lifetime of the asset. A robust condition survey regime is required during the asset's operational lifetime to ensure protection levels remain sufficient.

# 7. CBRA ASSESSMENT

| Zones | | | | Water Depth (m below LAT) | | | Geophysical/Geotechnical Data | | | | | | | Shipping Data (Anchoring Assessment) | | | | Fishing Data | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No. | Start KP | End KP | Length (km) | MAX | MIN | Mean | Survey Block | Dominant Sediment Type | Predominant Density (0-2m where applicable) | Predominant Shear Strength (0-2m where applicable) | Mobile Features (where applicable) | Categorisation for Anchor Penetration Calculation | Offset (m) | Risk from Anchoring? | Shipping Buffer Size (m) | Observation (WD) | Recommended DoL for Protection against Anchor Strike (m) | Presence of Fishing | Recommended DoL for Protection against Fishing Gear (including 20% Factor of Safety) (m) | Territorial minimum DoL Requirement (m) | Recommended Minimum Depth of Lowering (m) | Target Depth of Lowering (m) |
| 1 | 0.000 | 9.214 | 9.214 | -8.680 | 12.130 | -4.230 | Block 01 | Very Low Strength Clay with Extremely Low Veneer (0.4m) | | Extremely Low to Low | | SAND and CLAY (≥10 to <100 kPa) & CLAY (≥10 to <100 kPa) | 0.4 | Yes | 100 | 0m to 30m (Under Pilotage) | 1.30 | Yes | 0.36 | N/A | 1.30 | 1.70 |
| 2 | 9.214 | 14.300 | 5.086 | -13.950 | -8.080 | -10.440 | Block 01 | Low Strength Clay with Veneer of Extremely Low Strength Clay (0.5m) | | Low | Ripples | SAND and CLAY (≥10 to <100 kPa) & CLAY (≥10 to <100 kPa) | 0.5 | Yes | 250 | 0m to 30m (Under Pilotage) | 1.85 | Yes | 0.36 | N/A | 1.85 | 2.00 |
| 3 | 14.300 | 29.999 | 15.699 | -19.940 | -13.890 | -17.981 | Block 01 | Low Strength Clay/Loose Sand | Loose | Low | Ripples | SAND and CLAY (≥10 to <100 kPa) & CLAY (≥10 to <100 kPa) | | Yes | 2000 | 0m to 30m | 1.55 | Yes | 0.36 | N/A | 1.55 | 1.70 |
| 4 | 29.999 | 37.066 | 7.067 | -17.410 | -11.010 | -13.473 | Block 01 | Medium Dense Sand | Medium Dense | | Ripples & Megaripples | MEDIUM DENSE SAND | 0.15 | Yes | 2000 | 0m to 30m | 0.70 | Yes | 0.36 | N/A | 0.70 | 1.50 |
| 5 | 37.066 | 39.997 | 2.931 | -16.650 | -12.180 | -15.196 | Block 01 | Loose Sand | Loose | | Ripples | LOOSE SAND | | Yes | 2000 | 0m to 30m | 1.05 | Yes | 0.36 | N/A | 1.05 | 1.50 |
| 6 | 39.997 | 43.998 | 4.001 | -18.920 | -11.750 | -15.360 | Block 01 | Medium Dense Sand | Medium Dense | | Ripples | MEDIUM DENSE SAND | 0.15 | Yes | 2000 | 0m to 30m | 0.70 | Yes | 0.36 | N/A | 0.70 | 1.50 |
| 7 | 43.998 | 50.972 | 6.974 | -26.590 | -15.310 | -20.174 | Block 01 - 02 | Loose Sand | Loose | | Ripples | LOOSE SAND | | Yes | 2000 | 0m to 30m | 1.05 | Yes | 0.36 | N/A | 1.05 | 1.50 |
| 8 | 50.972 | 57.239 | 6.267 | -22.300 | -16.410 | -19.348 | Block 02 | Dense Sand | Dense | | Ripples | MEDIUM DENSE SAND | 0.15 | Yes | 2000 | 0m to 30m | 0.70 | Yes | 0.36 | N/A | 0.70 | 1.50 |
| 9 | 57.239 | 60.969 | 3.730 | -20.650 | -15.740 | -19.055 | Block 02 | Loose Sand | Loose | | Ripples | LOOSE SAND | | Yes | 2000 | 0m to 30m | 1.05 | Yes | 0.36 | N/A | 1.05 | 1.50 |
| 10 | 60.969 | 64.970 | 4.001 | -16.910 | -14.050 | -15.547 | Block 02 | Medium Dense Sand | Medium Dense | | Ripples | MEDIUM DENSE SAND | 0.15 | Yes | 2000 | 0m to 30m | 0.70 | Yes | 0.36 | N/A | 0.70 | 1.50 |
| 11 | 64.970 | 70.969 | 5.999 | -19.290 | -14.950 | -17.151 | Block 02 | Dense Sand | Dense | | Ripples | MEDIUM DENSE SAND | 0.15 | Yes | 2000 | 0m to 30m | 0.70 | Yes | 0.36 | N/A | 0.70 | 1.50 |
| 12 | 70.969 | 75.968 | 4.999 | -19.330 | -16.160 | -17.280 | Block 02 | High Strength Clay | | High to Very High | | HIGH STRENGTH CLAY (≥100 kPa) | | Yes | 2000 | 0m to 30m | 0.80 | Yes | 0.36 | N/A | 0.80 | 1.50 |
| 13 | 75.968 | 76.963 | 0.995 | -18.460 | -15.910 | -17.055 | Block 02 | Sand | No Information | | Ripples | VERY LOOSE SAND | | Yes | 2000 | 0m to 30m | 1.15 | Yes | 0.36 | N/A | 1.15 | 1.50 |
| 14 | 76.963 | 77.803 | 0.840 | -21.400 | -16.350 | -18.676 | Block 02 | Very Low Strength Clay | | Very Low | Ripples | SAND and CLAY (≥10 to <100 kPa) & CLAY (≥10 to <100 kPa) | | Yes | 2000 | 0m to 30m | 1.25 | Yes | 0.36 | N/A | 1.25 | 1.50 |
| 15 | 77.803 | 79.095 | 1.292 | -20.370 | -12.280 | -18.037 | Block 02 | Sand | No Information | | Ripples | VERY LOOSE SAND | | Yes | 2000 | 0m to 30m | 1.15 | Yes | 0.36 | N/A | 1.15 | 1.50 |
| 16 | 79.095 | 83.069 | 3.974 | -29.980 | -12.500 | -20.109 | Block 02 | Dense Sand | Dense | | Ripples & Sand Waves | MEDIUM DENSE SAND | 0.15 | Yes | 2000 | 0m to 30m | 0.60 | Yes | 0.36 | N/A | 0.60 | 1.50 |
| 17 | 83.069 | 85.595 | 2.526 | -31.360 | -24.170 | -28.730 | Block 02 | High Strength Clay | | Very High | | HIGH STRENGTH CLAY (≥100 kPa) | | Yes | 2000 | 0m to 30m | 0.80 | Yes | 0.36 | N/A | 0.80 | 1.50 |
| 18 | 85.595 | 88.550 | 2.955 | -39.990 | -28.720 | -34.093 | Block 02 | High Strength Clay | | Very High | Ripples | HIGH STRENGTH CLAY (≥100 kPa) | | Yes | 2000 | 0m to 30m | 0.80 | Yes | 0.36 | N/A | 0.80 | 1.50 |
| 19 | 88.550 | 90.796 | 2.246 | -31.530 | -23.060 | -26.403 | Block 02 | High Strength Clay | | Very High | Ripples | HIGH STRENGTH CLAY (≥100 kPa) | | Yes | 2000 | 0m to 30m | 0.80 | Yes | 0.36 | N/A | 0.80 | 1.50 |
| 20 | 90.796 | 93.322 | 2.526 | -42.650 | -28.830 | -37.800 | Block 02 | High Strength Clay | | Very High | Ripples | HIGH STRENGTH CLAY (≥100 kPa) | | Yes | 2000 | 0m to 30m | 0.80 | Yes | 0.36 | N/A | 0.80 | 1.50 |
| 21 | 93.322 | 101.884 | 8.562 | -28.850 | -25.100 | -27.109 | Block 02 - 03 | High Strength Clay | | Very High | Ripples | HIGH STRENGTH CLAY (≥100 kPa) | | Yes | 2000 | 0m to 30m | 0.80 | Yes | 0.36 | N/A | 0.80 | 1.50 |
| 22 | 101.884 | 113.069 | 11.185 | -32.740 | -25.130 | -28.295 | Block 03 | High Strength Clay | | Very High | Ripples, Megaripples & Sand Waves | HIGH STRENGTH CLAY (≥100 kPa) | | Yes | 2000 | 0m to 30m | 0.80 | Yes | 0.36 | N/A | 0.80 | 1.50 |
| 23 | 113.069 | 115.299 | 2.230 | -33.350 | -21.690 | -29.116 | Block 03 | Medium Dense Sand | Medium Dense | | Ripples, Megaripples & Sand Waves | MEDIUM DENSE SAND | 0.15 | Yes | 2000 | 0m to 30m | 0.70 | Yes | 0.36 | N/A | 0.70 | 1.50 |
| 24 | 115.299 | 119.533 | 4.234 | -39.430 | -28.950 | -33.404 | Block 03 | High Strength Clay | | Very High | Ripples | HIGH STRENGTH CLAY (≥100 kPa) | | Yes | 2000 | 30m to 50m | 0.80 | Yes | 0.36 | N/A | 0.80 | 1.50 |
| 25 | 119.533 | 127.273 | 7.740 | -45.930 | -34.610 | -38.861 | Block 03 | High Strength Clay | | Very High | Ripples & Megaripples | HIGH STRENGTH CLAY (≥100 kPa) | | Yes | 2000 | 30m to 50m | 0.70 | Yes | 0.36 | N/A | 0.70 | 1.50 |
| 26 | 127.273 | 134.000 | 6.727 | -52.470 | -37.660 | -45.623 | Block 03 | Dense Sand with Loose Sand Veneer (0.3m) | Dense | | Ripples, Megaripples & Sand Waves | MEDIUM DENSE SAND | 0.3 | Yes | 2000 | 30m to 50m | 0.85 | Yes | 0.36 | N/A | 0.85 | 1.50 |
| 27 | 134.000 | 139.716 | 5.716 | -63.470 | -45.010 | -54.392 | Block 03 | Dense Sand with Loose Sand Veneer (0.3m) | Dense | | Ripples, Megaripples & Sand Waves | MEDIUM DENSE SAND | 0.3 | Yes | 2000 | 50m to 75m | 0.80 | Yes | 0.36 | N/A | 0.80 | 1.50 |
| 28 | 139.716 | 154.341 | 14.625 | -55.550 | -38.540 | -47.130 | Block 03 | Dense Sand with Loose Sand Veneer (0.3m) | Dense | | Ripples, Megaripples & Sand Waves | MEDIUM DENSE SAND | 0.3 | Yes | 2000 | 30m to 50m | 0.85 | Yes | 0.36 | N/A | 0.85 | 1.50 |
| 29 | 154.341 | 181.674 | 27.333 | -48.610 | -34.620 | -42.603 | Block 03 - 04 | Dense Sand with Loose Sand Veneer (0.3m) | Dense | | Ripples, Megaripples & Sand Waves | MEDIUM DENSE SAND | 0.3 | Yes | 2000 | 30m to 50m | 0.85 | Yes | 0.36 | N/A | 0.85 | 1.50 |
| 30 | 181.674 | 182.027 | 0.353 | -46.160 | -40.090 | -44.432 | Block 04 | Very Loose Sand over Medium Clay | Very Loose | Medium | Ripples, Megaripples & Sand Waves | VERY LOOSE SAND | | Yes | 2000 | 30m to 50m | 1.05 | Yes | 0.36 | N/A | 1.05 | 1.50 |
| 31 | 182.027 | 197.298 | 15.271 | -50.410 | -37.050 | -44.376 | Block 04 | Medium Dense Sand with Loose Sand Veneer (0.3m) | Medium Dense | | Ripples, Megaripples & Sand Waves | MEDIUM DENSE SAND | 0.3 | Yes | 2000 | 30m to 50m | 0.85 | Yes | 0.36 | N/A | 0.85 | 1.50 |
| 32 | 197.298 | 205.967 | 8.669 | -57.880 | -46.310 | -52.575 | Block 04 - 05 | Medium Dense Sand with Loose Sand Veneer (0.3m) | Medium Dense | | Ripples, Megaripples & Sand Waves | MEDIUM DENSE SAND | 0.3 | Yes | 2000 | 50m to 75m | 0.80 | Yes | 0.36 | N/A | 0.80 | 1.50 |
| 33 | 205.967 | 209.792 | 3.825 | -47.950 | -37.890 | -41.924 | Block 05 | Medium Dense Sand with Loose Sand Veneer (0.3m) | Medium Dense | | Ripples, Megaripples & Sand Waves | MEDIUM DENSE SAND | 0.3 | Yes | 2000 | 30m to 50m | 0.80 | Yes | 0.36 | N/A | 0.80 | 1.50 |
| 34 | 209.792 | 224.069 | 14.277 | -45.110 | -31.780 | -40.060 | Block 05 | Medium Dense Sand with Loose Sand Veneer (0.3m) | Medium Dense | | Ripples, Megaripples & Sand Waves | MEDIUM DENSE SAND | 0.3 | Yes | 2000 | 30m to 50m | 0.85 | Yes | 0.36 | N/A | 0.85 | 1.50 |
| 35 | 224.069 | 226.072 | 2.003 | -40.830 | -36.380 | -38.911 | Block 05 | Medium Strength Clay | | Medium to high | Ripples, Megaripples & Sand Waves | SAND and CLAY (≥10 to <100 kPa) & CLAY (≥10 to <100 kPa) | | Yes | 2000 | 30m to 50m | 1.25 | Yes | 0.36 | N/A | 1.25 | 1.50 |
| 36 | 226.072 | 232.074 | 6.002 | -37.350 | -25.610 | -33.242 | Block 05 | Dense Sand with Loose Sand Veneer (0.3m) | Dense | | Ripples, Megaripples & Sand Waves | MEDIUM DENSE SAND | 0.3 | Yes | 2000 | 30m to 50m | 0.80 | Yes | 0.36 | N/A | 0.80 | 1.50 |
| 37 | 232.074 | 242.071 | 9.997 | -40.790 | -32.680 | -38.411 | Block 05 | Medium Dense Sand with Loose Sand Veneer (0.3m) over High Strength Clay | Medium Dense | High to Very High | Ripples, Megaripples & Sand Waves | MEDIUM DENSE SAND | 0.3 | Yes | 2000 | 30m to 50m | 0.80 | Yes | 0.36 | N/A | 0.80 | 1.50 |
| 38 | 242.071 | 246.290 | 4.219 | -37.810 | -29.430 | -34.603 | Block 05 | Medium Dense Sand with Loose Sand Veneer (0.3m) | Medium Dense | | Ripples, Megaripples & Sand Waves | MEDIUM DENSE SAND | 0.3 | Yes | 2000 | 30m to 50m | 0.80 | Yes | 0.36 | N/A | 0.80 | 1.50 |
| 39 | 246.290 | 249.628 | 3.338 | -31.610 | -23.030 | -26.815 | Block 05 | Medium Dense Sand with Loose Sand Veneer (0.3m) | Medium Dense | | Ripples, Megaripples & Sand Waves | MEDIUM DENSE SAND | 0.3 | Yes | 2000 | 0m to 30m | 0.80 | Yes | 0.36 | N/A | 0.80 | 1.50 |
| 40 | 249.628 | 258.602 | 8.974 | -39.300 | -28.710 | -36.749 | Block 05 - 06 | Medium Dense Sand with Loose Sand Veneer (0.3m) | Medium Dense | | Ripples, Megaripples & Sand Waves | MEDIUM DENSE SAND | 0.3 | Yes | 2000 | 0m to 30m | 0.80 | Yes | 0.36 | N/A | 0.80 | 1.50 |
| 41 | 258.602 | 266.887 | 8.285 | -30.630 | -24.870 | -28.716 | Block 06 | Medium Dense Sand with Loose Sand Veneer (0.3m) | Medium Dense | | Ripples, Megaripples & Sand Waves | MEDIUM DENSE SAND | 0.3 | Yes | 2000 | 0m to 30m | 0.80 | Yes | 0.36 | N/A | 0.80 | 1.50 |
| 42 | 266.887 | 283.528 | 16.641 | -33.150 | -28.410 | -31.378 | Block 06 | Medium Dense Sand with Loose Sand Veneer (0.3m) | Medium Dense | | Ripples, Megaripples & Sand Waves | MEDIUM DENSE SAND | 0.3 | Yes | 2000 | 30m to 50m | 0.75 | Yes | 0.36 | N/A | 0.75 | 1.50 |
| 43 | 283.528 | 325.070 | 41.542 | -29.840 | -25.110 | -27.333 | Block 06 - 07 | Medium Dense Sand with Loose Sand Veneer (0.3m) | Medium Dense | | Ripples, Megaripples & Sand Waves | MEDIUM DENSE SAND | 0.3 | Yes | 2000 | 0m to 30m | 0.75 | Yes | 0.36 | N/A | 0.75 | 1.50 |
| 44 | 325.070 | 328.070 | 3.000 | -29.220 | -28.060 | -28.522 | Block 07 | Very Loose Sand | Very Loose | | | VERY LOOSE SAND | | Yes | 2000 | 0m to 30m | 0.75 | Yes | 0.36 | N/A | 0.75 | 1.50 |
| 45 | 328.070 | 335.083 | 7.013 | -31.430 | -29.080 | -30.436 | Block 07 | Very Low Strength Silty Sand with Extremely Low Strength Veneer (0.3m) | | Very Low | | SAND and CLAY (≥10 to <100 kPa) & CLAY (≥10 to <100 kPa) | 0.3 | Yes | 2000 | 30m to 50m | 0.85 | Yes | 0.36 | N/A | 0.85 | 1.50 |
| 46 | 335.083 | 341.250 | 6.167 | -31.630 | -31.270 | -31.362 | Block 07 | Very Low Strength Silty Sand with Extremely Low Strength Veneer (0.3m) | | Very Low | | SAND and CLAY (≥10 to <100 kPa) & CLAY (≥10 to <100 kPa) | 0.3 | Yes | 2000 | 30m to 50m | 1.55 | Yes | 0.36 | N/A | 1.55 | 1.70 |
| 47 | 341.250 | 352.068 | 10.818 | -34.730 | -31.560 | -33.176 | Block 07 - 08 | Very Low with Extremely Low Veneer (0.4m) | | Very Low | | SAND and CLAY (≥10 to <100 kPa) & CLAY (≥10 to <100 kPa) | 0.4 | Yes | 2000 | 30m to 50m | 0.95 | Yes | 0.36 | N/A | 0.95 | 1.50 |
| 48 | 352.068 | 355.069 | 3.001 | -35.560 | -34.710 | -35.150 | Block 08 | Very Low with Extremely Low Veneer (0.4m) | | Very Low | | SAND and CLAY (≥10 to <100 kPa) & CLAY (≥10 to <100 kPa) | 0.4 | Yes | 2000 | 30m to 50m | 0.95 | Yes | 0.36 | N/A | 0.95 | 1.50 |
| 49 | 355.069 | 360.070 | 5.001 | -36.890 | -35.530 | -36.283 | Block 08 | Very Low with Extremely Low Veneer (0.5m) | | Very Low | | SAND and CLAY (≥10 to <100 kPa) & CLAY (≥10 to <100 kPa) | 0.5 | Yes | 2000 | 30m to 50m | 1.05 | Yes | 0.36 | N/A | 1.05 | 1.50 |
| 50 | 360.070 | 362.055 | 1.985 | -37.210 | -36.850 | -37.048 | Block 08 | Very Low Strength Silty Sand/Clay | | Very Low | | SAND and CLAY (≥10 to <100 kPa) & CLAY (≥10 to <100 kPa) | | Yes | 2000 | 30m to 50m | 0.55 | Yes | 0.36 | N/A | 0.55 | 1.50 |
| 51 | 362.055 | 364.070 | 2.015 | -37.540 | -37.160 | -37.345 | Block 08 | Very Low with Extremely Low Veneer (0.4m) | | Very Low | | SAND and CLAY (≥10 to <100 kPa) & CLAY (≥10 to <100 kPa) | 0.4 | Yes | 2000 | 30m to 50m | 0.95 | Yes | 0.36 | N/A | 0.95 | 1.50 |
| 52 | 364.070 | 366.069 | 1.999 | -37.770 | -37.510 | -37.649 | Block 08 | Very Low Strength Clay | | Very Low | | SAND and CLAY (≥10 to <100 kPa) & CLAY (≥10 to <100 kPa) | | Yes | 2000 | 30m to 50m | 0.55 | Yes | 0.36 | N/A | 0.55 | 1.50 |
| 53 | 366.069 | 368.072 | 2.003 | -38.050 | -37.720 | -37.894 | Block 08 | Very Low with Extremely Low Veneer (0.4m) | | Very Low | | SAND and CLAY (≥10 to <100 kPa) & CLAY (≥10 to <100 kPa) | 0.4 | Yes | 2000 | 30m to 50m | 0.95 | Yes | 0.36 | N/A | 0.95 | 1.50 |
| 54 | 368.072 | 370.070 | 1.998 | -38.210 | -38.010 | -38.112 | Block 08 | Very Low Strength Clay | | Very Low | | SAND and CLAY (≥10 to <100 kPa) & CLAY (≥10 to <100 kPa) | | Yes | 2000 | 30m to 50m | 0.55 | Yes | 0.36 | N/A | 0.55 | 1.50 |
| 55 | 370.070 | 374.369 | 4.299 | -38.310 | -38.110 | -38.210 | Block 08 | Very Low with Extremely Low Veneer (0.4m) | | Very Low | | SAND and CLAY (≥10 to <100 kPa) & CLAY (≥10 to <100 kPa) | 0.4 | Yes | 2000 | 30m to 50m | 0.95 | Yes | 0.36 | N/A | 0.95 | 1.50 |
| 56 | 374.369 | 382.070 | 7.701 | -38.280 | -37.460 | -37.993 | Block 08 | Very Low with Extremely Low Veneer (0.6m) | | Very Low | | SAND and CLAY (≥10 to <100 kPa) & CLAY (≥10 to <100 kPa) | 0.4 | Yes | 2000 | 30m to 50m | 1.50 | Yes | 0.36 | N/A | 1.50 | 1.70 |
| 57 | 382.070 | 388.068 | 5.998 | -37.480 | -36.750 | -36.975 | Block 08 | Very Low Strength Clay | | Very Low | | SAND and CLAY (≥10 to <100 kPa) & CLAY (≥10 to <100 kPa) | | Yes | 2000 | 30m to 50m | 0.55 | Yes | 0.36 | N/A | 0.55 | 1.50 |
| 58 | 388.068 | 390.070 | 2.002 | -36.910 | -36.770 | -36.824 | Block 08 | Very Low with Extremely Low Veneer (0.5m) | | Very Low | | SAND and CLAY (≥10 to <100 kPa) & CLAY (≥10 to <100 kPa) | 0.5 | Yes | 2000 | 30m to 50m | 0.55 | Yes | 0.36 | N/A | 0.55 | 1.50 |
| 59 | 390.070 | 401.070 | 11.000 | -36.950 | -36.760 | -36.852 | Block 08 - 09 | Very Low Strength Clay | | Very Low | | SAND and CLAY (≥10 to <100 kPa) & CLAY (≥10 to <100 kPa) | | Yes | 2000 | 30m to 50m | 0.55 | Yes | 0.36 | N/A | 0.55 | 1.50 |
| 60 | 401.070 | 407.069 | 5.999 | -36.960 | -36.730 | -36.833 | Block 09 | Very Loose Silty Sand | | | | SAND and CLAY (≥10 to <100 kPa) & CLAY (≥10 to <100 kPa) | | Yes | 2000 | 30m to 50m | 0.55 | Yes | 0.36 | N/A | 0.55 | 1.50 |
| 61 | 407.069 | 416.243 | 9.174 | -36.960 | -36.630 | -36.806 | Block 09 | Very Low with Extremely Low Veneer (0.6m) | | Very Low | | SAND and CLAY (≥10 to <100 kPa) & CLAY (≥10 to <100 kPa) | 0.6 | Yes | 2000 | 30m to 50m | 1.15 | Yes | 0.36 | N/A | 1.15 | 1.50 |
| 62 | 416.243 | 420.912 | 4.669 | -36.790 | -36.590 | -36.705 | Block 09 | Very Low Strength Clay/Sandy Clay | | Very Low | | SAND and CLAY (≥10 to <100 kPa) & CLAY (≥10 to <100 kPa) | | Yes | 2000 | 30m to 50m | 0.55 | Yes | 0.36 | N/A | 0.55 | 1.50 |
| 63 | 420.912 | 426.983 | 6.071 | -36.640 | -36.290 | -36.444 | Block 09 | Very Low Strength Clay/Sandy Clay | | Very Low | | SAND and CLAY (≥10 to <100 kPa) & CLAY (≥10 to <100 kPa) | | Yes | 2000 | 30m to 50m | 1.25 | Yes | 0.36 | N/A | 1.25 | 1.50 |
| 64 | 426.983 | 430.070 | 3.087 | -36.350 | -36.120 | -36.211 | Block 09 | Very Low Strength Clay/Sandy Clay | | Very Low | | SAND and CLAY (≥10 to <100 kPa) & CLAY (≥10 to <100 kPa) | | Yes | 2000 | 30m to 50m | 0.55 | Yes | 0.36 | N/A | 0.55 | 1.50 |
| 65 | 430.070 | 434.707 | 4.637 | -36.290 | -35.930 | -36.117 | Block 09 | Very Low with Extremely Low Veneer (0.5m) | | Very Low | | SAND and CLAY (≥10 to <100 kPa) & CLAY (≥10 to <100 kPa) | 0.5 | Yes | 2000 | 30m to 50m | 1.40 | Yes | 0.36 | N/A | 1.40 | 1.50 |
| 66 | 434.707 | 441.019 | 6.312 | -35.980 | -35.150 | -35.640 | Block 09 | Very Low Strength Clay/Sandy Clay | | Very Low | | SAND and CLAY (≥10 to <100 kPa) & CLAY (≥10 to <100 kPa) | | Yes | 2000 | 30m to 50m | 1.25 | Yes | 0.36 | N/A | 1.25 | 1.50 |
| 67 | 441.019 | 445.241 | 4.222 | -36.290 | -34.980 | -35.870 | Block 09 - 10 | Very Loose Clayey Sand | Loose | | | SAND and CLAY (≥10 to <100 kPa) & CLAY (≥10 to <100 kPa) | | Yes | 2000 | 30m to 50m | 0.90 | Yes | 0.36 | N/A | 0.90 | 1.50 |
| 68 | 445.241 | 452.104 | 6.863 | -35.460 | -34.860 | -35.154 | Block 10 | Loose Sand | Loose | | | LOOSE SAND | | Yes | 2000 | 30m to 50m | 0.60 | Yes | 0.36 | N/A | 0.60 | 1.50 |
| 69 | 452.104 | 455.478 | 3.374 | -35.980 | -35.200 | -35.467 | Block 10 | Low Strength Sandy Clay | | Low | | SAND and CLAY (≥10 to <100 kPa) & CLAY (≥10 to <100 kPa) | | Yes | 2000 | 30m to 50m | 0.70 | Yes | 0.36 | N/A | 0.70 | 1.50 |
| 70 | 455.478 | 459.173 | 3.695 | -36.630 | -35.950 | -36.273 | Block 10 | Very Loose Sand | Very Loose | | | VERY LOOSE SAND | | Yes | 2000 | 30m to 50m | 0.60 | Yes | 0.36 | N/A | 0.60 | 1.50 |
| 71 | 459.173 | 466.173 | 7.000 | -37.260 | -36.580 | -37.000 | Block 10 | Very Low Strength Sandy Clay with Extremely Low Veneer (0.5m) | | Extremely Low | | SAND and CLAY (≥10 to <100 kPa) & CLAY (≥10 to <100 kPa) | | Yes | 2000 | 30m to 50m | 1.05 | Yes | 0.36 | N/A | 1.05 | 1.70 |
| 72 | 466.173 | 481.845 | 15.672 | -38.140 | -37.210 | -37.716 | Block 10 | Very Loose Sand | Very Loose | | | VERY LOOSE SAND | | Yes | 2000 | 30m to 50m | 0.75 | Yes | 0.36 | N/A | 0.75 | 1.50 |
| 73 | 481.845 | 490.175 | 8.330 | -38.270 | -37.080 | -37.520 | Block 10 | Very Loose Silty Sand | | Extremely Low | | SAND and CLAY (≥10 to <100 kPa) & CLAY (≥10 to <100 kPa) | | Yes | 2000 | 30m to 50m | 0.70 | Yes | 0.36 | N/A | 0.70 | 1.50 |
| 74 | 490.175 | 508.853 | 18.678 | -37.130 | -34.850 | -36.278 | Block 10 - 11 | Very Loose Sand | Very Loose | | | VERY LOOSE SAND | | Yes | 2000 | 30m to 50m | 0.75 | Yes | 0.36 | N/A | 0.75 | 1.50 |
| 75 | 508.853 | 524.365 | 15.512 | -35.230 | -32.060 | -33.350 | Block 11 - 12 | Dense Sand with Loose Sand Veneer (0.3m) | Dense | | | MEDIUM DENSE SAND | 0.3 | Yes | 2000 | 30m to 50m | 0.60 | Yes | 0.36 | N/A | 0.60 | 1.50 |
| 76 | 524.365 | 542.366 | 18.001 | -32.820 | -30.860 | -31.764 | Block 12 | Medium Dense Sand with Loose Sand Veneer (0.2m) | Medium Dense | | | MEDIUM DENSE SAND | 0.2 | Yes | 2000 | 30m to 50m | 0.65 | Yes | 0.36 | 1.50 | 1.50 | 1.50 |
| 77 | 542.366 | 573.365 | 30.999 | -33.920 | -31.820 | -33.238 | Block 12 - 13 | Loose Sand | Loose | | | LOOSE SAND | | Yes | 2000 | 30m to 50m | 0.85 | Yes | 0.36 | 1.50 | 1.50 | 1.50 |
| 78 | 573.365 | 580.490 | 7.125 | -33.160 | -32.900 | -33.038 | Block 13 | Very Loose Sand | Very Loose | | | VERY LOOSE SAND | | Yes | 2000 | 30m to 50m | 0.60 | Yes | 0.36 | 1.50 | 1.50 | 1.50 |
| 79 | 580.490 | 591.364 | 10.874 | -33.830 | -32.990 | -33.370 | Block 13 | Medium Dense Sand with Loose Sand Veneer (1.0m) | Medium Dense | | | MEDIUM DENSE SAND | 0.15 | Yes | 2000 | 30m to 50m | 0.45 | Yes | 0.36 | 1.50 | 1.50 | 1.50 |
| 80 | 591.364 | 595.367 | 4.003 | -33.900 | -33.360 | -33.698 | Block 13 | Loose Sand with Very Loose Sand Veneer (1.0m) | Loose | | | LOOSE SAND | | Yes | 2000 | 30m to 50m | 0.60 | Yes | 0.36 | 1.50 | 1.50 | 1.50 |
| 81 | 595.367 | 604.365 | 8.998 | -33.400 | -28.450 | -31.315 | Block 13 | Loose Sand | Loose | | | LOOSE SAND | | Yes | 2000 | 30m to 50m | 0.85 | Yes | 0.36 | 1.50 | 1.50 | 1.50 |
| 82 | 604.365 | 614.831 | 10.466 | -28.470 | -21.610 | -25.515 | Block 13 | Medium Dense Sand with Loose Sand Veneer (0.15m) | Medium Dense | | | MEDIUM DENSE SAND | 0.15 | Yes | 2000 | 0m to 30m | 0.75 | Yes | 0.36 | 2.00 | 2.00 | 2.00 |
| 83 | 614.831 | 629.440 | 14.609 | -23.480 | -20.080 | -21.730 | Block 13 - 14 | Medium Dense Sand with Loose Sand Veneer (0.15m) | Medium Dense | | Ripples | MEDIUM DENSE SAND | 0.15 | Yes | 2000 | 0m to 30m | 0.75 | Yes | 0.36 | 2.00 | 2.00 | 2.00 |
| 84 | 629.440 | 632.364 | 2.924 | -23.310 | -20.400 | -21.413 | Block 14 | Medium Strength Clay with Low Strength Veneer (0.2m) | | Medium | | SAND and CLAY (≥10 to <100 kPa) & CLAY (≥10 to <100 kPa) | | Yes | 2000 | 0m to 30m | 1.35 | Yes | 0.36 | 1.50 | 1.50 | 1.50 |
| 85 | 632.364 | 645.366 | 13.002 | -24.780 | -17.780 | -20.279 | Block 14 | Medium Dense Sand with Very Loose Sand Veneer (0.15m) | Medium Dense | | Ripples | MEDIUM DENSE SAND | 0.15 | Yes | 2000 | 0m to 30m | 0.70 | Yes | 0.36 | 1.50 | 1.50 | 1.50 |
| 86 | 645.366 | 647.396 | 2.030 | -19.500 | -19.220 | -19.349 | Block 14 | Low Strength Clay with Medium Dense Sand Veneer (0.4m) | | Low | | SAND and CLAY (≥10 to <100 kPa) & CLAY (≥10 to <100 kPa) | | Yes | 2000 | 0m to 30m | 1.55 | Yes | 0.36 | 1.50 | 1.50 | 1.50 |
| 87 | 647.396 | 649.365 | 1.969 | -19.270 | -18.610 | -18.937 | Block 14 | Medium Dense Sand with Very Loose Sand Veneer (0.15m) | Medium Dense | | | MEDIUM DENSE SAND | 0.15 | Yes | 2000 | 0m to 30m | 0.70 | Yes | 0.36 | 1.50 | 1.50 | 1.50 |
| 88 | 649.365 | 700.718 | 51.353 | -21.130 | 10.190 | -9.589 | Block 15 | N/A | N/A | N/A | Ripples, Megaripples & Sand Waves | N/A | | N/A | N/A | N/A | TBC | Yes | 0.36 | TBC | TBC | TBC |

# 8. CONCLUSION AND RECOMMENDATIONS

The cable burial risk assessment has shown that the following hazards are present along the NeuConnect cable route. The main areas of concern are explained below:

**Sediment Mobility**

Sediment mobility in itself does not pose a threat to a submarine cable but it can lead to issues with the thermal conductivity of cables (over burial), and exposure of cables (scour); burial under excess sand can change the thermal properties of the soil and cause hotspots along the cable, while exposure increases the risk of damage due to external aggressors such as trawling and anchoring and potentially mechanical damage from free spans.

There are a number of areas within the NeuConnect 500m corridor where there are bedforms present which could be mobile.

The first indication of mobile bedforms can be observed at KP11. These have been interpreted by the route survey contractor, MMT, as ripples and have a wave length of <15m and height <1.0 m. Ripples are observed intermittently throughout the route where they terminate at KP304 and do not appear again until KP620 from which they then extend to the end of the route at KP700. While these may indicate some levels of sediment movement it is not thought that these minor bedforms will have an impact on the cable installation or operability.

Mega Ripples are also observed intermittently throughout the corridor, between KP108 & KP190 and then between KP669 and KP700. These are slightly larger than ripples and have a wave length of 15-50m and height 1-3m so may pose a risk to an installed cable within its lifetime.

Sandwaves present within the route corridor and are first observed between KP78 and KP 80. These have been interpreted by MMT to have a wave length 50-200m and height of >3 m. Sandwaves are next present at KP 106 and remain as intermittent features until KP294. They do not appear again until between KP673 and KP700.

For the purposes of burial targets (RMDOL & TDOL) all depths are to be measured against trough depth and after any required route engineering has been undertaken to flatten mobile sediments.

**Fishing Risk**

The entire route is within water depth range in which mobile gear fishing could take place, thus we recommend the cable is given sufficient protection from potential fishing gear interaction along the entire route.

The Carbon Trust' guidance (ref 12) indicates that penetration of fishing gear into the seabed is limited to a maximum of 0.3 m penetration even in soft sediment based on previous literature research. Adding a 20% Factor of Safety (FoS) to account for measurement errors and deformation of soil beneath fishing gear gives a RMDOL of 0.36m for fishing risk alone.

In practice a DOL < 0.5m is not advisable due to the instability of some trenching tools at these depths. Therefore, TDOL would be >0.5m if based on fishing risk only.

**Anchoring Risk**

Vessel Automatic Identification System (AIS) data has been used to determine the size and quantity of vessels which operate in the vicinity of the cable route. Vessels are grouped into size categories based on their deadweight tonnage (DWT) from Band A (0-100 DWT) to Band K (325K-460K DWT) and an appropriate associated anchor size is assigned to each band. Analysis of this data determines the probability of anchor-cable interactions for each vessel banding and thus the size of anchor which must be protected against in order to reduce risk to the cable to ALARP.

Assessment of the anchor risk strike for a surface laid cable demonstrated an unacceptable level of risk to the cable (failure probability of 97.75% over the lifetime of the cable) and thus there is a requirement to protect the cable against anchors interaction.

Anchoring risk exceeds fishing risk in in all zones of the route and thus determines RMDOL (except for zones in Germany where the legislative DOL requirements exceed the minimum DOL calculated by the probabilistic assessment). DOL has been calculated for protection against the anchor size associated with each vessel band in each cable route zone. Following this, the RMDOL has been selected for each individual zone in order that the overall risk to the cable over the project lifetime is reduced to ALARP. This varies from 0.55-2.00m. The full results by zone are provided in **Appendix E**. As can be seen if RMDOL is achieved during installation (and maintained throughout the project life) then the NeuConnect cable would have an annual failure probability of 9.00E-04. This equates to a return period of 1111.27 years and a failure probability over the (40 year) lifetime of 3.54%.

**Conclusions and recommendations**

TDOL is determined as what can reasonably be added to RMDOL without incurring a step change in costs and which represents a practical target for burial tools on the market.

TDOL has been set at 1.5m for the vast majority of the route and varies up to a maximum TDOL of 2m in some zones due either to anchor risk or legislative requirements. The DOL specification by cable route zone are provided in **Appendix E**. As can be seen if TDOL is achieved during installation (and maintained throughout the project life) then the NeuConnect cable would have an annual failure probability of 5.37E-04. This equates to a return period of 1863.84 years and a failure probability over the (40 year) lifetime of 2.12%.

# REFERENCES

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4 AIS data. Oceaneering

5 MMT Survey Data: Contacts

6 MMT Survey Data: Seabed Sediments

7 MMT Survey Data: Geology

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10 MMT Geophysical Report and Survey Results, *102553-NEU-MMT-SUR-REP-OPERFR-02*

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12 Risk assessment of pipeline protection, DNV_RP_F107

13 Guidance for the Preparation of Cable Burial Depth of Lowering Specification, Carbon Trust CTC835

14 Anchor Tests German Bight, Deltares

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17 Marine & Coastguard Agency, DNV 2005

18 MMT Crossing Survey report, *102553-NEU-MMT-SUR-REP-CROSSRE-02*

# APPENDIX A

## Seabed Sediments

| Seabed Index Scale (SI) | Typical Seabed Sediment |
|---|---|
| 1 | Shallow Bedrock (<1.00m) |
| 2 | Bedrock / Obstruction (>1.00m) |
| 3 | Very dense granular, very to extremely high strength cohesive |
| 4 | Medium to high strength cohesive |
| 5 | Dense granular |
| 6 | Medium dense granular |
| 7 | Loose granular, low to medium strength cohesive |
| 8 | Very loose granular, low strength cohesive |
| 9 | Very low strength sandy cohesive |
| 10 | Extremely low strength cohesive |

| Descriptive term | Shear strength rang (kPa) |
|---|---|
| extremely low | <10 |
| very low | 10 to 20 |
| low | 20 to 40 |
| medium | 40 to 75 |
| high | 75 to 150 |
| very high | 150 to 300 |

| Descriptive term | Cone resistance range (Relative density) Mpa |
|---|---|
| very loose | <2.5 |
| loose | 2.5 to 5 |
| medium dense | 5 to 10 |
| dense | 10 to 20 |
| very dense | >20 |

| Zone | Comments/Assumptions | Route KP | Location | Type | Seabed Index at 1.5m | Top Layer | | | | Layer 2 | | | | Layer 3 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Top Layer Thickness (m) | Top Layer Description | Top Lay Relative density Description | Top Layer Shear Strength Description | Layer 2 Thickness (m) | Layer 2 Desription | Layer 2 relative density Decription | Layer 2 Shear Strength Description | Layer 3 Thickness (m) | Layer 3 Desription | Layer 3 relative density Decription | Layer 3 Shear Strength Description |
| 1 | Very Low Strength Clay with Extremely Low Veneer (0.4m) | 2.285 | VC-B01-002 | VC | 8 | 0.65 | Clay | | Extremely Low | 3.5 | Silty Sand | | | | | | |
| 1 | Very Low Strength Clay with Extremely Low Veneer (0.4m) | 2.287 | CPT-B01-002 | CPT | 8 | 0.72 | Clay | | Extremely Low | 4.18 | Silty Sand | Medium Dense to Dense | | | | | |
| 1 | Very Low Strength Clay with Extremely Low Veneer (0.4m) | 3.157 | VC-B01-003 | VC | 8 | 1.35 | Clay | | Low | 1.05 | Silty Sand | | | 0.17 | Clay | | |
| 1 | Very Low Strength Clay with Extremely Low Veneer (0.4m) | 3.999 | VC-B01-004 | VC | 8 | 0.55 | Sand | | | 0.98 | Clay | | Very Low | 1.9 | Sand | | |
| 1 | Very Low Strength Clay with Extremely Low Veneer (0.4m) | 4.001 | CPT-B01-004 | CPT | 8 | 1.28 | Silty Sand | Very Loose to Loose | | 1.1 | Clay | | Low | 3.02 | Sand | Medium Dense to Dense | |
| 1 | Very Low Strength Clay with Extremely Low Veneer (0.4m) | 5.052 | VC-B01-005 | VC | 8 | 0.4 | Sand | | | 0.6 | Clay | | Extremely Low | 2.9 | Sand | | |
| 1 | Very Low Strength Clay with Extremely Low Veneer (0.4m) | 6.006 | VC-B01-006 | VC | 9 | 0.2 | Sand | | | 2.2 | Clay | | Very Low | 1.78 | Sand with thin bands of Clay | | |
| 1 | Very Low Strength Clay with Extremely Low Veneer (0.4m) | 6.008 | CPT-B01-006 | CPT | 9 | 0.24 | Sand | Very Loose to Loose | | 2.3 | Clay | | Extremely Low | 1.64 | Sand with thin bands of Clay | Very Loose to Loose | |
| 1 | Very Low Strength Clay with Extremely Low Veneer (0.4m) | 7 | VC-B01-007 | VC | 8 | 3.49 | Sand with thin bands of Clay | | | | | | | | | | |
| 1 | Low Strength Clay | 9.262 | VC-B01-009 | VC | 8 | 0.67 | Sand with thin bands of Clay | | Extremely Low | 0.53 | Clay | | | 2 | Sand with thin bands of Clay | | |
| 1 | Low Strength Clay | 9.834 | VC-B01-010A | VC | 8 | 0.29 | Clay | | Low | 2.2 | Sand with thin bands of Clay | | | | | | |
| 1 | Low Strength Clay | 9.834 | CPT-B01-010 | CPT | 8 | 0.56 | Clay | | Extremely Low | 4.74 | Sand with thin bands of Clay | Medium Dense to Dense | | | | | |
| 1 | Low Strength Clay | 11.011 | VC-B01-011A | VC | 8 | 4.18 | Sand with thin bands of Clay | | | | | | | | | | |
| 1 | Low Strength Clay | 12.049 | VC-B01-012A | VC | 9 | 1.95 | Clay | | Extremely low to Low | 0.32 | Sand with thin bands of Clay | | | 2.3 | Sand | | |
| 1 | Low Strength Clay | 12.049 | CPT-B01-012 | CPT | 9 | 2.68 | Clay | | Low (Extremely low veneer 0.5m) | 2.58 | Sand | Medium Dense to Dense | | | | | |
| 1 | Low Strength Clay | 13.088 | VC-B01-013 | VC | 9 | 3.2 | Clay | | Low | 0.68 | Silt | | Very Low | 2.4 | Sand | | |
| 2 | Low Strength Clay/Loose Sand | 14.3 | CPT-B01-014 | CPT | 9 | 0.18 | Gravel | Very Loose | | 2.66 | Clay | | Very Low to High | 0.86 | Sand | Medium Dense to Dense | |
| 2 | Low Strength Clay/Loose Sand | 14.301 | VC-B01-014 | VC | 9 | 0.28 | Gravel | Medium Dense | | 1.52 | Clay | | Very Low | 1.9 | Sand | Loose to Medium Dense | |
| 2 | Low Strength Clay/Loose Sand | 15.059 | VC-B01-015 | VC | 7 | 1.64 | Clay | | Medium | 2.7 | Sand | | | | | | |
| 2 | Low Strength Clay/Loose Sand | 15.828 | VC-B01-016 | VC | 7 | 4 | Clay | | Low | | | | | | | | |
| 2 | Low Strength Clay/Loose Sand | 15.83 | CPT-B01-016 | CPT | 7 | 2.44 | Clay | | Low | 0.66 | Sand | Medium Dense | - | 2.16 | Clay | | Low |
| 2 | Low Strength Clay/Loose Sand | 16.97 | VC-B01-017 | VC | 7 | 0.6 | Silt | | Very Low | 1.01 | Sand | | | 0.9 | Silt | | |
| 2 | Low Strength Clay/Loose Sand | 17.975 | VC-B01-018 | VC | 8 | 0.88 | Clay | | Low | 2 | Sand | | | 1.64 | Clay | | |
| 2 | Low Strength Clay/Loose Sand | 17.976 | CPT-B01-018 | CPT | 8 | 0.92 | Clay | | Low to Medium | 2.4 | Sand | Medium Dense to Dense | | 1.84 | Clay | | Medium |
| 2 | Low Strength Clay/Loose Sand | 20.001 | CPT-B01-020 | CPT | 8 | 4.66 | Sand | Loose to Medium Dense | | 0.26 | Clay | | Medium | 0.3 | Sand | Medium Dense | |
| 2 | Low Strength Clay/Loose Sand | 20.002 | VC-B01-020 | VC | 8 | 3.98 | Sand with thin bands of Clay | | | 0.27 | Clay | | Medium | | | | |
| 2 | Low Strength Clay/Loose Sand | 20.651 | VC-B01-021 | VC | 8 | 4.34 | Sand with thin bands of Clay | | | | | | | | | | |
| 2 | Low Strength Clay/Loose Sand | 21.96 | VC-B01-022 | VC | 8 | 4.3 | Sand | | | | | | | | | | |
| 2 | Low Strength Clay/Loose Sand | 21.96 | CPT-B01-022 | CPT | 8 | 5.3 | Sand with thin bands of Clay | Very Loose to Loose | | | | | | | | | |
| 2 | Low Strength Clay/Loose Sand | 23.104 | VC-B01-023 | VC | 8 | 4.87 | Sand with thin bands of Clay | | | | | | | | | | |
| 2 | Low Strength Clay/Loose Sand | 23.816 | VC-B01-024 | VC | 8 | 4.95 | Sand with thin bands of Clay | | | | | | | | | | |
| 2 | Low Strength Clay/Loose Sand | 23.817 | CPT-B01-024 | CPT | 8 | 5.24 | Sand with thin bands of Clay | Loose to Medium Dense | | | | | | | | | |
| 2 | Low Strength Clay/Loose Sand | 25.3 | VC-B01-025 | VC | 8 | 0.53 | Clay | | Very Low | 1.09 | Sand with thin bands of Clay | | | 3.13 | Clay | | |
| 2 | Low Strength Clay/Loose Sand | 26.032 | CPT-B01-026 | CPT | 8 | 0.64 | Sandy Clay | Loose | Extremely Low | 1.74 | Sand with thin bands of Clay | Loose | | 1.72 | Clay | | Low to Medium |
| 2 | Low Strength Clay/Loose Sand | 26.033 | VC-B01-026 | VC | 8 | 1.45 | Sandy Clay | | Very Low | 2.65 | Clay | | Very Low | | | | |
| 2 | Low Strength Clay/Loose Sand | 27 | VC-B01-027 | VC | 8 | 2.68 | Sand | | | 1.94 | Clay | | Medium | | | | |
| 2 | Low Strength Clay/Loose Sand | 27.998 | VC-B01-028 | VC | 8 | 4.5 | Sand | | | | | | | | | | |
| 2 | Low Strength Clay/Loose Sand | 28.003 | CPT-B01-028 | CPT | 8 | 3.36 | Sand with thin bands of Clay | Loose to Medium Dense | | 1.82 | Sand with thin bands of Clay | Very Loose to Loose | | | | | |
| 2 | Low Strength Clay/Loose Sand | 29 | VC-B01-029 | VC | 8 | 3.9 | Sand with thin bands of Clay | | Very Low | | | | | | | | |
| 2 | Low Strength Clay/Loose Sand | 29.998 | CPT-B01-030 | CPT | 7 | 0.34 | Sand | | | 1.5 | Clay | | Medium | 2.46 | Sand | Loose to Medium Dense | |
| 2 | Low Strength Clay/Loose Sand | 29.999 | VC-B01-030 | VC | 7 | 0.75 | Clay | | | 2.75 | Sand | | | | | | |
| 3 | Medium Dense Sand | 31.001 | VC-B01-031 | VC | 4 | 1.04 | Sand | | | 2.63 | Clay | | Medium | | | | |
| 3 | Medium Dense Sand | 31.603 | CPT-B01-032 | CPT | 4 | 0.48 | Sand | Medium Dense | | 4.88 | Gravelly Clay | | Medium to High | | | | |
| 3 | Medium Dense Sand | 31.606 | VC-B01-032A | VC | 5 | 1.96 | Sand | | | | | | | | | | |
| 3 | Medium Dense Sand | 33 | VC-B01-033 | VC | 6 | 3.41 | Sand | | | | | | | | | | |
| 3 | Medium Dense Sand | 33.969 | VC-B01-034 | VC | 8 | 3.31 | Sand | | Very Low | | | | | | | | |
| 3 | Medium Dense Sand | 33.971 | CPT-B01-034 | CPT | 8 | 1.06 | Sand | Medium Dense to Dense | | 2.6 | Silt | Loose | | 0.54 | Clay | | Low |
| 3 | Medium Dense Sand | 34.999 | VC-B01-035 | VC | 8 | 4.4 | Sand | | | | | | | | | | |
| 3 | Medium Dense Sand | 35.998 | VC-B01-036A | VC | 6 | 4.11 | Sand | | | | | | | | | | |
| 3 | Medium Dense Sand | 36.001 | CPT-B01-036 | CPT | 6 | 5.1 | Sand | Dense to Very Dense | | | | | | | | | |
| 3 | Medium Dense Sand | 37.066 | VC-B01-037A | VC | 6 | 3.88 | Sand | | | | | | | | | | |
| 4 | Loose Sand | 38.135 | CPT-B01-038 | CPT | 8 | 2.16 | Sand with thin bands of Clay | Loose to Medium Dense | | 2.96 | Sand | Medium Dense to Dense | | | | | |
| 4 | Loose Sand | 38.136 | VC-B01-038 | VC | 8 | 1.55 | Sand | | | 0.23 | Clay | | | 1.85 | Sand | | |
| 4 | Loose Sand | 39 | VC-B01-039 | VC | 8 | 6 | Sand with thin bands of Clay | | Very Low | | | | | | | | |
| 5 | Medium Dense Sand | 39.997 | CPT-B01-040 | CPT | 8 | 2.78 | Sand | Medium Dense to Dense | | 2.2 | Clay | | Low to Medium | | | | |
| 5 | Medium Dense Sand | 40 | VC-B01-040 | VC | 8 | 4.9 | Sand | | | | | | | | | | |
| 5 | Medium Dense Sand | 41 | VC-B01-041A | VC | 8 | 0.69 | Sand | | | 1.16 | Gravelly Clay | | | 2.23 | Clay | | |
| 5 | Medium Dense Sand | 41.834 | CPT-B01-042 | CPT | 8 | 2.54 | Gravelly Sand | Medium Dense | | | | | | | | | |
| 5 | Medium Dense Sand | 41.837 | VC-B01-042 | VC | 8 | 6 | Coarse Sand and Gravel | | | | | | | | | | |
| 5 | Medium Dense Sand | 41.843 | CPT-B01-042A | CPT | 8 | 1.2 | Sand | Medium Dense to Dense | | 3.88 | Sand with thin bands of Clay | Loose to Medium Dense | | | | | |
| 5 | Medium Dense Sand | 42.999 | VC-B01-043 | VC | 8 | 2.97 | Sand | | | 0.36 | Clay | | Very Low | 2.24 | Sand | | |
| 5 | Medium Dense Sand | 43.998 | VC-B01-044 | VC | 8 | 6 | Sand | | | | | | | | | | |
| 6 | Loose Sand | 43.999 | CPT-B01-044 | CPT | 8 | 2.38 | Sand | Loose to Medium Dense | | 2.68 | Sand | Dense to Very Dense | | | | | |
| 6 | Loose Sand | 45.001 | VC-B01-045 | VC | 8 | 5.33 | Sand | | | | | | | | | | |
| 6 | Loose Sand | 45.999 | VC-B01-046 | VC | 7 | 6 | Sand | | | | | | | | | | |
| 6 | Loose Sand | 46 | CPT-B01-046 | CPT | 7 | 5.14 | Sand | Medium Dense to Dense | | | | | | | | | |
| 6 | Loose Sand | 46.999 | VC-B01-047 | VC | 7 | 6 | Sand | | | | | | | | | | |
| 6 | Loose Sand | 48.001 | VC-B01-048 | VC | 7 | 6 | Sand | | | | | | | | | | |
| 6 | Loose Sand | 48.002 | CPT-B01-048 | CPT | 7 | 1.06 | Sand | Very Loose to Medium Dense | | 4.06 | Sand | Dense to Very Dense | | | | | |
| 6 | Loose Sand | 48.999 | VC-B01-049 | VC | 7 | 6 | Sand | | | | | | | | | | |
| 6 | Loose Sand | 49.969 | VC-B02-050 | VC | 7 | 4.88 | Sand | | | | | | | | | | |
| 6 | Loose Sand | 50.97 | VC-B02-051 | VC | 7 | 4 | Sand | | | | | | | | | | |
| 7 | Dense Sand | 50.972 | CPT-B02-051 | CPT | 7 | 5.16 | Sand | Dense to Very Dense | | | | | | | | | |
| 7 | Dense Sand | 51.97 | VC-B02-052 | VC | 7 | 4 | Sand | | | | | | | | | | |
| 7 | Dense Sand | 52.968 | VC-B02-053 | VC | 7 | 4.18 | Sand | | | | | | | | | | |
| 7 | Dense Sand | 52.969 | CPT-B02-053 | CPT | 7 | 5.04 | Sand | Dense to Very Dense | | | | | | | | | |
| 7 | Dense Sand | 53.968 | VC-B02-054 | VC | 7 | 4.72 | Sand | | | 1.11 | Clay | | Very High | | | | |
| 7 | Dense Sand | 54.969 | CPT-B02-055 | CPT | 7 | 5.14 | Sand | Dense to Very Dense | | | | | | | | | |
| 7 | Dense Sand | 54.973 | VC-B02-055B | VC | 7 | 5.41 | Sand | | | | | | | | | | |
| 7 | Dense Sand | 55.971 | VC-B02-056 | VC | 7 | 4.6 | Sand | | | | | | | | | | |
| 7 | Dense Sand | 57.235 | VC-B02-057A | VC | 7 | 3.33 | Sand | | | | | | | | | | |
| 8 | Loose Sand | 57.239 | CPT-B02-057 | CPT | 7 | 0.62 | Sand | Very Loose to Medium Dense | | 4.54 | Sand | Medium Dense to Very Dense | | | | | |
| 8 | Loose Sand | 57.968 | VC-B02-058 | VC | 7 | 4.46 | Sand | | | | | | | | | | |
| 8 | Loose Sand | 58.969 | VC-B02-059 | VC | 7 | 5.97 | Sand | | | | | | | | | | |
| 8 | Loose Sand | 58.969 | CPT-B02-059 | CPT | 7 | 0.62 | Sand | Very Loose to Dense | | 4.86 | Sand | Dense to Very Dense | | | | | |
| 8 | Loose Sand | 60.128 | VC-B02-060 | VC | 7 | 3.24 | Sand | | | 1.29 | Clay | | Low | | | | |
| 9 | Medium Dense Sand | 60.969 | CPT-B02-061 | CPT | 4 | 1.1 | Sand | Dense to Very Dense | | 4.16 | Clay | | Low to Medium | | | | |
| 9 | Medium Dense Sand | 60.97 | VC-B02-061B | VC | 7 | 2.18 | Sand | | | 0.5 | Clay | | Medium | | | | |
| 9 | Medium Dense Sand | 61.967 | VC-B02-062B | VC | 7 | 1.28 | Sand | | | 3.06 | Gravelly Clay | | | | | | |
| 9 | Medium Dense Sand | 63.061 | CPT-B02-063 | CPT | 7 | 1.8 | Sand | Medium to Dense | | 1.4 | Clay | | Medium to High | | | | |
| 9 | Medium Dense Sand | 63.066 | VC-B02-063B | VC | 7 | 2.74 | Sand | | | 1.04 | Clay | | | | | | |
| 9 | Medium Dense Sand | 63.971 | VC-B02-064 | VC | 7 | 4.64 | Sand | | | | | | | | | | |
| 9 | Medium Dense Sand | 64.97 | VC-B02-065 | VC | 7 | 2.82 | Sand | | | 0.52 | Clay | | Medium | | | | |
| 10 | Dense Sand | 64.97 | CPT-B02-065 | CPT | 7 | 2.82 | Sand | Dense to Very Dense | | 2.36 | Clay | | High to Very High | | | | |
| 10 | Dense Sand | 65.973 | VC-B02-066A | VC | 7 | 3 | Sand | | | | | | | | | | |
| 10 | Dense Sand | 66.97 | CPT-B02-067 | CPT | 5 | 3.8 | Sand | Dense to Very Dense | | 1.4 | Clay | | Medium | | | | |
| 10 | Dense Sand | 66.971 | VC-B02-067 | VC | 5 | 3.46 | Sand | | | | | | | | | | |
| 10 | Dense Sand | 67.874 | VC-B02-068 | VC | 5 | 3.47 | Sand | | | | | | | | | | |
| 10 | Dense Sand | 68.969 | CPT-B02-069 | CPT | 3 | 5.24 | Sand | Very Dense | | | | | | | | | |
| 10 | Dense Sand | 68.972 | VC-B02-069B | VC | 3 | 2.89 | Sand | | | | | | | | | | |
| 10 | Dense Sand | 70.021 | VC-B02-070A | VC | 4 | 2.45 | Sandy Clay | | Medium | | | | | | | | |
| 11 | High Strength Clay | 70.969 | VC-B02-071A | VC | 4 | 0.22 | Sand | | | 1.3 | Clay | | Very High | | | | |
| 11 | High Strength Clay | 70.969 | CPT-B02-071 | CPT | 4 | 0.48 | Sand | Dense to Very Dense | | 4.9 | Clay | | Medium to High | | | | |
| 11 | High Strength Clay | 72.049 | VC-B02-072 | VC | 4 | 2.78 | Clay | | Very High | | | | | | | | |
| 11 | High Strength Clay | 72.968 | VC-B02-073 | VC | 4 | 2.1 | Clay | | Very High | | | | | | | | |
| 11 | High Strength Clay | 72.969 | CPT-B02-073 | CPT | 4 | 5.1 | Clay | | High to Very High | | | | | | | | |
| 11 | High Strength Clay | 73.969 | VC-B02-074 | VC | 4 | 3.45 | Clay | | Very High | | | | | | | | |
| 11 | High Strength Clay | 74.97 | VC-B02-075 | VC | 4 | 3.83 | Clay | | Very High | | | | | | | | |
| 11 | High Strength Clay | 74.971 | CPT-B02-075 | CPT | 4 | 5.26 | Clay | | High | | | | | | | | |
| 12 | Sand | 75.968 | VC-B02-076 | VC | 6 | 6 | Sand | | | | | | | | | | |
| 13 | Very Low Strength Clay | 76.963 | VC-B02-077 | VC | 9 | 3.85 | Clay | | Very Low | | | | | | | | |
| 13 | Very Low Strength Clay | 76.964 | CPT-B02-077 | CPT | 9 | 1.78 | Clay | | Very Low | 1.22 | Sand | Medium Dense to Dense | | | | | |
| 14 | Sand | 77.803 | VC-B02-078 | VC | 7 | 6 | Sand | | | | | | | | | | |
| 14 | Sand | 79.095 | VC-B02-079 | VC | 7 | 6 | Sand | | | | | | | | | | |
| 15 | Dense Sand | 79.095 | CPT-B02-079 | CPT | 7 | 1.28 | Sand | Dense to Very Dense | | 0.5 | Clay | - | Low to Medium | 1.6 | Sand | Dense to Very Dense | |
| 15 | Dense Sand | 80.086 | VC-B02-080 | VC | 5 | 5 | Sand | | | | | | | | | | |
| 15 | Dense Sand | 81.056 | CPT-B02-081 | CPT | 5 | 5 | Sand | Dense to Very Dense | | | | | | | | | |
| 15 | Dense Sand | 81.058 | VC-B02-081 | VC | 5 | 4.3 | Sand | | | | | | | | | | |
| 15 | Dense Sand | 82.071 | VC-B02-082 | VC | 4 | 1.39 | Sand | | | 1.5 | Clay | | High | | | | |
| 16 | High Strength Clay | 83.069 | CPT-B02-083 | CPT | 4 | 0.42 | Gravel | Loose | | 4.82 | Clay | | High to Very High | | | | |
| 16 | High Strength Clay | 83.07 | VC-B02-083A | VC | 4 | 2.74 | Sandy Clay | | | | | | | | | | |
| 16 | High Strength Clay | 84.069 | VC-B02-084A | VC | 4 | 3.5 | Clay | | Very High | | | | | | | | |
| 16 | High Strength Clay | 85.07 | CPT-B02-085 | CPT | 4 | 0.26 | Gravel | Medium Dense | | 3.8 | Clay | | High to Very High | | | | |
| 16 | High Strength Clay | 85.074 | VC-B02-085A | VC | 4 | 0.36 | Gravel | | | 2 | Clay | | Very High | | | | |
| 16 | High Strength Clay | 86.07 | VC-B02-086 | VC | 4 | 3.2 | Clay | | Very High | | | | | | | | |
| 16 | High Strength Clay | 87.07 | CPT-B02-087 | CPT | 9 | 0.18 | Gravel | Loose | | 4.9 | Clay | | Very Low to Low | | | | |
| 16 | High Strength Clay | 87.071 | VC-B02-087 | VC | 4 | 0.24 | Gravel | | | 1.46 | Clay | | Very High | | | | |
| 16 | High Strength Clay | 88.07 | VC-B02-088 | VC | 4 | 3.55 | Clay | | Very High | | | | | | | | |
| 16 | High Strength Clay | 89.071 | CPT-B02-089 | CPT | 4 | 0.16 | Sand | Medium Dense | | 4.96 | Clay | | High to Very High | | | | |
| 16 | High Strength Clay | 89.072 | VC-B02-089 | VC | 4 | 0.74 | Sand | | | 2.26 | Clay | | Very High | | | | |
| 16 | High Strength Clay | 90.071 | VC-B02-090 | VC | 4 | 0.88 | Sand | | | 2.57 | Clay | | Very High | | | | |
| 16 | High Strength Clay | 90.852 | CPT-B02-091 | CPT | 4 | 0.16 | Gravel | Dense | | 5.14 | Clay | | High | | | | |
| 16 | High Strength Clay | 90.853 | VC-B02-091 | VC | 4 | 3.6 | Clay | | Very High | | | | | | | | |
| 16 | High Strength Clay | 92.069 | VC-B02-092 | VC | 4 | 2.14 | Clay | | Very High | | | | | | | | |
| 16 | High Strength Clay | 93.069 | CPT-B02-093 | CPT | 4 | 0.26 | Sand | Dense | | 4.92 | Clay | | High to Very High | | | | |
| 16 | High Strength Clay | 93.071 | VC-B02-093 | VC | 4 | 1.55 | Clay | | Very High | | | | | | | | |
| 16 | High Strength Clay | 94.069 | VC-B02-094 | VC | 4 | 0.23 | Gravel | | | 1.17 | Clay | | Very High | | | | |
| 16 | High Strength Clay | 95.07 | VC-B02-095A | VC | 4 | 0.29 | Gravelly Clay | | | 1.19 | Clay | | Very High | | | | |
| 16 | High Strength Clay | 95.07 | CPT-B02-095 | CPT | 4 | 0.12 | Gravel | Medium Dense | | 4.92 | Clay | | High to Very High | | | | |
| 16 | High Strength Clay | 96.071 | VC-B02-096 | VC | 4 | 0.98 | Clay | | Very High | | | | | | | | |
| 16 | High Strength Clay | 97.07 | VC-B02-097 | VC | 4 | 1.42 | Clay | | Very High | | | | | | | | |
| 16 | High Strength Clay | 97.07 | CPT-B02-097 | CPT | 4 | 0.34 | Gravel | Very Dense | | 4.8 | Clay | | High to Very High | | | | |
| 16 | High Strength Clay | 98.07 | VC-B02-098A | VC | 4 | 0.25 | Gravel | | | 1.18 | Clay | | High | | | | |
| 16 | High Strength Clay | 99.068 | VC-B02-099A | VC | 4 | 0.29 | Gravel | | | 1.38 | Clay | | Very High | | | | |
| 16 | High Strength Clay | 99.07 | CPT-B02-099 | CPT | 4 | 0.2 | Gravel | Medium Dense | | 4.94 | Clay | | High | | | | |
| 16 | High Strength Clay | 100.072 | VC-B02-100A | VC | 4 | 1.57 | Clay | | Very High | | | | | | | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 16 | High Strength Clay | 101.069 | VC-B02-101 | VC | 4 | 2.5 | Clay | | Very High | | | | | | | | |
| 16 | High Strength Clay | 101.07 | CPT-B02-101 | CPT | 4 | 0.22 | Gravel | Medium Dense to Dense | | 4.82 | Clay | | High to Very High | | | | |
| 16 | High Strength Clay | 102.072 | VC-B03-102 | VC | 4 | 0.18 | Sand | | | 1.5 | Clay | | | | | | |
| 16 | High Strength Clay | 103.069 | VC-B03-103A | VC | 4 | 1.34 | Clay | | Medium | | | | | | | | |
| 16 | High Strength Clay | 103.07 | CPT-B03-103 | CPT | 4 | 0.4 | Sand | | | 4.66 | Clay | | High to Very High | | | | |
| 16 | High Strength Clay | 103.904 | VC-B03-104 | VC | 4 | 0.43 | Gravel | | | 1.87 | Clay | | Very High | | | | |
| 16 | High Strength Clay | 105.07 | CPT-B03-105 | CPT | 4 | 0.24 | Gravel | Dense | | 4.82 | Clay | | High to Very High | | | | |
| 16 | High Strength Clay | 105.073 | VC-B03-105 | VC | 4 | 1.92 | Clay | | Very High | | | | | | | | |
| 16 | High Strength Clay | 106.074 | VC-B03-106A | VC | 4 | 0.31 | Sand | | | 1.92 | Clay | | Very High | | | | |
| 16 | High Strength Clay | 107.099 | VC-B03-107 | VC | 4 | 0.58 | Sand | | | 0.85 | Clay | | Very High | | | | |
| 16 | High Strength Clay | 107.099 | CPT-B03-107 | CPT | 4 | 0.38 | Sand | Dense | | 4.68 | Clay | | High | | | | |
| 16 | High Strength Clay | 108.07 | VC-B03-108 | VC | 4 | 1.2 | Clay | | Very High | | | | | | | | |
| 16 | High Strength Clay | 109.07 | VC-B03-109 | VC | 4 | 2 | Clay | | Very High | | | | | | | | |
| 16 | High Strength Clay | 109.07 | CPT-B03-109 | CPT | 4 | 0.24 | Gravel | Dense | | 4.74 | Clay | | High | | | | |
| 16 | High Strength Clay | 110.025 | VC-B03-110A | VC | 4 | 1.31 | Clay | | Very High | | | | | | | | |
| 16 | High Strength Clay | 110.926 | CPT-B03-111 | CPT | 4 | 0.22 | Clay | | Low | 5.26 | Clay | | High | | | | |
| 16 | High Strength Clay | 110.927 | VC-B03-111 | VC | 4 | 0.99 | Clay | | Very High | | | | | | | | |
| 16 | High Strength Clay | 112.559 | VC-B03-112 | VC | 4 | 1.6 | Clay | | Very High | | | | | | | | |
| 17 | Medium Dense Sand | 113.069 | CPT-B03-113 | CPT | 6 | 0.78 | Sand | Very Loose to Dense | | 1.06 | Sand | Medium Dense to Very Dense | | 3.24 | Clay | | Medium to High |
| 17 | Medium Dense Sand | 113.073 | VC-B03-113 | VC | 4 | 1.08 | Sand | | | 1.08 | Clay | | High | | | | |
| 17 | Medium Dense Sand | 114.074 | VC-B03-114A | VC | 6 | 2.7 | Sand | | | 1.3 | Clay | | Medium | | | | |
| 18 | High Strength Clay | 115.299 | VC-B03-115 | VC | 4 | 2.27 | Clay | | Very High | | | | | | | | |
| 18 | High Strength Clay | 115.3 | CPT-B03-115 | CPT | 4 | 0.22 | Clay | | Extremely Low | 3.84 | Clay | | High | | | | |
| 18 | High Strength Clay | 116.432 | VC-B03-116 | VC | 4 | 1.36 | Clay | | Very High | | | | | | | | |
| 18 | High Strength Clay | 117.07 | CPT-B03-117 | CPT | 4 | 0.28 | Gravelly Clay | | Extremely Low | 4.98 | Clay | | High to Very High | | | | |
| 18 | High Strength Clay | 117.071 | VC-B03-117A | VC | 4 | 0.56 | Gravel | | | 1.44 | Clay | | Very High | | | | |
| 18 | High Strength Clay | 118.068 | VC-B03-118 | VC | 4 | 1.86 | Clay | | Very High | | | | | | | | |
| 18 | High Strength Clay | 119.068 | VC-B03-119A | VC | 4 | 0.2 | Gravel | | | 1.6 | Clay | | Very High | | | | |
| 18 | High Strength Clay | 119.071 | CPT-B03-119 | CPT | 4 | 0.26 | Sand | Dense | | 4.96 | Clay | | High to Very High | | | | |
| 18 | High Strength Clay | 120.07 | VC-B03-120 | VC | 4 | 1.3 | Clay | | Very High | | | | | | | | |
| 18 | High Strength Clay | 121.071 | VC-B03-121A | VC | 4 | 1.93 | Clay | | High | | | | | | | | |
| 18 | High Strength Clay | 121.071 | CPT-B03-121 | CPT | 4 | 0.26 | Cay | | Extremely Low | 1.36 | Clay | | High | | | | |
| 18 | High Strength Clay | 121.071 | CPT-B03-121A | CPT | 4 | 0.36 | Clay | | Extremely Low | 4.12 | Clay | | High | | | | |
| 18 | High Strength Clay | 122.07 | VC-B03-122 | VC | 4 | 0.24 | Sand | | | 1.86 | Clay | | Very High | | | | |
| 18 | High Strength Clay | 123.07 | CPT-B03-123 | CPT | 4 | 3.6 | Clay | | High to Very High | | | | | | | | |
| 18 | High Strength Clay | 123.072 | VC-B03-123A | VC | 4 | 0.3 | Gravel | | | 1.16 | Clay | | Very High | | | | |
| 18 | High Strength Clay | 124.07 | VC-B03-124 | VC | 4 | 0.3 | Gravel | | | 1.27 | Clay | | Very High | | | | |
| 18 | High Strength Clay | 124.966 | VC-B03-125A | VC | 4 | 0.21 | Gravel | | | 1.06 | Clay | | Very High | | | | |
| 18 | High Strength Clay | 124.968 | CPT-B03-125 | CPT | 4 | 0.26 | Gravelly Clay | | | 4.96 | Clay | | High to Very High | | | | |
| 18 | High Strength Clay | 126.071 | VC-B03-126 | VC | 4 | 0.24 | Gravel | | | 1.23 | Clay | | Very High | | | | |
| 19 | Dense Sand with Loose Sand Veneer (0.3m) | 127.273 | CPT-B03-127 | CPT | 5 | 2.64 | Sand | Dense to Very Dense | | 2.54 | Clay | | High | | | | |
| 19 | Dense Sand with Loose Sand Veneer (0.3m) | 127.274 | VC-B03-127 | VC | 5 | 2.48 | Sand | | | 0.6 | Clay | | Very High | | | | |
| 19 | Dense Sand with Loose Sand Veneer (0.3m) | 128.072 | VC-B03-128 | VC | 5 | 4 | Sand | | | 1.9 | Chalk | | | | | | |
| 19 | Dense Sand with Loose Sand Veneer (0.3m) | 129.05 | CPT-B03-129 | CPT | 5 | 0.58 | Gravelly Sand | Very Loose to Dense | | 2.54 | Gravelly Sand | Very Dense | | | | | |
| 19 | Dense Sand with Loose Sand Veneer (0.3m) | 129.057 | VC-B03-129A | VC | 5 | 2.86 | Sand | | | 1.04 | Chalk | | | | | | |
| 19 | Dense Sand with Loose Sand Veneer (0.3m) | 130.131 | VC-B03-130 | VC | 5 | 3 | Sand | | | 0.99 | Chalk | | | | | | |
| 19 | Dense Sand with Loose Sand Veneer (0.3m) | 131.497 | VC-B03-131 | VC | 5 | 6 | Sand | | | | | | | | | | |
| 19 | Dense Sand with Loose Sand Veneer (0.3m) | 131.517 | CPT-B03-131 | CPT | 5 | 0.44 | Gravelly Sand | Very Loose to Dense | | 3.66 | Gravelly Sand | Very Dense | | | | | |
| 19 | Dense Sand with Loose Sand Veneer (0.3m) | 131.842 | VC-B03-132 | VC | 5 | 5.93 | Sand | | | | | | | | | | |
| 19 | Dense Sand with Loose Sand Veneer (0.3m) | 133.064 | VC-B03-133 | VC | 5 | 4.5 | Sand | | | | | | | | | | |
| 19 | Dense Sand with Loose Sand Veneer (0.3m) | 133.069 | CPT-B03-133 | CPT | 5 | 0.38 | Gravelly Sand | Very Loose to Dense | | 4.54 | Gravelly Sand | Very Dense | | | | | |
| 19 | Dense Sand with Loose Sand Veneer (0.3m) | 134.134 | VC-B03-134 | VC | 5 | 4.79 | Sand | | | | | | | | | | |
| 19 | Dense Sand with Loose Sand Veneer (0.3m) | 135.069 | CPT-B03-135 | CPT | 5 | 0.5 | Gravelly Sand | Very Loose to Dense | | 4.74 | Gravelly Sand | Very Dense | | | | | |
| 19 | Dense Sand with Loose Sand Veneer (0.3m) | 135.07 | VC-B03-135 | VC | 5 | 4.6 | Sand | | | | | | | | | | |
| 19 | Dense Sand with Loose Sand Veneer (0.3m) | 136.02 | VC-B03-136 | VC | 5 | 5.61 | Sand | | | | | | | | | | |
| 19 | Dense Sand with Loose Sand Veneer (0.3m) | 137.008 | VC-B03-137 | VC | 5 | 3.84 | Sand | | | | | | | | | | |
| 19 | Dense Sand with Loose Sand Veneer (0.3m) | 137.072 | CPT-B03-137 | CPT | 5 | 0.46 | Gravelly Sand | Very Loose to Dense | | 4.8 | Gravelly Sand | Very Dense | | | | | |
| 19 | Dense Sand with Loose Sand Veneer (0.3m) | 138.07 | VC-B03-138A | VC | 5 | 4.56 | Sand | | | | | | | | | | |
| 19 | Dense Sand with Loose Sand Veneer (0.3m) | 139.092 | CPT-B03-139 | CPT | 5 | 0.68 | Gravelly Sand | Loose to Dense | | 4.52 | Gravelly Sand | Very Dense | | | | | |
| 19 | Dense Sand with Loose Sand Veneer (0.3m) | 139.095 | VC-B03-139 | VC | 5 | 3.44 | Sand | | | | | | | | | | |
| 19 | Dense Sand with Loose Sand Veneer (0.3m) | 140.082 | VC-B03-140 | VC | 5 | 4.73 | Sand | | | | | | | | | | |
| 19 | Dense Sand with Loose Sand Veneer (0.3m) | 141.087 | VC-B03-141 | VC | 5 | 4.92 | Sand | | | | | | | | | | |
| 19 | Dense Sand with Loose Sand Veneer (0.3m) | 141.095 | CPT-B03-141 | CPT | 5 | 0.32 | Gravelly Sand | Very Loose to Dense | | 4.72 | Gravelly Sand | Very Dense | | | | | |
| 19 | Dense Sand with Loose Sand Veneer (0.3m) | 142.054 | VC-B03-142 | VC | 5 | 4.56 | Sand | | | | | | | | | | |
| 19 | Dense Sand with Loose Sand Veneer (0.3m) | 143.068 | VC-B03-143 | VC | 5 | 5.16 | Sand | | | | | | | | | | |
| 19 | Dense Sand with Loose Sand Veneer (0.3m) | 143.072 | CPT-B03-143 | CPT | 5 | 0.44 | Gravelly Sand | Very Loose to Dense | | 4.82 | Gravelly Sand | Very Dense | | | | | |
| 19 | Dense Sand with Loose Sand Veneer (0.3m) | 144.108 | VC-B03-144 | VC | 5 | 4.36 | Sand | | | | | | | | | | |
| 19 | Dense Sand with Loose Sand Veneer (0.3m) | 145.07 | VC-B03-145 | VC | 5 | 3.16 | Sand | | | | | | | | | | |
| 19 | Dense Sand with Loose Sand Veneer (0.3m) | 145.072 | CPT-B03-145 | CPT | 5 | 0.58 | Gravelly Sand | Very Loose to Dense | | 3.7 | Gravelly Sand | Very Dense | | | | | |
| 19 | Dense Sand with Loose Sand Veneer (0.3m) | 146.07 | VC-B03-146 | VC | 5 | 4.89 | Sand | | | | | | | | | | |
| 19 | Dense Sand with Loose Sand Veneer (0.3m) | 146.947 | VC-B03-147 | VC | 5 | 2.58 | Sand | | | | | | | | | | |
| 19 | Dense Sand with Loose Sand Veneer (0.3m) | 146.95 | CPT-B03-147 | CPT | 5 | 0.64 | Gravelly Sand | Very Loose to Dense | | 4.54 | Gravelly Sand | Very Dense | | | | | |
| 19 | Dense Sand with Loose Sand Veneer (0.3m) | 148.091 | VC-B03-148 | VC | 5 | 3.63 | Sand | | | | | | | | | | |
| 19 | Dense Sand with Loose Sand Veneer (0.3m) | 149.062 | VC-B03-149A | VC | 6 | 3.86 | Sand | | | | | | | | | | |
| 19 | Dense Sand with Loose Sand Veneer (0.3m) | 149.065 | CPT-B03-149 | CPT | 6 | 0.54 | Gravelly Sand | Very Loose to Dense | | 4.68 | Gravelly Sand | Very Dense | | | | | |
| 19 | Dense Sand with Loose Sand Veneer (0.3m) | 150.056 | VC-B03-150 | VC | 5 | 3.24 | Sand | | | | | | | | | | |
| 19 | Dense Sand with Loose Sand Veneer (0.3m) | 152.071 | CPT-B03-152 | CPT | 5 | 5.06 | Gravelly Sand | Very Dense | | | | | | | | | |
| 19 | Dense Sand with Loose Sand Veneer (0.3m) | 152.072 | VC-B03-152 | VC | 5 | 3.58 | Sand | | | | | | | | | | |
| 19 | Dense Sand with Loose Sand Veneer (0.3m) | 153.07 | VC-B03-153 | VC | 5 | 5.91 | Sand | | | | | | | | | | |
| 19 | Dense Sand with Loose Sand Veneer (0.3m) | 154.065 | CPT-B03-154 | CPT | 6 | 0.86 | Gravelly Sand | Very Loose to Dense | | 4.2 | Gravelly Sand | Very Dense | | | | | |
| 19 | Dense Sand with Loose Sand Veneer (0.3m) | 154.071 | VC-B03-154A | VC | 6 | 2.82 | Sand | | | | | | | | | | |
| 19 | Dense Sand with Loose Sand Veneer (0.3m) | 155.109 | VC-B03-155 | VC | 5 | 4.16 | Sand | | | | | | | | | | |
| 19 | Dense Sand with Loose Sand Veneer (0.3m) | 156.052 | CPT-B03-156 | CPT | 5 | 0.4 | Gravelly Sand | Very Loose to Dense | | 4.7 | Gravelly Sand | Very Dense | | | | | |
| 19 | Dense Sand with Loose Sand Veneer (0.3m) | 156.053 | VC-B03-156 | VC | 5 | 4 | Sand | | | | | | | | | | |
| 19 | Dense Sand with Loose Sand Veneer (0.3m) | 157.084 | VC-B03-157 | VC | 5 | 5.15 | Sand | | | | | | | | | | |
| 19 | Dense Sand with Loose Sand Veneer (0.3m) | 158.069 | CPT-B03-158 | CPT | 5 | 0.52 | Gravelly Sand | Very Loose to Dense | | 4.62 | Gravelly Sand | Very Dense | | | | | |
| 19 | Dense Sand with Loose Sand Veneer (0.3m) | 158.07 | VC-B03-158 | VC | 5 | 3.48 | Sand | | | | | | | | | | |
| 19 | Dense Sand with Loose Sand Veneer (0.3m) | 159.07 | VC-B04-159A | VC | 5 | 3.91 | Sand | | | | | | | | | | |
| 19 | Dense Sand with Loose Sand Veneer (0.3m) | 160.112 | CPT-B04-160 | CPT | 5 | 0.36 | Sand | Very Loose to Dense | | 4.8 | Sand | Very Dense | | | | | |
| 19 | Dense Sand with Loose Sand Veneer (0.3m) | 160.112 | VC-B04-160 | VC | 5 | 3.05 | Sand | | | | | | | | | | |
| 19 | Dense Sand with Loose Sand Veneer (0.3m) | 161.065 | VC-B04-161 | VC | 5 | 4.23 | Sand | | | | | | | | | | |
| 19 | Dense Sand with Loose Sand Veneer (0.3m) | 162.07 | CPT-B04-162 | CPT | 6 | 0.54 | Sand | Very Loose to Dense | | 4.66 | Sand | Very Dense | | | | | |
| 19 | Dense Sand with Loose Sand Veneer (0.3m) | 162.07 | VC-B04-162 | VC | 6 | 3.91 | Sand | | | | | | | | | | |
| 19 | Dense Sand with Loose Sand Veneer (0.3m) | 162.986 | VC-B04-163 | VC | 6 | 5.16 | Sand | | | | | | | | | | |
| 19 | Dense Sand with Loose Sand Veneer (0.3m) | 164.29 | VC-B04-164 | VC | 6 | 4.14 | Clayey Sand | | Very Low | | | | | | | | |
| 19 | Dense Sand with Loose Sand Veneer (0.3m) | 164.291 | CPT-B04-164 | CPT | 6 | 5.06 | Sand | Very Dense | | | | | | | | | |
| 19 | Dense Sand with Loose Sand Veneer (0.3m) | 165.07 | VC-B04-165 | VC | 6 | 4.76 | Sand | | | | | | | | | | |
| 19 | Dense Sand with Loose Sand Veneer (0.3m) | 166.067 | CPT-B04-166A | CPT | 6 | 2.92 | Sand | Very Dense | | | | | | | | | |
| 19 | Dense Sand with Loose Sand Veneer (0.3m) | 166.068 | VC-B04-166 | VC | 6 | 5.23 | Sand | | | | | | | | | | |
| 19 | Dense Sand with Loose Sand Veneer (0.3m) | 167.071 | VC-B04-167 | VC | 5 | 5.35 | Sand | | | | | | | | | | |
| 19 | Dense Sand with Loose Sand Veneer (0.3m) | 168.071 | CPT-B04-168 | CPT | 5 | 0.66 | Sand | Loose | | 4.56 | Sand | Very Dense | | | | | |
| 19 | Dense Sand with Loose Sand Veneer (0.3m) | 168.074 | VC-B04-168 | VC | 5 | 1.48 | Sand | | | 0.72 | Gravel | | | 3.77 | Sand | | |
| 19 | Dense Sand with Loose Sand Veneer (0.3m) | 169.074 | VC-B04-169A | VC | 5 | 5.63 | Sand | | | | | | | | | | |
| 19 | Dense Sand with Loose Sand Veneer (0.3m) | 170.068 | CPT-B04-170 | CPT | 5 | 3.32 | Sand | Very Dense | | | | | | | | | |
| 19 | Dense Sand with Loose Sand Veneer (0.3m) | 170.071 | VC-B04-170 | VC | 5 | 5.59 | Sand | | | | | | | | | | |
| 19 | Dense Sand with Loose Sand Veneer (0.3m) | 171.07 | VC-B04-171 | VC | 5 | 3.14 | Sand | | | 0.15 | Clay | | Medium | 2.52 | Sand | | |
| 19 | Dense Sand with Loose Sand Veneer (0.3m) | 172.063 | CPT-B04-172 | CPT | 6 | 0.8 | Sand | Loose to Dense | | 4.02 | Sand | Very Dense | | | | | |
| 19 | Dense Sand with Loose Sand Veneer (0.3m) | 172.063 | VC-B04-172A | VC | 6 | 5.41 | Sand | | | | | | | | | | |
| 19 | Dense Sand with Loose Sand Veneer (0.3m) | 173.069 | VC-B04-173 | VC | 6 | 5.37 | Sand | | | | | | | | | | |
| 19 | Dense Sand with Loose Sand Veneer (0.3m) | 174.068 | CPT-B04-174 | CPT | 5 | 0.38 | Sand | Very Loose to Dense | | 4.76 | Sand | Very Dense | | | | | |
| 19 | Dense Sand with Loose Sand Veneer (0.3m) | 174.068 | VC-B04-174 | VC | 5 | 6 | Sand | | | | | | | | | | |
| 19 | Dense Sand with Loose Sand Veneer (0.3m) | 175.07 | VC-B04-175 | VC | 5 | 5.9 | Sand | | | | | | | | | | |
| 19 | Dense Sand with Loose Sand Veneer (0.3m) | 176.089 | CPT-B04-176 | CPT | 5 | 5.02 | Sand | Very Dense | | | | | | | | | |
| 19 | Dense Sand with Loose Sand Veneer (0.3m) | 176.089 | VC-B04-176 | VC | 5 | 6 | Sand | | | | | | | | | | |
| 19 | Dense Sand with Loose Sand Veneer (0.3m) | 177.103 | VC-B04-177 | VC | 5 | 6 | Sand with thin bands of Clay | | | | | | | | | | |
| 19 | Dense Sand with Loose Sand Veneer (0.3m) | 178.074 | VC-B04-178 | VC | 5 | 6 | Sand | | | | | | | | | | |
| 19 | Dense Sand with Loose Sand Veneer (0.3m) | 178.079 | CPT-B04-178 | CPT | 5 | 0.42 | Sand | Very Loose to Dense | | 4.78 | Sand | Very Dense | | | | | |
| 19 | Dense Sand with Loose Sand Veneer (0.3m) | 179.323 | VC-B04-179 | VC | 5 | 6 | Sand | | | | | | | | | | |
| 19 | Dense Sand with Loose Sand Veneer (0.3m) | 180.064 | CPT-B04-180 | CPT | 5 | 0.38 | Sand | Very Loose to Dense | | 4.86 | Sand | Very Dense | | | | | |
| 19 | Dense Sand with Loose Sand Veneer (0.3m) | 180.065 | VC-B04-180 | VC | 5 | 3 | Sand | | | | | | | | | | |
| 19 | Dense Sand with Loose Sand Veneer (0.3m) | 181.647 | VC-B04-181 | VC | 5 | 5.6 | Sand | | | | | | | | | | |
| 20 | Very Loose Sand over Medium Clay | 182.024 | CPT-B04-182 | CPT | 5 | 0.56 | Sand | Very Loose to Loose | | 0.58 | Clay | | High | 4.18 | Sand | Very Dense | |
| 20 | Very Loose Sand over Medium Clay | 182.027 | VC-B04-182 | VC | 5 | 0.35 | Gravel | | | 1.01 | Clay | | Low | 1.4 | Sand | | |
| 21 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 182.799 | VC-B04-183 | VC | 5 | 3.56 | Sand | | | 1.25 | Clay | | Medium | | | | |
| 21 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 183.702 | CPT-B04-184 | CPT | 6 | 0.66 | Sand | Very Loose to Dense | | 4.46 | Sand | Dense to Very Dense | | | | | |
| 21 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 183.702 | VC-B04-184 | VC | 6 | 4.83 | Sand | | | | | | | | | | |
| 21 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 185.069 | VC-B04-185 | VC | 6 | 4.8 | Sand | | | | | | | | | | |
| 21 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 186.067 | CPT-B04-186 | CPT | 6 | - | - | - | - | - | - | - | - | - | - | - | - |
| 21 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 186.067 | CPT-B04-186A | CPT | 6 | 5.22 | Sand | Dense to Very Dense | | | | | | | | | |
| 21 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 186.069 | VC-B04-186 | VC | 6 | 5.15 | Sand | | | | | | | | | | |
| 21 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 187.071 | VC-B04-187A | VC | 6 | 5.78 | Sand | | | | | | | | | | |
| 21 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 188.069 | VC-B04-188 | VC | 7 | 2.77 | Sand | | | | | | | | | | |
| 21 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 188.072 | CPT-B04-188 | CPT | 7 | 1.08 | Sand | Very Loose to Dense | | 4.06 | Sand | Dense to Very Dense | | | | | |
| 21 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 189.07 | VC-B04-189 | VC | 7 | 5.99 | Sand | | | | | | | | | | |
| 21 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 190.082 | CPT-B04-190 | CPT | 5 | 0.46 | Sand | Very Loose to Dense | | 4.82 | Sand | Very Dense | | | | | |
| 21 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 190.084 | VC-B04-190 | VC | 5 | 4.82 | Sand | | | | | | | | | | |
| 21 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 191.07 | VC-B04-191 | VC | 7 | 1.2 | Sand | | | 3.16 | Clay | | Medium | | | | |
| 21 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 192.026 | CPT-B04-192 | CPT | 5 | 0.74 | Sand | Very Loose to Dense | | 3.42 | Sand | Very Dense | | | | | |
| 21 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 192.027 | VC-B04-192 | VC | 6 | 6 | Sand | | | | | | | | | | |
| 21 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 193.07 | VC-B04-193 | VC | 6 | 6 | Sand | | | | | | | | | | |
| 21 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 194.069 | VC-B04-194 | VC | 5 | 4.86 | Sand | | | | | | | | | | |
| 21 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 194.074 | CPT-B04-194 | CPT | 5 | 0.42 | Sand | Very Loose to Dense | | 1.9 | Sand | Very Dense | | | | | |
| 21 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 194.108 | CPT-B04-194A | CPT | 5 | 0.52 | Sand | Very Loose to Dense | | 4.4 | Sand | Dense to Very Dense | | | | | |
| 21 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 195.07 | VC-B04-195 | VC | 6 | 1 | Sand | | | 0.75 | Clay | | Low | 3.76 | Sand | Very Dense | |
| 21 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 196.075 | CPT-B04-196 | CPT | 6 | 0.72 | Sand | Medium Dense | | 0.56 | Clay | | Medium to high | 3.98 | Sand | | |
| 21 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 196.075 | VC-B04-196 | VC | 6 | 0.5 | Sand | | | 0.95 | Clay | | Very Low | 4.55 | Sand | | |
| 21 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 197.068 | VC-B04-197 | VC | 6 | 5.3 | Sand | | | | | | | | | | |
| 21 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 198.067 | CPT-B04-198 | CPT | 6 | 3 | Sand | Dense to Very Dense | | 1.18 | Clay | | High to Very High | 0.84 | Sand | Very Dense | |
| 21 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 198.07 | VC-B04-198 | VC | 6 | 4 | Sand | | | 1.6 | Clay | | Low | | | | |
| 21 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 198.634 | VC-B05-199 | VC | 6 | 5.45 | Sand | | | | | | | | | | |
| 21 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 200.071 | VC-B05-200 | VC | 6 | 5.22 | Sand | | | | | | | | | | |
| 21 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 200.074 | CPT-B05-200 | CPT | 6 | 0.36 | Sand | Loose to Dense | | 1.96 | Sand | Very Dense | | 2.94 | Sand | Medium to Very Dense | |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 21 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 201.071 | VC-B05-201 | VC | 6 | 5.82 | Sand | | | | | | | | | | |
| 21 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 202.049 | VC-B05-202 | VC | 5 | 6 | Sand | | | | | | | | | | |
| 21 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 202.058 | CPT-B05-202 | CPT | 5 | 0.38 | Sand | Very Loose to Dense | | 4.88 | Sand | Medium Dense to Dense | | | | | |
| 21 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 203.224 | VC-B05-203 | VC | 7 | 0.26 | Sand | | | 3.37 | Clay | | High | | | | |
| 21 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 204.115 | CPT-B05-204 | CPT | 6 | 0.86 | Sand | Medium Dense to Dense | | 0.64 | Clay | | High to Very High | 2.94 | Sand | Very Dense | |
| 21 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 204.117 | VC-B05-204 | VC | 6 | 1.25 | Sand | | | 1 | Clay | | Very Low | 1.75 | Sand | | |
| 21 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 205.071 | VC-B05-205 | VC | 7 | 0.44 | Sand | | | 0.52 | Clay | | Very Low | 2.57 | Silty Clay | | |
| 21 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 206.066 | CPT-B05-206 | CPT | 7 | 0.84 | Sand | Very Loose to Medium Dense | | 4.24 | Sand | Dense to Very Dense | | | | | |
| 21 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 206.072 | VC-B05-206 | VC | 7 | 0.45 | Sand | | | 4.48 | Sand with Clay | | | | | | |
| 21 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 207.071 | VC-B05-207 | VC | 6 | 5.34 | Sand | | | | | | | | | | |
| 21 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 208.244 | VC-B05-208 | VC | 6 | 5.7 | Sand | | | | | | | | | | |
| 21 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 208.244 | CPT-B05-208 | CPT | 6 | 0.88 | Sand | Loose to Dense | | 4.3 | Sand | Medium Dense to Dense | | | | | |
| 21 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 209.54 | VC-B05-209 | VC | 6 | 4 | Sand | | | | | | | | | | |
| 21 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 210.068 | VC-B05-210 | VC | 6 | 4.68 | Sand | | | | | | | | | | |
| 21 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 210.069 | CPT-B05-210 | CPT | 6 | 1.02 | Sand | Very Loose to Very Dense | | 4.06 | Sand | Very Dense | | | | | |
| 21 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 211.066 | VC-B05-211A | VC | 6 | 4.56 | Sand | | | | | | | | | | |
| 21 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 212.191 | VC-B05-212 | VC | 6 | 3.65 | Sand | | | | | | | | | | |
| 21 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 212.191 | CPT-B05-212 | CPT | 6 | 0.78 | Sand | Loose to Dense | | 4.24 | Sand | Very Dense | | 2.5 | Clay | - | Medum to High |
| 21 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 213.068 | VC-B05-213 | VC | 6 | 3.82 | Sand | | | 1.18 | Clay | | High | | | | |
| 21 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 214.069 | CPT-B05-214 | CPT | 6 | 1.12 | Sand | Very Loose to Dense | | 1.24 | Sand | Medium Dense to Very Dense | | 2.74 | Clay | - | Medum to High |
| 21 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 214.071 | VC-B05-214 | VC | 6 | 2.85 | Sand | | | 2.24 | Clay | | Medium | | | | |
| 21 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 215.072 | VC-B05-215 | VC | 6 | 1.96 | Sand | | | 2.31 | Clay | | Medium | | | | |
| 21 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 216.067 | CPT-B05-216 | CPT | 7 | 1.62 | Sand | Very Loose to Very Dense | | 3.6 | Clay | | Medium to High | | | | |
| 21 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 216.072 | VC-B05-216A | VC | 7 | 2.73 | Sand | | | 1.21 | Clay | | Medium | | | | |
| 21 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 217.069 | VC-B05-217A | VC | 5 | 4.78 | Sand | | | | | | | | | | |
| 21 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 218.069 | CPT-B05-218 | CPT | 5 | 0.62 | Sand | Very Loose to Dense | | 3.5 | Sand | Very Dense | | | | | |
| 21 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 218.07 | VC-B05-218 | VC | 5 | 5.81 | Sand | | | | | | | | | | |
| 21 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 219.07 | VC-B05-219A | VC | 5 | 5.64 | Sand | | | | | | | | | | |
| 21 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 220.067 | CPT-B05-220 | CPT | 5 | 0.68 | Sand | Loose to Dense | | 2.3 | Sand | Dense to Very Dense | | 2.26 | Clay | | High to Very High |
| 21 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 220.071 | VC-B05-220 | VC | 5 | 4.49 | Sand | | | 1.64 | Clay | | Medium | | | | |
| 21 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 221.069 | VC-B05-221 | VC | 4 | 0.98 | Sand | | | 1.97 | Clay | | Medium | | | | |
| 21 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 222.067 | VC-B05-222 | VC | 6 | 3.11 | Sand | | | 1.54 | Clay | | Medium | | | | |
| 21 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 222.073 | CPT-B05-222 | CPT | 6 | 1.94 | Sand | Loose to Very Dense | | 3.3 | Clay | | Medium to High | | | | |
| 21 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 223.066 | VC-B05-223 | VC | 6 | 5.97 | Sand | | | | | | | | | | |
| 22 | Medium Strength Clay | 224.069 | VC-B05-224 | VC | 4 | 2.97 | Clay and Sand | | Medium | | | | | | | | |
| 22 | Medium Strength Clay | 224.07 | CPT-B05-224 | CPT | 4 | 2.16 | Clay and Sand | | Medium to High | 1 | Sand | Medium Dense | | 2.1 | Clay | | High |
| 22 | Medium Strength Clay | 225.073 | VC-B05-225A | VC | 4 | 2 | Clay and Sand | | Medium | | | | | | | | |
| 22 | Medium Strength Clay | 226.07 | CPT-B05-226 | CPT | 4 | 0.86 | Clay and Sand | | Extremely Low to High | 4.38 | Clay and Sand | | Medium to High | | | | |
| 23 | Dense Sand with Loose Sand Veneer (0.3m) | 226.072 | VC-B05-226A | VC | 4 | 1.66 | Sand | | Medium | | | | | | | | |
| 23 | Dense Sand with Loose Sand Veneer (0.3m) | 227.067 | VC-B05-227B | VC | 4 | 1.47 | Sand | | | 3.23 | Clay | | High | | | | |
| 23 | Dense Sand with Loose Sand Veneer (0.3m) | 228.068 | VC-B05-228 | VC | 6 | 1.94 | Sand | | | 1.93 | Clay | | Medium | | | | |
| 23 | Dense Sand with Loose Sand Veneer (0.3m) | 228.072 | CPT-B05-228 | CPT | 6 | 0.36 | Sand | Very Loose to Dense | | 1.88 | Sand | Very Dense | | 2.76 | Clay | | High to Very High |
| 23 | Dense Sand with Loose Sand Veneer (0.3m) | 229.069 | VC-B05-229 | VC | 6 | 4.41 | Sand | | Medium | 0.9 | Clay | | Medium | | | | |
| 23 | Dense Sand with Loose Sand Veneer (0.3m) | 230.068 | VC-B05-230 | VC | 6 | 5.58 | Sand | | | | | | | | | | |
| 23 | Dense Sand with Loose Sand Veneer (0.3m) | 230.072 | CPT-B05-230 | CPT | 6 | 0.5 | Sand | Very Loose to Dense | | 4.48 | Sand | Dense to Very Dense | | | | | |
| 23 | Dense Sand with Loose Sand Veneer (0.3m) | 231.117 | VC-B05-231 | VC | 6 | 4.79 | Sand | | | 0.21 | Clay | | Medium | | | | |
| 23 | Dense Sand with Loose Sand Veneer (0.3m) | 232.068 | VC-B05-232 | VC | 7 | 2.88 | Sand | | | 2.32 | Clay | | High | | | | |
| 23 | Dense Sand with Loose Sand Veneer (0.3m) | 232.074 | CPT-B05-232 | CPT | 7 | 2.5 | Sand | Very Loose to Very Dense | | 2.52 | Clay | | High to Very High | | | | |
| 24 | Medium Dense Sand with Loose Sand Veneer (0.3m) over High Strength Clay | 233.07 | VC-B05-233 | VC | 4 | 0.85 | Sand | | | 1.76 | Clay | | Very High | 0.48 | Silty Sand | | |
| 24 | Medium Dense Sand with Loose Sand Veneer (0.3m) over High Strength Clay | 234.372 | VC-B05-234 | VC | 4 | 0.56 | Sand | | | 3.44 | Clay | | Very High | | | | |
| 24 | Medium Dense Sand with Loose Sand Veneer (0.3m) over High Strength Clay | 234.372 | CPT-B05-234 | CPT | 4 | 0.78 | Gravel | Very Loose to Medium Dense | - | 4.18 | Clay | | High to Very High | | | | |
| 24 | Medium Dense Sand with Loose Sand Veneer (0.3m) over High Strength Clay | 235.07 | VC-B05-235 | VC | 4 | 0.8 | Sand | | | 3.2 | Clay | | Very High | | | | |
| 24 | Medium Dense Sand with Loose Sand Veneer (0.3m) over High Strength Clay | 236.067 | CPT-B05-236 | CPT | 4 | 0.6 | Sand | Very Loose to Very Dense | | 4.4 | Clay | | High to Very High | | | | |
| 24 | Medium Dense Sand with Loose Sand Veneer (0.3m) over High Strength Clay | 236.07 | VC-B05-236 | VC | 4 | 0.32 | Sand | | | 0.62 | Clay | | High | 3.17 | Clay | | |
| 24 | Medium Dense Sand with Loose Sand Veneer (0.3m) over High Strength Clay | 237.191 | VC-B05-237 | VC | 4 | 0.44 | Sand | | | 4.44 | Clay | | Very High | | | | |
| 24 | Medium Dense Sand with Loose Sand Veneer (0.3m) over High Strength Clay | 238.068 | VC-B05-238 | VC | 4 | 0.59 | Sand | | | 3.14 | Clay | | Very High | | | | |
| 24 | Medium Dense Sand with Loose Sand Veneer (0.3m) over High Strength Clay | 238.07 | CPT-B05-238 | CPT | 4 | 0.6 | Sand | Very Loose to Medium Dense | | 4.6 | Clay | | High to Very High | | | | |
| 24 | Medium Dense Sand with Loose Sand Veneer (0.3m) over High Strength Clay | 238.919 | VC-B05-239 | VC | 4 | 0.44 | Sand | | | 3.89 | Clay | | Very High | | | | |
| 24 | Medium Dense Sand with Loose Sand Veneer (0.3m) over High Strength Clay | 240.07 | VC-B05-240 | VC | 4 | 0.53 | Sand | | | 3.61 | Clay | | Very High | | | | |
| 24 | Medium Dense Sand with Loose Sand Veneer (0.3m) over High Strength Clay | 240.07 | CPT-B05-240 | CPT | 4 | 0.74 | Gravel | Very Loose to Medium Dense | | 4.64 | Clay | | High to Very High | | | | |
| 24 | Medium Dense Sand with Loose Sand Veneer (0.3m) over High Strength Clay | 241.073 | VC-B05-241 | VC | 4 | 1.35 | Sand | | | 2.87 | Clay | | Very High | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 242.071 | VC-B05-242 | VC | 6 | 3.96 | Sand | | | 0.69 | Clay | | Very High | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 242.073 | CPT-B05-242 | CPT | 6 | 0.38 | Sand | Very Loose to Very Dense | | 3.2 | Sand | Very Dense | | 1.7 | Clay | | High to Very High |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 243.065 | VC-B05-243 | VC | 6 | 2.05 | Sand | | | 1.81 | Clay | | Very High | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 244.07 | VC-B05-244 | VC | 4 | 0.61 | Sand | | | 2.88 | Clay | | Very High | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 244.07 | CPT-B05-244 | CPT | 4 | 0.7 | Sand | Very Loose to Dense | | 0.42 | Clay | | Low to Medium | 4.14 | Clay | | High to Very High |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 245.073 | VC-B05-245 | VC | 7 | 0.34 | Sand | | | 3.07 | Clay | | Very High | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 246.128 | CPT-B05-246 | CPT | 7 | 0.64 | Sand | Very Loose to Dense | | 4.42 | Sand | Dense to Very Dense | | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 246.129 | VC-B05-246 | VC | 6 | 5.65 | Sand | | | | | | | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 247.071 | VC-B05-247 | VC | 6 | 5.6 | Sand | | | | | | | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 248.069 | CPT-B05-248 | CPT | 5 | 0.5 | Sand | Very Loose to Dense | | 4.62 | Sand | Very Dense | | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 248.07 | VC-B05-248A | VC | 5 | 5.8 | Sand | | | | | | | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 249.069 | VC-B05-249 | VC | 6 | 4.48 | Sand | | | | | | | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 250.069 | CPT-B05-250 | CPT | 6 | 3.84 | Sand | Loose to Very Dense | | 1.44 | Clay | | High to Very High | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 250.071 | VC-B05-250 | VC | 6 | 4.25 | Sand | | | 1.75 | Clay | | Very High | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 251.072 | VC-B06-251A | VC | 4 | 0.37 | Sand | | | 0.45 | Clay | | Medium | 1.26 | Clay | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 251.912 | VC-B06-252 | VC | 4 | 0.21 | Sand | | | 0.39 | Clay | | Medium | 1.01 | Clay | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 251.916 | CPT-B06-252 | CPT | 4 | 0.32 | Sand | Loose to Dense | | 4.5 | Clay | | High to Very High | 0.32 | Sand | Very Dense | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 253.068 | VC-B06-253 | VC | 4 | 1.21 | Sand | | | 1.25 | Clay | | Very High | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 254.397 | VC-B06-254B | VC | 4 | 0.55 | Sand | | | 1.15 | Clay | | High | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 254.398 | CPT-B06-254 | CPT | 4 | 0.82 | Gravel | Very Loose to Medium Dense | | 3.64 | Clay | | High to Very High | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 255.023 | VC-B06-255 | VC | 4 | 0.45 | Sand | | | 1.4 | Clay | | Medium | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 256.07 | VC-B06-256A | VC | 4 | 0.28 | Sand | | | 1.29 | Clay | | High | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 256.071 | CPT-B06-256 | CPT | 4 | 0.3 | Gravel | Very Loose to Dense | | 4.96 | Clay | | High to Very High | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 257.069 | VC-B06-257 | VC | 5 | 2.09 | Sand | | | 1.01 | Clay | | Very High | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 258.069 | VC-B06-258 | VC | 5 | 5.32 | Sand | | | | | | | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 258.071 | CPT-B06-258 | CPT | 5 | 0.34 | Sand | Very Loose to Dense | | 4.96 | Sand | Very Dense | | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 259.321 | VC-B06-259 | VC | 5 | 6 | Sand | | | | | | | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 260.069 | VC-B06-260 | VC | 5 | 6 | Sand | | | | | | | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 260.071 | CPT-B06-260 | CPT | 5 | 0.34 | Sand | | | 4.94 | Sand | Very Dense | | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 261.069 | VC-B06-261 | VC | 5 | 5.32 | Sand | | | | | | | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 261.718 | CPT-B06-262 | CPT | 5 | 0.52 | Sand | Loose to Dense | | 2.98 | Sand | Very Dense | | 1.04 | Clay | | High |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 262.07 | VC-B06-262 | VC | 5 | 6 | Sand | | | | | | | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 262.811 | VC-B06-263 | VC | 5 | 4.04 | Sand | | | 1.41 | Clay | | Medium | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 264.071 | VC-B06-264 | VC | 5 | 4.77 | Sand | | | | | | | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 264.072 | CPT-B06-264 | CPT | 5 | 0.36 | Sand | Very Loose to Dense | | 4.94 | Sand | Very Dense | | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 265.22 | VC-B06-265 | VC | 5 | 5.47 | Sand | | | | | | | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 266.039 | VC-B06-266 | VC | 5 | 4.97 | Sand | | | | | | | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 266.047 | CPT-B06-266 | CPT | 5 | 0.64 | Sand | Medium Dense to Very Dense | | 4.42 | Sand | Very Dense | | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 266.997 | VC-B06-267 | VC | 5 | 4.86 | Sand | | | | | | | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 268.401 | CPT-B06-268 | CPT | 6 | 0.52 | Sand | Very Loose to Very Dense | | 4.74 | Sand | Very Dense | | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 268.404 | VC-B06-268 | VC | 6 | 5 | Sand | | | | | | | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 269.05 | VC-B06-269 | VC | 6 | 5 | Sand | | | | | | | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 270.068 | CPT-B06-270 | CPT | 6 | 0.64 | Sand | Medium Dense to Very Dense | | 4.56 | Sand | Very Dense | | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 270.069 | VC-B06-270 | VC | 6 | 5.22 | Sand | | | | | | | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 271.069 | VC-B06-271 | VC | 6 | 4.28 | Sand | | | | | | | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 272.068 | VC-B06-272 | VC | 6 | 4.8 | Sand | | | | | | | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 272.068 | CPT-B06-272 | CPT | 6 | 0.28 | Sand | Very Loose to Very Dense | | 5.02 | Sand | Dense to Very Dense | | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 273.139 | VC-B06-273 | VC | 6 | 5.52 | Sand | | | | | | | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 274.069 | VC-B06-274 | VC | 6 | 5.5 | Sand | | | | | | | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 274.07 | CPT-B06-274 | CPT | 6 | 0.48 | Sand | Very Loose to Very Dense | | 2.06 | Sand | Very Dense | | 2.18 | Sand | Dense | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 275.068 | VC-B06-275 | VC | 6 | 5.56 | Sand | | | | | | | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 276.066 | VC-B06-276 | VC | 7 | 4.23 | Sand | | | | | | | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 276.07 | CPT-B06-276 | CPT | 7 | 0.34 | Sand | Medium Dense to Very Dense | | 0.82 | Sand | Very Dense | | 4.08 | Sand | Dense to Very Dense | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 277.068 | VC-B06-277 | VC | 6 | 5.26 | Sand | | | | | | | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 278.07 | VC-B06-278 | VC | 6 | 5.3 | Sand | | | | | | | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 278.071 | CPT-B06-278 | CPT | 6 | 0.52 | Sand | Loose to Very Dense | | 4.72 | Sand | Very Dense | | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 279.07 | VC-B06-279 | VC | 6 | 5.57 | Sand | | | | | | | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 280.039 | CPT-B06-280 | CPT | 6 | 0.4 | Sand | Very Loose to Very Dense | | 4.78 | Sand | Very Dense | | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 280.041 | VC-B06-280 | VC | 6 | 5.5 | Sand | | | | | | | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 281.069 | VC-B06-281 | VC | 6 | 5.16 | Sand | | | | | | | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 282.067 | VC-B06-282 | VC | 6 | 5.52 | Sand | | | | | | | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 282.07 | CPT-B06-282 | CPT | 6 | 0.44 | Sand | Very Loose to Very Dense | | 4.78 | Sand | Very Dense | | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 283.068 | VC-B06-283 | VC | 6 | 5.31 | Sand | | | | | | | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 283.967 | VC-B06-284 | VC | 5 | 2.48 | Sand | | | 0.3 | Clay | | Medium | 0.38 | Sand | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 283.97 | CPT-B06-284 | CPT | 5 | 0.5 | Sand | Loose to Very Dense | | 1.98 | Sand | Very Dense | | 0.38 | Clay | | Medium to High |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 285.166 | VC-B06-285 | VC | 6 | 4.84 | Sand | | | | | | | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 286.07 | CPT-B06-286 | CPT | 6 | 0.34 | Sand | Very Loose to Very Dense | | 4.82 | Sand | Very Dense | | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 286.071 | VC-B06-286 | VC | 6 | 5.53 | Sand | | | | | | | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 287.073 | VC-B06-287 | VC | 6 | 5.7 | Sand | | | | | | | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 288.069 | CPT-B06-288 | CPT | 5 | 0.54 | Sand | Very Loose to Very Dense | | 4.6 | Sand | Very Dense | | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 288.072 | VC-B06-288 | VC | 5 | 5.71 | Sand | | | | | | | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 289.072 | VC-B06-289 | VC | 5 | 5.84 | Sand | | | | | | | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 290.111 | VC-B06-290 | VC | 5 | 6 | Sand | | | | | | | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 290.111 | CPT-B06-290 | CPT | 5 | 0.54 | Sand | Loose to Very Dense | | 4.6 | Sand | Very Dense | | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 291.07 | VC-B06-291 | VC | 5 | 6 | Sand | | | | | | | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 291.89 | VC-B06-292 | VC | 5 | 5.65 | Sand | | | | | | | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 291.893 | CPT-B06-292 | CPT | 5 | - | - | - | - | - | - | - | - | - | - | - | - |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 291.894 | CPT-B06-292A | CPT | 5 | - | - | - | - | - | - | - | - | - | - | - | - |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 291.894 | CPT-B06-292B | CPT | 5 | 0.46 | Sand | Loose to Very Dense | | 4.86 | Sand | Dense to Very Dense | | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 293.069 | VC-B06-293 | VC | 5 | 5.57 | Sand | | | | | | | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 294.069 | VC-B06-294 | VC | 6 | 5.56 | Sand | | | | | | | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 294.071 | CPT-B06-294 | CPT | 6 | 0.38 | Sand | Very Loose to Very Dense | | 4.9 | Sand | Dense to Very Dense | | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 295.069 | VC-B06-295 | VC | 6 | 5.65 | Sand | | | | | | | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 296.071 | VC-B06-296 | VC | 6 | 5.7 | Sand | | | | | | | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 296.071 | CPT-B06-296 | CPT | 6 | 0.4 | Sand | Very Loose to Very Dense | | 4.86 | Sand | Medium Dense to Very Dense | | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 297.072 | VC-B06-297 | VC | 6 | 5.49 | Sand | | | | | | | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 298.069 | VC-B06-298 | VC | 6 | 5.52 | Sand | | | | | | | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 298.07 | CPT-B06-298 | CPT | 6 | 0.36 | Sand | Very Loose to Very Dense | | 4.9 | Sand | Medium Dense to Very Dense | | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 299.068 | VC-B06-299A | VC | 6 | 5.81 | Sand | | | | | | | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 299.931 | VC-B06-300 | VC | 6 | 5.7 | Sand | | | | | | | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 299.931 | CPT-B06-300 | CPT | 6 | 0.48 | Sand | Very Loose to Very Dense | | 4.54 | Sand | Dense to Very Dense | | | | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 301.14 | VC-B07-301 | VC | 5 | 5.6 | Sand | | | | | | | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 302.07 | VC-B07-302 | VC | 5 | 5.42 | Sand | | | | | | | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 302.07 | CPT-B07-302 | CPT | 5 | 0.56 | Sand | Loose to Very Dense | | 4.34 | Sand | Dense to Very Dense | | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 303.068 | VC-B07-303 | VC | 5 | 5.68 | Sand | | | | | | | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 304.068 | VC-B07-304 | VC | 5 | 5.89 | Sand | | | | | | | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 304.069 | CPT-B07-304 | CPT | 5 | 0.44 | Sand | Loose to Very Dense | | 4.78 | Sand | Dense to Very Dense | | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 305.07 | VC-B07-305 | VC | 5 | 6 | Sand | | | | | | | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 306.07 | CPT-B07-306 | CPT | 5 | 1.18 | Sand | Loose to Dense | | 4 | Sand | Dense to Very Dense | | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 306.071 | VC-B07-306 | VC | 5 | 5.98 | Sand | | | | | | | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 307.172 | VC-B07-307 | VC | 5 | 5.96 | Sand | | | | | | | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 308.069 | CPT-B07-308 | CPT | 7 | 5.22 | Sand | Medium Dense to Dense | | | | | | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 308.07 | VC-B07-308 | VC | 7 | 5.94 | Sand | | | | | | | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 309.072 | VC-B07-309 | VC | 7 | 6 | Sand | | | | | | | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 310.069 | CPT-B07-310 | CPT | 7 | 5.14 | Sand | Medium Dense to Dense | | | | | | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 310.072 | VC-B07-310 | VC | 7 | 5.96 | Sand | | | | | | | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 311.07 | VC-B07-311 | VC | 7 | 6 | Sand | | | | | | | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 311.824 | CPT-B07-312 | CPT | 7 | 5.12 | Sand | Medium Dense to Dense | | | | | | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 311.826 | VC-B07-312 | VC | 7 | 6 | Sand | | | | | | | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 313.07 | VC-B07-313 | VC | 7 | 5.81 | Sand | | | | | | | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 313.622 | CPT-B07-314 | CPT | 7 | 5.3 | Sand | Very Loose to Medium Dense | | | | | | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 313.623 | VC-B07-314 | VC | 7 | 6 | Sand | | | | | | | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 315.07 | VC-B07-315 | VC | 7 | 6 | Sand | | | | | | | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 316.067 | CPT-B07-316 | CPT | 7 | 5.18 | Sand | Very Loose to Medium Dense | | | | | | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 316.07 | VC-B07-316 | VC | 7 | 6 | Sand | | | | | | | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 317 | VC-B07-317 | VC | 7 | 4.13 | Sand | | | | | | | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 318.07 | VC-B07-318 | VC | 7 | 4.87 | Sand | | | 0.73 | Silt | | Extremely Low | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 318.071 | CPT-B07-318 | CPT | 7 | 5.26 | Sand | Loose to Medium Dense | | | | | | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 319.07 | VC-B07-319 | VC | 7 | 4.51 | Sand | | | | | | | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 320.069 | CPT-B07-320 | CPT | 7 | 5.3 | Sand | Very Loose to Dense | | | | | | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 320.07 | VC-B07-320 | VC | 7 | 4.25 | Sand | | | | | | | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 321.071 | VC-B07-321 | VC | 7 | 6 | Sand | | | | | | | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 322.07 | VC-B07-322 | VC | 7 | 6 | Sand | | | | | | | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 322.07 | CPT-B07-322 | CPT | 7 | 5.26 | Sand | Loose to Medium Dense | | | | | | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 323.072 | VC-B07-323 | VC | 7 | 4.54 | Sand | | | | | | | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 323.788 | VC-B07-324 | VC | 7 | 5.54 | Sand | | | | | | | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 323.788 | CPT-B07-324 | CPT | 7 | 5.26 | Sand | Loose to Medium Dense | | | | | | | | | |
| 25 | Medium Dense Sand with Loose Sand Veneer (0.3m) | 325.07 | VC-B07-325 | VC | 7 | 6 | Sand | | | | | | | | | | |
| 26 | Very Loose Sand | 326.07 | CPT-B07-326 | CPT | 8 | 5.26 | Sand | Very Loose to Medium Dense | | | | | | | | | |
| 26 | Very Loose Sand | 326.072 | VC-B07-326 | VC | 8 | 5.61 | Sand | | | | | | | | | | |
| 26 | Very Loose Sand | 327.071 | VC-B07-327 | VC | 8 | 5.58 | Sand | | | | | | | | | | |
| 26 | Very Loose Sand | 328.07 | VC-B07-328 | VC | 8 | 5.36 | Sand | | | | | | | | | | |
| 26 | Very Loose Sand | 328.07 | CPT-B07-328 | CPT | 8 | 5.26 | Sand | Very Loose to Loose | | | | | | | | | |
| 27 | Very Low to Low Strength Silty Sand with Extremely Low Strength Veneer (0.4m) | 329.07 | VC-B07-329 | VC | 8 | 5.47 | Silty Sand | | Extremely Low | | | | | | | | |
| 27 | Very Low to Low Strength Silty Sand with Extremely Low Strength Veneer (0.4m) | 330.071 | VC-B07-330 | VC | 8 | 5.95 | Silty Sand | | Extremely Low | | | | | | | | |
| 27 | Very Low to Low Strength Silty Sand with Extremely Low Strength Veneer (0.4m) | 330.071 | CPT-B07-330 | CPT | 8 | 1.46 | Silty Sand | | Very Low with Extremely Low Veneer (0.3m) | 3.8 | Sand | Very Loose to Loose | | | | | |
| 27 | Very Low to Low Strength Silty Sand with Extremely Low Strength Veneer (0.4m) | 331.11 | VC-B07-331 | VC | 8 | 6 | Silty Sand | | Extremely Low | | | | | | | | |
| 27 | Very Low to Low Strength Silty Sand with Extremely Low Strength Veneer (0.4m) | 332.09 | VC-B07-332 | VC | 8 | 6 | Silty Sand | | Extremely Low | | | | | | | | |
| 27 | Very Low to Low Strength Silty Sand with Extremely Low Strength Veneer (0.4m) | 332.091 | CPT-B07-332 | CPT | 8 | 1.44 | Silty Sand | | Very Low with Extremely Low Veneer (0.3m) | 3.82 | Sand | Very Loose to Loose | | | | | |
| 27 | Very Low to Low Strength Silty Sand with Extremely Low Strength Veneer (0.4m) | 333.072 | VC-B07-333 | VC | 8 | 5 | Sand | | | | | | | | | | |
| 27 | Very Low to Low Strength Silty Sand with Extremely Low Strength Veneer (0.4m) | 334.07 | VC-B07-334 | VC | 8 | 6 | Sand | | | | | | | | | | |
| 27 | Very Low to Low Strength Silty Sand with Extremely Low Strength Veneer (0.4m) | 334.071 | CPT-B07-334 | CPT | 8 | 1.78 | Silty Sand | | Very Low with Extremely Low Veneer (0.3m) | 3.64 | Sand | Very Loose to Loose | | | | | |
| 27 | Very Low to Low Strength Silty Sand with Extremely Low Strength Veneer (0.4m) | 335.071 | VC-B07-335 | VC | 8 | 5.87 | Silty Sand | | Extremely Low | | | | | | | | |
| 27 | Very Low to Low Strength Silty Sand with Extremely Low Strength Veneer (0.4m) | 336.07 | CPT-B07-336 | CPT | 8 | 1.46 | Silty Sand | | Very Low with Extremely Low Veneer (0.3m) | 3.88 | Sand | Very Loose to Loose | | | | | |
| 27 | Very Low to Low Strength Silty Sand with Extremely Low Strength Veneer (0.4m) | 336.071 | VC-B07-336 | VC | 8 | 5.87 | Silty Sand | | Extremely Low | | | | | | | | |
| 27 | Very Low to Low Strength Silty Sand with Extremely Low Strength Veneer (0.4m) | 337.07 | VC-B07-337 | VC | 8 | 5.98 | Silty Sand | | Extremely Low | | | | | | | | |
| 27 | Very Low to Low Strength Silty Sand with Extremely Low Strength Veneer (0.4m) | 338.069 | CPT-B07-338 | CPT | 8 | 1.42 | Silty Sand | | Very Low with Extremely Low Veneer (0.3m) | 3.9 | Sand | Very Loose to Loose | | | | | |
| 27 | Very Low to Low Strength Silty Sand with Extremely Low Strength Veneer (0.4m) | 338.071 | VC-B07-338 | VC | 8 | 0.99 | Silty Sand | | Extremely Low | 5.01 | Sand | | | | | | |
| 27 | Very Low to Low Strength Silty Sand with Extremely Low Strength Veneer (0.4m) | 339.071 | VC-B07-339 | VC | 8 | 0.95 | Silty Sand | | Extremely Low | 5.05 | Sand | | | | | | |
| 27 | Very Low to Low Strength Silty Sand with Extremely Low Strength Veneer (0.4m) | 340.068 | VC-B07-340 | VC | 8 | 0.96 | Silty Sand | | | 4.8 | Sand | | | | | | |
| 27 | Very Low to Low Strength Silty Sand with Extremely Low Strength Veneer (0.4m) | 340.069 | CPT-B07-340 | CPT | 8 | 2.04 | Silty Sand | | Very Low with Extremely Low Veneer (0.3m) | 2.34 | Sand | Very Loose to Loose | | | | | |
| 27 | Very Low to Low Strength Silty Sand with Extremely Low Strength Veneer (0.4m) | 341.07 | VC-B07-341 | VC | 8 | 0.94 | Silty Sand | | Extremely Low | 4.96 | Sand | | | | | | |
| 27 | Very Low to Low Strength Silty Sand with Extremely Low Strength Veneer (0.4m) | 342.07 | VC-B07-342 | VC | 8 | 0.95 | Silty Sand | | Extremely Low | 5.05 | Sand | | | | | | |
| 27 | Very Low to Low Strength Silty Sand with Extremely Low Strength Veneer (0.4m) | 342.07 | CPT-B07-342 | CPT | 8 | 1.52 | Silty Sand | | Very Low with Extremely Low Veneer (0.4m) | 3.86 | Sand | Very Loose to Loose | | | | | |
| 27 | Very Low to Low Strength Silty Sand with Extremely Low Strength Veneer (0.4m) | 343.07 | VC-B07-343 | VC | 8 | 0.95 | Silty Sand | | Extremely Low | 5.05 | Sand | | | | | | |
| 27 | Very Low to Low Strength Silty Sand with Extremely Low Strength Veneer (0.4m) | 344.07 | CPT-B07-344 | CPT | 8 | 1.52 | Silty Sand | | Very Low with Extremely Low Veneer (0.4m) | 3.86 | Sand | Very Loose to Loose | | | | | |
| 27 | Very Low to Low Strength Silty Sand with Extremely Low Strength Veneer (0.4m) | 344.073 | VC-B07-344 | VC | 8 | 0.9 | Silty Sand | | Extremely Low | 5.1 | Sand | | | | | | |
| 27 | Very Low to Low Strength Silty Sand with Extremely Low Strength Veneer (0.4m) | 345.07 | VC-B07-345 | VC | 8 | 5.62 | Silty Sand | | Extremely Low | | | | | | | | |
| 27 | Very Low to Low Strength Silty Sand with Extremely Low Strength Veneer (0.4m) | 346.07 | VC-B07-346 | VC | 8 | 0.88 | Silty Sand | | Extremely Low | 4.39 | Sand | | | | | | |
| 27 | Very Low to Low Strength Silty Sand with Extremely Low Strength Veneer (0.4m) | 346.07 | CPT-B07-346 | CPT | 8 | 1.6 | Silty Sand | | Very Low with Extremely Low Veneer (0.4m) | 2.26 | Sand | Very Loose to Loose | | 1.32 | Silt Sand | | Extremely Low to Low |
| 27 | Very Low to Low Strength Silty Sand with Extremely Low Strength Veneer (0.4m) | 347.068 | VC-B07-347B | VC | 8 | 4.19 | Silty Sand | | | | | | | | | | |
| 27 | Very Low to Low Strength Silty Sand with Extremely Low Strength Veneer (0.4m) | 348.069 | CPT-B07-348 | CPT | 8 | 3.82 | Silty Sand | | Very Low with Extremely Low Veneer (0.4m) | 1.58 | Sand | Medium Dense to Very Dense | | | | | |
| 27 | Very Low to Low Strength Silty Sand with Extremely Low Strength Veneer (0.4m) | 348.07 | VC-B07-348 | VC | 8 | 4.87 | Silty Sand | | | | | | | | | | |
| 27 | Very Low to Low Strength Silty Sand with Extremely Low Strength Veneer (0.4m) | 349.07 | VC-B07-349 | VC | 8 | 5.49 | Sand | | | | | | | | | | |
| 27 | Very Low to Low Strength Silty Sand with Extremely Low Strength Veneer (0.4m) | 350.068 | VC-B07-350 | VC | 8 | 5.6 | Sand | | | | | | | | | | |
| 27 | Very Low to Low Strength Silty Sand with Extremely Low Strength Veneer (0.4m) | 350.07 | CPT-B07-350 | CPT | 8 | 4.04 | Silty Sand | | Very Low with Extremely Low Veneer (0.4m) | 1.34 | Sand | Very Dense | | | | | |
| 27 | Very Low to Low Strength Silty Sand with Extremely Low Strength Veneer (0.4m) | 351.071 | VC-B08-351 | VC | 7 | 5.98 | Sand | | | | | | | | | | |
| 27 | Very Low to Low Strength Silty Sand with Extremely Low Strength Veneer (0.4m) | 352.068 | CPT-B08-352 | CPT | 7 | 3.58 | Silty Sand | | Very Low with Extremely Low Veneer (0.4m) | 1.76 | Sand | Dense | | | | | |
| 28 | Very Low Strength Sandy Clay with Extremely Low Strength Veneer (0.4m) | 352.07 | VC-B08-352 | VC | 9 | 1.96 | Clay | | Extremely Low | 2.04 | Gravelly Clay | | Extremely Low | | | | |
| 28 | Very Low Strength Sandy Clay with Extremely Low Strength Veneer (0.4m) | 352.766 | VC-B08-353 | VC | 8 | 2.81 | Sandy Clay | | Extremely Low | 0.99 | Sandy Gravel | | | | | | |
| 28 | Very Low Strength Sandy Clay with Extremely Low Strength Veneer (0.4m) | 354.069 | VC-B08-354 | VC | 9 | 5 | Sandy Clay | | Very Low | | | | | | | | |
| 28 | Very Low Strength Sandy Clay with Extremely Low Strength Veneer (0.4m) | 354.069 | CPT-B08-354 | CPT | 8 | 3.26 | Sandy Clay | | Very Low with Extremely Low Veneer (0.4m) | 2.14 | Sand | Dense | | | | | |
| 29 | Very Low Strength Silty Sand with Extremely Low Strength Veneer (0.4m) | 355.069 | VC-B08-355 | VC | 8 | 5 | Coarse Sand | | | | | | | | | | |
| 29 | Very Low Strength Silty Sand with Extremely Low Strength Veneer (0.4m) | 356.068 | CPT-B08-356 | CPT | 8 | 2.94 | Silty Sand | | Very Low with Extremely Low Veneer (0.5m) | 2.18 | Sand | Dense | | | | | |
| 29 | Very Low Strength Silty Sand with Extremely Low Strength Veneer (0.4m) | 356.07 | VC-B08-356 | VC | 9 | 4.86 | Silty Sand | | Extremely Low | | | | | | | | |
| 29 | Very Low Strength Silty Sand with Extremely Low Strength Veneer (0.4m) | 357.069 | VC-B08-357 | VC | 9 | 3.64 | Silty Sand | | Very Low | | | | | | | | |
| 29 | Very Low Strength Silty Sand with Extremely Low Strength Veneer (0.4m) | 358.068 | CPT-B08-358 | CPT | 8 | 2.38 | Silty Sand | | Very Low with Extremely Low Veneer (0.5m) | 3.04 | Sand | Dense to Very Dense | | | | | |
| 29 | Very Low Strength Silty Sand with Extremely Low Strength Veneer (0.4m) | 358.07 | VC-B08-358 | VC | 9 | 5.51 | Silty Sand | | Very Low | | | | | | | | |
| 29 | Very Low Strength Silty Sand with Extremely Low Strength Veneer (0.4m) | 359.072 | VC-B08-359 | VC | 8 | 5.49 | Silty Sand | | Very Low | | | | | | | | |
| 29 | Very Low Strength Silty Sand with Extremely Low Strength Veneer (0.4m) | 360.069 | CPT-B08-360 | CPT | 8 | 2.34 | Silty Sand | | Very Low with Extremely Low Veneer (0.5m) | 2.84 | Sand | Dense to Very Dense | | | | | |
| 30 | Very Low Strength Silty Sand/Clay | 360.07 | VC-B08-360 | VC | 9 | 1.35 | Silty Sand | | Very Low | 0.9 | Clay | | | 2.45 | Sand | | |
| 30 | Very Low Strength Silty Sand/Clay | 361.07 | VC-B08-361 | VC | 9 | 2.1 | Clay | | Very Low | 3.1 | Sand | | | | | | |
| 30 | Very Low Strength Silty Sand/Clay | 362.055 | VC-B08-362 | VC | 9 | 2.1 | Sandy Clay | | Very Low | 0.19 | Peat | | | 3.28 | Gravelly Sand | | |
| 31 | Very Low Strength Silty Sand with Extremely Low Strength Veneer (0.4m) | 362.069 | CPT-B08-362 | CPT | 8 | 2.1 | Sandy Clay | | Very Low with Extremely Low Veneer (0.4m) | 0.3 | Peat | | Very High | 2.04 | Sand | Very Dense | |
| 31 | Very Low Strength Silty Sand with Extremely Low Strength Veneer (0.4m) | 362.825 | VC-B08-363 | VC | 9 | 1.13 | Silty Sand | | Extremely Low | 2.24 | Sandy Clay | | Very Low | | | | |
| 31 | Very Low Strength Silty Sand with Extremely Low Strength Veneer (0.4m) | 364.069 | CPT-B08-364 | CPT | 8 | 1.8 | Silty Sand | | Very Low with Extremely Low Veneer (0.4m) | 3.58 | Silty Sand | Dense to Very Dense | | | | | |
| 32 | Very Low Strength Clay | 364.07 | VC-B08-364 | VC | 9 | 2.22 | Clay | | Very Low | 1.96 | Sand | | | | | | |
| 32 | Very Low Strength Clay | 365.07 | VC-B08-365 | VC | 8 | 2 | Clay | | Very Low | 3.02 | Sand | | | | | | |
| 32 | Very Low Strength Clay | 366.069 | VC-B08-366 | VC | 8 | 1.6 | Clay | | Very Low | 2.96 | Sand | | | | | | |
| 33 | Very Low Strength Silty Sand with Extremely Low Strength Veneer (0.4m) | 366.07 | CPT-B08-366 | CPT | 8 | 1.52 | Silty Sand | | Very Low with Extremely Low Veneer (0.4m) | 3.7 | Sand | Very Dense | | | | | |
| 33 | Very Low Strength Silty Sand with Extremely Low Strength Veneer (0.4m) | 367.069 | VC-B08-367 | VC | 9 | 2.2 | Clay | | Very Low | 2.96 | Sand | | | | | | |
| 33 | Very Low Strength Silty Sand with Extremely Low Strength Veneer (0.4m) | 368.07 | CPT-B08-368 | CPT | 7 | 1.4 | Silty Sand | | Very Low with Extremely Low Veneer (0.4m) | 0.78 | Sand | Very Loose to Dense | | 3.9 | Sand | Very Dense | |
| 34 | Very Low Strength Clay | 368.072 | VC-B08-368 | VC | 7 | 1.34 | Clay | | Very Low | 2.15 | Sand | | | | | | |
| 34 | Very Low Strength Clay | 369.069 | VC-B08-369 | VC | 7 | 1.2 | Clay | | Very Low | 3.05 | Sand | | | | | | |
| 34 | Very Low Strength Clay | 370.069 | VC-B08-370 | VC | 6 | 0.65 | Clay | | Very Low | 4.78 | Sand | | | | | | |
| 35 | Very Low Strength Silty Sand/Clay with Extremely Low Strength Veneer (0.4m) | 370.07 | CPT-B08-370 | CPT | 6 | 1.2 | Clay | | Very Low with Extremely Low Veneer (0.4m) | 4.1 | Sand | Medium Dense to Very Dense | | | | | |
| 35 | Very Low Strength Silty Sand/Clay with Extremely Low Strength Veneer (0.4m) | 371.07 | VC-B08-371 | VC | 6 | 4.51 | Silty Sand | | Extremely Low | | | | | | | | |
| 35 | Very Low Strength Silty Sand/Clay with Extremely Low Strength Veneer (0.4m) | 371.517 | VC-B08-372 | VC | 8 | 1.21 | Silty Sand | | Extremely Low | 0.24 | Peat | | | 1.77 | Silty Sand | | |
| 35 | Very Low Strength Silty Sand/Clay with Extremely Low Strength Veneer (0.4m) | 371.518 | CPT-B08-372 | CPT | 8 | 1.26 | Silty Sand | | Very Low with Extremely Low Veneer (0.4m) | 0.2 | Peat | | | 3.86 | Silty Sand | Loose to Medium Dense | |
| 35 | Very Low Strength Silty Sand/Clay with Extremely Low Strength Veneer (0.4m) | 373.211 | VC-B08-373 | VC | 8 | 1.95 | Silty Sand | | Very Low | 0.54 | Clay | | Medium | 2.51 | Silty Sand | | |
| 35 | Very Low Strength Silty Sand/Clay with Extremely Low Strength Veneer (0.4m) | 373.769 | VC-B08-374 | VC | 7 | 1.51 | Clay | | Very Low | 3.73 | Sand | | | | | | |
| 35 | Very Low Strength Silty Sand/Clay with Extremely Low Strength Veneer (0.4m) | 373.769 | CPT-B08-374 | CPT | 7 | 1.66 | Silty Sand | | Very Low with Extremely Low Veneer (0.4m) | | | | | | | | |
| 35 | Very Low Strength Silty Sand/Clay with Extremely Low Strength Veneer (0.6m) | 375.196 | VC-B08-375 | VC | 7 | 1.34 | Clay | | Very Low | 3.87 | Sand | | | | | | |
| 35 | Very Low Strength Silty Sand/Clay with Extremely Low Strength Veneer (0.6m) | 376.07 | CPT-B08-376 | CPT | 8 | 1.78 | Silty Sand | | Very Low with Extremely Low Veneer (0.6m) | 2.82 | Sand | Very Dense | | | | | |
| 35 | Very Low Strength Silty Sand/Clay with Extremely Low Strength Veneer (0.6m) | 376.071 | VC-B08-376 | VC | 8 | 1.45 | Clay | | Very Low | 3.69 | Sand | | | | | | |
| 35 | Very Low Strength Silty Sand/Clay with Extremely Low Strength Veneer (0.6m) | 377.071 | VC-B08-377 | VC | 8 | 1.43 | Silty Sand | | Very Low | 3.41 | Sand | | | | | | |
| 35 | Very Low Strength Silty Sand/Clay with Extremely Low Strength Veneer (0.6m) | 378.071 | CPT-B08-378 | CPT | 9 | 1.76 | Silty Sand | | Very Low with Extremely Low Veneer (0.6m) | 3.36 | Sand | Very Dense | | | | | |
| 35 | Very Low Strength Silty Sand/Clay with Extremely Low Strength Veneer (0.6m) | 378.072 | VC-B08-378 | VC | 8 | 1.47 | Clay | | Very Low | 4.36 | Sand | | | | | | |
| 35 | Very Low Strength Silty Sand/Clay with Extremely Low Strength Veneer (0.6m) | 379.495 | VC-B08-379 | VC | 9 | 1.98 | Clay | | Very Low | 3.95 | Sand | | | | | | |
| 35 | Very Low Strength Silty Sand/Clay with Extremely Low Strength Veneer (0.6m) | 380.069 | CPT-B08-380 | CPT | 9 | 2.28 | Silty Sand | | Very Low with Extremely Low Veneer (0.6m) | 0.38 | Peat | | | 2.56 | Sand | Medium to Very Dense | |
| 35 | Very Low Strength Silty Sand/Clay with Extremely Low Strength Veneer (0.6m) | 380.071 | VC-B08-380 | VC | 9 | 1.6 | Clay | | Very Low | 0.77 | Peat | | | 0.15 | Sand | | |
| 35 | Very Low Strength Silty Sand/Clay with Extremely Low Strength Veneer (0.6m) | 380.949 | VC-B08-381 | VC | 9 | 1.57 | Clay | | Very Low | 3.77 | Sand | | | | | | |
| 35 | Very Low Strength Silty Sand/Clay with Extremely Low Strength Veneer (0.6m) | 382.07 | VC-B08-382 | VC | 9 | 2.2 | Clay | | Very Low | 3.67 | Sand | | | | | | |
| 36 | Very Low Strength Clay | 382.07 | CPT-B08-382 | CPT | 9 | 1.82 | Clay | | Very Low to Medium | 3.58 | Sand | Medium Dense to Very Dense | | | | | |
| 36 | Very Low Strength Clay | 383.072 | VC-B08-383 | VC | 9 | 2.16 | Silty Sandy Clay | | Very Low | 0.19 | Peat | | | 2.71 | Sand | | |
| 36 | Very Low Strength Clay | 383.695 | CPT-B08-384 | CPT | 9 | 2.28 | Silty Sandy Clay | | Very Low | 3.12 | Sand | Medium Dense to Very Dense | | | | | |
| 36 | Very Low Strength Clay | 383.7 | VC-B08-384 | VC | 9 | 1.64 | Silty Sand | | Very Low | 3.82 | Sand | | | | | | |
| 36 | Very Low Strength Clay | 385.073 | VC-B08-385 | VC | 9 | 2.39 | Clay | | Very Low | 3.29 | Sand | | | | | | |
| 36 | Very Low Strength Clay | 386.068 | VC-B08-386 | VC | 9 | 1.78 | Sandy Clay | | Very Low | 0.92 | Clay | | Very Low | 2.91 | Silt | | |
| 36 | Very Low Strength Clay | 386.07 | CPT-B08-386 | CPT | 9 | 2.46 | Clay | | Very Low | 2.94 | Clay | | Medium to High | | | | |
| 36 | Very Low Strength Clay | 387.068 | VC-B08-387 | VC | 9 | 0.96 | Clay | | Very Low | 3.53 | Sand | | | | | | |
| 36 | Very Low Strength Clay | 388.067 | VC-B08-388 | VC | 9 | 2.36 | Clay | | Low | 3.03 | Sand | | | | | | |
| 37 | Extremely Low Strength Clay with Extremely Low Veneer (0.5m) | 388.068 | CPT-B08-388 | CPT | 9 | 2.02 | Clay | | Very Low with Extremely Low Veneer (0.5m) | 3.22 | Sand | Dense to Very Dense | | | | | |
| 37 | Extremely Low Strength Clay with Extremely Low Veneer (0.5m) | 388.634 | VC-B08-389 | VC | 9 | 1.6 | Clay | | Very Low | 4.28 | Sand | | | | | | |
| 37 | Extremely Low Strength Clay with Extremely Low Veneer (0.5m) | 390.069 | CPT-B08-390 | CPT | 9 | 2.4 | Clay | | Very Low with Extremely Low Veneer (0.5m) | 2.2 | Peat | | Medium to High | 2.64 | Sand | Dense to Very Dense | |
| 38 | Very Low Strength Clay | 390.07 | VC-B08-390 | VC | 9 | 2.29 | Clay | | Low | 0.13 | Peat | | | 3.38 | Sand | | |
| 38 | Very Low Strength Clay | 391.07 | VC-B08-391 | VC | 9 | 2.55 | Clay | | Low | 0.15 | Peat | | | 2.94 | Sand | | |
| 38 | Very Low Strength Clay | 392.068 | CPT-B08-392 | CPT | 9 | 2.9 | Clay | | Very Low | 1.34 | Sand | Dense to Very Dense | | | | | |
| 38 | Very Low Strength Clay | 392.07 | VC-B08-392 | VC | 9 | 2.92 | Clay | | Very Low | 2.24 | Sand | | | | | | |
| 38 | Very Low Strength Clay | 393.071 | VC-B08-393 | VC | 9 | 3.32 | Clay | | Very Low | 1.21 | Sand | | | | | | |
| 38 | Very Low Strength Clay | 394.069 | CPT-B08-394 | CPT | 9 | 2.7 | Clay | | Very Low | 2.44 | Sand | Dense to Very Dense | | | | | |
| 38 | Very Low Strength Clay | 394.072 | VC-B08-394 | VC | 9 | 2.9 | Clay | | Very Low | 2.1 | Sand | | | | | | |
| 38 | Very Low Strength Clay | 395.07 | VC-B08-395 | VC | 9 | 3.42 | Clay | | Very Low | 1.07 | Sand | | | | | | |
| 38 | Very Low Strength Clay | 396.071 | VC-B08-396 | VC | 9 | 5.43 | Sandy Clay | | Very Low | | | | | | | | |
| 38 | Very Low Strength Clay | 396.071 | CPT-B08-396 | CPT | 9 | 2.72 | Clay | | Very Low | 1.82 | Silty Sand | Medium Dense to Very Dense | | | | | |
| 38 | Very Low Strength Clay | 397.072 | VC-B08-397 | VC | 9 | 2.16 | Clay | | Very Low | 1.19 | Silty Sand | | Very Low | | | | |
| 38 | Very Low Strength Clay | 398.069 | CPT-B08-398 | CPT | 9 | 2.8 | Clay | | Extremely Low to Medium | 2.6 | Sand | Medium Dense to Very Dense | | | | | |
| 38 | Very Low Strength Clay | 398.07 | VC-B08-398 | VC | 9 | 2.86 | Clay | | Very Low | 2.14 | Silty Sand | | | | | | |
| 38 | Very Low Strength Clay | 399.07 | VC-B08-399 | VC | 9 | 2.72 | Clay | | Very Low | 1.46 | Silty Sand | | | | | | |
| 38 | Very Low Strength Clay | 400.07 | VC-B08-400 | VC | 9 | 2.8 | Clay | | Very Low | 0.1 | Peat | | | 1.11 | Sand | | |
| 38 | Very Low Strength Clay | 400.07 | CPT-B08-400 | CPT | 9 | 2.94 | Clay | | Very Low High | 0.14 | Peat | | High | 2.1 | Sand | Medium to Very Dense | |
| 39 | Very Loose Silty Sand | 401.07 | VC-B09-401 | VC | 8 | 3.29 | Silty Sand | | Extremely Low | 0.32 | Clay | | Low | 1.07 | | | |
| 39 | Very Loose Silty Sand | 402.07 | VC-B09-402 | VC | 8 | 3.94 | Silty Sand | | Very Low | 0.86 | Clay | | Low | | | | |

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| 39 | Very Loose Silty Sand | 402.071 | CPT-B09-402 | CPT | 8 | 2.66 | Silty Sand | Very Loose | | 2.1 | Clay | | Medium to High | 0.22 | Peat | | |
| 39 | Very Loose Silty Sand | 402.579 | VC-B09-403 | VC | 8 | 4.55 | Silty Sand | | Very Low | 1.44 | Clay | | Low | | | | |
| 39 | Very Loose Silty Sand | 404.346 | CPT-B09-404 | CPT | 8 | 2.58 | Silty Sand | Very Loose | | 2.08 | Clay | | Medium to Very High | 0.32 | Peat | | Very High |
| 39 | Very Loose Silty Sand | 404.348 | VC-B09-404 | VC | 8 | 2.56 | Silty Gravelly Sand | | Very Low | 1.44 | Silty Clay | | Very Low | 0.55 | Clay | | |
| 39 | Very Loose Silty Sand | 404.818 | VC-B09-405 | VC | 8 | 2.6 | Silty Sand | | Very Low | 2.6 | Clay | | Low | 0.36 | Peat | | |
| 39 | Very Loose Silty Sand | 406.33 | CPT-B09-406 | CPT | 8 | 3.9 | Silty Sand | Very Loose | | 0.12 | Peat | | Medium | 1.18 | Sand | | Very Loose to Dense |
| 39 | Very Loose Silty Sand | 406.331 | VC-B09-406 | VC | 8 | 2.9 | Silty Sand | | Extremely Low | 1.02 | Clay | | Low | 0.91 | Sand | | |
| 39 | Very Loose Silty Sand | 407.069 | VC-B09-407 | VC | 9 | 1.15 | Silty Sand | | Extremely Low | 2.2 | Clay | | Low | 1.3 | Clay | | |
| 40 | Very Low Strength Clay with Extremely Low Veneer (0.6m) | 408.07 | VC-B09-408 | VC | 9 | 2.54 | Clay | | Very Low | 0.49 | Peat | | | 0.31 | Sand | | |
| 40 | Very Low Strength Clay with Extremely Low Veneer (0.6m) | 408.161 | CPT-B09-408 | CPT | 9 | 3.36 | Silty Clay | | Very Low with Extremely Low Veneer (0.6m) | 0.32 | Peat | | | 1.54 | Sand | Loose to Very Dense | |
| 40 | Very Low Strength Clay with Extremely Low Veneer (0.6m) | 409.07 | VC-B09-409 | VC | 9 | 2.61 | Clay | | Very Low | 0.8 | Peat | | | 2.24 | Sand | | |
| 40 | Very Low Strength Clay with Extremely Low Veneer (0.6m) | 410.233 | VC-B09-410 | VC | 9 | 4.14 | Clay | | Very Low | 0.66 | Peat | | | | | | |
| 40 | Very Low Strength Clay with Extremely Low Veneer (0.6m) | 410.233 | CPT-B09-410 | CPT | 9 | 4.12 | Clay | | Very Low with Extremely Low Veneer (0.6m) | 1.08 | Clayey Peat | | Medium | | | | |
| 40 | Very Low Strength Clay with Extremely Low Veneer (0.6m) | 411.171 | VC-B09-411 | VC | 9 | 2.01 | Clay | | Very Low | 2.35 | Peat | | Low | 0.75 | | | |
| 40 | Very Low Strength Clay with Extremely Low Veneer (0.6m) | 412.07 | CPT-B09-412 | CPT | 9 | 2.9 | Clay | | Very Low with Extremely Low Veneer (0.6m) | 2.32 | Sand | Very Dense | | | | | |
| 40 | Very Low Strength Clay with Extremely Low Veneer (0.6m) | 412.071 | VC-B09-412 | VC | 9 | 2.87 | Clay | | Very Low | 1.58 | Sand | | | | | | |
| 40 | Very Low Strength Clay with Extremely Low Veneer (0.6m) | 413.05 | VC-B09-413 | VC | 9 | 2.48 | Clay | | Very Low | 1.2 | Sand | | | | | | |
| 40 | Very Low Strength Clay with Extremely Low Veneer (0.6m) | 414.07 | CPT-B09-414 | CPT | 9 | 2.88 | Clay | | Very Low with Extremely Low Veneer (0.6m) | 2.34 | Sand | Very Dense | | | | | |
| 40 | Very Low Strength Clay with Extremely Low Veneer (0.6m) | 414.072 | VC-B09-414 | VC | 9 | 2.62 | Clay | | Very Low | 1.72 | Silty Sand | | | | | | |
| 40 | Very Low Strength Clay with Extremely Low Veneer (0.6m) | 414.988 | VC-B09-415 | VC | 9 | 2.4 | Clay | | Very Low | 2.49 | Sand | | | | | | |
| 40 | Very Low Strength Clay with Extremely Low Veneer (0.6m) | 416.242 | CPT-B09-416 | CPT | 9 | 2.56 | Clay | | Very Low with Extremely Low Veneer (0.6m) | 1.36 | Sand | Very Dense | | | | | |
| 41 | Very Low Strength Clay/Sandy Clay | 416.243 | VC-B09-416 | VC | 9 | 2.53 | Clay | | Very Low | 1.11 | Sand | | | | | | |
| 41 | Very Low Strength Clay/Sandy Clay | 417.07 | VC-B09-417 | VC | 9 | 0.9 | Clay | | Very Low | 4.01 | Sand | | | | | | |
| 41 | Very Low Strength Clay/Sandy Clay | 418.068 | CPT-B09-418 | CPT | 9 | 2.86 | Clay | | Very Low | 1.36 | Sand | Very Dense | | | | | |
| 41 | Very Low Strength Clay/Sandy Clay | 418.07 | VC-B09-418 | VC | 9 | 2.4 | Clay | | Very Low | 2.41 | Sand | | | | | | |
| 41 | Very Low Strength Clay/Sandy Clay | 418.789 | VC-B09-419 | VC | 9 | 2.15 | Clay | | Very Low | 0.83 | Sand | | | 0.31 | Clay | | |
| 41 | Very Low Strength Clay/Sandy Clay | 420.238 | CPT-B09-420 | CPT | 9 | 2.62 | Clay | | Very Low | 2.82 | Sand | Medium Dense to Very Dense | | | | | |
| 41 | Very Low Strength Clay/Sandy Clay | 420.24 | VC-B09-420 | VC | 9 | 2.98 | Silty Sand | | Extremely Low | 0.33 | Clay | | Medium | 2.61 | Sand | | |
| 41 | Very Low Strength Clay/Sandy Clay | 421.07 | VC-B09-421 | VC | 9 | 2.78 | Sandy Clay | | Very Low | 2.77 | Sand | | | | | | |
| 41 | Very Low Strength Clay/Sandy Clay | 422.069 | CPT-B09-422 | CPT | 9 | 2.52 | Sandy Clay | | Very Low | 0.72 | Sand | Medium Dense | | 1.66 | Clay | | Medium to Very High |
| 41 | Very Low Strength Clay/Sandy Clay | 422.07 | VC-B09-422 | VC | 9 | 2.38 | Sandy Clay | | Very Low | 3.01 | Sand | | | | | | |
| 41 | Very Low Strength Clay/Sandy Clay | 423.459 | VC-B09-423 | VC | 9 | 2.6 | Sandy Clay | | Very Low | 0.66 | Sand | | | 1.27 | Clay | | |
| 41 | Very Low Strength Clay/Sandy Clay | 424.07 | VC-B09-424 | VC | 9 | 5.68 | Sandy Clay | | Very Low | | | | | | | | |
| 41 | Very Low Strength Clay/Sandy Clay | 424.07 | CPT-B09-424 | CPT | 9 | 2.2 | Sandy Clay | | Very Low to Medium | 0.38 | Sand | Loose | | 2.28 | Sand | Dense to Very Dense | |
| 41 | Very Low Strength Clay/Sandy Clay | 424.819 | VC-B09-425 | VC | 9 | 2.5 | Sandy Clay | | Very Low | 3.73 | Sand | | | | | | |
| 41 | Very Low Strength Clay/Sandy Clay | 425.966 | VC-B09-426 | VC | 9 | 2.32 | Sandy Clay | | Very Low | 2.58 | Sand | | | | | | |
| 41 | Very Low Strength Clay/Sandy Clay | 425.969 | CPT-B09-426 | CPT | 9 | 1.92 | Sandy Clay | | | 0.44 | Sand | Very Loose | | 0.64 | Sand | Medium to Very Dense | |
| 41 | Very Low Strength Clay/Sandy Clay | 427.138 | VC-B09-427 | VC | 9 | 2.09 | Sandy Clay | | Very Low | 0.83 | Silt | | Low | 0.32 | Peat | | |
| 41 | Very Low Strength Clay/Sandy Clay | 427.704 | CPT-B09-428 | CPT | 9 | 2.28 | Clay | | Very Low | 0.74 | Sand | Very Loose | | 1.44 | Clay | | Medium to High |
| 41 | Very Low Strength Clay/Sandy Clay | 427.706 | VC-B09-428 | VC | 9 | 2.48 | Sandy Clay | | Very Low | 0.52 | Sand | | | 2.06 | Clay | | |
| 41 | Very Low Strength Clay/Sandy Clay | 429.068 | VC-B09-429 | VC | 9 | 1.76 | Sandy Clay | | Very Low | 3.1 | Sand | | | | | | |
| 41 | Very Low Strength Clay/Sandy Clay with Extremely Low Veneer (0.5m) | 430.07 | VC-B09-430 | VC | 9 | 1.44 | Sandy Clay | | Very Low | 3.02 | Sand | | | | | | |
| 42 | Very Low Strength Clay/Sandy Clay with Extremely Low Veneer (0.5m) | 430.07 | CPT-B09-430 | CPT | 9 | 1.6 | Clay | | Very Low with Extremely Low Veneer (0.5m) | 3.8 | Sand | Very Dense | | | | | |
| 42 | Very Low Strength Clay/Sandy Clay with Extremely Low Veneer (0.5m) | 431.206 | VC-B09-431 | VC | 8 | 1.49 | Sandy Clay | | Very Low | 2.79 | Sand | | | | | | |
| 42 | Very Low Strength Clay/Sandy Clay with Extremely Low Veneer (0.5m) | 432.068 | CPT-B09-432 | CPT | 9 | 1.58 | Clay | | Very Low with Extremely Low Veneer (0.5m) | 3.82 | Sand | Medium Dense to Very Dense | | | | | |
| 42 | Very Low Strength Clay/Sandy Clay with Extremely Low Veneer (0.5m) | 432.07 | VC-B09-432 | VC | 9 | 1.63 | Sandy Clay | | Extremely Low | 2.96 | Sand | | | | | | |
| 42 | Very Low Strength Clay/Sandy Clay with Extremely Low Veneer (0.5m) | 432.768 | VC-B09-433 | VC | 9 | 1.88 | Sandy Clay | | Very Low | 2.45 | Sand with thin bands of Clay | | Low | | | | |
| 42 | Very Low Strength Clay/Sandy Clay with Extremely Low Veneer (0.5m) | 434.706 | CPT-B09-434 | CPT | 8 | 1.12 | Clay | | Very Low with Extremely Low Veneer (0.5m) | 1.04 | Sand | Medium Dense to Very Dense | | 0.36 | Clay | | Medium to High |
| 43 | Very Low Strength Clay/Sandy Clay with Extremely Low Veneer (0.5m) | 434.707 | VC-B09-434 | VC | 8 | 0.84 | Sandy Clay | | Very Low | 1.32 | Sand | | | | | | |
| 43 | Very Low Strength Clay/Sandy Clay | 435.364 | VC-B09-435 | VC | 8 | 0.7 | Sandy Clay | | Very Low | 1.04 | Peat | | | 0.43 | Sandy Silt | | |
| 43 | Very Low Strength Clay/Sandy Clay | 436.069 | CPT-B09-436 | CPT | 6 | 0.92 | Clay | | Very Low | 3.48 | Sand | Medium Dense to Very Dense | | | | | |
| 43 | Very Low Strength Clay/Sandy Clay | 436.072 | VC-B09-436 | VC | 6 | 1.13 | Sandy Clay | | Very Low | 3.3 | Sand | | | | | | |
| 43 | Very Low Strength Clay/Sandy Clay | 436.902 | VC-B09-437 | VC | 6 | 1.2 | Sandy Clay | | Very Low | 3.65 | Sandy Gravel | | | | | | |
| 43 | Very Low Strength Clay/Sandy Clay | 438.067 | VC-B09-438 | VC | 6 | 0.66 | Sandy Clay | | Very Low | 4.29 | Sand | | | | | | |
| 43 | Very Low Strength Clay/Sandy Clay | 438.068 | CPT-B09-438 | CPT | 6 | 1.1 | Clay | | Very Low | 1.28 | Sand | Very Loose to Dense | | 2.03 | Sand | Very Dense | |
| 43 | Very Low Strength Clay/Sandy Clay | 439.175 | VC-B10-439 | VC | 6 | 0.9 | Sandy Clay | | Very Low | 3.47 | Sand | | | | | | |
| 43 | Very Low Strength Clay/Sandy Clay | 440.173 | CPT-B10-440 | CPT | 6 | 1.14 | Sandy Clay | | Very Low | 0.78 | Sand | Very Loose to Dense | | 3.08 | Sand | Very Dense | |
| 43 | Very Low Strength Clay/Sandy Clay | 440.174 | VC-B10-440 | VC | 6 | 0.81 | Silty Sand | | Very Low | 4.29 | Sand | | | | | | |
| 44 | Very Loose Clayey Sand | 441.019 | VC-B10-441 | VC | 6 | 5.39 | Sand | | | | | | | | | | |
| 44 | Very Loose Clayey Sand | 442.299 | VC-B10-442 | VC | 5 | 4.97 | Sand/Clayey Sand | | | | | | | | | | |
| 44 | Very Loose Clayey Sand | 442.299 | CPT-B10-442 | CPT | 5 | 1.08 | Clayey Sand | Very Loose | | 4.3 | Sand | Medium Dense to Very Dense | | | | | |
| 44 | Very Loose Clayey Sand | 443.791 | VC-B10-444 | VC | 6 | 5.6 | Sand | | | | | | | | | | |
| 44 | Very Loose Clayey Sand | 443.792 | CPT-B10-444 | CPT | 6 | 0.84 | Clayey Sand | Very Loose | | 3.04 | Sand | Dense to Very Dense | | | | | |
| 45 | Loose Sand | 445.241 | VC-B10-445 | VC | 6 | 4 | Sand | | | | | | | | | | |
| 45 | Loose Sand | 446.17 | VC-B10-446 | VC | 6 | 4.9 | Sand | | | | | | | | | | |
| 45 | Loose Sand | 446.173 | CPT-B10-446 | CPT | 6 | 1.2 | Sand | Medium Dense to Dense | | 3.72 | Sand | Very Dense | | | | | |
| 45 | Loose Sand | 447.173 | VC-B10-447 | VC | 6 | 4.7 | Sand | | | | | | | | | | |
| 45 | Loose Sand | 448.173 | CPT-B10-448 | CPT | 8 | 1.8 | Sand | Very Loose to Medium Dense | | 1.9 | Clay | | Low to Very High | 1.42 | Sand | Dense to Very Dense | |
| 45 | Loose Sand | 448.174 | VC-B10-448 | VC | 8 | 6 | Sand | | | | | | | | | | |
| 45 | Loose Sand | 449.075 | VC-B10-449 | VC | 6 | 1.97 | Sand | | | 0.77 | Clay | | Very Low | 0.38 | Peat | | |
| 45 | Loose Sand | 450.123 | VC-B10-450 | VC | 6 | 5.78 | Sand | | | | | | | | | | |
| 45 | Loose Sand | 450.123 | CPT-B10-450 | CPT | 6 | 1.22 | Sand | Loose to Medium Dense | | 3.96 | Sand | Dense to Very Dense | | | | | |
| 45 | Loose Sand | 451.22 | VC-B10-451 | VC | 6 | 5.68 | Sand | | | | | | | | | | |
| 45 | Loose Sand | 452.103 | VC-B10-452 | VC | 6 | 6 | Sand | | | | | | | | | | |
| 46 | Low Strength Sandy Clay | 452.104 | CPT-B10-452 | CPT | 6 | 0.88 | Sandy Clay | | Very Low to Low | 4.42 | Sand | Very Dense | | | | | |
| 46 | Low Strength Sandy Clay | 453.173 | VC-B10-453 | VC | 6 | 5.36 | Sand | | | | | | | | | | |
| 46 | Low Strength Sandy Clay | 454.173 | VC-B10-454 | VC | 5 | 4.87 | Sand | | | | | | | | | | |
| 46 | Low Strength Sandy Clay | 454.174 | CPT-B10-454 | CPT | 5 | 0.78 | Sandy Clay | | Low to Medium | 4.58 | Sand | Very Dense | | | | | |
| 47 | Very Loose Sand | 455.478 | VC-B10-455 | VC | 6 | 5.24 | Sand | | | | | | | | | | |
| 47 | Very Loose Sand | 456.173 | VC-B10-456 | VC | 6 | 6 | Sand | | | | | | | | | | |
| 47 | Very Loose Sand | 456.174 | CPT-B10-456 | CPT | 6 | 0.86 | Clayey Sand | Very Loose | | 4.54 | Sand | Very Dense | | | | | |
| 47 | Very Loose Sand | 457.173 | VC-B10-457 | VC | 6 | 6 | Sand | | | | | | | | | | |
| 47 | Very Loose Sand | 458.173 | VC-B10-458 | VC | 6 | 5.2 | Sand | | | | | | | | | | |
| 47 | Very Loose Sand | 458.174 | CPT-B10-458 | CPT | 6 | 1.06 | Sand | Very Loose | | 4.32 | Sand | Very Dense | | | | | |
| 48 | Very Low Strength Clay/Sandy Clay with Extremely Low Veneer (0.5m) | 459.173 | VC-B10-459 | VC | 6 | 0.5 | Sandy Clay | | Extremely Low | 5.5 | Sand | | | | | | |
| 48 | Very Low Strength Clay/Sandy Clay with Extremely Low Veneer (0.5m) | 460.173 | VC-B10-460 | VC | 5 | 0.95 | Sandy Clay | | Very Low | 0.34 | Gravel | | | 4.71 | Sand | | |
| 48 | Very Low Strength Clay/Sandy Clay with Extremely Low Veneer (0.5m) | 460.173 | CPT-B10-460 | CPT | 5 | 0.9 | Sandy Clay | Very Loose | | 4.54 | Sand | Very Dense | | | | | |
| 48 | Very Low Strength Clay/Sandy Clay with Extremely Low Veneer (0.5m) | 461.131 | VC-B10-461 | VC | 5 | 6 | Sand | | | | | | | | | | |
| 48 | Very Low Strength Clay/Sandy Clay with Extremely Low Veneer (0.5m) | 462.172 | VC-B10-462 | VC | 5 | 0.78 | Sandy Clay | | Very Low | 4.39 | Sand | | | | | | |
| 48 | Very Low Strength Clay/Sandy Clay with Extremely Low Veneer (0.5m) | 462.174 | CPT-B10-462 | CPT | 5 | 0.82 | Sandy Clay | | Extremely Low | 4.36 | Sand | Very Dense | | | | | |
| 48 | Very Low Strength Clay/Sandy Clay with Extremely Low Veneer (0.5m) | 463.173 | VC-B10-463 | VC | 5 | 0.82 | Sandy Clay | | Very Low | 4.15 | Sand | | | | | | |
| 48 | Very Low Strength Clay/Sandy Clay with Extremely Low Veneer (0.5m) | 464.173 | VC-B10-464 | VC | 5 | 0.88 | Sandy Clay | | Very Low | 3.44 | Sand | | | | | | |
| 48 | Very Low Strength Clay/Sandy Clay with Extremely Low Veneer (0.5m) | 464.174 | CPT-B10-464 | CPT | 5 | 0.62 | Sandy Clay | | Extremely Low | 3.7 | Sand | Very Dense | | | | | |
| 48 | Very Low Strength Clay/Sandy Clay with Extremely Low Veneer (0.5m) | 465.173 | VC-B10-465 | VC | 5 | 1.83 | Silty Sand | | Very Low | 0.25 | Peat | | | 1.72 | Sand | | |
| 48 | Very Low Strength Clay/Sandy Clay with Extremely Low Veneer (0.5m) | 466.173 | VC-B10-466 | VC | 5 | 0.74 | Silty Sand | | Very Low | 4.35 | Sand | | | | | | |
| 49 | Very Loose Sand | 466.174 | CPT-B10-466 | CPT | 5 | 1.1 | Gravelly Sand | Very Loose | | 3.16 | Sand | Very Dense | | | | | |
| 49 | Very Loose Sand | 467.174 | VC-B10-467 | VC | 5 | 2.4 | Sand | | | 0.12 | Clay | | Medium | 2.21 | Sand | | |
| 49 | Very Loose Sand | 468.174 | VC-B10-468 | VC | 7 | 6 | Sand | | | | | | | | | | |
| 49 | Very Loose Sand | 468.174 | CPT-B10-468 | CPT | 7 | 0.98 | Sand | Very Loose | | 1.1 | Sand | Medium Danese to Dense | | 3.34 | Sand | Very Dense | |
| 49 | Very Loose Sand | 469.173 | VC-B10-469 | VC | 5 | 5.46 | Sand | | | | | | | | | | |
| 49 | Very Loose Sand | 470.174 | VC-B10-470 | VC | 5 | 5.65 | Sand | | | | | | | | | | |
| 49 | Very Loose Sand | 470.174 | CPT-B10-470 | CPT | 5 | 0.9 | Sand | Very Loose | | 4.6 | Sand | Very Dense | | | | | |
| 49 | Very Loose Sand | 471.174 | VC-B10-471 | VC | 5 | 1.12 | Silty Sand | | Very Low | 3.85 | Sand | | | | | | |
| 49 | Very Loose Sand | 472.173 | VC-B10-472 | VC | 5 | 6 | Sand | | | | | | | | | | |
| 49 | Very Loose Sand | 472.173 | CPT-B10-472 | CPT | 5 | 0.98 | Silty Sand | Very Loose | | 4.44 | Sand | Very Dense | | | | | |
| 49 | Very Loose Sand | 473.172 | VC-B10-473 | VC | 5 | 1.83 | Silty Sand | | Very Low | 0.1 | Clay | | Low | 3.64 | Sand | | |
| 49 | Very Loose Sand | 474.172 | VC-B10-474 | VC | 5 | 6 | Sand | | | | | | | | | | |
| 49 | Very Loose Sand | 474.174 | CPT-B10-474 | CPT | 5 | 0.94 | Sand | Very Loose | | 4.46 | Sand | Very Dense | | | | | |
| 49 | Very Loose Sand | 475.172 | VC-B10-475 | VC | 5 | 5.45 | Sand | | | | | | | | | | |
| 49 | Very Loose Sand | 476.174 | VC-B10-476 | VC | 8 | 1.15 | Sand | | | 1.14 | Clay | | Very Low | 3.19 | Sand | | |
| 49 | Very Loose Sand | 476.174 | CPT-B10-476 | CPT | 8 | 1.78 | Sand | Very Loose to Medium Dense | | 1.3 | Clay | | Low to Medium | 0.84 | Sand | Very Loose to Dense | |
| 49 | Very Loose Sand | 477.172 | VC-B10-477 | VC | 8 | 2.23 | Sand | | | 2.08 | Sandy Silt | | Very Low | 1.41 | Sand | | |
| 49 | Very Loose Sand | 478.173 | VC-B10-478 | VC | 8 | 4.8 | Sand | | | | | | | | | | |
| 49 | Very Loose Sand | 478.173 | CPT-B10-478 | CPT | 8 | 1.94 | Sand | Very Loose to Medium Dense | | 3.46 | Sand | Very Dense | | | | | |
| 49 | Very Loose Sand | 479.175 | VC-B10-479 | VC | 8 | 0.73 | Sand | | | 5.27 | Sandy Silt | | Very Low | | | | |
| 49 | Very Loose Sand | 480.173 | VC-B10-480 | VC | 8 | 5.43 | Sand | | | | | | | | | | |
| 49 | Very Loose Sand | 480.174 | CPT-B10-480 | CPT | 8 | 1.7 | Sand | Loose | | 3.7 | Sand | Very Dense | | | | | |
| 49 | Very Loose Sand | 481.174 | VC-B10-481 | VC | 8 | 5.84 | Sand | | | | | | | | | | |
| 50 | Very Loose Sand | 481.845 | VC-B10-482 | VC | 8 | 0.94 | Silty Sand | | Extremely Low | 4.76 | Sand | | | | | | |
| 50 | Very Loose Sand | 481.846 | CPT-B10-482 | CPT | 8 | 1.56 | Silty Sand | Very Loose | | 2.56 | Sand | Very Dense | | | | | |
| 50 | Very Loose Sand | 483.173 | VC-B10-483 | VC | 8 | 0.5 | Sand | | | 1.1 | Sandy Clay | | Very Low | 4.2 | Sand | | |
| 50 | Very Loose Sand | 484.173 | VC-B10-484 | VC | 8 | 5.92 | Sand | | | | | | | | | | |
| 50 | Very Loose Sand | 484.173 | CPT-B10-484 | CPT | 8 | 1.5 | Sand | Very Loose | | 3.88 | Sand | Very Dense | | | | | |
| 50 | Very Loose Sand | 485.173 | VC-B10-485 | VC | 8 | 4.85 | Sand | | | | | | | | | | |
| 50 | Very Loose Sand | 486.173 | VC-B10-486 | VC | 9 | 0.46 | Sand | | | 1.95 | Clay | | Extremely Low | 0.49 | Peat | | |
| 50 | Very Loose Sand | 486.174 | CPT-B10-486 | CPT | 9 | 2.52 | Sand | Very Loose | Extremely Low | 0.78 | Clayey Peat | | Low to Medium | 1.72 | Sand | Very Dense | |
| 50 | Very Loose Sand | 487.173 | VC-B10-487 | VC | 5 | 5.6 | Sand | | | | | | | | | | |
| 50 | Very Loose Sand | 488.173 | VC-B10-488 | VC | 5 | 0.89 | Silty Sand | | Extremely Low | 5.11 | Sand | | | | | | |
| 50 | Very Loose Sand | 488.174 | CPT-B10-488 | CPT | 5 | 0.74 | Silty Sand | Very Loose | | 4.6 | Sand | Very Dense | | | | | |
| 50 | Very Loose Sand | 489.173 | VC-B10-489 | VC | 5 | 0.94 | Silty Sand | | Extremely Low | 4.64 | Sand | | | | | | |
| 50 | Very Loose Sand | 490.174 | VC-B10-490 | VC | 5 | 0.89 | Silty Sand | | Extremely Low | 4.82 | Sand | | | | | | |
| 50 | Very Loose Sand | 490.175 | CPT-B10-490 | CPT | 5 | 0.76 | Silty Sand | Very Loose | | 4.62 | Sand | Very Dense | | | | | |
| 51 | Very Loose Sand | 491.174 | VC-B10-491 | VC | 5 | 4.95 | Sand | | | | | | | | | | |
| 51 | Very Loose Sand | 492.174 | VC-B10-492 | VC | 5 | 5.55 | Sand | | | | | | | | | | |
| 51 | Very Loose Sand | 492.177 | CPT-B10-492 | CPT | 5 | 0.48 | Clayey Sand | Very Loose to Loose | | 4.72 | Sand | Very Dense | | | | | |
| 51 | Very Loose Sand | 493.174 | VC-B10-493 | VC | 5 | 5.42 | Sand | | | | | | | | | | |
| 51 | Very Loose Sand | 494.27 | VC-B10-494 | VC | 5 | 6 | Sand | | | | | | | | | | |
| 51 | Very Loose Sand | 494.271 | CPT-B10-494 | CPT | 5 | 0.8 | Silty Sand | Very Loose | | 4.58 | Sand | Very Dense | | | | | |
| 51 | Very Loose Sand | 495.173 | VC-B10-495 | VC | 5 | 5.67 | Sand | | | | | | | | | | |
| 51 | Very Loose Sand | 496.173 | VC-B10-496 | VC | 5 | 6 | Sand | | | | | | | | | | |
| 51 | Very Loose Sand | 496.174 | CPT-B10-496 | CPT | 5 | 0.56 | Silty Sand | Very Loose to Loose | | 4.66 | Sand | Very Dense | | | | | |
| 51 | Very Loose Sand | 497.174 | VC-B10-497 | VC | 5 | 4.24 | Sand | | | 1.01 | Clay | | Medium | | | | |
| 51 | Very Loose Sand | 498.173 | VC-B10-498 | VC | 5 | 3.66 | Sand | | | 1.18 | Clay | | Medium | | | | |
| 51 | Very Loose Sand | 498.175 | CPT-B10-498 | CPT | 5 | 0.58 | Silty Sand | Very Loose to Loose | | 3.4 | Sand | Very Dense | | 0.9 | Clay | | Medium to High |
| 51 | Very Loose Sand | 499.174 | VC-B10-499 | VC | 5 | 5.32 | Sand | | | 0.28 | Clay | | Medium | | | | |
| 51 | Very Loose Sand | 500.173 | VC-B10-500 | VC | 5 | 2.16 | Sand | | | 1.04 | Clay | | Medium | | | | |
| 51 | Very Loose Sand | 500.173 | CPT-B10-500 | CPT | 6 | 0.72 | Silty Sand | Very Loose | | 1.44 | Sand | Very Dense | | 2.31 | Clay | | High |
| 51 | Very Loose Sand | 500.734 | VC-B10-501 | VC | 6 | 3.53 | Silty Sand | | Very Low | 0.1 | Peat | | | 1.31 | Sand | | |
| 51 | Very Loose Sand | 502.173 | VC-B10-502 | VC | 4 | 1.16 | Sand | | | 1.48 | Clay | | Medium | | | | |
| 51 | Very Loose Sand | 502.174 | CPT-B10-502 | CPT | 4 | 0.74 | Sand | Very Loose to Loose | | 0.48 | Sand | Dense | | 3.96 | Clay | | High to Very High |
| 51 | Very Loose Sand | 503.173 | VC-B10-503 | VC | 4 | 1.65 | Sand | | | 2.89 | Clay | | High | | | | |
| 51 | Very Loose Sand | 504.173 | VC-B10-504 | VC | 4 | 1.6 | Sand | | | 2.34 | Clay | | Very High | | | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 51 | Very Loose Sand | 504.174 | CPT-B10-504 | CPT | 4 | 1.26 | Sand | Very Loose to Medium Dense | | 1.66 | Clay | | High to Very High | 0.66 | Sand | Very Dense | |
| 51 | Very Loose Sand | 505.173 | VC-B10-505 | VC | 4 | 0.54 | Sand | | | 1.71 | Clay | | High | 3.41 | Sand | | |
| 51 | Very Loose Sand | 507.279 | VC-B11-507 | VC | 5 | 5.85 | Sand | | | | | | | | | | |
| 51 | Very Loose Sand | 508.851 | VC-B11-508 | VC | 5 | 5.77 | Sand | | | | | | | | | | |
| 52 | Dense Sand with Loose Sand Veneer (0.3m) | 508.853 | CPT-B11-508 | CPT | 5 | 0.52 | Sand | Very Loose to Dense | | 3.26 | Sand | Very Dense | | | | | |
| 52 | Dense Sand with Loose Sand Veneer (0.3m) | 509.365 | VC-B11-509 | VC | 5 | 5.44 | Sand | | | | | | | | | | |
| 52 | Dense Sand with Loose Sand Veneer (0.3m) | 510.527 | VC-B11-510 | VC | 5 | 1.02 | Sand | | | 0.33 | Clay | | Medium | 4.28 | Sand | | |
| 52 | Dense Sand with Loose Sand Veneer (0.3m) | 510.528 | CPT-B11-510 | CPT | 5 | 1.44 | Sand | Very Loose to Dense | | 0.2 | Clay | | High to Very High | 0.8 | Sand | Very Dense | |
| 52 | Dense Sand with Loose Sand Veneer (0.3m) | 511.365 | VC-B11-511 | VC | 5 | 5.62 | Sand | | | | | | | | | | |
| 52 | Dense Sand with Loose Sand Veneer (0.3m) | 512.365 | VC-B11-512 | VC | 5 | 5.81 | Sand | | | | | | | | | | |
| 52 | Dense Sand with Loose Sand Veneer (0.3m) | 512.365 | CPT-B11-512 | CPT | 5 | 1.16 | Sand | Very Loose to Dense | | 0.08 | Clay | | Very High | 1.32 | Sand | Very Dense | |
| 52 | Dense Sand with Loose Sand Veneer (0.3m) | 512.366 | CPT-B11-512A | CPT | 5 | 0.54 | Sand | Very Loose to Dense | | 2.1 | Sand | Very Dense | | 1.08 | Sand | Loose to Medium Dense | |
| 52 | Dense Sand with Loose Sand Veneer (0.3m) | 513.365 | VC-B11-513 | VC | 5 | 5.4 | Sand | | | | | | | | | | |
| 52 | Dense Sand with Loose Sand Veneer (0.3m) | 514.364 | VC-B11-514 | VC | 5 | 5.65 | Sand | | | | | | | | | | |
| 52 | Dense Sand with Loose Sand Veneer (0.3m) | 514.366 | CPT-B11-514 | CPT | 5 | 0.56 | Sand | Very Loose to Dense | | 4.58 | Sand | Very Dense | | | | | |
| 52 | Dense Sand with Loose Sand Veneer (0.3m) | 515.366 | VC-B11-515 | VC | 5 | 5.16 | Sand | | | | | | | | | | |
| 52 | Dense Sand with Loose Sand Veneer (0.3m) | 515.908 | VC-B11-516 | VC | 5 | 5.31 | Sand | | | | | | | | | | |
| 52 | Dense Sand with Loose Sand Veneer (0.3m) | 515.909 | CPT-B11-516 | CPT | 5 | 0.54 | Sand | Loose to Dense | | 1.8 | Sand | Very Dense | | | | | |
| 52 | Dense Sand with Loose Sand Veneer (0.3m) | 515.909 | CPT-B11-516A | CPT | 5 | 0.44 | Sand | Loose to Dense | | 4.04 | Sand | Very Dense | | | | | |
| 52 | Dense Sand with Loose Sand Veneer (0.3m) | 517.414 | VC-B11-517 | VC | 5 | 5.82 | Sand | | | | | | | | | | |
| 52 | Dense Sand with Loose Sand Veneer (0.3m) | 518.08 | VC-B11-518 | VC | 5 | 5.47 | Sand | | | | | | | | | | |
| 52 | Dense Sand with Loose Sand Veneer (0.3m) | 518.081 | CPT-B11-518 | CPT | 5 | 0.46 | Sand | Loose to Dense | | 3.74 | Sand | Very Dense | | | | | |
| 52 | Dense Sand with Loose Sand Veneer (0.3m) | 519.758 | VC-B12-519 | VC | 5 | 5.86 | Sand | | | | | | | | | | |
| 52 | Dense Sand with Loose Sand Veneer (0.3m) | 519.959 | VC-B12-520 | VC | 5 | 6 | Sand | | | | | | | | | | |
| 52 | Dense Sand with Loose Sand Veneer (0.3m) | 519.96 | CPT-B12-520 | CPT | 5 | 0.44 | Sand | Very Loose to Dense | | 3.04 | Sand | Very Dense | | 1.46 | Sand | Medium Dense | |
| 52 | Dense Sand with Loose Sand Veneer (0.3m) | 521.363 | VC-B12-521A | VC | 5 | 6 | Sand | | | | | | | | | | |
| 52 | Dense Sand with Loose Sand Veneer (0.3m) | 522.365 | CPT-B12-522 | CPT | 3 | 0.54 | Sand | Loose to Very Dense | | 4.68 | Sand | Very Dense | | | | | |
| 52 | Dense Sand with Loose Sand Veneer (0.3m) | 522.365 | VC-B12-522 | VC | 3 | 6 | Sand | | | | | | | | | | |
| 52 | Dense Sand with Loose Sand Veneer (0.3m) | 523.365 | VC-B12-523 | VC | 5 | 5.64 | Sand | | | | | | | | | | |
| 52 | Dense Sand with Loose Sand Veneer (0.3m) | 524.365 | CPT-B12-524 | CPT | 5 | 0.46 | Sand | Loose to Dense | | 4.82 | Sand | Very Dense | | | | | |
| 53 | Medium Dense Sand with Loose Sand Veneer (0.2m) | 524.365 | VC-B12-524 | VC | 5 | 5.48 | Sand | | | | | | | | | | |
| 53 | Medium Dense Sand with Loose Sand Veneer (0.2m) | 525.367 | VC-B12-525 | VC | 5 | 4.94 | Sand | | | | | | | | | | |
| 53 | Medium Dense Sand with Loose Sand Veneer (0.2m) | 526.364 | CPT-B12-526 | CPT | 5 | 0.58 | Sand | Loose to Very Dense | | 4.71 | Sand | Very Dense | | | | | |
| 53 | Medium Dense Sand with Loose Sand Veneer (0.2m) | 526.364 | VC-B12-526 | VC | 5 | 5.7 | Sand | | | | | | | | | | |
| 53 | Medium Dense Sand with Loose Sand Veneer (0.2m) | 526.886 | VC-B12-527 | VC | 6 | 5.51 | Sand | | | | | | | | | | |
| 53 | Medium Dense Sand with Loose Sand Veneer (0.2m) | 528.49 | VC-B12-528 | VC | 6 | 2.26 | Sand | | | 0.4 | Peat | | | 2.53 | Sand | | |
| 53 | Medium Dense Sand with Loose Sand Veneer (0.2m) | 528.491 | CPT-B12-528 | CPT | 6 | 2.22 | Sand | Loose to Very Dense | | 0.6 | Sand | Loose to Medium Dense | | 2.42 | Sand | Very Dense | |
| 53 | Medium Dense Sand with Loose Sand Veneer (0.2m) | 529.365 | VC-B12-529 | VC | 7 | 4.46 | Sand | | | | | | | | | | |
| 53 | Medium Dense Sand with Loose Sand Veneer (0.2m) | 530.365 | CPT-B12-530 | CPT | 7 | 0.54 | Sand | Very Loose to Dense | | 1.9 | Sand | Dense | | 2.06 | Sand | Very Dense | |
| 53 | Medium Dense Sand with Loose Sand Veneer (0.2m) | 530.366 | VC-B12-530 | VC | 7 | 4.98 | Sand | | | | | | | | | | |
| 53 | Medium Dense Sand with Loose Sand Veneer (0.2m) | 531.365 | VC-B12-531 | VC | 7 | 4.98 | Sand | | | | | | | | | | |
| 53 | Medium Dense Sand with Loose Sand Veneer (0.2m) | 532.365 | CPT-B12-532 | CPT | 7 | 4.16 | Sand | Medium Dense to Dense | | 1.2 | Sand | Very Dense | | | | | |
| 53 | Medium Dense Sand with Loose Sand Veneer (0.2m) | 532.365 | VC-B12-532 | VC | 7 | 5 | Sand | | | | | | | | | | |
| 53 | Medium Dense Sand with Loose Sand Veneer (0.2m) | 533.491 | VC-B12-533 | VC | 6 | 4.84 | Sand | | | | | | | | | | |
| 53 | Medium Dense Sand with Loose Sand Veneer (0.2m) | 534.401 | CPT-B12-534 | CPT | 6 | 1.02 | Sand | Very Loose to Dense | | 4.26 | Sand | Very Dense | | | | | |
| 53 | Medium Dense Sand with Loose Sand Veneer (0.2m) | 534.402 | VC-B12-534 | VC | 6 | 5.54 | Sand | | | | | | | | | | |
| 53 | Medium Dense Sand with Loose Sand Veneer (0.2m) | 535.366 | VC-B12-535 | VC | 6 | 6 | Sand | | | | | | | | | | |
| 53 | Medium Dense Sand with Loose Sand Veneer (0.2m) | 536.495 | VC-B12-536 | VC | 6 | 5.76 | Sand | | | | | | | | | | |
| 53 | Medium Dense Sand with Loose Sand Veneer (0.2m) | 536.496 | CPT-B12-536 | CPT | 6 | 0.86 | Sand | Very Loose to Dense | | 4.44 | Sand | Very Dense | | | | | |
| 53 | Medium Dense Sand with Loose Sand Veneer (0.2m) | 537.106 | VC-B12-537 | VC | 5 | 5.62 | Sand | | | | | | | | | | |
| 53 | Medium Dense Sand with Loose Sand Veneer (0.2m) | 539.054 | VC-B12-538 | VC | 5 | 5.71 | Sand | | | | | | | | | | |
| 53 | Medium Dense Sand with Loose Sand Veneer (0.2m) | 539.055 | CPT-B12-538 | CPT | 5 | 1.5 | Sand | Very Loose to Dense | | 3.8 | Sand | Very Dense | | | | | |
| 53 | Medium Dense Sand with Loose Sand Veneer (0.2m) | 539.377 | VC-B12-539 | VC | 7 | 4.05 | Sand | | | | | | | | | | |
| 53 | Medium Dense Sand with Loose Sand Veneer (0.2m) | 540.44 | VC-B12-540 | VC | 7 | 5.89 | Sand | | | | | | | | | | |
| 53 | Medium Dense Sand with Loose Sand Veneer (0.2m) | 540.441 | CPT-B12-540 | CPT | 7 | 2 | Sand | Medium Dense to Dense | | 0.08 | Clay | | High | 3.2 | Sand with thin bands of Clay | Very Loose to Dense | Low |
| 53 | Medium Dense Sand with Loose Sand Veneer (0.2m) | 541.037 | VC-B12-541 | VC | 7 | 5.61 | Sand | | | | | | | | | | |
| 53 | Medium Dense Sand with Loose Sand Veneer (0.2m) | 542.364 | VC-B12-542 | VC | 7 | 2.9 | Silty Sand | | | 1.54 | Clay | | Medium | | | | |
| 53 | Medium Dense Sand with Loose Sand Veneer (0.2m) | 542.366 | CPT-B12-542 | CPT | 7 | 2.38 | Sand | Medium Dense to Dense | | 0.4 | Clay | | Medium to High | 0.64 | Sand | Very Dense | |
| 54 | Loose Sand | 543.219 | VC-B12-543 | VC | 6 | 6 | Sand | | | | | | | | | | |
| 54 | Loose Sand | 544.365 | VC-B12-544 | VC | 6 | 5.9 | Sand | | | | | | | | | | |
| 54 | Loose Sand | 544.367 | CPT-B12-544 | CPT | 6 | 1.24 | Sand | Very Loose to Dense | | 3.18 | Sand | Very Dense | | | | | |
| 54 | Loose Sand | 545.236 | VC-B12-545 | VC | 6 | 1.9 | Sand | | | 0.23 | Peat | | | 2.13 | Sand | | |
| 54 | Loose Sand | 546.838 | VC-B12-546 | VC | 7 | 5.66 | Sand | | | | | | | | | | |
| 54 | Loose Sand | 546.84 | CPT-B12-546 | CPT | 7 | 2 | Sand | Very Loose to Dense | | 3.25 | Sand | Very Dense | | | | | |
| 54 | Loose Sand | 547.436 | VC-B12-547 | VC | 8 | 5.36 | Sand | | | | | | | | | | |
| 54 | Loose Sand | 548.365 | CPT-B12-548 | CPT | 8 | 2.14 | Sand | Very Loose to Dense | | 3.16 | Sand | Very Dense | | | | | |
| 54 | Loose Sand | 548.365 | VC-B12-548 | VC | 8 | 5.79 | Sand | | | | | | | | | | |
| 54 | Loose Sand | 549.48 | VC-B12-549 | VC | 8 | 1.97 | Sand | | | 0.5 | Peat | | | 3.4 | Sand | | |
| 54 | Loose Sand | 550.491 | VC-B12-550 | VC | 8 | 1.77 | Sand | | | 0.27 | Peat | | | 3.32 | Sand | | |
| 54 | Loose Sand | 550.492 | CPT-B12-550 | CPT | 8 | 2.16 | Sand | Very Loose to Medium Dense | | 0.3 | Peat | | Medium to High | 0.4 | Sand | Dense to Very Dense | |
| 54 | Loose Sand | 551.821 | VC-B12-551 | VC | 8 | 2.05 | Sand | | | 1.13 | Peat | | | 2.63 | Sand | | |
| 54 | Loose Sand | 552.364 | VC-B12-552 | VC | 8 | 2.57 | Sand | | | 0.25 | Silt | | | 2.95 | Sand | | |
| 54 | Loose Sand | 552.365 | CPT-B12-552 | CPT | 8 | 1.54 | Sand | Very Loose to Dense | | 1.22 | Sand | Very Dense | | 0.6 | Clay | | Medium to High |
| 54 | Loose Sand | 553.365 | VC-B12-553 | VC | 8 | 2.23 | Sand | | | 0.13 | Silt | | Very Low | 1.3 | Sand | | |
| 54 | Loose Sand | 554.464 | CPT-B12-554 | CPT | 8 | 1.62 | Sand | Very Loose to Loose | | 0.5 | Clay | | Medium to High | 3.16 | Sand | Very Dense | |
| 54 | Loose Sand | 554.465 | VC-B12-554 | VC | 8 | 5.1 | Sand | | | | | | | | | | |
| 54 | Loose Sand | 555.242 | VC-B12-555 | VC | 8 | 6 | Sand | | | | | | | | | | |
| 54 | Loose Sand | 556.658 | VC-B12-556 | VC | 8 | 1.55 | Sand | | | 0.32 | Peat | | | 4.13 | Sand | | |
| 54 | Loose Sand | 556.659 | CPT-B12-556 | CPT | 8 | 1.18 | Sand | Very Loose to Medium Dense | | 0.36 | Clayey Peat | | Medium | 3.66 | Sand | Very Dense | |
| 54 | Loose Sand | 557.364 | VC-B12-557 | VC | 7 | 5.72 | Sand | | | | | | | | | | |
| 54 | Loose Sand | 558.365 | CPT-B12-558 | CPT | 7 | 1.16 | Sand | Very Loose to Loose | | 0.18 | Clayey Peat | | | 3.86 | Sand | Very Dense | |
| 54 | Loose Sand | 558.365 | VC-B12-558 | VC | 7 | 1.48 | Sand | | | 0.28 | Peat | | | 4.02 | Silty Sand | | |
| 54 | Loose Sand | 559.598 | VC-B12-559 | VC | 7 | 1.61 | Silty Sand | | | 1.12 | Peat and Clay | | | 3.27 | Sand | | |
| 54 | Loose Sand | 560.364 | CPT-B12-560 | CPT | 5 | 0.74 | Sand | Very Loose to Dense | | 4.36 | Sand | Very Dense | | | | | |
| 54 | Loose Sand | 560.365 | VC-B12-560 | VC | 5 | 5.69 | Sand | | | | | | | | | | |
| 54 | Loose Sand | 561.602 | VC-B12-561 | VC | 5 | 4.75 | Sand | | | | | | | | | | |
| 54 | Loose Sand | 562.364 | CPT-B12-562 | CPT | 5 | 0.9 | Sand | Very Loose to Medium Dense | | 0.4 | Clay | | Low to Medium | 3.86 | Sand | Very Dense | |
| 54 | Loose Sand | 562.365 | VC-B12-562 | VC | 5 | 5.51 | Sand | | | | | | | | | | |
| 54 | Loose Sand | 563.367 | VC-B12-563 | VC | 5 | 5.61 | Sand | | | | | | | | | | |
| 54 | Loose Sand | 563.911 | CPT-B12-564 | CPT | 5 | 0.76 | Sand | Very Loose to Loose | | 4.38 | Sand | Very Dense | | | | | |
| 54 | Loose Sand | 563.914 | VC-B12-564 | VC | 5 | 0.69 | Sand | | | 0.19 | Peat | | | 4.43 | Sand | | |
| 54 | Loose Sand | 565.449 | VC-B12-565 | VC | 5 | 5.89 | Sand | | | | | | | | | | |
| 54 | Loose Sand | 566.365 | VC-B12-566 | VC | 5 | 5.46 | Sand | | | | | | | | | | |
| 54 | Loose Sand | 566.366 | CPT-B12-566 | CPT | 5 | 0.7 | Sand | Very Loose to Dense | | 4.44 | Sand | Very Dense | | | | | |
| 54 | Loose Sand | 567.364 | VC-B12-567 | VC | 6 | 4.91 | Sand | | | | | | | | | | |
| 54 | Loose Sand | 568.437 | CPT-B12-568 | CPT | 6 | 1.36 | Sand | Very Loose to Very Dense | | 3.8 | Sand | Very Dense | | | | | |
| 54 | Loose Sand | 568.437 | VC-B12-568 | VC | 6 | 5.06 | Sand | | | | | | | | | | |
| 54 | Loose Sand | 569.22 | VC-B13-569 | VC | 6 | 4.85 | Sand | | | | | | | | | | |
| 54 | Loose Sand | 571.49 | VC-B13-571 | VC | 6 | 5.65 | Sand | | | | | | | | | | |
| 54 | Loose Sand | 572.364 | VC-B13-572 | VC | 6 | 1.77 | Sand | | | 1.35 | Clay and Peat | | Low | 2.69 | Sand | | |
| 54 | Loose Sand | 572.366 | CPT-B13-572 | CPT | 6 | 1.52 | Sand | Very Loose to Dense | | 1.34 | Clay and Peat | | Low to Medium | 2.08 | Sand | Very Dense | |
| 55 | Very Loose Sand | 573.365 | VC-B13-573 | VC | 6 | 4.76 | Sand | | | | | | | | | | |
| 55 | Very Loose Sand | 574.06 | VC-B13-574 | VC | 6 | 4.36 | Sand | | | | | | | | | | |
| 55 | Very Loose Sand | 574.061 | CPT-B13-574 | CPT | 6 | 0.9 | Sand | Very Loose to Medium Dense | | 4.24 | Sand | Very Dense | | | | | |
| 55 | Very Loose Sand | 575.365 | VC-B13-575 | VC | 6 | 6 | Sand | | | | | | | | | | |
| 55 | Very Loose Sand | 576.364 | VC-B13-576 | VC | 6 | 1.51 | Sand | | | 0.09 | Peat | | | 3.08 | Sand | | |
| 55 | Very Loose Sand | 576.366 | CPT-B13-576 | CPT | 6 | 1.2 | Sand | Very Loose to Loose | | 0.24 | Clay and Peat | | Very High | 3.69 | Sand | Very Dense | |
| 55 | Very Loose Sand | 577.366 | VC-B13-577 | VC | 9 | 1.25 | Sand | | | 1.34 | Clay and Peat | | Very Low | 1.11 | Sand | | |
| 55 | Very Loose Sand | 578.366 | VC-B13-578 | VC | 6 | 1.63 | Sand | | | 0.54 | Clay | | Extremely Low | 3.83 | Sand | | |
| 55 | Very Loose Sand | 578.366 | CPT-B13-578 | CPT | 6 | 1.18 | Sand | Very Loose to Dense | | 0.14 | Clay | | Low to Medium | 3.8 | Sand | Very Dense | |
| 55 | Very Loose Sand | 579.21 | VC-B13-579 | VC | 9 | 1.23 | Sand | | | 1.54 | Clay and Peat | | Low | 1.03 | Sand | | |
| 56 | Medium Dense Sand with Loose Sand Veneer (1.0m) | 580.49 | VC-B13-580 | VC | 8 | 1.93 | Sand | | | 0.65 | Clay and Peat | | Very Low | 3.16 | Sand | | |
| 56 | Medium Dense Sand with Loose Sand Veneer (1.0m) | 580.492 | CPT-B13-580 | CPT | 8 | 2.02 | Sand | Loose to Dense | | 1.02 | Clay | | Low to Medium | 0.2 | Peat | | |
| 56 | Medium Dense Sand with Loose Sand Veneer (1.0m) | 581.08 | VC-B13-581 | VC | 8 | 0.76 | Sand | | | 1.99 | Silt and Clay | | Extremely Low | 0.34 | Peat | | |
| 56 | Medium Dense Sand with Loose Sand Veneer (1.0m) | 582.467 | VC-B13-582 | VC | 8 | 2.19 | Sand | | | 1.77 | Silt and Clay | | Very Low | 0.23 | Peat | | |
| 56 | Medium Dense Sand with Loose Sand Veneer (1.0m) | 582.469 | CPT-B13-582 | CPT | 8 | 2.16 | Sand | Very Loose to Dense | | 1.32 | Clay | | Low to Medium | 0.36 | Peat | | High |
| 56 | Medium Dense Sand with Loose Sand Veneer (1.0m) | 583.365 | VC-B13-583 | VC | 8 | 3.67 | Sandy Silt | | | 0.99 | Clay and Peat | | Low | 1.34 | Sand | | |
| 56 | Medium Dense Sand with Loose Sand Veneer (1.0m) | 584.365 | VC-B13-584 | VC | 8 | 2.37 | Sand | | | 2.43 | Sandy Silt | | Very Low | 0.41 | Clay and Peat | | |
| 56 | Medium Dense Sand with Loose Sand Veneer (1.0m) | 584.366 | CPT-B13-584 | CPT | 8 | 3.21 | Sand | Loose to Very Dense | | 1.54 | Sandy Silt | | Low to High | 0.14 | Peat | | High |
| 56 | Medium Dense Sand with Loose Sand Veneer (1.0m) | 585.364 | VC-B13-585 | VC | 8 | 1.39 | Sand | | | 2.55 | Sandy Silt | | Very Low | 0.27 | Clay | | |
| 56 | Medium Dense Sand with Loose Sand Veneer (1.0m) | 586.365 | VC-B13-586 | VC | 8 | 3.54 | Sand | | | 1.37 | Silt and Clay | | Very Low | 0.72 | Clay and Peat | | |
| 56 | Medium Dense Sand with Loose Sand Veneer (1.0m) | 586.366 | CPT-B13-586 | CPT | 8 | 3.48 | Sand | Very Loose to Medium Dense | | 1.64 | Clay | | Low to High | 0.32 | Peat | | Medium |
| 56 | Medium Dense Sand with Loose Sand Veneer (1.0m) | 587.365 | VC-B13-587 | VC | 8 | 2.14 | Sand | | | 3.11 | Silt and Clay | | Very Low | 0.52 | Sand and Peat | | |
| 56 | Medium Dense Sand with Loose Sand Veneer (1.0m) | 588.365 | VC-B13-588 | VC | 8 | 4.95 | Sand and Silt | | | 1.05 | Clay | | Low | | | | |
| 56 | Medium Dense Sand with Loose Sand Veneer (1.0m) | 588.366 | CPT-B13-588 | CPT | 8 | 2 | Sand and Silt | Very Loose to Medium Dense | | 1.64 | Clay | | Medium to High | 0.8 | Sand | Loose | |
| 56 | Medium Dense Sand with Loose Sand Veneer (1.0m) | 589.365 | VC-B13-589 | VC | 8 | 1.08 | Sand | | | 4.01 | Silt and Clay | | | 0.81 | Clay | | |
| 56 | Medium Dense Sand with Loose Sand Veneer (1.0m) | 590.366 | VC-B13-590 | VC | 7 | 0.76 | Sand | | | 2.41 | Sandy Silt | | Very Low | 2.16 | Clay | | |
| 56 | Medium Dense Sand with Loose Sand Veneer (1.0m) | 590.368 | CPT-B13-590 | CPT | 7 | 1.14 | Sand | Very Loose to Medium Dense | | 4.08 | Sandy Silt | | Low to High | | | | |
| 57 | Loose Sand with Very Loose Sand Veneer (1.0m) | 591.364 | VC-B13-591 | VC | 8 | 3.83 | Sand and Silt | | | 0.23 | Peat | | | 1.94 | Sand | | |
| 57 | Loose Sand with Very Loose Sand Veneer (1.0m) | 592.826 | VC-B13-592 | VC | 8 | 3.71 | Veneer of Gravel then Silt | | | 0.13 | Peat | | | 2.16 | Sand | | |
| 57 | Loose Sand with Very Loose Sand Veneer (1.0m) | 592.827 | CPT-B13-592 | CPT | 8 | 2.84 | Veneer of Gravel then Silt | Very Loose to Loose | | 0.92 | Clay | | Medium to High | 0.12 | Peat | | |
| 57 | Loose Sand with Very Loose Sand Veneer (1.0m) | 593.366 | VC-B13-593 | VC | 8 | 3.83 | Veneer of Gravel then Silt | | | 0.23 | Peat | | | 1.94 | Sand | | |
| 57 | Loose Sand with Very Loose Sand Veneer (1.0m) | 594.364 | CPT-B13-594 | CPT | 8 | 3.2 | Veneer of Gravel then Silt | Very Loose to Medium Dense | | 0.12 | Peat | | Medium | 1.74 | Sand | Very Dense | |
| 57 | Loose Sand with Very Loose Sand Veneer (1.0m) | 594.366 | VC-B13-594 | VC | 8 | 3.08 | Veneer of Gravel then Silt | | | 0.06 | Peat | | | 2.86 | Sand | | |
| 57 | Loose Sand with Very Loose Sand Veneer (1.0m) | 595.367 | VC-B13-595 | VC | 8 | 6 | Sand with thin bands of Clay | | | | | | | | | | |
| 58 | Loose Sand | 596.364 | CPT-B13-596 | CPT | 9 | 1.12 | Sand | Very Loose to Medium Dense | | 0.78 | Clay and Peat | | | 3.42 | Sand | Very Dense | |
| 58 | Loose Sand | 596.365 | VC-B13-596 | VC | 9 | 1.39 | Sand and Silt | | Extremely Low | 0.86 | Clay and Peat | | | 3.42 | Sand | | |
| 58 | Loose Sand | 597.365 | VC-B13-597 | VC | 7 | 5.95 | Sand | | | | | | | | | | |
| 58 | Loose Sand | 598.365 | CPT-B13-598 | CPT | 7 | 1.42 | Sand | Very Loose to Loose | | 3.84 | Sand | Very Dense | | | | | |
| 58 | Loose Sand | 598.366 | VC-B13-598 | VC | 7 | 5.61 | Sand | | | | | | | | | | |
| 58 | Loose Sand | 599.365 | VC-B13-599 | VC | 7 | 5.92 | Sand | | | | | | | | | | |
| 58 | Loose Sand | 600.364 | CPT-B13-600 | CPT | 5 | 0.72 | Sand | Very Loose to Dense | | 4.56 | Sand | Very Dense | | | | | |
| 58 | Loose Sand | 600.365 | VC-B13-600 | VC | 5 | 5.6 | Sand | | | | | | | | | | |
| 58 | Loose Sand | 601.365 | VC-B13-601 | VC | 5 | 0.22 | Sand | | | 0.48 | Peat | | | 3.64 | Sand | | |
| 58 | Loose Sand | 602.363 | VC-B13-602 | VC | 5 | 0.6 | Sand | | | 0.68 | Peat | | | 4.29 | Sand | | |
| 58 | Loose Sand | 602.365 | CPT-B13-602 | CPT | 5 | 0.6 | Sand | Very Loose to Loose | | 0.56 | Peat | | High | 4.2 | Sand | Very Dense | |
| 58 | Loose Sand | 603.364 | VC-B13-603 | VC | 5 | 3.75 | Sand | | | 0.14 | Clay | | Low | 1.44 | Sand | | |
| 59 | Medium Dense Sand with Loose Sand Veneer (0.15m) | 604.365 | VC-B13-604 | VC | 5 | 6 | Sand | | | | | | | | | | |
| 59 | Medium Dense Sand with Loose Sand Veneer (0.15m) | 604.367 | CPT-B13-604 | CPT | 5 | 0.7 | Sand | Very Loose to Medium Dense | | 4.7 | Sand | Very Dense | | | | | |
| 59 | Medium Dense Sand with Loose Sand Veneer (0.15m) | 605.364 | VC-B13-605 | VC | 5 | 5.9 | Sand | | | | | | | | | | |
| 59 | Medium Dense Sand with Loose Sand Veneer (0.15m) | 606.277 | VC-B13-606 | VC | 5 | 4.86 | Sand | | | 0.14 | Clay | | Very Low | 0.83 | Sand | | |
| 59 | Medium Dense Sand with Loose Sand Veneer (0.15m) | 606.277 | CPT-B13-606 | CPT | 5 | 1 | Sand | Loose to Dense | | 0.2 | Clay | | Medium | 4.1 | Sand | Very Dense | |

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 59 | Medium Dense Sand with Loose Sand Veneer (0.15m) | 607.365 | VC-B13-607 | VC | 5 | 6 | Sand | | | | | | | | | | |
| 59 | Medium Dense Sand with Loose Sand Veneer (0.15m) | 608.295 | VC-B13-608 | VC | 3 | 6 | Sand | | | | | | | | | | |
| 59 | Medium Dense Sand with Loose Sand Veneer (0.15m) | 608.296 | CPT-B13-608 | CPT | 3 | 0.54 | Sand | Loose to Dense | | 4.72 | Sand | Very Dense | | | | | |
| 59 | Medium Dense Sand with Loose Sand Veneer (0.15m) | 609.365 | VC-B13-609 | VC | 7 | 5.69 | Sand | | | 0.31 | Clay | | Very Low | | | | |
| 59 | Medium Dense Sand with Loose Sand Veneer (0.15m) | 610.656 | VC-B13-610 | VC | 7 | 6 | Sand | | | | | | | | | | |
| 59 | Medium Dense Sand with Loose Sand Veneer (0.15m) | 610.657 | CPT-B13-610 | CPT | 7 | 1.04 | Sand | Loose to Dense | | 1.3 | Clay | | Medium to High | 2.91 | Sand | Very Dense | |
| 59 | Medium Dense Sand with Loose Sand Veneer (0.15m) | 611.365 | VC-B13-611 | VC | 6 | 6 | Sand | | | | | | | | | | |
| 59 | Medium Dense Sand with Loose Sand Veneer (0.15m) | 612.364 | VC-B13-612 | VC | 6 | 6 | Sand | | | | | | | | | | |
| 59 | Medium Dense Sand with Loose Sand Veneer (0.15m) | 612.365 | CPT-B13-612 | CPT | 6 | 1.06 | Sand | Very Loose to Dense | | 4.22 | Sand | Very Dense | | | | | |
| 59 | Medium Dense Sand with Loose Sand Veneer (0.15m) | 613.365 | VC-B13-613A | VC | 5 | 5.08 | Sand | | | | | | | | | | |
| 59 | Medium Dense Sand with Loose Sand Veneer (0.15m) | 614.365 | VC-B13-614 | VC | 5 | 3.62 | Sand | | | | | | | | | | |
| 59 | Medium Dense Sand with Loose Sand Veneer (0.15m) | 614.365 | CPT-B13-614 | CPT | 5 | 0.7 | Sand | Very Loose to Dense | | 4.38 | Sand | Very Dense | | | | | |
| 59 | Medium Dense Sand with Loose Sand Veneer (0.15m) | 615.364 | VC-B13-615 | VC | 5 | 5.73 | Sand | | | | | | | | | | |
| 59 | Medium Dense Sand with Loose Sand Veneer (0.15m) | 616.364 | VC-B13-616 | VC | 5 | 5.85 | Sand | | | | | | | | | | |
| 59 | Medium Dense Sand with Loose Sand Veneer (0.15m) | 616.366 | CPT-B13-616 | CPT | 5 | 0.6 | Sand | Medium Dense to Dense | | 4.5 | Sand | Very Dense | | | | | |
| 59 | Medium Dense Sand with Loose Sand Veneer (0.15m) | 617.365 | VC-B13-617 | VC | 5 | 5.62 | Sand | | | | | | | | | | |
| 59 | Medium Dense Sand with Loose Sand Veneer (0.15m) | 618.675 | VC-B13-618 | VC | 5 | 6 | Sand | | | | | | | | | | |
| 59 | Medium Dense Sand with Loose Sand Veneer (0.15m) | 618.675 | CPT-B13-618 | CPT | 5 | 1.7 | Sand | Loose to Very Dense | | 3.4 | Sand | Very Dense | | | | | |
| 59 | Medium Dense Sand with Loose Sand Veneer (0.15m) | 619.19 | VC-B14-619 | VC | 5 | 4.16 | Sand | | | 0.39 | Silty Peat | | | 1.25 | Sand | | |
| 59 | Medium Dense Sand with Loose Sand Veneer (0.15m) | 620.365 | CPT-B14-620 | CPT | 3 | 0.56 | Sand | Loose to Dense | | 4.56 | Sand | Very Dense | | | | | |
| 59 | Medium Dense Sand with Loose Sand Veneer (0.15m) | 620.365 | VC-B14-620 | VC | 3 | 4.2 | Sand | | | | | | | | | | |
| 59 | Medium Dense Sand with Loose Sand Veneer (0.15m) | 621.716 | VC-B14-621 | VC | 3 | 5.5 | Sand | | | | | | | | | | |
| 59 | Medium Dense Sand with Loose Sand Veneer (0.15m) | 622.364 | CPT-B14-622 | CPT | 3 | 0.48 | Sand | Loose to Dense | | 4.6 | Sand | Very Dense | | | | | |
| 59 | Medium Dense Sand with Loose Sand Veneer (0.15m) | 622.364 | VC-B14-622 | VC | 3 | 2.32 | Sand | | | 3.43 | Sand with thin bands of Clay | | | | | | |
| 59 | Medium Dense Sand with Loose Sand Veneer (0.15m) | 623.395 | VC-B14-623 | VC | 5 | 5.9 | Sand | | | | | | | | | | |
| 59 | Medium Dense Sand with Loose Sand Veneer (0.15m) | 624.756 | CPT-B14-624 | CPT | 5 | 5.12 | Sand | Medium Dense to Very Dense | | | | | | | | | |
| 59 | Medium Dense Sand with Loose Sand Veneer (0.15m) | 624.758 | VC-B14-624 | VC | 5 | 6 | Sand | | | | | | | | | | |
| 59 | Medium Dense Sand with Loose Sand Veneer (0.15m) | 625.365 | VC-B14-625 | VC | 5 | 5.84 | Sand | | | | | | | | | | |
| 59 | Medium Dense Sand with Loose Sand Veneer (0.15m) | 627.015 | VC-B14-626 | VC | 5 | 5.41 | Sand | | | | | | | | | | |
| 59 | Medium Dense Sand with Loose Sand Veneer (0.15m) | 627.016 | CPT-B14-626 | CPT | 5 | 1.18 | Sand | Medium Dense to Very Dense | | 3.98 | Sand | Very Dense | | | | | |
| 59 | Medium Dense Sand with Loose Sand Veneer (0.15m) | 627.575 | VC-B14-627 | VC | 6 | 2.3 | Sand | | | 0.35 | Clay | | Low | 3.19 | Sand | | |
| 59 | Medium Dense Sand with Loose Sand Veneer (0.15m) | 628.398 | CPT-B14-628 | CPT | 6 | 3.02 | Sand | Loose to Dense | | 2.08 | Sand | Very Dense | | | | | |
| 59 | Medium Dense Sand with Loose Sand Veneer (0.15m) | 628.398 | VC-B14-628 | VC | 6 | 5.54 | Sand | | | | | | | | | | |
| 59 | Medium Dense Sand with Loose Sand Veneer (0.15m) | 629.44 | VC-B14-629 | VC | 6 | 5.72 | Sand | | | | | | | | | | |
| 60 | Medium Strength Clay with Low Strength Veneer (0.2m) | 630.058 | VC-B14-630 | VC | 7 | 1.35 | Clay | | Medium | 0.49 | Peat | | | 3.78 | Sand | | |
| 60 | Medium Strength Clay with Low Strength Veneer (0.2m) | 630.061 | CPT-B14-630 | CPT | 7 | 1.32 | Clay | | Medium Strength Clay with Low Strength Veneer (0.2m) | 0.54 | Peat | | Very High | 1.25 | Sand | Very Dense | |
| 60 | Medium Strength Clay with Low Strength Veneer (0.2m) | 630.907 | VC-B14-631 | VC | 7 | 2.12 | Silty Sand | | | 0.46 | Peat | | | 2.84 | Sand | | |
| 61 | Medium Dense Sand with Very Loose Sand Veneer (0.15m) | 632.364 | CPT-B14-632 | CPT | 6 | 0.54 | Silty Sand | Loose to Dense | | 4.58 | Sand | Very Dense | | | | | |
| 61 | Medium Dense Sand with Very Loose Sand Veneer (0.15m) | 632.365 | VC-B14-632 | VC | 6 | 5.6 | Sand | | | | | | | | | | |
| 61 | Medium Dense Sand with Very Loose Sand Veneer (0.15m) | 633.479 | VC-B14-633 | VC | 6 | 4.06 | Sand | | | 1.14 | Clay | | Medium | | | | |
| 61 | Medium Dense Sand with Very Loose Sand Veneer (0.15m) | 634.672 | CPT-B14-634 | CPT | 7 | 2.04 | Sand | Loose to Very Dense | | 0.16 | Peat | | High | 2.92 | Sand | Very Dense | |
| 61 | Medium Dense Sand with Very Loose Sand Veneer (0.15m) | 634.674 | VC-B14-634 | VC | 7 | 1.23 | Sand | | | 0.1 | Clay | | Very Low | 4.13 | Sand | | |
| 61 | Medium Dense Sand with Very Loose Sand Veneer (0.15m) | 635.366 | VC-B14-635 | VC | 7 | 5.6 | Sand | | | | | | | | | | |
| 61 | Medium Dense Sand with Very Loose Sand Veneer (0.15m) | 636.365 | CPT-B14-636 | CPT | 3 | 0.54 | Sand | Very Loose to Dense | | 3.58 | Sand | Very Dense | | 1.02 | Clay | | Medium to High |
| 61 | Medium Dense Sand with Very Loose Sand Veneer (0.15m) | 636.365 | VC-B14-636 | VC | 3 | 4.62 | Sand | | | 1.38 | Clay | | Low | | | | |
| 61 | Medium Dense Sand with Very Loose Sand Veneer (0.15m) | 637.365 | VC-B14-637 | VC | 8 | 4.12 | Sand | | | 1.69 | Clay | | Medium | | | | |
| 61 | Medium Dense Sand with Very Loose Sand Veneer (0.15m) | 638.676 | VC-B14-638 | VC | 8 | 2.82 | Sand | | | 1.93 | Clay | | Medium | | | | |
| 61 | Medium Dense Sand with Very Loose Sand Veneer (0.15m) | 638.677 | CPT-B14-638 | CPT | 8 | 1.12 | Sand | Very Loose to Very Dense | | 3.98 | Clay | | Low to Medium | | | | |
| 61 | Medium Dense Sand with Very Loose Sand Veneer (0.15m) | 639.364 | VC-B14-639 | VC | 5 | 0.9 | Sand | | | 0.74 | Silt | | Medium | 3.86 | Sand | | |
| 61 | Medium Dense Sand with Very Loose Sand Veneer (0.15m) | 640.366 | CPT-B14-640 | CPT | 5 | 0.58 | Sand | Loose to Dense | | 4.5 | Sand | Very Dense | | | | | |
| 61 | Medium Dense Sand with Very Loose Sand Veneer (0.15m) | 640.366 | VC-B14-640 | VC | 5 | 3.77 | Sand | | | 0.46 | Clay | | Medium | 1.46 | Sand | | |
| 61 | Medium Dense Sand with Very Loose Sand Veneer (0.15m) | 641.366 | VC-B14-641 | VC | 6 | 4.09 | Sand | | | 1.01 | Clay | | Medium | 0.25 | Peat | | |
| 61 | Medium Dense Sand with Very Loose Sand Veneer (0.15m) | 642.749 | VC-B14-642 | VC | 6 | 2.6 | Sand | | | 0.14 | Clay | | Very Low | 1.77 | Sand | | |
| 61 | Medium Dense Sand with Very Loose Sand Veneer (0.15m) | 642.75 | CPT-B14-642 | CPT | 6 | 2.82 | Sand | Medium Dense to Dense | | 1.46 | Sand | Very Dense | | 0.82 | Clay | | Medium |
| 61 | Medium Dense Sand with Very Loose Sand Veneer (0.15m) | 643.365 | VC-B14-643 | VC | 6 | 4.5 | Sand | | | | | | | | | | |
| 61 | Medium Dense Sand with Very Loose Sand Veneer (0.15m) | 644.241 | VC-B14-644 | VC | 7 | 3.18 | Sand | | | 1.23 | Clay | | Low | 0.76 | Sand | | |
| 61 | Medium Dense Sand with Very Loose Sand Veneer (0.15m) | 644.242 | CPT-B14-644 | CPT | 7 | 0.38 | Sand | Loose to Medium Dense | | 4.7 | Sand | Medium Dense to Very Dense | | | | | |
| 61 | Medium Dense Sand with Very Loose Sand Veneer (0.15m) | 645.366 | VC-B14-645 | VC | 8 | 5.5 | Sand | | | | | | | | | | |
| 62 | Low Strength Clay with Medium Dense Sand Veneer (0.4m) | 646.365 | CPT-B14-646 | CPT | 8 | 1.6 | Sand and Clay | Medium Dense to Dense | Low | 0.3 | Peat | | High | 3.38 | Sand | Very Dense | |
| 62 | Low Strength Clay with Medium Dense Sand Veneer (0.4m) | 646.366 | VC-B14-646 | VC | 8 | 1.36 | Sand and Clay | | Very Low | 0.27 | Peat | | | 4.21 | Sand | | |
| 63 | Medium Dense Sand with Very Loose Sand Veneer (0.15m) | 647.396 | VC-B14-647 | VC | 8 | 1.41 | Sand | | | 0.14 | Peat | | | 4.25 | Sand | | |
| 63 | Medium Dense Sand with Very Loose Sand Veneer (0.15m) | 648.152 | VC-B14-648 | VC | 5 | 5.59 | Sand | | | | | | | | | | |
| 63 | Medium Dense Sand with Very Loose Sand Veneer (0.15m) | 648.153 | CPT-B14-648 | CPT | 5 | 0.86 | Sand | Loose to Very Dense | | 0.1 | Clay | | Medium | 4.3 | Sand | Very Dense | |
| 63 | Medium Dense Sand with Very Loose Sand Veneer (0.15m) | 649.365 | VC-B14-649 | VC | 5 | 0.25 | Sand | | | 0.14 | Clay | | Very Low | 3.73 | Sand | | |

# APPENDIX B

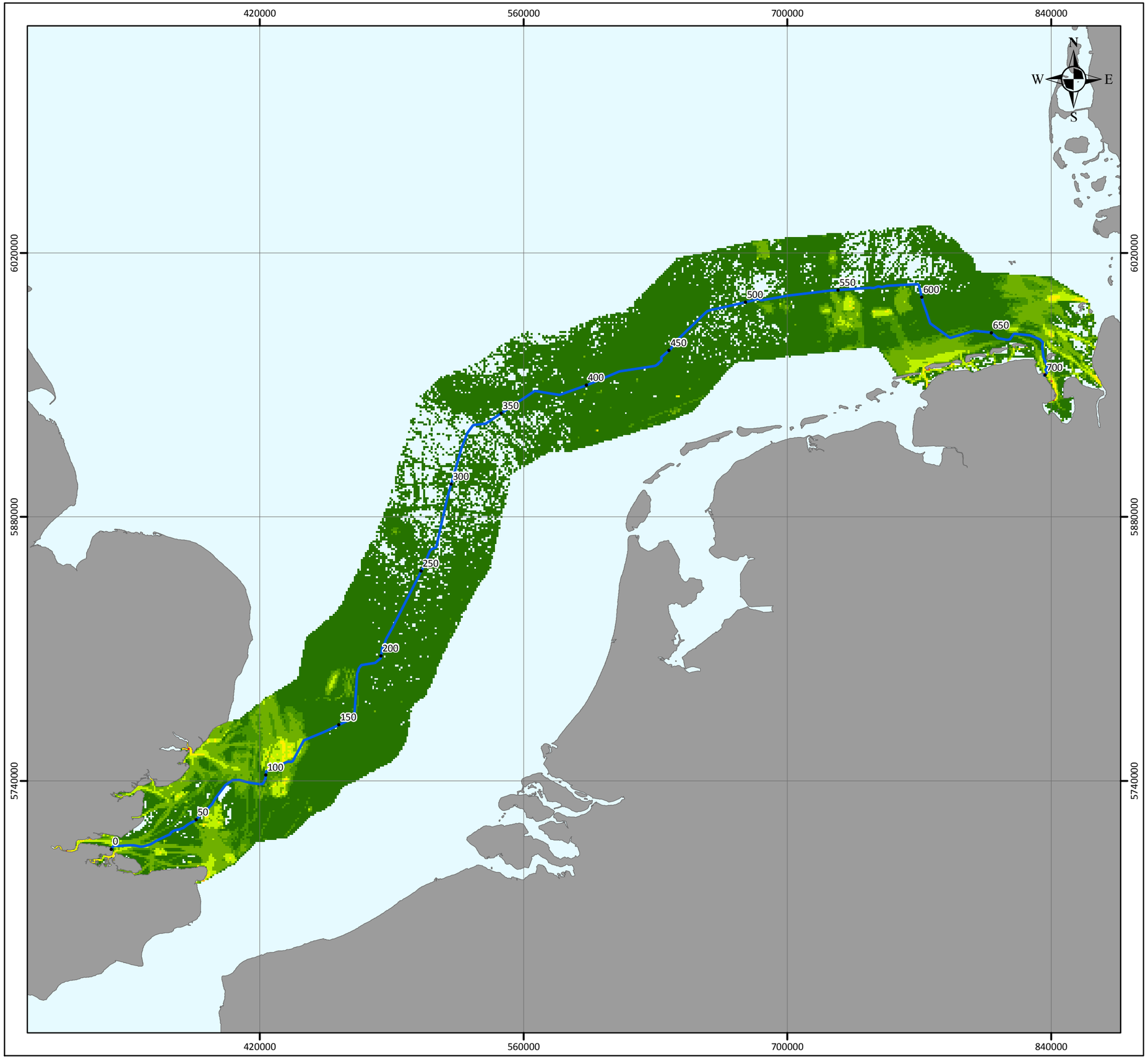
## CRBA – Risk Register

| Hazard log Ref No. | Hazard Class | Hazard Description (potential) | Risk Description | Initial Risk Rating | | | Mitigation | Residual Risk Rating | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Likelihood | Severity | Risk rating | | Likelihood | Severity | Risk rating |
| **Natural** | | | | | | | | | | |
| 1 | Bathymetry | Influences presence of other natural and anthropogenic hazards. | See hazard No.12 (Mobile Sediment) for risk from bathymetric features identified along the NeuConnect Interconnector route. | | | | | | | |
| 2 | Seabed topography | Uneven seabed topography may lead to more variable burial requirements. | The NeuConnect crosses area of ripples (<1m height) and mege-ripples (1 to 3 m height) and sandwaves.<br><br>Local burial depth may be adjusted upwards by the sandwave height resulting in degraded thermal performance leading to potential derating. | 4 | 2 | 8 | Ensure cable's design can tolerate short spans of increased burial depths. | 1 | 2 | 2 |
| 3 | Seabed obstructions (not identified during pre-installation) | Obstruction will result in section out of burial specification. | Not applicable, only applicable to as-built cable. **Not scored** | | | | | | | |
| 4 | Shallow gas | Represent a danger to vessels / personnel. | Applicable to installation and as-built cable but not to present CBRA. **Not scored.** | | | | | | | |
| 5 | Currents / waves | Abrasion, stress and fatigue where cable crosses rock/rough terrrain. Can induce loading on cable connectors.<br><br>Can mobilise sediment exposing cables to further primary hazards. Metocean conditions likely to impact on surface laid cable and also influence sediment mobility. | Risk associated with protection for rocky terrain is design specific, thus outside CBRA scope. **Not scored.**<br><br>See hazard No.12 for risk from Mobile Sediment.<br><br>For surface laid there would be potential for damage from wave/current actions, predominantly in shallow waters. | 2 | 3 | 6 | CBRA to include consideration of wave/current action should surface laid be acceptable from anthropogenic threats.<br><br>For protection in rocky areas, a design risk assessment would be required. | 1 | 2 | 2 |
| 6 | Density / turbidity currents | These may results from a number of phenomena and can travel at speed over great distances to significant depths. Can cause tensional breaks, abrasions or may bury cables. | Risk associated with unprotected cables (torsional breaks and abrasions) is design specific, thus outside CRBA scope. **Not Scored.**<br><br>See hazard No.12 for risk from increased burial depth (Mobile Sediment). | | | | | | | |
| 7 | Fish bites | Can damage insulation: historically mainly occurred with telegraph cables but recent occurences have been noted occasionally. | Not plausible threat to a power cable. | 1 | 1 | 1 | No futher mitigation anticipated. | | | |
| 8 | Extreme weather | An increase in current and wave strengh, can increase sediment input and bury cables deeper than designed. | See hazard No.12 for risk from increased/decreased burial depth (Mobile Sediment). | | | | | | | |
| 9 | Submarine earthquakes | Cause submarine landslides or turbidity currents increasing/reducing sediment cover exposing cables to primary risk. | The NeuConnect route resides in an area that is tectonically stable and away from a continental shelf/plate boundary; therefore, is it not expected that any significant hazards of this nature present on the route. No areas of unstable sediment were encountered along the NeuConnect route. | 1 | 3 | 3 | No futher mitigation anticipated. | | | |
| 10 | Submarine volcanoes | Directly impact cables through contact or trigger submarine landslides (see above). | No live submarine volcano in the area. **Not scored.** | | | | | | | |
| 11 | Icebergs | Can directly impact on cables in shallow water depth as they scour the seabed. Not anticipated along the cable's route. | Not plausible. **Not scored.** | | | | | | | |
| **Soil Conditions** | | | | | | | | | | |
| 12 | Mobile Sediment | Sand Wave or megaripple mobility could cause deburial or increased burial of the cable. | There are a number of areas within the NeuConnect 500m corridor where there are bedforms present which could be mobile. The first indication of mobile bedforms can be observed at KP11. These have been interpreted by MMT as ripples and have a wave length of <15m and height <1.0 m. Ripples are observed intermittently throughout the route where they terminate at KP304 and do not appear again until KP620 and extent to the end of the route at KP700. While these may indicate some levels of sediment movement it is not thought that these minor bedforms will have an impact to the cable installation or operability.<br><br>Mega Ripples are also observed intermittently throughout the corridor, between KP108 & KP190 and then between KP669 and KP700. These are slightly larger than ripples and have a wave length of 15-50m and height 1-3m so may pose a risk to an installed cable within its lifetime.<br><br>Sandwaves present within the route corridor and are first observed between KP78 and KP 80. These have been interpreted by MMT to have a wave length 50-200m and height of >3 m. Sandwaves are next present at KP 106 and remain as intermittent features until KP294. They do not appear again until between KP673 and KP700.<br><br>The risk is that information gaps concerning the extent of sediment mobility means that the recommended DoL contingency is either too low or too high. The consequence is either lower protection or higher CAPEX. | 3 | 2 | 6 | | | | |
| **Anthropogenic** | | | | | | | | | | |
| 13 | Fishing | Snagging of cables with fishing gear and damage during retrieval of gear. Seabed interacting gear reducing sediment coverage above cable. | Due to inaccurate characterisation of presence of mobile fishing types there is a risk of misunderstanding the risk of mechanical damage to the installed cable.<br><br>Consequence is misspecification of recommended minimum DoL leading to either greater CAPEX or greater risk of damege to the installed cable. Leads to requirement to inspect and potentially to repair. Other consequence is cable outtage and increase of monitoring requirements. | 1 | 1 | 1 | No further mitigation expected. Base case assumes sufficient burial to protect from known regional fishing threats applied to the whole cable route. | 1 | 1 | 1 |
| 14.A | Shipping/Anchoring | Snagging of cables during normal or emergency anchoring procedures. | Due to inaccurate characterisation of shipping or soils there is a risk of misunderstanding the risk of mechanical damage to the installed cable.<br><br>Consequence is misspecification of recommended minimum DoL leading to either greater CAPEX or greater risk of damege to the installed cable. Leads to requirement to inspect and potentially to repair. Other consequence is cable outtage and increase of monitoring requirements. | 3 | 3 | 9 | Revise the CBRA following significant changes to shippings patterns. (scored on a basis of shipping pattern changes). | 2 | 2 | 4 |
| 14.B | | | Due to cable design for a return period of 40 years, there is a residual risk of mechanical damage. | 1 | 2 | 2 | No further mitigation required. | 1 | 1 | 1 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 15 | Dredging / Aggregate Extraction / Subsea Mining / Dumping | Direct contact to the cable from the dredging equipment or reduction in seabed cover increasing risk to cable. | Aggregation, dredging and dumping ground have all been avoided with the exception on the very nearshore landfall area in Germany. The route has no option but to cross a known dredging area between approximately KP 696 and 697. Within this area the water depth is constantly maintained at 17.6m. The Nordergründe Export Cable is also observed to cross this area. The as laid data indicates that the export cable is buried to between 5 and 6m crossing the dredged area. | 3 | 3 | 9 | Sufficent DoL will be defined in the CBRA assessment to mitigate risk | 2 | 3 | 6 |
| 16 | Other cables, umbilical, Pipelines | Reduced depth of lowering at crossing and/or proximity of third-party operation. | The NeuConnect Interconnector will cross a total of 89 existing subsea linear assets (29 in services cables, 45 out of service cable1 13 in service pipeline and 2 abandonned pipelines). Outside of CBRA scope, thus **not scored.** | | | | Crossings will be subject to design risk assessment. | | | |
| 17 | Exclusions Misc. Activities | Such as construction, rock dumping, marine surveys, leisure activities. Any activity that directly interacts with the seabed and reduces the seabed cover. | Misc, activities are outside of the CBRA scope. N**ot scored.** | | | | | | | |
| 18 | Exclusions physical | Defense and acts of unintended military aggressions. | Outside of CBRA scope. **Not scored.** | | | | | | | |
| 19 | Exclusions planning | Updated information which significantly changes the recommendations of the CBRA | Potential to require re-routing outside of survey corridor. **Not scored.** | | | | | | | |

# APPENDIX C

## Vessel Density Heat Maps

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# NeuConnect CBRA

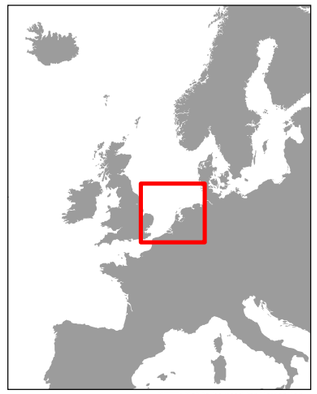
## Vessel Density August 2016 to July 2017 - Band A

**Legend**

- KP's
- NeuConnect Route

**Band A Vessel Hours Per Year (1km x 1km grid)**

- 0 - 5
- 5 - 10
- 10 - 50
- 50 - 200
- 200 - 4000
- 4000 - 8000
- 8000 - 16000
- 16000 - 28000
- 28000 - 55000
- 55000 - 81000



NOTE: Not to be used for Navigation

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| **Datum** | D_WGS_1984 |
| **Data Source** | GEBCO, NEUCONNECT, OCEANEERING |
| **File Reference** | J:\P2131\Mxd\CBRA\ Band_A.mxd |
| **Created By** | Chris Carroll |
| **Reviewed By** | Chris Goode |
| **Approved By** | Louis Dumenil |

NeuConnect intertek

0 10 20 30 40 km

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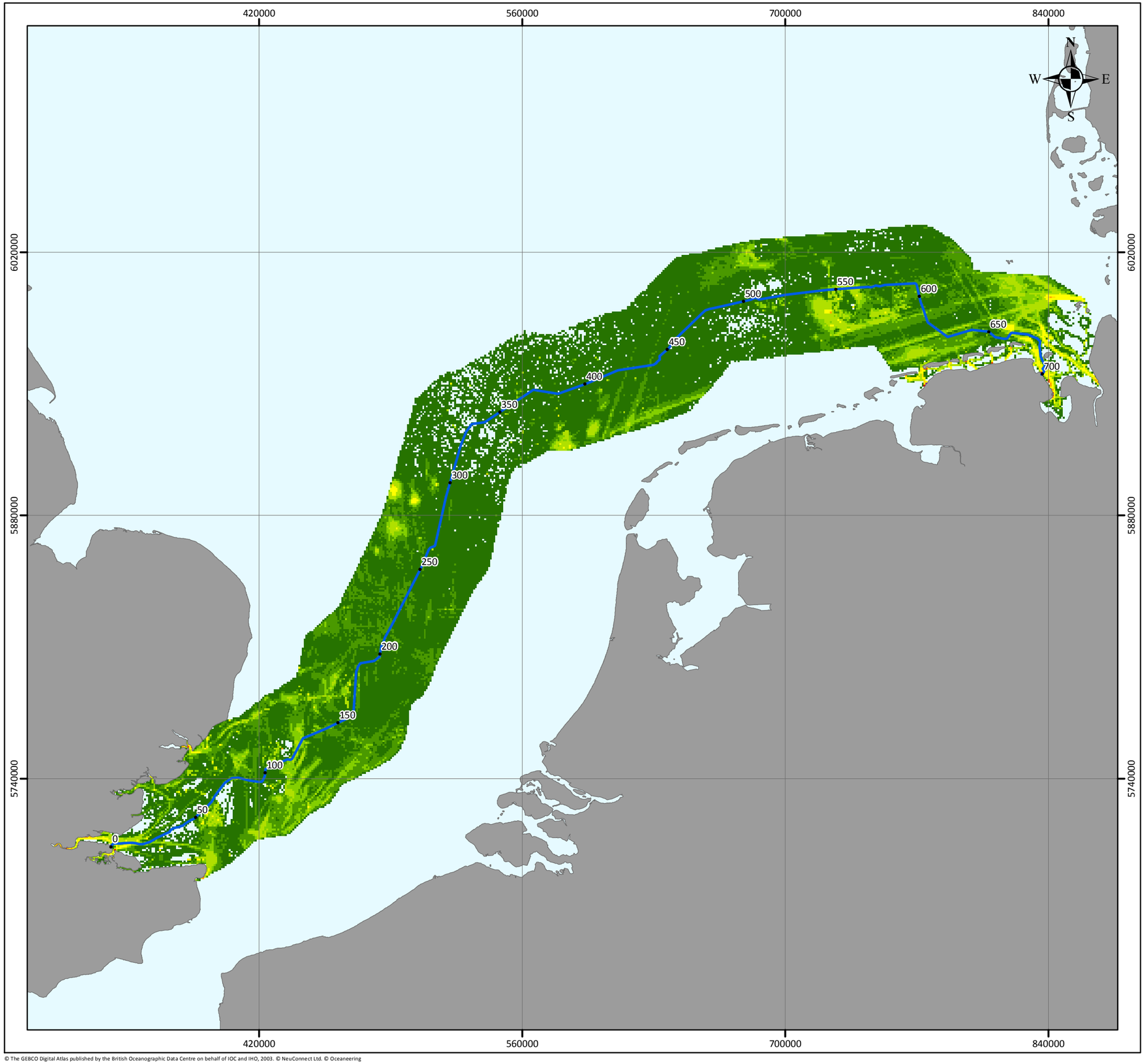



# NeuConnect CBRA

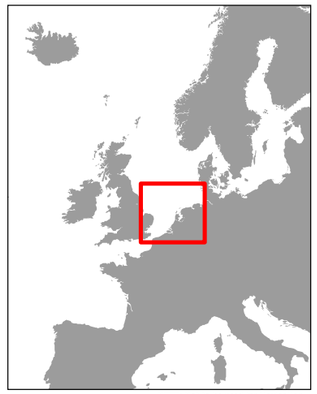
## Vessel Density August 2016 to July 2017 - Band B

**Legend**

- KP's
- NeuConnect Route

**Band B Vessel Hours Per Year (1km x 1km grid)**

- 0 - 2
- 2 - 5
- 5 - 10
- 10 - 50
- 50 - 600
- 600 - 1200
- 1200 - 3400
- 3400- 9000
- 9000 - 23000
- 23000 - 53000



NOTE: Not to be used for Navigation

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| **File Reference** | J:\P2131\Mxd\CBRA\ Band_B.mxd |
| **Created By** | Chris Carroll |
| **Reviewed By** | Chris Goode |
| **Approved By** | Louis Dumenil |

NeuConnect intertek

0 10 20 30 40 km

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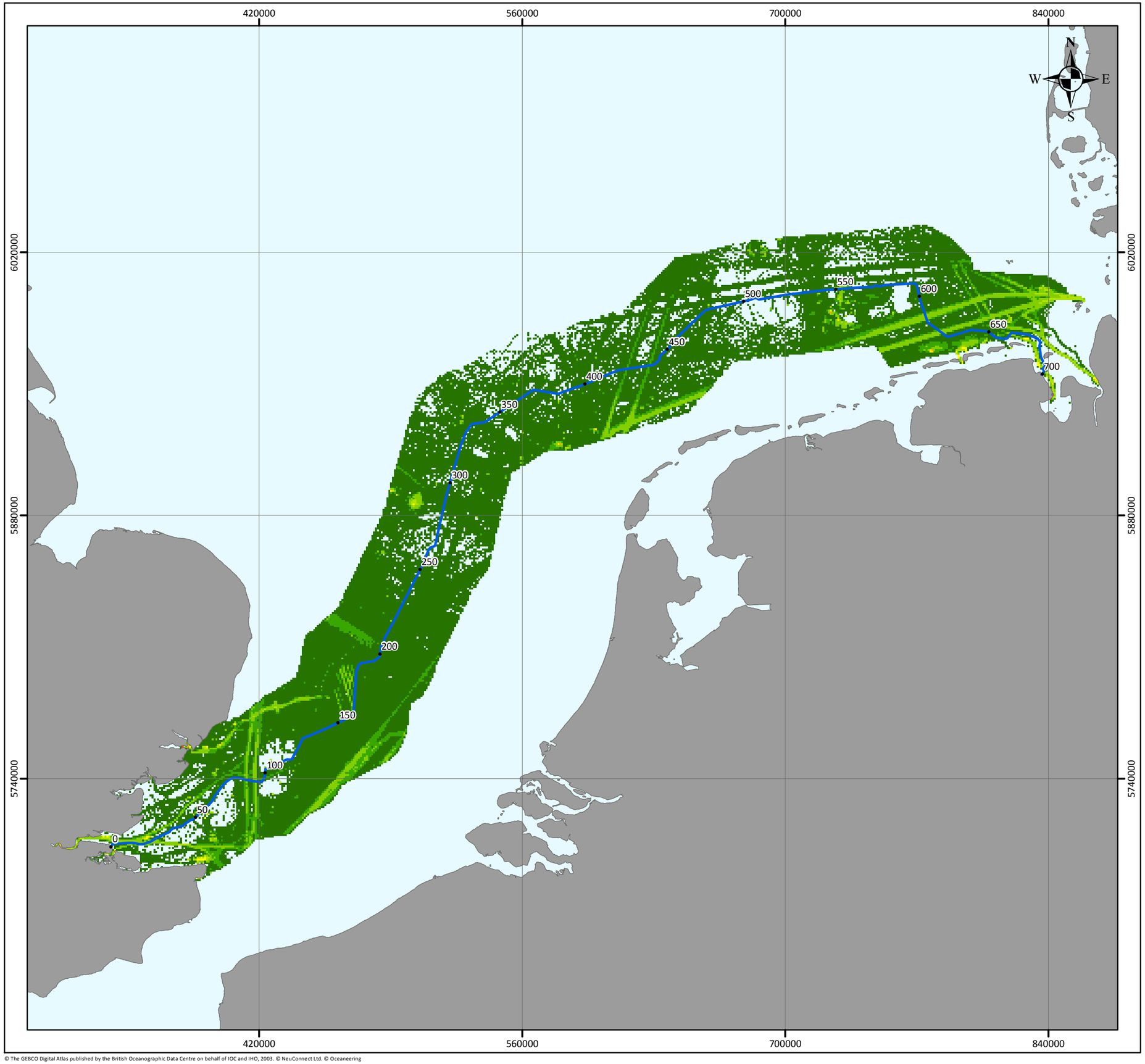



# NeuConnect CBRA

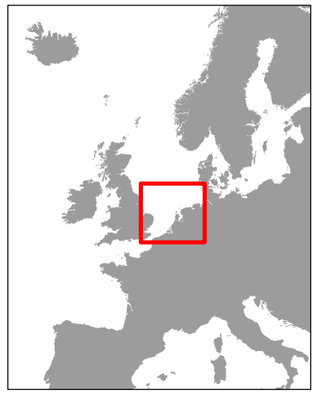
## Vessel Density August 2016 to July 2017 - Band C

**Legend**

- KP's
- NeuConnect Route

**Band C Vessel Hours Per Year (1km x 1km grid)**

- 0 - 5
- 5 - 10
- 10 - 50
- 50 - 200
- 200 - 700
- 700 - 1600
- 1600 - 4000
- 4000 - 10000
- 10000 - 15000
- 15000 - 22900



NOTE: Not to be used for Navigation

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| **Created By** | Chris Carroll |
| **Reviewed By** | Chris Goode |
| **Approved By** | Louis Dumenil |

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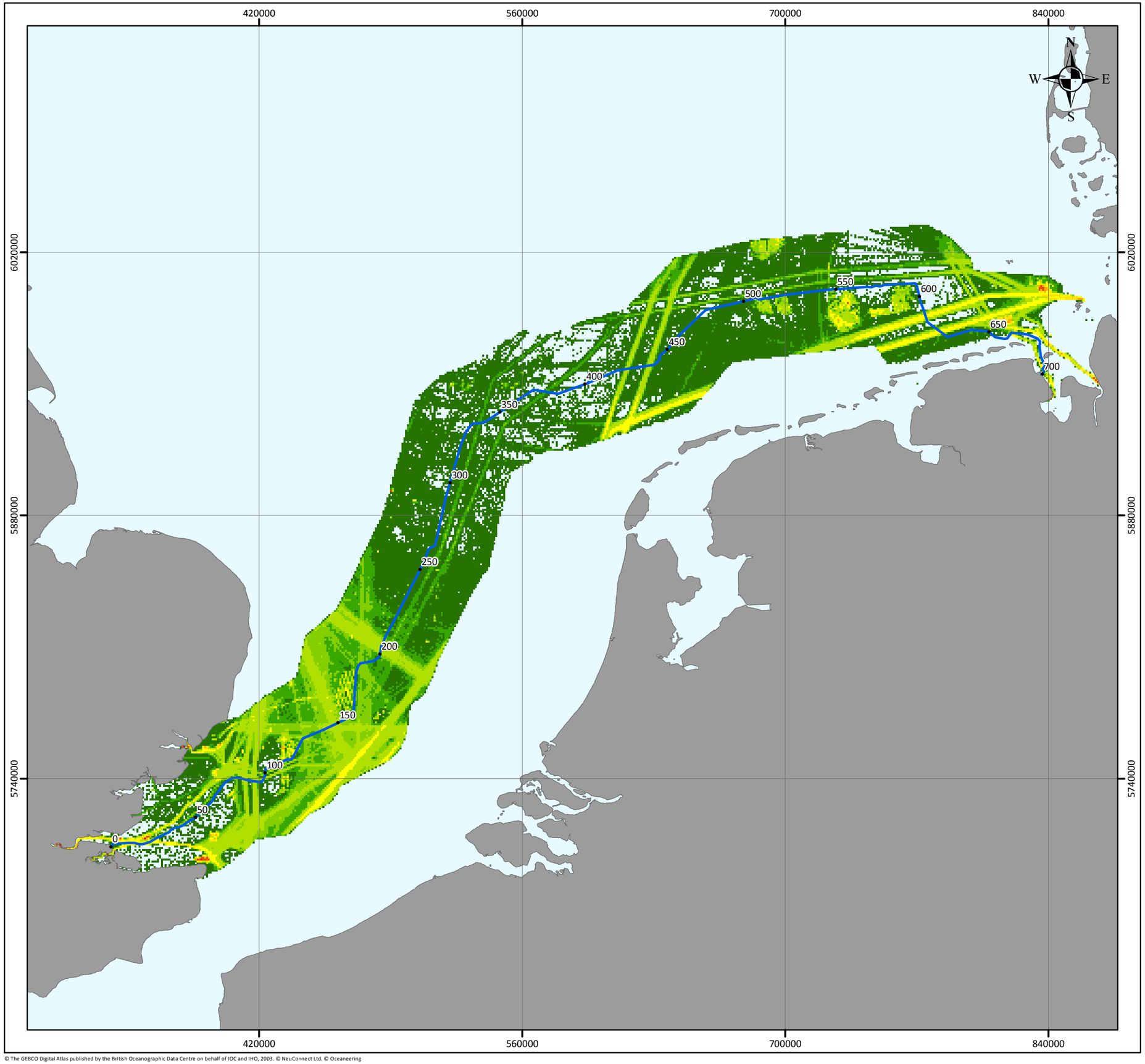


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# NeuConnect CBRA

## Vessel Density August 2016 to July 2017 - Band D

**Legend**

- KP's
- NeuConnect Route

**Band D Vessel Hours Per Year (1km x 1km grid)**

- 0 - 2
- 2 - 5
- 5 - 10
- 10 - 50
- 50 - 200
- 200 - 500
- 500 - 1000
- 1000 - 2500
- 2500 - 6000
- 6000 - 13000

NOTE: Not to be used for Navigation

| | |
|---|---|
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| **File Reference** | J:\P2131\Mxd\CBRA\ Band_D.mxd |
| **Created By** | Chris Carroll |
| **Reviewed By** | Chris Goode |
| **Approved By** | Louis Dumenil |

NeuConnect intertek

0 10 20 30 40 km

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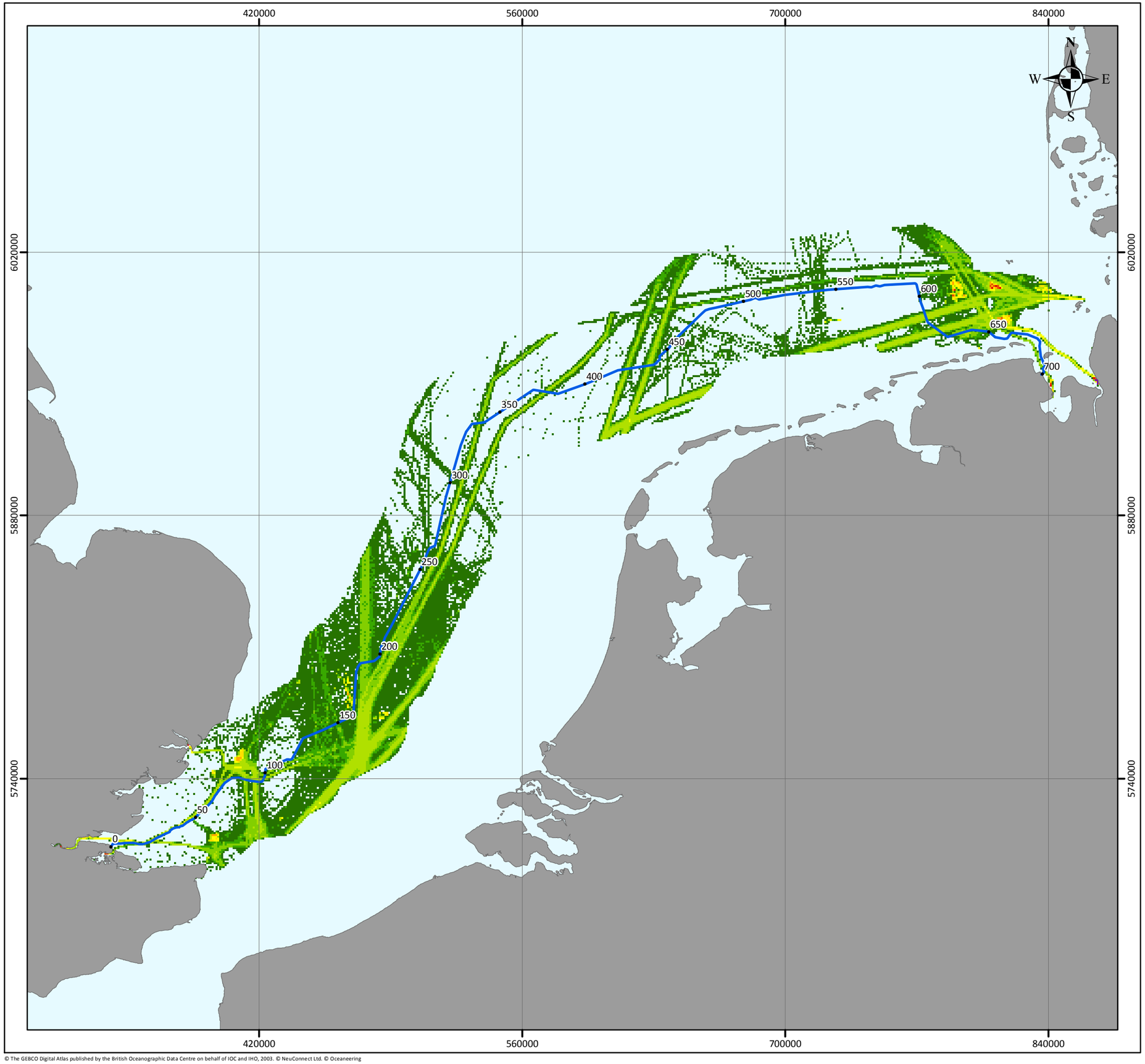


# NeuConnect CBRA

## Vessel Density August 2016 to July 2017 - Band E

**Legend**

- KP's
- NeuConnect Route

**Band E Vessel Hours Per Year (1km x 1km grid)**

- 0 - 1
- 1 - 2
- 2 - 5
- 5 - 20
- 20 - 80
- 80 - 200
- 200 - 400
- 400 - 800
- 800 - 1500
- 1500 - 3900

NOTE: Not to be used for Navigation

| | |
|---|---|
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| **Spheroid** | WGS_1984 |
| **Datum** | D_WGS_1984 |
| **Data Source** | GEBCO, NEUCONNECT, OCEANEERING |
| **File Reference** | J:\P2131\Mxd\CBRA\ Band_E.mxd |
| **Created By** | Chris Carroll |
| **Reviewed By** | Chris Goode |
| **Approved By** | Louis Dumenil |

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0 10 20 30 40 km

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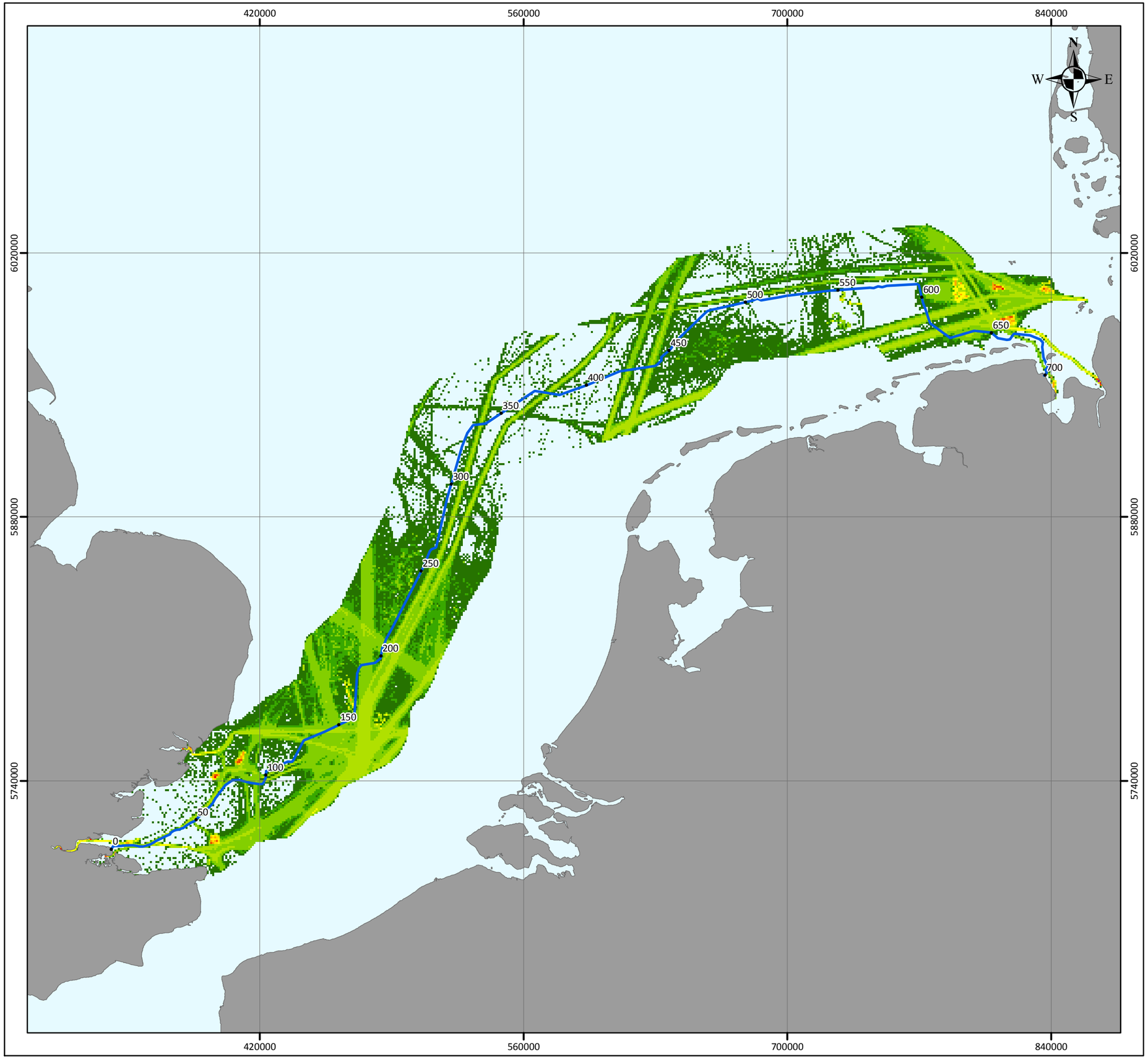


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# NeuConnect CBRA

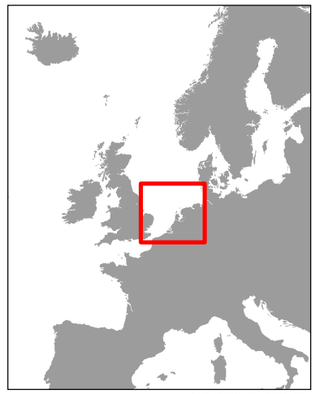
## Vessel Density August 2016 to July 2017 - Band F

**Legend**

- KP's
- NeuConnect Route

**Band F Vessel Hours Per Year (1km x 1km grid)**

- 0 - 1
- 1 - 2
- 2 - 10
- 10 - 50
- 50 - 150
- 150 - 320
- 320 - 650
- 650 - 1300
- 1300 - 6500
- 3000 - 6500



NOTE: Not to be used for Navigation

| | |
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| **Data Source** | GEBCO, NEUCONNECT, OCEANEERING |
| **File Reference** | J:\P2131\Mxd\CBRA\ Band_F.mxd |
| **Created By** | Chris Carroll |
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| **Approved By** | Louis Dumenil |

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0 10 20 30 40 km

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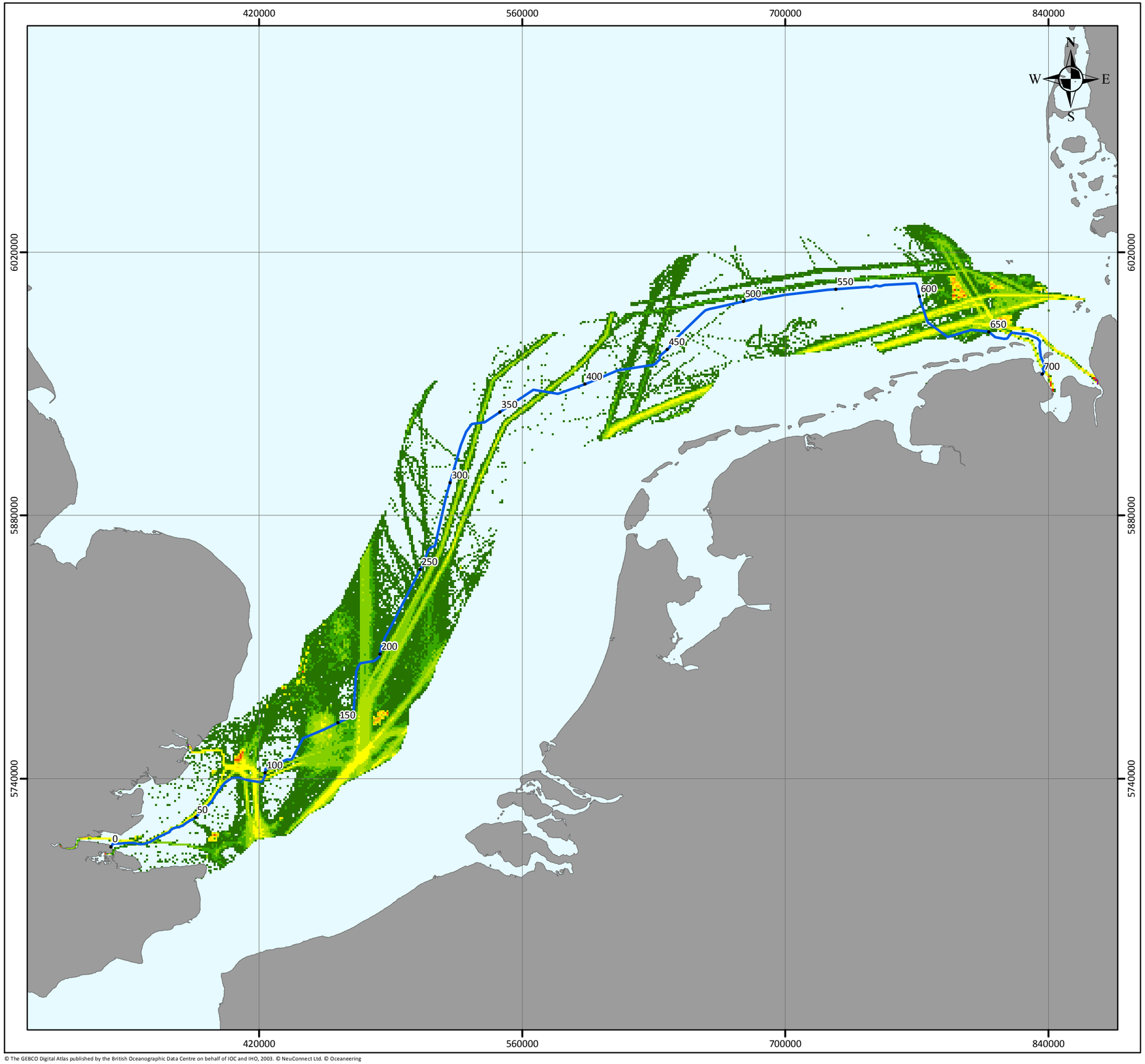


# NeuConnect CBRA

## Vessel Density August 2016 to July 2017 - Band G

**Legend**

- KP's
- NeuConnect Route

**Band G Vessel Hours Per Year (1km x 1km grid)**

- 0 - 1
- 1 - 2
- 2 - 5
- 5 - 10
- 10 - 50
- 50 - 150
- 150 - 300
- 300 - 1000
- 1000 - 3000
- 3000 - 85000

NOTE: Not to be used for Navigation

| | |
|---|---|
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| **File Reference** | J:\P2131\Mxd\CBRA\ Band_G.mxd |
| **Created By** | Chris Carroll |
| **Reviewed By** | Chris Goode |
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0 10 20 30 40 km

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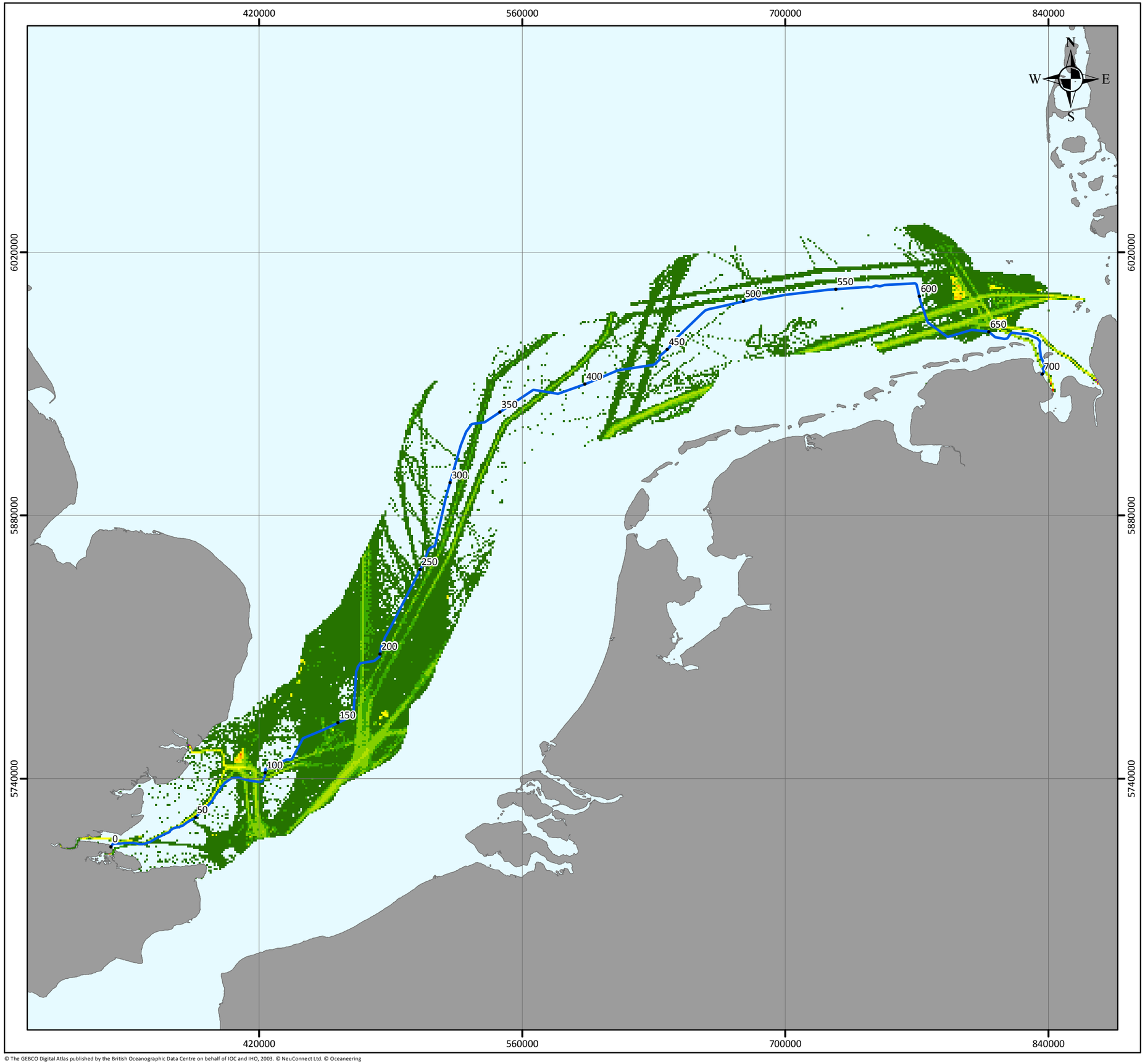


# NeuConnect CBRA

## Vessel Density August 2016 to July 2017 - Band H

**Legend**

- KP's
- NeuConnect Route

**Band H Vessel Hours Per Year (1km x 1km grid)**

- 0 - 1
- 1 - 2
- 2 - 5
- 5 - 10
- 10 - 50
- 50 - 150
- 150 - 300
- 300 - 600
- 600 - 2000
- 2000 - 3400

NOTE: Not to be used for Navigation

| | |
|---|---|
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km
0 10 20 30 40

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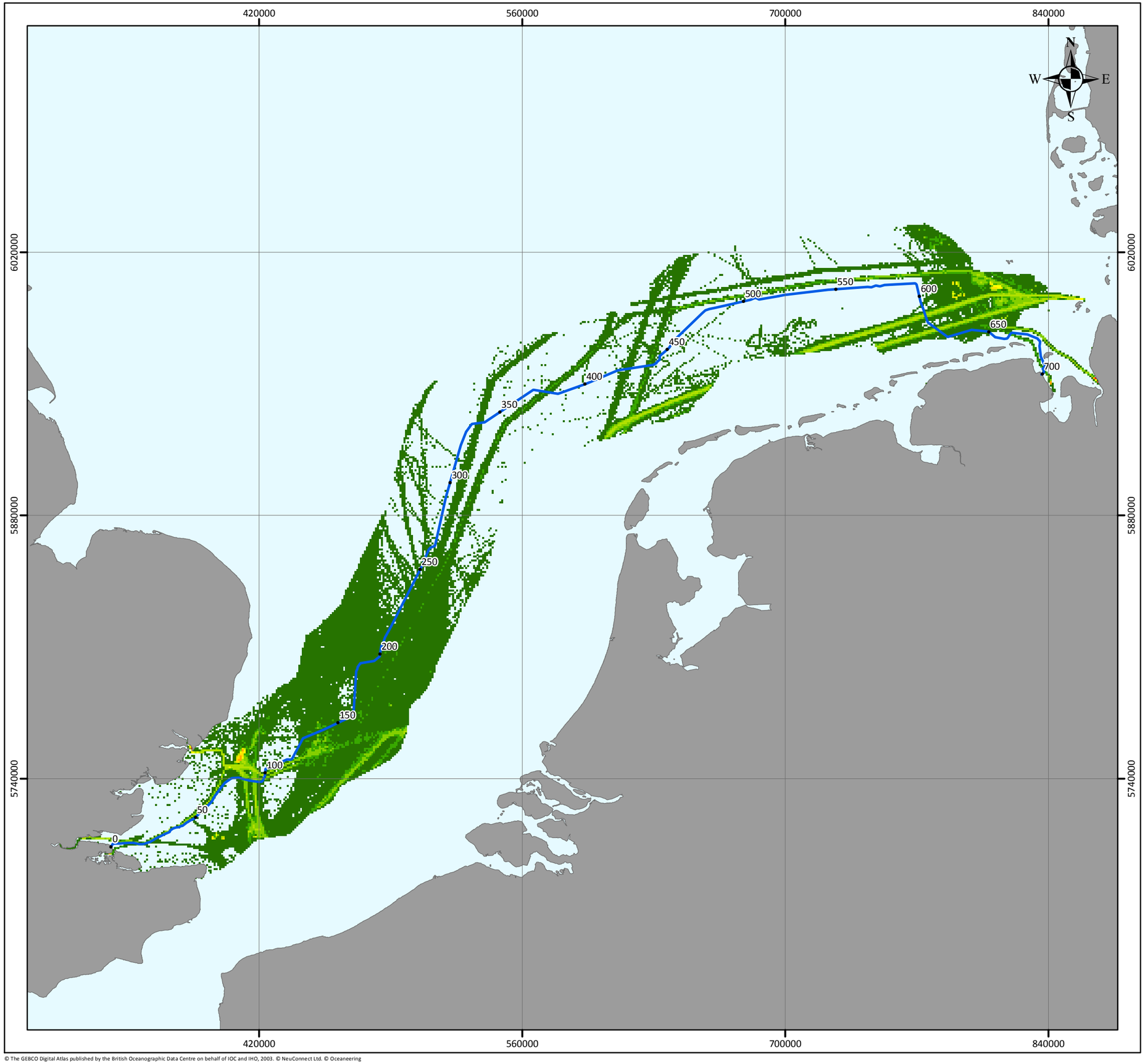


# NeuConnect CBRA

## Vessel Density August 2016 to July 2017 - Band I

**Legend**

- KP's
- NeuConnect Route

**Band I Vessel Hours Per Year (1km x 1km grid)**

- 0 - 1
- 1 - 2
- 2 - 5
- 5 - 20
- 20 - 50
- 50 - 150
- 150 - 400
- 400 - 800
- 800 - 1800
- 1800 - 5700

NOTE: Not to be used for Navigation

| | |
|---|---|
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| **Reviewed By** | Chris Goode |
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0 10 20 30 40 km

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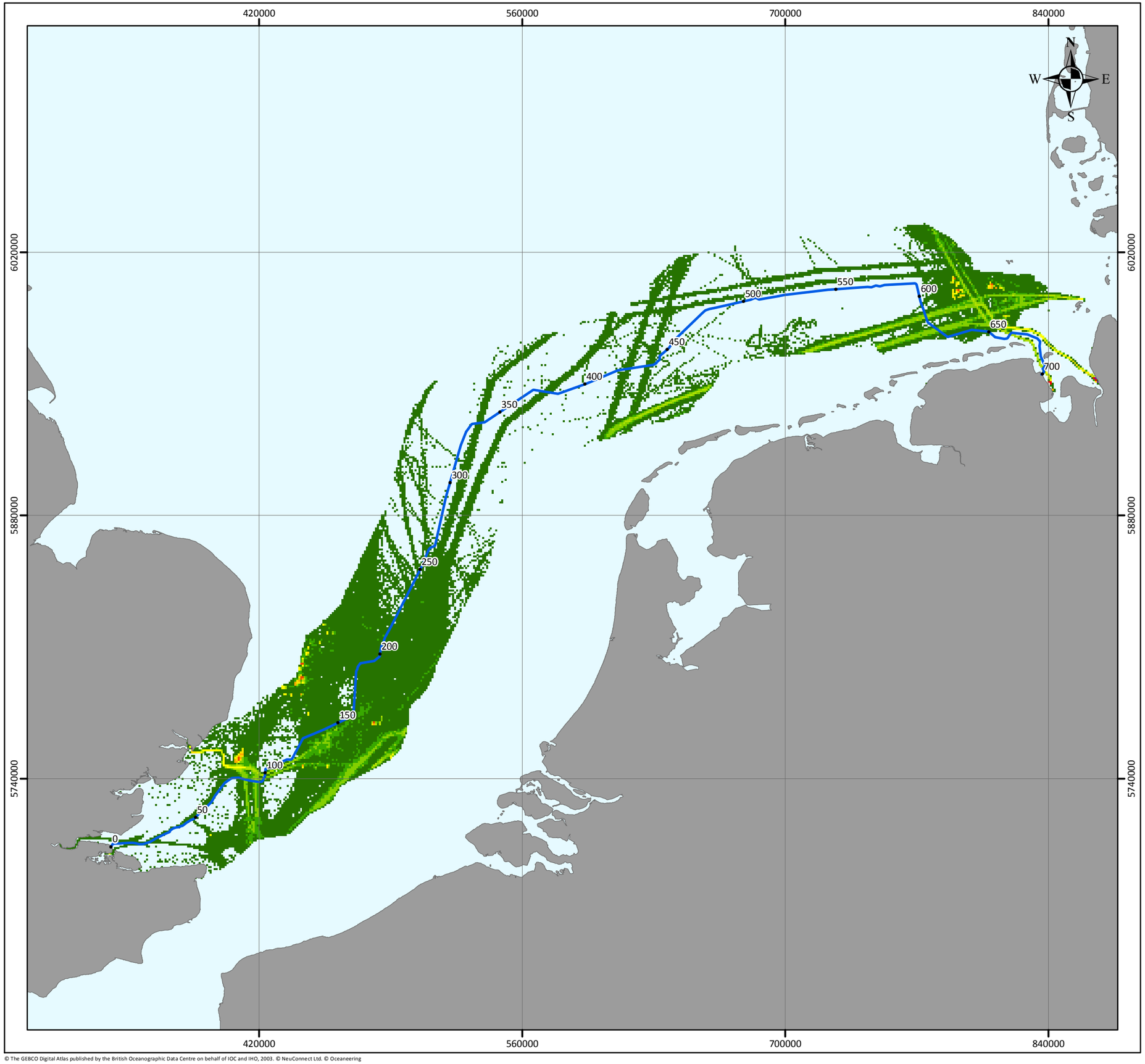


# NeuConnect CBRA

## Vessel Density August 2016 to July 2017 - Band J

**Legend**

- KP's
- NeuConnect Route

**Band J Vessel Hours Per Year (1km x 1km grid)**

- 0 - 1
- 1 - 2
- 1 - 5
- 5 - 10
- 10 - 25
- 25 - 50
- 50 - 100
- 100 - 250
- 250 - 3000
- 3000 - 5500

NOTE: Not to be used for Navigation

| | |
|---|---|
| **Date** | Monday, December 17, 2018 14:08:12 |
| **Projection** | WGS_1984_UTM_Zone_31N |
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| **Reviewed By** | Chris Goode |
| **Approved By** | Louis Dumenil |

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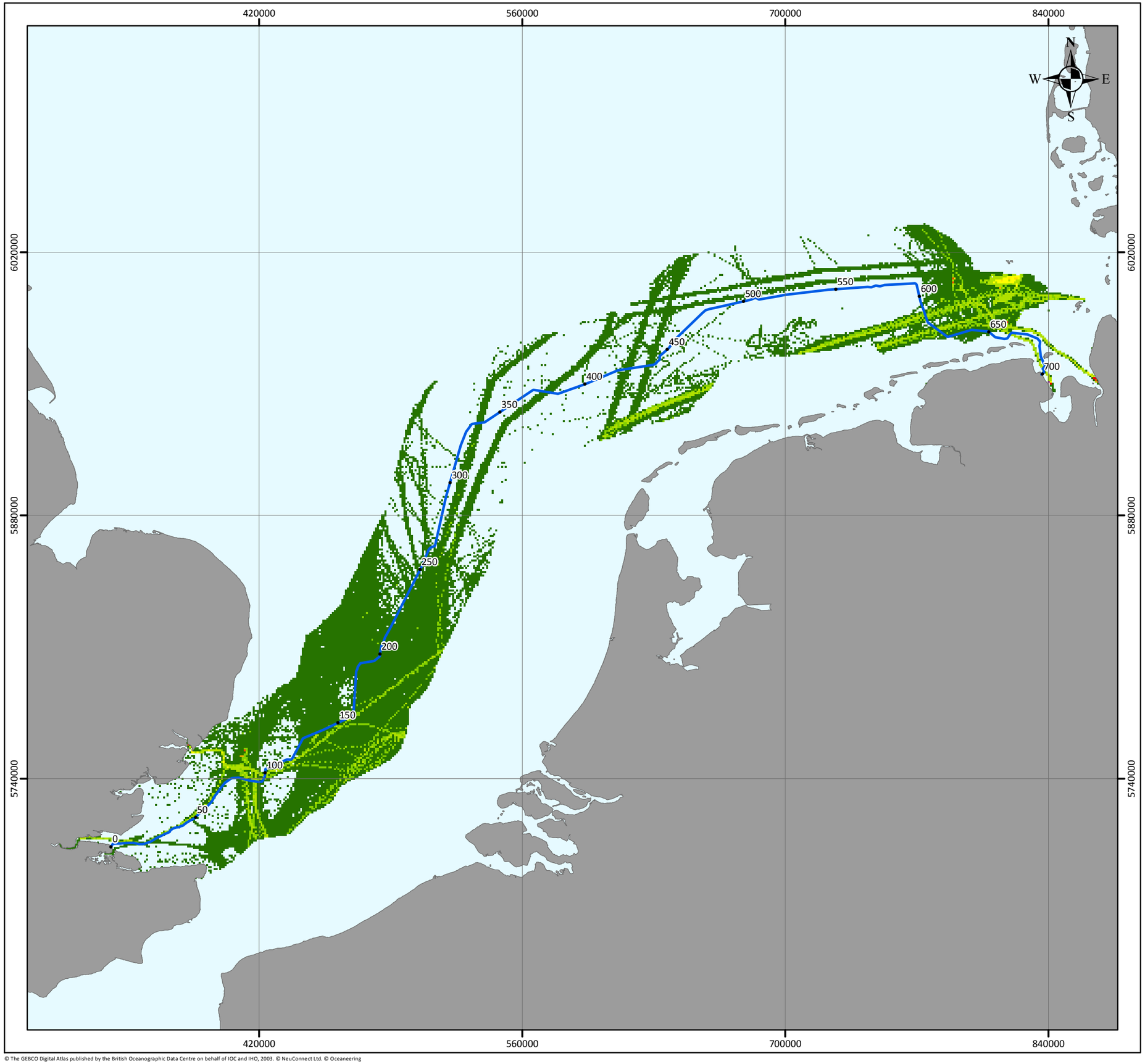


# NeuConnect CBRA

## Vessel Density August 2016 to July 2017 - Band K

**Legend**

- KP's
- NeuConnect Route

**Band K Vessel Hours Per Year (1km x 1km grid)**

- 0.0 - 0.02
- 0.02 - 0.05
- 0.05 - 0.1
- 0.1 - 1
- 1 - 2
- 2 - 5
- 5 - 10
- 10 - 50
- 50 - 150
- 150 - 250

NOTE: Not to be used for Navigation

| | |
|---|---|
| **Date** | Monday, December 17, 2018 14:08:12 |
| **Projection** | WGS_1984_UTM_Zone_31N |
| **Spheroid** | WGS_1984 |
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| **Data Source** | GEBCO, NEUCONNECT, OCEANEERING |
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| **Created By** | Chris Carroll |
| **Reviewed By** | Chris Goode |
| **Approved By** | Louis Dumenil |

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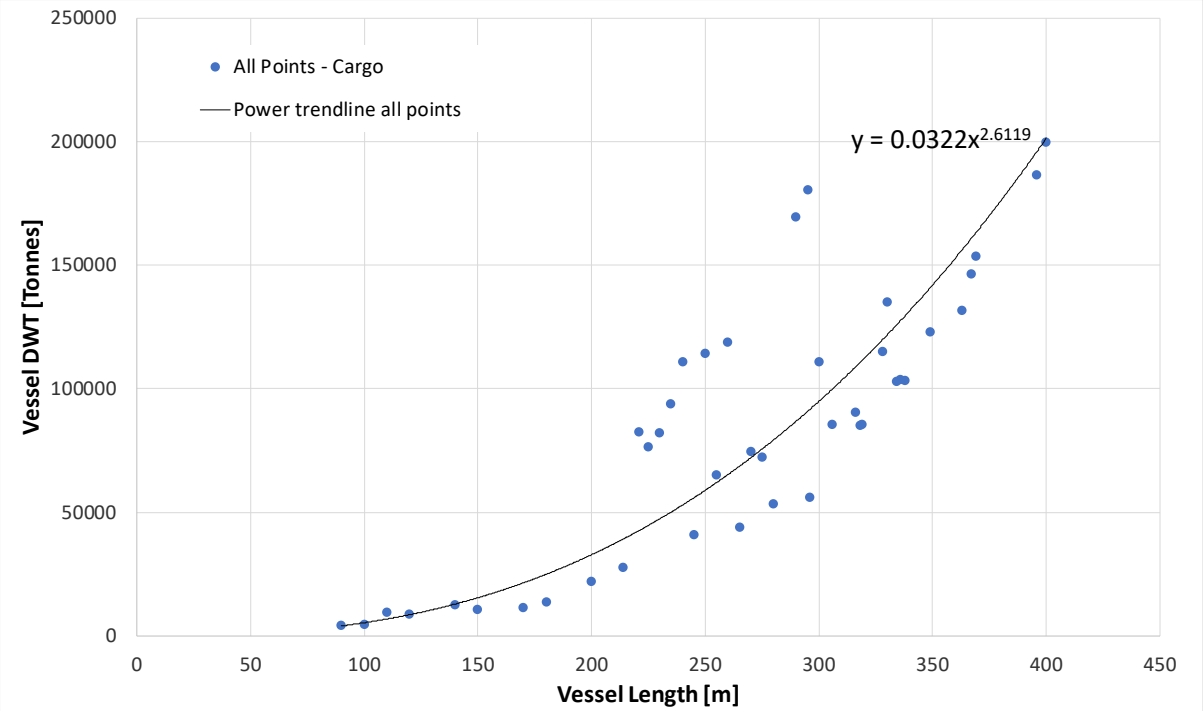
# APPENDIX D

## Vessel DWT charts

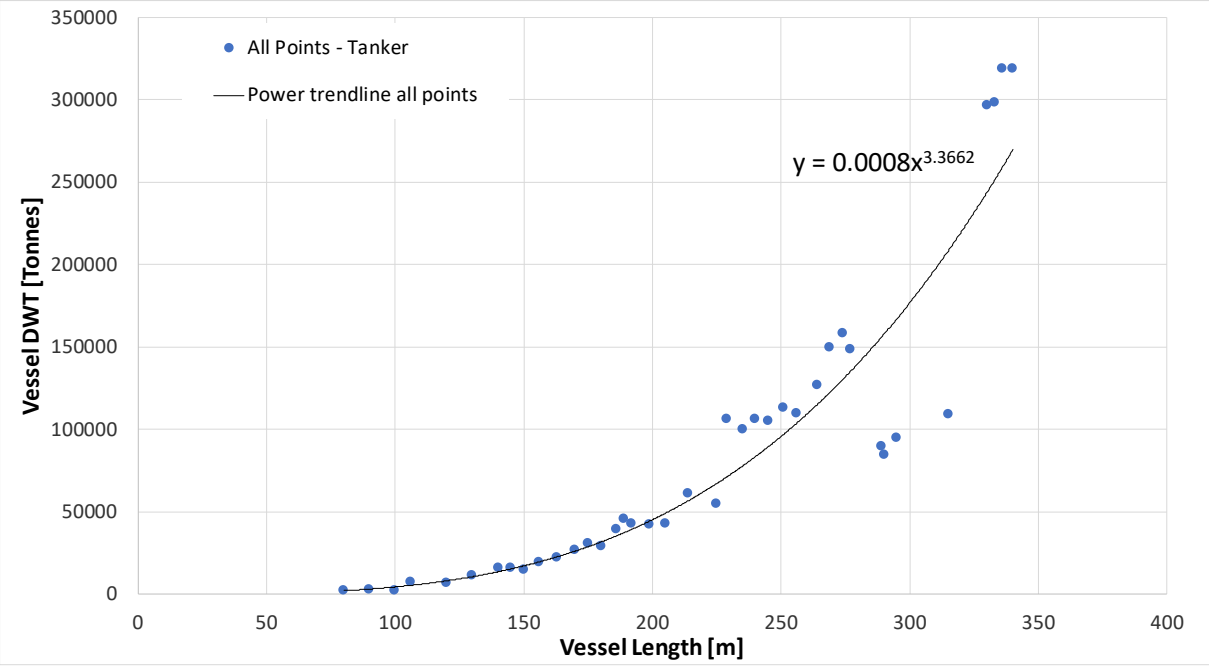
# D.1 APPENDIXH1

### Figure D-1 Cargo Vessels



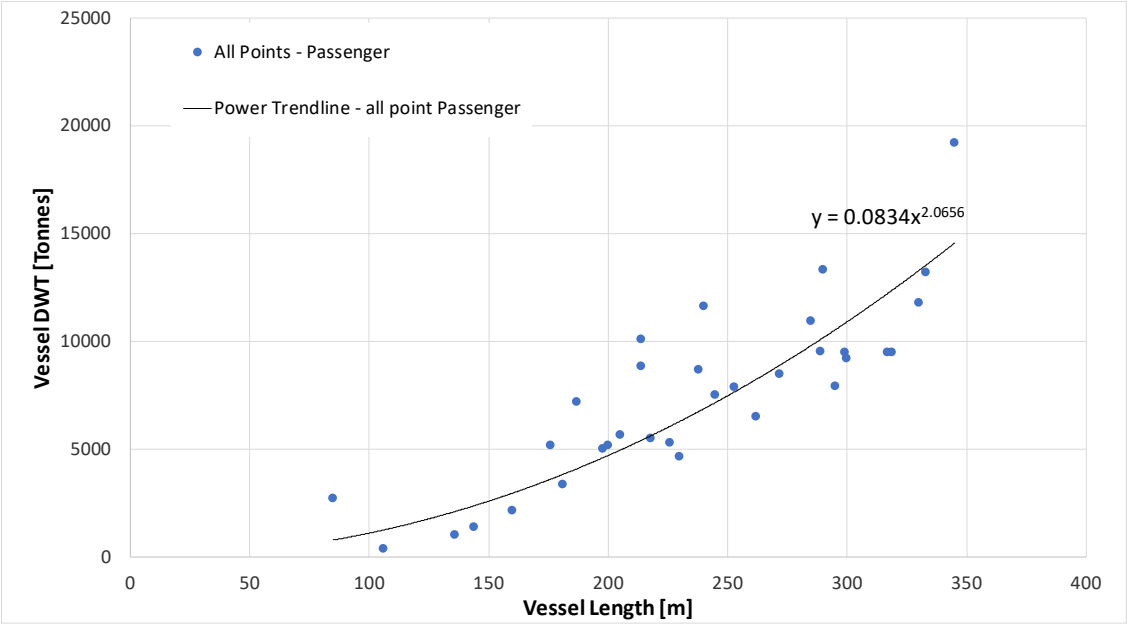

# D.2 TANKER VESSELS

### Figure D-2 Tanker Vessels



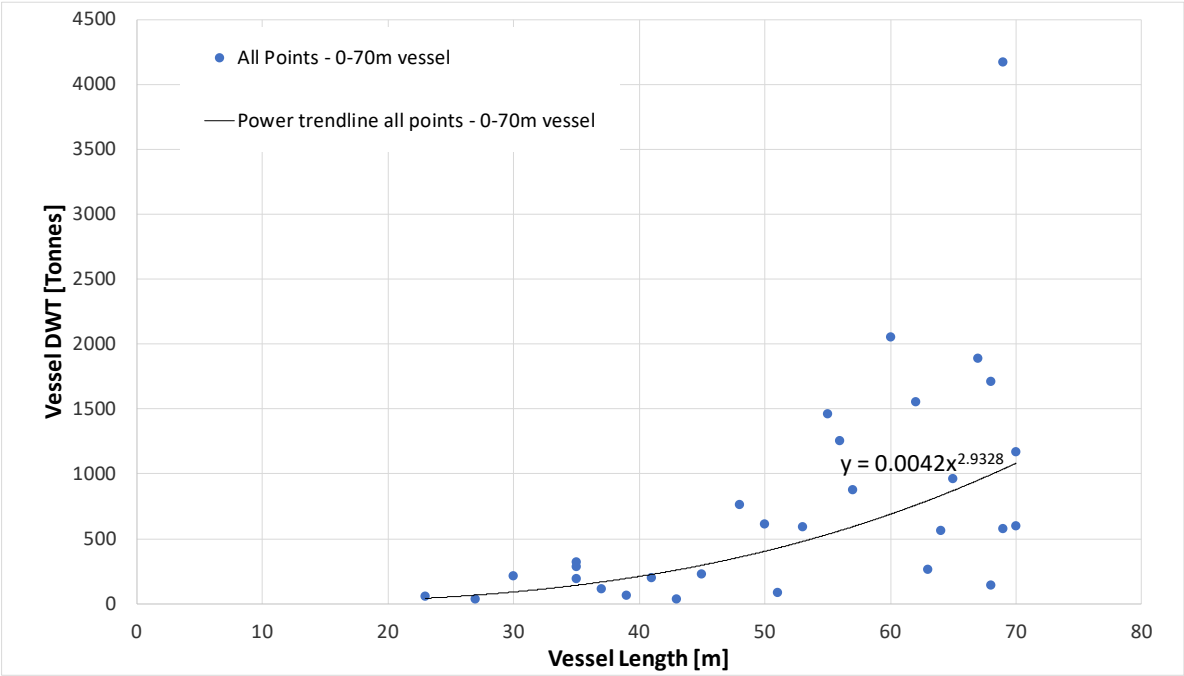
# D.3 PASSENGER VESSELS

### Figure D-3 Passenger Vessels




# D.4 VESSELS SMALLER THAN 70 METRES

### Figure D-4 Vessels Smaller than 70 Metres



# APPENDIX E

## Probabilistic Assessment Results

| Zone | Conservative Dominant soil type for risk assessment | Scenario 1 - Protection against Band A: Recommended Minimum DoL (m) | Scenario 1: Segment annual failure probability $P_{anchor\ damage}$ | Scenario 2 - Protection against Bands A to B: Recommended Minimum DoL (m) | Scenario 2: Segment annual failure probability $P_{anchor\ damage}$ | Scenario 3 - Protection against Bands A to C: Recommended Minimum DoL (m) | Scenario 3: Segment annual failure probability $P_{anchor\ damage}$ |
|---|---|---|---|---|---|---|---|
| Zone 1 | SAND and CLAY (≥10 to <100 kPa) & CLAY (≥10 to <100 kPa) | 0.85 | 1.70E-03 | 0.95 | 1.17E-03 | 1.10 | 9.45E-04 |
| Zone 2 | SAND and CLAY (≥10 to <100 kPa) & CLAY (≥10 to <100 kPa) | 0.95 | 2.77E-03 | 1.05 | 2.45E-03 | 1.20 | 2.30E-03 |
| Zone 3 | SAND and CLAY (≥10 to <100 kPa) & CLAY (≥10 to <100 kPa) | 0.45 | 3.32E-02 | 0.55 | 3.22E-02 | 0.70 | 3.01E-02 |
| Zone 4 | MEDIUM DENSE SAND | 0.30 | 3.68E-03 | 0.35 | 3.67E-03 | 0.40 | 3.62E-03 |
| Zone 5 | LOOSE SAND | 0.30 | 1.58E-03 | 0.40 | 1.57E-03 | 0.50 | 1.54E-03 |
| Zone 6 | MEDIUM DENSE SAND | 0.30 | 1.80E-03 | 0.35 | 1.79E-03 | 0.40 | 1.77E-03 |
| Zone 7 | LOOSE SAND | 0.30 | 2.80E-03 | 0.40 | 2.67E-03 | 0.50 | 2.63E-03 |
| Zone 8 | MEDIUM DENSE SAND | 0.30 | 2.53E-03 | 0.35 | 2.34E-03 | 0.40 | 2.29E-03 |
| Zone 9 | LOOSE SAND | 0.30 | 1.48E-03 | 0.40 | 1.38E-03 | 0.50 | 1.37E-03 |
| Zone 10 | MEDIUM DENSE SAND | 0.30 | 1.40E-03 | 0.35 | 1.30E-03 | 0.40 | 1.29E-03 |
| Zone 11 | MEDIUM DENSE SAND | 0.30 | 2.16E-03 | 0.35 | 2.05E-03 | 0.40 | 2.03E-03 |
| Zone 12 | HIGH STRENGTH CLAY (≥100 kPa) | 0.25 | 9.93E-04 | 0.30 | 8.93E-04 | 0.35 | 8.71E-04 |
| Zone 13 | VERY LOOSE SAND | 0.40 | 2.09E-04 | 0.50 | 1.76E-04 | 0.60 | 1.67E-04 |
| Zone 14 | SAND and CLAY (≥10 to <100 kPa) & CLAY (≥10 to <100 kPa) | 0.45 | 2.25E-04 | 0.55 | 1.96E-04 | 0.70 | 1.72E-04 |
| Zone 15 | VERY LOOSE SAND | 0.40 | 3.28E-04 | 0.50 | 2.87E-04 | 0.60 | 2.58E-04 |
| Zone 16 | MEDIUM DENSE SAND | 0.30 | 4.58E-04 | 0.35 | 3.38E-04 | 0.40 | 2.82E-04 |
| Zone 17 | HIGH STRENGTH CLAY (≥100 kPa) | 0.25 | 1.05E-03 | 0.30 | 9.80E-04 | 0.35 | 8.30E-04 |
| Zone 18 | HIGH STRENGTH CLAY (≥100 kPa) | 0.25 | 2.01E-04 | 0.30 | 1.92E-04 | 0.35 | 1.78E-04 |
| Zone 19 | HIGH STRENGTH CLAY (≥100 kPa) | 0.25 | 1.00E-03 | 0.30 | 9.57E-04 | 0.35 | 8.37E-04 |
| Zone 20 | HIGH STRENGTH CLAY (≥100 kPa) | 0.25 | 2.69E-04 | 0.30 | 2.64E-04 | 0.35 | 2.45E-04 |
| Zone 21 | HIGH STRENGTH CLAY (≥100 kPa) | 0.25 | 2.81E-03 | 0.30 | 2.68E-03 | 0.35 | 2.49E-03 |
| Zone 22 | HIGH STRENGTH CLAY (≥100 kPa) | 0.25 | 3.18E-03 | 0.30 | 2.66E-03 | 0.35 | 2.54E-03 |
| Zone 23 | MEDIUM DENSE SAND | 0.30 | 1.01E-03 | 0.35 | 9.17E-04 | 0.40 | 8.97E-04 |
| Zone 24 | HIGH STRENGTH CLAY (≥100 kPa) | 0.25 | 4.49E-04 | 0.30 | 4.23E-04 | 0.35 | 4.20E-04 |
| Zone 25 | HIGH STRENGTH CLAY (≥100 kPa) | 0.25 | 7.01E-04 | 0.30 | 6.50E-04 | 0.35 | 6.40E-04 |
| Zone 26 | MEDIUM DENSE SAND | 0.45 | 2.67E-04 | 0.50 | 2.35E-04 | 0.55 | 2.28E-04 |
| Zone 27 | MEDIUM DENSE SAND | 0.45 | 9.66E-05 | 0.50 | 9.66E-05 | 0.55 | 9.34E-05 |
| Zone 28 | MEDIUM DENSE SAND | 0.45 | 8.35E-04 | 0.50 | 8.00E-04 | 0.55 | 7.82E-04 |
| Zone 29 | MEDIUM DENSE SAND | 0.45 | 1.07E-03 | 0.50 | 1.01E-03 | 0.55 | 9.13E-04 |
| Zone 30 | VERY LOOSE SAND | 0.40 | 2.57E-05 | 0.50 | 2.49E-05 | 0.60 | 2.35E-05 |
| Zone 31 | MEDIUM DENSE SAND | 0.45 | 4.45E-04 | 0.50 | 4.24E-04 | 0.55 | 4.01E-04 |
| Zone 32 | MEDIUM DENSE SAND | 0.45 | 1.32E-04 | 0.50 | 1.32E-04 | 0.55 | 1.24E-04 |
| Zone 33 | MEDIUM DENSE SAND | 0.45 | 1.28E-04 | 0.50 | 1.21E-04 | 0.55 | 1.17E-04 |
| Zone 34 | MEDIUM DENSE SAND | 0.45 | 1.36E-04 | 0.50 | 1.13E-04 | 0.55 | 1.02E-04 |
| Zone 35 | SAND and CLAY (≥10 to <100 kPa) & CLAY (≥10 to <100 kPa) | 0.45 | 1.26E-05 | 0.55 | 1.06E-05 | 0.70 | 9.39E-06 |
| Zone 36 | MEDIUM DENSE SAND | 0.45 | 3.53E-05 | 0.50 | 2.76E-05 | 0.55 | 2.47E-05 |
| Zone 37 | MEDIUM DENSE SAND | 0.45 | 6.21E-05 | 0.50 | 4.82E-05 | 0.55 | 4.59E-05 |
| Zone 38 | MEDIUM DENSE SAND | 0.45 | 1.88E-05 | 0.50 | 1.50E-05 | 0.55 | 1.38E-05 |
| Zone 39 | MEDIUM DENSE SAND | 0.45 | 9.31E-05 | 0.50 | 6.43E-05 | 0.55 | 5.93E-05 |
| Zone 40 | MEDIUM DENSE SAND | 0.45 | 3.59E-05 | 0.50 | 2.34E-05 | 0.55 | 2.23E-05 |
| Zone 41 | MEDIUM DENSE SAND | 0.45 | 2.07E-04 | 0.50 | 9.76E-05 | 0.55 | 9.13E-05 |
| Zone 42 | MEDIUM DENSE SAND | 0.45 | 3.40E-05 | 0.50 | 2.10E-05 | 0.55 | 1.97E-05 |
| Zone 43 | MEDIUM DENSE SAND | 0.45 | 5.30E-04 | 0.50 | 2.80E-04 | 0.55 | 1.40E-04 |
| Zone 44 | VERY LOOSE SAND | 0.40 | 4.34E-05 | 0.50 | 2.78E-05 | 0.60 | 1.78E-05 |
| Zone 45 | SAND and CLAY (≥10 to <100 kPa) & CLAY (≥10 to <100 kPa) | 0.75 | 8.31E-06 | 0.85 | 5.94E-06 | 1.00 | 4.10E-06 |
| Zone 46 | SAND and CLAY (≥10 to <100 kPa) & CLAY (≥10 to <100 kPa) | 0.75 | 1.69E-04 | 0.85 | 1.67E-04 | 1.00 | 1.65E-04 |
| Zone 47 | SAND and CLAY (≥10 to <100 kPa) & CLAY (≥10 to <100 kPa) | 0.85 | 1.78E-05 | 0.95 | 1.23E-05 | 1.10 | 1.10E-05 |
| Zone 48 | SAND and CLAY (≥10 to <100 kPa) & CLAY (≥10 to <100 kPa) | 0.85 | 7.09E-06 | 0.95 | 3.94E-06 | 1.10 | 3.60E-06 |
| Zone 49 | SAND and CLAY (≥10 to <100 kPa) & CLAY (≥10 to <100 kPa) | 0.95 | 7.28E-06 | 1.05 | 4.88E-06 | 1.20 | 3.98E-06 |
| Zone 50 | SAND and CLAY (≥10 to <100 kPa) & CLAY (≥10 to <100 kPa) | 0.45 | 5.47E-06 | 0.55 | 8.56E-07 | 0.70 | 2.23E-07 |
| Zone 51 | SAND and CLAY (≥10 to <100 kPa) & CLAY (≥10 to <100 kPa) | 0.85 | 5.78E-06 | 0.95 | 1.29E-06 | 1.10 | 3.48E-07 |
| Zone 52 | SAND and CLAY (≥10 to <100 kPa) & CLAY (≥10 to <100 kPa) | 0.45 | 3.00E-06 | 0.55 | 9.00E-07 | 0.70 | 4.50E-07 |
| Zone 53 | SAND and CLAY (≥10 to <100 kPa) & CLAY (≥10 to <100 kPa) | 0.85 | 2.22E-06 | 0.95 | 1.52E-06 | 1.10 | 1.14E-06 |
| Zone 54 | SAND and CLAY (≥10 to <100 kPa) & CLAY (≥10 to <100 kPa) | 0.45 | 1.93E-06 | 0.55 | 1.39E-06 | 0.70 | 1.02E-06 |
| Zone 55 | SAND and CLAY (≥10 to <100 kPa) & CLAY (≥10 to <100 kPa) | 0.85 | 5.13E-06 | 0.95 | 1.90E-06 | 1.10 | 1.26E-06 |
| Zone 56 | SAND and CLAY (≥10 to <100 kPa) & CLAY (≥10 to <100 kPa) | 1.05 | 2.98E-04 | 1.15 | 2.92E-04 | 1.30 | 2.90E-04 |
| Zone 57 | SAND and CLAY (≥10 to <100 kPa) & CLAY (≥10 to <100 kPa) | 0.45 | 7.69E-06 | 0.55 | 2.88E-06 | 0.70 | 2.43E-06 |
| Zone 58 | SAND and CLAY (≥10 to <100 kPa) & CLAY (≥10 to <100 kPa) | 0.95 | 1.76E-06 | 1.05 | 9.01E-07 | 1.20 | 7.51E-07 |
| Zone 59 | SAND and CLAY (≥10 to <100 kPa) & CLAY (≥10 to <100 kPa) | 0.45 | 1.24E-05 | 0.55 | 4.95E-06 | 0.70 | 2.47E-06 |
| Zone 60 | SAND and CLAY (≥10 to <100 kPa) & CLAY (≥10 to <100 kPa) | 0.45 | 8.32E-06 | 0.55 | 2.70E-06 | 0.70 | 1.35E-06 |
| Zone 61 | SAND and CLAY (≥10 to <100 kPa) & CLAY (≥10 to <100 kPa) | 1.05 | 1.26E-05 | 1.15 | 5.85E-06 | 1.30 | 4.13E-06 |
| Zone 62 | SAND and CLAY (≥10 to <100 kPa) & CLAY (≥10 to <100 kPa) | 0.45 | 1.26E-05 | 0.55 | 8.88E-06 | 0.70 | 7.98E-06 |
| Zone 63 | SAND and CLAY (≥10 to <100 kPa) & CLAY (≥10 to <100 kPa) | 0.45 | 3.55E-04 | 0.55 | 3.48E-04 | 0.70 | 3.31E-04 |
| Zone 64 | SAND and CLAY (≥10 to <100 kPa) & CLAY (≥10 to <100 kPa) | 0.45 | 8.99E-06 | 0.55 | 6.24E-06 | 0.70 | 5.67E-06 |
| Zone 65 | SAND and CLAY (≥10 to <100 kPa) & CLAY (≥10 to <100 kPa) | 0.95 | 1.34E-04 | 1.05 | 1.30E-04 | 1.20 | 1.26E-04 |
| Zone 66 | SAND and CLAY (≥10 to <100 kPa) & CLAY (≥10 to <100 kPa) | 0.45 | 5.19E-04 | 0.55 | 5.12E-04 | 0.70 | 4.91E-04 |
| Zone 67 | SAND and CLAY (≥10 to <100 kPa) & CLAY (≥10 to <100 kPa) | 0.45 | 3.66E-05 | 0.55 | 3.29E-05 | 0.70 | 3.13E-05 |
| Zone 68 | LOOSE SAND | 0.30 | 1.73E-05 | 0.40 | 1.25E-05 | 0.50 | 1.10E-05 |
| Zone 69 | SAND and CLAY (≥10 to <100 kPa) & CLAY (≥10 to <100 kPa) | 0.45 | 5.62E-06 | 0.55 | 3.95E-06 | 0.70 | 3.19E-06 |
| Zone 70 | VERY LOOSE SAND | 0.40 | 8.72E-06 | 0.50 | 6.60E-06 | 0.60 | 5.63E-06 |
| Zone 71 | SAND and CLAY (≥10 to <100 kPa) & CLAY (≥10 to <100 kPa) | 0.95 | 1.75E-05 | 1.05 | 1.34E-05 | 1.20 | 1.15E-05 |
| Zone 72 | VERY LOOSE SAND | 0.40 | 4.43E-05 | 0.50 | 3.29E-05 | 0.60 | 2.22E-05 |
| Zone 73 | SAND and CLAY (≥10 to <100 kPa) & CLAY (≥10 to <100 kPa) | 0.45 | 1.86E-05 | 0.55 | 1.45E-05 | 0.70 | 1.07E-05 |
| Zone 74 | VERY LOOSE SAND | 0.40 | 1.21E-04 | 0.50 | 1.10E-04 | 0.60 | 1.06E-04 |
| Zone 75 | MEDIUM DENSE SAND | 0.45 | 2.46E-04 | 0.50 | 2.30E-04 | 0.55 | 2.29E-04 |
| Zone 76 | MEDIUM DENSE SAND | 0.35 | 7.94E-05 | 0.40 | 5.78E-05 | 0.45 | 4.75E-05 |
| Zone 77 | LOOSE SAND | 0.30 | 3.79E-04 | 0.40 | 1.76E-04 | 0.50 | 8.39E-05 |
| Zone 78 | VERY LOOSE SAND | 0.40 | 1.33E-05 | 0.50 | 5.56E-06 | 0.60 | 1.60E-06 |
| Zone 79 | MEDIUM DENSE SAND | 0.30 | 1.26E-04 | 0.35 | 1.06E-04 | 0.40 | 1.04E-04 |
| Zone 80 | VERY LOOSE SAND | 0.40 | 1.13E-05 | 0.50 | 3.21E-06 | 0.60 | 2.31E-06 |
| Zone 81 | LOOSE SAND | 0.30 | 5.20E-05 | 0.40 | 3.48E-05 | 0.50 | 2.70E-05 |
| Zone 82 | MEDIUM DENSE SAND | 0.30 | 8.10E-03 | 0.35 | 7.83E-03 | 0.40 | 7.01E-03 |
| Zone 83 | MEDIUM DENSE SAND | 0.30 | 1.35E-02 | 0.35 | 1.31E-02 | 0.40 | 1.14E-02 |
| Zone 84 | SAND and CLAY (≥10 to <100 kPa) & CLAY (≥10 to <100 kPa) | 0.45 | 3.03E-04 | 0.55 | 2.36E-04 | 0.70 | 2.04E-04 |
| Zone 85 | MEDIUM DENSE SAND | 0.30 | 2.81E-03 | 0.35 | 2.46E-03 | 0.40 | 2.19E-03 |
| Zone 86 | SAND and CLAY (≥10 to <100 kPa) & CLAY (≥10 to <100 kPa) | 0.45 | 3.14E-04 | 0.55 | 2.87E-04 | 0.70 | 2.53E-04 |
| Zone 87 | MEDIUM DENSE SAND | 0.30 | 3.39E-04 | 0.35 | 3.02E-04 | 0.40 | 2.55E-04 |
| Zone 88 | N/A | TBC | TBC | TBC | TBC | TBC | TBC |
| Annual Failure Probability for Entire route | | 1.00E-01 | | 9.43E-02 | | 8.74E-02 | |
| Return Period (years) | | 9.96 | | 10.60 | | 11.45 | |
| Failure Probability in the lifetime (40 years) | | 98.55% | | 98.10% | | 97.42% | |

| Zone | Scenario 4 - Protection against Bands A to D: Recommended Minimum DoL (m) | Scenario 4: Segment annual failure probability $P_{anchor\ damage}$ | Scenario 5 - Protection against Bands A to E: Recommended Minimum DoL (m) | Scenario 5: Segment annual failure probability $P_{anchor\ damage}$ | Scenario 6 - Protection against Bands A to F: Recommended Minimum DoL (m) | Scenario 6: Segment annual failure probability $P_{anchor\ damage}$ | Scenario 7 - Protection against Bands A to G: Recommended Minimum DoL (m) | Scenario 7: Segment annual failure probability $P_{anchor\ damage}$ |
|---|---|---|---|---|---|---|---|---|
| Zone 1 | 1.30 | 0.00E+00 | 1.65 | 0.00E+00 | 1.65 | 0.00E+00 | 1.75 | 0.00E+00 |
| Zone 2 | 1.40 | 1.60E-03 | 1.75 | 2.63E-04 | 1.75 | 2.63E-04 | 1.85 | 8.51E-05 |
| Zone 3 | 0.90 | 1.96E-02 | 1.25 | 3.67E-03 | 1.25 | 3.67E-03 | 1.35 | 1.35E-03 |
| Zone 4 | 0.45 | 3.28E-03 | 0.60 | 1.65E-03 | 0.60 | 1.65E-03 | 0.65 | 5.52E-04 |
| Zone 5 | 0.60 | 1.40E-03 | 0.85 | 6.98E-04 | 0.85 | 6.98E-04 | 0.95 | 2.46E-04 |
| Zone 6 | 0.45 | 1.64E-03 | 0.60 | 8.33E-04 | 0.60 | 8.33E-04 | 0.65 | 2.76E-04 |
| Zone 7 | 0.60 | 2.43E-03 | 0.85 | 1.38E-03 | 0.85 | 1.38E-03 | 0.95 | 4.76E-04 |
| Zone 8 | 0.45 | 2.08E-03 | 0.60 | 1.19E-03 | 0.60 | 1.19E-03 | 0.65 | 4.12E-04 |
| Zone 9 | 0.60 | 1.29E-03 | 0.85 | 7.70E-04 | 0.85 | 7.70E-04 | 0.95 | 2.85E-04 |
| Zone 10 | 0.45 | 1.17E-03 | 0.60 | 6.89E-04 | 0.60 | 6.89E-04 | 0.65 | 2.54E-04 |
| Zone 11 | 0.45 | 1.84E-03 | 0.60 | 1.06E-03 | 0.60 | 1.06E-03 | 0.65 | 3.94E-04 |
| Zone 12 | 0.45 | 7.68E-04 | 0.65 | 4.14E-04 | 0.65 | 4.14E-04 | 0.70 | 1.58E-04 |
| Zone 13 | 0.75 | 1.25E-04 | 1.05 | 9.27E-05 | 1.10 | 5.39E-05 | 1.15 | 1.39E-05 |
| Zone 14 | 0.90 | 1.13E-04 | 1.25 | 4.95E-05 | 1.25 | 4.95E-05 | 1.35 | 1.32E-05 |
| Zone 15 | 0.75 | 1.73E-04 | 1.05 | 1.27E-04 | 1.10 | 7.13E-05 | 1.15 | 1.60E-05 |
| Zone 16 | 0.45 | 8.94E-05 | 0.60 | 3.46E-05 | 0.60 | 3.46E-05 | 0.65 | 1.88E-05 |
| Zone 17 | 0.45 | 4.76E-04 | 0.65 | 3.03E-04 | 0.65 | 3.03E-04 | 0.70 | 1.58E-04 |
| Zone 18 | 0.45 | 9.88E-05 | 0.65 | 6.49E-05 | 0.65 | 6.49E-05 | 0.70 | 3.52E-05 |
| Zone 19 | 0.45 | 4.68E-04 | 0.65 | 2.97E-04 | 0.65 | 2.97E-04 | 0.70 | 1.13E-04 |
| Zone 20 | 0.45 | 1.41E-04 | 0.65 | 9.51E-05 | 0.65 | 9.51E-05 | 0.70 | 3.73E-05 |
| Zone 21 | 0.45 | 1.66E-03 | 0.65 | 9.49E-04 | 0.65 | 9.49E-04 | 0.70 | 4.95E-04 |
| Zone 22 | 0.45 | 1.87E-03 | 0.65 | 9.90E-04 | 0.65 | 9.90E-04 | 0.70 | 6.48E-04 |
| Zone 23 | 0.45 | 3.27E-04 | 0.60 | 1.57E-04 | 0.60 | 1.57E-04 | 0.65 | 9.97E-05 |
| Zone 24 | 0.45 | 1.99E-04 | 0.65 | 6.68E-05 | 0.65 | 6.68E-05 | 0.70 | 4.40E-05 |
| Zone 25 | 0.45 | 2.75E-05 | 0.65 | 5.92E-06 | 0.65 | 5.92E-06 | 0.70 | 2.79E-06 |
| Zone 26 | 0.60 | 1.64E-04 | 0.75 | 2.88E-05 | 0.75 | 2.88E-05 | 0.80 | 1.12E-05 |
| Zone 27 | 0.60 | 8.13E-05 | 0.75 | 2.89E-05 | 0.75 | 2.89E-05 | 0.80 | 8.36E-06 |
| Zone 28 | 0.60 | 5.14E-04 | 0.75 | 1.63E-04 | 0.75 | 1.63E-04 | 0.80 | 5.44E-05 |
| Zone 29 | 0.60 | 3.79E-04 | 0.75 | 7.95E-05 | 0.75 | 7.95E-05 | 0.80 | 4.18E-05 |
| Zone 30 | 0.75 | 3.47E-06 | 1.05 | 6.99E-07 | 1.10 | 3.68E-07 | 1.15 | 2.46E-07 |
| Zone 31 | 0.60 | 2.93E-04 | 0.75 | 8.06E-05 | 0.75 | 8.06E-05 | 0.80 | 3.44E-05 |
| Zone 32 | 0.60 | 9.13E-05 | 0.75 | 1.11E-05 | 0.75 | 1.11E-05 | 0.80 | 3.87E-06 |
| Zone 33 | 0.60 | 6.99E-05 | 0.75 | 4.65E-06 | 0.75 | 4.65E-06 | 0.80 | 2.24E-06 |
| Zone 34 | 0.60 | 6.72E-05 | 0.75 | 2.02E-05 | 0.75 | 2.02E-05 | 0.80 | 1.38E-05 |
| Zone 35 | 0.90 | 6.91E-06 | 1.25 | 1.88E-06 | 1.25 | 1.88E-06 | 1.35 | 1.43E-06 |
| Zone 36 | 0.60 | 1.88E-05 | 0.75 | 4.23E-06 | 0.75 | 4.23E-06 | 0.80 | 3.29E-06 |
| Zone 37 | 0.60 | 3.84E-05 | 0.75 | 7.50E-06 | 0.75 | 7.50E-06 | 0.80 | 3.75E-06 |
| Zone 38 | 0.60 | 1.16E-05 | 0.75 | 1.77E-06 | 0.75 | 1.77E-06 | 0.80 | 3.80E-07 |
| Zone 39 | 0.60 | 4.98E-05 | 0.75 | 1.03E-05 | 0.75 | 1.03E-05 | 0.80 | 1.25E-06 |
| Zone 40 | 0.60 | 1.45E-05 | 0.75 | 2.02E-06 | 0.75 | 2.02E-06 | 0.80 | 0.00E+00 |
| Zone 41 | 0.60 | 6.34E-05 | 0.75 | 1.24E-05 | 0.75 | 1.24E-05 | 0.80 | 3.11E-06 |
| Zone 42 | 0.60 | 1.47E-05 | 0.75 | 1.25E-06 | 0.75 | 1.25E-06 | 0.80 | 0.00E+00 |
| Zone 43 | 0.60 | 6.23E-05 | 0.75 | 0.00E+00 | 0.75 | 0.00E+00 | 0.80 | 0.00E+00 |
| Zone 44 | 0.75 | 1.12E-06 | 1.05 | 1.12E-06 | 1.10 | 0.00E+00 | 1.15 | 0.00E+00 |
| Zone 45 | 1.20 | 2.21E-06 | 1.55 | 6.31E-07 | 1.55 | 6.31E-07 | 1.65 | 3.16E-07 |
| Zone 46 | 1.20 | 1.49E-04 | 1.55 | 3.45E-05 | 1.55 | 3.45E-05 | 1.65 | 8.74E-06 |
| Zone 47 | 1.30 | 6.17E-06 | 1.65 | 0.00E+00 | 1.65 | 0.00E+00 | 1.75 | 0.00E+00 |
| Zone 48 | 1.30 | 2.70E-06 | 1.65 | 0.00E+00 | 1.65 | 0.00E+00 | 1.75 | 0.00E+00 |
| Zone 49 | 1.40 | 2.48E-06 | 1.75 | 0.00E+00 | 1.75 | 0.00E+00 | 1.85 | 0.00E+00 |
| Zone 50 | 0.90 | 7.44E-08 | 1.25 | 0.00E+00 | 1.25 | 0.00E+00 | 1.35 | 0.00E+00 |
| Zone 51 | 1.30 | 1.96E-07 | 1.65 | 0.00E+00 | 1.65 | 0.00E+00 | 1.75 | 0.00E+00 |
| Zone 52 | 0.90 | 3.00E-07 | 1.25 | 0.00E+00 | 1.25 | 0.00E+00 | 1.35 | 0.00E+00 |
| Zone 53 | 1.30 | 3.46E-07 | 1.65 | 0.00E+00 | 1.65 | 0.00E+00 | 1.75 | 0.00E+00 |
| Zone 54 | 0.90 | 2.70E-07 | 1.25 | 0.00E+00 | 1.25 | 0.00E+00 | 1.35 | 0.00E+00 |
| Zone 55 | 1.30 | 6.45E-07 | 1.65 | 0.00E+00 | 1.65 | 0.00E+00 | 1.75 | 0.00E+00 |
| Zone 56 | 1.50 | 2.65E-04 | 1.85 | 7.46E-05 | 1.85 | 7.46E-05 | 1.95 | 2.46E-05 |
| Zone 57 | 0.90 | 1.98E-06 | 1.25 | 4.50E-07 | 1.25 | 4.50E-07 | 1.35 | 0.00E+00 |
| Zone 58 | 1.40 | 6.01E-07 | 1.75 | 7.51E-08 | 1.75 | 7.51E-08 | 1.85 | 0.00E+00 |
| Zone 59 | 0.90 | 1.65E-06 | 1.25 | 0.00E+00 | 1.25 | 0.00E+00 | 1.35 | 0.00E+00 |
| Zone 60 | 0.90 | 9.00E-07 | 1.25 | 0.00E+00 | 1.25 | 0.00E+00 | 1.35 | 0.00E+00 |
| Zone 61 | 1.50 | 2.75E-06 | 1.85 | 0.00E+00 | 1.85 | 0.00E+00 | 1.95 | 0.00E+00 |
| Zone 62 | 0.90 | 5.85E-06 | 1.25 | 3.50E-07 | 1.25 | 3.50E-07 | 1.35 | 0.00E+00 |
| Zone 63 | 0.90 | 1.94E-04 | 1.25 | 7.92E-06 | 1.25 | 7.92E-06 | 1.35 | 2.00E-06 |
| Zone 64 | 0.90 | 3.61E-06 | 1.25 | 4.40E-07 | 1.25 | 4.40E-07 | 1.35 | 2.08E-07 |
| Zone 65 | 1.40 | 8.43E-05 | 1.75 | 3.83E-06 | 1.75 | 3.83E-06 | 1.85 | 2.92E-06 |
| Zone 66 | 0.90 | 2.91E-04 | 1.25 | 1.64E-05 | 1.25 | 1.64E-05 | 1.35 | 1.01E-05 |
| Zone 67 | 0.90 | 2.10E-05 | 1.25 | 2.47E-06 | 1.25 | 2.47E-06 | 1.35 | 1.39E-06 |
| Zone 68 | 0.60 | 7.10E-06 | 0.85 | 2.06E-06 | 0.85 | 2.06E-06 | 0.95 | 1.54E-06 |
| Zone 69 | 0.90 | 2.02E-06 | 1.25 | 2.53E-07 | 1.25 | 2.53E-07 | 1.35 | 2.53E-07 |
| Zone 70 | 0.75 | 4.24E-06 | 1.05 | 2.77E-06 | 1.10 | 1.39E-06 | 1.15 | 1.39E-06 |
| Zone 71 | 1.40 | 8.92E-06 | 1.75 | 3.94E-06 | 1.75 | 3.94E-06 | 1.85 | 3.94E-06 |
| Zone 72 | 0.75 | 1.36E-05 | 1.05 | 6.23E-06 | 1.10 | 1.53E-06 | 1.15 | 1.53E-06 |
| Zone 73 | 0.90 | 5.00E-06 | 1.25 | 1.25E-06 | 1.25 | 1.25E-06 | 1.35 | 1.25E-06 |
| Zone 74 | 0.75 | 3.81E-05 | 1.05 | 1.91E-05 | 1.10 | 8.41E-06 | 1.15 | 5.60E-06 |
| Zone 75 | 0.60 | 3.49E-06 | 0.75 | 0.00E+00 | 0.75 | 0.00E+00 | 0.80 | 0.00E+00 |
| Zone 76 | 0.50 | 2.11E-05 | 0.65 | 0.00E+00 | 0.65 | 0.00E+00 | 0.70 | 0.00E+00 |
| Zone 77 | 0.60 | 2.95E-05 | 0.85 | 0.00E+00 | 0.85 | 0.00E+00 | 0.95 | 0.00E+00 |
| Zone 78 | 0.75 | 5.34E-07 | 1.05 | 0.00E+00 | 1.10 | 0.00E+00 | 1.15 | 0.00E+00 |
| Zone 79 | 0.45 | 0.00E+00 | 0.60 | 0.00E+00 | 0.60 | 0.00E+00 | 0.65 | 0.00E+00 |
| Zone 80 | 0.75 | 2.01E-06 | 1.05 | 1.80E-06 | 1.10 | 0.00E+00 | 1.15 | 0.00E+00 |
| Zone 81 | 0.60 | 2.43E-05 | 0.85 | 6.75E-07 | 0.85 | 6.75E-07 | 0.95 | 0.00E+00 |
| Zone 82 | 0.45 | 3.14E-03 | 0.60 | 1.08E-03 | 0.60 | 1.08E-03 | 0.65 | 5.55E-04 |
| Zone 83 | 0.45 | 5.66E-03 | 0.60 | 1.78E-03 | 0.60 | 1.78E-03 | 0.65 | 7.54E-04 |
| Zone 84 | 0.90 | 1.73E-04 | 1.25 | 5.22E-05 | 1.25 | 5.22E-05 | 1.35 | 5.70E-06 |
| Zone 85 | 0.45 | 1.69E-03 | 0.60 | 4.66E-04 | 0.60 | 4.66E-04 | 0.65 | 1.34E-04 |
| Zone 86 | 0.90 | 2.37E-04 | 1.25 | 6.43E-05 | 1.25 | 6.43E-05 | 1.35 | 2.51E-05 |
| Zone 87 | 0.45 | 2.19E-04 | 0.60 | 6.76E-05 | 0.60 | 6.76E-05 | 0.65 | 2.77E-05 |
| Zone 88 | TBC | TBC | TBC | TBC | TBC | TBC | TBC | TBC |
| Annual Failure Probability for Entire route | 5.71E-02 | | 2.00E-02 | | 1.99E-02 | | 7.93E-03 | |
| Return Period (years) | 17.51 | | 49.99 | | 50.28 | | 126.06 | |
| Failure Probability in the lifetime (40 years) | 90.48% | | 55.44% | | 55.23% | | 27.28% | |

| Zone | Scenario 8 - Protection against Bands A to H: Recommended Minimum DoL (m) | Scenario 8: Segment annual failure probability $P_{anchor\ damage}$ | Scenario 9 - Protection against Bands A to I: Recommended Minimum DoL (m) | Scenario 9: Segment annual failure probability $P_{anchor\ damage}$ | Scenario 10 - Protection against Bands A to J: Recommended Minimum DoL (m) | Scenario 10: Segment annual failure probability $P_{anchor\ damage}$ |
|---|---|---|---|---|---|---|
| Zone 1 | 1.95 | 0.00E+00 | 1.95 | 0.00E+00 | 1.95 | 0.00E+00 |
| Zone 2 | 2.05 | 6.10E-07 | 2.05 | 6.10E-07 | 2.05 | 6.10E-07 |
| Zone 3 | 1.55 | 5.89E-06 | 1.55 | 5.89E-06 | 1.55 | 5.89E-06 |
| Zone 4 | 0.70 | 2.65E-06 | 0.70 | 2.65E-06 | 0.70 | 2.65E-06 |
| Zone 5 | 1.05 | 2.20E-06 | 1.05 | 2.20E-06 | 1.05 | 2.20E-06 |
| Zone 6 | 0.70 | 1.95E-06 | 0.70 | 1.95E-06 | 0.70 | 1.95E-06 |
| Zone 7 | 1.05 | 2.62E-06 | 1.05 | 2.62E-06 | 1.05 | 2.62E-06 |
| Zone 8 | 0.70 | 2.35E-06 | 0.70 | 2.35E-06 | 0.70 | 2.35E-06 |
| Zone 9 | 1.05 | 1.40E-06 | 1.05 | 1.40E-06 | 1.05 | 1.40E-06 |
| Zone 10 | 0.70 | 1.65E-06 | 0.70 | 1.65E-06 | 0.70 | 1.65E-06 |
| Zone 11 | 0.70 | 2.25E-06 | 0.70 | 2.25E-06 | 0.70 | 2.25E-06 |
| Zone 12 | 0.80 | 0.00E+00 | 0.80 | 0.00E+00 | 0.80 | 0.00E+00 |
| Zone 13 | 1.30 | 2.57E-06 | 1.35 | 0.00E+00 | 1.35 | 0.00E+00 |
| Zone 14 | 1.55 | 0.00E+00 | 1.55 | 0.00E+00 | 1.55 | 0.00E+00 |
| Zone 15 | 1.30 | 3.68E-06 | 1.35 | 0.00E+00 | 1.35 | 0.00E+00 |
| Zone 16 | 0.70 | 0.00E+00 | 0.70 | 0.00E+00 | 0.70 | 0.00E+00 |
| Zone 17 | 0.80 | 1.99E-06 | 0.80 | 1.99E-06 | 0.80 | 1.99E-06 |
| Zone 18 | 0.80 | 4.43E-07 | 0.80 | 4.43E-07 | 0.80 | 4.43E-07 |
| Zone 19 | 0.80 | 1.68E-06 | 0.80 | 1.68E-06 | 0.80 | 1.68E-06 |
| Zone 20 | 0.80 | 5.68E-07 | 0.80 | 5.68E-07 | 0.80 | 5.68E-07 |
| Zone 21 | 0.80 | 6.42E-06 | 0.80 | 6.42E-06 | 0.80 | 6.42E-06 |
| Zone 22 | 0.80 | 4.19E-06 | 0.80 | 4.19E-06 | 0.80 | 4.19E-06 |
| Zone 23 | 0.70 | 1.17E-06 | 0.70 | 1.17E-06 | 0.70 | 1.17E-06 |
| Zone 24 | 0.80 | 9.53E-07 | 0.80 | 9.53E-07 | 0.80 | 9.53E-07 |
| Zone 25 | 0.80 | 0.00E+00 | 0.80 | 0.00E+00 | 0.80 | 0.00E+00 |
| Zone 26 | 0.85 | 0.00E+00 | 0.85 | 0.00E+00 | 0.85 | 0.00E+00 |
| Zone 27 | 0.85 | 6.00E-07 | 0.85 | 6.00E-07 | 0.85 | 6.00E-07 |
| Zone 28 | 0.85 | 1.10E-06 | 0.85 | 1.10E-06 | 0.85 | 1.10E-06 |
| Zone 29 | 0.85 | 1.43E-06 | 0.85 | 1.43E-06 | 0.85 | 1.43E-06 |
| Zone 30 | 1.30 | 1.14E-07 | 1.35 | 0.00E+00 | 1.35 | 0.00E+00 |
| Zone 31 | 0.85 | 0.00E+00 | 0.85 | 0.00E+00 | 0.85 | 0.00E+00 |
| Zone 32 | 0.85 | 0.00E+00 | 0.85 | 0.00E+00 | 0.85 | 0.00E+00 |
| Zone 33 | 0.85 | 0.00E+00 | 0.85 | 0.00E+00 | 0.85 | 0.00E+00 |
| Zone 34 | 0.85 | 0.00E+00 | 0.85 | 0.00E+00 | 0.85 | 0.00E+00 |
| Zone 35 | 1.55 | 0.00E+00 | 1.55 | 0.00E+00 | 1.55 | 0.00E+00 |
| Zone 36 | 0.85 | 0.00E+00 | 0.85 | 0.00E+00 | 0.85 | 0.00E+00 |
| Zone 37 | 0.85 | 0.00E+00 | 0.85 | 0.00E+00 | 0.85 | 0.00E+00 |
| Zone 38 | 0.85 | 0.00E+00 | 0.85 | 0.00E+00 | 0.85 | 0.00E+00 |
| Zone 39 | 0.85 | 0.00E+00 | 0.85 | 0.00E+00 | 0.85 | 0.00E+00 |
| Zone 40 | 0.85 | 0.00E+00 | 0.85 | 0.00E+00 | 0.85 | 0.00E+00 |
| Zone 41 | 0.85 | 0.00E+00 | 0.85 | 0.00E+00 | 0.85 | 0.00E+00 |
| Zone 42 | 0.85 | 0.00E+00 | 0.85 | 0.00E+00 | 0.85 | 0.00E+00 |
| Zone 43 | 0.85 | 0.00E+00 | 0.85 | 0.00E+00 | 0.85 | 0.00E+00 |
| Zone 44 | 1.30 | 0.00E+00 | 1.35 | 0.00E+00 | 1.35 | 0.00E+00 |
| Zone 45 | 1.85 | 0.00E+00 | 1.85 | 0.00E+00 | 1.85 | 0.00E+00 |
| Zone 46 | 1.85 | 0.00E+00 | 1.85 | 0.00E+00 | 1.85 | 0.00E+00 |
| Zone 47 | 1.95 | 0.00E+00 | 1.95 | 0.00E+00 | 1.95 | 0.00E+00 |
| Zone 48 | 1.95 | 0.00E+00 | 1.95 | 0.00E+00 | 1.95 | 0.00E+00 |
| Zone 49 | 2.05 | 0.00E+00 | 2.05 | 0.00E+00 | 2.05 | 0.00E+00 |
| Zone 50 | 1.55 | 0.00E+00 | 1.55 | 0.00E+00 | 1.55 | 0.00E+00 |
| Zone 51 | 1.95 | 0.00E+00 | 1.95 | 0.00E+00 | 1.95 | 0.00E+00 |
| Zone 52 | 1.55 | 0.00E+00 | 1.55 | 0.00E+00 | 1.55 | 0.00E+00 |
| Zone 53 | 1.95 | 0.00E+00 | 1.95 | 0.00E+00 | 1.95 | 0.00E+00 |
| Zone 54 | 1.55 | 0.00E+00 | 1.55 | 0.00E+00 | 1.55 | 0.00E+00 |
| Zone 55 | 1.95 | 0.00E+00 | 1.95 | 0.00E+00 | 1.95 | 0.00E+00 |
| Zone 56 | 2.15 | 0.00E+00 | 2.15 | 0.00E+00 | 2.15 | 0.00E+00 |
| Zone 57 | 1.55 | 0.00E+00 | 1.55 | 0.00E+00 | 1.55 | 0.00E+00 |
| Zone 58 | 2.05 | 0.00E+00 | 2.05 | 0.00E+00 | 2.05 | 0.00E+00 |
| Zone 59 | 1.55 | 0.00E+00 | 1.55 | 0.00E+00 | 1.55 | 0.00E+00 |
| Zone 60 | 1.55 | 0.00E+00 | 1.55 | 0.00E+00 | 1.55 | 0.00E+00 |
| Zone 61 | 2.15 | 0.00E+00 | 2.15 | 0.00E+00 | 2.15 | 0.00E+00 |
| Zone 62 | 1.55 | 0.00E+00 | 1.55 | 0.00E+00 | 1.55 | 0.00E+00 |
| Zone 63 | 1.55 | 0.00E+00 | 1.55 | 0.00E+00 | 1.55 | 0.00E+00 |
| Zone 64 | 1.55 | 0.00E+00 | 1.55 | 0.00E+00 | 1.55 | 0.00E+00 |
| Zone 65 | 2.05 | 0.00E+00 | 2.05 | 0.00E+00 | 2.05 | 0.00E+00 |
| Zone 66 | 1.55 | 0.00E+00 | 1.55 | 0.00E+00 | 1.55 | 0.00E+00 |
| Zone 67 | 1.55 | 0.00E+00 | 1.55 | 0.00E+00 | 1.55 | 0.00E+00 |
| Zone 68 | 1.05 | 0.00E+00 | 1.05 | 0.00E+00 | 1.05 | 0.00E+00 |
| Zone 69 | 1.55 | 0.00E+00 | 1.55 | 0.00E+00 | 1.55 | 0.00E+00 |
| Zone 70 | 1.30 | 1.39E-06 | 1.35 | 0.00E+00 | 1.35 | 0.00E+00 |
| Zone 71 | 2.05 | 0.00E+00 | 2.05 | 0.00E+00 | 2.05 | 0.00E+00 |
| Zone 72 | 1.30 | 1.53E-06 | 1.35 | 0.00E+00 | 1.35 | 0.00E+00 |
| Zone 73 | 1.55 | 0.00E+00 | 1.55 | 0.00E+00 | 1.55 | 0.00E+00 |
| Zone 74 | 1.30 | 4.20E-06 | 1.35 | 0.00E+00 | 1.35 | 0.00E+00 |
| Zone 75 | 0.85 | 0.00E+00 | 0.85 | 0.00E+00 | 0.85 | 0.00E+00 |
| Zone 76 | 0.75 | 0.00E+00 | 0.75 | 0.00E+00 | 0.75 | 0.00E+00 |
| Zone 77 | 1.05 | 0.00E+00 | 1.05 | 0.00E+00 | 1.05 | 0.00E+00 |
| Zone 78 | 1.30 | 0.00E+00 | 1.35 | 0.00E+00 | 1.35 | 0.00E+00 |
| Zone 79 | 0.70 | 0.00E+00 | 0.70 | 0.00E+00 | 0.70 | 0.00E+00 |
| Zone 80 | 1.30 | 0.00E+00 | 1.35 | 0.00E+00 | 1.35 | 0.00E+00 |
| Zone 81 | 1.05 | 0.00E+00 | 1.05 | 0.00E+00 | 1.05 | 0.00E+00 |
| Zone 82 | 0.70 | 3.92E-06 | 0.70 | 3.92E-06 | 0.70 | 3.92E-06 |
| Zone 83 | 0.70 | 5.48E-06 | 0.70 | 5.48E-06 | 0.70 | 5.48E-06 |
| Zone 84 | 1.55 | 0.00E+00 | 1.55 | 0.00E+00 | 1.55 | 0.00E+00 |
| Zone 85 | 0.70 | 0.00E+00 | 0.70 | 0.00E+00 | 0.70 | 0.00E+00 |
| Zone 86 | 1.55 | 0.00E+00 | 1.55 | 0.00E+00 | 1.55 | 0.00E+00 |
| Zone 87 | 0.70 | 0.00E+00 | 0.70 | 0.00E+00 | 0.70 | 0.00E+00 |
| Zone 88 | TBC | TBC | TBC | TBC | TBC | TBC |
| Annual Failure Probability for Entire route | 6.70E-05 | | 5.35E-05 | | 5.35E-05 | |
| Return Period (years) | 14923.81 | | 18684.52 | | 18684.52 | |
| Failure Probability in the lifetime (40 years) | 0.27% | | 0.21% | | 0.21% | |

| Zone | Scenario 11- Protection against Bands A to K: Recommended Minimum DoL (m) | Scenario 11: Segment annual failure probability $P_{anchor\ damage}$ | Scenario 12-Selected Protection Section by Section: Recommended Minimum DoL (m) | Scenario 12: Segment annual failure probability $P_{anchor\ damage}$ | Target DoL (m): Target DoL (m) | Target DoL: Segment annual failure probability $P_{anchor\ damage}$ |
|---|---|---|---|---|---|---|
| Zone 1 | 2.15 | 0.00E+00 | 1.30 | 0.00E+00 | 1.70 | 0.00E+00 |
| Zone 2 | 2.25 | 0.00E+00 | 1.85 | 8.51E-05 | 2.00 | 8.51E-05 |
| Zone 3 | 1.75 | 0.00E+00 | 1.55 | 5.89E-06 | 1.70 | 5.89E-06 |
| Zone 4 | 0.75 | 0.00E+00 | 0.70 | 2.65E-06 | 1.50 | 0.00E+00 |
| Zone 5 | 1.20 | 0.00E+00 | 1.05 | 2.20E-06 | 1.50 | 0.00E+00 |
| Zone 6 | 0.75 | 0.00E+00 | 0.70 | 1.95E-06 | 1.50 | 0.00E+00 |
| Zone 7 | 1.20 | 0.00E+00 | 1.05 | 2.62E-06 | 1.50 | 0.00E+00 |
| Zone 8 | 0.75 | 0.00E+00 | 0.70 | 2.35E-06 | 1.50 | 0.00E+00 |
| Zone 9 | 1.20 | 0.00E+00 | 1.05 | 1.40E-06 | 1.50 | 0.00E+00 |
| Zone 10 | 0.75 | 0.00E+00 | 0.70 | 1.65E-06 | 1.50 | 0.00E+00 |
| Zone 11 | 0.75 | 0.00E+00 | 0.70 | 2.25E-06 | 1.50 | 0.00E+00 |
| Zone 12 | 0.90 | 0.00E+00 | 0.80 | 0.00E+00 | 1.50 | 0.00E+00 |
| Zone 13 | 1.50 | 0.00E+00 | 1.15 | 1.39E-05 | 1.50 | 0.00E+00 |
| Zone 14 | 1.75 | 0.00E+00 | 1.25 | 4.95E-05 | 1.50 | 1.32E-05 |
| Zone 15 | 1.50 | 0.00E+00 | 1.15 | 1.60E-05 | 1.50 | 0.00E+00 |
| Zone 16 | 0.75 | 0.00E+00 | 0.60 | 3.46E-05 | 1.50 | 0.00E+00 |
| Zone 17 | 0.90 | 0.00E+00 | 0.80 | 1.99E-06 | 1.50 | 0.00E+00 |
| Zone 18 | 0.90 | 0.00E+00 | 0.80 | 4.43E-07 | 1.50 | 0.00E+00 |
| Zone 19 | 0.90 | 0.00E+00 | 0.80 | 1.68E-06 | 1.50 | 0.00E+00 |
| Zone 20 | 0.90 | 0.00E+00 | 0.80 | 5.68E-07 | 1.50 | 0.00E+00 |
| Zone 21 | 0.90 | 0.00E+00 | 0.80 | 6.42E-06 | 1.50 | 0.00E+00 |
| Zone 22 | 0.90 | 0.00E+00 | 0.80 | 4.19E-06 | 1.50 | 0.00E+00 |
| Zone 23 | 0.75 | 0.00E+00 | 0.70 | 1.17E-06 | 1.50 | 0.00E+00 |
| Zone 24 | 0.90 | 0.00E+00 | 0.80 | 9.53E-07 | 1.50 | 0.00E+00 |
| Zone 25 | 0.90 | 0.00E+00 | 0.70 | 2.79E-06 | 1.50 | 0.00E+00 |
| Zone 26 | 0.90 | 0.00E+00 | 0.85 | 0.00E+00 | 1.50 | 0.00E+00 |
| Zone 27 | 0.90 | 0.00E+00 | 0.80 | 8.36E-06 | 1.50 | 0.00E+00 |
| Zone 28 | 0.90 | 0.00E+00 | 0.85 | 1.10E-06 | 1.50 | 0.00E+00 |
| Zone 29 | 0.90 | 0.00E+00 | 0.85 | 1.43E-06 | 1.50 | 0.00E+00 |
| Zone 30 | 1.50 | 0.00E+00 | 1.05 | 6.99E-07 | 1.50 | 0.00E+00 |
| Zone 31 | 0.90 | 0.00E+00 | 0.85 | 0.00E+00 | 1.50 | 0.00E+00 |
| Zone 32 | 0.90 | 0.00E+00 | 0.80 | 3.87E-06 | 1.50 | 0.00E+00 |
| Zone 33 | 0.90 | 0.00E+00 | 0.80 | 2.24E-06 | 1.50 | 0.00E+00 |
| Zone 34 | 0.90 | 0.00E+00 | 0.85 | 0.00E+00 | 1.50 | 0.00E+00 |
| Zone 35 | 1.75 | 0.00E+00 | 1.25 | 1.88E-06 | 1.50 | 1.43E-06 |
| Zone 36 | 0.90 | 0.00E+00 | 0.80 | 3.29E-06 | 1.50 | 0.00E+00 |
| Zone 37 | 0.90 | 0.00E+00 | 0.80 | 3.75E-06 | 1.50 | 0.00E+00 |
| Zone 38 | 0.90 | 0.00E+00 | 0.80 | 3.80E-07 | 1.50 | 0.00E+00 |
| Zone 39 | 0.90 | 0.00E+00 | 0.80 | 1.25E-06 | 1.50 | 0.00E+00 |
| Zone 40 | 0.90 | 0.00E+00 | 0.80 | 0.00E+00 | 1.50 | 0.00E+00 |
| Zone 41 | 0.90 | 0.00E+00 | 0.80 | 3.11E-06 | 1.50 | 0.00E+00 |
| Zone 42 | 0.90 | 0.00E+00 | 0.75 | 1.25E-06 | 1.50 | 0.00E+00 |
| Zone 43 | 0.90 | 0.00E+00 | 0.75 | 0.00E+00 | 1.50 | 0.00E+00 |
| Zone 44 | 1.50 | 0.00E+00 | 0.75 | 1.12E-06 | 1.50 | 0.00E+00 |
| Zone 45 | 2.05 | 0.00E+00 | 0.85 | 5.94E-06 | 1.50 | 2.21E-06 |
| Zone 46 | 2.05 | 0.00E+00 | 1.55 | 3.45E-05 | 1.70 | 8.74E-06 |
| Zone 47 | 2.15 | 0.00E+00 | 0.95 | 1.23E-05 | 1.50 | 6.17E-06 |
| Zone 48 | 2.15 | 0.00E+00 | 0.95 | 3.94E-06 | 1.50 | 2.70E-06 |
| Zone 49 | 2.25 | 0.00E+00 | 1.05 | 4.88E-06 | 1.50 | 2.48E-06 |
| Zone 50 | 1.75 | 0.00E+00 | 0.55 | 8.56E-07 | 1.50 | 0.00E+00 |
| Zone 51 | 2.15 | 0.00E+00 | 0.95 | 1.29E-06 | 1.50 | 1.96E-07 |
| Zone 52 | 1.75 | 0.00E+00 | 0.55 | 9.00E-07 | 1.50 | 0.00E+00 |
| Zone 53 | 2.15 | 0.00E+00 | 0.95 | 1.52E-06 | 1.50 | 3.46E-07 |
| Zone 54 | 1.75 | 0.00E+00 | 0.55 | 1.39E-06 | 1.50 | 0.00E+00 |
| Zone 55 | 2.15 | 0.00E+00 | 0.95 | 1.90E-06 | 1.50 | 6.45E-07 |
| Zone 56 | 2.35 | 0.00E+00 | 1.50 | 2.65E-04 | 1.70 | 2.65E-04 |
| Zone 57 | 1.75 | 0.00E+00 | 0.55 | 2.88E-06 | 1.50 | 0.00E+00 |
| Zone 58 | 2.25 | 0.00E+00 | 0.55 | 2.70E-06 | 1.50 | 6.01E-07 |
| Zone 59 | 1.75 | 0.00E+00 | 0.55 | 4.95E-06 | 1.50 | 0.00E+00 |
| Zone 60 | 1.75 | 0.00E+00 | 0.55 | 2.70E-06 | 1.50 | 0.00E+00 |
| Zone 61 | 2.35 | 0.00E+00 | 1.15 | 5.85E-06 | 1.50 | 2.75E-06 |
| Zone 62 | 1.75 | 0.00E+00 | 0.55 | 8.88E-06 | 1.50 | 0.00E+00 |
| Zone 63 | 1.75 | 0.00E+00 | 1.25 | 7.92E-06 | 1.50 | 2.00E-06 |
| Zone 64 | 1.75 | 0.00E+00 | 0.55 | 6.24E-06 | 1.50 | 2.08E-07 |
| Zone 65 | 2.25 | 0.00E+00 | 1.40 | 8.43E-05 | 1.50 | 8.43E-05 |
| Zone 66 | 1.75 | 0.00E+00 | 1.25 | 1.64E-05 | 1.50 | 1.01E-05 |
| Zone 67 | 1.75 | 0.00E+00 | 0.90 | 2.10E-05 | 1.50 | 1.39E-06 |
| Zone 68 | 1.20 | 0.00E+00 | 0.60 | 7.10E-06 | 1.50 | 0.00E+00 |
| Zone 69 | 1.75 | 0.00E+00 | 0.70 | 3.19E-06 | 1.50 | 2.53E-07 |
| Zone 70 | 1.50 | 0.00E+00 | 0.60 | 5.63E-06 | 1.50 | 0.00E+00 |
| Zone 71 | 2.25 | 0.00E+00 | 1.05 | 1.34E-05 | 1.70 | 8.92E-06 |
| Zone 72 | 1.50 | 0.00E+00 | 0.75 | 1.36E-05 | 1.50 | 0.00E+00 |
| Zone 73 | 1.75 | 0.00E+00 | 0.70 | 1.07E-05 | 1.50 | 1.25E-06 |
| Zone 74 | 1.50 | 0.00E+00 | 0.75 | 3.81E-05 | 1.50 | 0.00E+00 |
| Zone 75 | 0.90 | 0.00E+00 | 0.60 | 3.49E-06 | 1.50 | 0.00E+00 |
| Zone 76 | 0.80 | 0.00E+00 | 1.50 | 0.00E+00 | 1.50 | 0.00E+00 |
| Zone 77 | 1.20 | 0.00E+00 | 1.50 | 0.00E+00 | 1.50 | 0.00E+00 |
| Zone 78 | 1.50 | 0.00E+00 | 1.50 | 0.00E+00 | 1.50 | 0.00E+00 |
| Zone 79 | 0.75 | 0.00E+00 | 1.50 | 0.00E+00 | 1.50 | 0.00E+00 |
| Zone 80 | 1.50 | 0.00E+00 | 1.50 | 0.00E+00 | 1.50 | 0.00E+00 |
| Zone 81 | 1.20 | 0.00E+00 | 1.50 | 0.00E+00 | 1.50 | 0.00E+00 |
| Zone 82 | 0.75 | 0.00E+00 | 2.00 | 0.00E+00 | 2.00 | 0.00E+00 |
| Zone 83 | 0.75 | 0.00E+00 | 2.00 | 0.00E+00 | 2.00 | 0.00E+00 |
| Zone 84 | 1.75 | 0.00E+00 | 1.50 | 5.70E-06 | 1.50 | 5.70E-06 |
| Zone 85 | 0.75 | 0.00E+00 | 1.50 | 0.00E+00 | 1.50 | 0.00E+00 |
| Zone 86 | 1.75 | 0.00E+00 | 1.50 | 2.51E-05 | 1.50 | 2.51E-05 |
| Zone 87 | 0.75 | 0.00E+00 | 1.50 | 0.00E+00 | 1.50 | 0.00E+00 |
| Zone 88 | TBC | TBC | TBC | 0.00E+00 | TBC | 0.00E+00 |
| Annual Failure Probability for Entire route | 0.00E+00 | | 9.00E-04 | | 5.37E-04 | |
| Return Period (years) | - | | 1111.27 | | 1863.84 | |
| Failure Probability in the lifetime (40 years) | 0.00% | | 3.54% | | 2.12% | |

# Bijlage 9: Detailed UXO Risk Assessment, 1st line defence, 10 augustus 2018

# Detailed Unexploded Ordnance (UXO) Risk Assessment

| | |
|---|---|
| **Project Name** | HVDC Electricity Transmission Interconnector between the Isle of Grain, UK and Wilhelmshaven, Germany |
| **Client** | Intertek |
| **Site Address** | Kent, England to Lower Saxony, Germany |
| **Report Reference** | DA6316-01 |
| **Date** | 10th August 2018 |
| **Originator** | MN |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# Executive Summary

## Description and Location of Study Area

The proposed HVDC (high voltage direct current) Electricity Transmission Interconnector is understood to be a new subsea cable between existing substations and electricity grids in the UK and continental Europe.

The HVDC project is designed to provide the first direct energy link between the UK and Germany, with the aim of delivering an increased security of supply, fuel diversity and greater competition to both nation's networks. It will allow a capacity of up to 1.4GW of electricity to flow in both directions, connecting two of Europe's largest energy markets and allowing the integration of renewable energy sources.

The study area is approximately 700km in length and spans the southern section of the North Sea. It stretches through the UK's TW (territorial waters) and EEZ (exclusive economic zone), the Netherlands' EEZ and Germanys' TW and EEZ; including small areas of initial landfall identified at the Isle of Grain, UK and Hooksiel, Germany.

The study area comprises one singular route between the approximate latitudes and longitudes: **51°27'48.31"N 0°42'43.77"E** (at its western endpoint) and **53°38'12.20"N 8° 5'14.08"E** (at its eastern endpoint). It does not connect between these points in a straight course.

The western end of the study area, situated on the UK mainland, comprises a small area of coastline and surrounding rural land on the Isle of Grain. The eastern end of the study, situated on the German mainland, occupies a small area of open land surrounding the Am Tiefen Fahrwasser roadway and the coastline of Hooksiel.

The remainder of the study area occupies a large expanse of open water within the Thames Estuary and the North Sea.

## Proposed Works

At the time of the production of this report, it is understood that a geotechnical survey is already underway, with geotechnical sampling planned at every 1km across the study area between the UK and Germany. Limited information was provided by the client regarding the exact scope of this survey, which is anticipated to include vibrocore and cone penetrometer tests (CPT) within areas of open water and investigatory boreholes and trial pits within areas of landfall.

It is understood that the project is currently going through a period of further project development ahead of a full submission being made to the UK and German regulators in 2019. Final approval for the scheme is expected in 2020, allowing construction to start shortly afterwards. The current target date for project completion is 2023.

As a result, limited information is available concerning the final methodology of the proposed cable installation. However, typical intrusive activities within the marine environment for this type of project could include the use of anchors, cable trenching equipment, pre-lay grapnel runs, boulder removal ploughs, mass flow excavators, dredging and the placement of material mattresses on the seabed.

It should be noted that such activities might exceed the boundary of the proposed study area provided. A 1km buffer zone has therefore been considered on either side of the centre line of the proposed cable area for the purpose of this report.

## Seabed Geology

The British Geological Survey (BGS) map, the German Federal Institute for Geosciences and Natural Resources (BGR) Geoviewer and the European Marine Observation and Data Network (EMODnet) were consulted for the purpose of this report. These sources show the bedrock geology of the western endpoint of the study area, within the UK landfall on the Isle of Grain, to be underlain by the London Clay Formation – clay and silt, with superficial deposits of Alluvium – clay, silt, sand, peat and gravel. The bedrock geology of the eastern endpoint of the study area, within the German landfall, is shown to consist of sedimentary material overlain by clay, silt and sand.

The offshore bedrock geology varies considerably over the length of the proposed route and includes areas underlain by:

- Mudstone and sandstone (undifferentiated) and tuff.
- Rock, siliciclastic, argillaceous with sandstone (undifferentiated).
- Brielle Ground Formation - sand.
- Pliocene sedimentary material.


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**UXO Risk Assessment**

1st Line Defence has assessed a potential risk within the location of the study area from UXO contamination, based on the following potential sources:

**Coastal Armament Training Areas**

- The firing areas of three historic armament training ranges are situated directly across the section of the study area within the Thames Estuary on WWII-era armament training and 'danger area' mapping. These comprise the former Sheerness and Grain, Yantlet and Shoeburyness Artillery Ranges, the latter of which still plays an extensive role in the testing and development of ordnance on behalf of the MoD today. Two smaller historic ranges are also denoted within the Thames Estuary, to the south-east of this section of the study area. Barton Point, a heavy and light anti-aircraft range, was situated at a distance of approximately 2-5km and 22 Leysdown, an RAF live bombing range, was situated at a distance of approximately 5-6km.
- Based on the available historical documentation, it is anticipated that both live and practice ammunition would been deployed during these ranges operation, with both categories of ordnance still employed at Shoeburyness today. The presence of these armament ranges therefore significantly increases the likelihood that items of Allied ordnance could have been expended through training exercises or firing practices within the westernmost of the study area, from the Isle of Grain to the approaches to the Thames Estuary. This is further demonstrated by the large number of UXO discoveries within the region in the post war period. Selective imagery, taken from hundreds of items found during UXO clearance dredging operations in the Princess Channel in the 2000s, is presented in **Annex O**.
- The majority of items or ordnance used in the coastal armament training areas within the Thames Estuary will have consisted of LSA and SAA. Though larger, aerial delivered bombs will have been deployed at the site of the 22 Leysdon RAF range. The smallest type of LSA typically used by British forces during the WWII-era were three pounder projectiles, though smaller sizes of projectiles may have been utilised. Items of ordnance fired within the estuary's danger areas are not anticipated to have always detonated on impact with the water and have the potential to remain live and settle within the estuary's bed.

**Munitions Dumpsites**

- A concentration of historic munitions dumpsites has been identified within the eastern section of the study area, off the coastline of North Germany. These dumpsites are believed to have formed part of a wider programme of ammunition dumping across the German North Sea Coast at the end of WWII, resulting in an estimated 750,000 to 1.5 million tons of munitions dumped from both German and Allied sources. This included an estimated 250,000 tons of ammunition shipped from the Port of Wilhelmshaven alone. Although the closest three dumpsites are situated at an approximate distance of 1-2km from the study area, this is still of concern, as it is possible that dumped munitions may have either been deposited outside their designated areas or have else migrated within the region over time.
- Extensive munition recovery is known to have been undertaken in the region between 1952-1958 to recover various UXO related metals. However this type of clearance work is rarely comprehensive and subsequent experimental recovery operations undertaken by the German government in the 1990's are known to have still resulted in the discovery of large volumes of items, including the recovery of 3,000kg of munitions in 1991 and 4,669kg of munitions in 1999. It is therefore anticipated that large amounts of ammunition are still present on and around these former dumping areas, with some sources suggesting that an estimated 10,000-50,000 tons of munitions may still be present in Lower Saxonian waters.

**Aerial Bombing**

- The risk of contamination from items of air delivered UXO is considered most significant within the eastern endpoint of the study area, at the approach to the Jade Bight. This is due to the number of Allied air raids carried out on Wilhelmshaven during WWII. An estimated 5,327.5 tons of bombs are believed to have been dropped by 2,141 bombers of the USAAF on targets on and around the city, which is anticipated to have led to a significant increase in the density of bombing in the surrounding area. It should be noted however that the eastern endpoint section of the study area has undergone significant land reclamation since the 1970's and that such activity will have significantly mitigated the potential for larger items of UXO remain, provided that the fill material used was not from a contaminated source.
- The western endpoint of the study area was situated within a district of Kent that sustained a low-moderate density of German aerial bombing throughout the war. However its location within the Isle of Grain, at the confluence of the River Medway and Thames, is anticipated to elevate bombing due to its position on Luftwaffe flights paths and the presence of several significant nearby Luftwaffe targets, such as the former Grain oil refinery, the Allhallows bombing decoy sites and Sheerness Docks.
- The density of aerial bombing is anticipated to have been considerably lower across the offshore areas that occupy the vast majority of the proposed study area. However, potential sources of contamination identified in this


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**UXO Risk Assessment**

environment include the dumping of ordnance during plane to plane engagements and attacks on military and merchant shipping. The possibility that such items may be present within any offshore area subsequently cannot be completely discounted. Furthermore, the risk of contamination from aerial delivered bomb is considered to increase within the Thames Estuary and within areas close to the German coastline, due to the increased volume of Luftwaffe and Allied bomber activity documented in these regions.

**Wartime Coastal Defences**

- Due to its strategic location, the Isle of Grain was occupied by an extensive network of coastal military defences, including fortified structures, coastal artillery batteries and other gun emplacements throughout the 19th and early 20th centuries. The majority of these defences were deemed redundant after WWI with only Grain Fort, Dummy Battery and Grain Tower Battery armed and operational at the start of WWII. However, a number of anti-aircraft emplacements, emergency coastal artillery batteries and static defensive potions, such as anti-tank blocks, were later established across combat the increased potential threat of a Nazi invasion, as well as to combat Luftwaffe raids.
- It is anticipated that these defensive positions on and surrounding the western endpoint of the study area would have been manned by the relevant members of the Armed Forces for a significant period before, during and after both world wars. This suggests that SAA and LSA would have been stored in these areas and highlights the potential for contamination to have resulted at key points, especially when the threat of invasion rescinded mid-way through WWII and surplus weaponry would have needed disposal. Defensive positions such as anti-aircraft batteries, coastal batteries and other gun emplacements could also have resulted in contamination across the wider area of this section of the study area, across the Thames Estuary.

**Sea Mines**

- Sizeable mine laying campaigns were undertaken by both Britain and Germany across the North Sea in WWI and WWII. The majority of the study area appears to have been situated across several of the more prominent of the WWII-era minefields, including significant defensive areas off the east coast of Britain and the north coast of Germany. Evidence has also been found to indicate that air deployed mines were regularly dropped within the Thames Estuary by the Luftwaffe between 1940-1941.
- A precise assessment of the current risk from mines across the length of the study area is difficult to ascertain. Efforts were made by both Germany and Britain post-war to remove or make safe the areas mined during the war. However such clearance tasks do not guarantee the complete removal of all mines within a danger area, especially as such items have the potential to migrate or became covered due to sediment and tidal action over a long period of time. It is therefore not possible to discount the possibility of encountering aerial, surface or submarine laid sea mines across any offshore section of the proposed study area.

**Wreck Sites**

- A number of listed historic wrecks have been identified on and around the study area. The majority of these wrecks are situated within shallower waters, at the approach to the Thames Estuary and off the coastlines of Germany. These wrecks often demonstrate the presence of both sea mines and aerial bombing during WWI and WWII.
- The majority of wrecks identified are commercial vessels, though several WWII-era British military wrecks are also recorded in the western and central sections of the study area, including the submarine HMS Truculent, three destroyers and several minesweeper trawlers. The eastern section of the study area, off the German coastline, contains several German military wrecks. These consist of the WWI-era cruiser SMS Yorck, the WWII-era DW 07 Patrol Boat (Trinchen Behrens) and two WWII-era minesweepers. Such vessels are anticipated to have carried items of ordnance at the time of their loss and, if not recovered, could have contaminated their immediate surroundings.

**Torpedoes/Anti-Submarine Weapons**

- It is well documented that both torpedoes and anti-submarine weapons were employed as part of aerial and naval warfare across the North Sea during WWI and WWII, although their numbers were relatively low when compared with other types of munitions. However, historical records indicate that submarine activity within the region was limited by the presence of defensive minefields and the British blockades of German ports and as a result, the U-boat campaigns of both world wars were predominantly focused on more viable shipping targets in the Atlantic Ocean. This is correlated by the available data concerning wreck sites, which indicates that only one WWI-era torpedo related wreck is situated in the vicinity of the study area and none related to anti-submarine weaponry, despite its length and position. Nevertheless it not possible to completely discount the presence of such items at the location of the study area to their usage in the wider area.


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## UXO Risk Mitigation

This report has concluded that there is a risk from unexploded ordnance along the proposed HVDC Electricity Transmission Interconnector between the Isle of Grain, United Kingdom and Wilhelmshaven, Germany. The risk has been broadly split into five different zones, which each contain varying levels of assessed risk from different potential sources:

- UK Mainland – Risk from German air delivered ordnance and historic Allied ordnance.
- Thames Estuary – Significant risk from smaller items of LSA/SAA originating from historic and contemporary ranges within the estuary.
- Main Offshore Area (North Sea) – Primary risk from larger items, originating from historic sea minefields.
- German Approaches –Significant risk from both larger and smaller items of UXO, originating from a number of historic munitions dumps.
- German Mainland – Primary risk from Allied air delivered ordnance.

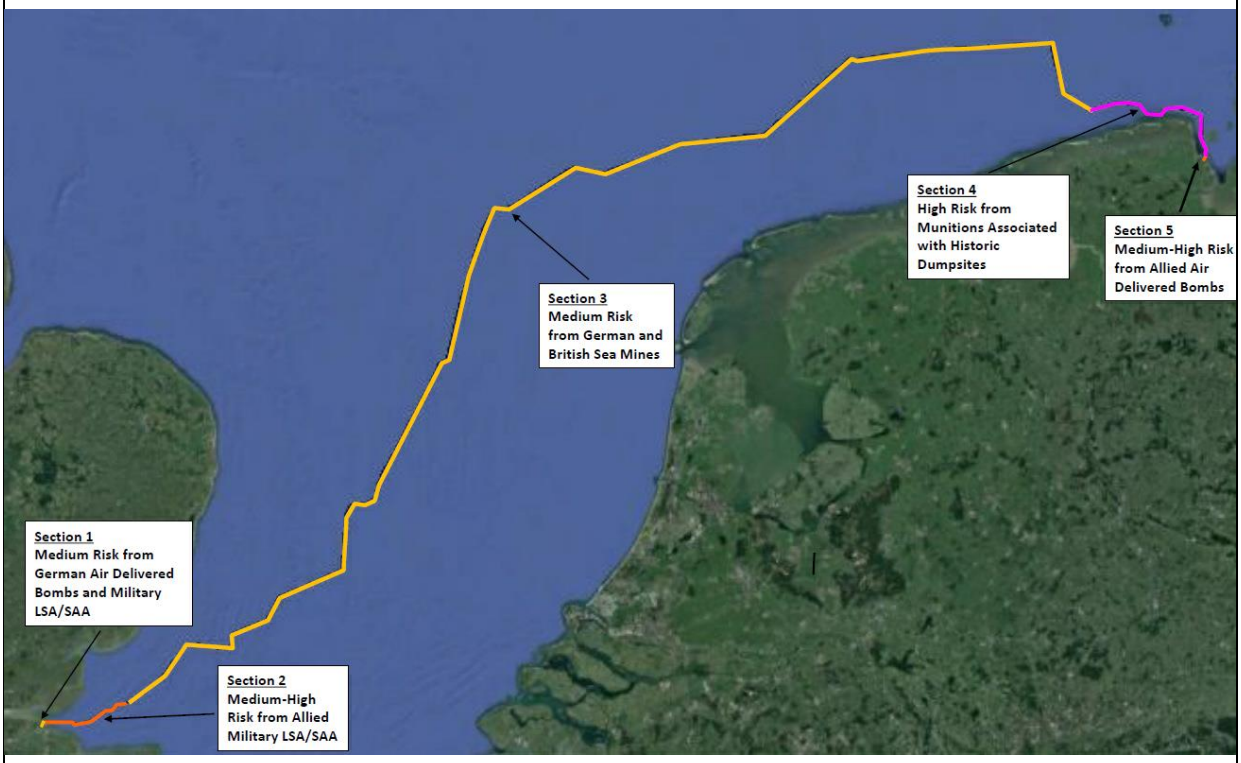
**Offshore UXO Risk Mitigation**

Due to the level of risk identified, it is recommended that 1st Line Defence Risk are contacted to discuss the creation of risk mitigation plan for each specific phase of works within the study area. The methodology of any measures should be tailored to take into account the nature and size of UXO items assessed most likely to be encountered in each section of the study area.

**Onshore/Nearshore UXO Risk Mitigation**

For onshore/foreshore works at both the western and eastern end points of the route, it is also recommended that proactive support is provided by a UXO specialist. This would include UXO Safety and Awareness Briefings for all operatives conducting intrusive works, UXO support for trial pits and the clearance of all proposed boreholes by magnetometer survey. Depending on the ground conditions present it may also be viable to undertake a non-intrusive magnetometer survey and target investigation on beach and inland areas.

## Risk Map




*For indicative purposes – not to scale.*

Low Risk | Medium Risk | Medium-High Risk | High Risk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# Glossary

| Abbreviation | Definition |
|---|---|
| **AA** | Anti-Aircraft |
| **AAA** | Anti-Aircraft Ammunition |
| **AFS** | Auxiliary Fire Service |
| **AP** | Anti-Personnel |
| **ARP** | Air Raid Precautions |
| **AXO** | Abandoned Explosive Ordnance |
| **DA** | Delay-action |
| **EOC** | Explosive Ordnance Clearance |
| **EOD** | Explosive Ordnance Disposal |
| **FP** | Fire Pot |
| **GM** | G Mine (Parachute mine) |
| **HAA** | Heavy Anti-Aircraft |
| **HE** | High Explosive |
| **IB** | Incendiary Bomb |
| **LAA** | Light Anti-Aircraft |
| **LRRB** | Long Range Rocket Bomb (V-2) |
| **LSA** | Land Service Ammunition |
| **MOL** | Molotov (Incendiary Bomb) |
| **OB** | Oil Bomb |
| **PAC** | Pilotless Aircraft (V-1) |
| **PB** | Phosphorous Bomb |
| **PM** | Parachute Mine |
| **POW** | Prisoner Of War |
| **RAF** | Royal Air Force |
| **RFC** | Royal Flying Corps |
| **RNAS** | Royal Naval Air Service |
| **SAA** | Small Arms Ammunition |
| **SD1000** | 1,000kg high explosive bomb |
| **SD2** | Anti-personnel “Butterfly Bomb” |
| **SIP** | Self-Igniting Phosphorous |
| **U/C** | Unclassified bomb |
| **UP** | Unrotated Projectile (rocket) |
| **USAAF** | United States Army Air Force |
| **UX** | Unexploded |
| **UXAA** | Unexploded Anti-Aircraft |
| **UXB** | Unexploded Bomb |
| **UXO** | Unexploded Ordnance |
| **V-1** | Flying Bomb (Doodlebug) |
| **V-2** | Long Range Rocket |
| **WAAF** | Women’s Auxiliary Air Force |
| **X** | Exploded |


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# 1st Line Defence Limited
# Detailed Unexploded Ordnance (UXO) Risk Assessment

Site: HVDC Electricity Transmission Interconnector between the Isle of Grain, United Kingdom and Wilhelmshaven, Germany.
Client: Intertek

## 1. Introduction

### 1.1. Background

1st Line Defence has been commissioned by Intertek to conduct an Offshore Detailed Unexploded Ordnance (UXO) Risk Assessment for the planned works at HVDC Electricity Transmission Interconnector between the Isle of Grain, United Kingdom, and Wilhelmshaven, Germany. (Note - for the purposes of this report the name of the project will also be referred to as 'the study area' or will else be shortened to 'the HVDC Electricity Transmission Interconnector'.)

UXO in offshore areas of the UK can originate from three principal sources:

1. Munitions resulting from wartime activities including ship-to-ship engagements, aerial bombing, long range shelling and defensive activities in both WWI and WWII.
2. Munitions deposited as a result of military training and exercises.
3. Munitions lost, burnt, buried or otherwise discarded either deliberately, accidentally, or ineffectively.

During WWI and WWII, significant quantities of explosive ordnance was either dropped from the air or placed on and around the beaches of the UK, including both bombs and mines. There is also a legacy of military activity which has led to contamination off the UK coast – including offshore munitions dumping, firing ranges, training exercises, military related wrecks, torpedoes and depth charges. UXO which was deployed during such military activities, but failed to initiate, or else has been dumped at sea can present a significant risk to construction works and development projects. The discovery of a suspect device during works can cause considerable disruption to operations as well as cause unwanted delays and expense.

This report will assess the potential factors that may contribute to the risk of UXO contamination, by examining the history of the area, and the activities and deployment of various types of weaponry that may have led to contamination. The risk of ordnance remaining, of ordnance being encountered and the consequences of any encounter will also be examined. If an elevated risk is identified at the site, this report will suggest appropriate mitigation measures, in order to reduce the risk to as low as is reasonably practicable.

This report complies with the guidelines outlined in *CIRIA C754*, 'Assessment and Management of Unexploded Ordnance (UXO) Risk in the Marine Environment'.


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## 2. Method Statement

### 2.1. Report Objectives

The aim of this report is to conduct a comprehensive assessment of the potential risk from UXO during and prior to the installation of the HVDC Electricity Transmission Interconnector. The report will also suggest appropriate site and work-specific risk mitigation measures to reduce the risk from explosive ordnance during the envisaged works to a level that is as low as reasonably practicable.

### 2.2. Risk Assessment Process

1st Line Defence has undertaken a five-step process for assessing the risk of UXO contamination:

1. The risk that the study area was contaminated with UXO.
2. The risk that UXO remains within the study area.
3. The risk that UXO may be encountered during the proposed works.
4. The risk that UXO may be initiated.
5. The consequences of initiating or encountering UXO.

In order to address the above 1st Line Defence has taken into consideration site specific and non-site specific factors including:

- The military history of the area.
- Offensive and defensive mine laying.
- Firing ranges.
- Naval exercise areas.
- Official and unofficial munitions dumping sites.
- Use of torpedoes and depth charges.
- Military-related wrecks.
- Records of aerial bombing.

### 2.3. Sources of Information

Every reasonable effort has been made to ensure that relevant evidence has been consulted and presented in order to produce a thorough and comprehensible report for the client. To achieve this the following, which includes military records and archive material held in the public domain, have been accessed:

- The National Archives (Kew, England), the German Federal Archives (Koblenz, Germany), he Archive of the City of Wilhelmshaven, the Netherlands National Archives, The Hague Record Office and Kent Record Office.
- The UK Hydrographic Office, the OSPAR Commission and wrecksite.eu.
- Relevant information supplied by Intertek.
- Available material from 33 Engineer Regiment (EOD) Archive.
- 1st Line Defence's extensive historical archives, library and UXO geo-datasets.
- Open sources such as published books and internet resources.

Research involved a visit to The National Archives and the UK Hydrographic Office.


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### 2.4. General Considerations of Historical Research

This desktop assessment is based largely upon analysis of historical evidence. Every reasonable effort has been made to locate and present significant and pertinent information. 1st Line Defence cannot be held accountable for any changes to the assessed risk level or risk mitigation measures, based on documentation or other data that may come to light at a later date, or which was not available to 1st Line Defence during the production of this report.

It is often problematic and sometimes impossible to verify the completeness and accuracy of WWII-era records. This is compounded offshore by the limitations of record keeping over water, where the observation and positional accuracy of incidents was difficult to maintain. As a consequence, conclusions as to the exact location and nature of a UXO risk can rarely be quantified and are to a degree subjective. To counter this, a range of sources have been consulted and analysed. The same methodology is applied to each report during the risk assessment process. 1st Line Defence cannot be held responsible for any inaccuracies or the incompleteness in available historical information.

## 3. UK Legislative and Regulatory Environment

### 3.1. General

There is no formal obligation requiring a UXO risk assessment to be undertaken for construction projects in the UK, nor is there any specific legislation stipulating the management or mitigation of UXO risk. However, it is implicit in the legislation outlined below that those responsible for intrusive works (archaeology, site investigation, drilling, piling, excavation etc.) should undertake a comprehensive and robust assessment of the potential risks to employees and that mitigation measures are implemented to address any identified hazards. Outside of the UK, other EU member states have very similar legislation to ensure high standard of health, safety and welfare during construction projects. Outside of the EU, local requirements may not correspond to the standard of EU requirements.

### 3.2. CDM Regulations 2015

The Construction (Design and Management) Regulations 2015 (CDM 2015) define the responsibilities of parties involved in the design and construction of temporary or permanent structures in the UK and associated territorial waters. As well as the construction of any renewable energy structures in the renewable energy zone, defined as any area outside of UK territorial waters designated for the utilisation of energy from water or winds.

For construction projects located beyond UK territorial waters but within the UK continental shelf there is no specific health and safety legislation, but current practice is to adopt a proactive approach on construction projects by applying the principles of existing CDM legislation. The UK continental shelf is defined by the greater of the natural prolongation of land territory to the continental margin's outer edge or 200 nautical miles from the coastal state's baseline.

The CDM 2015 establishes a duty of care extending from clients, principle co-ordinators, designers, and contractors to those working on, or affected by, a project. Those responsible for construction projects may therefore be accountable for the personal or proprietary loss of third parties, if correct health and safety procedure has not been applied. Although the CDM does not specifically reference UXO, the risk presented by such items is both within the scope and purpose of the legislation. It is therefore implied that there is an obligation on parties to:

- Provide an appropriate assessment of potential UXO risks at the site (or ensure such an assessment is completed by others).


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- Put in place appropriate risk mitigation measures if necessary.
- Supply all parties with information relevant to the risks presented by the project.
- Ensure the preparation of a suitably robust emergency response plan.

### 3.3. The 1974 Health and Safety at Work etc. Act

All employers have a responsibility under the Health and Safety at Work etc. Act 1974 and the Management of Health and Safety at Work Regulations 1999, to ensure the health and safety of their employees and third parties, so far as is reasonably practicable and conduct suitable and sufficient risk assessments.

### 3.4. Additional Legislation

In the event of a casualty resulting from the failure of an employer/client to address the risks relating to UXO, the organisation may be criminally liable under the Corporate Manslaughter and Corporate Homicide Act 2007.

## 4. Role of Commercial UXO Contractors and The Authorities

### 4.1. Commercial UXO Specialists

The role of UXO Specialist such as 1st Line Defence (often referred to also as UXO Consultant or UXO Contractor) is to provide expert knowledge and guidance to the client on the most appropriate and cost-effective approach to UXO risk management at a site.

The principal role of a UXO Specialist is to provide the client with an appropriate assessment of the risk posed by UXO for a specific project, and identify suitable methodology for the mitigation of any identified risks to reduce them to an acceptable level. If required the UXO consultant may also provide additional support, such as the sign-off of documentation, post appointment.

The requirement for a UXO Specialist should ideally be identified in the initial stages of a project, and it is recommended that this occur prior to the start of any detailed design. This will enable the client to budget for expenditure that may be required to address the risks from UXO, and may enable the project team to identify appropriate techniques to eliminate or reduce potential risks through considered design, without the need for UXO specific mitigation measures.

1st Line Defence also have the capability to provide whatever UXO risk mitigation services are required in order to reduce a risk to as low as reasonably practicable. In the marine environment, this can involve the provision of appropriate survey and clearance methodology, as well as what to do should a suspect anomaly or item of ordnance be encountered either on the seabed or on board a vessel.

For more information on the role of commercial UXO specialists, see *CIRIA C754 and C681*.

### 4.2. The Authorities

In the UK the police are responsible for coordinating the emergency services in the event of encountering a high-risk item of UXO above the high water mark (HWM) and HM Coastguard below. This will include establishing a cordon and evacuating people from the area. In specific circumstances operations above the high water mark will be undertaken by the Royal Logistical Corps or the Corps of Royal Engineers and operations below the HWM undertaken by the Royal Navy. Note however that the Corps of Royal Engineers remain responsible for land mines encountered below the HWM and that the RAF is responsible for Allied air delivered weaponry on RAF technical ranges, regardless of their position in relation to the HWM.


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The police have a responsibility to co-ordinate the emergency services in the event of an ordnance-related incident at a construction site on land (such as works on or beyond the beach). Upon inspection they may impose a safety cordon, order an evacuation, and call the military authorities Joint Services Explosive Ordnance Disposal (JSEOD) to arrange for investigation and/or disposal. The JSEOD are responsible for tasking appropriate MoD assets to provide military EOD support where there is a perceived threat to life or unacceptable economic damage. In the absence of a UXO specialist, police officers will usually employ such precautionary safety measures, thereby causing works to cease, and possibly requiring the evacuation of neighbouring businesses and properties.

The priority given to the police request will depend on JSEOD's judgement of the nature of the UXO risk, the location, people and assets at risk, as well as the availability of resources. The speed of response varies; authorities may respond immediately or in some cases it may take several days for the item of ordnance to be dealt with. Where there is a realistic expectation of encountering munitions during works and a threat to life does not exist the JSEOD may not treat each occurrence as an emergency and will recommend the construction company puts in place alternative procedures, such as the appointment of a commercial UXO contractor to manage the situation.

Depending on the on-site risk assessment the item of ordnance may be removed from the site and/or destroyed by a controlled explosion. The latter process is lengthy and may necessitate the establishment of additional cordons and evacuations. Following the removal of an item of UXO, the military authorities will only undertake further investigations or clearance operations in high risk situations.


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# 5. The Study Area

## 5.1. Background

The proposed HVDC (high voltage direct current) Electricity Transmission Interconnector is understood to be a new subsea cable between existing substations and electricity grids in the UK and continental Europe.

The project is designed to provide the first direct energy link between the UK and Germany, with the aim of delivering an increased security of supply, fuel diversity and greater competition to both nation's networks. It will allow a capacity of up to 1.4GW of electricity to flow in both directions, connecting two of Europe's largest energy markets and allowing the integration of renewable energy sources.

## 5.2. Location of the Study Area

The study area is approximately 700km in length and spans the southern section of the North Sea. It stretches through the UK's TW (territorial waters) and EEZ (exclusive economic zone), the Netherlands' EEZ and Germanys' TW and EEZ; including small areas of initial landfall identified at the Isle of Grain, UK and Hooksiel, Germany.

The study area comprises one singular route between the approximate latitudes and longitudes: **51°27'48.31"N 0°42'43.77"E** (at its western endpoint) and **53°38'12.20"N 8° 5'14.08"E** (at its eastern endpoint). It does not connect between these points in a straight course.

Location maps are presented in **Annex A**.

## 5.3. Description of the Study Area

The western end of the study area, situated on the UK mainland, comprises a small area of coastline and surrounding rural land on the Isle of Grain. The eastern end of the study, situated on the German mainland, occupies a small area of open land surrounding the Am Tiefen Fahrwasser roadway and the coastline of Hooksiel.

The remainder of the study area occupies a large expanse of open water within the Thames Estuary and the North Sea. According to information provided by the client, the maximum water depth encountered in this area is 62 metres.

Recent aerial imagery of the study area is presented in **Annex B**.

## 5.4. Ordnance Survey Historical Maps

Historical ordnance survey maps were obtained for this report and are presented in **Annex C**. See below for a summary of the site history shown on acquired mapping.

| **The Isle of Grain / Thames Estuary** | |
|---|---|
| **Date** | **Description** |
| 1896 | This map edition is of both small scale and limited quality. However, it is possible to discern that that the western endpoint of the study area, on UK landfall, is predominantly occupied by open marshland within the Isle of Grain. White Hall Farm is identifiable to the west, the village of Grain to the south and Grain Tower to the south-east.<br>The remaining visible section of the study area is occupied by open water within the Thames Estuary. Southend and Shoeburyness are identifiable across this body of water to the far north and north-east of this section of the study area. |


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| | |
|---|---|
| 1937- 1958 | This map is of larger scale and subsequently shows the western endpoint of the study area in more detail. This area has remained occupied by open ground, though it is labelled 'saltings' and shown to be intersected by a footpath.<br>Of note is the presence of an artillery range and Yantlet Battery to the west, within Grain Marsh. Grain Fort and Wing Battery are outlined to the south-east. |

| **Wilhelmshaven/ North Germany** | |
|---|---|
| **Date** | **Description** |
| 1901 | This map edition depicts the eastern endpoint of the study area, situated between the North Sea and the Jade Blight. The endpoint of the route itself is situated some distance from the German coastline during this period, indicating that significant land reclamation has taken place in this area in later years. The wider surrounding area of land appears relatively rural in nature, aside from the position of Wilhelmshaven to the south. |

# 6. Scope of the Proposed Works

## 6.1. General

The proposed works are believed to comprise a series of pre-construction surveys, followed by the subsequent subsea cable installation.

### 6.1.1. The Survey Campaign

At the time of the production of this report, it is understood that a geotechnical survey is already underway, with geotechnical sampling planned at every 1km across the study area between the UK and Germany. Limited information was provided by the client regarding the exact scope of this survey, which is anticipated to include vibrocore and cone penetrometer tests (CPT) within areas of open water and investigatory boreholes and trial pits within areas of landfall.

It is also anticipated that additional survey methodology will be employed for future survey work, including the use of swath bathymetry, sidescan sonar, sub bottom profiling, magnetometry, and ROV grabs, to acquire data for the confirmation of the location of the offshore route; as well as to determine the appropriate installation and protection methods to be adopted.

### 6.1.2. The Cable Installation

It is understood that the project is currently going through a period of further project development ahead of a full submission being made to the UK and German regulators in 2019. Final approval for the scheme is expected in 2020, allowing construction to start shortly afterwards. The current target date for project completion is 2023.

As a result, limited information is available concerning the final methodology of the proposed cable installation. However, typical intrusive activities within the marine environment for this type of project could include the use of anchors, cable trenching equipment, pre-lay grapnel runs, boulder removal ploughs, mass flow excavators, dredging and the placement of material mattresses on the seabed.

It should be noted that such activities might exceed the boundary of the proposed study area provided. A 1km buffer zone has therefore been considered on either side of the centre line of the proposed cable area for the purpose of this report.


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# 7. Ground Conditions

## 7.1. General Geology

The British Geological Survey (BGS) map, the German Federal Institute for Geosciences and Natural Resources (BGR) Geoviewer and the European Marine Observation and Data Network (EMODnet) were consulted for the purpose of this report. These sources show the bedrock geology of the western endpoint of the study area, within the UK landfall on the Isle of Grain, to be underlain by the London Clay Formation – clay and silt, with superficial deposits of Alluvium – clay, silt, sand, peat and gravel. The bedrock geology of the eastern endpoint of the study area, within the German landfall, is shown to consist of sedimentary material overlain by clay, silt and sand.

The offshore bedrock geology varies considerably over the length of the proposed route and includes areas underlain by:

- Mudstone and sandstone (undifferentiated) and tuff.
- Rock, siliciclastic, argillaceous with sandstone (undifferentiated).
- Brielle Ground Formation - sand.
- Pliocene sedimentary material.

## 7.2. Site Specific Geology

Site specific geotechnical data was not available during the production of this report.

# 8. Introduction to UXO and The Marine Environment

## 8.1. General

Many different types of UXO can be found in marine environments, primarily as a result of historic military activity. 'Poor housekeeping' by armed forces has also led to the loss or deliberate dumping of items of UXO within shores and waters. The United Nations distinguishes these activities into the following categories: defensive military activity, offensive military activity and AXO (Abandoned Explosive Ordnance). Further background to these categories in relation to the site location is provided in Section 9 of this report.

The following sections will provide an introduction to the types of ordnance that might be discovered on marine sites, their failure rates and their potential for initiation; as well as an introduction to the interaction between UXO and the marine environment.

## 8.2. Generic Types of Ordnance found in the Marine Environment

An understanding of the principal types of ordnance encountered in marine environments allows a more informed assessment of the hazards posed by any unexploded items that may remain in situ on a site. Items of ordnance most commonly found on maritime sites include:

- Sea mines
- Depth charges
- Torpedoes
- Air delivered iron bombs
- Artillery projectiles


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- LSA (Land Service Ammunition)
- SAA (Small Arms Ammunition)

Images and brief summaries of the characteristics of the above listed types of ordnance are presented in **Annex D**. Please note that their descriptions are not exhaustive and it is possible that other forms of UXO will be present in the marine environment.

### 8.3. Failure Rate of Ordnance

It has been estimated that 10% of conventional ordnance failed to function as designed and remained unexploded. Reasons for why such weapons might have failed to function as designed include:

- Malfunction of the fuze or gain mechanism (manufacturing fault, sabotage by forced labour or faulty installation).
- Many were fitted with a clockwork mechanism that could become immobilised on impact.
- Failure of vessels to arm weaponry due to human error or an equipment defect.
- Aircraft jettisoning a bomb before it was armed or from a very low altitude. This most likely occurred if bomber aircraft was under attack or crashing.

From 1940 to 1945 bomb disposal teams on land dealt with a total of 50,000 explosive items of 50kg, over, 7,000 anti-aircraft projectiles and 300,000 beach mines. Unexploded ordnance is still regularly encountered across both the UK and mainland Europe; see press articles in **Annex E**.

### 8.4. Initiation of Unexploded Ordnance

Unexploded ordnance does not spontaneously explode. All high explosive filling requires significant energy to create the conditions for detonation to occur. In the case of unexploded ordnance discovered within the marine environment, there are a number of potential initiation mechanisms (see table below)

| **UXO Initiation Mechanisms** | |
|---|---|
| **Direct Impact** | Unless the fuze or fuze pocket is struck, there needs to be a significant impact e.g. from piling or large and violent mechanical excavation, onto the main body of the weapon to initiate a buried iron bomb. Such violent action can cause the bomb to detonate. |
| **Friction Impact** | The most likely scenario resulting in the detonation of a UXO is friction impact initiating the shock-sensitive fuze explosive. The combined effects of the marine environment and general degradation over time can cause explosive compounds to crystallise and extrude out from the main body of the bomb. It may only require a limited amount of energy to initiate the extruded explosive which could detonate the main charge. |
| **Sympathetic Detonation** | The positioning of several items of UXO in close proximity may result in the sympathetic detonation of multiple items, following the initial detonation of just one item. This can occur within features such as munitions dumps and minefield, where large number of UXO are closely grouped together. |
| **Natural Events** | Seismological events, such as earthquakes and tsunamis, can generate sufficient kinetic energy to detonate UXO. |

### 8.5. The Physical Marine Environment

The physical conditions that exist within the marine environment and their behaviour over time can have a significant impact on the position and condition of items of UXO. The following physical aspects


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are described in the table below, alongside an overview of how these physical conditions and changes can interact with UXO

| Physical Conditions | Description | Effect on UXO |
|---|---|---|
| **Geology and Sediments** | Much of the marine environment comprises underlying rock overlain by less consolidated sediments, such as silts, clays, sands and gravels. The extent of overlying sediment cover can vary significantly between areas of little or no sediment cover, such as areas of exposed rock, and areas of the seabed with a sediment thickness greater than hundreds of metres. | The composition of the sediment cover present and the underlying geology will determine the depth to which some items of UXO initially penetrate the seabed or shore. As well as to what extent such items may subsequently become buried by natural processes. |
| **Bedforms** | Bedforms may form depressions, such as channels, and extrusions across large areas of the seabed and typically include mobile sediments, such as mega ripples and sand waves. Subsequently many areas of the seabed are not uniformly flat. More substantial features, such as sand ridges, sand ribbons and sand or gravel banks may also be present in some cases.<br>Bedform features are often indicative of the relationship between the physical processes and sediments present. The asymmetry of bedforms can demonstrate active processes of sediment erosion, transport and deposition. | The presence of a bedform can be used to determine the net direction of active sediment transport. Highly mobile seabed and shore areas are more likely to result in notable changes to bed levels over time and can be monitored to infer more information regarding the potential burial or exposure of items of UXO present. |
| **Coastal Processes** | The energy generated from physical processes, such as winds, water and tides have their greatest effect on the surface of a water body and reduce with the depth of a water column. These forces may be affected by the modification of both wave and tidal processes in areas near to the shore, which can cause larger forces to be exerted on items or sediments present on the sea bed. | The force of these coastal process is affected by the relationship between water depth and wave length. Information about these factors can be used to determine the depth of a wave influence and whether the wave will have a significant interaction with items of UXO present on the seabed. |
| **Sediment Transport and Morphological Change** | Physical forces exerted onto the seabed or shore may also cause sediment transport, depending on the size of the sediment grains and the level of force. This movement can take the form of bedload transport, where sediment moves directly across the seabed or suspended load transport, where sediment is instead transported across the water column. | Sediment transport can take the form of a gradual, progressive trend or can occur rapidly as a result of storm or surge events. Significant sediment movement is therefore difficult to determine. The influence of this sediment transport and any resulting morphological change can affect the exposure and movement of UXO present. |


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## 8.6. Interaction between UXO and the Marine Environment

These physical marine conditions can interact with items of UXO present in the marine environment in the following three principal ways:

### 8.6.1. Exposure or Penetration into the Seabed or Shore

Some types of UXO will be initially deployed directly on the seabed or the shore, such as sea and land mines. Whilst other types of UXO, including artillery projectiles, depth charges, air delivered bombs, LSA and SAA may only reach these surfaces after travelling through air and water. The initial resting place and penetration of UXO depends on a large number of factors, including the geology of the seabed or shore, the presence and thickness of any overlying sediment layers, the residual kinetic energy of the item of UXO and its angle of entry.

The initial position of an item of UXO within the seabed or shore surface can be classified as unburied, partially buried or fully buried. In addition, it should be noted that some items, such as buoyant sea mines, are not initially deployed directly on the seabed but will sink over time and come to rest of the seabed's surface.

### 8.6.2. The Subsequent Burial or Uncovering of UXO

After its initial position within the marine environment an item of UXO may experience burial, due to the vertical deposition of sediments or uncovering due to the vertical erosion of sediments. Consequently, some items will experience cycles of burial, uncovering and re-burial due to regular trends of erosion deposition. These sediment movements can be the result of both near-field and far-field process and can be formed by gradual ongoing erosion trends or cycles of change dominated by temporal effects, such as seasonal cycles.

### 8.6.3. Migration of UXO

UXO in the marine environment has the potential to migrate if subject to sufficient force from metocean processes. Due to the weight and density of most large types of UXO, migration distances are likely to be small for such items, but can be greater during storm events or surges, or within areas where the seabed slopes significantly. Smaller types of UXO, such as LSA and SAA, are much more likely to migrate within the marine environment.

An exception to this description of migration are buoyant sea mines. These items should be considered separately because they have the potential for much greater distances of migration, driven by tidal currents, if they become loose from their moorings. Theoretically migration distances in this scenario could be as far as the distance of the tidal excursion each day and could extend up to several kilometres. However, such items will lose buoyancy over time and will come to rest upon the seabed, following which the normal rules of migration will apply.

Studies of UXO migration in the marine environment are still relatively limited today and require detailed information about the type of UXO and the metocean conditions present, as well as data regarding the composition of seabed sediments, bedforms and the underlying geology. It is therefore rarely possible to determine the initial location of an item of UXO in the marine environment or its potential migration distance with a great deal of accuracy.


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# 9. The Risk from UXO

The presence of UXO in the marine environment can broadly be classified as the legacy of three activities: defensive military activity, offensive military activity and AXO (abandoned explosive ordnance). These categories are however not definitive, as some UXO items may be multi-category.

## 9.1. Defensive Military Activity

Defensive military activity incorporates defensive munitions employed not only during periods of major conflict, such as WWI and WWII, but also the intervening years. Defensive munitions are most likely to be found within areas used to guard maritime zones, such as designated sea minefields and coastal armament areas, as well as areas associated with military training, such as ranges and camps. Consequently, defensive munitions can include sea mines, land mines, artillery projectiles and LSA.

Defensive naval activity played a significant role in Europe during both WWI and WWII, as each side attempted to defend their territories from invasion and reinforce certain key points and areas overseas. Such activities also played a significant part in the economic survival of each nation during these periods, with a large number of both munitions and vessels regularly deployed to defend merchant shipping from attack.

## 9.2. Offensive Military Activity

UXO associated with offensive military activity is more likely to originate from periods of major conflict, particularly during WWI and WWII in Europe. Offensive munitions may consist of any item used to attack or engage a target in combat and can result from such activities as aerial bombing, sea mining and vessel to vessel engagements. Offensive munitions therefore cover a broad variety of items and can include aerial bombs, sea mines, land mines, torpedoes, artillery projectiles, LSA and depth charges.

Offensive naval military activity in Western Europe during WWI and WWII included the blockade of ports, attacks on merchant shipping, the transport of military forces and large scale naval conflicts, such as the Battle of Jutland.

## 9.3. Abandoned Explosive Ordnance (AXO)

Items of AXO are more likely to be found on or near areas where the deliberate dumping of munitions is recorded to have taken place, or else in close proximity to the wrecks of munition carrying aircraft and naval vessels. One well-documented case close to the study area is the wreck of the SS Richard Montgomery, an American liberty ship, which ran aground on a sandbank in the Medway in August 1944. This vessel is recorded to have been carrying 6,127 tons of munitions and is still designated as dangerous under the Protection of Wrecks Act today.

Large numbers of AXO present today result from the practice of sea dumping, which was the internationally accepted method of disposal of surplus munitions at the end of WWII. For example, the British Army designated over 1.2 million tons of ordnance to be disposed of during this period, with Beaufort's Dyke, situated off Stranraer, designated as the principal offshore disposal point. Beauforts Dyke remains Europe's biggest underwater dump for surplus ammunition today, with more than one millions ton of ordnance, including bombs, projectiles and explosive material deposited between 1920 and 1976.


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# 10. Wrecks

## 10.1. General

Many military and civilian vessels were sunk in European waters during WWI and WWII, predominantly due to U-boat activity as well as the presence of offensive and defensive mining. Often, research into the location of wrecks and the reason for their loss can indicate the types of weapons that were deployed in an area – whether they were bombed, torpedoed or mined for example – and therefore the nature of any items that might remain.

Some wrecks can pose a threat today due to their particular cargo, especially those in use by the military or responsible for the transportation of weapons and explosives. However, seabed contamination from military-related wrecks tends to be fairly localised since the munitions are generally enclosed within the hull of the vessel, or will often collect in scours around the wreck. Furthermore, weapons in transit were typically unfuzed so pose less of a direct threat than weaponry that has fired but failed to detonate.

## 10.2. Shipwrecks

Records of shipwrecks between the Isle of Grain and Wilhelmshaven were obtained from wrecksite.eu and the UKHO. An overlay showing the locations of recorded wrecks on aerial imagery is presented in **Annexes F1-F7**. Shipwrecks recorded within the study area and its immediate surroundings have been included and are detailed in the accompanying tables presented in **Annexes F9-F10.**

This data shows the majority of shipwrecks to be concentrated within the western section of the proposed study area, across the approach to the Thames Estuary. Most of the wrecks within this region were the result of mines (potentially British or German in origin), with 13 vessels recorded as sunk by this method. A smaller number of vessels are recorded to have been sunk by German WWII-era raids, as well as by circumstances unrelated to explosive ordnance.

Significantly fewer wrecks are recorded across the more central sections of the study area, across what is now the British and Dutch EEZ's. The majority of wrecks within this region are recorded to be the result of mines originating from German submarines, though one German torpedo incident and three circumstances unrelated to explosive ordnance are also noted.

The concentration of wrecks slightly increases within the eastern section of the study area, within what is now the German EEZ. The majority of these wrecks are recorded to have been the result of Allied WWII-era air raids, with the exceptions of one unspecified wreck and another that was the result of a German defensive mine in WWI.

### 10.2.1. Military Related Shipwrecks

The majority of wrecks recorded within the western and central section of the study area concerned either Neutral or Allied cargo ships, though several British military wrecks are also recorded within the area during WWII. These included the submarine HMS Truculent, the destroyers HMS Coquette, HMS Vimiera and HMS Ivanhoe and several minesweeper trawlers. One U-boat wreck (U-31) is also recorded in this region in 1915.

The eastern section of the study area, off the German coastline, contains several German military wrecks. These consist of the WWI-era cruiser SMS Yorck, the WWII-era DW 07 Patrol Boat (Trinchen Behrens) and two WWII-era minesweepers.

A number of these military vessels are recorded to have contained specific armaments, such as QF 12 pounder guns, QF 6 pounders guns, A.A emplacements, Lewis Guns and torpedoes (see **Annex F9** for


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further details). However even unspecified military related vessels have the potential to have been carrying items of unexploded ordnance at the time of their loss.

### 10.3. Aircraft Crashes

During WWII, many hundreds of aircraft were shot down and lost over Western Europe. The English Channel and the North Sea were the focus of a significant proportion of air activity during this period, with many hundreds of aircraft being abandoned or crash-landed due to combat damage or technical failures. Losses by the Luftwaffe and by RAF Fighter Command were most significant during the four months of the Battle of Britain (Jul 1940 - Oct 1940), during which 234 RAF aircraft are documented to have crashed within British waters.

Given the relatively low speed of impact, aircraft that crashed at sea were often largely intact as they came to rest on the sea floor and may have remained so. Although subsequent damage by shipping, corrosion and movements in the physical marine environment, such as storm surges, can have a significant impact on a crash site. The risk of encountering UXO at aircraft crash sites is determined through considerations of the aircraft's specification, its potential bomb load, the nature of the crash and the extent of any recovery operations.

One aircraft crash site has been identified approximately 370m from the western section of the study area, at the mouth of the Thames Estuary. The name and category of this aircraft is not specified, though it is likely to be a WWII-era bomber because of the size of its fuselage (recorded at 40ft across). The cause and date of this crash is not known, with the wreck site discovered in 1991.

No evidence could be found to suggest the presence of any other wartime era aircraft wrecks in the study area in wrecksite.eu or the available UKHO records. However, it is conceivable that additional unrecorded aircraft wrecks may be present in the region. This is because a large section of the study area is anticipated to have been regularly patrolled by both Luftwaffe and RAF aircraft during WWII, when undertaking operations such as reconnaissance tasks, bombing sorties or the escort of merchant and naval shipping. Furthermore, the exact locations of wartime era crash sites over water were often difficult to accurately record and locate.

### 10.4. Deductions

The position and concentration of wrecks across the approach to the Thames Estuary suggest the presence of a sizeable minefield within this section of the proposed study area. This is likely to have been present during the earlier period of WWII, with all mine-related wrecks in this area dated between 1940-1942. Two wrecks also indicate that German air raids on shipping occurred in this region in 1940.

The positioning of wrecks within the more central areas of the study area are fewer and further between. Nevertheless, the nature of these wrecks indicates that areas of minefields were present between UK and German waters during both WWI and WWII, with a small number of mine related wrecks recorded from both periods; mainly situated off the east coast of England. A single torpedo related wreck dating from 1939 and a U-boat wreck in 1915, suggests that U-boat activity was relatively limited across the majority of the study area during both wartime periods.

In contrast, the nature of most of the wrecks within the eastern section of the study area, off the German coastline, indicates Allied aerial bombing on shipping in the region. These consist of five vessels sunk by Allied torpedo bombers and aerial deployed mines in 1944. One wreck, the SMS Yorck, also indicates the presence of a German defensive minefield in the vicinity in WWI.


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# 11. Sea Mines

## 11.1. General

Sea mines are self-contained explosive devices placed in water to destroy ships, submarines and other watercraft. These weapons are laid and left until they are triggered by the approach, or contact with a vessel. Naval mines can be used offensively, to hamper enemy shipping and restrict it to a harbour, or defensively, to protect friendly shipping and create "safe zones".

During WWI, it is estimated that up to around 128,000 mines were laid in the sea around the coast of the UK, both offensively by the German Navy and defensively by the British Navy. This included minefields actively laid by German aircraft, destroyers and minelayers off British harbours. Both navies continued to deploy defensive and offensive defensive fields during WWII, with approximately 100,000 mines laid in the North Sea and Thames Estuary alone. Although attempts were made to remove or make safe sea mines deployed during WWII around the coastlines of Europe, it is estimated by some sources that up to 70% of sea mines were not recovered.

Mines are most frequently classified by their position in the water, delivery method and method of activation. A mine's position in the water can include bottom mines which rest on the ground, moored mines used for deeper-water areas and drifting mines, which float freely. Delivery methods include aircraft-laid mines, surface-laid mines and submarine-laid mines. The method of activation can be divided into two categories. Contact mines are designed to explode on contact with the hull of a ship and influence mines are triggered by the vicinity of a ship or submarine, rather than by direct physical contact.

Further details of these classifications, alongside examples of common types, are presented in **Annexes D1-D3**.

## 11.2. Historical Accounts

Historical accounts of minelaying operations across the study area were found in both online and written texts, most notably including *The War at Sea 1939-1945* by S W Roskill, *The Battle of the East Coast (1939-1945)* by J.P. Foynes and at Naval-History.net. The most relevant information found has been divided into several regions, presented in the sections below:

### 11.2.1. The East Coast

Several detailed references have been found to the development of one of the largest WWII-era British minefields, known as the 'East Coast Mine Barrier' between Scotland and the Dover Straits. This mine area, declared on the 24th December 1939, was initially constructed over an eight-month period in 1940, following the laying of over 17,000 contact and influence mines. It is indicated to have had an average mine density of 10-11 items per square mile, across an area that was over 500 miles long and more than 15 miles in width in certain sections, with five gap areas (Gaps A-E) present to allow the safe transit of Allied and neutral vessels.

This defensive minefield was initially predominantly designed to protect merchant shipping conveys travelling off the East Coast of England from German U-Boat attacks, but was later expanded and readapted as an anti-invasion measure in 1941 and 1942. An approximate sketch of this minefield, taken from The *War at Sea 1939-1945*, is presented in **Annex G1**. This source indicates that the East Coast Barrier intercepted a section of the study area, off the coast of East Anglia.

### 11.2.2. The North Sea

These secondary sources also specify the development of additional German and British minefields within the North Sea in WWII. It is indicated that a German Declared Mine area was announced on the


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3rd September 1939 over a large rectangular area, 180 miles in length and 60 miles in width, stretching north from Dutch waters. This feature is shown to have been overlapped to the east by a British Declared Mine Area, announced on the 4th September 1939, which was presumably designed to counteract the aforementioned German minefield's position. Their positions are also approximately depicted in **Annex G1** and are shown to occupy a significant section of the east of the study area.

Both of these North Sea mine areas are believed to have remained in place for the remainder of the war, with the British Declared Area subsequently reinforced during the military offensives on Europe in 1944-1945. No further details could be found regarding the type or number of mines in each mine area, nor their exact locations.

### 11.2.3. The Thames Estuary

Due to the presence of the Thames Estuary Boom and surrounding coastal defences, there was little viable opportunity for German naval forces to lay mines directly within the Thames Estuary during both world wars. However, a number of written accounts have been found to suggest that German air minelaying did regularly take place within the estuary in WWII, mostly in an attempt to disrupt commercial shipping travelling to and from the docklands of London. These air raids predominantly took place between 1940-1941 and reached their peak during the 8-15th December 1940, when approximately 350 IX Loftkorps aircraft, armed with two mines apiece, sunk 16 ships in the region. These raids included the use of delayed action mines, causing shipping losses to occur into the New Year.

A map depicting the main area targeted during this period and the locations of ships sunk is presented in **Annex G1**. This source confirms that aerially deployed mines were dropped within the westernmost section of the study area, within and across the approach to the Thames Estuary.

## 11.3. Mine Charts

During the outbreak of WWII an index chart, showing Allied and Axis mining activities in home waters was produced by the British Admiralty Office. This source, which was updated every fortnight consisted of an outline chart showing command limits, overprinted in red for details of mines and searched channels. During the latter years of the war, it was re-schemed and extended to include the eastern shores of the North Sea. This chart, labelled 'No. Z 27' and several other special charts in this series, giving details of shallow and deep minefields, were obtained from the National Archives and the UKHO. The relevant excerpts are presented in **Annexes G2-G6** and are described in the accompanying table below.

| **Mine Charts– Annexes G2-G6** | |
|---|---|
| **Name and Date Range** | **Comments** |
| British Islands: Approximate Position of Minefields – January 1915 | This mine map was contained within an operations logbook compiled by the British Admiralty during WWI. It depicts several German minefields off the east coast of Britain, including one area labelled as the 'Southwould Area' at the western section of the study area. A British minefield is shown to the south of the study area on the approach to the Channel and is surrounded by an area of 'drifting British mines'. Some of these drifting mines also appear to intercept a small section of the study area. |
| **No. Z 28** British Islands and North Sea: Deep Minefields – November 1940 | This map does not show any deep minefields on or near the study area. Several small lines of deep mines are however show in the wider surrounding area, off the east coast of Britain. Note - the 'East Coast Mine Barrier' is also depicted within this map edition and shows that a part of the study area was situated within 'Gap E'. |


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| | |
|---|---|
| **No. Z 36** The North Sea: Positions of British and German Sea Mines – 1941 | The central section of the study area is shown to pass through two separate German minefields, one of which also contains a small circular British minefield. The far eastern section of the study area intercepts the edge of another German minefield before passing through several British minefields off the coast of Northern Germany. |
| **No. Z 27** British Islands and Adjacent Waters Minefields – July 1945 | This map is believed to provide a consolidated record of major WWII-era minefields in the region. It shows a large British declared mine area (believed to be the East Coast Mine Barrier discussed in section 11.2.1) off the east coast of Britain, intercepting the western section of the study area. The central and eastern sections of the study area are positioned across several significant German and British Minefields situated across the North Sea. |

It should be noted that the positions of minefields depicted within these record sets are based on navigational practices and equipment dating to WWI/WWII. Furthermore, all of these map editions are off relatively small scale. They are therefore used to provide an approximate guide of the locations of historical mine areas, whose true positions may have differed.

### 11.4. Deductions

It is rarely possible to compile a completely accurate picture of the location and composition of historic minefields in the marine environment. Nevertheless, both the primary and secondary historical sources discussed above indicate that sizeable mine laying campaigns were undertaken by both Britain and Germany across the North Sea in WWI and WWII. The majority of the study area appears to have been situated across several of these WWII-era minefields, including significant defensive areas off the east coast of Britain and the North German coastline. Evidence has also been found to indicate that air deployed mines were regularly dropped within the Thames Estuary by the Luftwaffe between 1940-1941.

Efforts were made by both Germany and Britain post-war to remove or make safe the areas mined during the war. However such clearance tasks do not guarantee the complete removal of all mines within a danger area, especially as such items have the potential to migrate or became covered due to sediment and tidal action over a long period of time. It was common practice to cut the mooring cables of buoyant mines using minesweeper vessels, and then to shoot and sink any mines which came to the surface. Inevitably, some cables will not have been cut and many mines will not have been detonated by the shooting. These would end up sinking but still being 'viable' weapons. Furthermore, some WWII-era mines were fitted with scuttling circuits which caused them to sink after a specified period of time, on occasion prior to the period of post-war clearance. It is therefore not possible to discount the possibility of encountering surface or submarine laid sea mines across the proposed study area.


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# 12. Torpedoes

## 12.1. General

A torpedo is a self-propelled weapon with an explosive warhead, launched above or below the water surface, propelled underwater towards a target, and designed to detonate either on contact with its target or in proximity to it.

Torpedo design changed little from 1870 until the 1940s. During WWI torpedoes were widely used in to disrupt shipping and to sink submarines. Germany disrupted supply lines to Britain largely through use of submarine torpedoes, while Britain targeted U-boats with the weapon (sinking a total of 20 in this way over the course of the war). In WWII both Allied and Axis forces used torpedoes primarily against enemy warships. During this period, torpedoes were aimed to explode underneath a ship, to counter the heavy armour of these vessels and instead damage its keel, or the other structural members in the hull.

Failed torpedoes can sink to the seabed with their warheads intact when they run out of fuel. They are sometimes encountered off the UK coastline, mainly by fishermen – for example, one was recovered by trawlermen off the coast of Eastbourne in March 2013. Typically, the warheads contain around 200-300kg of explosives.

Examples of WWII-era torpedoes are presented in **Annex D4**.

## 12.2. Torpedoes in the Study Area

Information regarding the usage of torpedoes by any vessel is generally difficult to ascertain, as historic naval records rarely clarify the exact location and numbers of torpedoes deployed during wartime. Some information regarding the potential presence of torpedoes at a site location can however be inferred by the nature of recorded shipwrecks in the region.

The wreck data obtained from Wrecksite.eu and the UKHO only records one vessel, the SS Kaunas, to have been sunk by a torpedo attack in the vicinity of the study area. This cargo ship was sunk by the German U-boat U-57 on the 17th November 1939. No other WWII-era torpedo related shipwrecks were recorded in this region.

The wrecks of the U-boat U-31 and the German torpedo ship S-22, though not torpedo related, do indicate that vessels capable of deploying torpedoes were operational in the study area during WWII. Likewise, an overlay of U-boat losses presented in **Annex H** suggests that these types of vessels were also present in the North Sea in WWII. This source also shows that the Port of Wihelmshaven, near the easternmost point of the study area, was the home of the 2nd U-boat flotilla from Sep 1936 to May 1941.

## 12.3. Deductions

It is well documented that torpedoes were employed as part of both aerial and naval warfare across the North Sea during WWI and WWII, although their numbers were relatively low when compared with other types of munitions. Historical records indicate that a number of vessels within the region were subject to torpedo attacks as part of a policy of 'unrestricted submarine warfare' during both world wars, but that submarine activity within the region was limited by the presence of defensive minefields and the British blockades of German ports. As a result, the U-boat campaigns of both world wars were predominantly focused on more viable shipping targets in the Atlantic Ocean, in an attempt to disrupt transport and supply between the US and the UK.

This limitation of torpedo attacks in the region is correlated by the available data concerning wreck sites, which indicates that only one WWI-era torpedo related wreck is situated in the vicinity of the


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study area, despite its length and position. However, it is not possible to completely discount the possibility of unrecorded torpedo activity, due to the known deployment of such items across the wider region.

## 13. Anti-Submarine Weapons

### 13.1. General

The most common anti-submarine weapon was a depth charge. The weapon is dropped into water (either by a ship or aircraft) near a target, detonates, and consequently subjects it to a powerful and destructive hydraulic shock. Most depth charges use high explosive charges and a fuze set to detonate the charge, typically at a specific depth.

Depth charges were developed during WWI by Britain for use against German U-boats and were subsequently utilised in both war periods. While deployed far less than torpedoes, the weapon acted as the principal anti-submarine weapon for surface ships. The first models were steel canisters filled with TNT explosives and detonated at a depth pre-set by a hydrostatic valve. The first recorded sinking of a German U-boat as a result of a depth charge occurred on 22nd March 1916, off the coast of Ireland.

Anti-submarine spigot mortars were also deployed by the Royal Navy from 1942. The most common was the Hedgehog mortar which had contact fuzing and was fired in batches of 24 (16kg charge weight). The larger Squid mortar was fired in salvoes of three and had a charge weight of 45kg. These devices accounted for more U-boat losses than depth charges and their ratio of successes to attacks was much better. However up to the middle of 1944 depth charges remained the principal anti-submarine weapon for surface ships

Examples of anti-submarine weapons are presented in **Annex D5**.

### 13.2. Anti-Submarine Weapons in the Study Area

As with torpedoes, the exact locations and number of anti-submarine weapons deployed during wartime is often difficult to determine – generally even more so than for torpedoes. Information from Wrecksite.eu and the UKHO does not indicate that any wrecks related to anti-submarine weaponry occurred directly within the study area but does suggest that these types of incidents occurred across other parts of the North Sea. An overlay of WWII-era U-boat losses presented in **Annex H,** records seven U-boat losses in the general surrounding area. However only one vessel, situated approximately 13 miles off the coastline of East Anglia, is labelled to have been sunk by depth charges.

### 13.3. Deductions

Anti-submarine weapons were deployed by most major military powers in the waters of Europe during WWI and WWII. Such items were not generally deployed in high numbers but were concentrated within regions subject to high volumes of German submarine activity, off the south and east coasts of the English mainland and across the North Atlantic.

Historical records indicate that depth charges were most commonly deployed to combat German U-boats in the North Sea, with other anti-submarine weapons, such as the Hedgehog and Squid spigot mortars put into operation from 1942. However little evidence could be found to support the presence of any anti-submarine activity in the immediate vicinity of the study area, as no wrecks related to these types of munitions are documented in the vicinity. Nevertheless it not possible to completely discount the presence of such items at the location of the study area to their usage in the wider area.


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# 14. Offshore Munitions Dumps

## 14.1. General

Large quantities of munitions were dumped at designated sites or randomly jettisoned into the sea following WWI and WWII. These included conventional munitions such as bombs, grenades, torpedoes and mines, as well as incendiary devices and chemical munitions.

The presence of munitions in the sea can pose a risk to fishermen, coastal users and the offshore construction industry. As recently as 2005, three fishermen were killed in the southern North Sea when a WWII bomb believed to originate from a dump site exploded on their fishing vessel after having been caught in their nets.

Information on the amounts and locations of dumped munitions is recognised to be incomplete, but the existence of dumped munitions should always be a consideration for offshore construction projects. In 2004, OSPAR began a programme to establish the extent of munitions dumping and to monitor the frequency of encounters. This has revealed that munitions were dumped at 148 sites and that 1,879 encounters with munitions have occurred since 2004. Around 58% of reported munitions were encountered by fishermen and 29% found on the shore. Following discovery, 76%, of these items were removed from the sea or neutralised; 11% were returned to the sea for safety reasons.

## 14.2. Munitions Dumps in the Study Area

The overlay provided in **Annex I** shows the approximate location of historic munitions dumpsites recorded by OSPAR in the region of the study area. Two conventional munitions dumpsites are recorded in the vicinity of the western section of the study area, off the coastline of Essex and off the coastline of East Anglia. Seven munition dumpsites are clustered around the easternmost section of the study area, around the islands of Spiekeroog and Wangerooge and to the north of the Jade Blight.

Information was obtained from an assessment of Sea Ammunition Pollution by the German Federal Government concerning two of the dumpsites near the eastern section of the study area. One of these sites, located approximately 3.5 miles north of the eastern-tip of Spiekeroog is described as containing 'an unknown amount of mustard gas and other chemical warfare agents from both world wars[1].' Whilst the dumpsite situated just off the Jade Blight, near the eastern endpoint of the study area, is described to have been subject to the dumping of between 716,000 and 1.32 million tons of munitions in the immediate post war period. Salvage operations in the 1950s later discovered 'numerous shells, bombs, and other munitions containing mustard gas and other chemical warfare agents[2]'.

## 14.3. Deductions

The two dumpsites recorded within the western section of the site, off the coastline of the UK are not considered to be of close enough proximity to pose a direct risk to the study area, with the nearest plotted approximately 4km west of the study area's centre line.

Of more significant concern is the proximity of a cluster of munitions dumpsites surrounding the eastern section of the site, off the coastline of North Germany. These dumpsites are believed to have formed part of a wider programme of ammunition dumping across the German North Sea Coast at the end of WWII, resulting in an estimated 750,000 to 1.5 million tons of munitions dumped from both

[1] *."Munitionsbelastung der deutschen Meeresgewässer – Bestandsaufnahme und Empfehlungen (Stand 2011)" Meeresumwelt: Bundes-Länder Messprogramm., 2011 P. 48*

[2] *"Munitionsbelastung der deutschen Meeresgewässer – Bestandsaufnahme und Empfehlungen (Stand 2011)" Meeresumwelt: Bundes-Länder Messprogramm., 2011 P. 42*


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German and Allied sources. This included an estimated 250,000 tons of ammunition shipped from the Port of Wilhelmshaven alone.

Extensive munition recovery was subsequently undertaken by the German authorities between 1952-1958, as part of the recovery of valuable metals (see **Annex J)**. This was predominantly based at a plant in Wilhelmshaven, which is known to have recovered over 50,000 tons of munitions at its peak between 1952-1954. However this type of clearance work is rarely comprehensive and subsequent experimental recovery operations undertaken by the German government in the 1990's are known to have still resulted in the discovery of large volumes of items, including the recovery of 3000kg of ammunition (including over 1000 individual shells) in 1991 and 4,669kg of munitions in 1999. It is therefore anticipated that large amounts of ammunition are still present on and around these former dumping areas, with some sources suggesting that an estimated 10,000-50,000 tons of munitions may still be present in Lower Saxonian waters[3].

## 15. Coastal Armament Training Areas

### 15.1. General

There are a number of historic and contemporary armament firing ranges recorded located across the Thames Estuary. Such ranges will have left a legacy of UXO contamination along the coast, which may pose a threat to offshore intrusive works and dredging.

### 15.2. Armament Training Area Mapping

A set of mapping was acquired from The National Archives showing the location of WWII-era armament training areas in the UK in relation to the study area. A relent section of this record, presented in **Annexes K,** shows the westernmost section of the study area to directly intercept the following three armament training areas.

- A81 Shoeburyness Artillery Range.
- A83 Yantlet Zone Coastal Artillery Range.
- A85 Sheerness and Grain Coastal Artillery Range.

These ranges have a designated 'danger area' of up to 20,000ft, 13,000ft and 6,000ft respectively and appear to cover a significant portion of the Thames Estuary from each side. Two smaller ranges are also denoted to the south-east of this section of the route. N25 Barton Point, a Heavy and Light anti-aircraft range, is situated at a distance of approximately 2-5km and 22 Leysdown, an RAF live bombing range, is situated at a distance of approximately 5-6km. These ranges have a designated 'danger area' up to 20,000ft and 25,000ft respectively.

### 15.3. Shoeburyness Ranges

MoD Shoeburyness is the only significant military installation still active within the Thames Estuary today. Situated approximately 6km north of the study area, this range was originally formed around the time of the Crimean War, by the Board of Ordnance in 1849, and was commissioned as an artillery testing and practice range. Over the years it became the site of the Royal Artillery School of Gunnery and was significantly expanded to include Foulness, New England and Havengore Islands. During both world wars the site remained predominantly in use as a coastal artillery school, before transitioning into more of a weapons development and testing role in the post-war period. A plan of Shoeburyness Ranges, based on WWII-era Bye-Laws, is presented in **Annex L**.

[3] *Dumping and re-occurrence of ammunition on the German North Sea coast, from Chemical munition dump sites in coastal environments Gerd Liebezeit.*


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Today some of the former range area has closed or since been subject to redevelopment, but the remainder remains managed by Qinetiq, on behalf of the Ministry of Defence for 'defence testing and evaluation'. This includes testing weapons systems at various stages of their development, the disposal of expired ammunition and live-ammunition training in Explosive Ordnance Disposal techniques.

### 15.4. Yantlet Range (Grain Island Firing Point)

In 1917 the Admiralty requisitioned marshland to the east of Yantlet Creek, approximately 1.5km west of the western endpoint of the study area. Weapons testing commenced in 1919 and in the 1920s the War Office formerly purchased this area for the purpose of a building a firing point for the testing of artillery and other large weapons. This was known as both Grain Island Firing Point and Yantlet Battery and essentially functioned as an 'out' battery for the experimental establishment at Shoeburyness, on the opposite side of the Thames Estuary (discussed in section 15.3). Between the 1920s and the 1940s this establishment was predominantly used for the observation of the trajectory and landing of long range shells fired towards Maplin Sands in Shoeburyness, along the 'Grange Range Line' depicted in **Annex L2**. Infrastructure is known to have included a gun emplacement, a railway gun emplacement, domestic quarters, administrative offices, an internal railway linked to the national network and a wharf for the transport of munitions, guns and mountings. Some of these features are visible within the WWII-era imagery of the facility presented in **Annex M1**.

Post war the facility at Yantlet Creek was largely dismantled following a decrease in the testing of heavy artillery projectiles. The War Office's use of the area shifted to the establishment of a demolition range at a nearby location, on the coastline of the Isle of Grain. This feature is depicted in the 1960's Bye-Law plan in **Annex M2**, which shows the boundary of the associated danger area to be situated just outside of the western point of the study area. Live firing ceased in the Isle of Grain in the 1950's but this demolition area is believed to still be occasionally used for munitions disposal.

### 15.5. Sheerness and Grain Range

The Sheerness and Grain Artillery Range was comprised of three different firing points, based at Grain Battery, approximately 800m east of the study area, Sheerness Battery, opposite the River Medway and Fletcher Battery, on the Isle of Sheppey. Historical Bye-Law records indicate that the range was predominantly used to practice the firing of heavy artillery projectiles and was operational from the pre-war period through to the 1950s. A sample firing programme from 1932 shows the Grain and Sheerness batteries to have conduced live firing practice for 52 days and 20 nights in a calendar year, with Fletcher Battery used for 6 days during the same period.

Grain Battery is of particular interest, due to its close proximity to the westernmost point of the study area. This feature was constructed between 1900-1901 as a concrete emplacement with earth embankments. It operated in association with Grain Fort to the north (more detail of which is provided in section 16.2.2) and was originally armed with four 6 inch breech loading guns. In 1915 one of these guns was replaced with an M.I.R gun but the battery largely retained the same layout and composition until its decommission in the post-war period.

### 15.6. Deductions

The majority of items of ordnance used at the coastal armament training areas within the Thames Estuary will have consisted of LSA and SAA. Though larger aerially delivered bombs will have been deployed at the site of the 22 Leysdon RAF range. The smallest type of LSA typically used by British forces during the WWII-era were three pounder projectiles (such as the Hotchkiss, Vickers and Nordenfelt 47mm varieties), which were generally used by naval guns, coastal defence guns and anti-aircraft guns. Smaller sizes of projectiles may have been utilised at the ranges, but the most common small projectile is likely to have been the aforementioned three pounder HE. Items of ordnance fired


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within the estuary's danger areas are not anticipated to have always detonated on impact with the water and have the potential to remain live and settle within the estuary's bed.

Based on the available historical documentation it is anticipated that both live and practice ammunition would been employed during these range's operation, with both categories of ordnance still employed at Shoeburyness today. The presence of these armament ranges therefore significantly increases the likelihood that items of Allied ordnance could have been expended within the westernmost of the study area, from the Isle of Grain to the approaches to the Thames Estuary. This is demonstrated by the number of UXO discoveries within the region in the post war period. Example imagery of items found during UXO clearance dredging operations in the Princes Channel in the 2000s is presented in **Annex O**.

## 16. Wartime Coastal Defences

### 16.1. General

Prior to and during the early stages of WWII, defensive positions were established along the British coastline in order to delay or prevent the threat of invasion. This network was known as the 'coastal crust' and comprised a vast network of hundreds of pillboxes, constructed across vulnerable points, as well as a mixture of defensive features including coastal batteries, pipe mines, machine gun turrets, anti-tank guns and barbed wire. The 'coastal crust' was devised in conjunction with the General Headquarters Line (GHQ Line) defensive line and was then subdivided into a network of Command Lines and Corps Lines, designed to protect specific geographical areas or directional approaches. Similar defensive networks were established along the coastline of Great Britain during both WWI and the pre-war era.

In comparison, very little information is available concerning the wartime defence of the German North Sea coastline. Due to the geographical position and the presence of extensive sea minefields in the surround the region of the site location was not identified as a viable location for invasion during and is not anticipated to have been defended to the extent of the coastlines of France and the Netherlands. Nevertheless some positions are believed to have been present as part of the defence of the port of Wilhelmshaven, including anti-aircraft positions.

### 16.2. The Defence of the Isle of Grain

The Defence of Britain Project database was accessed during the production of this report; this database records the '20$^{th}$ century militarised landscape of the United Kingdom' and is based on field and documentary work undertaken in the late 20$^{th}$ century. This records numerous defensive positions within and surrounding the western endpoint of the study area on the Isle of Grain.

In general, defensive positions can be split into two categories – anti-invasion and anti-aircraft. These will be discussed in turn in the following subsections, alongside a summary of the relevant positions recorded on site. The locations of these positions are annotated on WWII-era RAF aerial photography, see **Annex N**.

#### 16.2.1. Anti-Invasion Defences

Due to its strategic location, covering the confluence of the River Thames and the River Medway, the Isle of Grain is recorded to have contained numerous anti-invasion defences dating back to as early as the 1500's. A brief description of each of the WWI and WWII-era defences in the region, separated by installation type, is presented in the table below. The majority of these positions are highlighted in the WWII-era imagery presented in **Annex N**.


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| **Anti-Invasion Defences** | |
|---|---|
| **Type of Installation** | **Summary** |
| **Coastal Batteries** | Wing Battery and Grain Battery were both situated near Grain Fort, approximately 1km south of the study area and were operational during WWI. The former comprising two 4.7" QF guns and two 11" RMLS and the latter comprising four 6" BL guns. The original Grain Battery (later renamed Dummy Battery) was situated 1km further south of these batteries, off Port Victoria Road. This position was operational throughout both world wars but was considered obsolete as an artillery battery by WWI and was instead armed with two 3" anti-aircraft guns, manned by the Kent RGA Territorials.<br>Additional WWII-era coastal artillery batteries were also referenced across the Isle of Grain in the surrounding area of the western endpoint of the study area. However not further details regarding the exact locations of these emergency batteries could be found. |
| **Gun Emplacements (Grain Tower)** | The most significant gun emplacement within the Isle of Grain was Grain Tower (otherwise known as 'The Three Gun Tower'), which was positioned on a tidal mudflat off the Medway Channel, approximately 2km south of the western endpoint of the study area. This former 19th century Martello Tower was adapted over time for different armament and was used up to and during the Second World War. During the First World War it contained two mounted 4.7-inch breech-loading guns and was used as the anchor point for a defensive boom across to Sheerness. In the Second World War it contained a twin 6-pounder quick-firing gun installation and functioned as both an anti-motor torpedo boat site and a searchlight. The tower was reduced to care and maintenance in 1944 and decommissioned in 1956.<br>Several additional gun emplacements are referenced within the Isle of Grain, the exact locations of which cannot be confirmed. |
| **Anti-Tank Blocks** | A length of anti-tank obstacles (referred to as 'dragon's teeth') were constructed along the north shore of the Isle of Grain in the early period of WWII. These obstacles extend to the north-west of the isle and are shown to directly intercept the western endpoint of the study area in 1946 imagery, see **Annex N**. Most of these features are still present today. |
| **Machine Gun Emplacements** | Several machine gun emplacements were present in the Isle of Grain during WWII. Imagery of these emplacements in front of Grain Fort and on the foreshore of the isle are also presented in **Annex N**. |
| **Pillbox** | The nearest pillbox is recorded approximately 1km south of the western endpoint of the study area, near Grain Fort. A series of pillboxes are recorded at a further distance from the study area, along the Isle of Grain coastline. |
| **Spigot Mortar Emplacement** | A spigot mortar emplacement is recorded within the southern side of Grain Fort during WWII, approximately 1km south of the western endpoint of the study area, |
| **Coastal Artillery Searchlights** | Two WWII-era coastal artillery searchlights are recorded approximately 900m east of the western endpoint of the study area, in front of Grain Fort. Several additional installations of this type were situated further along the coastline of the Isle of Grain. |

### 16.2.2. Grain Fort


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Grain Fort is of particular interest due to its close proximity to the western endpoint of the study area. This feature was initially constructed during the 1860s as an anti-invasion measure against Napoleonic France and was designed as a self-defensible keep which, in the event of invasion could co-operate with Slough Fort in Allhallows to defend the time Isle of Grain. It was subsequently modified and improved during both world wars, including the addition of two 4.7-inch breech loading guns shortly before WWI and the installation of a twin 6 pounder, 10 cwt. QF (quick firing) coastal artillery gun installation in WWII. The fort was decommissioned in 1956 and subsequently demolished, with only the fort's earthworks and a brick revetment still visible today.

### 16.2.3. Isle of Grain Seaplane Station

This station, situated approximately 2.5km south of the western endpoint of the study area, off Port Victoria Road, was developed in 1912 by the Royal Naval Air Service. It was initially designed to house aircraft and up to 800 accompanying airmen to intercept Zeppelin's raids over the Thames. Towards the end of WWI the station was taken over by the newly formed RAF and took on more of an experimental role, including use for seaplane testing. This continued until 1922 when the facility was taken over by the Royal Navy as an armament depot. Its buildings later formed a residential area known as Bungalow Town, until its demolition in the 1950s.

## 16.3. Anti-Aircraft Artillery (AAA)

Anti-aircraft guns were installed on the coastline to deter enemy aircraft from carrying out bombing raids inland on valuable targets. During WWII three main types of gun sites existed: heavy anti-aircraft (HAA), light anti-aircraft (LAA) and 'Z' batteries (ZAA). If the projectiles and rockets fired from these guns failed to explode or strike an aircraft, they would descend back to land.

| **Anti-Aircraft Artillery** | |
|---|---|
| **Type of Installation** | **Summary** |
| **HAA** | These large calibre guns such as the 3.7" QF (Quick Firing) were used to engage high flying enemy bombers. They often fired large HE projectiles, usually initiated by integral fuzes which triggered by impact, area, time delay or a combination of aforementioned mechanisms.<br>A WWII-era HAA gun battery and an accompanying 40mm LAA Bofors gun emplacements were situated in the immediate vicinity of the western endpoint of the study area, at White Hall Farm These positions are visible in the WWII-era imagery presented in **Annex N**, alongside an accompanying military camp. This position is also recorded to have contained two 6" BL guns as a temporary wartime emergency battery in 1915.<br>Other HAA installations in the region include an additional HAA battery 2km to the south near the Medway Channel and a 1930's era 4.5" gun at Grain Fort. |
| **LAA** | These mobile guns were intended to engage fast, low flying aircraft. They were typically rotated between locations on the perimeters of towns and strategically important industrial works. As they could be moved to new positions with relative ease when required, records of their locations are limited.<br>A number of LAA positions comprising both 40mm Bofors guns and 20mm Oerlikon guns are recorded across the Isle of Grain, mostly along the isle's north and eastern coastlines. |
| **Machine gun posts** | These posts were established at some significant military and industrial positions. Machine guns rounds were a largely ineffective form of AAA (Anti-Aircraft Ammunition). Machine guns usually fired the .303 round. |


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| | |
|---|---|
| | Several machine gun emplacements were situated within the Isle of Grain during WWI, however these positions are not believed to have been employed as anti-aircraft guns. |

Illustrations of Anti-Aircraft artillery, projectiles and rockets are presented at **Annex Q**.

### 16.4. The Defence of Hooksiel/Wilhelmshaven

Detailed information concerning German WWI and WWII-era military defences is difficult to access in the public domain, with significant quantities of records held by the German military authorities believed to have been lost or destroyed during the process of both world wars. It has been possible however to establish that a ring of defences, mainly comprising anti-aircraft emplacements, were situated around the port of Wilhelmshaven during WWI and WWII.

The closest of these defences to the eastern endpoint of the study area is believed to be a battery position at Hooksiel, situated approximately 4km to the west. This battery was equipped with four 15cm Howitzers guns during WWI and secured with a water-filled ditch, barbed wire fencing and trenches. After the war, the building was closed as part of German disarmament but was subsequently reoccupied on the outbreak of WWII in 1939. During this period, three 8.8 cm Flak 18 anti-aircraft guns were manned within this facility sheltered by a fortified casemate. The entire military complex was expanded during the later years of the war to house additional military personnel and was protected by a series of static defensive positions, including grenade launchers and machine guns.

### 16.5. Deductions

Due to its strategic location, the Isle of Grain was occupied by a concentration of coastal military defences, including fortified structures, coastal artillery batteries and other gun emplacements throughout the 19$^{th}$ and early 20$^{th}$ centuries. The majority of these defences were deemed redundant after WWI with only Grain Fort, Dummy Battery and Grain Tower Battery armed and operational at the start of WWII. A number of anti-aircraft emplacements, emergency coastal artillery batteries and static defensive potions, such as anti-tank blocks, were however later established across the isle to combat the increased potential threat of a German invasion and German air raids.

It is anticipated that these defensive positions on and surrounding the western endpoint of the study area, on the Isle of Grain, would have been manned by the relevant members of the Armed Forces for a significant period before during and after both world wars. This suggests that SAA and LSA would have been stored in these areas and highlights the potential for contamination to have resulted at key points, especially when the threat of invasion rescinded mid-way through WWII and surplus weaponry would have needed disposal. Defensive positions such as anti-aircraft batteries, coastal batteries and other gun emplacements could also have resulted in contamination across the wider area of this section of the study area, across the Thames Estuary.

No evidence could be found to suggest that any defensive positions were established on or surrounding the immediate area of the eastern end point of the study area during WWI or WWII. This is largely due to its occupation by open water during both periods, which was not reclaimed until the 1970's. A ring of positions was however situated in the wider area, as part of the defence of Wilhelmshaven.

## 17. Aerial Delivered Iron Bombs

### 17.1. World War I

During WWI Britain was targeted and bombed by Zeppelin Airships as well as Gotha and Giant fixed-wing aircraft. A WWI map of air raids and naval bombardments across England is presented in **Annex**


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**S**. Though records indicate that Sheerness experienced air raids during WWII, there is no evidence to suggest that the Isle of Grain was ever directly subjected to WWI-era bombing.

The Royal Naval Air Service (RNAS) undertook a number of bombing missions on strategic military and industrial targets on Germany during WWI, predominantly focused on Zeppelin airbases. Though relatively few in number it is estimated that through the process of these raids Britain dropped 660 tons of bombs on Germany, approximately double that dropped by Germany on Britain. No information could be found to suggest that the area surrounding Wilhelmshaven was bombed during WWI. Very little information was compiled about WWI-era bombing in offshore areas.

WWI bombs were generally smaller than those used in WWII and were dropped from a lower altitude. This resulted in limited UXB penetration depths. Aerial bombing was often such a novelty at the time that it attracted public interest and even spectators to watch the raids in progress. For these reasons there is a limited risk that UXBs passed undiscovered, especially in an urban environment. When combined with the relative infrequency of attacks and an overall low bombing density the risk from WWI UXBs is considered low and will not be further addressed in this report.

## 17.2. World War II

### 17.2.1. Britain

The Luftwaffe's main objective for the attacks on Britain was to inhibit the country's economic and military capability. To achieve this they targeted airfields, depots, docks, warehouses, wharves, railway lines, factories, and power stations. As the war progressed the Luftwaffe bombing campaign expanded to include the indiscriminate bombing of civilian areas in an attempt to subvert public morale.

During WWII the western endpoint of the study area was situated within the Strood Rural District, which sustained an overall low-moderate density of bombing. However, available accounts indicate that bombing in the Isle of Grain was more severe when compared to other parts of the district. This is anticipated to have been partially due to its location between the Thames and Medway estuaries, which Luftwaffe bomber pilots would use as a navigational aid to reach targets in London. Bombing in the region can also be accounted for by the presence of several significant visible targets including a N series naval decoy for Chatham Docks near Allhallows, an oil terminal bombing decoy at Hook's Fleet, Sheerness Dockyard and Naval Base, Grain Fort and the various oil depots in the south of the Isle of Grain, in Wallend. A number of these targets are highlighted within Luftwaffe aerial reconnaissance mapping and imagery presented in **Annex T**.

### 17.2.2. Germany

The Allied Forces conducted extensive bombing raids over Germany during WWII, from the outbreak of war through to the eve of VE Day. RAF raids were generally initially focused on prominent military and industrial targets across the country, which took place during a series of daylight operations between 1939-1942. As the war progressed these raids gradually shifted to incorporate a wider range of targets and following the issue of the 'Area Bombing Directive' on the 14th February 1942, also became officially focused on damaging the morale of the German population. Following the entry of the US in the war and USAAF bombing sorties across Europe, RAF bombing operations on Germany in 1944-1945 were largely shifted to night raids. Operations also supported the Allied armies in the build up to D-Day and the subsequent invasion of Europe.

The city of Wilhelmshaven was identified early on by the Allied forces as a major objective for aerial bombing raids, due to its importance to German Naval production and relatively accessible position across the North Sea. It was subject to the first RAF Bomber Command raid of WWII on the 4th September 1939 and subsequently sustained a number of significant RAF raids between 1939-1943, mostly focused on the city's harbour and naval infrastructure. From 1943 to 1945 the city was also


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subject to heavy raids from USAAF bombers. Combined these air raids reportedly resulted in the demolition of two thirds of the city's port buildings and infrastructure.

#### 17.2.3. Offshore

In contrast, records concerning aerial bombing over European offshore areas are much more limited. This is because of restrictions in observation and the fact that very few permanent industrial or military targets of significance were situated offshore; though it was not uncommon for pilots to target both merchant and naval shipping with aerial bombardment through both planned and opportunistic raids. It is also possible that bombs could have been aerially deployed within European waters because of aerial engagements between Axis and Allied pilots, as well as the deliberate dumping of munitions by pilots attempting to return home.

### 17.3. WWII Bombing of Isle of Grain

#### 17.3.1. Home Office Bombing Statistics

The following table summarises the quantity of German aerial delivered bombs (excluding 1kg incendiaries and anti-personnel bombs) dropped on the Strood Rural District between 1940 and 1945. Note this record is not believed to cover any offshore areas.

| Record of German Ordnance Dropped on the Strood Rural District | | |
|---|---|---|
| **Area Acreage** | | **48,811** |
| Weapons | High Explosive bombs (all types) | 1,804 |
| | Parachute mines | 24 |
| | Oil bombs | 55 |
| | Phosphorus bombs | 117 |
| | Fire pots | 14 |
| | Pilotless aircraft (V-1) | 37 |
| | Long range rocket bombs (V-2) | 9 |
| **Total** | | **2,060** |
| **Number of Items per 1,000 acres** | | **42.2** |

Source: Home Office Statistics
This table does not include UXO found during or after WWII.

Detailed records of the quantity and locations of the 1kg incendiary and anti-personnel bombs were not routinely maintained by the authorities as they were frequently too numerous to record. Although the risk relating to incendiary bombs (IB's) is lesser than that relating to larger high explosive bombs (HE's), they were similarly designed to inflict damage and injury. Anti-personnel bombs were used in much smaller quantities and are rarely found today but are potentially more dangerous. Although Home Office statistics were not recorded, both types of item should not be overlooked when assessing the general risk to personnel and equipment.

Examples of German Air-Delivered Ordnance are presented in **Annex R**.

#### 17.3.2. Kent ARP Daily Bomb Maps

A collection of wartime map sheets of the county of Kent, showing the locations of dropped HE bombs, parachute mines, incendiary bombs, cross channel shelling and aircraft crash incidents, were obtained from the Kent Library and History Centre. Incidents were recorded daily throughout the early stages of the war, although map editions from 1942 onwards record strikes over multiple days.


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Due to the information being recorded on small scale mapping depicting the whole county, it has not been possible to determine the exact locations of individual strikes, beyond establishing the approximate locality of the incident. Moreover, it is typical that single plotted strikes may represent numerous incidents of bombing. This is especially likely in cases of incendiary bombing, as incendiary bombs were frequently deployed in high numbers.

The maps that show bomb strikes on and in the vicinity of the site are presented in **Annex U**.

| **Kent ARP Daily Bomb Maps – Annex U** | |
|---|---|
| **Date Range** | **Comments** |
| 11th July 1940 | Incendiary and HE bombing is recorded in the general area. |
| 10th August 1940 | Incendiary and HE bombing is recorded in the general area. |
| 30th August 1940 | Two German planes downed offshore in the general vicinity. |
| 11th September 1940 | HE bombing is recorded to the south. |
| 7th October 1940 | HE bombing is recorded to the south |
| 17th October 1940 | HE bombing is recorded to the south. |
| 18th October 1940 | HE bombing is recorded to the east. |
| 17th November 1940 | Incendiary bombing is recorded to the south |
| 27th November 1940 | HE bombing is recorded to the immediate south-east |
| 13th December 1940 | Three parachute mines are recorded to the east, in the Thames Estuary. |
| 19th April 1941 | HE bombing is recorded to the south and east. |
| 1st June 1941 | HE bombing is recorded to the south-east. |

### 17.3.3. Written Bomb Incident Records

Written incident records were obtained from the Kent History and Library Centre. Records for Strood Rural District do not appear to be comprehensive, with only a single day in 1940 and 1941 covered and the main body of the records only appearing to begin in 1942. As Kent ARP bomb maps indicate, raids in the vicinity of the site occurred across multiple dates during 1940 and 1941, so if any incidents did occur directly within the site area, these would not likely be covered by the date range of these records. Furthermore, it is considered unlikely that any detailed records would have been maintained concerning bombing incidents within areas of open water.

### 17.3.4. WWII-Era Aerial Photographs

High resolution scans of WWII-era aerial photography for the western endpoint of the study area were obtained from the National Monuments Record Office (Historic England). This photography is dated 28th August 1942 and 1st May 1946 and provides a record of the potential composition of the site during the war, as well as its condition immediately following the war (see **Annex V**).

Imagery indicates that the western endpoint of the study area was occupied by a small area of coastline and adjacent open grassland during WWII, much as it is today. It is intercepted by a row of anti-tank blocks, situated surrounding the coastline and is located in close proximity to a HAA battery, which comprises several individual gunpoints. An associated camp, connected to this HAA battery by a roadway, comprises rows of nissen huts and other similar structures, which may have been used for storage or the billeting of troops. This could have included relevant anti-aircraft divisions or members of the Home Guard.


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No obvious indicators of bomb damage, such as structural damage, cratering or other such ground disturbances could be identified within the immediate area of this section of the study area. Such features can however be difficult to discern within open ground and may have been obscured by the date of this image, taken several years after the main period of bombing in the region.

### 17.3.5. Bombing Decoy Sites

The decoy principal – drawing German bombers away from their designated targets onto dummy sites five or six miles away – began in the UK in WWI to protect RAF stations. In 1939, a new department was set up to investigate and coordinate the concept of defence by deception. A whole range of decoy sites were developed – some of them became very elaborate and covered large areas.

| **Common WWII Decoy Site Variants** | |
|---|---|
| **Decoy Type** | **Description** |
| K-site | Daytime dummy airfield. Dummy aircraft and infrastructure. |
| Q-site | Night time dummy airfield. Intended to represent the working lights of an airfield after dark. |
| QL | Night time dummy infrastructure. Replicating the lights and workings of marshalling yards, naval installations, armament factories etc. |
| QF | Fire based decoy. Initially for aircraft factories, RAF maintenance units and ordnance works to simulate them on fire following bombing. |
| Oil QF | Simulation of burning oil tanks. |
| Starfish | Replicating a city under incendiary attack. |

By June 1944, decoy sites had been attacked on 730 occasions. Attacks ranged from a single night-time bomber dropping its load onto a "Q" site, to the mass attacks on Starfish sites. In diverting the high explosives and incendiaries from the intended targets they were undoubtedly responsible for saving the lives of thousands of people.

Works planned in the vicinity of WWII decoy sites can be at an elevated risk from UXBs as the facilities were specifically designed to be bombed. It was not uncommon for evidence of UXBs at a decoy site to be overlooked following a raid. Given that the sites were on open ground, sometimes agricultural fields, UXB entry holes were not always evident.

In-house data sets indicate that several WWII-era bombing decoy sites were present in the general proximity of the western endpoint of the study area on the Isle of Grain. An Oil QF is recorded approximately 3km to the west near Allhallows to decoy a series of significant gas installations situated at Wallend. An N-Series Naval Decoy was also recorded adjacent to the aforementioned decoy, at Binney Farm, and was designed to divert bombing from Chatham Docks. The decoy site mapping, presented in **Annex W**, confirms the presence of QF Decoy sites within the Isle of Grain, although their positon and number does vary between map editions.

## 17.4. Inland Abandoned Bombs

A post air-raid survey of buildings, facilities, and installations would have included a search for evidence of bomb entry holes. If evidence of an entry hole was encountered, Bomb Disposal Officer Teams would normally have been requested to attempt to locate, render safe, and dispose of the bomb. Occasionally, evidence of UXBs was discovered but due to a relatively benign position, access problems, or a shortage of resources the UXB could not be exposed and rendered safe. Such an incident may have been recorded and noted as an ‘abandoned bomb’.


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Given the inaccuracy of WWII records and the fact that these bombs were 'abandoned', their locations cannot be considered definitive or the lists exhaustive. The MoD states that 'action to make the devices safe would be taken only if it was thought they were unstable'. It should be noted that other than the 'officially' abandoned bombs, there will inevitably be UXBs that were never recorded.

1st Line Defence holds no records of officially registered abandoned bombs at or near the western endpoint of the study area, in the Isle of Grain.

### 17.5. Inland Bomb Disposal Tasks

1st Line Defence has no evidence that any official ordnance clearance operations have taken place on or near the western endpoint of the study area, in the Isle of Grain. Note however that we have not received confirmation of this fact from 33 EOD Regiment.

### 17.6. WWII Bombing of Friesland

#### 17.6.1. Bomb/Damage Statistics

No official statistics regarding the number and types of bombs dropped by Allied forces are believed to have been compiled for the eastern endpoint of the study area, in North Germany. Largely due to the relatively rural composition of the local area and its occupation in part by open water during WWII.

Detailed records of the quantity and locations of bomb strikes on the nearby city of Wilhelmshaven, situated approximately 13km to the south, are however anticipated to have been compiled by the relevant German authorities. Information provided from both the German Federal Archives, Koblenz, and the Archive of the City of Wilhelmshaven, indicates that the majority of such records were lost or destroyed during the process of the war, but the following statistics have been correlated across several online and published secondary sources.

| Record of Buildings Destroyed in Wilhelmshaven | |
|---|---|
| | **City and Shipyard** |
| Commercial | 406 |
| Industrial | 11 |
| Civil and Local Government | 15 |
| Residential | 5,600 |
| **Total** | **6,079** |

| Record of Allied Ordnance Dropped on Wilhelmshaven | | |
|---|---|---|
| | **City** | **Shipyard** |
| High Explosive Bomb | 11,045 | 863 |
| Aerial Mines | 35 | 8 |
| Incendiary Bombs | 73,295 | 16,577 |
| **Total** | **84,375** | **17,448** |

#### 17.6.2. Written Records

A total of 102 air strikes are believed to have taken place on Wilhelmshaven between the 4th September 1939 and the 30th March 1945, 17 of which were classified as ' major attacks'. Written information about each of these major attacks raid has been obtained from a number of secondary historical texts, including *Daylight Bombing Operations 1939-1942* by W Martin, *The Mighty Eighth War Diary* by Roger Freeman and a transcript of the Campaign Diary for RAF Bomber Command, which


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was compiled for the organisation's 60th Anniversary. Details of each raid are presented in the tables below, which are divided into RAF and USAAF air raids.

| **RAF Air Raids 1939-1943** | |
|---|---|
| **Date Range** | **Comments** |
| 4th September 1939 | Ten Bristol Blenheims of No. 110 and No. 107 Squadrons attacked units of the German fleet at low altitude, losing half their number without achieving any significant damage. |
| 18th December 1939 | Battle of the Heligoland Bight. RAF bombers approaching the German Bight en route to targets within Wilhelmshaven were engaged by German fighters, inflicting heavy casualties and destroying 12 of the 22 Vickers Wellingtons. |
| 8th July 1941 | Three bombers of No. 90 Squadron RAF, carrying two tons of bombs each, bombed from an altitude too high for German interceptors to reach but only one was able to drop ordnance on their target. |
| 28-29th December 1941 | 217 sorties by RAF Bomber Command; Wilhelmshaven, Hüls, and Emden were the main targets. |
| 11-12th February 1943 | 220 sorties were flown by 177 aircraft, comprising 129 Lancasters, 40 Halifaxes and eight Stirlings from RAF Bomber Command, targeting the major Kriegsmarine bases around Wilhelmshaven. The naval arsenal, including ammunition, mine and torpedo stores at Mariensel exploded, destroying approximately 50 hectares of structures. Three aircraft were lost. |

| **USAAF Air Raids 1943-1945** | |
|---|---|
| **Date Range** | **Comments** |
| 27th January 1943 | 55 bombers of the Eighth Bomber Command dropped 137 tons of bombs on warehouses and industrial plants, losing three aircraft. |
| 22nd March 1943 | Attack by six groups of B-17s and B-24 Liberators on a U-boat yard. |
| 21st May 1943 | German fighter reaction against a raid by 77 B-17s on Wilhelmshaven resulted in the loss of ten per cent of the bomber force. |
| 11th June 1943 | 252 B-17's are dispatched against a U-boat yard at Wilhelmshaven and the Cuxhaven port area. |
| 26th July 1943 | Wilhelmshaven bombed as a target of opportunity by the 94th Bomb Group. |
| 3rd November 1943 | 21 groups totalling 539 aircraft attacked the port area of Wilhelmshaven. |
| 3rd February 1944 | Major attack by 609 B-17s on the port area of Wilhelmshaven. |
| 3rd March 1944 | 91 B-17s of the 1st Bomb Division bombed Wilhelmshaven as a target of opportunity when bad weather forced the rest of the 760-bomber mission force to turn back from the first attack on Berlin |
| 27th August 1944 | Wilhelmshaven again bombed as a target of opportunity, by 34 B-17s originally sent to Berlin |
| 27-28th February 1945 | Night mission by 8AF and RAF Pathfinder Force on Wilhelmshaven's oil storage facilities |
| 30th March 1945 | 358 B-24s of the Eighth Air Force undertake the final major air raid on the city. |

### 17.6.3. Bomb Damage Mapping

Bomb damage mapping of the Wilhelmshaven area of the site was obtained from the Archive of the City of Wilhelmshaven and is presented in **Annex Y**. This source is indicated to have been compiled by British intelligence, based on damage visible in aerial imagery dated October 1944. It demonstrates


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the severity and extent of bomb damage across the city during this period, which appears to have been concentrated around the industrial and naval dockyards in the south and east of the city.

This level of damage displayed approximately correlated with sources that suggest Wilhelmshaven was one of the most destroyed cities in Lower Saxony. 60 percent of the residential buildings were destroyed.

### 17.7. Deductions

The western endpoint of the study area was situated within a district of Kent that sustained an overall low-moderate density of bombing during the war. Despite this, the volume of bombing within the immediate locality, within the Isle of Grain, is anticipated to be elevated in comparison to the surrounding area. This is due to the presence of several significant Luftwaffe targets, such as the Port of the Admiralty Oil Refinery to the south at Wallend, naval and oil decoy sites to the west near Allhallows and Sheerness Docks to the east. In addition, its position at the confluence of the River Medway and Thameswould have increased the potential for opportunistic 'tip and run' bombing by Luftwaffe pilots travelling to and from targets in London and the Medway towns. Subsequently, despite the presence of nearby military infrastructure, it is not possible to discount the possibility of an item of UXO falling unnoticed within the section of the study area; especially considering the open, rural nature of the groundcover present.

Less detailed information is available concerning the deployment of aerial delivered ordnance within the offshore areas that occupy the vast majority of the proposed study area. However, potential sources of contamination identified include the dumping of ordnance during plane-to-plane engagements and attacks on military and merchant shipping, both of which are recorded in number across the North Sea for the main duration of WWII. Any bombs falling during such circumstances are not likely to have been observed or investigated and thus the possibility that aerially delivered UXO may be present within any offshore areas also cannot be completely discounted, though the likelihood of contamination from such items across the majority of the study area is not considered to be high.

The risk of encountering German aerial delivered bombs is however considered to be elevated within the Thames Estuary, on account of the documented number of Luftwaffe bombers that used this feature as a navigational aid to reach targets within London and within the estuary, which is referenced to have been specifically targeted on several occasions in its own right. Likewise, the risk of encountering Allied aerial delivered is considered to increase within offshore areas situated closer to the German coastline, where a greater number of Allied attacks on shipping is known to have taken place.

The risk of contamination from items of air delivered UXO is considered most significant within the eastern endpoint of the study area, at the approach to the Jade Bight. This is due to the number of air raids conducted on the area of Wilhelmshaven during WWII, with an estimated 5,327.5 tons of bombs dropped by 2,141 bombers of the USAAF alone – with is anticipated to have had a significant effect on the density of bombs dropped in the surrounding area. It should be noted however that the eastern endpoint section of the study area has undergone significant land reclamation since the 1970ss and that such activity will have significantly mitigated the potential for larger item of UXO remain, provided that the fill material used was not from a contaminated source, such as bomb rubble.

## 18. Munitions Encounters in the Study Area

### 18.1. OSPAR Commission Data

The OSPAR Commission has been collecting data on offshore encounters with munitions since 1999 and has compiled an extensive database of such incidents off the UK coast and in the North Sea. A total of 1,879 encounters were reported by Belgium, France, Germany, Ireland, the Netherlands,


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Spain, Sweden and the UK. Of the 1,879 munitions encounters reported, 1,595 (85%) were described as conventional, 30 (2%) as chemical and 254 (14%) were of unknown type. In this report, phosphorus devices are taken to be conventional munitions. The devices encountered on 786 occasions (42%) were reported to be in various stages of corrosion, from partly to completely corroded, 14 (1%) were described as being live or in good condition and the state of the remainder were unknown or not reported.

An overlay depicting the approximate locations of offshore munition encounters reported in close vicinity to the study area, as recorded by OSPAR since 2004, is presented in **Annexes Z1-Z6**. This covers the OSPAR maritime area, which includes both the North Sea and the remaining offshore areas of the proposed study area. However due to the nature of its compilation, this record should not be considered to be comprehensive.

Three offshore munition encounters are indicated near the western section of the study area, at the approach to the Thames Estuary. 11 munition encounters are clustered in the central section of the site between UK and Dutch waters, with three more encounters identified in the eastern section of the site, on the approach to the Jade Bight. The munitions found are all of the conventional type, with the exception of one 'unknown' item. Data related to these encounters is transcribed in the table presented in **Annexes Z7-Z8**.

### 18.2. UXO Clearance / EOC Tasks

1st Line Defence holds a database of historic EOC (Explosive Ordnance Clearance) tasks carried across Great Britain by 33 EOD Regiment. Though this source is understood to not be comprehensive, no clearance tasks are recorded within the immediate area of the western endpoint of the study area, in the Isle of Grain.

### 18.3. Deductions

The documented munition encounters within the Thames Estuary are most likely attributable to the presence of several historic and contemporary armament ranges in the region. Munition encounters across the remainder of the region could be the result of a wider range of potential sources, such as historic minefields, ship-to-ship engagements, munitions dumps and aerial bombing. These encounters demonstrate the potential for other such items to be present within the region.

## 19. 1st Line Defence Risk Assessment

### 19.1. Risk Assessment Stages

Taking into account the quality of the historical evidence, the assessment of the overall risk from unexploded ordnance is based on the following five considerations:

1. That the study area was contaminated with unexploded ordnance.
2. That unexploded ordnance remains within the study area.
3. That such items will be encountered during the proposed works.
4. That ordnance may be initiated by the works operations.
5. The consequences of encountering or initiating ordnance.

### 19.2. The Risk that the Site was contaminated with UXO


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After considering the following facts, 1st Line Defence believes that there is a risk of UXO contamination from the following sources across the study area:

**Coastal Armament Training Areas**

- The firing areas of three historic armament training ranges are situated directly across the section of the study area within the Thames Estuary on WWII-era armament training and 'danger area' mapping. These comprise the former Sheerness and Grain, Yantlet and Shoeburyness Artillery Ranges, the latter of which still plays an extensive role in the testing and development of ordnance on behalf of the MoD today. Two smaller historic ranges are also denoted within the Thames Estuary, to the south-east of this section of the study area. Barton Point, a heavy and light anti-aircraft range, was situated at a distance of approximately 2-5km and 22 Leysdown, an RAF live bombing range, was situated at a distance of approximately 5-6km.
- Based on the available historical documentation, it is anticipated that both live and practice ammunition would been deployed during these ranges operation, with both categories of ordnance still employed at Shoeburyness today. The presence of these armament ranges therefore significantly increases the likelihood that items of Allied ordnance could have been expended through training exercises or firing practices within the westernmost of the study area, from the Isle of Grain to the approaches to the Thames Estuary. This is further demonstrated by the large number of UXO discoveries within the region in the post war period. Selective imagery, taken from hundreds of items found during UXO clearance dredging operations in the Princess Channel in the 2000s, is presented in **Annex O**.
- The majority of items or ordnance used in the coastal armament training areas within the Thames Estuary will have consisted of LSA and SAA. Though larger, aerial delivered bombs will have been deployed at the site of the 22 Leysdon RAF range. The smallest type of LSA typically used by British forces during the WWII-era were three pounder projectiles, though smaller sizes of projectiles may have been utilised. Items of ordnance fired within the estuary's danger areas are not anticipated to have always detonated on impact with the water and have the potential to remain live and settle within the estuary's bed.

**Munitions Dumpsites**

- A concentration of historic munitions dumpsites has been identified within the eastern section of the study area, off the coastline of North Germany. These dumpsites are believed to have formed part of a wider programme of ammunition dumping across the German North Sea Coast at the end of WWII, resulting in an estimated 750,000 to 1.5 million tons of munitions dumped from both German and Allied sources. This included an estimated 250,000 tons of ammunition shipped from the Port of Wilhelmshaven alone. Although the closest three dumpsites are situated at an approximate distance of 1-2km from the study area, this is still of concern, as it is possible that dumped munitions may have either been deposited outside their designated areas or have else migrated within the region over time.
- Extensive munition recovery is known to have been undertaken in the region between 1952-1958 to recover various UXO related metals. However this type of clearance work is rarely comprehensive and subsequent experimental recovery operations undertaken by the German government in the 1990's are known to have still resulted in the discovery of large volumes of items, including the recovery of 3,000kg of munitions in 1991 and 4,669kg of munitions in 1999. It is therefore anticipated that large amounts of ammunition are still present on and around these former dumping areas, with some sources suggesting that an estimated 10,000-50,000 tons of munitions may still be present in Lower Saxonian waters.

**Aerial Bombing**

- The risk of contamination from items of air delivered UXO is considered most significant within the eastern endpoint of the study area, at the approach to the Jade Bight. This is due to the number of Allied air raids carried out on Wilhelmshaven during WWII. An estimated 5,327.5 tons of bombs are believed to have been dropped by 2,141 bombers of the USAAF on targets on and around the city, which is anticipated to have led to a significant increase in


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the density of bombing in the surrounding area. It should be noted however that the eastern endpoint section of the study area has undergone significant land reclamation since the 1970's and that such activity will have significantly mitigated the potential for larger items of UXO remain, provided that the fill material used was not from a contaminated source.

- The western endpoint of the study area was situated within a district of Kent that sustained a low-moderate density of German aerial bombing throughout the war. However its location within the Isle of Grain, at the confluence of the River Medway and Thames, is anticipated to elevate bombing due to its position on Luftwaffe flights paths and the presence of several significant nearby Luftwaffe targets, such as the former Grain oil refinery, the Allhallows bombing decoy sites and Sheerness Docks.
- The density of aerial bombing is anticipated to have been considerably lower across the offshore areas that occupy the vast majority of the proposed study area. However, potential sources of contamination identified in this environment include the dumping of ordnance during plane to plane engagements and attacks on military and merchant shipping. The possibility that such items may be present within any offshore area subsequently cannot be completely discounted. Furthermore, the risk of contamination from aerial delivered bomb is considered to increase within the Thames Estuary and within areas close to the German coastline, due to the increased volume of Luftwaffe and Allied bomber activity documented in these regions.

**Wartime Coastal Defences**

- Due to its strategic location, the Isle of Grain was occupied by an extensive network of coastal military defences, including fortified structures, coastal artillery batteries and other gun emplacements throughout the 19th and early 20th centuries. The majority of these defences were deemed redundant after WWI with only Grain Fort, Dummy Battery and Grain Tower Battery armed and operational at the start of WWII. However, a number of anti-aircraft emplacements, emergency coastal artillery batteries and static defensive potions, such as anti-tank blocks, were later established to combat the increased potential threat of a Nazi invasion, as well as to combat Luftwaffe raids.
- It is anticipated that these defensive positions on and surrounding the western endpoint of the study area would have been manned by the relevant members of the Armed Forces for a significant period before, during and after both world wars. This suggests that SAA and LSA would have been stored in these areas and highlights the potential for contamination to have resulted at key points, especially when the threat of invasion rescinded mid-way through WWII and surplus weaponry would have needed disposal. Defensive positions such as anti-aircraft batteries, coastal batteries and other gun emplacements could also have resulted in contamination across the wider area of this section of the study area, across the Thames Estuary.

**Sea Mines**

- Sizeable mine laying campaigns were undertaken by both Britain and Germany across the North Sea in WWI and WWII. The majority of the study area appears to have been situated across several of the more prominent of the WWII-era minefields, including significant defensive areas off the east coast of Britain and the north coast of Germany. Evidence has also been found to indicate that air deployed mines were regularly dropped within the Thames Estuary by the Luftwaffe between 1940-1941.
- A precise assessment of the current risk from mines across the length of the study area is difficult to ascertain. Efforts were made by both Germany and Britain post-war to remove or make safe the areas mined during the war. However, such clearance tasks do not guarantee the complete removal of all mines within a danger area, especially as such items have the potential to migrate or became covered due to sediment and tidal action over a long period of time. It is therefore not possible to discount the possibility of encountering aerial, surface or submarine laid sea mines across any offshore section of the proposed study area.

**Wreck Sites**


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- A number of listed historic wrecks have been identified on and around the study area. The majority of these wrecks are situated within shallower waters, at the approach to the Thames Estuary and off the coastlines of Germany. These wrecks often demonstrate the presence of both sea mines and aerial bombing during WWI and WWII.
- The majority of wrecks identified are commercial vessels, though several WWII-era British military wrecks are also recorded in the western and central sections of the study area, including the submarine HMS Truculent, three destroyers and several minesweeper trawlers. The eastern section of the study area, off the German coastline, contains several German military wrecks. These consist of the WWI-era cruiser SMS Yorck, the WWII-era DW 07 Patrol Boat (Trinchen Behrens) and two WWII-era minesweepers. Such vessels are anticipated to have carried items of ordnance at the time of their loss and, if not recovered, could have contaminated their immediate surroundings.

**Torpedoes/Anti-Submarine Weapons**

- It is well documented that both torpedoes and anti-submarine weapons were employed as part of aerial and naval warfare across the North Sea during WWI and WWII, although their numbers were relatively low when compared with other types of munitions. However, historical records indicate that submarine activity within the region was limited by the presence of defensive minefields and the British blockades of German ports. As a result, the U-boat campaigns of both world wars were predominantly focused on more viable shipping targets in the Atlantic Ocean. This is correlated by the available data concerning wreck sites, which indicates that only one WWI-era torpedo related wreck is situated in the vicinity of the study area and none related to anti-submarine weaponry, despite its length and position. Nevertheless it not possible to completely discount the presence of such items at the location of the study area due to their usage in the wider area.

### 19.3. The Risk that UXO Remains

One of the main activities which can reduce the risk of encountering UXO in the marine environment is dredging. For instance, regular dredging can lower the risk of encountering smaller items of ordnance, such as projectiles. This type of activity is anticipated to have taken place during land reclamation on and around the eastern endpoint of the study area in the 1970's, off Hooksiel. It is considered significantly less likely for larger items of wartime era UXO to remain within new areas of post-war land fill, provided that such land was not drawn from a contaminated source.

Generally, UXO in the marine environment will not have a great penetration capability into the seabed. However, heavier items such as iron bombs can settle into soft sediment or mud and on occasions become completely buried and thus remain in situ. (This penetration depth will vary based on the depth of water and geotechnical properties present.) The composition of offshore geology is understood to vary considerably across the study area and will likely include superficial deposits of a soft nature. At such locations there is a potential risk that UXO could be buried on or partially beneath the seabed which would require further investigation/consideration.

As well as the risk from ordnance remaining in-situ there is also a possibility that ordnance may have migrated within the study area. As physical processes, such as currents and tidal action can result in UXO being moved significant distances from their point of origin.

### 19.4. The Risk that UXO may be Encountered during the Works

The probability of encountering items of UXO is based both on the composition of the site, i.e. its history and physical environment and the type of project works undertaken. These factors are addressed in turn below:


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#### 19.4.1. Historical Context

1st Line Defence has identified several potential historical sources of UXO contamination within the proposed HVDC Electricity Transmission Interconnector route. There is a residual risk from torpedoes, anti-submarine weapons, mines, air-delivered bombs and from munitions associated with military related wrecks / dump sites within the offshore environment. Significant risk from Allied Land Service Ammunition (LSA) of various age and calibre has been identified in the area surrounding the Thames estuary and from munitions dumpsites. This site history will also affect the prospective distribution and positions of items of UXO, as well as its initiation failure rates.

#### 19.4.2. Physical Environment

Physical environmental factors affecting UXO encounter will include the bathymetry and depth of water present, the seabed geology and the impact of physical processes, such as storm surges and tidal currents, which may cause UXO uncovering, burial and migration.

#### 19.4.3. Type of Project Works

Given the nature of the proposed works, there is a risk that UXO may be encountered during intrusive activities during both the initial geotechnical survey campaign and the subsequent cable installation. Intrusive works within the marine survey includes geotechnical sampling planned at every 1km across the study area between the UK and Germany. This is anticipated to include vibrocore and cone penetrometer tests (CPT) within areas of open water and investigatory boreholes and trial pits within areas of landfall.

Limited information is available concerning the final methodology of the proposed cable installation. However, intrusive activities may include the usage of pre-lay grapnel runs and removal ploughs; as well as the use of cable trenching equipment to install cabling into the seabed. During such operations, the risk to the vessel and to operatives will depend on factors such as the distance behind the vessel that the equipment and cabling will be towed. There is also a small potential for smaller items of UXO to be caught up on equipment which comes into contact with the seabed and brought on board the vessel.

### 19.5. The Risk that UXO may be Initiated

The risk that UXO could be initiated if encountered will depend on its condition, how it is found and the energy with which it is struck. Most unexploded munitions do not become less dangerous with age and could still function as designed if disturbed. Furthermore, it is possible that seawater may have degraded certain types of munition over time leaving them in a more sensitive state.

Unexploded munitions do not spontaneously explode. All high explosive requires significant energy to create the conditions for detonation to occur. In the case of unexploded munitions discovered within the marine environment, there are a number of potential initiation mechanisms:

- Direct impact onto the main body of the weapon

  Unless the fuze or fuze pocket is struck, there needs to be a significant impact e.g. from piling or large and violent mechanical excavation, to initiate an item of ordnance such as an iron bomb. Such violent action can cause the bomb to detonate.

- Re-starting the clock timer in the fuze

  A small proportion of German WWII bombs employed clockwork fuzes. It is probable that significant corrosion would have taken place within the fuze mechanism over the last 60


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years that would prevent clockwork mechanisms from functioning, but the possibility cannot be discounted.

- Friction impact initiating the shock-sensitive fuze explosive

  This is the most likely scenario resulting in the weapon detonating. The combined effects of seasonal changes in temperature and general degradation over time can cause explosive compounds to crystallise and extrude out from the main body of the bomb. It may only require a limited amount of energy to initiate the extruded explosive which could detonate the main charge.

- It is considered unlikely that magnetic or acoustic sea WWI and WWII-era mines would function as originally designed, due to failures in their power supply, however there have been reports of such mines brought up in fishing nets detonating in recent history – possibly as a result of mishandling. In principle, WWI and WWII contact mines could still be initiated through impact with chemical horns. If the firing circuit was intact the release of electrolyte could theoretically activate the battery and detonate the mine.

- In cases where multiple items of UXO are situated in close proximity, there is also the potential for the initiation of one item to initiate others through a process known as sympathetic detonation.

In summary the risk of initiation is dependent on what part of the UXO is contacted and with what type and degree of force, as well as the sensitivity of the component in question. In any case an item of UXO encountered that has not been initiated should always be treated as live.

### 19.5.1. Initiation and the Type of Project Works

Generally more aggressive activities increase the risk of initiating items of UXO. To illustrate this effect some examples of common offshore project works are displayed in the table below.

| Probability | Factors | Example |
|---|---|---|
| Very Low | Benign Activities | Non-intrusive geophysical surveys, eg side scan sonar and magnetometry. |
| Low | Relatively Benign Activities | Vibrocore Sampling |
| Medium | Relatively Aggressive Activities | Jack up barge installation, including the application of loads to each leg. |
| High | Aggressive Activities | Cable ploughing under load |
| Very High | Very Aggressive Activities | Pile driving from a jack up barge. |

## 19.6. The Consequences of Encountering or Initiating UXO

When considering the potential consequences of a detonation, it is necessary to identify the significant receptors that may be affected. The receptors that may potentially be at risk from UXO detonating offshore might include but are not limited to the following summarised below:

- People – death or injury of vessel operatives, divers, nearby public etc.
- Equipment – damage to vessels, ploughs, anchors etc.
- Natural Environment – death or injury to marine fauna (fish/marine mammals) and habitats.
- Historic Environment – damage or destruction of listed buildings, wrecks and landscapes.


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The initiation of a small item of ordnance such as a small calibre projectile at depth during intrusive works may result in damage to plant and potentially injury of personnel. However, the initiation of a larger weapon such as a high explosive bomb or sea mine during works could have severe consequences in terms of both damage and loss of life and limb.

If an item of ordnance is accidentally brought on board without it being noticed, even a small projectile or item of Land Service Ammunition can pose a significant risk to vessel operatives.

### 19.7. Assessed Risk Level

Taking into consideration the findings of this study, 1st Line Defence does not consider the risk from UXO to be homogenous across the study area. Different sections have been assessed as at varying levels of risk, originating from different ordnance types. An assessment of the risk posed by UXO across the proposed HVDC Electricity Transmission Interconnector between the Isle of Grain, United Kingdom and Wilhelmshaven, Germany has therefore been divided into the following four areas, which are outlined in **Appendix i**.

**Section 1: The UK Mainland**

| Ordnance Type | Risk Level | | | |
|---|---|---|---|---|
| | Negligible | Low | Medium | High |
| Air Delivered Bombs | | | ✓ | |
| Anti-Aircraft Artillery Projectiles | | | ✓ | |
| Allied Military Land Service Ammunition (Grenades, Mortars etc.) | | | ✓ | |

**Section 2: Thames Estuary**

| Ordnance Type | Risk Level | | | |
|---|---|---|---|---|
| | Negligible | Low | Medium | High |
| Air Delivered Bombs | | | ✓ | |
| British Sea Mines | | ✓ | | |
| German Sea Mines | | | ✓ | |
| Allied Military Land Service Ammunition (Grenades, Mortars etc.) | | | ✓ | |
| Torpedoes | | ✓ | | |
| Anti- Submarine Weapons | | ✓ | | |
| Munitions Dumpsites | | ✓ | | |

**Section 3: Main Offshore Area (North Sea)**


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| Ordnance Type | Risk Level | | | |
|---|---|---|---|---|
| | Negligible | Low | Medium | High |
| Air Delivered Bombs | | ✓ | | |
| British Sea Mines | | | ✓ | |
| German Sea Mines | | | ✓ | |
| Allied Military Land Service Ammunition (Grenades, Mortars etc.) | ✓ | | | |
| Torpedoes | | ✓ | | |
| Anti- Submarine Weapons | | ✓ | | |
| Munitions Associated with Dumpsites[4] | | ✓ | | |

**Section 4: German Approaches**

| Ordnance Type | Risk Level | | | |
|---|---|---|---|---|
| | Negligible | Low | Medium | High |
| Air Delivered Bombs | | | ✓ | |
| British Sea Mines | | | ✓ | |
| German Sea Mines | | ✓ | | |
| Allied Military Land Service Ammunition (Grenades, Mortars etc.) | | ✓ | | |
| Torpedoes | | ✓ | | |
| Anti- Submarine Weapons | | ✓ | | |
| Munitions Associated with Dumpsites[5] | | | | ✓ |

**Section 5: The German Mainland**

| Ordnance Type | Risk Level | | | |
|---|---|---|---|---|
| | Negligible | Low | Medium | High |

[4] *This assessed risk level is based on the current location of the study area, as depicted in the annexes of this report. If the location of the study area was to change significantly in relation to the location of recorded munition dumpsites 1st Line Defence should be contacted and this risk level reassessed.*

[5] *This assessed risk level is based on the current location of the study area, as depicted in the annexes of this report. If the location of the study area was to change significantly in relation to the location of recorded munition dumpsites 1st Line Defence should be contacted and this risk level reassessed.*


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| | | | | |
|---|---|---|---|---|
| Air Delivered Bombs | | | ✓ | |
| Anti-Aircraft Artillery Projectiles | | ✓ | | |
| Allied Military Land Service Ammunition (Grenades, Mortars etc.) | | ✓ | | |

**Note** - The risk from UXO originating from wrecks/crashed aircraft is considered to be low across the study area as a whole, as such features have been identified as few and far between. The localised risk will however be increased within the area of any military related wrecks present directly on route.

## 20. UXO Risk Mitigation

### 20.1. General

This report has concluded that there is a risk from unexploded ordnance along the proposed HVDC Electricity Transmission Interconnector between the Isle of Grain, United Kingdom and Wilhelmshaven, Germany. The risk has been broadly split into five different zones, which each contain varying levels of assessed risk from different potential sources:

- UK Mainland – Risk from German air delivered ordnance and historic Allied ordnance.
- Thames Estuary – Significant risk from smaller items of LSA/SAA originating from historic and contemporary ranges within the estuary.
- Main Offshore Area (North Sea) – Primary risk from larger items, originating from historic sea minefields.
- German Approaches –Significant risk from both larger and smaller items of UXO, originating from a number of historic munitions dumps.
- German Mainland – Primary risk from Allied air delivered ordnance.

### 20.2. Offshore UXO Risk Mitigation

Due to the level of risk identified, it is recommended that 1st Line Defence Risk are contacted to discuss the creation of risk mitigation plan for each specific phase of works within the study area. The methodology of any measures should be tailored to take into account the nature and size of UXO items assessed most likely to be encountered in each section of the study area.

### 20.3. Onshore/Nearshore UXO Risk Mitigation

For onshore/foreshore works at both the western and eastern end points of the route, it is also recommended that proactive support is provided by a UXO specialist. This would include UXO Safety and Awareness Briefings for all operatives conducting intrusive works, UXO support for trial pits and the clearance of all proposed boreholes by magnetometer survey. Depending on the ground conditions present it may also be viable to undertake a non-intrusive magnetometer survey and target investigation on beach and inland areas.


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In making this assessment and recommending these risk mitigation measures, the proposed works outlined in the 'Scope of the Proposed Works' section were considered. Should the planned works be modified or additional intrusive engineering works be considered, 1st Line Defence should be consulted to see if a re-assessment of the risk or mitigation recommendations is necessary

**1st Line Defence Limited** **10th August 2018**

This Report has been produced in compliance with the Construction Industry Research and Information Association (CIRIA) C681 guidelines for the writing of Detailed UXO Risk Assessments.


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# Study Area Location Maps

Annex: **A**

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Hertfordshire. EN11 0EX
**Email:** info@1stlinedefence.co.uk
**Tel:** +44 (0)1992 245 020


Client: **Intertek**

**Approximate study area**

Project: **HVDC Electricity Transmission Interconnector between the Isle of Grain, UK and Wilhelmshaven, Germany**

N

Ref: **DA2985-01**

Source: Google Maps


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# Present-day Aerial Photography

Annex: **B**

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Client: **Intertek**

**Approximate study area**

N

Project: **HVDC Electricity Transmission Interconnector between the Isle of Grain, UK and Wilhelmshaven, Germany**

Ref: **DA2985-01**

Source: Google Earth ™ Mapping Services

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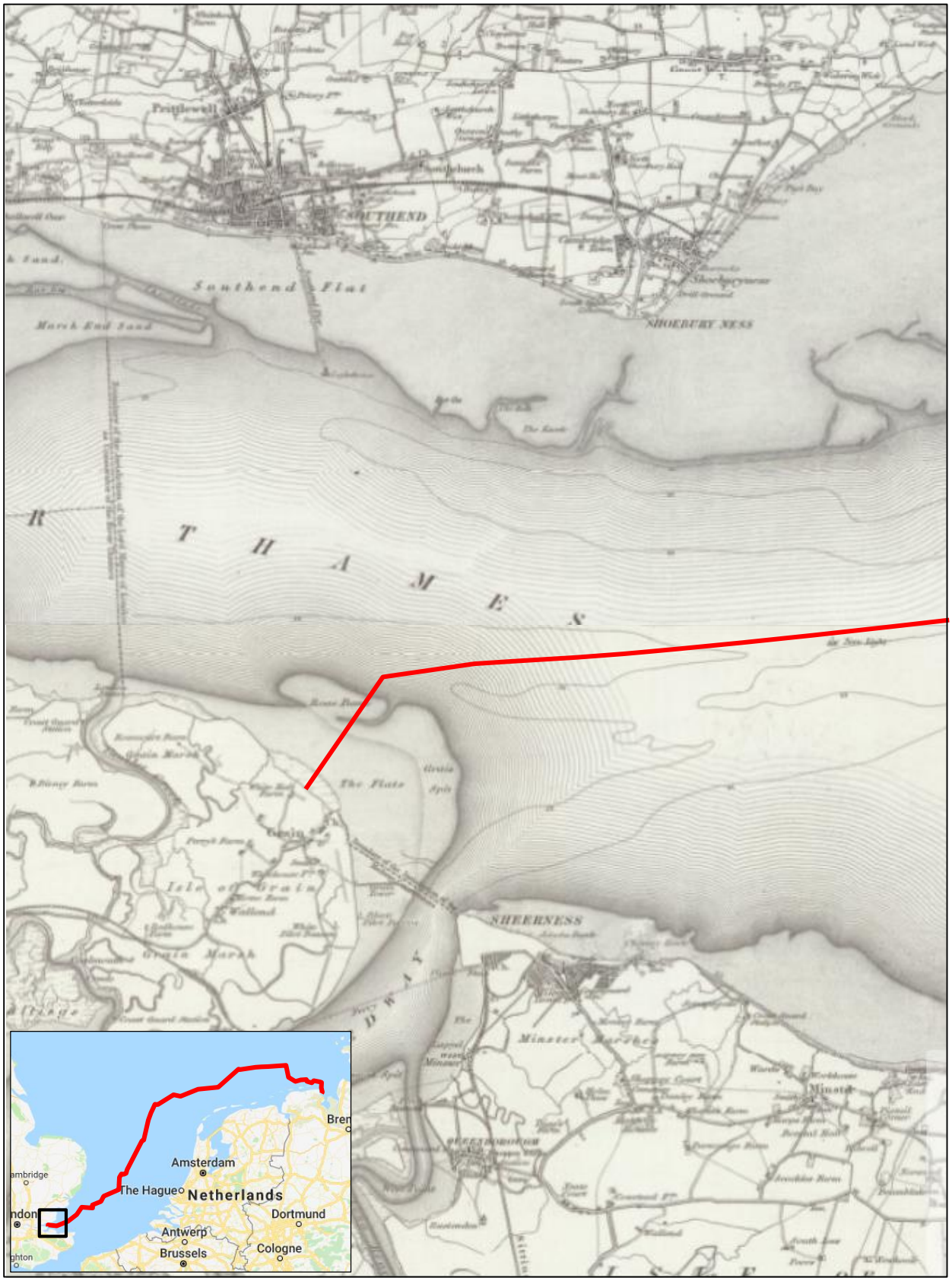
# 1896 Historical Map – Thames Estuary

Annex: **C1**

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Client: **Intertek**

Approximate study area

Project: **HVDC Electricity Transmission Interconnector between the Isle of Grain, UK and Wilhelmshaven, Germany**

N

Ref: **DA2985-01**

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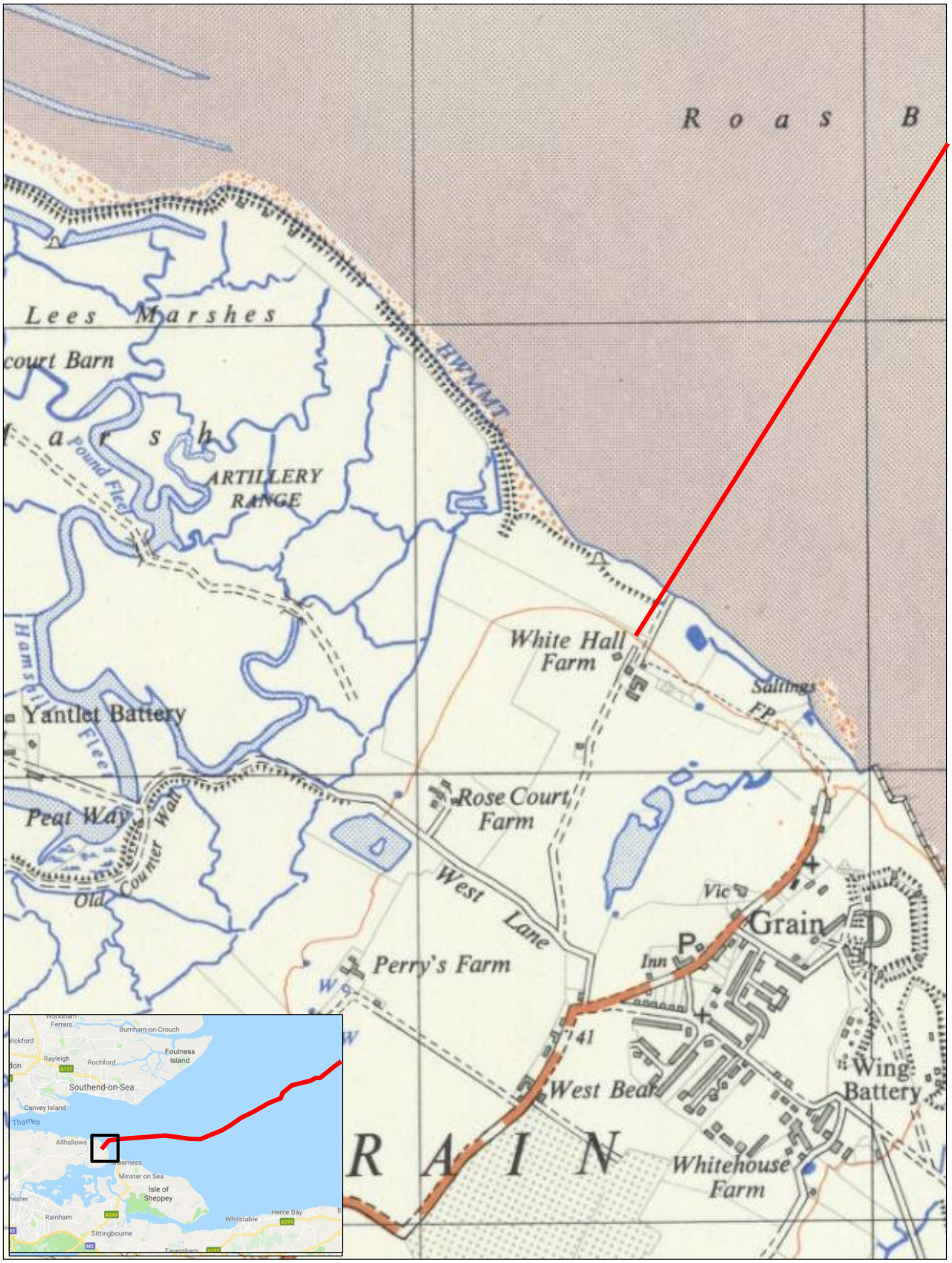
# 1937-1958 Historical Map – Isle of Grain

Annex: **C2**

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| Ref: | **DA2985-01** | Source: NLS Mapping |

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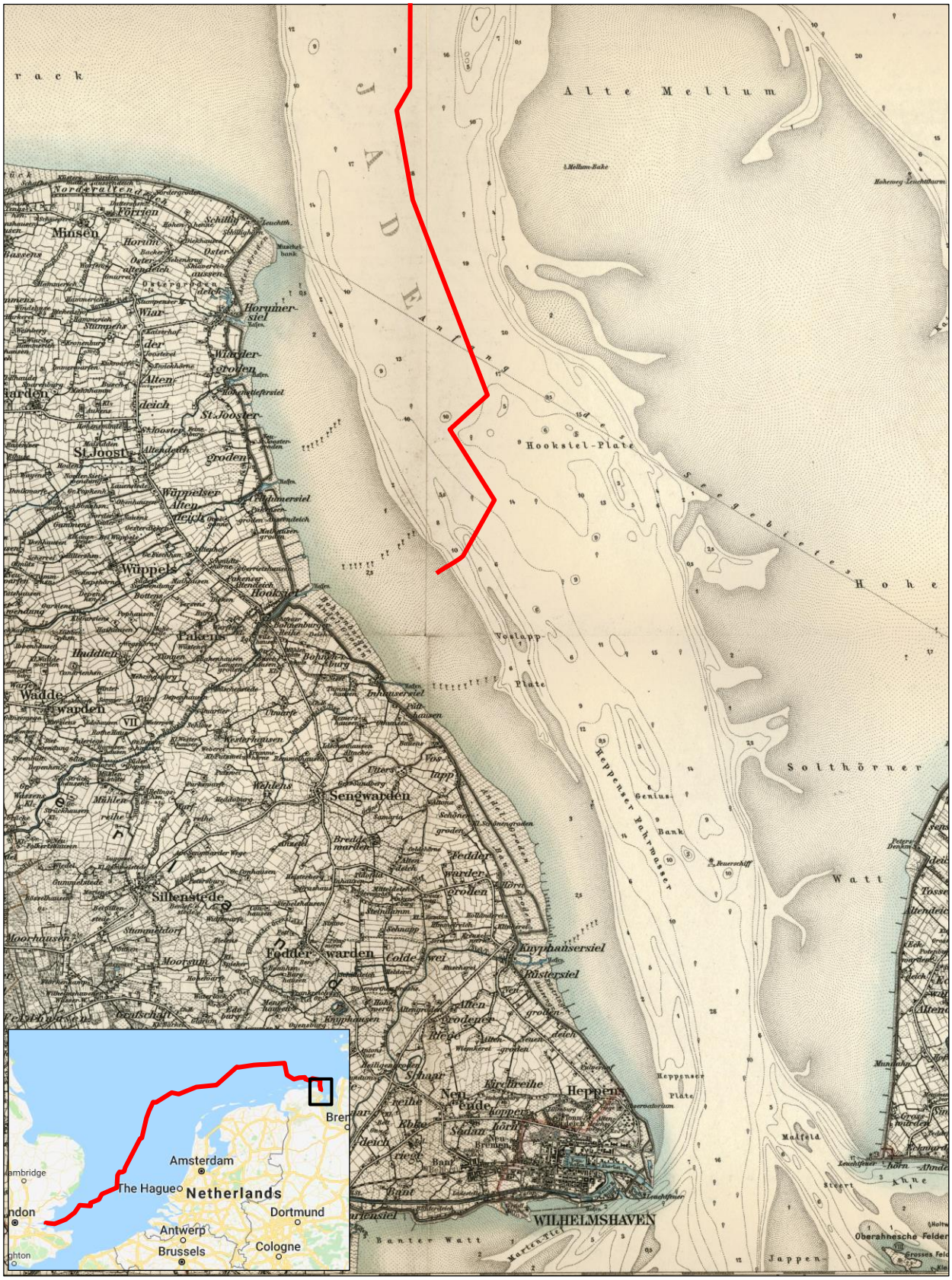
# 1901 Historical Map – Wilhelmshaven

Annex: **C3**

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|---|---|---|
| Client: | **Intertek** | **Approximate study area** |
| Project: | **HVDC Electricity Transmission Interconnector between the Isle of Grain, UK and Wilhelmshaven, Germany** | N |
| Ref: | **DA2985-01** | Source: NLS Mapping |


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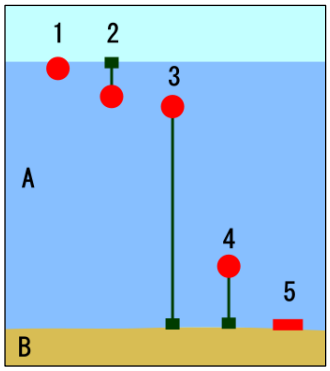
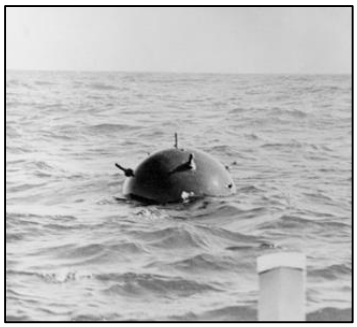
## 1. Position in the Water

- **Bottom mines** are most effective in shallow waters, such as rivers, harbours and tidal areas. These mines rest on the ground or sea bed and are intended to block passageways and prevent amphibious invasion.
- **Moored mines** are used for deep water areas and are designed to float below the surface of the water. They take into account the tidal level to remain out of site below the waterline and are connected via steel cable to an anchor on the sea bed. These mines are intended to inflict damage to valuable marine craft targets, such as aircraft carriers or battleships.
- **Drifting mines** are allowed to float freely in the water. They were generally utilised less frequently and mostly as a deterrence tactic. Moored mines could break from their anchoring cable and become drifting mines.

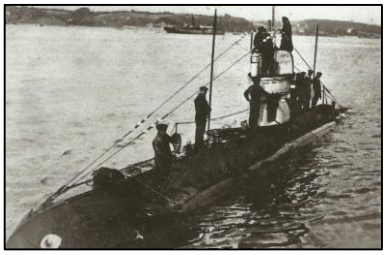


*Top left: Diagram displaying mine types. A: Underwater, B: Sea bed 1/2: Drifting Mine, 3/4: Moored Mine, 5: Bottom Mine.*
*Top right: Photograph of drifting mine. Left: Bottom mine.*

## 2. Delivery Method

- **Aircraft-laid mines** were deployed in the same manner as other aerial delivered items of ordnance, see **Section 11.2.2**. Fins or parachutes were stored in the mine to slow its velocity and reduce its impact when meeting the surface of the water. These mines were later converted to be used on land and are often referred to as parachute mines.
- **Surface-laid mines** are planted by surface marine craft and are used primarily for defensive purposes. The British Navy used these mines within and near Allied waterways to protecting shipping lanes from enemy attack.
- **Submarine-laid mines** are deployed as offensive weapons and are used primarily for defensive purposes. During WWII submarines planted a total of 576 mines resulting in 27 sunk ships and 27 damage. This is approximately one ship sunk or damaged for every 10 mines planted.



*Top right: Horned contact mines on the HMS Aurora .*

*Top left: Photograph of mine loading onto US aircraft. Bottom left: Mine-laying submarine UC-1, which could carry a total of 12 mines.*

## 3. Method of Activation

- **Contact mines** are designed to explode on direct contact with the hull of ship or other marine craft. They were mostly used by German forces during WWI although also saw later deployment. The specifics of this type of mine are fully detailed in **Annex D2**.
- **Influence mines** are trigged by the 'influence' of a ship, submarine or other marine craft rather than by direct physical contact. Advances in technology allowed these mines to utilise a range of sensors that would trigger their explosive filing. These mines are fully detailed in **Annex D3**.



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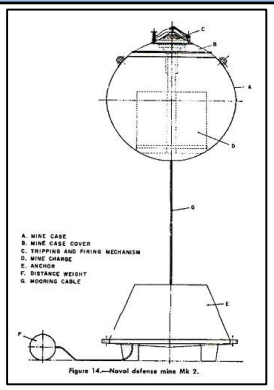
## Contact mines

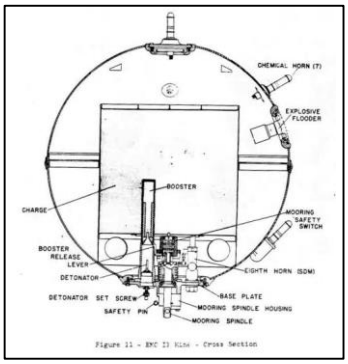
- Earliest form of naval mines used throughout both WWI and WWII. Contact mines need to be touched by the target to detonate, which limits the damage usually to vessel that triggers them. These were used primarily for defensive purposes, such as in the Royal Navy's defence of the English Channel.
- The main distinction in contact mine design was between inertia and Hertz-horn mines. Most adapted the latter during or after WWI; these proved effective as they remained active in water for several years after deployment. The mine's upper half would be studded with hollow lead protuberances, each containing a glass vial filled with sulfuric acid. Upon collision with an vessel the horn would be crushed, cracking the vial and allowing the acid to run down a tube into a lead-acid battery. This energises the battery, and detonates the explosive.
- By the onset of WWI, Germany had large stocks of reliable Hertz horn contact mines, all equipped with automatic anchors that used hydrostats to set mine depth and lock the mooring cables. Britain copied this design in 1917 by capturing a German mine and subsequently produced their first reliable model (Type H Mark II).




*Schematics of Navy Spherical Mine Mk 2.*

**Common types**

| Name | Type of laying | Diameter | Explosive charge | Notes |
|---|---|---|---|---|
| Navy Spherical Mine Marks I and II | Moored | Unknown | 250 lbs. (113 kg) | British mine using an automatic anchor and an arm-operated firing mechanism. only 4,000 available by the start of World War I. |
| "Type I" (British designation) | Moored | 31.5 in. (80 cm) | 180 lbs. (81.6 kg) | WWI-era German "Hertz horn" contact mine. |
| "Type II" (British designation) | Moored | 31.5 in. (80 cm) | 290 lbs. (131 kg) | Same as above. |
| Type H Mark II | Moored | Unknown | 320 lbs. (145 kg) | First reliable British "Hertz horn" contact mine, available from 1917 and used in early years of WWII. |
| EMA | Moored | 31.5 in. (80 cm) | 331 lbs. (150 kg) | First German mine with a chemical-horn firing system. |
| UMA | Unknown | 31.5 in. (80 cm) | 66 lbs. (30 kg) | German mine with five Hertz and three switch horns. Could be moored at either 160 or 320 feet (50 or 100 m). |




*Left: found July 1917 in Thames Estuary. Centre: found December 1914 in water off Scarborough, identified as "Type I" mine. Right: Schematics of moored contact mine with "Hertz horn" mechanics.*



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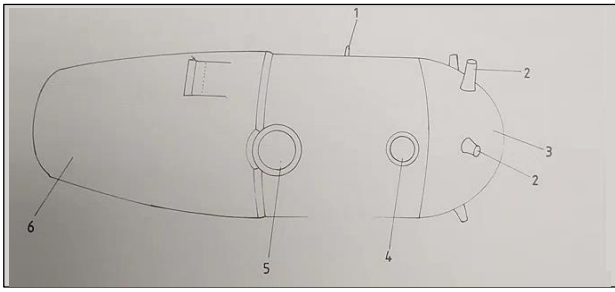
## Influence mines

- Influence mines are triggered by influences from external sources, such as a ship or submarine. Common sensors are:
  - **Magnetic sensors** – an induction or needle system detects a displacement of the ambient magnetic field, normally by the introduction of a ferrous metal object (such as a passing vessel), which initiates the detonation sequence.
  - **Acoustic sensors** – any 'positive shift' (i.e. closing) underwater sonar signal may be interpreted as a potential target vessel and so the mine's arming sequence is initiated followed by detonation.
  - **Hydrostatic pressure sensors** – any detected difference in water pressure (i.e. generated by a passing vessel) initiates detonation.
- Magnetic and acoustic mines were developed by German intelligence before the onset of WWII; some 1,500 magnetic mines were available in the Spring of 1940. Pressure mines were developed in 1943 but were not used until the 6-7th June 1944 in the Normandy Invasion area. The Allies developed separately, though utilised these mines largely for defensive purposes in contrast to the offensive approach taken by Axis forces.

*An SMA Mine.*

**Common types**

| Name | Type of laying | Diameter | Explosive charge | Notes |
|---|---|---|---|---|
| SMA (British designation "GO" | Moored | 46 in. (177 cm) | 772 lbs. (350 kg) | German moored influence mine laid by Type VIID and XB U-boats, introduced in 1942. Made of a aluminium alloy shell to reduce detection. Could be moored either 219 fathoms (400 m) or 328 fathoms (600 m) deep. |
| TMA (British designation "GT" | Moored | 21 in. (5cm) | 507 lbs. (230 kg) | German moored influence mine laid from the TT of U-boats. Used an aluminium alloy shell and used a 82 fathom (150 m) or 148 fathom (270 m) cable. |
| LMA | Floating | 26 in. (66 cm) | 661 lbs. (300 kg) | German magnetic mine, later converted to be aircraft-deployed. See **Annex X** for an example of one of these converted items. |
| Mark XVII | Moored | Unknown | 320 lbs. (145 kg), later upped to 500 lbs. | British moored acoustic mine for use against S and R-boats. |
| M Mark III | Ground | Unknown | 1,500 lbs. (680 kg), later upped to 1,750 lbs. (794 kg). | British CR magnetic mine, designed for laying from wide-track mine-layer rails in 6-20 fathoms (11-37 m). First deliveries in 1941. |




1. Lifting Lug
2. Anti-roll bars
3. Filling plate
4. Detonator cover plate
5. Clock starter plate
6. Parachute housing

*Left: Schematic of an LMA early pattern airborne parachute ground influence mine. Right: Mines aboard HMS Apollo ca 1945, likely to be M Mark I mines.*



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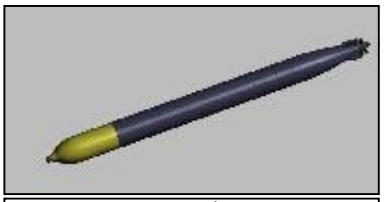
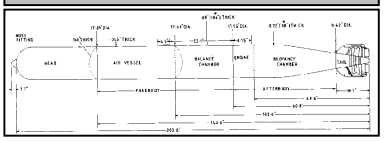
# Examples of Torpedoes

Annex: **D4**

## British 18in Mark XII

| | |
|---|---|
| Deployed by | Aircraft |
| Date of design/service | 1935/1937 |
| Weight | 1,548 lbs. (702kg) |
| Overall length | 16 ft 3 in (4.95m) |
| Explosive charge | 388 lbs. (176kg) TNT |
| Range / speed | 1,500 yards (1,370m)/40 knots or<br>3,500 yards (3,200 m)/37 knots |
| Remarks | Standard British airborne torpedo for the first half of WWII and still in limited use at the end. |

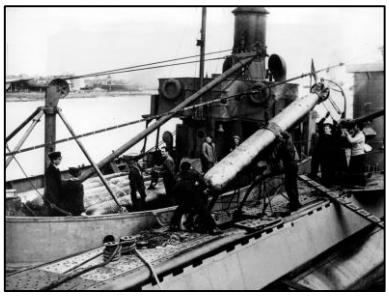




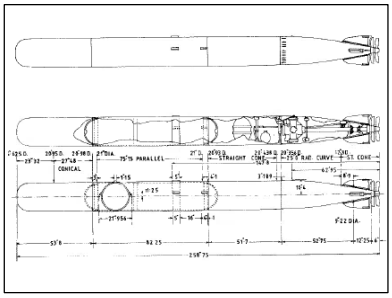
*Left: A Mark XII torpedo fitted to a Bristol Beaufighter. Top right: Model of the torpedo. Bottom left: schematics.*

## British 21in Mark VIII**

| | |
|---|---|
| Deployed by | All submarines from the "O" class on and MTBs |
| Date of design/service | About 1925/1927 |
| Weight | 3,452 lbs. (1,566 kg) |
| Overall length | 21 ft 7 in (6.58 m) |
| Explosive charge | 722 lbs. (327 kg) TNT |
| Range / speed | 5,000 yards (4,570 m) / 45.5 knots |
| Remarks | First burner-cycle torpedo. Used more than any other British torpedo, accounted for 56.4% of torpedoes fired by September 1944 (3,732 fired in this period). |



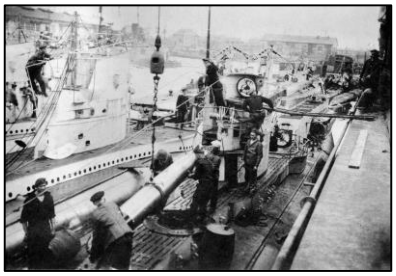
*Mark VIIIs loading to Polish Navy submarine ORP Sokół*



Schematics of a 21in MKVIII tornado

## German 45cm (17.7") C/06

| | |
|---|---|
| Deployed by | U-boats, starting with U-3 |
| Date of design/service | 1906/1907 |
| Weight | 1,704 lbs. (773 kg) |
| Overall length | 222 in (5.65 m) |
| Explosive charge | 270 lbs. (122.6 kg) TNT |
| Range / speed | 1,640 yards (1,500 m)/34.5 knots<br>3,380 yards (3,000 m)/26 knots |
| Remarks | First German torpedo which received a 4-cylinder instead of a 3-cylinder engine. |

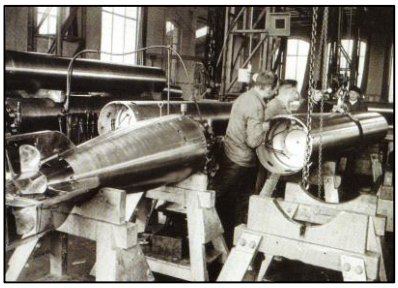


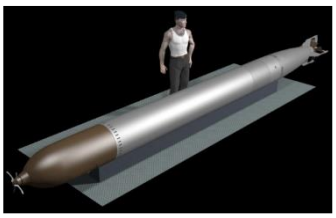
*Loading torpedoes aboard a U-Boat of the German Flanders Flotilla at Bruges*

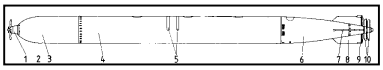
*A German Flotilla in port.*

## German 53.3cm (21") G7a T1

| | |
|---|---|
| Deployed by | Surface ships and submarines |
| Date of design/service | 1930/1938 |
| Weight | 3,369 lbs. (1,528 kg) |
| Overall length | 23 ft. 7 in. (7.186 m) |
| Explosive charge | 617 lbs. (280 kg) Hexanite |
| Range / speed | 6,560 yards (6,000 m) / 44 knots<br>8,750 yards (8,000 m) / 40 knots<br>15,000 yards (14,000 m) / 30 knots |
| Remarks | Issued throughout WWII and considered to be very reliable. |







*Left: G7a Torpedoes being repaired at Ostende in 1940. Top right: Model of the torpedo. Bottom right: Schematics.*

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Client: **Intertek**

Project: **HVDC Electricity Transmission Interconnector between the Isle of Grain, UK and Wilhelmshaven, Germany**

Ref: **DA2985-01**

Source: Various sources

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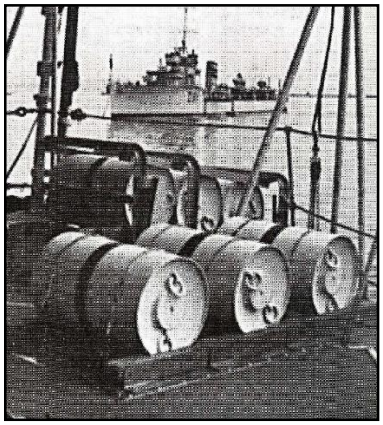
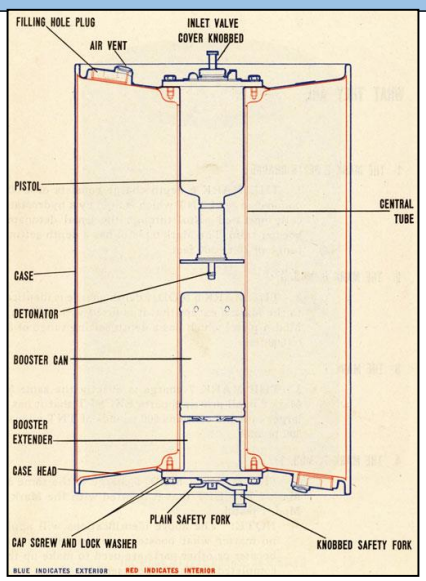
# Examples of Anti-Submarine Weapons

Annex: **D5**

## Depth Charge. Mk VII

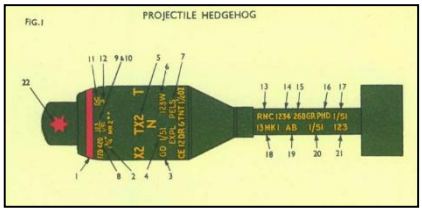
| | |
|---|---|
| Shape | Cylindrical, drum shaped |
| Explosive Weight | 132 kg |
| Fuze Type | Hydrostatic pistol |
| Dimensions | 70 cm long, 45 cm diameter |
| Use | Amatol charge was estimated to be capable of splitting a 2.2 cm submarine pressure hull at a distance of 6.1 m. Torpex (or Minol) explosives used post 1942 were reported to increase this distance to 7.9 and 15.8 m. |
| Remarks | The Mk VII was little changed from the WWI Type D. Initially the depth charge was simply dropped from the attacking vessel but from late 1940 /early 1941 a launcher was used which projected the weapon some 35 m. |





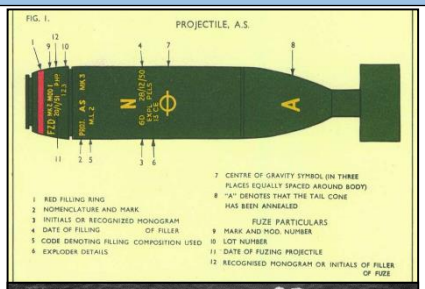

## "Hedgehog" Spigot Mortar

| | |
|---|---|
| Weight | 29 kg |
| Explosive Weight | 14 kg |
| Dimensions | 118 cm long, 17.8 cm diameter |
| Fuse Type | Contact fuze |
| Use | Fired from a launcher on the attacking ship, these projectiles were fired in an arc and were designed to land in an elliptical pattern in the water to hit enemy submarines. |
| Remarks | This weapon was invented in order to address the issue of "instantaneous echo" when an enemy submarine was so close to the attacking ship that it could not be accurately plotted by a sonar operator and was effectively invisible. |



## "Squid" Mortar

| | |
|---|---|
| Weight | 200 kg |
| Explosive Weight | 94 kg |
| Diameter | 30.5 cm diameter |
| Fuse Type | Timer fuze |
| Use | Fired from a launcher on the attacking ship, these projectiles were fired in an arc and were designed to land in a triangular pattern in the water to hit enemy submarines. |
| Remarks | Reportedly nine times more effective than standard depth charges in post-war trials, these bombs were designed to fall on either side of a submarine, with the resulting pressure wave crushing the enemy vessel. |



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# Examples of Land Service Ammunition finds in the UK

Annex: **E1**

## Unexploded Second World War bomb discovered under Somerset footpath

By Western Daily Press | Posted: January 21, 2014

The unexploded bomb was found in Somerset

Comments (0)

Report this article

An unexploded bomb dropped in Britain during the Second World War has finally been discovered – underneath a popular footpath in Somerset.



## Unexploded WW2 bomb found at Kenfig Pool, Bridgend

23 August 2014 Last updated at 15:01

Share

Dean Smith believes the shell was made in Germany

**Bomb experts have been called to a south Wales nature reserve after an unexploded World War Two shell was discovered by a walker in Bridgend.**

Dean Smith, 38, of Pyle, was walking near Kenfig Pool on Saturday when he saw a fin sticking out of the sand.

He reached down to pick it up, but ending up falling and landed with the 2ft-long (0.6m) bomb on top of him.

The site has been cordoned off by police and the Royal Logistics Corps will carry out a controlled explosion.

Related Stories

- 'Panic' as dog nearly thrown grenade
- WW2 bomb found at wind farm exploded
- WWII bomb found in kitchen cupboard

## Mortar thought to be from WWII found on Oshawa's Camp-X grounds

August 24, 2016 | 5:42 am

What is believed to be a World War II mortar has been discovered in south Oshawa. A man out in Intrepid Park, the site of the Camp-X Second World War training grounds, discovered the round with his metal detector on Tuesday evening. Durham police are held the scene overnight awaiting military officials from Trenton to come and properly detonate the mortar.

## Unexploded bomb found in farmer's field

17 May 2010

A live Second World War mortar shell was blown up by Army experts after a farmer found it in his field.

The discovery was made in the field alongside the A20 between Folkestone and Dover.

The mortar shell, which was around a foot long and 3in in diameter, was around 50ft from the main road.

The farmer alerted police and PC Trevor Moody and PCSO Michelle Brady went to the field.

PC Moody contacted the Army who sent in a bomb disposal unit.

An Army officer confirmed the live shell was from the Second World War and was packed with high explosives.

They moved it a safe distance away from the A20 and carried out a controlled explosion.

PC Moody said: "Given that we live in an area that saw much action during the Second World War, it is not uncommon for us to be alerted about unexploded bombs."

The incident was on Thursday.

Click here for more news from Kent.

## Royal Navy bomb disposal experts remove a World War Two shell discovered in a nature reserve

- A World War Two bomb was discovered in a Plymouth nature reserve
- Amateur metal detector found the shell and partially dug it up
- Royal Navy experts carried the explosive away before disposing of it

By VALERIE EDWARDS FOR MAILONLINE
**PUBLISHED:** 01:29, 13 January 2016 | **UPDATED:** 09:51, 13 January 2016

Share 338 shares 10 View comments

A World War Two bomb was reportedly found at Efford Nature Reserve in Plymouth after a member of the public was metal detecting and partially dug it up.

The Royal Navy Bomb Disposal team was called in to remove the bomb and police have closed off Military Lane, with the possibility of Military Road also being closed.

Police were called at around 1.30pm yesterday after what appeared to be a shell was discovered and partially dug up near Military Lane, Efford.

## Holiday beach cordoned off after landslip sends more than a THOUSAND Second World War bombs and rockets tumbling onto the sands

- Bad weather led to ground movement which exposed the huge arsenal at Mappleton, East Riding

© Jonathan Pow

Bomb Beach Alley: Rockets were found after a landslide on Mappleton beach in 2012

## Army bomb disposal team called to Blacksole Bridge in Herne Bay

by Aidan Barlow abarlow@thekmgroup.co.uk 08 July 2015

It was like a scene from Dad's Army when Army bomb disposal experts found wartime explosives made by the Home Guard in makeshift bottles.

A team was called to the Blacksole Bridge in Herne Bay after the wartime bombs were found.

The team from the Royal Logistics Corps set up a 30 metre exclusion zone for pedestrians around the railway embankment after the suspected homemade phosphorous bombs were found.

The scene at Blacksole Bridge after wartime explosives were found in the railway cutting

Tweet

Published by Huw Oxburgh
Posted: 03/06/14
Updated: 03/06/14

## Unexploded bomb found in Axminster

Update: The bomb disposal unit has made the device safe and the road has re-opened.

Six homes have been evacuated today after the discovery of an unexploded device in Axminster.

A Royal Navy bomb disposal team have been called to the scene after a 'historic German device' was discovered in a garden.

Police have set up a 20m cordon around the garden in Alexandra Road and evacuated homes in the surrounding area as a precaution.

## Storms and floods unearth unexploded wartime bombs

By Claire Marshall
BBC environment correspondent

**There has been a dramatic increase in the number of wartime bombs unearthed because of the winter storms and flooding.**

Bomb disposal teams in the South West have dealt with double the number of unexploded ordnance than in the same period last year.

Since mid December, the Royal Navy's Southern Dive Unit has recovered or disposed of 244 items of ordnance.

During the same period last year, they dealt with just 108 items.

The storms have uncovered a lethal past

Almost 70 years after the end of WWII, one legacy of that conflict continues to turn up on beaches and harbours around Britain.

Unexploded shells, bombs and mines continue to be discovered every year, and the Royal Navy's Southern Dive Unit is tasked with making these devices safe.

Its area of responsibility stretches for some 2,250km (1,400 miles). It begins from the highwater mark in Hull and proceeds seaward to the territorial limit, and then runs clockwise around the British Isles - including the Isle of Wight, Channel Islands, and Isles of Scilly - to finish in Liverpool.

Related Stories

- Ancient trees revealed by storms

Land Service Ammunition (LSA) resulting from historic military activity is commonly encountered across the UK by the public and construction industry alike. Such finds are much more common in rural areas than in urban environments, and can often be anticipated in areas such as former RAF stations or ranges. However, many such items are encountered entirely by surprise where the landowner or developer has no knowledge of any previous military use of the land.


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| Ref: | **DA2985-01** |
| Source: | Various news sources |


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# Examples of Offshore UXO finds in the UK

Annex: **E2**

30th April 2010

renewable energy focus.com

**Bomb at Sheringham Shoal offshore wind site**

*A 250lb air-dropped German WWII bomb has been safely detonated on the Sheringham Shoal Offshore Wind Farm site.*

Wind farm developer, Scira Offshore Energy Ltd commissioned an unexploded ordnances (UXO) survey as part of its reconstruction preparations and the bomb was found at the site of one of its foundation locations in the north-west of the offshore wind farm site.

A total of 52 targets were investigated by divers and using a remote operated vehicle (ROV). While most of the targets were debris or geological concentrations, several anchors and an old canon were found, as well as the unexploded bomb.

The bomb was found by divers from diving specialists Red7Marine and verified and detonated with explosives by disposal experts MACC International, earlier this month.

Project Director Rune Rønvik says safety is a priority during construction of the offshore wind farm and the discovery of the bomb full justified the use of such a technically precise survey, despite the additional time it required.

19th March 2014

BBC NEWS

**Plans to explode WW2 bombs found in seabed at Gwynt y Mor wind farm**

Preparations are under way to remove three unexploded bombs found on the sea bed at a wind farm site off the north Wales coast.

The World War Two bombs were discovered three weeks ago during ongoing construction at the Gwynt y Mor wind farm in Liverpool Bay.

Specialist contractors will carry out controlled explosions when the conditions are right in the next few weeks, RWE Innogy UK said.

9th August 2016

Worthing Herald

**Unexploded WW2 ordnance found during wind farm construction to be detonated**

Two unexploded WW2 devices will be detonated in a controlled explosion this week as works continue on the Rampion offshore wind farm.

Thought to date from the Second World War, the devices are located on the seabed, 3km off Lancing Beach at a depth of 13m.
They were discovered during unexploded ordnance (UXO) surveys which are carried out as protocol during offshore construction.

30th August 2017

UK edition

The Guardian

**Third WWII bomb found in Bristol Channel near Hinkley Point**

A half-mile (1km) exclusion zone has been set up in the Bristol Channel near the Hinkley Point nuclear power stations after a third unexploded second world war bomb was discovered in as many weeks.

Bomb disposal experts will carry out a controlled explosion on the 250lb (113kg) ordnance on Wednesday, two miles north-west of the power plants.

On 8 August, a 500lb device was discovered 2.5 miles from the coast. On 16 August, a 250lb bomb was found less than half a mile from the power station. Both were destroyed in controlled explosions.

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# WW2 German sea mine washes up near Bognor Regis

20 May 2018 Share

Paul Austin found the device about 500 yards from his front door

**A live German sea mine from World War Two washed up on the Sussex coast has been towed out to sea and blown up.**

The large metal device measuring about 6ft (1.8m) and thought to weigh about 1,000kg was found on Saturday.

The Maritime and Coastguard Agency (MCA) said the mine was "safely detonated" at about 17:10 BST.

Earlier, residents were alerted as a precaution and vessels were told to steer clear of the mine off Elmer Beach, near Bognor Regis.

A mile-wide maritime and air exclusion zone was in force, with coastguards broadcasting to vessels in the area.



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26th February 2015

DW Made for minds.

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## Unexploded WWII bomb found near Dortmund's Signal Iduna Park

An unexploded Second World War bomb was found near the Signal Iduna Park in Dortmund on Thursday morning. The bomb was defused safely midway through the afternoon.

© picture alliance /augenklick/firo Sportphoto

Just hours before Dortmund head coach Jürgen Klopp was due to give his press conference ahead of the derby against Schalke, a 250-kilogram (550-pound) unexploded bomb of British origin was discovered near Borussia Dortmund's stadium, the Signal Iduna Park. The bomb was difused at just after 15:00 local time (14:00 UTC), whereupon it was taken to a temporary holding in Hagen before it will later be destroyed in a disassembly plant in North Rhein-Westphalia.

With a 250-meter safety radius, both the stadium and the fan world were evacuated as well as everyone living in the area.

25th December 2016

The Guardian UK edition

## German city evacuated after discovery of unexploded RAF bomb

**Residents of 32,000 households in Augsburg allowed to return after 1.8-tonne second world war bomb is successfully defused**

▲ A police roadblock in Augsburg at the site where the unexploded RAF blockbuster bomb was discovered. Photograph: Tobias Hase/EPA

Explosives experts have defused a large second world war bomb in the German city of Augsburg, clearing the way for thousands of evacuated residents to return and hold their Christmas celebrations at home.

City police tweeted that they had "good news at Christmas" just before 7pm local time (18.00 GMT). Before that, they had been unable to say how long residents would have to stay away due to the sensitive explosives work being done.

1st September 2017

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## Frankfurt to evacuate 70,000 after British WW2 bomb found

1 September 2017 Share

World War Two

The British bomb was found on Wismarer Strasse, which is close to the city centre

**German police will evacuate about 70,000 people from their homes on Sunday after an unexploded World War Two bomb was discovered in Frankfurt.**

It will be one of the biggest operations of its kind carried out in Germany since the war.

April 20th 2018

The Washington Post
*Democracy Dies in Darkness*

## An unexploded WWII bomb forced a mass evacuation in Berlin. There will be more to come.

By Rick Noack April 20 Email the author

Police evacuated an area in the heart of Berlin April 20, as bomb disposal experts prepared to defuse a World War II bomb. (Reuters)

BERLIN — Other countries may have hurricanes, blizzards or flooding that regularly shut down major transport hubs. Germany, meanwhile, is still dealing with the legacy of a war the country launched itself: thousands of unexploded bombs, hidden beneath one of Europe's busiest cities in a nation now at peace.

Germany's main railway station in Berlin was forced to shut down on Friday in preparation for the defusing of one such a bomb, as authorities evacuated parts of the capital's city center until early afternoon local time.

The 1,000-pound, British-made bomb was successfully defused. Train services have since resumed, and workers are being allowed back into the city center, but it may not be long until the next large-scale evacuation here.



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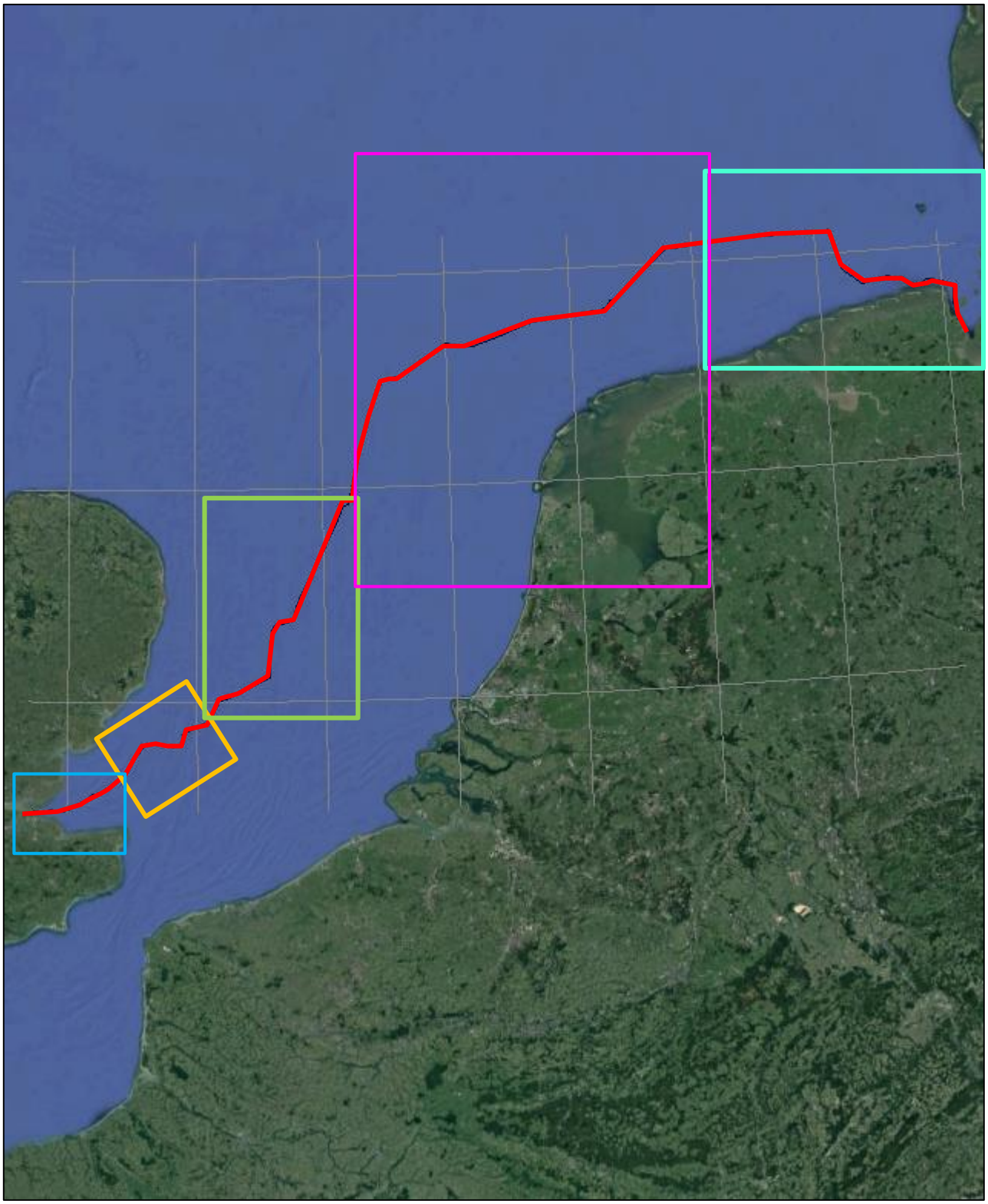
# Overlay of Wreck Sites

Annex: **F1**



Thames Estuary

British Waters 1

British Waters 2

Dutch Waters

German Waters

1ST LINE DEFENCE

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**Email:** info@1stlinedefence.co.uk
**Tel:** +44 (0)1992 245 020

Client: **Intertek**

**Approximate study area**

Project: **HVDC Electricity Transmission Interconnector between the Isle of Grain, UK and Wilhelmshaven, Germany**

N

Ref: **DA2985-01**

Source: Wrecksite.eu

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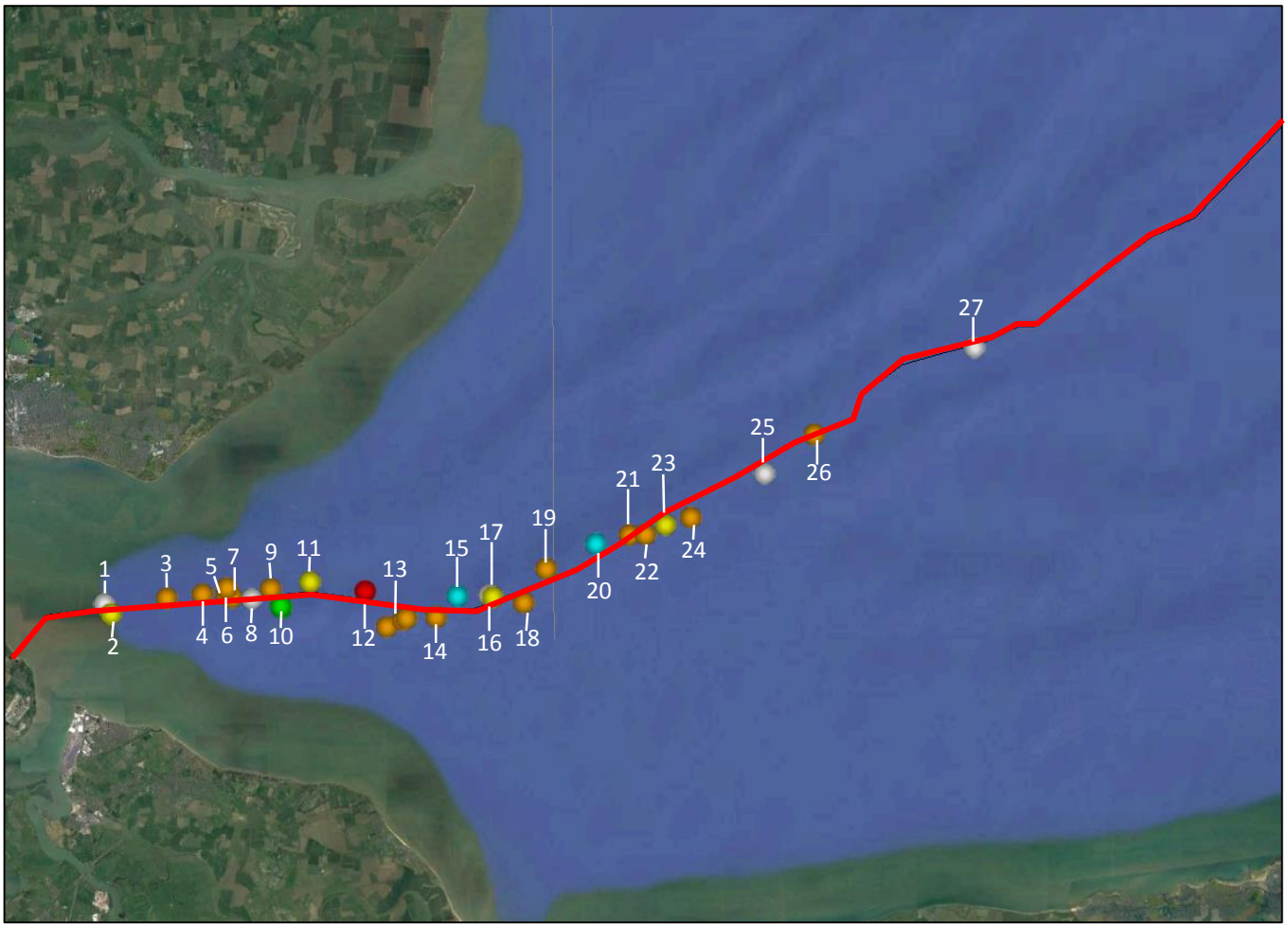
# Overlay of Wreck Sites – Thames Estuary

Annex: **F2**




1. Castor
2. Jeffie
3. SS Belvedere
4. SS Malrix
5. MV Araby
6. SS Inver
7. SS Beneficient
8. Van Tromp
9. MV Arinia
10. SS Herland (In two parts)
11. SS Bolbec
12. Unknown War Aircraft
13. HMS Vimiera (In three parts)
14. HMT Capricornus
15. SS Letchworth
16. Donald
17. HMS Truculent
18. HMS Devon County
19. HMT Ash
20. East Oaze Light Vessel (LTV No.60)
21. HMY Aisha
22. MV Actuality
23. MV Sigrun I
24. HMT Kennymore
25. Yelding
26. SS Margam Abbey
27. Consul

**Key:**

Mine | German Mine | Torpedo | Gunfire | WWII-era air raid | Not specified

WWI/WWII-era wreck – sunk circumstances unrelated to explosive ordnance | Crashed aircraft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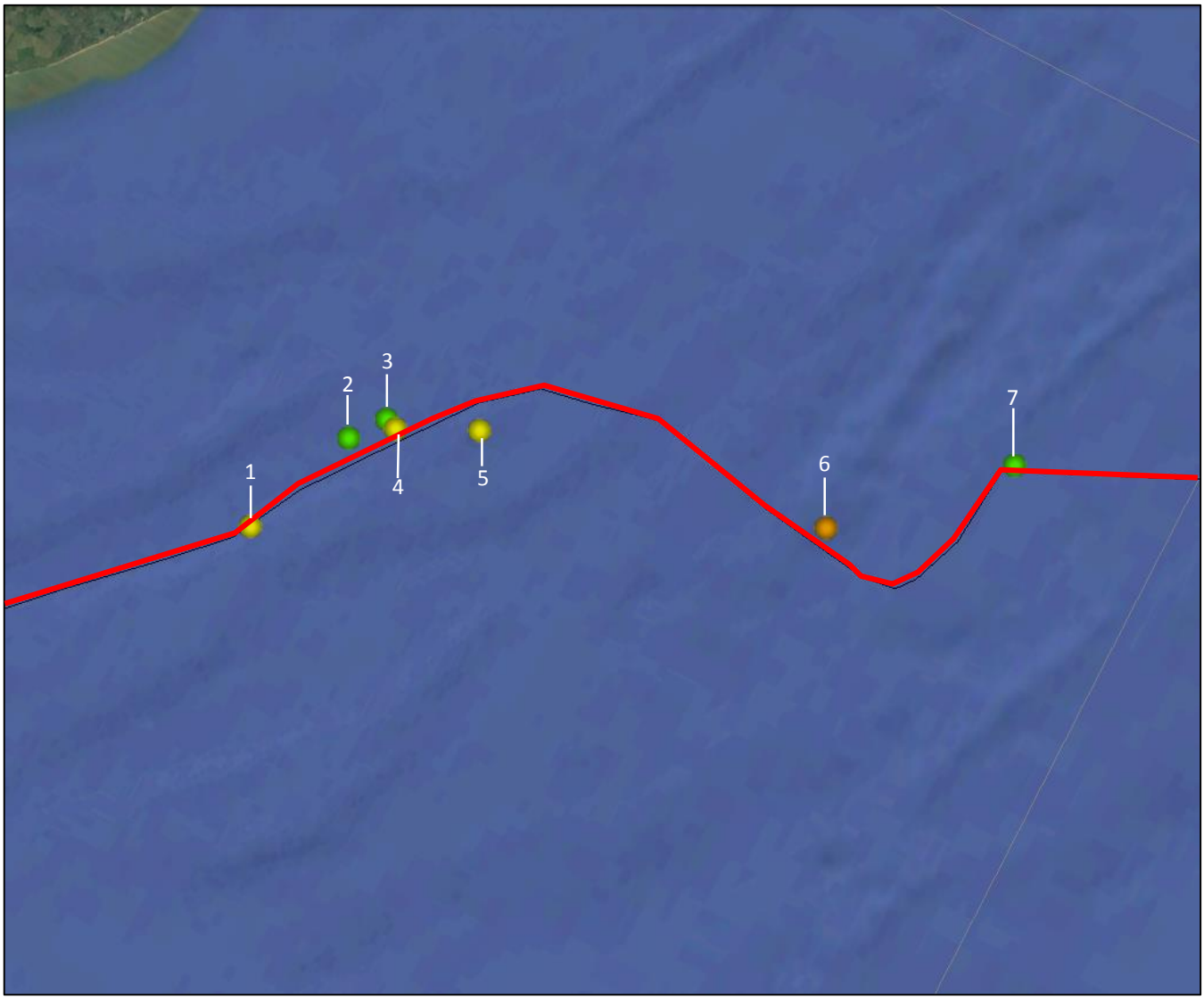
# Overlay of Wreck Sites – British EEZ 1

Annex: **F3**




1. SS Greenhill
2. HMS Coquette
3. SS Salerno
4. SS Iris
5. SS Peregrine
6. SS Haytor
7. SS Hendonhall

**Key:**

Mine | German Mine | Torpedo | Gunfire | WWII-era air raid | Not specified

WWI/WWII-era wreck – sunk circumstances unrelated to explosive ordnance | Crashed aircraft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Client: **Intertek**

**Approximate study area**

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Ref: **DA2985-01**

Source: Wrecksite.eu


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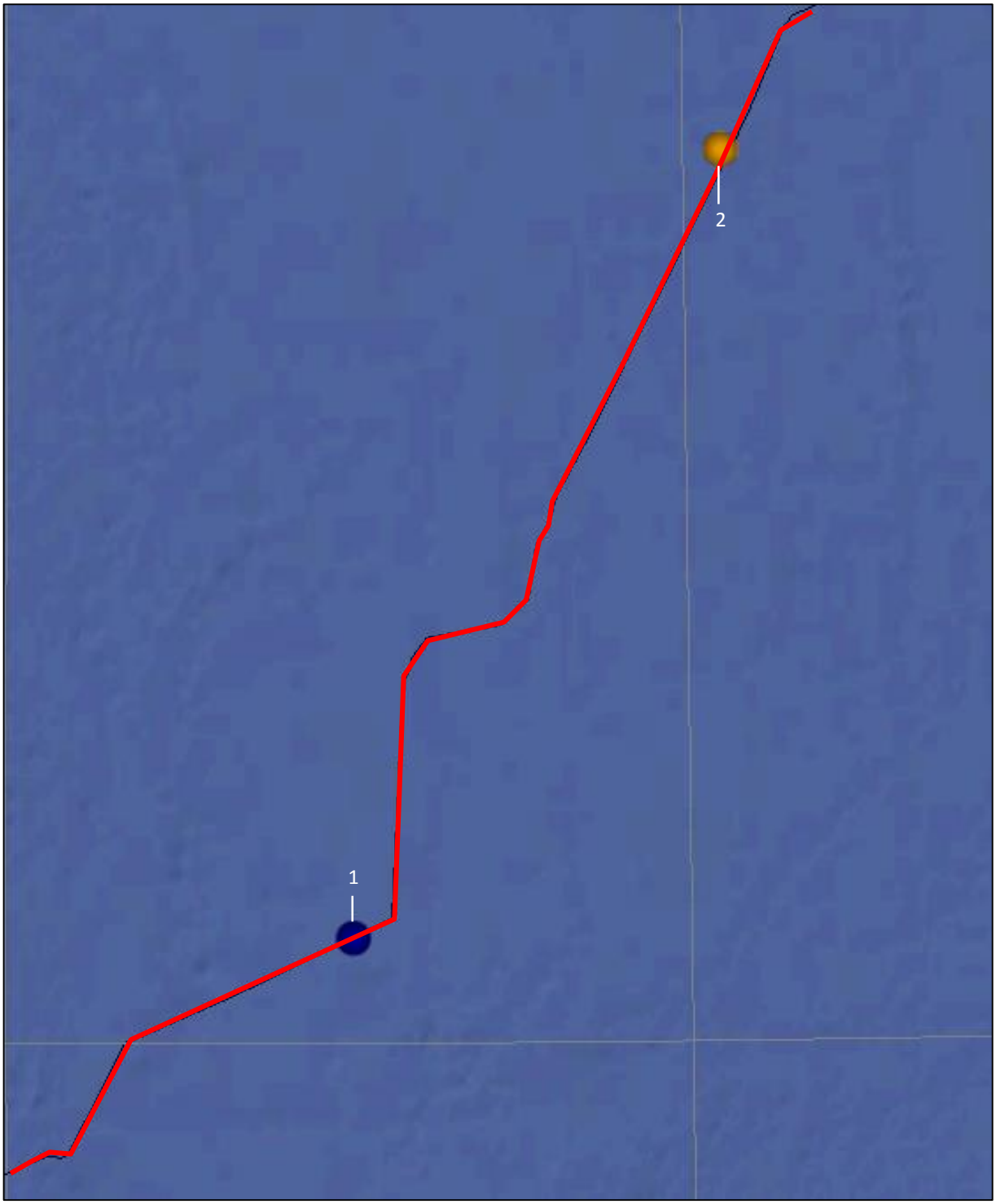
# Overlay of Wreck Sites – British EEZ 2

Annex: **F4**




1. SS Kaunas
2. U-31

**Key:**

Mine | German Mine | Torpedo | Gunfire | WWII-era air raid | Not specified

WWI/WWII-era wreck – sunk circumstances unrelated to explosive ordnance | Crashed aircraft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Client: **Intertek**

**Approximate study area**

Project: **HVDC Electricity Transmission Interconnector between the Isle of Grain, UK and Wilhelmshaven, Germany**

N

Ref: **DA2985-01**

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# Overlay of Wreck Sites – Dutch EEZ

Annex: **F5**

1. HMS Ivanhoe
2. Ivan
3. S-22

**Key:**

Mine | German Mine | Torpedo | Gunfire | WWII-era air raid | Not specified

WWI/WWII-era wreck – sunk circumstances unrelated to explosive ordnance | Crashed aircraft

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Client: **Intertek**

**Approximate study area**

Project: **HVDC Electricity Transmission Interconnector between the Isle of Grain, UK and Wilhelmshaven, Germany**

N

Ref: **DA2985-01**

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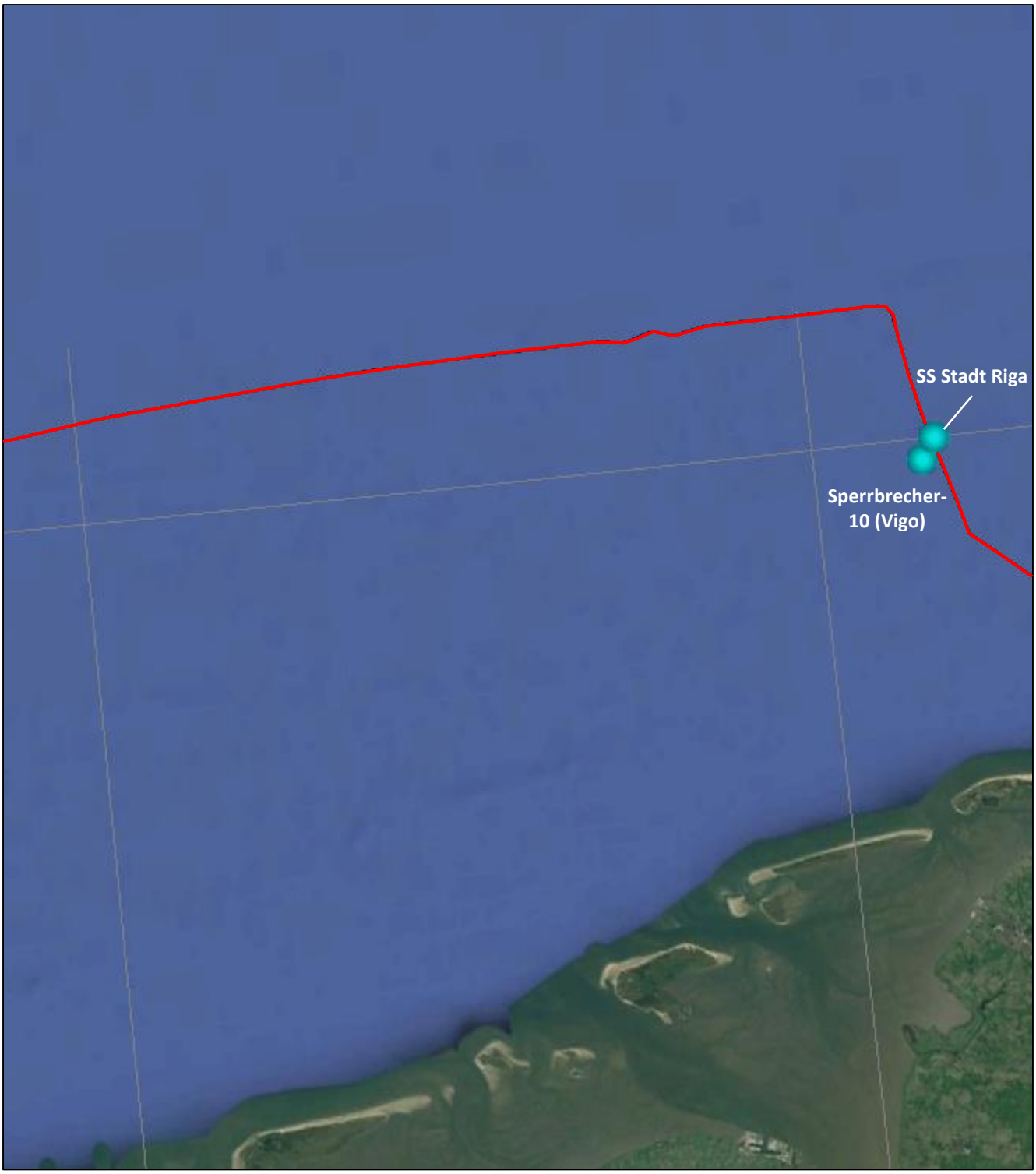
# Overlay of Wreck Sites – German Waters

Annex: **F6**




**Key:**

Mine | German Mine | Torpedo | Gunfire | WWII-era air raid | Not specified

WWI/WWII-era wreck – sunk circumstances unrelated to explosive ordnance | Crashed aircraft

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Client: **Intertek**

**Approximate study area**

Project: **HVDC Electricity Transmission Interconnector between the Isle of Grain, UK and Wilhelmshaven, Germany**

N

Ref: **DA2985-01**

Source: Wrecksite.eu

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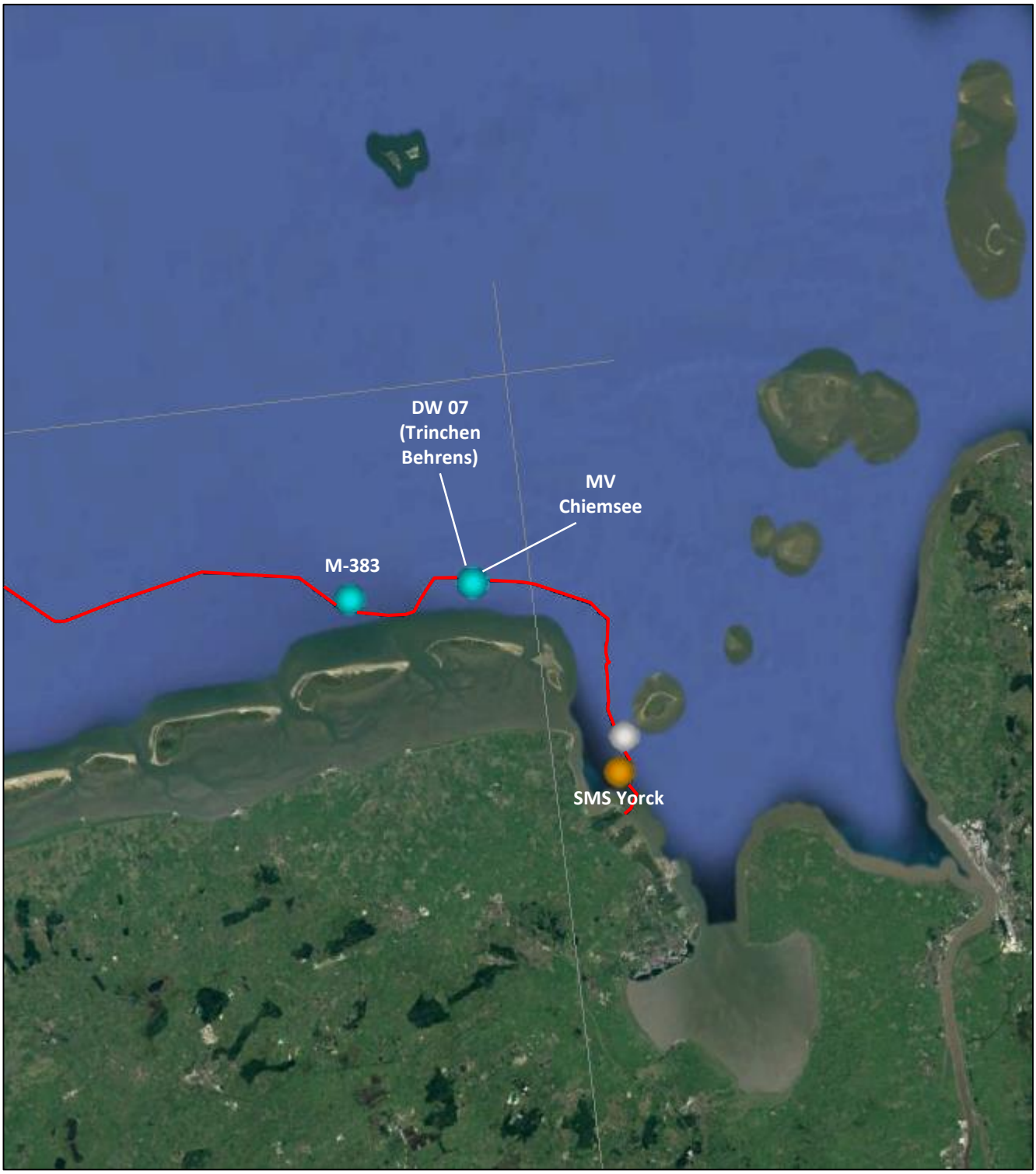
# Overlay of Wreck Sites – German Waters

Annex: **F7**




**Key:**

Mine | German Mine | Torpedo | Gunfire | WWII-era air raid | Not specified

WWI/WWII-era wreck – sunk circumstances unrelated to explosive ordnance | Crashed aircraft

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**Tel:** +44 (0)1992 245 020

Client: **Intertek**

**Approximate study area**

Project: **HVDC Electricity Transmission Interconnector between the Isle of Grain, UK and Wilhelmshaven, Germany**

N

Ref: **DA2985-01**

Source: Wrecksite.eu

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| Ship name | Type of ship | Armaments | Date of wreck | Reason given | Location |
|---|---|---|---|---|---|
| Castor | Not specified | Not specified | 1916 | Not specified | Within 220m N |
| Jeffie | Barge, lighter | Not specified | 1923 | Foundered | Within 20m S |
| SS Belvedere | Cargo ship | Not specified | 17/12/1940 | Sunk by a mine | Within 290m N |
| SS Malrix | Transport | Not specified | 17/12/1940 | Sunk by a mine | Within 300m N |
| MV Araby | Cargo ship | Not specified | 27/12/1940 | Sunk by a mine | Within 450m N |
| SS Inver | Coal cargo ship | Not specified | 17/12/1940 | Sunk by a mine | Within 230m N |
| SS Beneficient | Cargo ship | Not specified | 17/12/1940 | Sunk by a mine | Within 90m N |
| Van Tromp | Not specified | Not specified | Not specified | Not specified | Within 40m S |
| MV Arinia | Tanker | Not specified | 19/12/1940 | Sunk by a mine | Within 280m N |
| SS Herland (In two parts) | Cargo ship | Armed merchant ship | 07/11/1940 | Sunk by a German mine | Within 380m and 450m S |
| SS Bolbec | Cargo ship | Not specified | 09/01/1943 | Collision, foundered | Within 460m N |
| HMS Vimiera (In three parts) | Destroyer | 4 x 4", 2 x 2 pdr. A.A. or 1 x 12 pdr., 2 x 21" twin T.T. | 09/01/1942 | Sunk by a mine | Within 350m, 440m, 800m S |
| HMT Capricornus | Minesweeper | 1 x 6 pounder AA gun | 07/12/1940 | Sunk by a mine | Within 220m S |
| SS Letchworth | Coal cargo ship | Not specified | 01/11/1940 | Air Raid | Within 550m N |
| Donald | Barge, lighter | Not specified | 1920 | Not specified | Within 300m NW |
| HMS Truculent | Submarine | 6 bow, 4 external torpedo tubes, 16 torpedoes, QF 4 inch gun | 12/01/1950 | Collison | Within 200m NW |
| HMS Devon County | Drifter | 1 x 6pdr gun | 01/07/1941 | Sunk by a mine | Within 400m N |
| HMT Ash | Minesweeper | 1x 12 pdr gun, 2x 0.5 inch machine guns, 4 x Lewis guns | 05/06/1941 | Sunk by a mine | Within 460m NW |
| East Oaze Light Vessel (LTV No.60) | Lightship | Not specified | 01/11/1940 | Air Raid | Within 500m NW |
| HMY Aisha | Leisure yacht | Not specified | 11/10/1940 | Sunk by a mine | Within 130m NW |



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| | | | | | |
|---|---|---|---|---|---|
| MV Actuality | Cargo ship | Not specified | 08/12/1940 | Sunk by a mine | Within 190m SE |
| MV Sigrun I | Cargo ship | Not specified | 04/06/1916 | Capsized | Within 330m SE |
| HMT Kennymore | Minesweeper | Not specified | 25/11/1940 | Sunk by a mine | Within 530m SE |
| Yelding | Not specified | Not specified | 1924 | Not specified | Within 380m SE |
| SS Margam Abbey | Cargo ship | Not specified | 25/04/1940 | Sunk by a mine | Within 110m NW |
| Consul | Barge, lighter | Not specified | Not specified | Not specified | Within 40m SE |
| SS Greenhill | Cargo ship | Not specified | 16/12/1917 | Ran aground | Within 60m E |
| HMS Coquette | Destroyer | 1 × QF 12-pounder gun<br>1 x QF 6-pdr gun<br>2 × single tubes for 18" torpedoes | 07/03/1916 | Sunk by a mine from a German submarine | Within 1km NW |
| SS Salerno | Passenger/ Cargo ship | Not specified | 18/10/1915 | Sunk by a mine from a German submarine | Within 1.1km NW |
| SS Iris | Cargo ship | Not specified | 25/12/1917 | Ran aground | Within 900m NW |
| SS Peregrine | Passenger/ Cargo ship | Not specified | 29/12/1917 | Ran aground | Within 1.1km SE |
| SS Haytor | Cargo ship | Not specified | 26/07/1940 | Sunk by a mine | Within 350m N |
| SS Hendonhall | Cargo ship | Not specified | 01/05/1916 | Sunk by a mine from a German submarine | Within 100m SE |
| SS Kaunas | Cargo ship | Not specified | 17/11/1939 | Torpedoed by U-57 (a German submarine) | Within 300m SE |
| U-31 | German U-boat | 6 torpedoes, 4 T.T. 2 fwd and 2 aft, 1 x 105 mm gun | 13/01/1915 | Sunk by a mine | Within 700m NW |


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| Ship name | Type of ship | Armaments | Date of wreck | Reason given | Location |
|---|---|---|---|---|---|
| HMS Ivanhoe | Destroyer | 4 x 4.7", 8 x .5", A.A., 10 x 21"T.T. (5x2), 60 mines | 01/09/1940 | Sunk by a mine | Within 280m SE |
| Ivan | Not specified | Not specified | 24/10/1949 | Sunk by a mine | Within 600m N |
| S-22 | Torpedo Boat | 2 x 8.8 cm guns, 4 x 50 cm T.T., 18 mines | 26/03/1916 | Sunk by a mine | Within 1.45km S |

**Dutch EEZ**

| Ship name | Type of ship | Armaments | Date of wreck | Reason given | Location |
|---|---|---|---|---|---|
| SS Stadt Riga | Cargo ship | Not specified | 06/07/1944 | Air raid: This ship was sunk by British torpedo bombers near Borkum. | Within 400m E |
| Sperrbecher-10 (Vigo) | Minesweeper | Not specified | 07/03/1944 | Air Raid: The Vigo sank after a mine hit before Norderney. | Within 1.3km W |
| M-383 | Minesweeper | Not specified | 13/08/1944 | Air Raid: The German minesweeper M-383 was sunk in an air raid off Langeroog by RAF aircraft | Within 1km N |
| MV Chiemsee | Cargo Ship | Not specified | 15/10/1944 | Air Raid: Allied air attack by Beaufighters | Within 240m S |
| DW 07 (Trinchen Behrens) | Patrol boat | Guns: 2 x 30 mm + 1 x 20 mm AA + 3 x 15 mm AA | 30th June 1944 | Air Raid: Sank after hitting a mine launched by a British plane at N of Wangerooge, | Within 230m S |
| Unknown | Sailing ship | Not specified | 1919 | Not specified | Within 660m E |
| SMS Yorck | Cruiser | 4 x 8.3", 10 x 5.9", 14 x 3.5", 4 x 18" torpedo tubes | 4th Novemeber 1914 | Mine: Cruiser made a navigational error in heavy fog and accidentally sailed into a German defensive minefield. | Within 850m NW |

**German EEZ**



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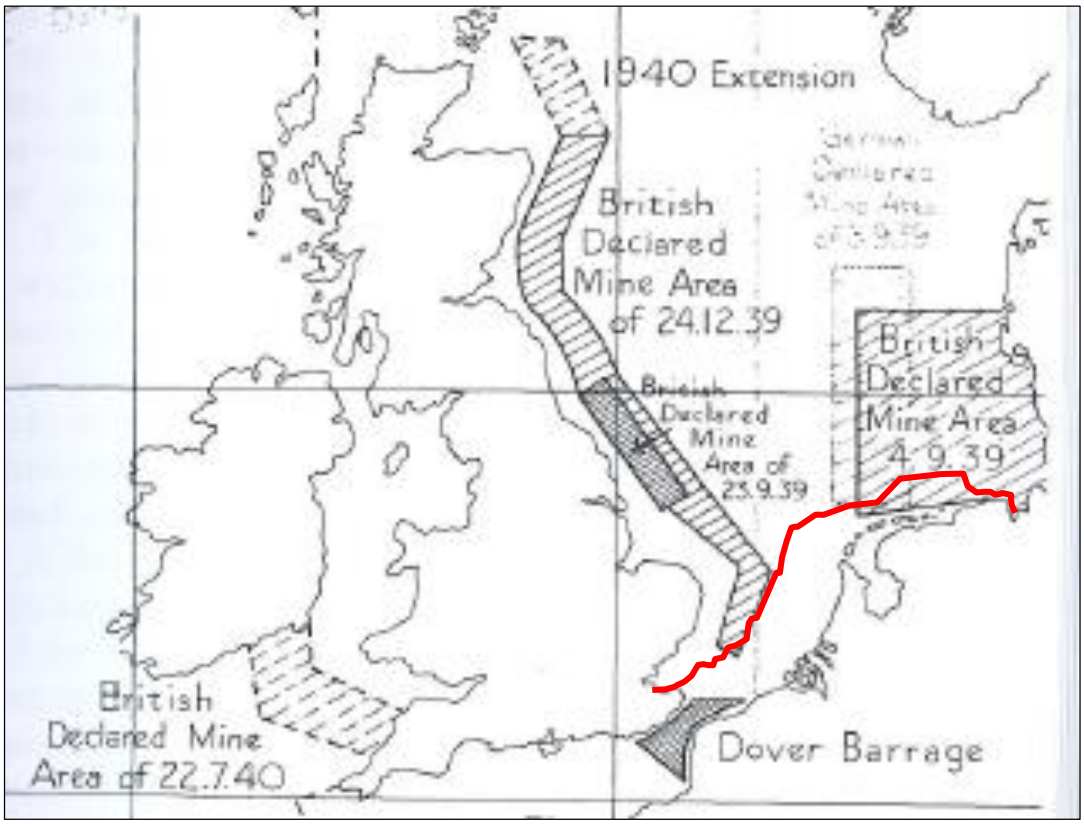
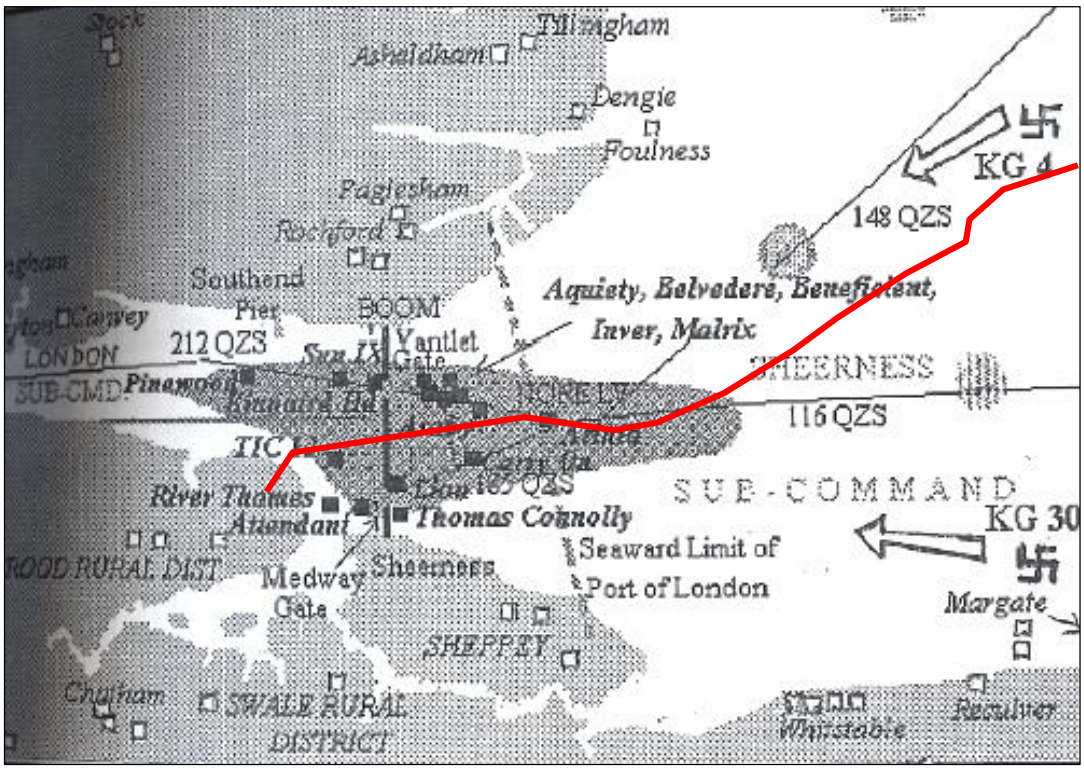
**British and German Declared Mine Areas 1939-1940**




**German Air Minelaying in the Thames Estuary 8-15th December**



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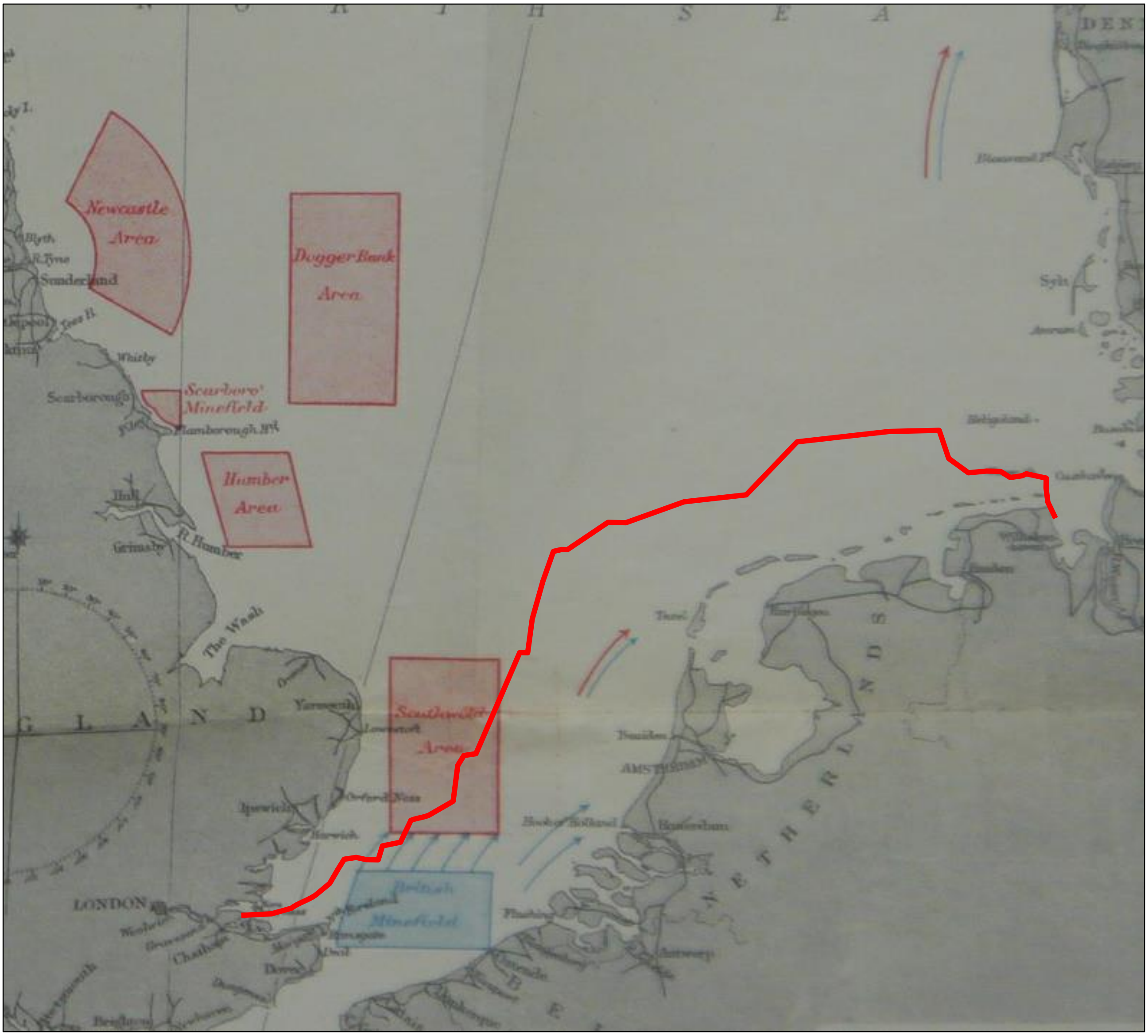
# Approximate Positions of Minefields 7th January 1915

Annex: **G2**



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| | | | |
|---|---|---|---|
| Client: | **Intertek** | **Approximate study area** | N |
| Project: | **HVDC Electricity Transmission Interconnector between the Isle of Grain, UK and Wilhelmshaven, Germany** | | |
| Ref: | **DA2985-01** | Source: The National Archives, Kew | |


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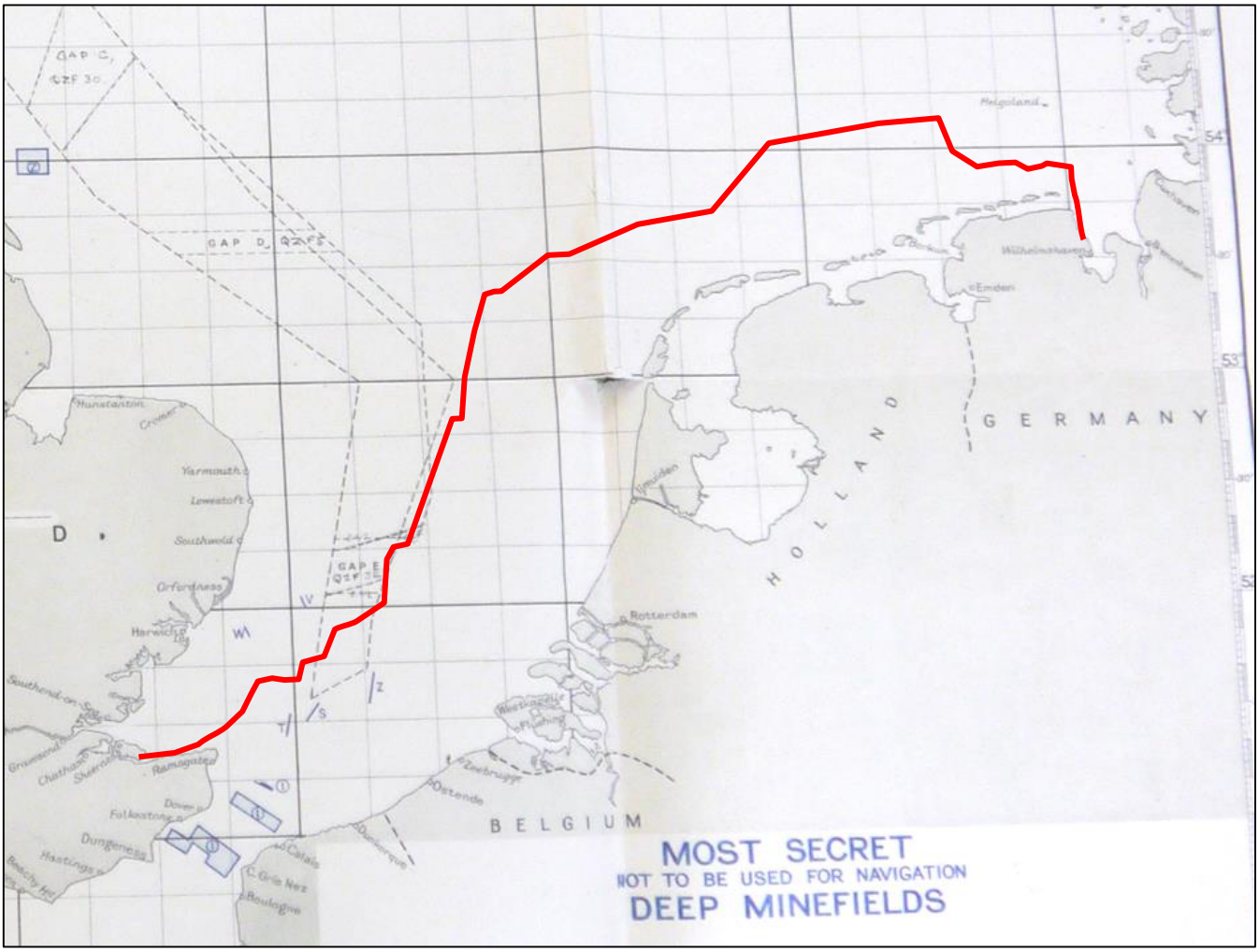


DETAILS OF MINEFIELDS
Additions etc. are to be noted in this Table

| LINES OF MINES | LIMITS OF LINES | | | DEPTH IN FEET OF SHALLOWEST MINE BELOW MEAN LOW WATER | REMARKS |
|---|---|---|---|---|---|
| ① | Dover | | | 40 | For details see 186 QZX & 188 QZX |
| ② | Between | Lat. 53°56'00"N Long. 0°08'00"E | and Lat. 54°03'00"N Long. 0°21'00"E | 80 | |
| A | From | Lat. 58°25'12"N Long. 1°28'00"W | 135° 6·6 miles | 79 | |
| B | From | Lat. 58°30'00"N Long. 1°27'00"W | 000° 8·5 miles | 90 | |
| C | From | Lat. 58°25'00"N Long. 1°14'00"W | 344° 3·8 miles | 90 | |
| D | From | Lat. 58°34'18"N Long. 1°37'30"W | 180° 17·0 miles | 86<br>105 | North of Lat. 58° 28·50"N<br>South of Lat. 58° 28·50"N |
| S | From | Lat. 51°30'00"N Long. 2°04'00"E | 035° 6·1 miles | 60 | |
| T | From | Lat. 51°32'00"N Long. 1°58'00"E | 190° 6·0 miles | 60 | |
| V | From | Lat. 52°00'00"N Long. 2°05'00"E | 350° 3·0 miles | 50 | |
| W | From | Lat. 51°55'13"N Long. 1°39'24"E | 158° 3·0 miles | 50 | |
| Z | From | Lat. 51°34'12"N Long. 2°31'00"E | 010° 8·0 miles | 65 | |
| S.N.41 | North-West Approaches | | | 70 | For details see 202 QZX |
| S.N.42 | " " " | | | 70 | " " " 209 QZX |
| S.N.43 | " " " | | | 70 | " " " 229 QZX |
| S.N.44 | " " " | | | 70 | " " " 227 QZX |
| S.N.45 | " " " | | | 70 | " " " 230 QZX |
| | Faeroes | | | 60 | " " " 224 QZX |
| ZME 10 25, 30-31 | St. George's Channel | | | 70 | " " " 256 QZX |
| ZME 24 26 | St. George's Channel | | | 55 | " " " 257 QZX |

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Client: **Intertek**

Approximate study area

Project: **HVDC Electricity Transmission Interconnector between the Isle of Grain, UK and Wilhelmshaven, Germany**

N

Ref: **DA2985-01**

Source: The National Archives, Kew

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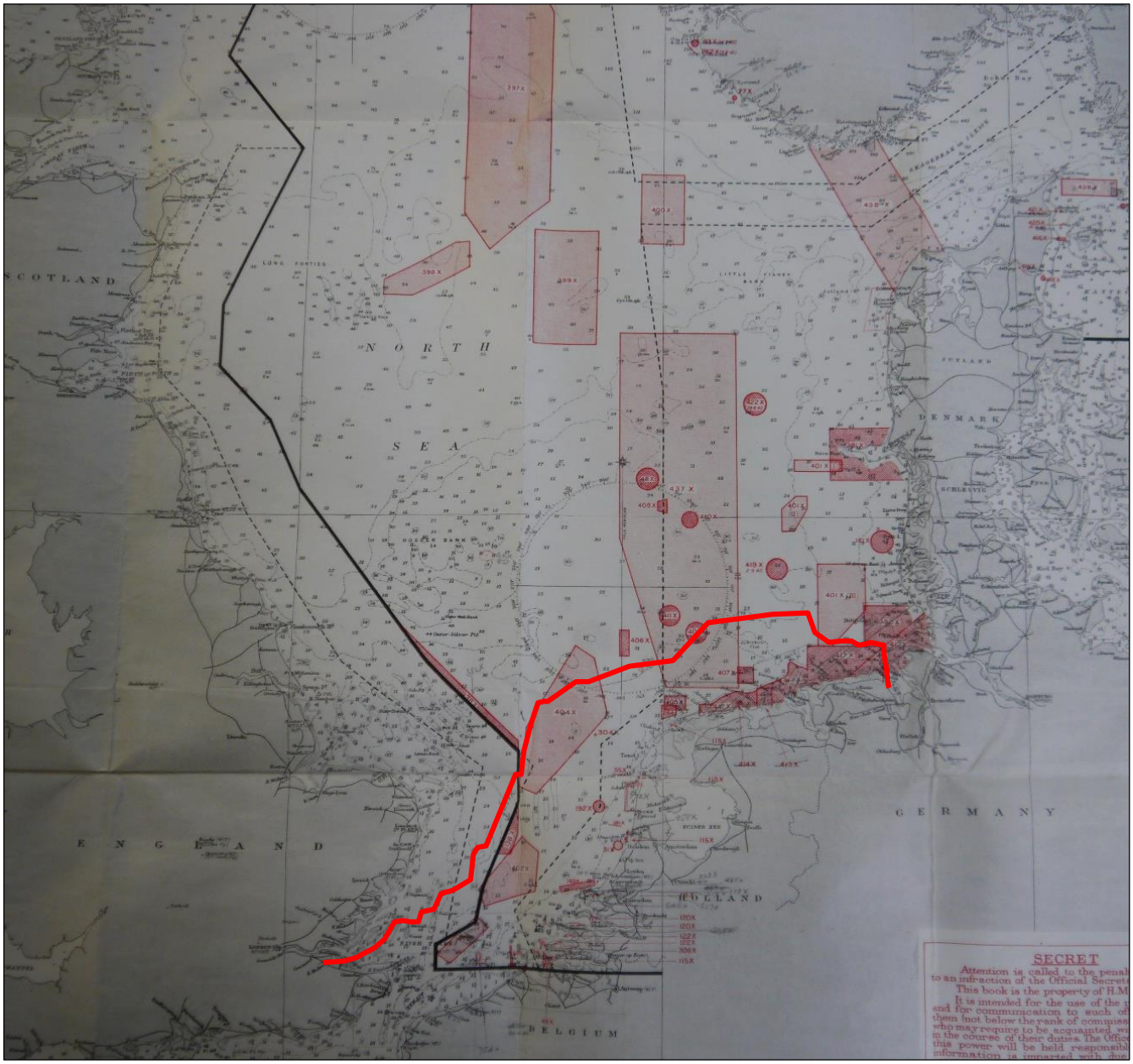
# The North Sea: Positions of British and German Sea Mines – 1941 Annex: G4



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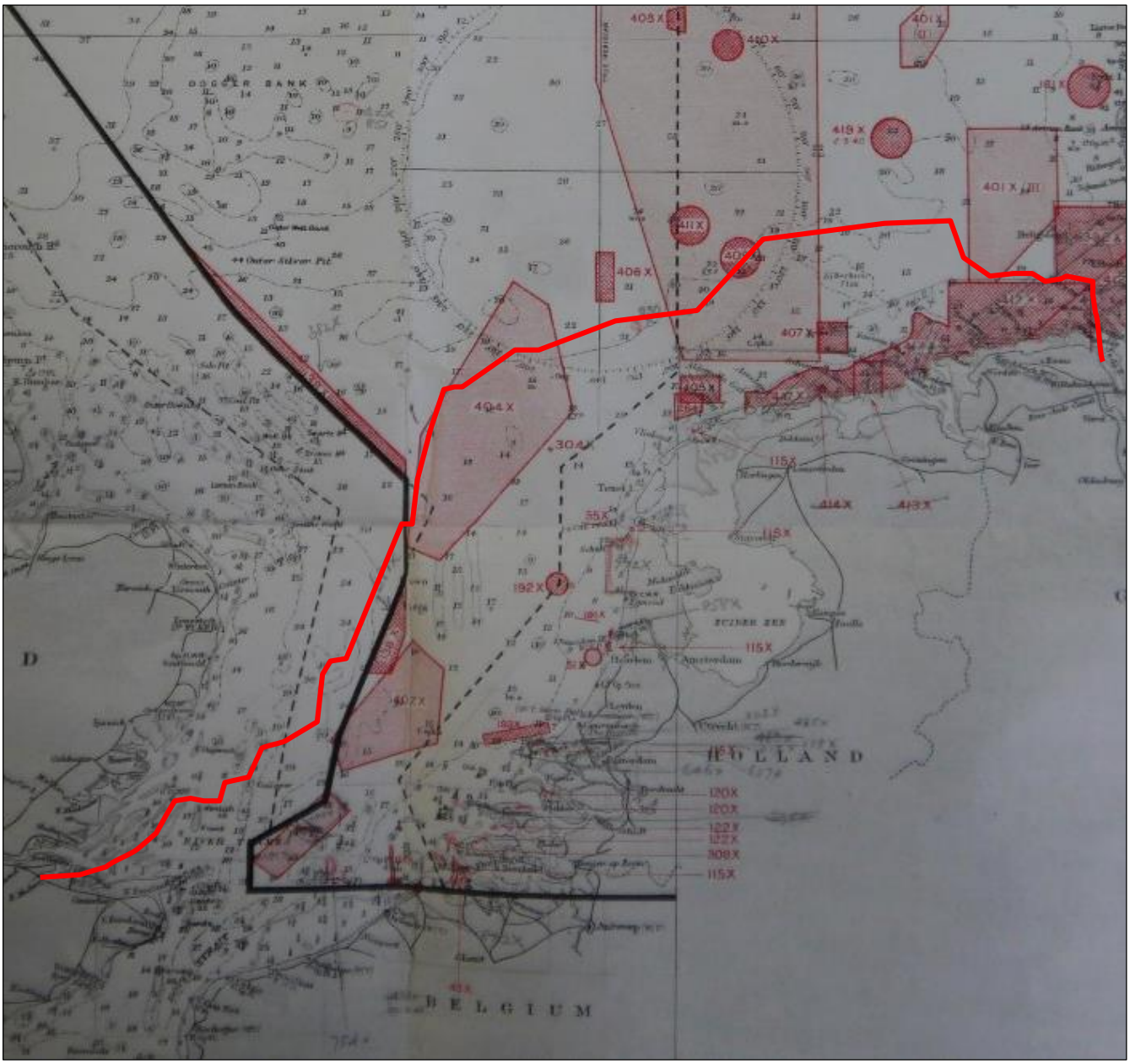

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Client: **Intertek**

**Approximate study area**

N

Project: **HVDC Electricity Transmission Interconnector between the Isle of Grain, UK and Wilhelmshaven, Germany**

Ref: **DA2985-01**

Source: The National Archives, Kew

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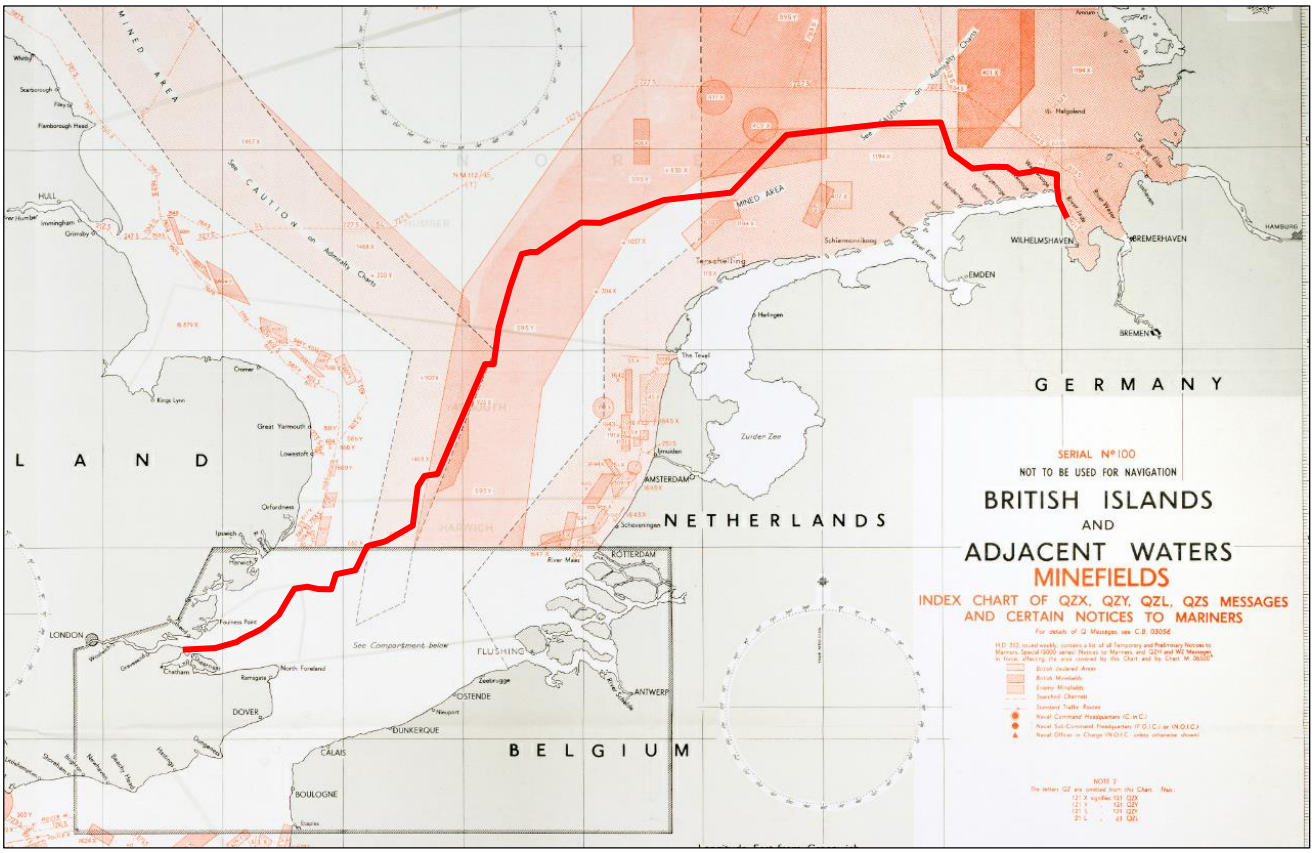
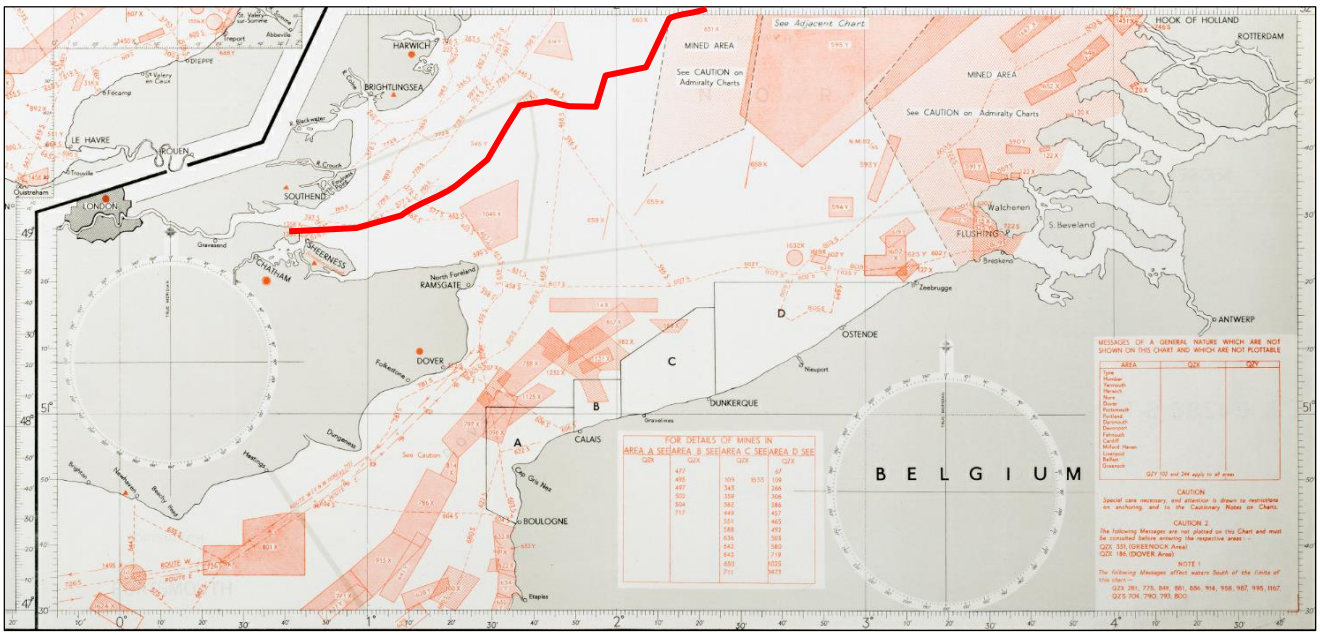
# British Islands and Adjacent Waters Minefields – July 1945

Annex: **G6**




- British declared Areas
- British Minefields
- Enemy Minefields
- Searched Channels
- Standard Traffic Routes
- Naval Command Headquarters (C. in C.)
- Naval Sub-Command Headquarters (F.O.I.C.) or (N.O.I.C.)
- Naval Officer in Charge (N.O.I.C. unless otherwise shown)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Client: **Intertek**

**Approximate study area**

Project: **HVDC Electricity Transmission Interconnector between the Isle of Grain, UK and Wilhelmshaven, Germany**

N

Ref: **DA2985-01**

Source: UKHO


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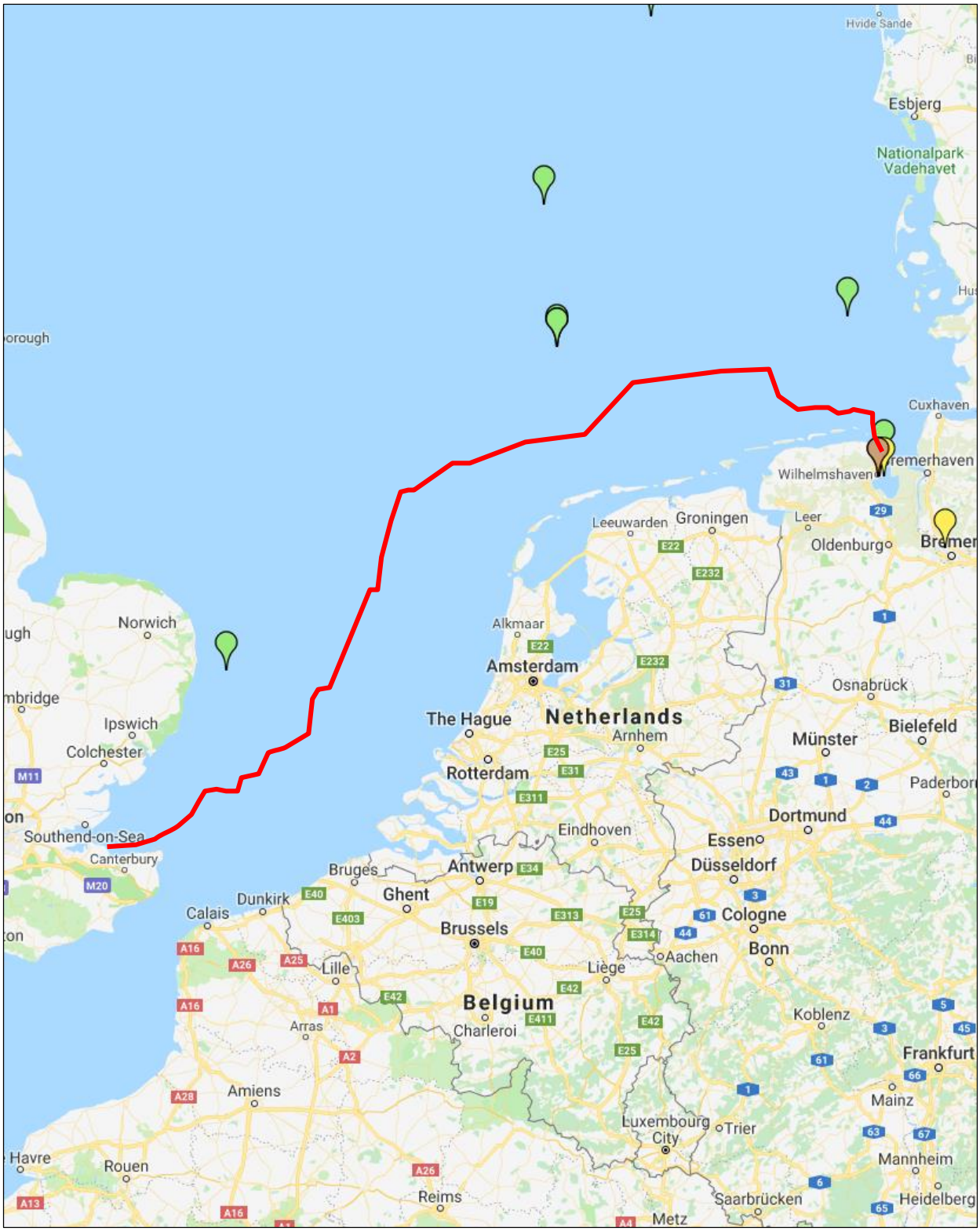
# Overlay of WWII-era U-boat losses in the North Sea

Annex: **H**




**Key:**

1940 | 1944 | U-Boat Flotilla Base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Client: **Intertek**

**Approximate study area**

Project: **HVDC Electricity Transmission Interconnector between the Isle of Grain, UK and Wilhelmshaven, Germany**

N

Ref: **DA2985-01**

Source: https://uboat.net/maps/north_sea.htm


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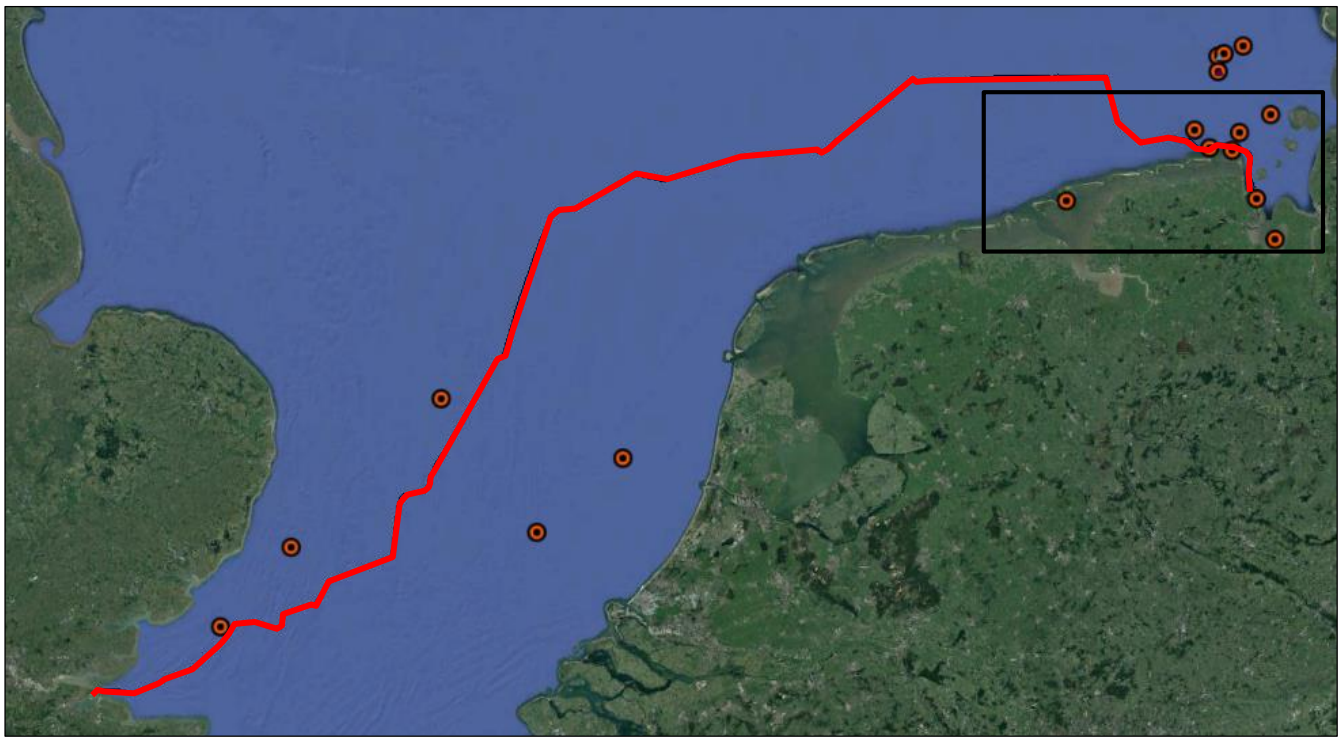
# Overlay of OSPAR Marine Munition Dumpsite Locations

Annex: I



**Key:**

Conventional Munitions Dumpsite

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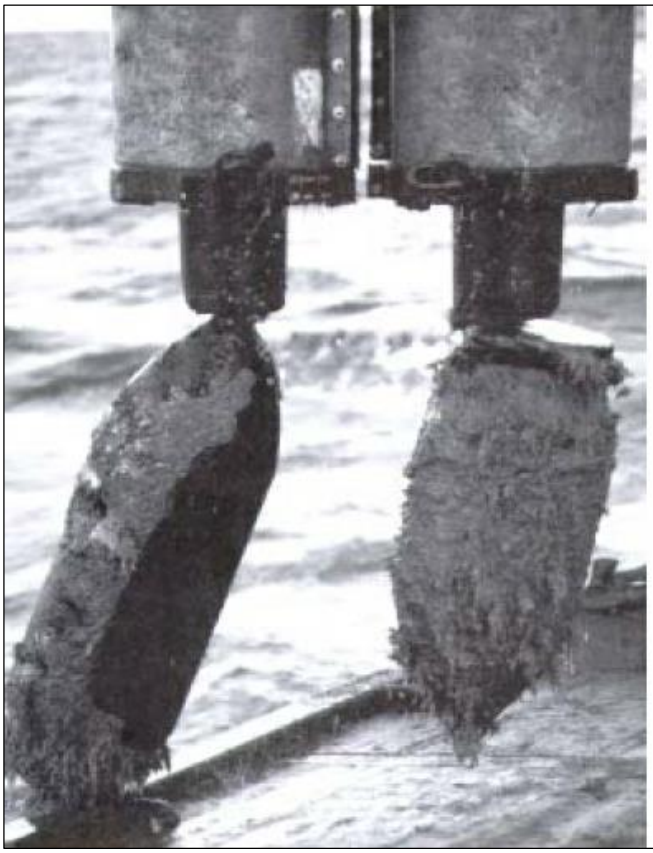

Recovered Ammunition at the Wilhelmshaven Plant, 1952



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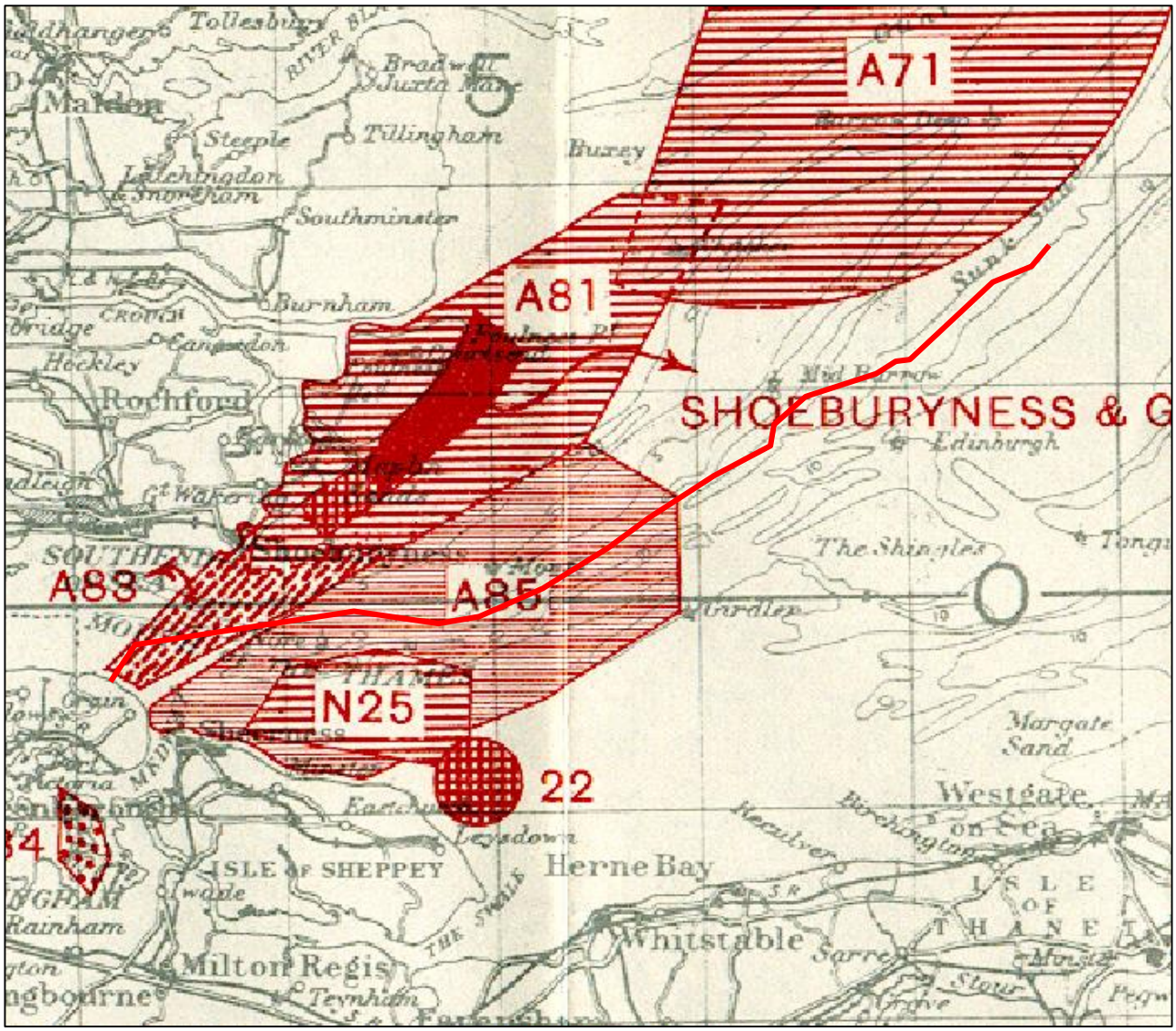
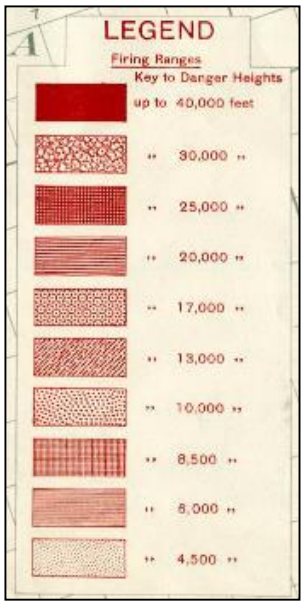
# WWII-era Armament Training Areas Mapping

Annex: **K**





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Client: **Intertek**

**Approximate study area**

N

Project: **HVDC Electricity Transmission Interconnector between the Isle of Grain, UK and Wilhelmshaven, Germany**

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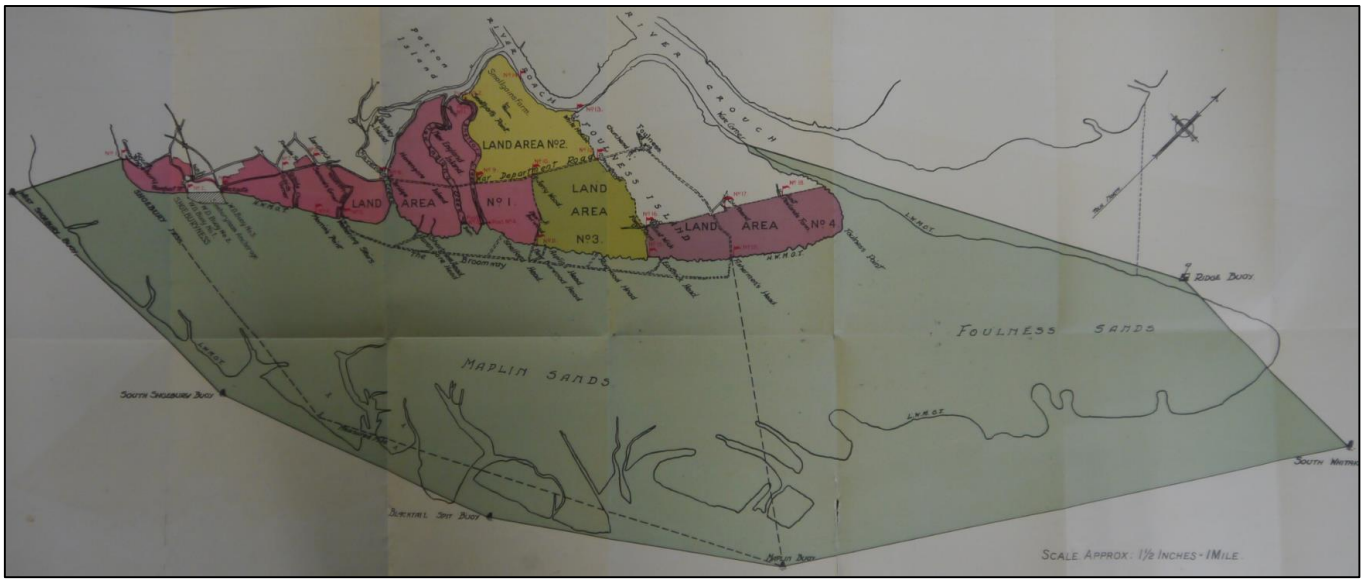


Mapping showing the extent of Shoeburyness Artillery Ranges, based on 1936 byelaw documentation.

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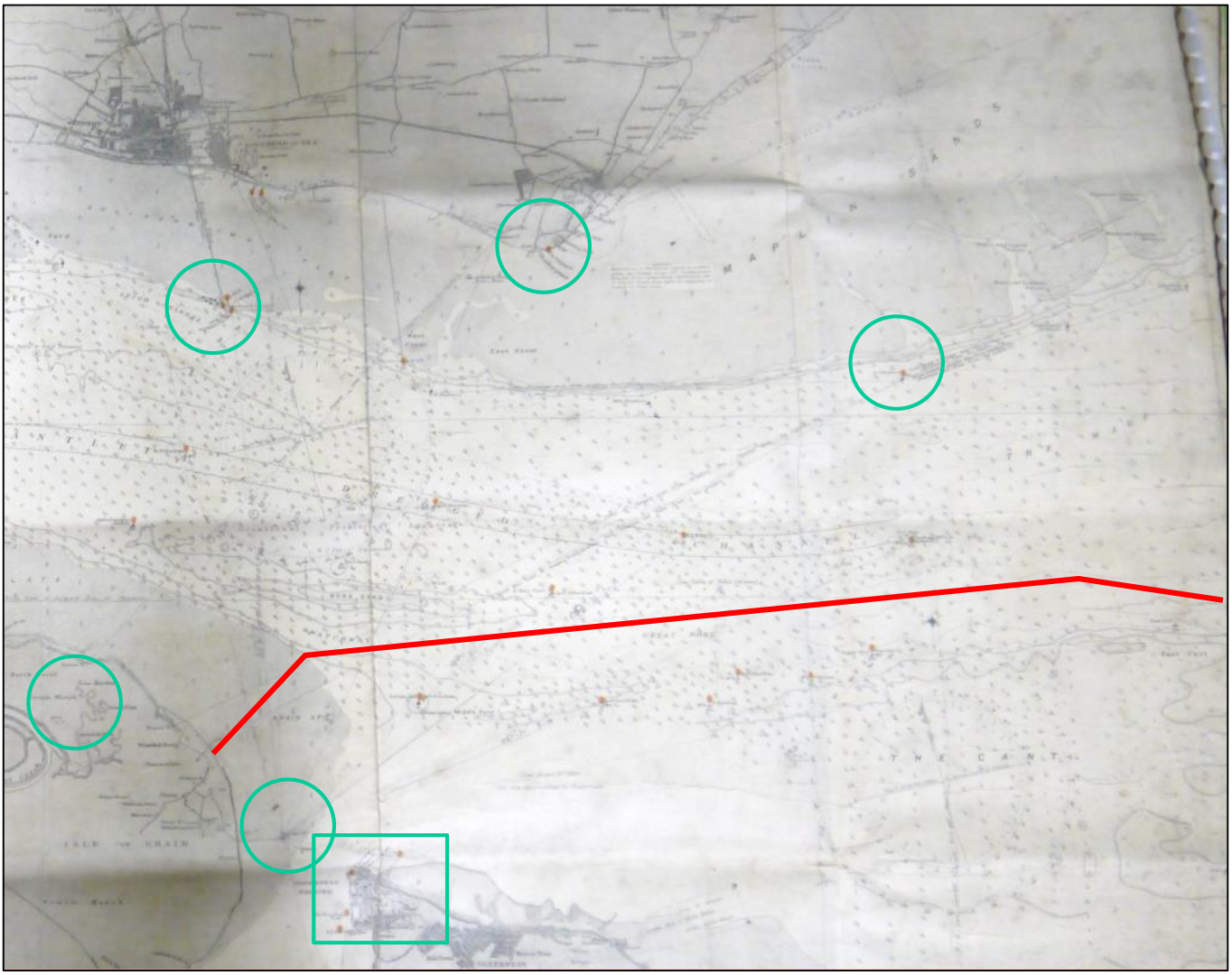
# Range Mapping - Thames Estuary Firing Range Lines

Annex: **L2**



WWII-era mapping showing the firing points of artillery ranges in the Thames Estuary. Any firing points of particular interest are highlighted in green.

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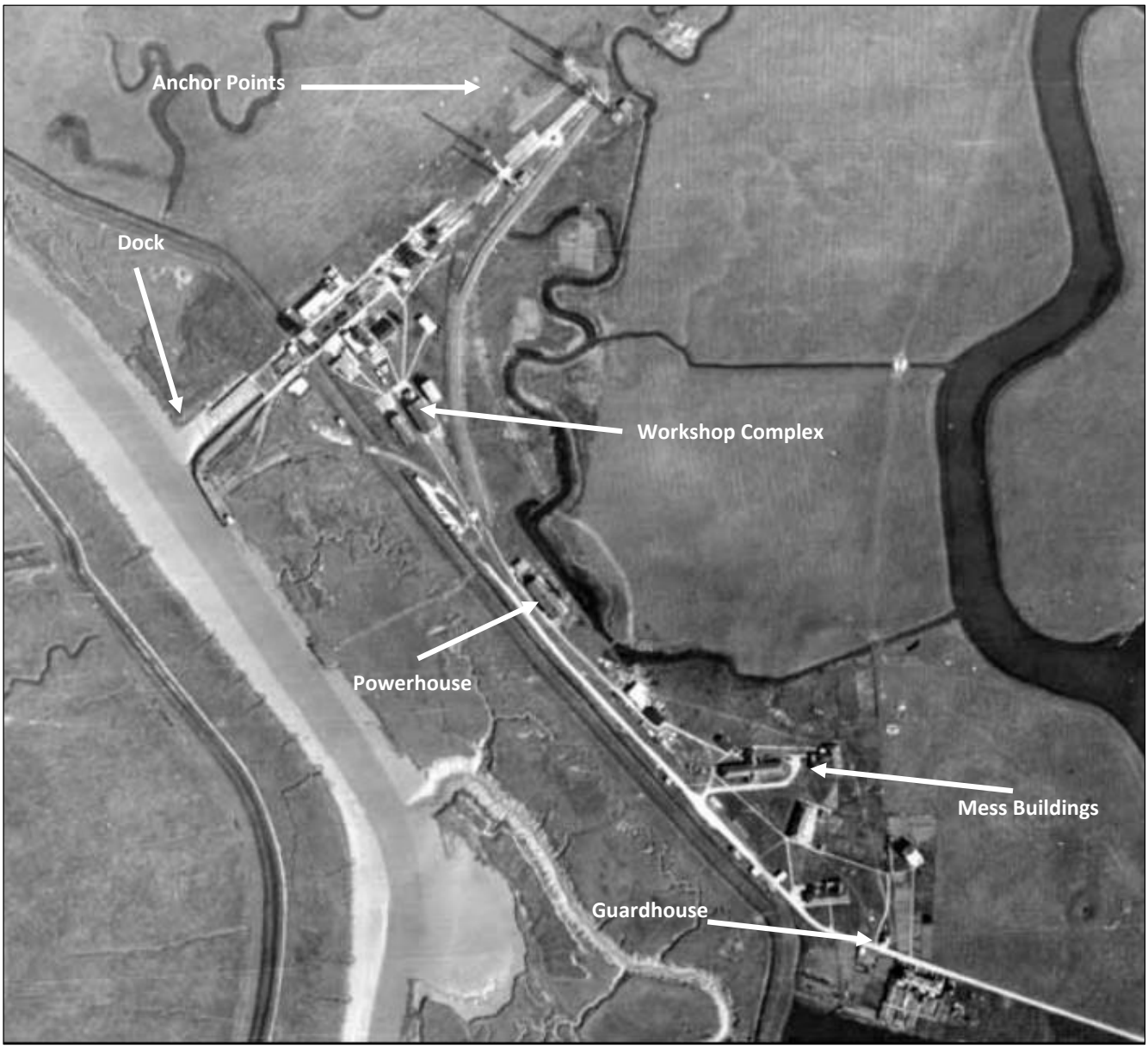
# Yantlet Battery / Grain Firing Point

Annex: **M1**




1946 aerial imagery of the Yantlet firing point main complex, situated approximately 1.5km west of the western endpoint of the study area. Railway firing points (and the rail tracks leading up to them), gun emplacements and gantry paths can all be identified surrounding this image.

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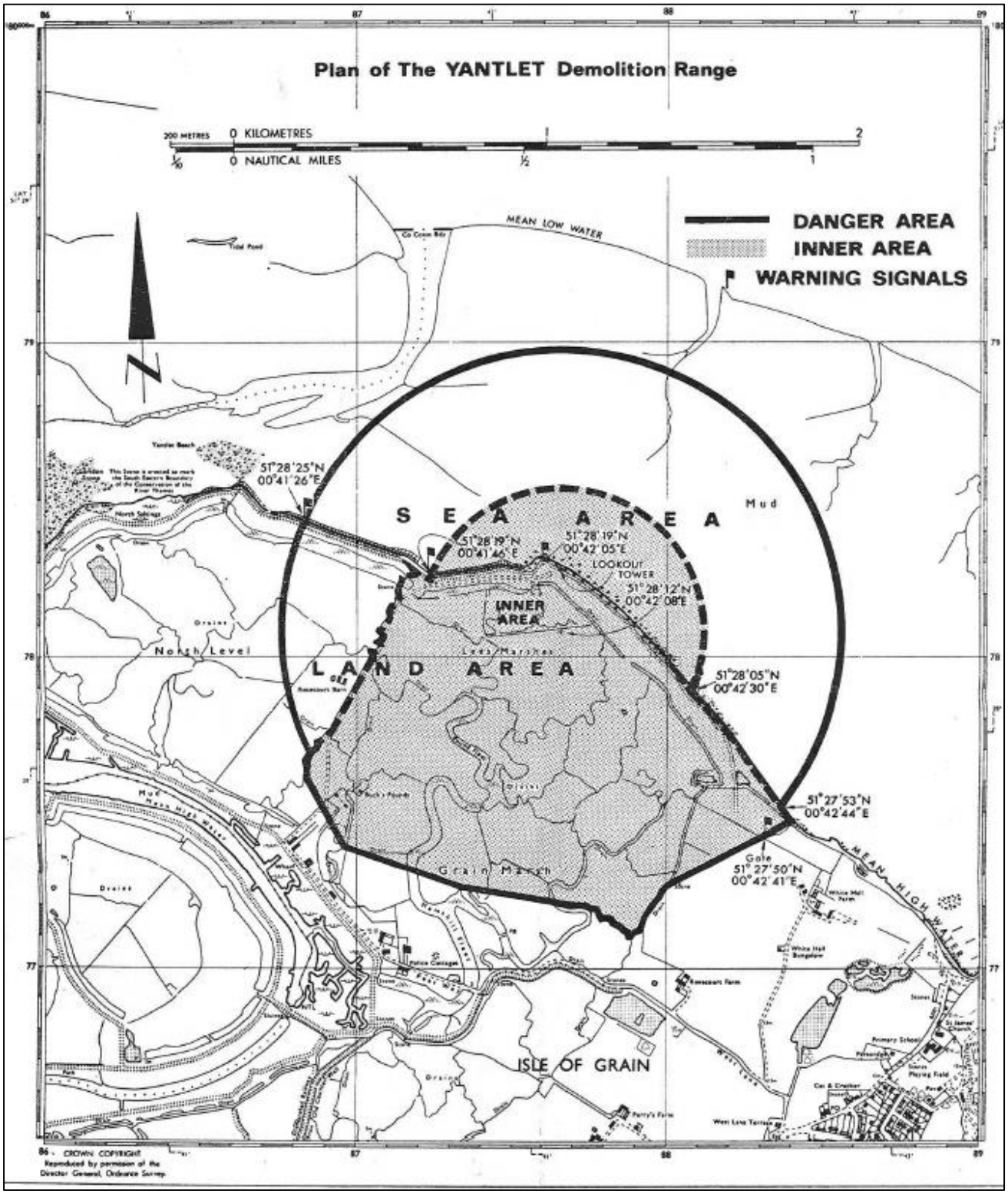


Post-war mapping showing the inner and outer danger areas of Yantlet Demolition Range.



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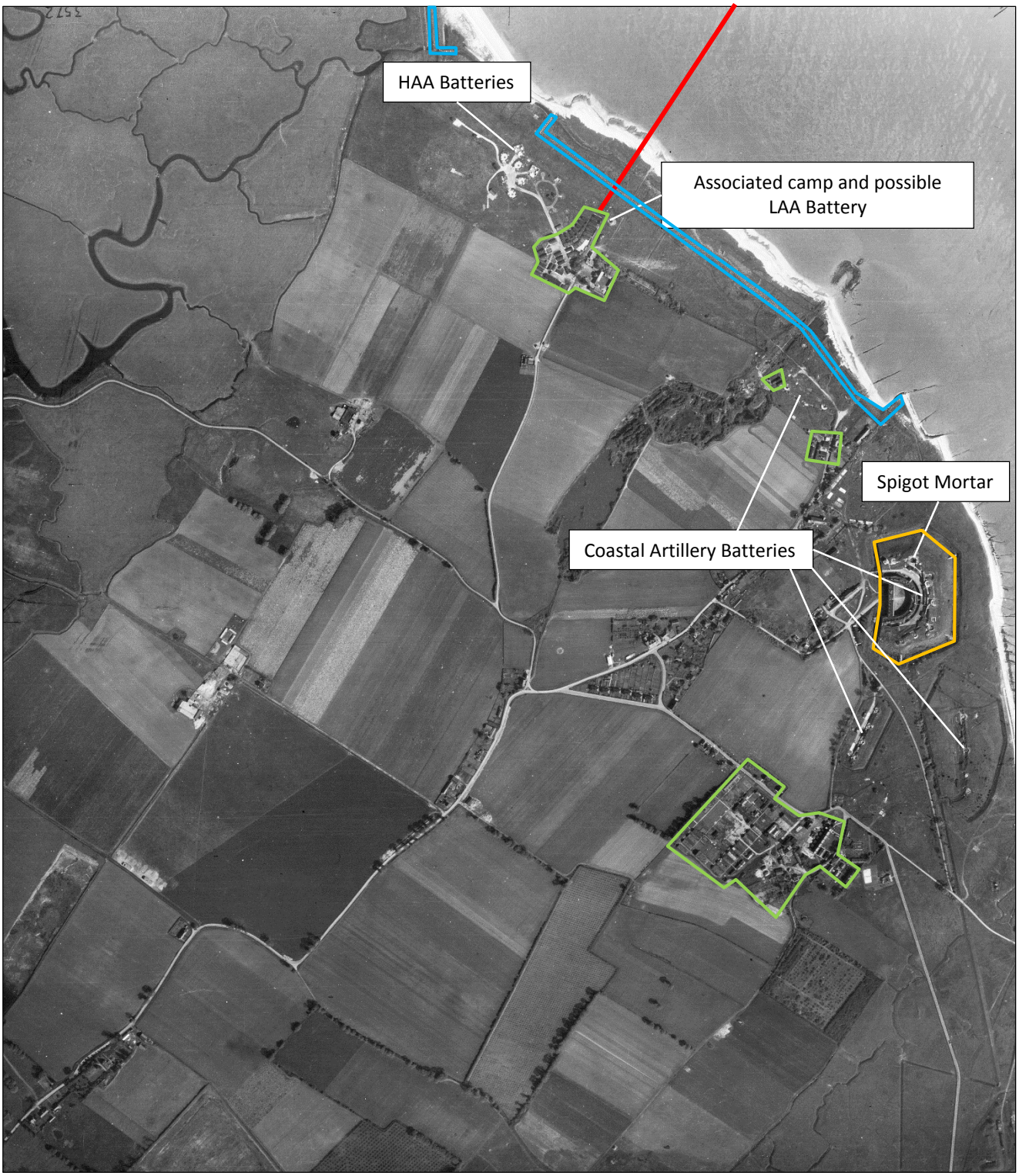
# Isle of Grain Military Features Overlay

Annex: **N1**




Military Structures

Grain Fort

Dragons Teeth (Anti-tank defences)

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# Examples of UXO Found in the Thames Estuary

Annex: **O1**

4” Solid Shot

Anti-Tank Mine

1.5 inch HE Hopkiss

2 Inch Solid Shot

2 X 12mm Solid Shot

Cannonball

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# Examples of UXO Found in Thames Estuary

Annex: **O2**

Mills Hand grenade

HE Fuze

20mm Shell Casing

14 Inch Projectile

3 Inch Projectile

Various Items

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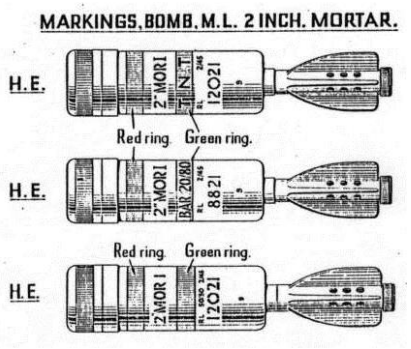
# Examples of Land Service Ammunition – Mortars

## 2 inch Mortar High Explosive

| | |
|---|---|
| Weight | 1.02kg (2.25lb) |
| Maximum Range | 460m (500yards) |
| Filling | 200g RDX/TNT |
| Dimensions | 51 x 290mm (2in x 11.4 in ) |
| Fuze Type | An impact fuze which detonates the fuze booster charge and in turn the high explosive charge. |
| Use | It had greater range and firepower over hand and rifle grenades, and was used to attack targets behind cover with high explosive rounds. |
| Identification | HE has a rounded edge to a flat back. Can either be a black body colour with red and yellow band or dark green with yellow band. Brass cap on top. Practice will have hole all the way through the top. |



## 2 inch Mortar Smoke

| | |
|---|---|
| Weight | 910g (2lb) |
| Maximum Range | 460m (500yards) |
| Filling | White phosphorus and smoke fill |
| Dimensions | 51 x 290mm (2in x 11.4 in ) |
| Fuze Type | An impact fuze which initiates a bursting charge. This ruptures the mortar bomb's body and disperses the phosphorus filler |
| Identification | Smoke mortars have a recess and emission holes. May still see light green body paint. Look for stained ground around munition. |
| Use | As a screening devices for unit movement or to impair enemy field of vision. |

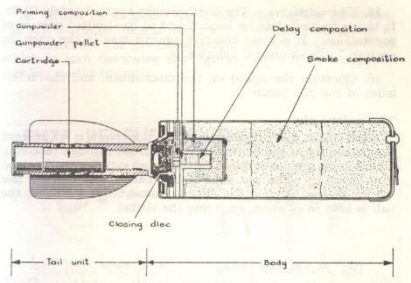
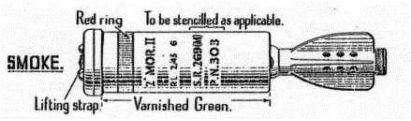
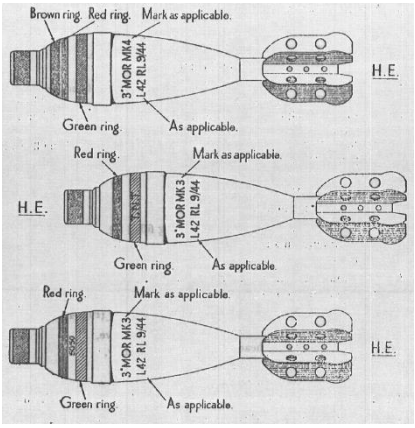


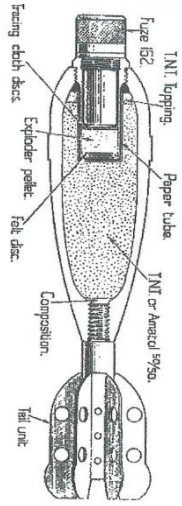

Fig 11.—The smoke bomb (mechanism)



## 3 inch Mortar High Explosive

| | |
|---|---|
| Weight | 4.5kg (10lb) |
| Maximum Range | 1,460 (Mk1) – 2,560m (Mk2) (1,600 – 2,800yds) |
| Dimensions | 81mm (3in) |
| Filling | Amatol |
| Firing Mechanism | Drop, fixed striker |
| Remarks | Fin-stabilised bomb fired by means of a charge consisting of a primary cartridge in the tail and four secondary cartridges |
| Identification | An old style mortar. No way of telling if HE or practice so treat as HE |



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Source: Various sources

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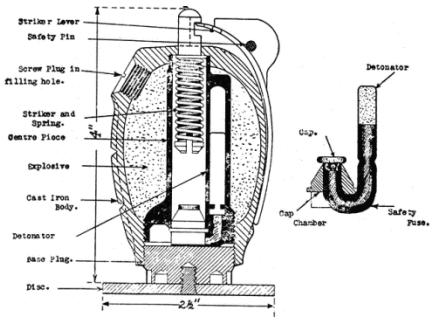
# Examples of Land Service Ammunition – Grenades

## No. 36 'Mills' Grenade

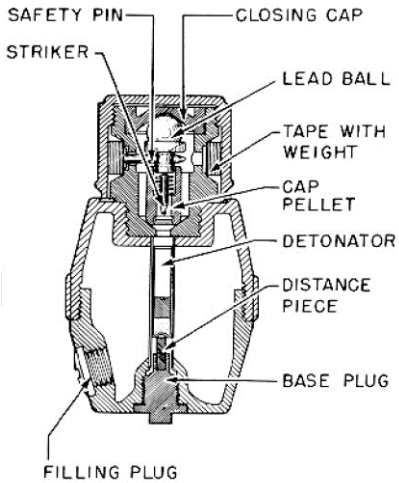
| | |
|---|---|
| Weight | 765g filled (1lb 11.25oz) |
| Explosive Weight | 71g (2oz) filling. |
| Fuze Type | 4-7 second delay hand-throwing fuze. No. 6 Detonator |
| Dimensions | 95 x 61mm (4 x 2.4in) |
| Use | Fragmentation explosive at approx. 30m range 100m range of damage. |
| Remarks | First introduced in 1915 its classic grooved, cast-iron 'pineapple' design was designed to provide uniform fragmentation. The detonator is inserted before use after removing the base plug. |



Left: baseplate and detonator removed

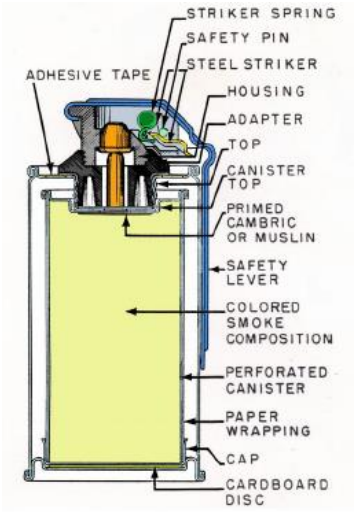
## No. 69 Grenade

| | |
|---|---|
| Weight | 383g ( 13.5oz) |
| Fill Weight | 93g (3.25 oz) of either Amatol, Baratol or Lyddite |
| Fuze Type | 'All-ways' Fuze. Compromised of a safety cap, a weighted streamer attached to a steel ball bearing and a safety bolt designed to detonate from any point of impact. |
| Dimensions | 115 x 60mm (4.5 x 2 .4 in) |
| Use | A blast grenade for use as an offensive weapon. Detonator was inserted before use. |
| Remarks | Introduced December 1940 and made from the plastic Bakelite as opposed to conventional metals. Detection is difficult due to this low metal content. |




## No. 83 Smoke Grenade

| | |
|---|---|
| Weight | Approx. 680g ( 1.5lb) |
| Explosive Weight | Approx. 170-200g. (6-7 oz) |
| Fuze Type | Originally used a friction system using a match head composition. Later developed to a striker lever ignition system. |
| Dimensions | Approx. 62 x 140mm (2.44 x 5.5 in) |
| Use | Use as a target or landing zone marking device and as a screening method for troop / unit movement. |
| Remarks | This basic design stayed relatively unchanged up to the 1980's. The letters CCC were often etched into the body of the grenade in the colour of the smoke. |

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# Examples of Land Service Ammunition – Projectiles

Annex: **P3**

## Examples of Projectiles

From left to right: a 6 pounder 8 cwt; 3 pdr 2 cwt; 2 pdr No. 2; 6 pdr 7 cwt.

## Ordnance QF 2-Pounder Gun

| | |
|---|---|
| Total weight | Between 1.86lb and 2.69lb |
| Calibre | 40 mm (1.575 in) |
| Remarks | British anti-tank and vehicle mounted gun, used early in WWII. |

Firing practise against beach obstacles in 1942

## Ordnance QF 3-Pounder Gun

| | |
|---|---|
| Total weight | 3lb 4oz |
| Calibre | 47-millimetre (1.85 in) |
| Remarks | British tank gun based on earlier naval gun, mounted on Vickers Medium Tanks in the 1920s and 1930s |

Vickers Medium Mk II (special) tank

## Ordnance QF 6-Pounder Gun

| | |
|---|---|
| Total weight | Between 6lb 4 oz and 7lb 2oz |
| Calibre | 2.24 in (57 mm) |
| Remarks | Primarily an anti-tank gun incorporated subsequently on a number of armoured fighting vehicles. First tank to go into action armed with the 6 pounder gun, was the Mark III version of the Churchill tank, in the Dieppe Raid of August 1942. |

6-pounder platoon

## Ordnance QF 20-Pounder Gun

| | |
|---|---|
| Total weight | 20lb |
| Calibre | 84 millimetres (3.31 in) |
| Remarks | British tank gun introduced in 1948 and used the Centurion main battle tank, Charioteer medium tank, and Caernarvon Mark II heavy tank. |

British Centurion Mk.3

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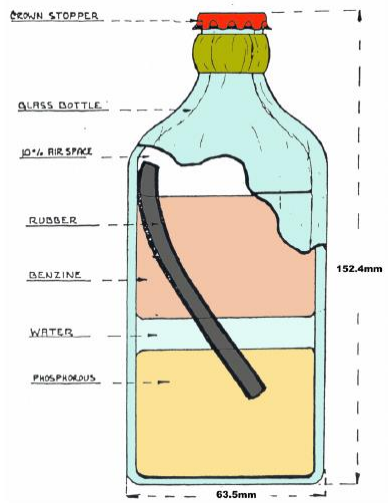
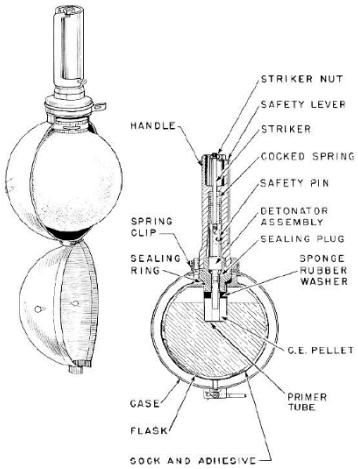
## No. 76 Self Igniting Phosphorous (SIP) Grenade

| | |
|---|---|
| Weight | 1lb 3oz |
| Filling | White Phosphorous and Benzene |
| Design | The filling was contained in a ½ pint sized glass bottle with water and a strip of rubber. Over time the rubber dissolved to create a sticky which would self ignite when the bottle broke. |
| Use | Originally intended as an anti-tank incendiary weapon deployed by hand. Designed to be produced cheaply without consuming materials needed to produce armaments on the front line. |
| Remarks | The Home Guard hid caches of these grenades during the war for use in the event of an invasion. Not all locations were officially recorded and some caches were lost and encountered post-war. In all cases, the grenades are still found to be dangerous. |




## No. 74 Grenade ("Sticky Bomb") Mk1

| | |
|---|---|
| Weight | Approx. 1.1kg (2.25lb) |
| Filling | Approx. 600g Nobel's No.283 (Nitro-glycerine) (1.33lb) |
| Design | A glass ball on the end of a Bakelite (plastic) handle. The inside of the ball would contain the explosive filling and the outside a very sticky adhesive coating. |
| Use | An anti-tank grenade primarily issued to the home guard. It required the user to come in very close proximity with the target and smash the glass explosive container against it. |
| Remarks | Timer fuze was located in the handle. This would explode after 3-6 secs.<br><br>9.5in Long<br>4.5in Diameter |




## Flame Fougasse Bomb

| | |
|---|---|
| Weight | Various |
| Filling | Initially a mixture of 40% petrol and 60% gas. Ammonal provided the propellant charge. |
| Design | Usually constructed from a 40-gallon drum dug into a roadside and camouflaged. |
| Use | As an improvised anti-tank bomb. When triggered the Fougasse could project a beam of burning sticky fuel in a fixed direction from up to 3m (10ft) wide and 27m (30yards) long. |
| Remarks | A highly unorthodox weapon designed by the Petroleum Warfare Department to address a critical lack of weapons in 1940. 50,000 are estimated to have been distributed around the UK. |

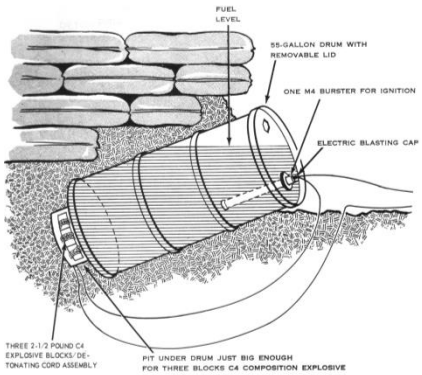



*Figure 22. Flame fougasse (55-gallon drum).*



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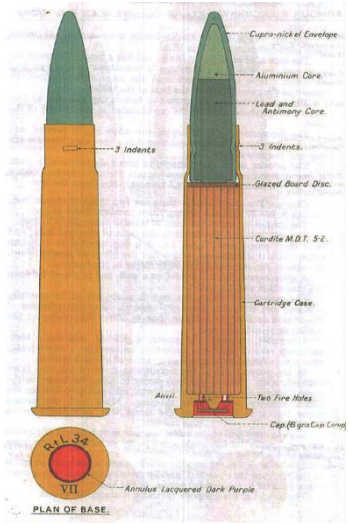
# Examples of Small Arms Ammunition

## Examples of British Small Arms Ammunition

## .303 Rifle

| | |
|---|---|
| Bullet Diameter | 7.92mm |
| Case length | 56.44mm |
| Overall length | 78.11mm |
| Type | Rifle Ammunition |
| Propellant | Originally black powder. Later Cordite followed by Nitrocellulose |
| Remarks | First produced in 1889 and still in use today, the .303inch cartridge has progressed through ten 'marks' which eventually extended to a total of around 26 variations. |

| Bullet Type | Colour of tip | Colour of Annulus |
|---|---|---|
| Armour Piercing | Green | Green |
| Ball | None | Purple |
| Incendiary | Blue | Blue |
| Observing | Black | Black |
| Proof | None | Yellow |
| Tracer Short Range | White | Red |
| Tracer Dark Ignition | Grey | Red |
| Tracer Long Range | Red | Red |




## Buried and Decayed Ammunition

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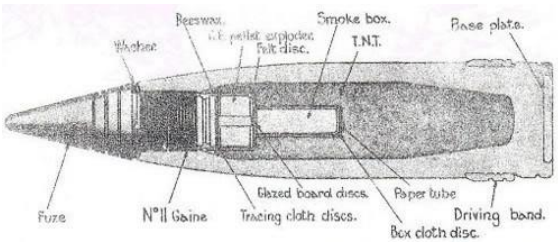
# Examples of Anti-Aircraft Projectiles

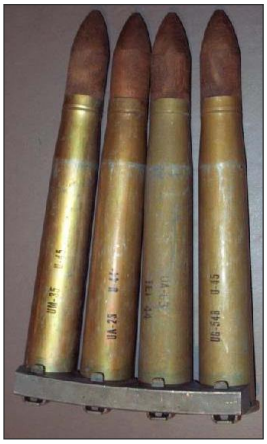
## 3.7 Inch QF Anti-Aircraft Projectile

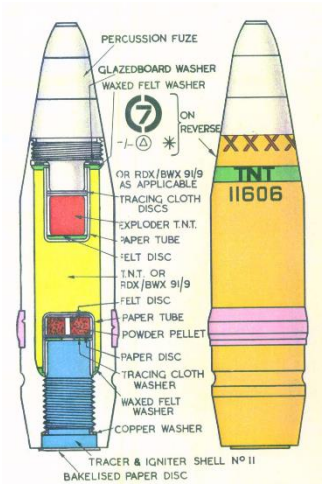
| | |
|---|---|
| Projectile Weight | 28lb (12.6 kg) |
| Explosive Weight | 2.52lbs |
| Fuze Type | Mechanical Time Fuze |
| Dimensions | 3.7in x 14.7in (94mm x 360mm) |
| Rate of Fire | 10 to 20 rounds per minute |
| Use | The 3.7in AA Mks 1-3 were the standard Heavy Anti-Aircraft guns of the British Army. |
| Ceiling | 30,000ft to 59,000ft |




## 40mm Bofors Projectile

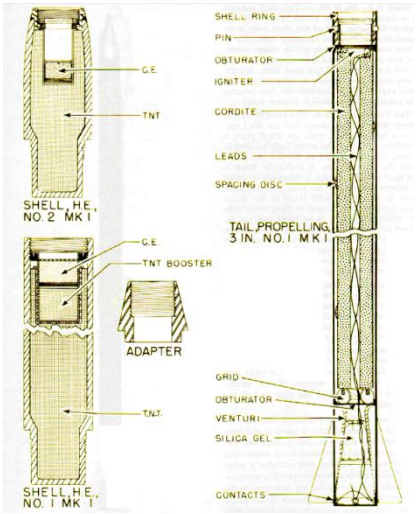
| | |
|---|---|
| Projectile Weight | 1.96lb (0.86kg) |
| Explosive Weight | 300g (0.6lb) |
| Fuze Type | Impact Fuze |
| Rate of Fire | 120 rounds per minute |
| Projectile Dimensions | 40 x 180mm |
| Ceiling | 23,000ft (7000m ) |
| Remarks | Light quick fire high explosive anti-aircraft projectile. Each projectile fitted with small tracer element. If no target hit, shell would explode when tracer burnt out. Designed to engage aircraft flying below 2,000ft |






## 3in Unrotated Projectile (UP) Anti-Aircraft Rocket ("Z" Battery)

| | |
|---|---|
| HE Projectile Weight | 3.4kg (7.6lb) |
| Explosive Weight | 0.96kg (2.13lb) |
| Filling | High Explosive – TNT. Fitted with aerial burst fuzing |
| Dimensions of projectile | 236 x 83mm (9.29 x 3.25in) |
| Remarks | As a short range rocket-firing anti-aircraft weapon developed for the Royal Navy. It was used extensively by British ships during the early days of World War II. The UP was also used in ground-based single and 128-round launchers known as Z Batteries. Shell consists of a steel cylinder reduced in diameter at the base and threaded externally to screw into the shell ring of the rocket motor |

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Client: **Intertek**

Project: **HVDC Electricity Transmission Interconnector between the Isle of Grain, UK and Wilhelmshaven, Germany**

Ref: **DA2985-01**

Source: Various sources

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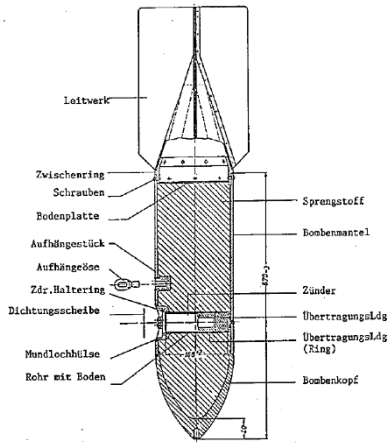
# Examples of German Air-Delivered Ordnance

Annex: **R1**

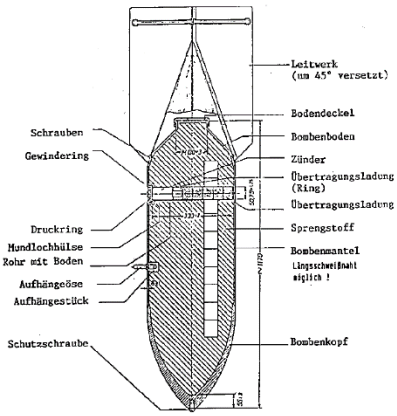
## SC 50kg High Explosive Bomb

| | |
|---|---|
| Bomb Weight | 40-54kg (88-119lb) |
| Explosive Weight | c25kg (55lb) |
| Fuze Type | Impact fuze/electro-mechanical time delay fuze |
| Bomb Dimensions | 1,090 x 280mm (42.9 x 11.0in) |
| Body Diameter | 200mm (7.87in) |
| Use | Against lightly damageable materials, hangars, railway rolling stock, ammunition depots, light bridges and buildings up to three stories. |
| Remarks | The smallest and most common conventional German bomb. Nearly 70% of bombs dropped on the UK were 50kg. |



## SC 250kg High Explosive Bomb

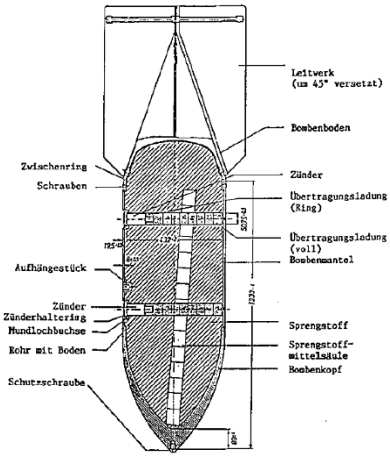
| | |
|---|---|
| Bomb Weight | 245-256kg (540-564lb) |
| Explosive Weight | 125-130kg (276-287lb) |
| Fuze Type | Electrical impact/mechanical time delay fuze. |
| Bomb Dimensions | 1640 x 512mm (64.57 x 20.16in) |
| Body Diameter | 368mm (14.5in) |
| Use | Against railway installations, embankments, flyovers, underpasses, large buildings and below-ground installations. |
| Remarks | It could be carried by almost all German bomber aircraft, and was used to notable effect by the Junkers Ju-87 Stuka (Sturzkampfflugzeug or dive-bomber). |

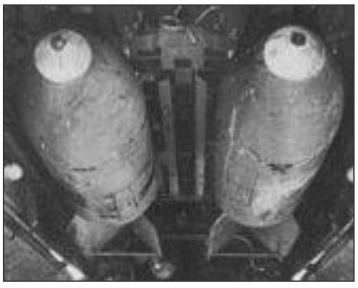


SC250 bomb being loaded onto German bomber

## SC 500kg High Explosive Bomb

| | |
|---|---|
| Bomb Weight | 480-520kg (1,058-1,146lb) |
| Explosive Weight | 250-260kg (551-573lb) |
| Fuze Type | Electrical impact/mechanical time delay fuze. |
| Bomb Dimensions | 1957 x 640mm (77 x 25.2in) |
| Body Diameter | 470mm (18.5in) |
| Use | Against fixed airfield installations, hangars, assembly halls, flyovers, underpasses, high-rise buildings and below-ground installations. |
| Remarks | 40/60 or 50/50 Amatol TNT, trialene. Bombs recovered with Trialen filling have cylindrical paper wrapped pellets 1-15/16 in. in length and diameter forming |



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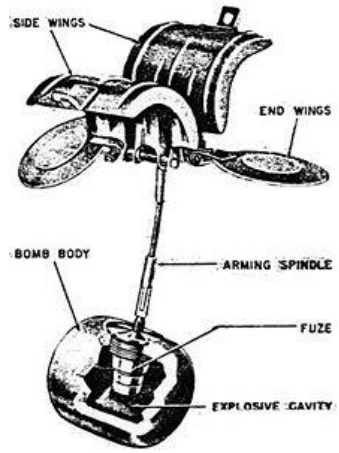
# Examples of German Air-Delivered Ordnance

Annex: **R2**

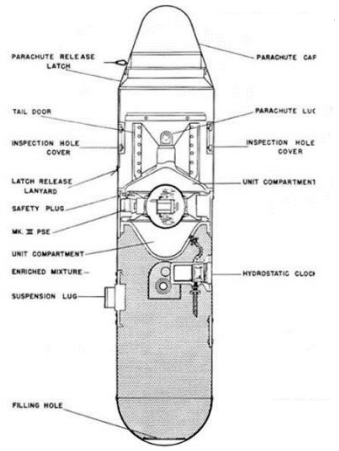
## SD2 Anti-Personnel 'Butterfly Bomb'

| | |
|---|---|
| Bomb Weight | 2kg (4.41lb) |
| Explosive Weight | 7.5oz (225 grams ) of Amatol surrounded by a layer of bituminous composition. |
| Fuze Type | 41 fuze (time) , 67 fuze (clockwork time delay) or 70 fuze (anti-handling device) |
| Body Diameter | 3in (7.62 cm) diameter, 3.1in (7.874) long |
| Use | Designed as an anti-personnel/ fragmentation weapon. They were delivered by air, being dropped in containers of 23-144 sub-munitions that opened at a predetermined height, thus scattering the bombs. |
| Remarks | Very rare. First used against Ipswich in 1940, but were also dropped on Kingston upon Hull, Grimsby and Cleethorpes in June 1943, amongst various other targets in UK. As the bombs fell the outer case flicked open by springs which caused four light metal drogues with a protruding 5 inch steel cable to deploy in the form of a parachute & wind vane which armed the device as it span. |



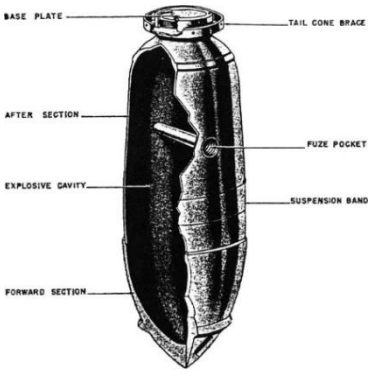
## Parachute Mine (Luftmine B / LMB)

| | |
|---|---|
| Bomb Weight | Approx. 990kg (2176lb) |
| Explosive Weight | Approx. 705kg (1,554lb) |
| Fuze Type | Impact/ Time delay / hydrostatic pressure fuze |
| Dimensions | 2.64m x 0.64m (3.04m with parachute housing) |
| Use | Against civilian, military and industrial targets. Used as blast bombs and designed to detonate above ground level to maximise damage to a wider area. |
| Remarks | Deployed a parachute when dropped in order to control its descent. Had the potential to destroy a whole street of housing in a 100m radius. |



## SC 1000kg

| | |
|---|---|
| Bomb Weight | 993-1027kg (2,189-2,264lb) |
| Explosive Weight | 530-620kg (1168-1367lb) |
| Fuze Type | Electrical impact/mechanical time delay fuze. |
| Filling | Mixture of 40% amatol and 60% TNT, but when used as an anti-shipping bomb it was filled with Trialen 105, a mixture of 15% RDX, 70% TNT and 15% aluminium powder. |
| Bomb Dimensions | 2800 x 654mm (110 x 25.8in) |
| Body Diameter | 654mm (18.5in) |
| Use | SC type bombs are General Purpose Bombs used primarily for general demolition work. Constructed of parallel walls with comparatively heavy noses. They are usually of three piece welded construction |



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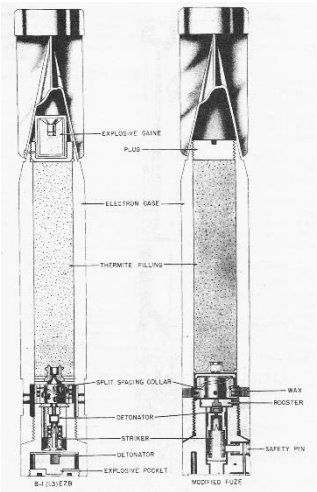
# German Incendiary Bombs

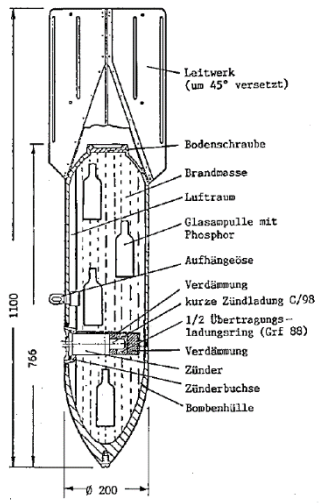
## 1kg Incendiary Bomb

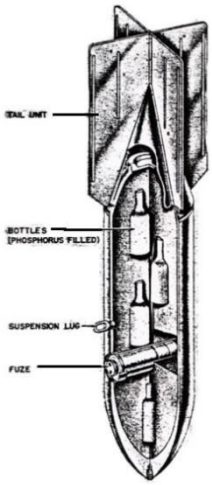
| | |
|---|---|
| Bomb Weight | 1.0 and 1.3kg (2.2 and 2.9lb) |
| Explosive Weight | 680g (1.3lb) Thermite<br>8-15gm Explosive Nitropenta |
| Fuze Type | Impact fuze |
| Bomb Dimensions | 350 x 50mm (13.8 x 1.97in) |
| Body Diameter | 50mm (1.97in) |
| Use | As incendiary – dropped in clusters against towns and industrial complexes |
| Remarks | Magnesium alloy case. Sometimes fitted with high explosive charge. The body is a cylindrical alloy casting threaded internally at the nose to receive the fuze holder and fuze. |



## C50 A Incendiary Bomb

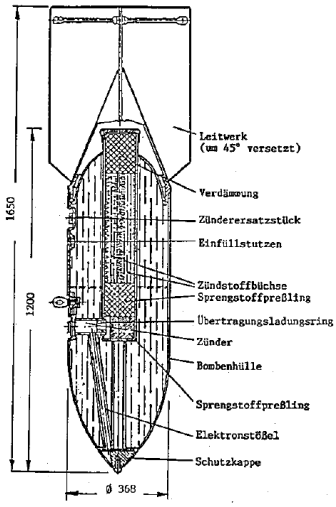
| | |
|---|---|
| Bomb Weight | c41kg (90.4lb) |
| Explosive Weight | 0.03kg (0.066lb) |
| Incendiary Filling | 12kg (25.5lb) liquid filling with phosphor igniters in glass phials. Benzine 85%; Phosphorus 4%; Pure Rubber 10% |
| Fuze Type | Electrical impact fuze |
| Bomb Dimensions | 1,100 x 280mm (43.2 x 8in) |
| Use | Against all targets where an incendiary effect is required |
| Remarks | Early fill was a phosphorous/carbon disulphide incendiary mixture |




## Flam C-250 Oil Bomb

| | |
|---|---|
| Bomb Weight | 125kg (276lb) |
| Explosive Weight | 1kg (2.2lb) |
| Fuze Type | Super-fast electrical impact fuze |
| Filling | Mixture of 30% petrol and 70% crude oil |
| Bomb Dimensions | 1,650 x 512.2mm (65 x 20.2in) |
| Body Diameter | 368mm (14.5in) |
| Use | Often used for surprise attacks on ground troops, against troop barracks and industrial installations. Thin casing – not designed for ground penetration |



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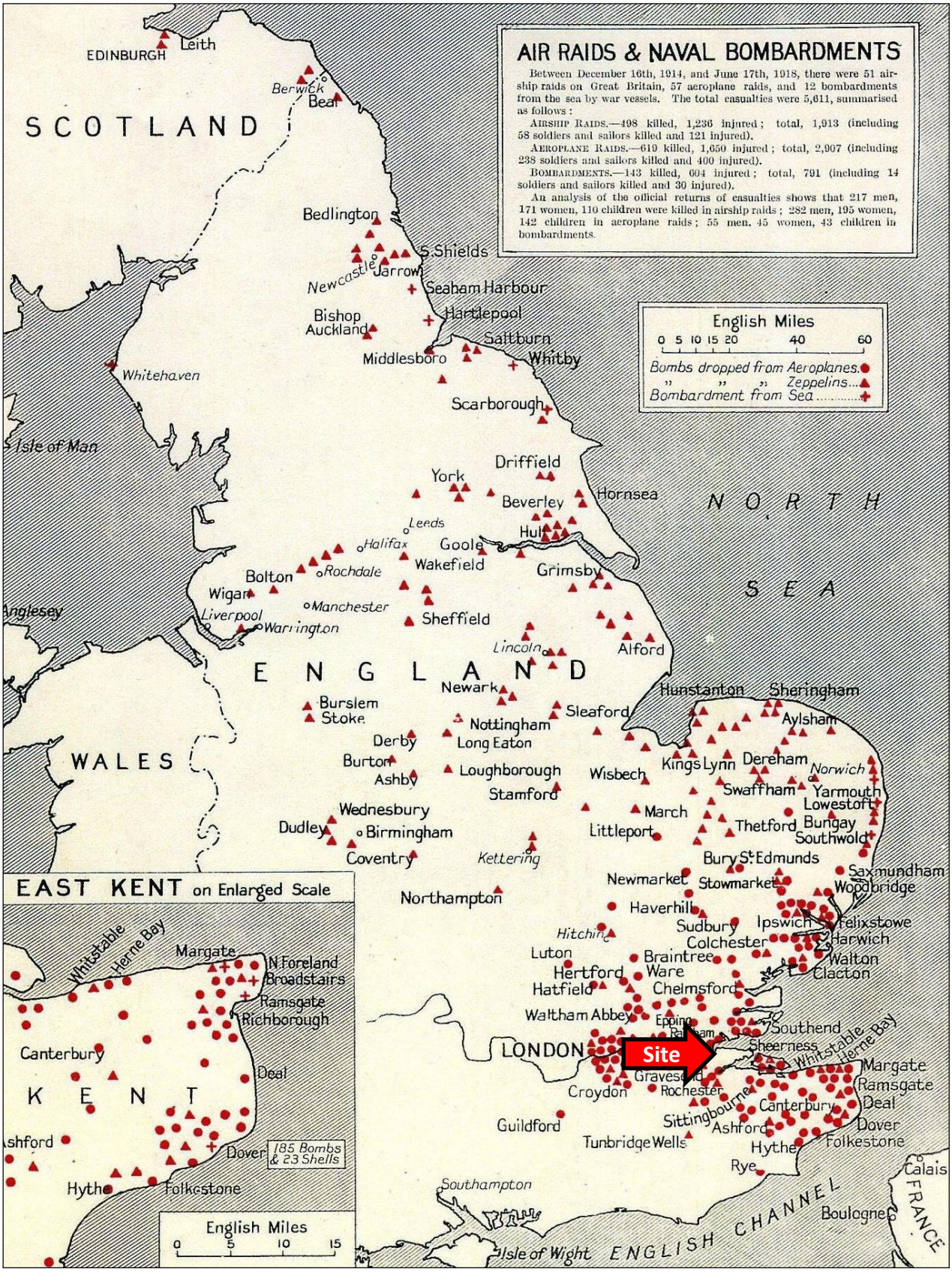
# WWI Map of Air Raids and Naval Bombardments

Annex: **S**





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Source: J. Morris, *German Air Raids on Britain*

N


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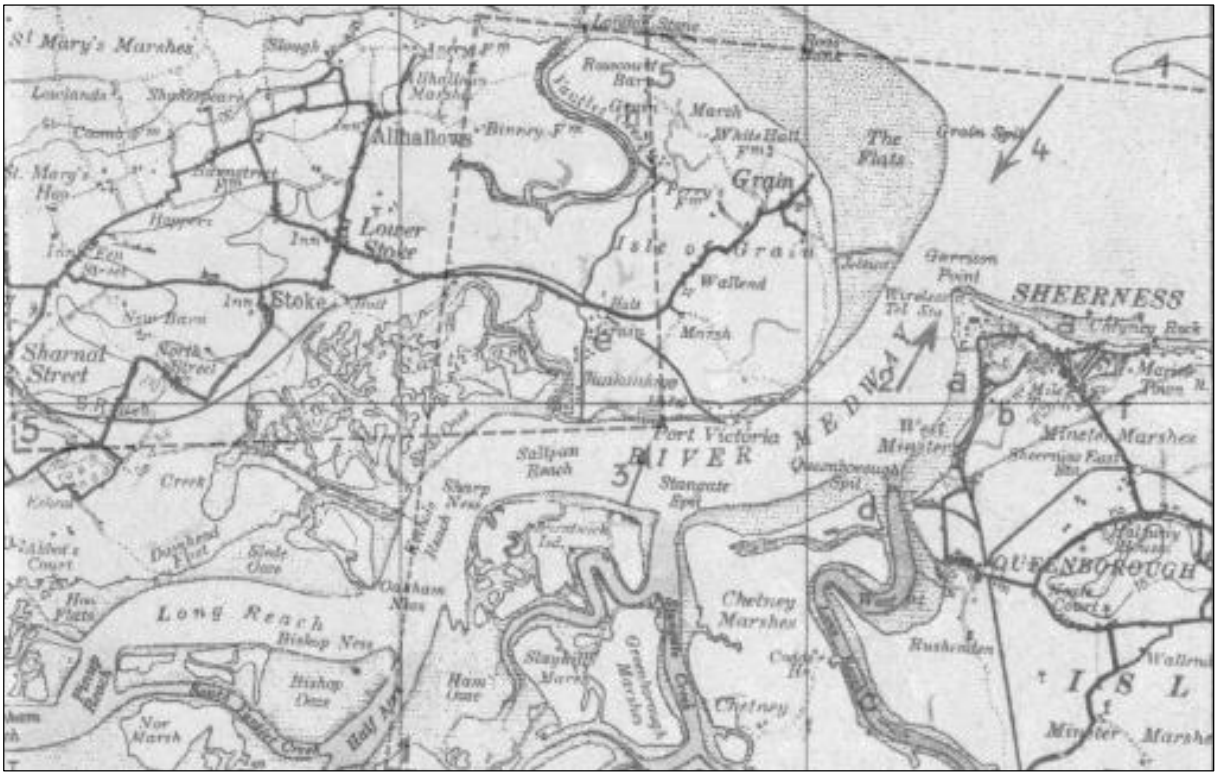

Luftwaffe aerial photograph of Pembroke Dock, a) b) c) d) e) f) g) h)




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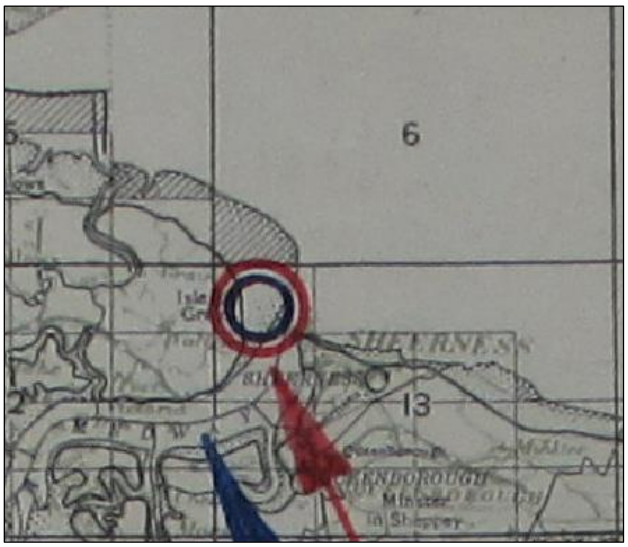
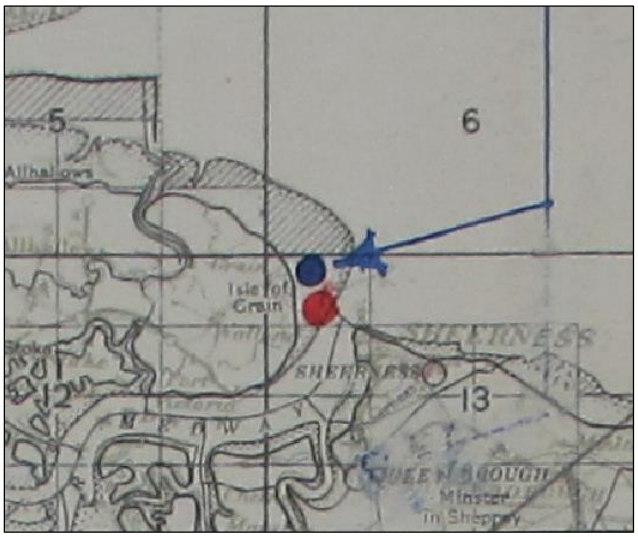
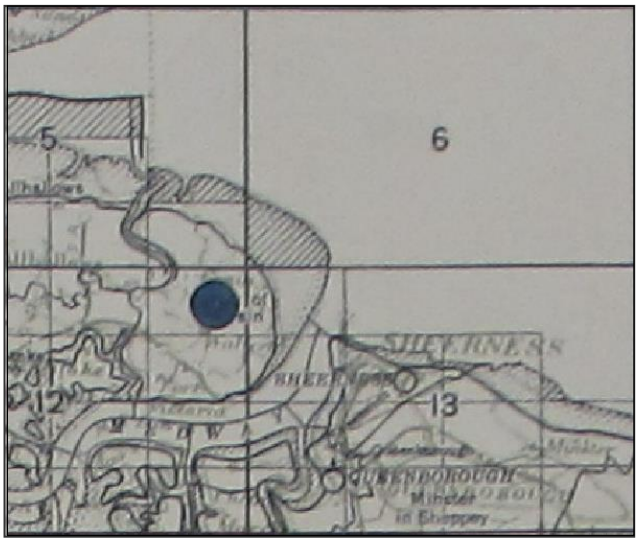



11th July 1940




10th August 1940

30th August 1940




11th September 1940

Incendiary Bomb

H.E Bomb

German Plane

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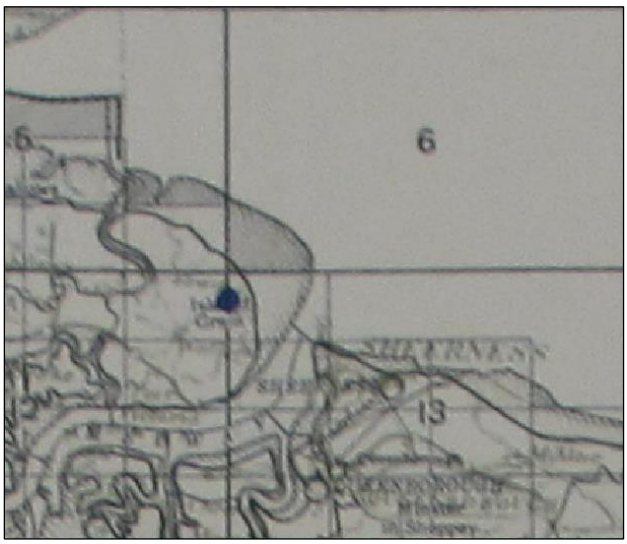
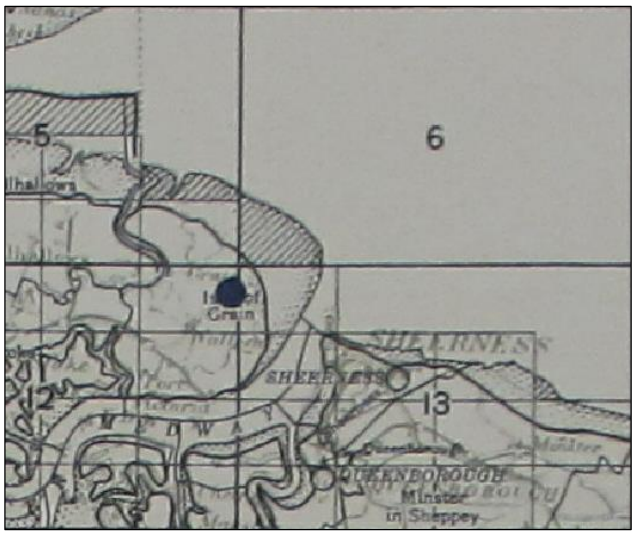
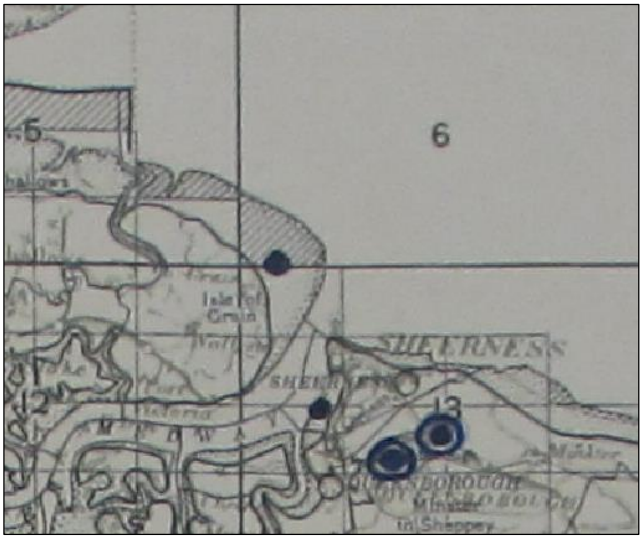


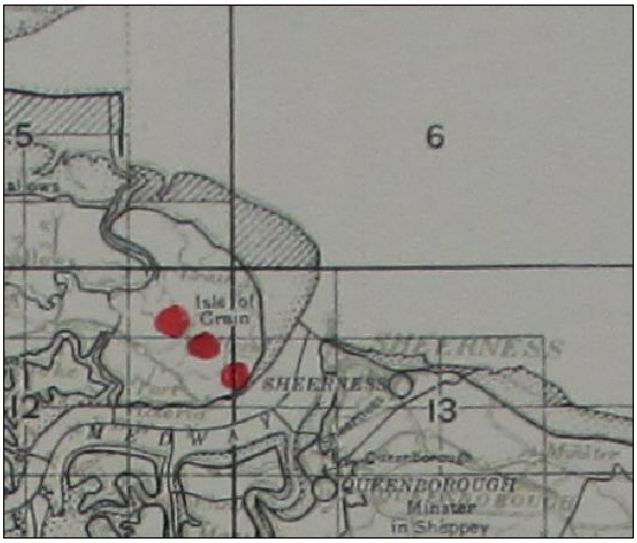

7th October 1940




17th October 1940




18th October 1940




17th November 1940

Incendiary Bomb

H.E Bomb

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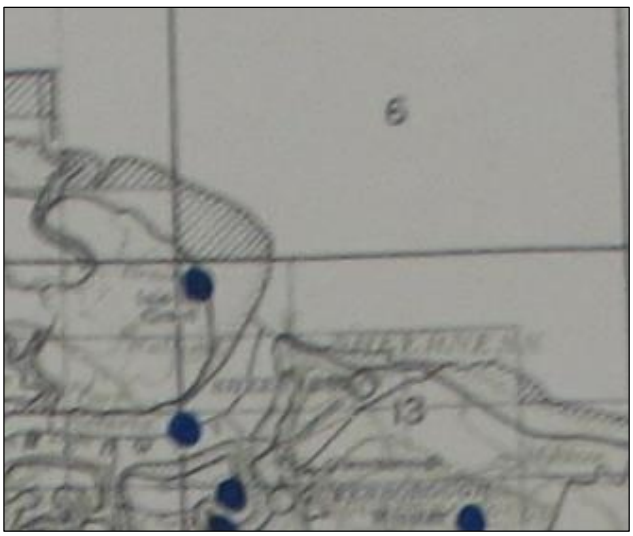
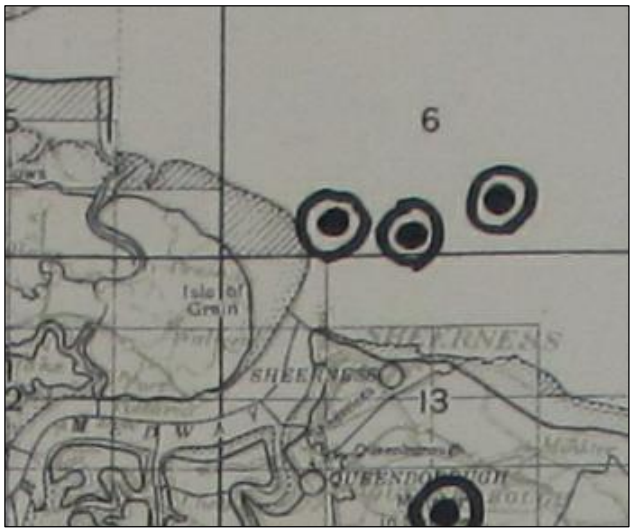
# Kent ARP Daily Bomb Mapping

Annex: **U3**

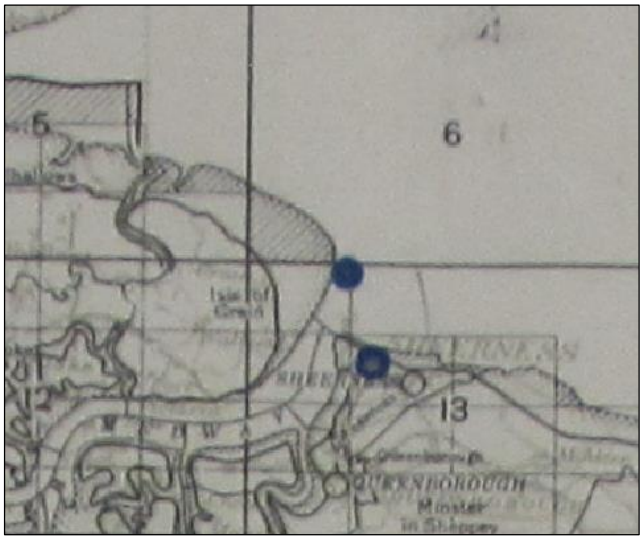



**27th November 1940**




**13th December 1940**

**19th April 1941**




**1st June 1941**

Incendiary Bomb  H.E Bomb  Parachute Mine

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Ref: **DA2985-01**  Source: Kent Archives

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# RAF Aerial Photography 28th August 1942

Annex: **V1**

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Client: **Intertek**

**Approximate study area**

Project: **HVDC Electricity Transmission Interconnector between the Isle of Grain, UK and Wilhelmshaven, Germany**

Ref: **DA2985-01**

Source: National Monuments Record Office (Historic England)

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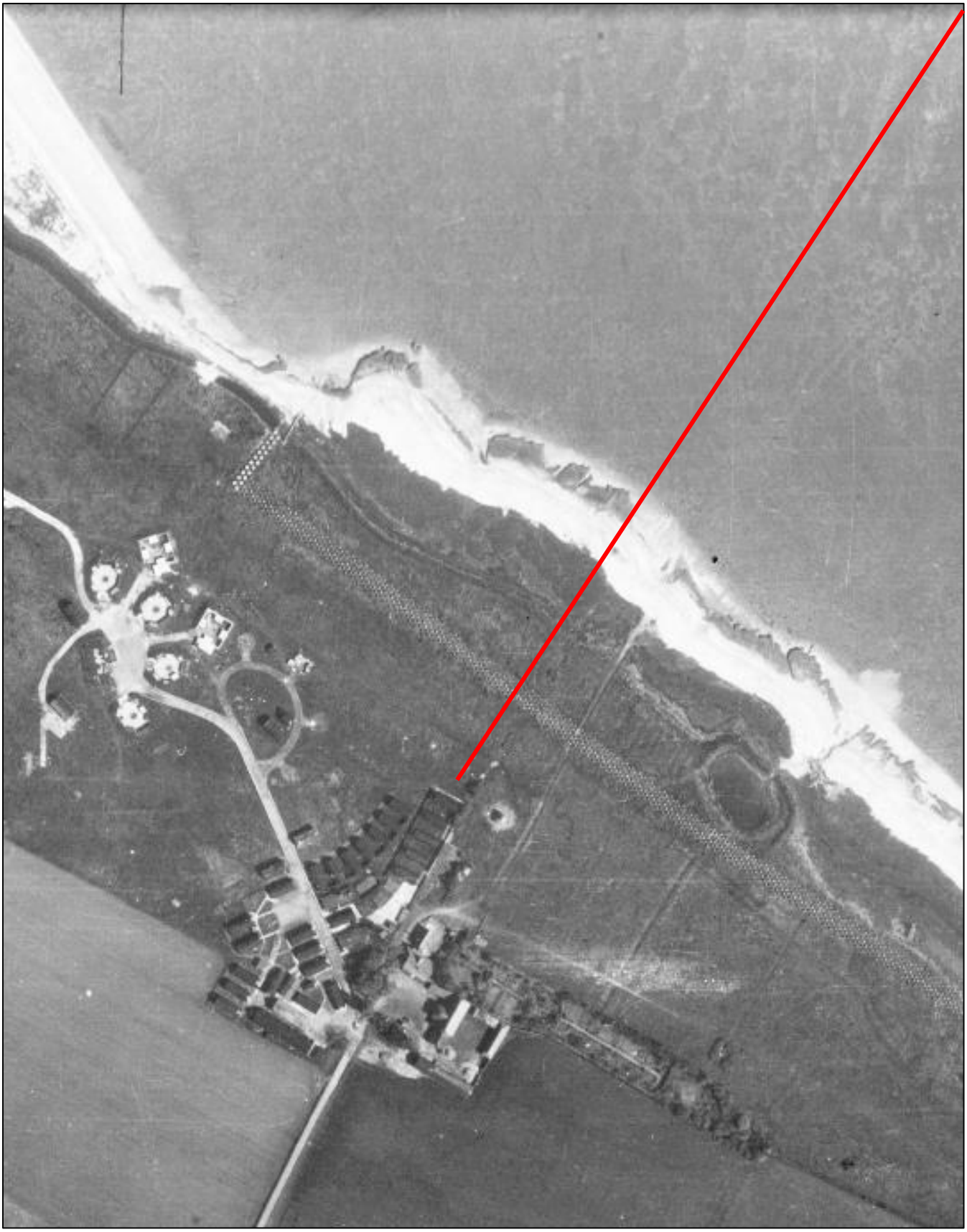
# RAF Aerial Photography 1st May 1946

Annex: **V2**



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**Approximate study area**

N

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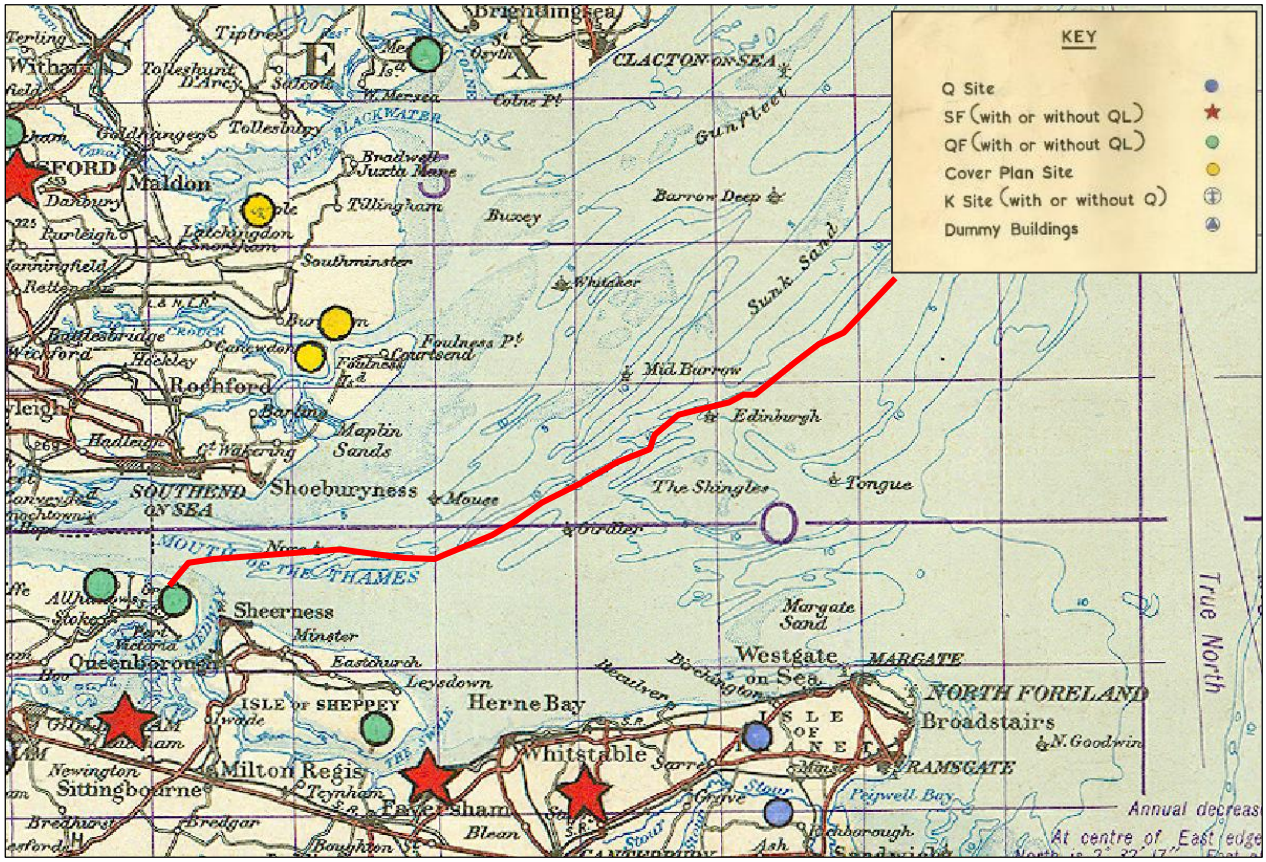
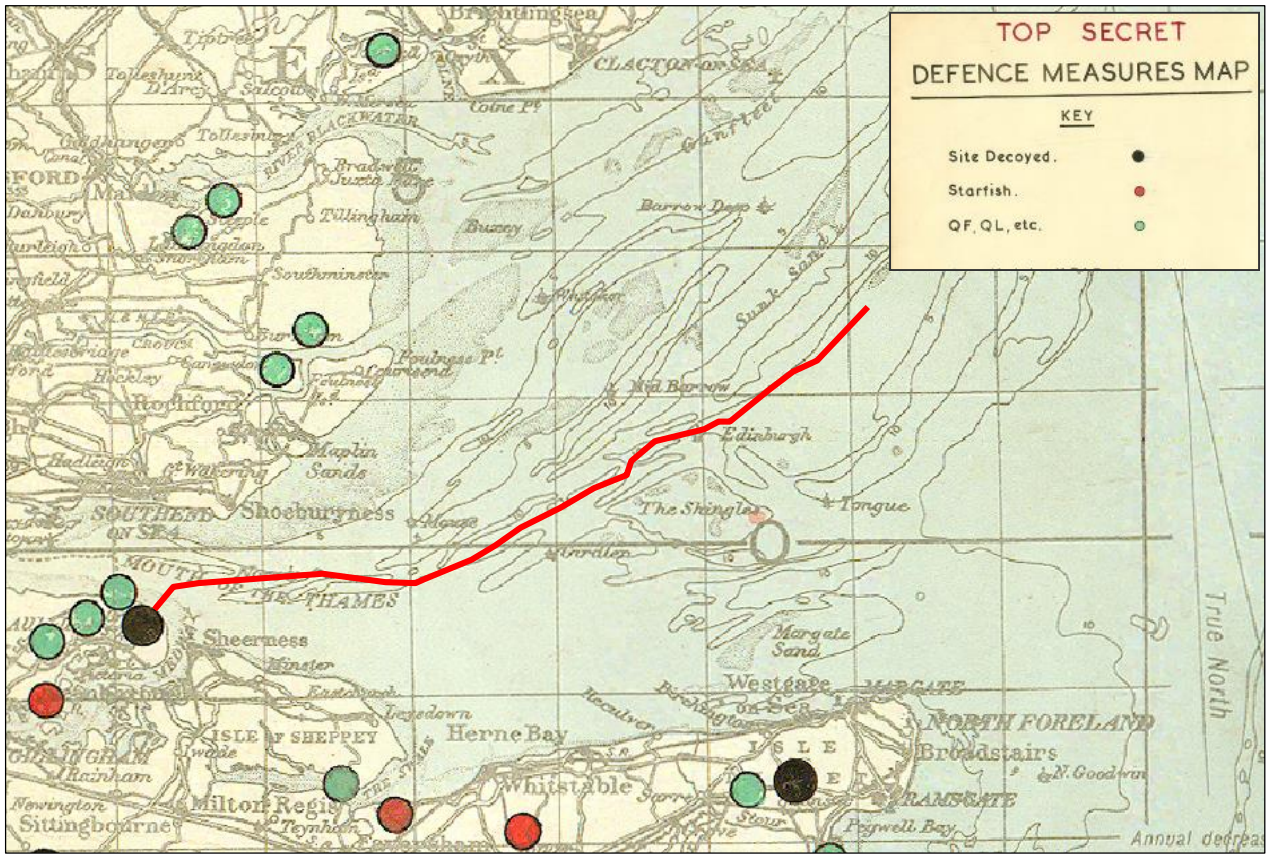
# Decoy Site Mapping

Annex: **W**

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Client: **Intertek**

**Approximate study area**

Project: **HVDC Electricity Transmission Interconnector between the Isle of Grain, UK and Wilhelmshaven, Germany**

N

Ref: **DA2985-01**

Source: The National Archives, Kew


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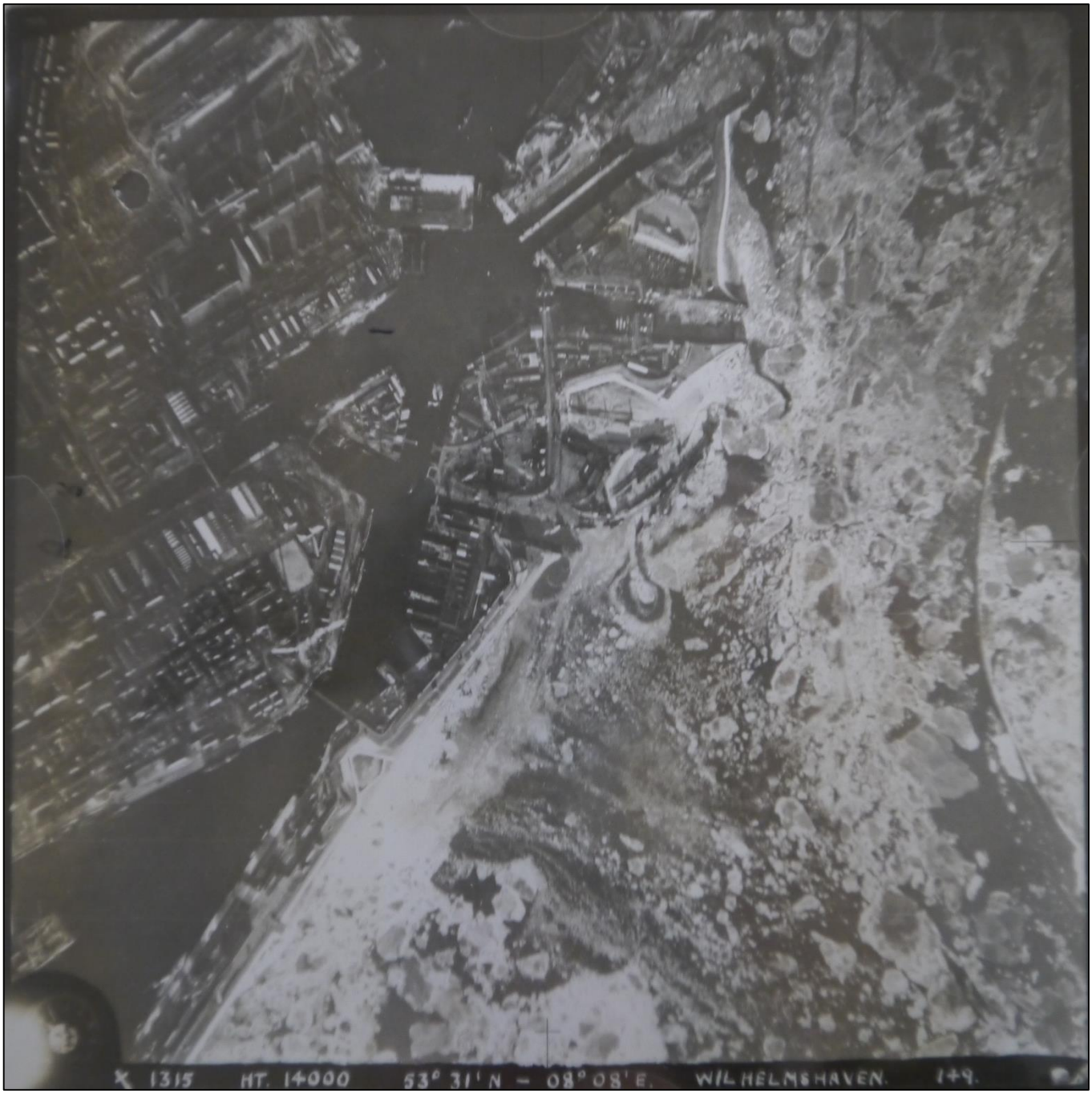
# Allied Target/Reconnaissance Photography of Wilhelmshaven

**Annex:** **X1**

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# Allied Target/Reconnaissance Photography of Wilhelmshaven

Annex: **X2**

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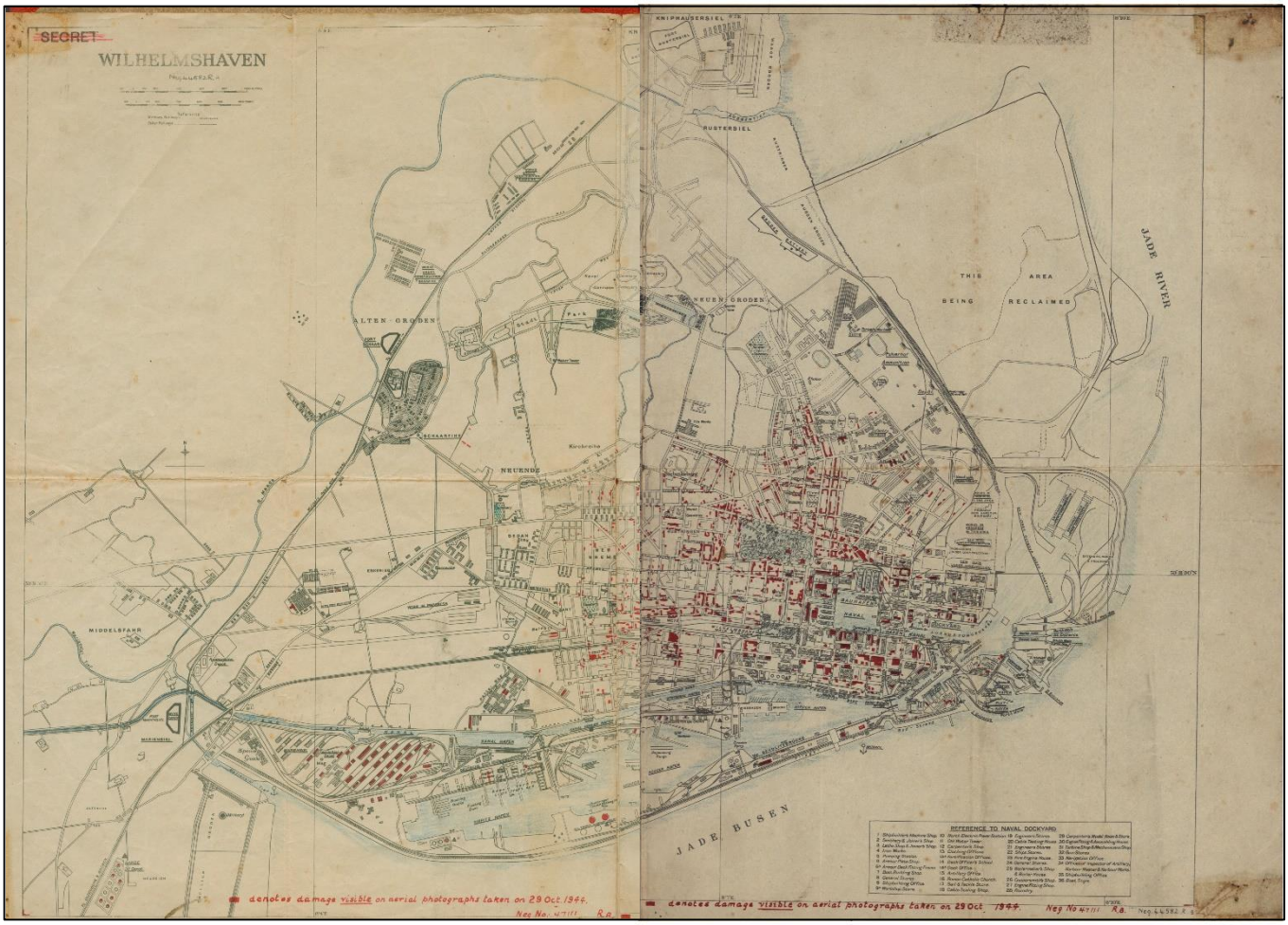
# Damage Mapping - Allied Bombing of Wilhelmshaven

**Annex:** **Y**



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Client: **Intertek**

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Ref: **DA2985-01**

Source: The City of Wilhelmshaven Archives


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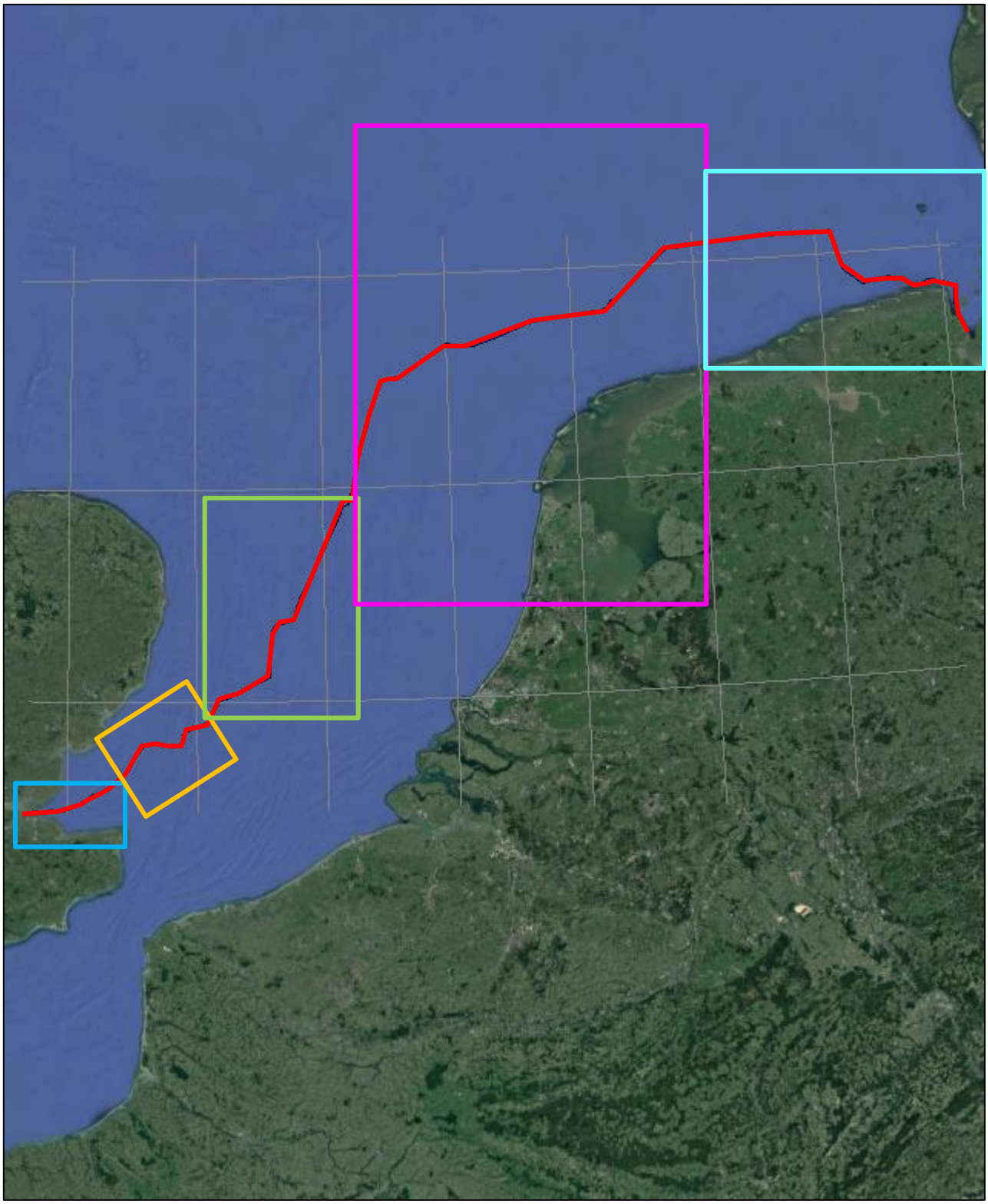
# OSPAR Munition Encounters

Annex: **Z1**



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Client: **Intertek**

**Approximate study area**

Project: **HVDC Electricity Transmission Interconnector between the Isle of Grain, UK and Wilhelmshaven, Germany**

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Ref: **DA2985-01**

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# OSPAR Munition Encounters

Annex: **Z2**

**Key:**

Conventional

Unknown

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# OSPAR Munition Encounters

Annex: **Z3**

**Key:**

Conventional

Unknown

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Ref: **DA2985-01**

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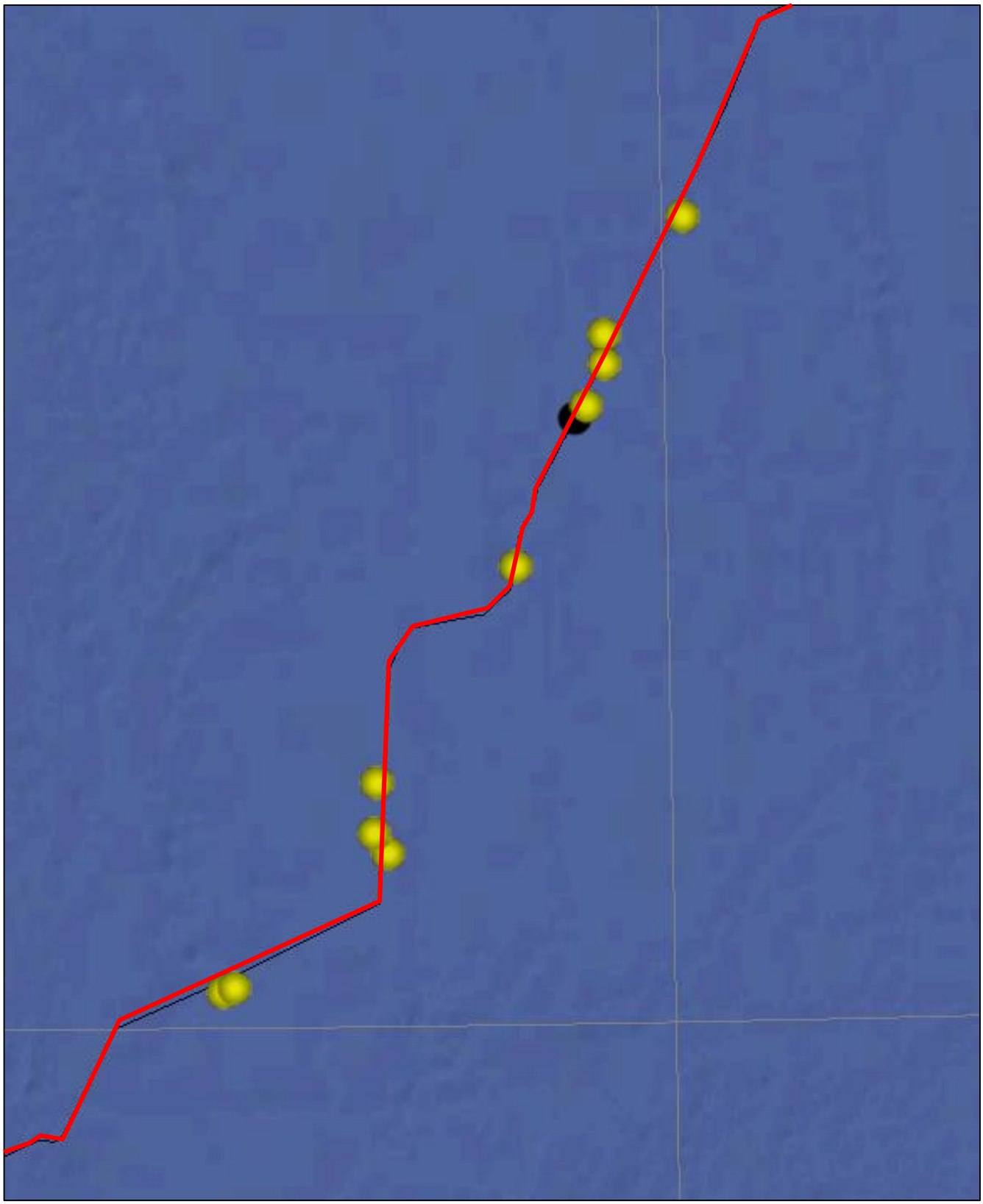
# OSPAR Munition Encounters

Annex: **Z4**



**Key:**

Conventional

Unknown

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Client: **Intertek**

**Approximate study area**

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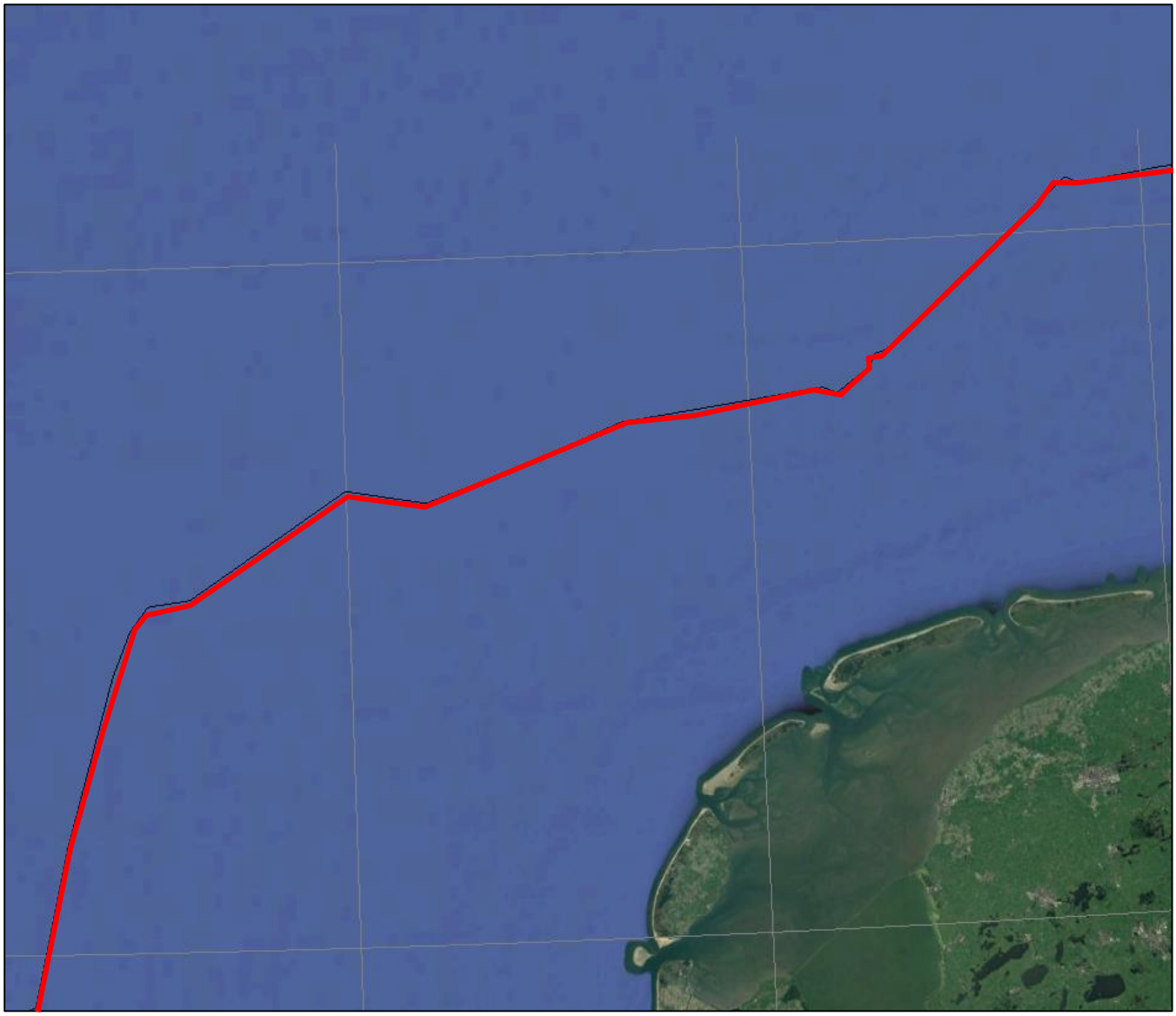
# OSPAR Munition Encounters

Annex: **Z5**



**Key:**

Conventional

Unknown

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Client: **Intertek**

**Approximate study area**

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# OSPAR Munition Encounters

Annex: **Z6**

**Key:**

Conventional

Unknown

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**Approximate study area**

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N

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| OSPAR Encounters with Dumped Conventional Munitions | | | | | | | |
|---|---|---|---|---|---|---|---|
| Ref | Lat/Long | Distance | Nature of find | Date | Action taken | State of munitions | Remarks |
| 503 | 51.58-0.785 | On route | Other | May 25, 2004 | Disposed of on land | Heavily corroded | None |
| 2119 | 51.481 -0.816 | On route | Entanglement in nets | July 13, 2006 | Destroyed | Partly corroded | Cylindrical float smoke |
| 2753 | 51.46-0.8405 | >0.75km | Entanglement in nets | April 8, 2011 | Destroyed | Partly corroded | None |
| 1340 | 52.033 -2.333 | >1.1km | Entanglement in nets | Nov 7, 2006 | Unknown | Unknown | None |
| 1082 | 52.034 -2.339 | >1.1km | Entanglement in nets | Nov 6 2006 | Unknown | Unknown | None |
| 2760 | 52.158 -2.58 | >0.8km | Entanglement in nets | May 14, 2009 | Unknown | Unknown | None |
| 2717 | 52.176 -2.559 | >0.8km | Entanglement in nets | Feb 24, 2009 | Unknown | Unknown | None |
| 2819 | 52.221 -2.564 | >0.7km | Entanglement in nets | Oct 28,2009 | Unknown | Unknown | None |
| 1091 | 52.416 -2.775 | On Route | Entanglement in nets | Nov 23, 2006 | Unknown | Unknown | Smoke float Mk5, |
| 2366 | 52.55-2.866 | >0.1km | Entanglement in nets | Sep 2, 2008 | Detonated by EODU | Unknown | Unexploded mine trawled by fishing vessel. |
| 1940 | 52.55-2.866 | >0.1km | Entanglement in nets | Sep 3, 2008 | Collected by EODU and destroyed | Unknown | Unexploded naval shell |
| 458 | 52.598 -2.911 | >0.4km | Entanglement in nets | Nov 29, 2005 | Destroyed | Unknown | None |
| 922 | 52.625 -2.912 | >0.9km | Entanglement in nets | April 24, 2006 | Destroyed | Unknown | None |
| 218365 | 52.783 -3.068 | >0.5km | Entanglement in nets | Sep 14, 2010 | Released at sea | Unknown | icked and dropped by FV Morgenster. Marked with Sonar buoy. Explosive o 31 on Dutch chart. 70*25cm with 1 detonator |



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| OSPAR Encounters with Dumped Conventional Munitions | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Ref** | **Lat/Long** | **Distance** | **Nature of find** | **Date** | **Action taken** | **State of munitions** | **Remarks** |
| 1593 | 53.816 -7.8 | >0.3km | Found on Shore | April 17, 2007 | Disposed of on land | Heavily Corroded | None |
| 1979 | 53.816 -7.91 | >2.5km | Found on Shore | 26 Nov, 2007 | Disposed of on land | Heavily Corroded | None |
| 2753 | 53.816 -7.91 | >2.5km | Found on Shore | Jan 1, 2006 | Disposed of on land | Heavily Corroded | None |
| 2003 | 53.816 -7.91 | >2.5km | Found on Shore | Jan 1, 2006 | Disposed of on land | Heavily Corroded | None |
| 2004 | 53.816 -7.91 | >2.5km | Found on Shore | Jan 1, 2007 | Disposed of on land | Heavily Corroded | None |
| 2005 | 53.816 -7.91 | >2.5km | Found on Shore | Jan 1, 2008 | Disposed of on land | Heavily Corroded | None |
| 1965 | 53.816 -7.91 | >2.5km | Found on Shore | 15 April, 2007 | Disposed of on land | Heavily Corroded | None |
| 2593[1] | 53.616 -8.129 | >3km | Dredging | Aug 31, 2009 | Disposed of on land | Partly Corroded | None |

[1] This munitions encounter is one of approximately 60 munitions encounters recorded at this grid reference.


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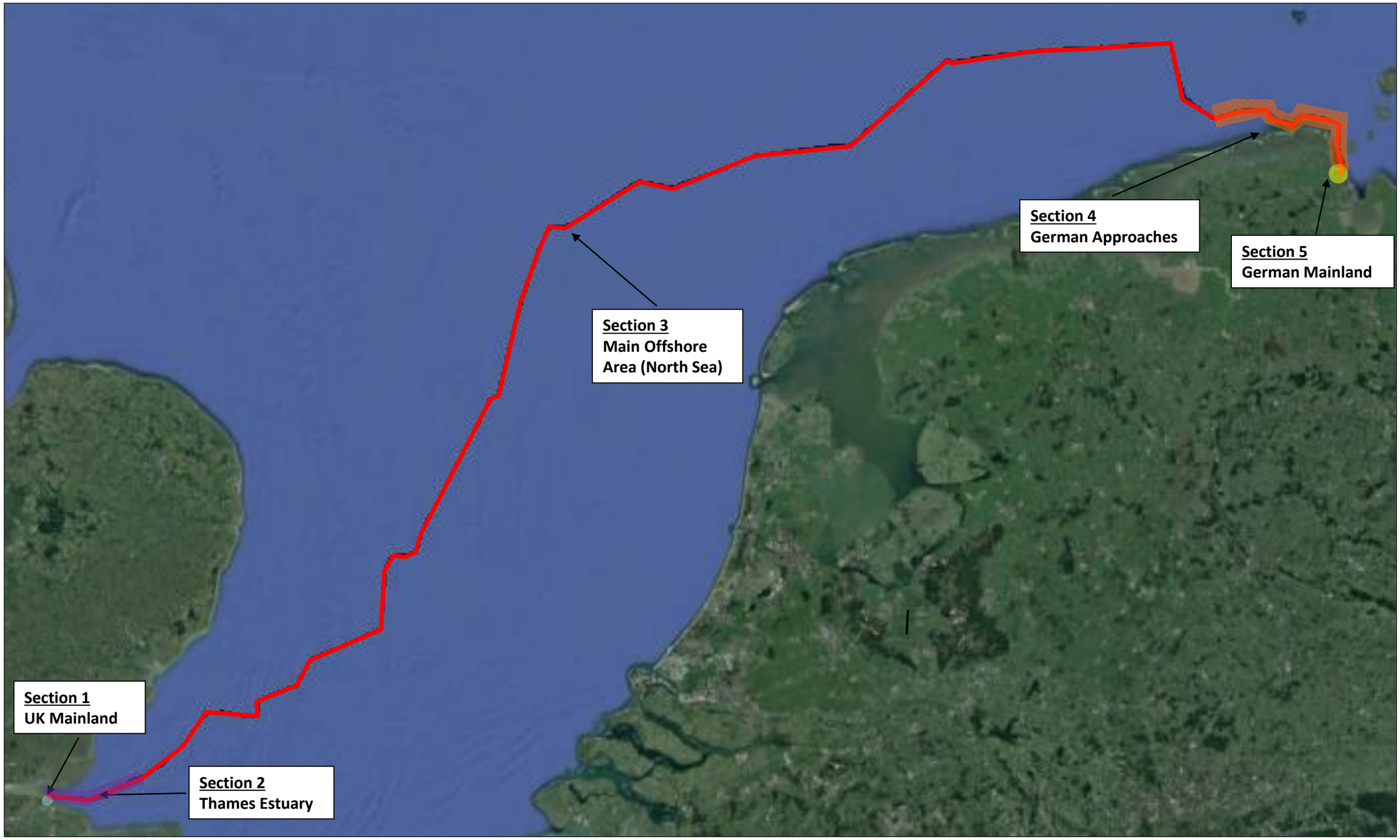
# Sections of the Study Area

Appendix: i

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Project: **HVDC Electricity Transmission Interconnector between the Isle of Grain, UK and Wilhelmshaven, Germany**

Ref: **DA6316-01**

**Approximate study area**

Source: 1st Line Defence

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# Overlay of Significant UXO Features - UK Mainland (Hoo Peninsula)

Appendix: ii

Wreck of SS Montgomery

Naval and Oil Bombing Decoy Sites

Yantlet Range (Firing Point)

Grain Fort

Grain Tower

Garrison Point, Sheerness

H Heavy Anti-Air Battery

L Light Anti-Aircraft Battery

P Pillbox

C Coastal Artillery Gun

*Extents of:*

Yantlet Demolition Range

Yantlet Range

Boom Defence

Anti-Tank Lines

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**Approximate study area**

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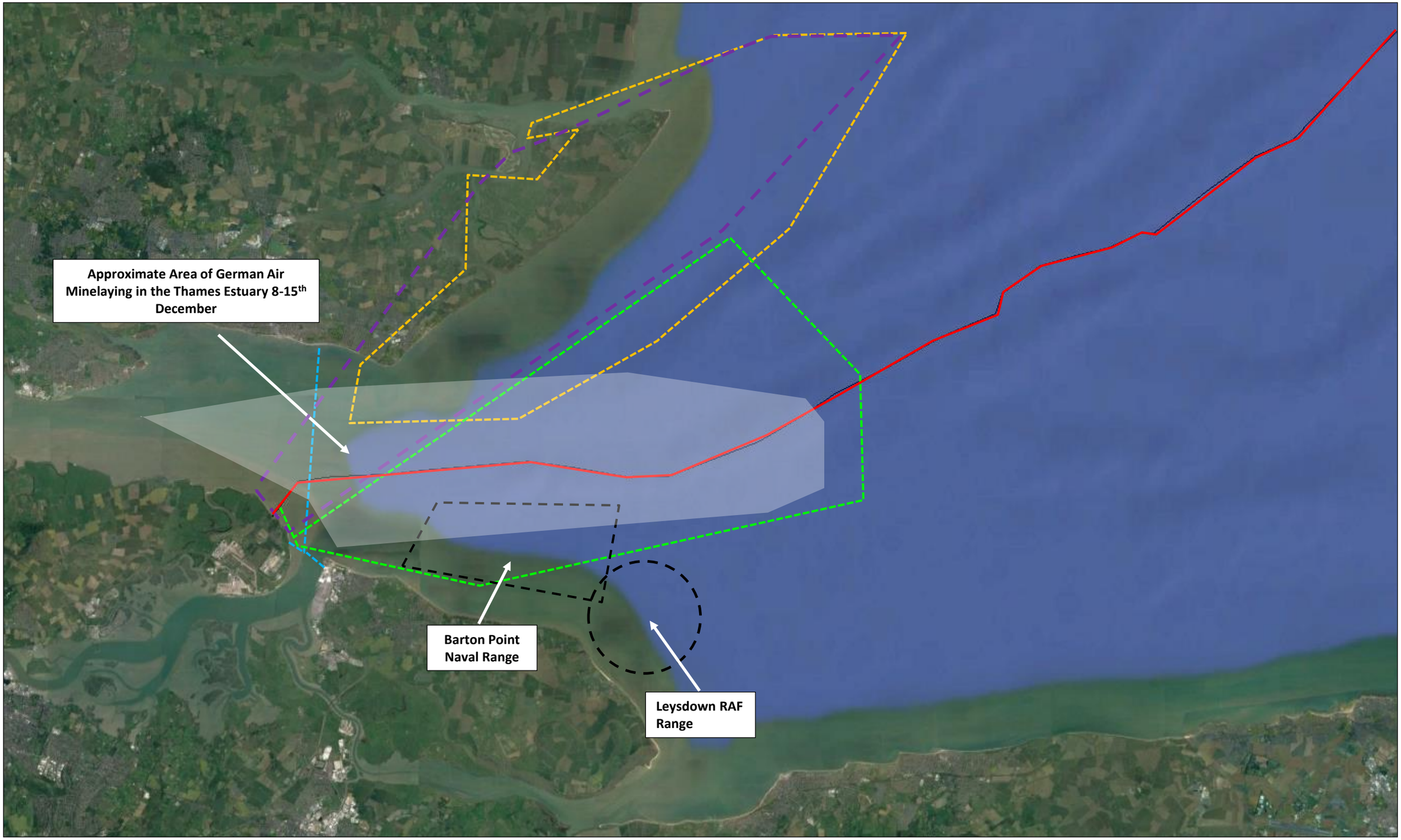
# Overlay of Significant UXO Features - Thames Estuary

Appendix: iii




*Extents of:*

Yantlet Range — Shoeburyness Range — Grain and Sheerness Range — Boom Defence

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| | | | |
|---|---|---|---|
| Client: | **Intertek** | **Approximate study area** | N |
| Project: | **HVDC Electricity Transmission Interconnector between the Isle of Grain, UK and Wilhelmshaven, Germany** | | |
| Ref: | **DA6316-01** | Source: 1st Line Defence | |

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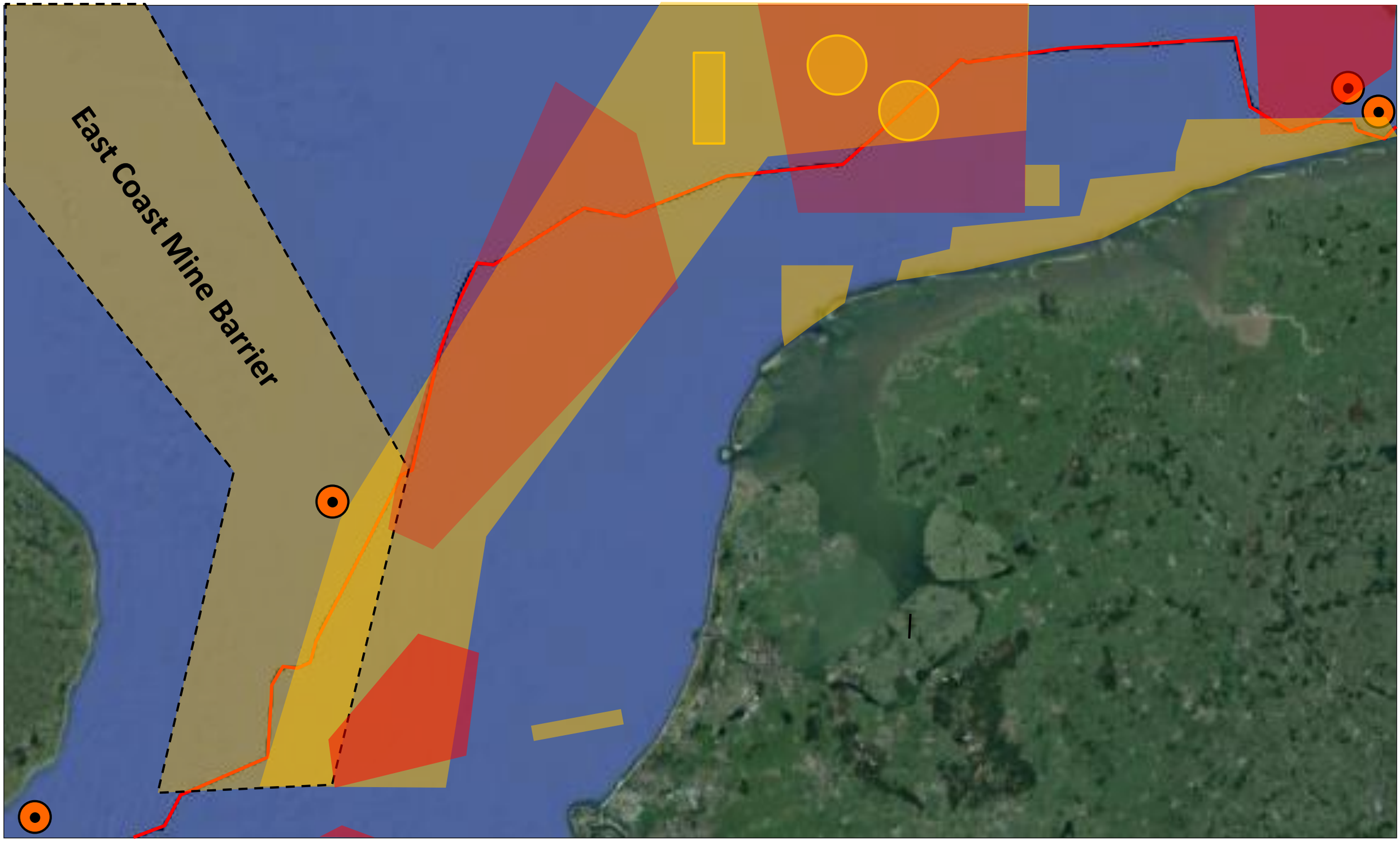
# Overlay of Significant UXO Features - Main Offshore Area

Appendix: iv




WWII-British Mine Area

WWII-German Mine Area

Conventional Munitions Dumpsites

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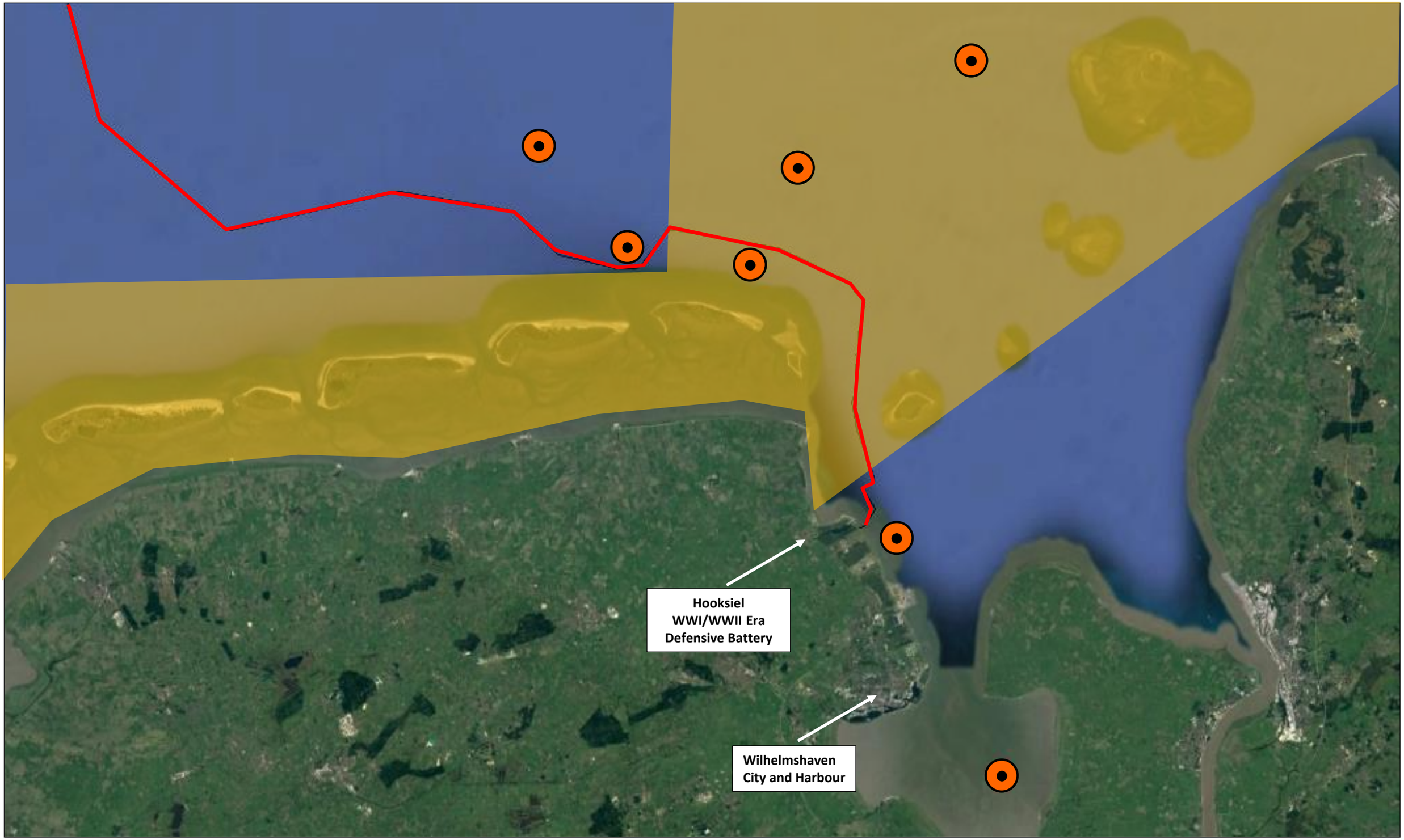
# Overlay of Significant UXO Features - German Approaches/German Mainland

Appendix: **v**




WWII-British Mine Area

Conventional Munitions Dumpsites

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**Tel:** +44 (0)1992 446 974

| | | | |
|---|---|---|---|
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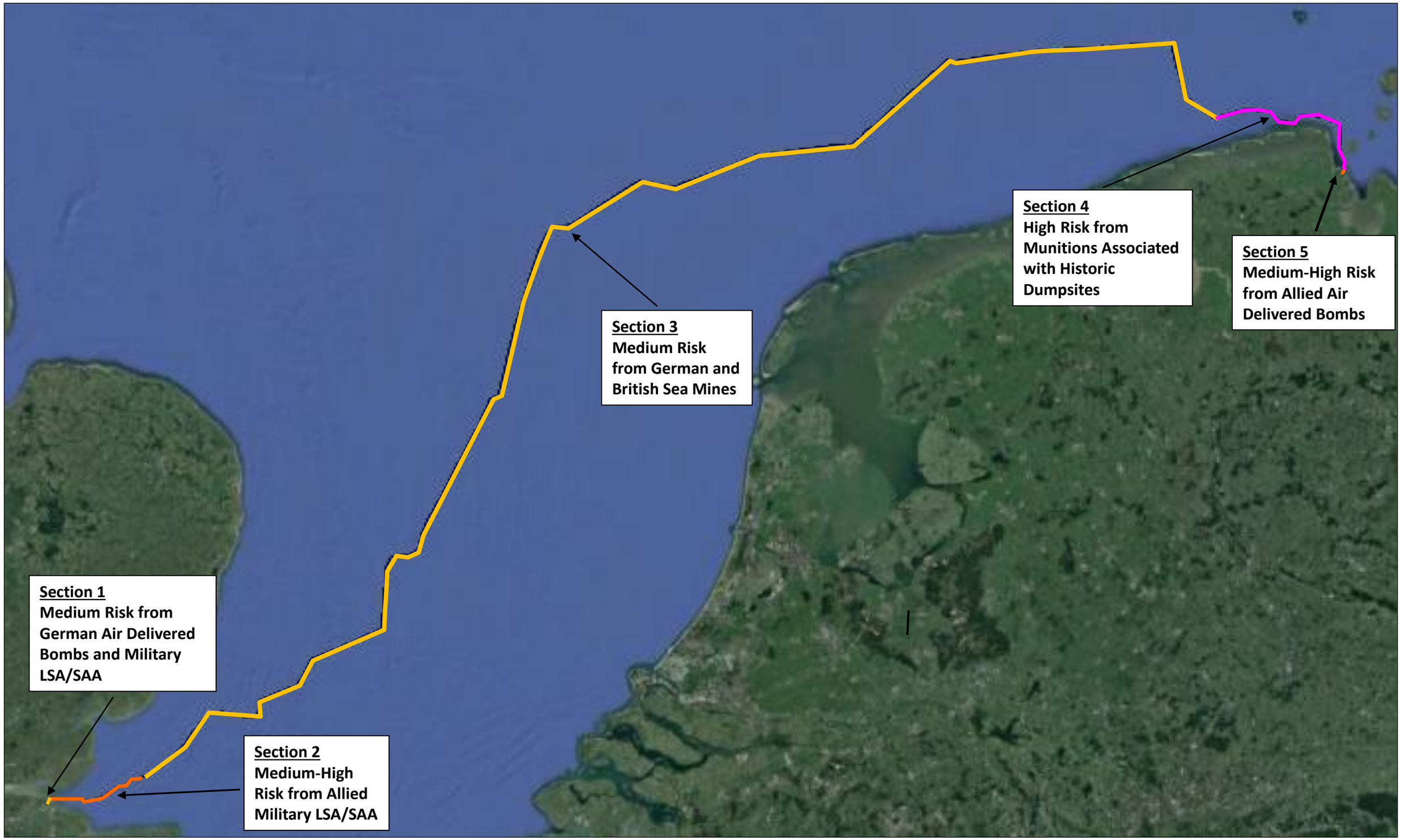


Low Risk | Medium Risk | Medium-High Risk | High Risk

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Ref: **DA6316-01**

**Approximate study area**

Source: 1st Line Defence

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# Bijlage 10: NC Fishery study, Orbicon/BioConsult SH, 3 april 2019

BioConsult SH

# Interconnector NeuConnect – Fishery study

**REPORT**

BioConsult SH

# Interconnector NeuConnect – Fishery study

**REPORT**

| | |
|---|---|
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| **Consultant** | Orbicon A/S<br>Linnés Allé 2<br>DK-2630 Taastrup |
| **Project no.** | 3621800039 |
| **Project manager** | Thoralf Hoth |
| **QA** | Anke Struve |
| **Document no.** | 02 |
| **Approved by** | Kristian Nehring Madsen |
| **Published** | 03-04-2019 |

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# 1 INTRODUCTION

NeuConnect is planning a new interconnector from the United Kingdom (UK) to Germany (Figure 1). This project is the development of a high voltage direct current (HVDC) electricity transmission interconnector between the Isle of Grain, Kent, mainland UK, and Hooksiel, Germany. It is routed through UK territorial waters (TW) and the exclusive economic zone (EEZ), the Dutch EEZ and the German TW and EEZ. Large infrastructure projects, like the HVDC-cable NeuConnect, will affect fishery during construction and operation phases. The fishery baseline study has been designed to provide the essential information on fleet and landing statistics on the trans-regional and regional level as well as an overview of the fishery in the near field of the alignment.

The present baseline report presents the official fishery and economic data available for the North Sea.

# 2 BACKGROUND AND OBEJECTIONS

NeuConnect Ltd. plans to connect the German and British energy markets with a high voltage cable. The NeuConnect project is a proposed 1,400 MW High Voltage Direct Current (HVDC) interconnector linking Germany and the United Kingdom. The interconnector will comprise HVDC submarine cables of approx. 680 km between Germany and the UK, with a section passing through Netherlands territorial waters (Figure 1). The interconnector will be designed to transmit electrical power in both directions across the Southern North Sea, UK territorial waters, through the Dutch EEZ and into German territorial waters and EEZ to link the electricity transmission systems in the UK and Germany.

A preliminary route has been proposed. It is subject to ongoing discussions with relevant stakeholders in each of the countries. A pair of cables will be buried in the seabed, typically to a depth of 2 to 3 meters.

The objective of this report is to provide comprehensive information about the fishery in the North Sea and the Dutch EEZ, the recent development of the landings, the distribution and the effort (measured as number of fished hours) of the fishery.

More specifically, the information from the collected data is essential for the assessment of which sections of the commercial fishery (e.g. fishing fleet and gear type) is most likely to be affected directly and indirectly by temporary and permanent impacts on fishery by the interconnector.

This baseline report summarizes the information of commercial fishery in the North Sea. It covers both trans-regional and regional data over the last 3 years (2014-2016). It was prepared to provide a solid foundation and refer-

ence for predicting and assessing possible changes to the fishery in relation to impacts caused by construction and operation of the interconnector.

Figure 1: Overview of the planned HVDC submarine cable between Germany and the UK with the section of the Netherlands EEZ (red line = cable route; dashed green line = EEZ borders; dotted blue line = territorial borders).

## 3 METHODOLOGY

The fishery in the North Sea is divided by international fishery zones where national and international fishery regulations, requirements and quotas apply. These zones (ICES subdivisions and ICES rectangles (approx. 30 x 30 nautical miles) are used as boundaries for the presentation of the official commercial fishery data. Table 1 and Figure 3 give an overview of the ICES rectangles that build the baseline for the presentation of fishery data. All references to near field and regional areas refer to data within these ICES rectangles.

The legal framework for using fishery data is based upon:

- Commission Decision of 18 December 2009 adopting a Multiannual Community Programme for the collection, management and use of data in the fisheries sector for the period 2011-2013 (2010/93/EU).
- Commission Implementing Decision of 13 August 2013 extending the programme as set out in Commission Decision 2010/93/EU to the period 2014-2016.
- Gentlemen agreement reached between DG Mare and the Member States about the evaluation of the fishing effort regimes.

Based on a request of the Commission to the STECF 'Working Group on Fishery-dependent Information' biologic data were compiled. They contain information about fishery regulated through fishing effort management schemes. The tables were prepared by processing and analyzing data from the fishing effort management schemes related to recovery and management plans in the following areas: the Baltic Sea, the North Sea, the Iberian Peninsula, the Western Channel and the Bay of Biscay, the western waters, the deep sea fishery and also fishery located in the Celtic Sea. Data are submitted by national authorities.

This baseline report gives a summary of the commercial fishery in the North Sea on a trans-regional and regional level over the last 3 available years (2014-2016).

For the description of the international fishery the eco-region “Greater North Sea” has been used as the investigation area (see Figure 1). This eco-region is covering the most important fishery areas in the North Sea. The national fishery of the Netherlands has been evaluated using ICES-rectangles for the Dutch EEZ (Figure 2 and Table 1).

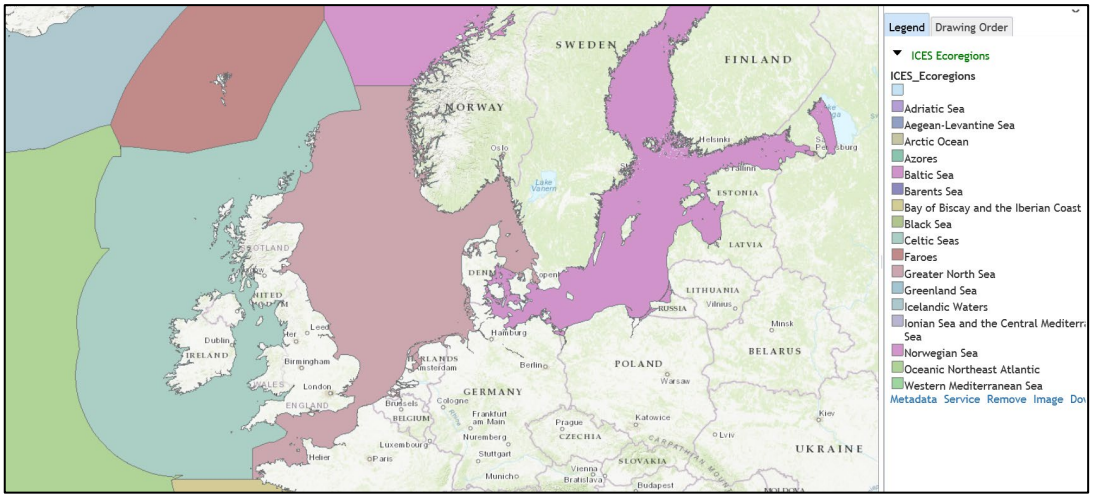



Figure 2: Overview on the several ecoregions in the North Sea. (data source: http://gis.ices.dk/sf/index.html?widget=visa&assessmentKey=9425).

## 3.1 Data sources

The current status of fishing was described based on activities, landing and effort data for the planned cable route as evaluated by the following authorities and institutions:

- ICES (International Council for the Exploration of the Sea),
- STECF 'Working Group on Fishery-dependent Information'.

The considered period shall cover at least the last three years in order to illustrate the development of the national and international fishery. The landing

data from the ICES and the STCW statistics provide information on existing fishery and the main target species. The ICES rectangles affected by the project have been analyzed in detail.

A map of the North Sea including the outlines of the ICES rectangles is shown in Figure 3. Table 1 gives an overview of ICES rectangles evaluated for the description of the fishery in the Dutch EEZ. The red lined squares show the rectangles, which will be affected directly by the projected cable route (34F3; 35F3; 35F4; 36F4; 36F5; 37F5; 37F6). These ICES-rectangles have been evaluated in detail to assess the impairment of the affected fishery or the commercially exploited fish species.

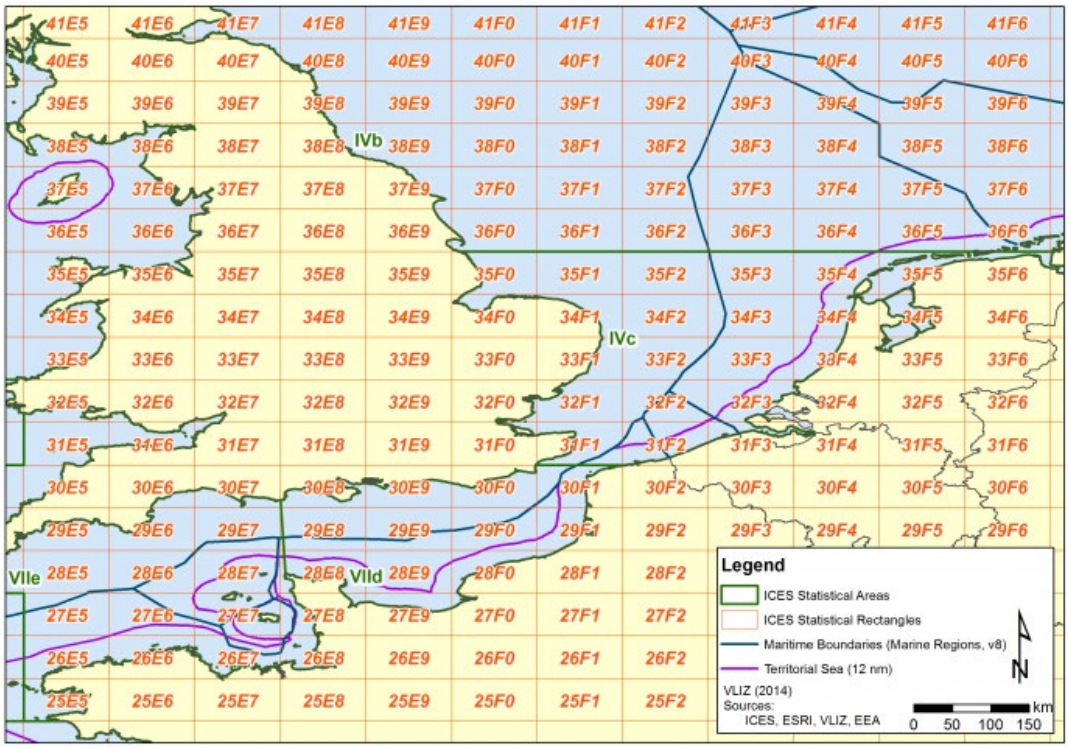



Figure 3: Overview of number and count of the ICES-rectangles within the Dutch EEZ. (data source: http://www.marineregions.org/maps.php?album=3753&pic=107478#photogallery).

It is important to note, that both the Dutch and European authorities are bound by laws that protect personal rights. These strongly limit what data and information they can make available. This resulted in numerous limitations of presenting more detailed data at the individual/vessel level in this baseline report. All official data were anonomised or they were of a character that did not divulge a fishing vessel or personal identity. Thus, data was generally received in a format that allowed only an overview of the fisheries with respect to data protection.

Table 1: Overview of the used ICES-rectangles which build the baseline for the assessment of the regional fisheries. (red lined squares = by the project directly affected rectangles).

| | | | | |
|---|---|---|---|---|
| | 40F3 | | | |
| | 39F3 | 39F4 | | |
| 38F2 | 38F3 | 38F4 | 38F5 | |
| 37F2 | 37F3 | 37F4 | 37F5 | 37F6 |
| 36F2 | 36F3 | 36F4 | 36F5 | 36F6 |
| | 35F3 | 35F4 | 35F5 | 35F6 |
| | 34F3 | 34F4 | 34F5 | |
| 33F2 | 33F3 | 33F4 | | |
| 32F2 | 32F3 | | | |
| 31F2 | 31F3 | | | |

# 4 RESULTS

## 4.1 Trans-regional fishery in the North Sea

The following chapter presents the analysis of the fishery activities on the trans-national level. The analyzed data cover the eco-region of the Greater North Sea and parts of the Celtic Seas (compare with Figure 2).

In the following, supra-regional and international fishery are presented on the basis of effort data. Effort data are available for the years 2014 to 2016. The distribution of the target fish species was recorded on the basis of catch data from ICES (International Council for the Exploration of the Sea). Data for the years after 2017 were not available. However, the evaluated data can be transferred to these years, as the various national fleet's fish generally on traditional target species in adjacent fishing areas.

### 4.1.1 Effort

Hereafter, the international fishery from the ecoregion "Greater North Sea" and parts of the "Celtic Seas" for the most important countries were analyzed (observation period 2006-2010).

In the recent years, the fishing activities in the area under consideration are mainly dominated by the nations Scotland accounting for 43% (15.166.867 t)

and England accounting for 20% (7.040.082 t). France, Northern Ireland and Denmark showed a significantly lower average of 6%-7% of the fished hours. All other countries reach a maximum of 4% of the total effort (see Figure 4 and Table 2).

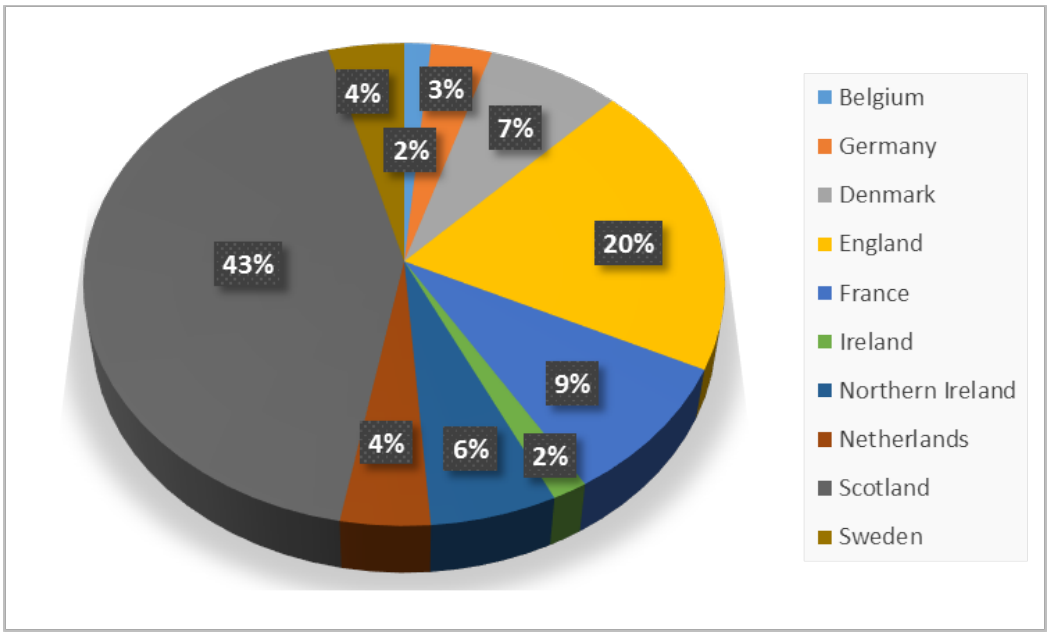


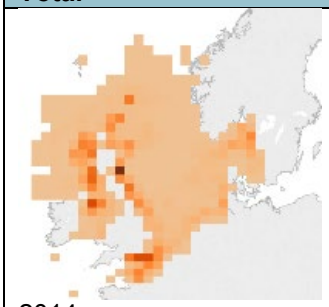
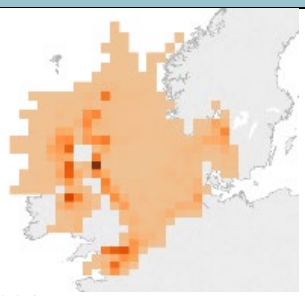
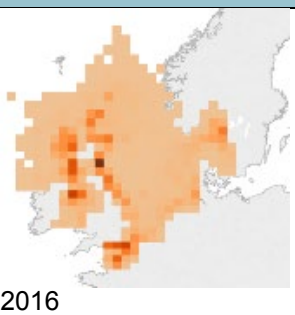

Figure 4: Overview of the percentage distribution of international fishery in the area under consideration.

Table 2: Overview of the effort (in fished hours) for the international fishery in the area under consideration.

| Country | 2014 | 2015 | 2016 | Total |
|---|---|---|---|---|
| Belgium | 180.985,00 | 170.080,00 | 170.052,00 | 521.117,00 |
| Germany | 382.446,00 | 399.712,00 | 411.943,00 | 1.194.101,00 |
| Denmark | 933.527,00 | 829.839,00 | 857.771,00 | 2.621.137,00 |
| England | 2.388.371,00 | 2.279.637,00 | 2.372.074,00 | 7.040.082,00 |
| France | 1.104.692,00 | 1.057.802,00 | 1.074.678,00 | 3.237.172,00 |
| Ireland | 182.226,00 | 186.451,00 | 209.911,00 | 578.588,00 |
| Northern Ireland | 718.162,00 | 675.605,00 | 679.978,00 | 2.073.745,00 |
| Netherlands | 497.233,00 | 478.123,00 | 489.321,00 | 1.464.677,00 |
| Scotland | 4.929.965,00 | 5.235.348,00 | 5.001.554,00 | 15.166.867,00 |
| Sweden | 476.096,00 | 495.646,00 | 515.198,00 | 1.486.940,00 |

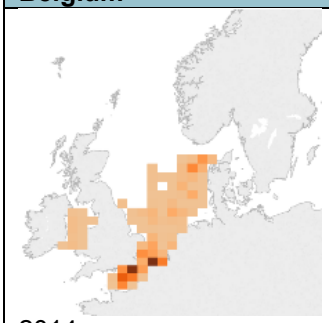
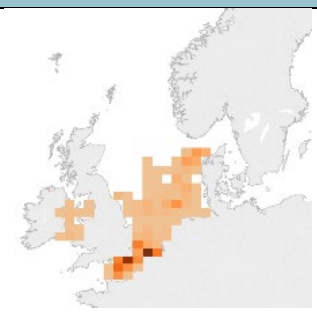
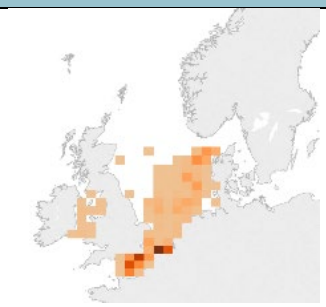
The main fishing areas for international fishery is located in the coastal areas of the neighboring countries. In particular, the English Channel and the coastal areas of Great Britain, Holland and Germany show the highest fishing activities (Table 3).

Table 3: Distribution of the Total fishing effort (in fished hours) in the area under consideration.

| Total | | |
|---|---|---|
|  2014 |  2015 |  2016 |

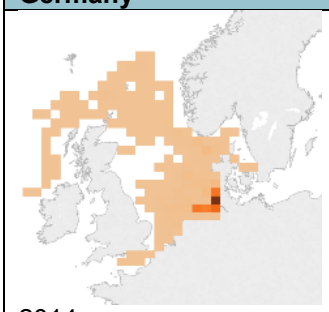
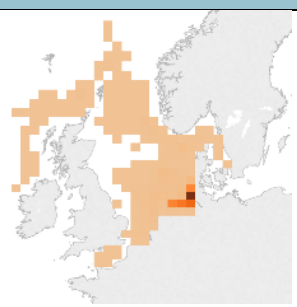
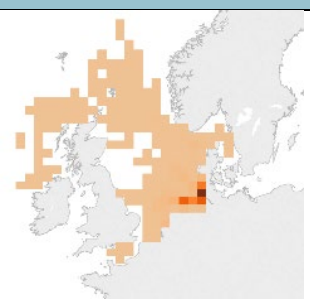
The Belgian fishery is concentrated in the southern North Sea. The English Channel and the Belgian territorial waters show the highest fishing effort (521.117 hours fished). Compared to the other nations, Belgian fisheries are of minor importance (Table 4).

Table 4: Distribution of the Belgium fishing effort (in fished hours) in the area under consideration.

| Belgium | | |
|---|---|---|
|  2014 |  2015 |  2016 |

The German fishery has their main fishing area within the German Bight. The most important fishing areas with the highest amount of fished hours are located in the coastal area of the territorial waters of Germany (Table 5). Compared to the other fishery nations, German fishery is of medium importance in the North Sea (1.194.101 hours fished).

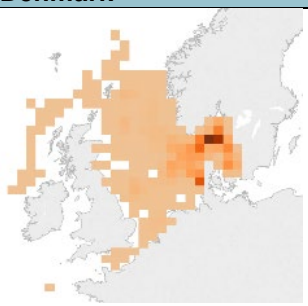
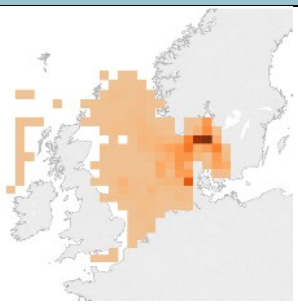
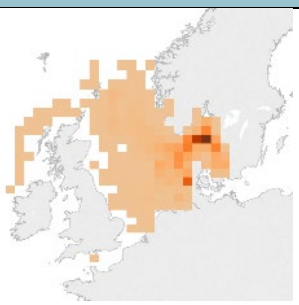
Table 5: Distribution of the German fishing effort (in fished hours) in the area under consideration.

| Germany | | |
|---|---|---|
|  2014 |  2015 |  2016 |

The Danish fishery is distributed over the entire North Sea. The coastal waters of Denmark and the sea areas of the Kattegat and Skagerrak show the

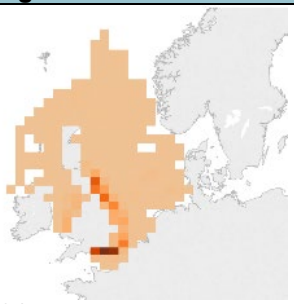
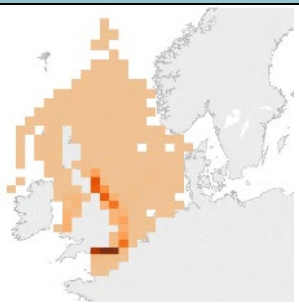
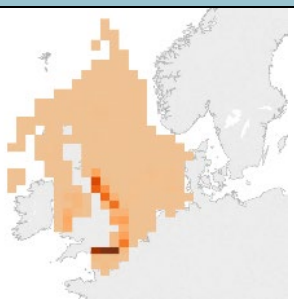
highest fishing effort in recent years (2.621.137 hours fished). Compared to the other fishery nations, Danish fishery are of medium importance in the North Sea (Table 6).

Table 6: Distribution of the Danish fishing effort (in fished hours) in the area under consideration.

| Denmark | | |
|---|---|---|
|  2014 |  2015 |  2016 |

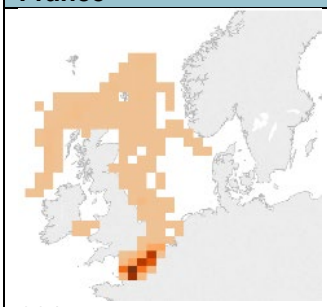
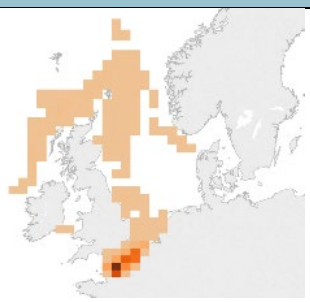
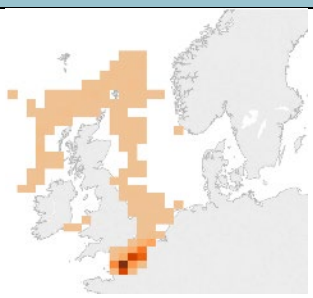
The English fishery extends to the whole North Sea. The areas of England's western coastal waters and the English Channel show the highest fishing intensity (7.040.082 hours fished). Differences in the distribution of fishery has not been observed in the last years. The English fishery is one of the two most important fisheries in the North Sea and has a high importance (Table 7 and Table 2).

Table 7: Distribution of the English fishing effort (in fished hours) in the area under consideration.

| England | | |
|---|---|---|
|  2014 |  2015 |  2016 |

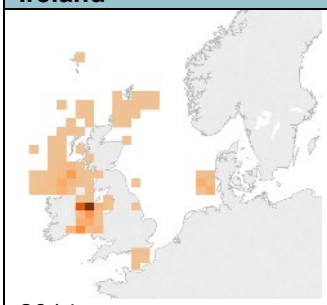
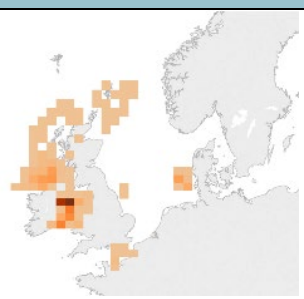
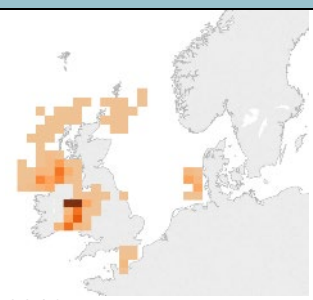
French fishery is particularly concentrated in the English Channel. In addition, the English coastal areas have a certain importance for French fishery. Compared to the other fishery nations, French fishery is of medium importance in the North Sea (3.237.172 hours fished).

Table 8: Distribution of the France fishing effort (in fished hours) in the area under consideration.

| France | | |
|---|---|---|
|  2014 |  2015 |  2016 |

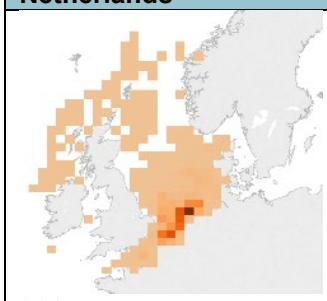
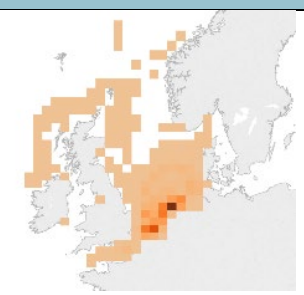
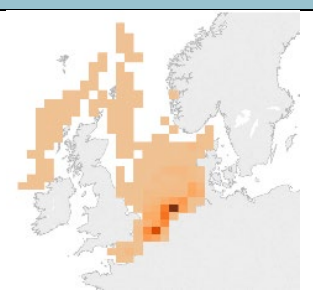
The Irish fishery is mainly concentrated in the Celtic Sea, where it has the highest number of fishing hours (578.588 hours fished). Irish fishery is of minor importance (Table 9).

Table 9: Distribution of the Irish fishing effort (in fished hours) in the area under consideration.

| Ireland | | |
|---|---|---|
|  2014 |  2015 |  2016 |

The southern North Sea and the English Channel are of major importance for Dutch fishery. The territorial waters of the Netherlands in particular show the highest fishing effort in the years under consideration (1.464.677 hours fished). Compared to international fishery, the Dutch fishery is of medium importance (Table 10 and Table 2).

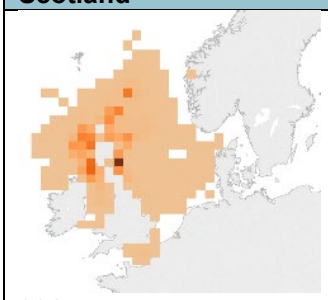
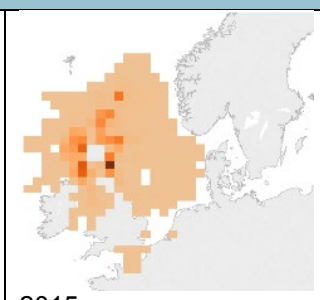
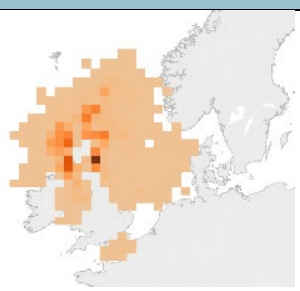
Table 10: Distribution on the Dutch fishing effort (in fished hours) in the area under consideration.

| Netherlands | | |
|---|---|---|
|  2014 |  2015 |  2016 |

Scottish fishery are concentrated in particular in the northern and central North Sea. The southern coastal areas have less fishing activities. The Scottish fishery dominate the international fishery. With 15,166,867 hours fished,

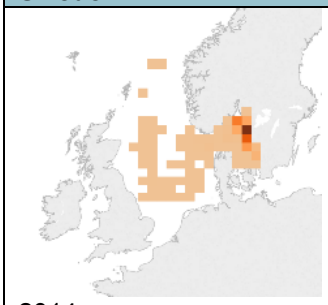
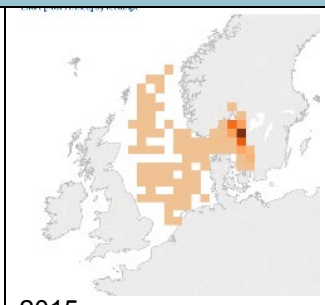
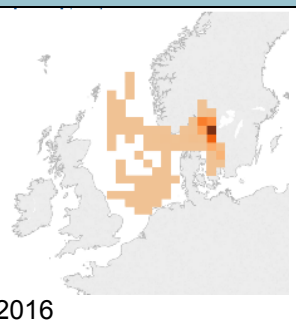
they represent more than 40% of the total North Sea fishery. Scottish fishery are the most important in the North Sea compared to international fishery (Table 11).

Table 11: Distribution of the Scottish fishing effort (in fished hours) in the area under consideration.

| Scotland | | |
|---|---|---|
|  2014 |  2015 |  2016 |

With 1,486,940 hours fished, the Swedish fishery shows a medium fishing intensity. It concentrates in particular on the waters of the Kattegat and Skagerrak. Compared with international fishery, Swedish fishery is insignificant in the North Sea (Table 12).

Table 12: Distribution of the Swedish fishing effort (in fished hours) in the area under consideration.

| Sweden | | |
|---|---|---|
|  2014 |  2015 |  2016 |

### 4.1.2 Landings

Fishery landings are mainly dominated by the species groups of fish and crustaceans. Both groups represent 94% of all landings from the North Sea (Figure 5). Crabs and shrimps are summarized to one group with together 6% of the total landings in the last decade. This group is characterized by the most important crab and shrimp species like Common shrimp and European lobster (compare with Table 13). About 88% of the total landings are composed by fish species. The most important commercial fish species in the last decade in the North Sea are Herring, Mackerel, Sandeel, Sprat, Blue Whiting, Plaice, Horsemackerel, Saithe, Haddock and Cod. The pelagical fish species Herring (23%), Mackerel (19%) and Sprat (15%) as well as Sandeel (12%) dominated the landings in the North Sea and the adjacent waters (Figure 5; Figure 6 and Table 13).

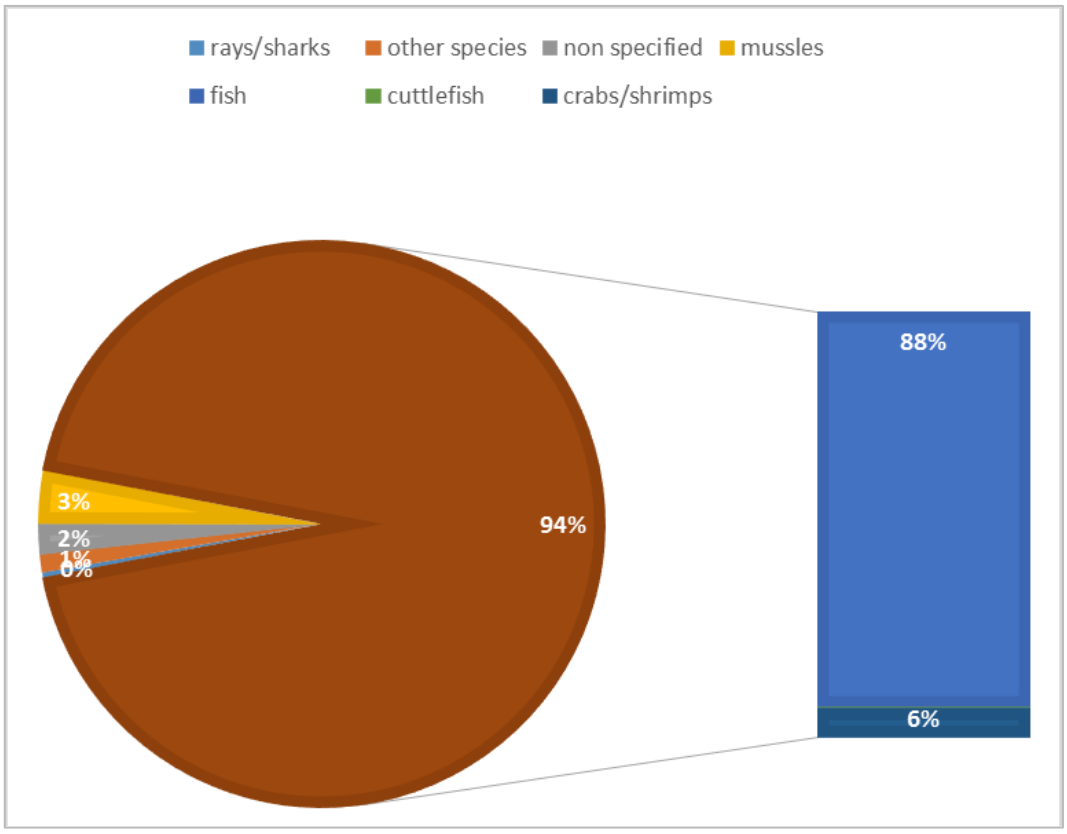



Figure 5: Overview of the percentage distribution of the target fishery species groups in the area under consideration.

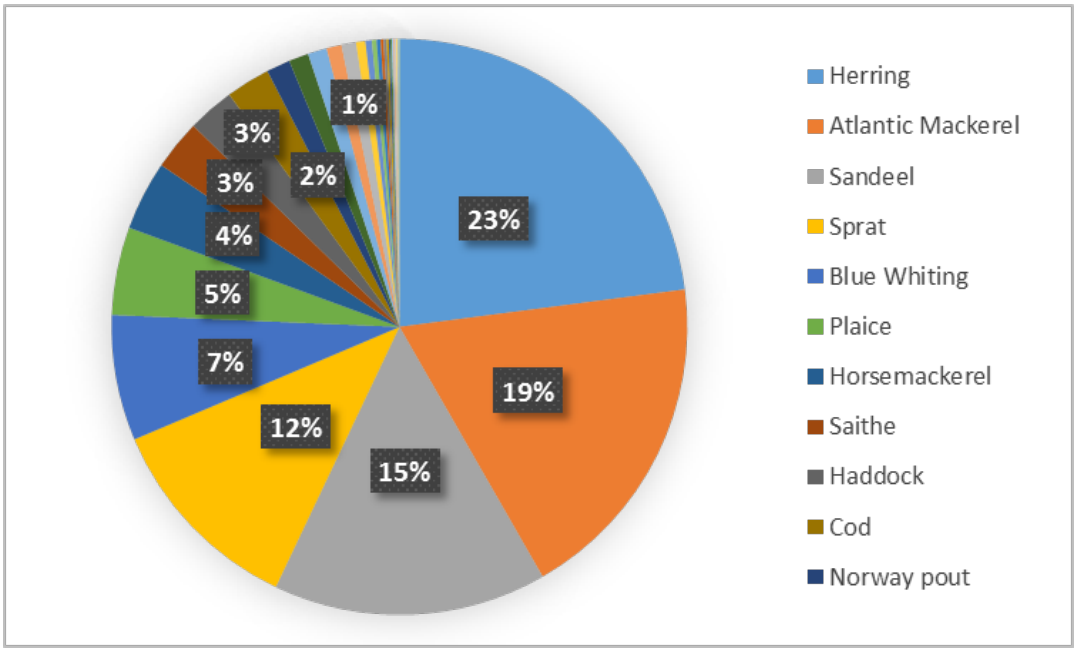



Figure 6: Overview of the percentage distribution of the target fish species in the area under consideration.

Table 13: Distribution of landings (in t) for the main target fishery species / species groups in the area under consideration.

| Landings in t | Species/species group | Commercial type |
|---|---|---|
| 4.645.646,30 | Herring | fish |
| 3.808.001,20 | Atlantic Mackerel | fish |
| 3.111.445,40 | Sandeel | fish |
| 2.340.465,40 | Sprat | fish |
| 1.429.489,30 | Blue Whiting | fish |
| 999.335,00 | Plaice | fish |
| 789.806,80 | Horsemackerel | fish |
| 618.500,90 | Norway lobster | crabs/shrimps |
| 569.465,00 | Saithe | fish |
| 532.984,70 | Haddock | fish |
| 502.498,70 | Cod | fish |
| 423.898,40 | Great Atlantic scallop | mussles |
| 387.598,30 | Common shrimps | crabs/shrimps |
| 357.336,00 | Edible crab | crabs/shrimps |
| 270.463,20 | Norway pout | fish |
| 224.900,50 | Common sole | fish |
| 219.910,80 | Blue mussel | mussles |
| 216.916,80 | Whiting | fish |
| 171.274,90 | Hake | fish |
| 165.250,80 | Anglerfishes | fish |
| 106.073,20 | Dab | fish |
| 72.724,00 | Ling | fish |
| 61.051,90 | Northern prawn | crabs/shrimps |
| 60.013,30 | Rays | rays/sharks |
| 53.486,50 | Lemon sole | fish |
| 46.786,60 | Queen scallop | mussles |
| 44.080,90 | Turbot | fish |
| 34.257,40 | Megrim | fish |
| 34.137,60 | Flounder | fish |
| 26.364,30 | Common cuttlefish | cuttlefish |
| 24.121,00 | Greater silver smelt | fish |
| 23.970,90 | squid | cuttlefish |
| 23.174,20 | European lobster | crabs/shrimps |
| 17.569,70 | Picked dogfish | fish |
| 17.462,60 | Black scabbard-fish | fish |
| 17.417,20 | Tub gurnard | fish |
| 16.452,90 | Blue ling | fish |
| 16.194,80 | European anchovy | fish |
| 15.950,20 | cat-shark | rays/sharks |
| 15.423,40 | European seabass | fish |
| 11.168,90 | Velvet swim crab | crabs/shrimps |
| 10.163,50 | Grenadier | fish |
| 9.558,80 | Surmullet | fish |
| *235.675,30* | *other species** | *other species** |
| *397.555,90* | *non specified** | *non specified** |

Over the last 10 years, varying landings have occurred for the main commercial fish species. The catches of the pelagic species (herring, mackerel, and sprat) increased continuously between 2003 and 2005. Subsequently, land-

ings for all three species decreased significantly. From 2011 catches recovered again and have remained relatively stable at values above 350,000 t (mackerel and herring). Since 2013, landings of sprat have also recovered and recorded the highest landings in 2015, within the entire time period. In contrast, the landings of sandeel showed relatively stable catches between 180,000 t and 330,000 t in the period until 2011. The last years show a decreasing trend for the sprat landings in the North Sea.

All other fish species showed very constant catches over the entire period under consideration. The landings were clearly below the quantities of the main target species (<100,000 t). However, these fish species are rather insignificant for fishing in the North Sea as a whole, they may well be of particular importance locally for the various national fishery.

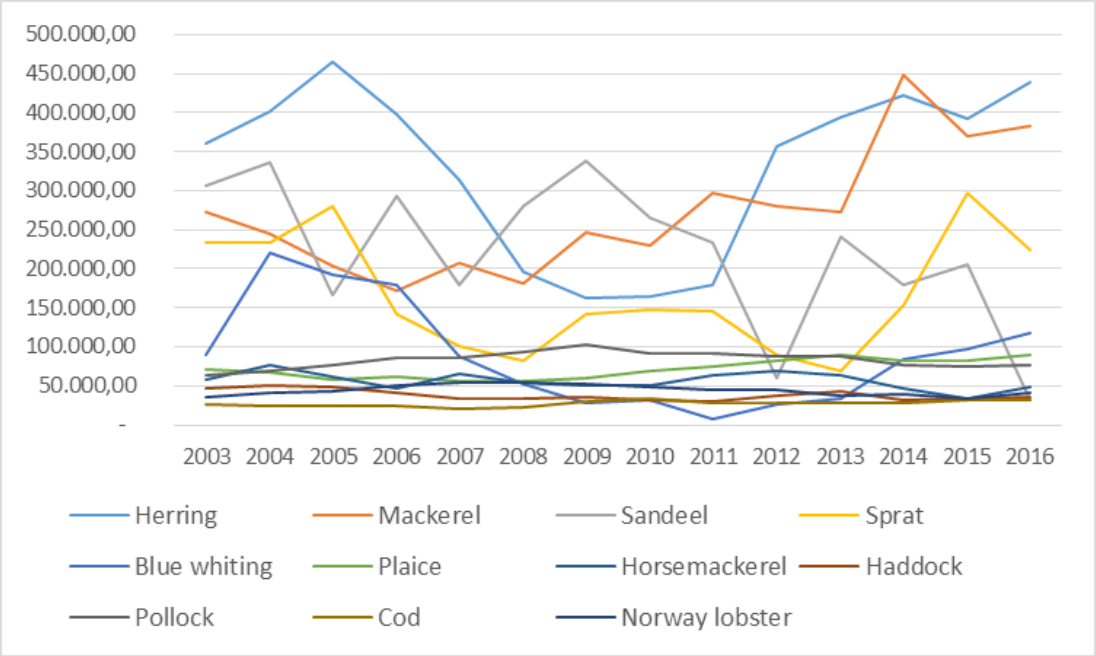



Figure 7: Overview of the development of landing of target fish species in the area under consideration in the last decade.

## 4.2 Regional fishery in the Dutch EEZ

The following chapter presents the analysis of the fishery activities on the national level. The analyzed data covers the Dutch EEZ and the territorial waters of the Netherlands (compare with chapter 3).

### 4.2.1 Effort

Within the Dutch EEZ, the Dutch fishery dominates in all years under consideration. The effort was consistently above 370,000 hours. This corresponds to more than 50% of the total fishing effort in the Dutch EEZ. In addition, German fishery also accounted for a maximum of 16% of the analyzed fishing effort (> 73,000 hours fished). The fishery nations Belgium, Denmark,

England and France had a low importance within the Dutch EEZ with a portion between 5% and 10% (Figure 8 and Table 14).

Table 14: Distribution of the total effort (in hours fished) for the international fishery in the Dutch EEZ in the recent years.

| Country | Total effort in hours | | | Total |
|---|---|---|---|---|
| | 2014 | 2015 | 2016 | |
| Belgium (BEL) | 61.986 | 58.874 | 63.060 | 183.920 |
| Germany (DEU) | 73.578 | 79.893 | 107.749 | 261.220 |
| Denmark (DNK) | 35.478 | 44.590 | 24.889 | 104.957 |
| England (ENG) | 52.718 | 51.534 | 49.815 | 154.067 |
| France (FRA) | 37.213 | 35.219 | 47.077 | 119.509 |
| Lithuania (LTU) | 20 | - | - | 20 |
| Northern Ireland (NIR) | 216 | 64 | 36 | 316 |
| Netherlands (NLD) | 396.827 | 371.524 | 369.383 | 1.137.734 |
| Scotland (SCO) | 10.345 | 12.849 | 22.071 | 45.265 |
| Sweden (SWE) | 258 | 601 | 909 | 1.768 |

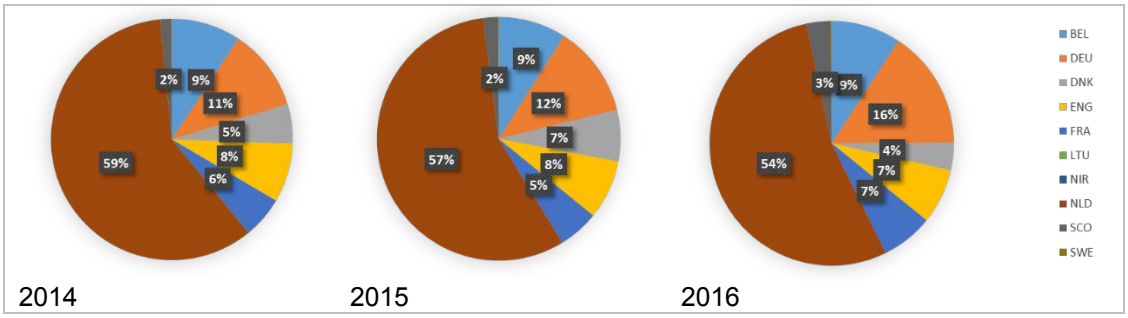
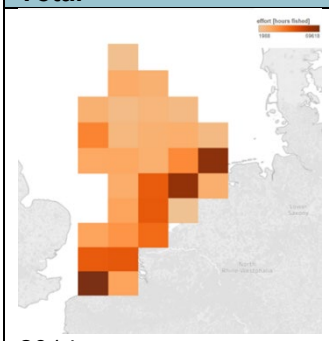
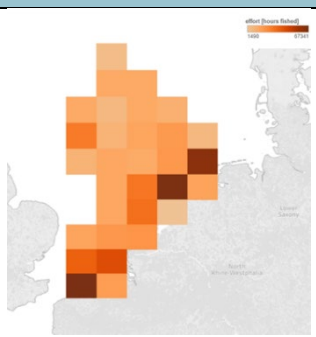
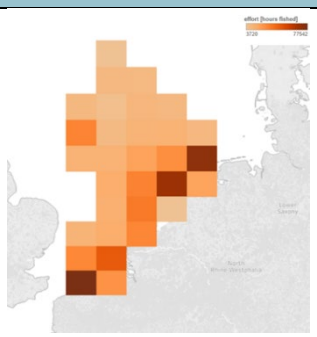



Figure 8: Overview of the proportion of fishing effort in the Dutch EEZ in the recent years.

A closer look at the distribution of fishing effort shows that the most important fishing grounds lie along the coastal areas of the Dutch EEZ. In contrast, the ICES rectangles which are affected by the cable project show a medium fishery effort compared to the ICES rectangles along the coast. On the other hand, the rectangles of the northern Dutch EEZ reveal a lower fishery effort.

Table 15: Overview of the distribution of fishing effort in the Dutch EEZ in the recent years.

| Total | | |
|---|---|---|
|  |  |  |
| 2014 | 2015 | 2016 |

In the next stage, the analysis of fishing effort shall be carried out separately categorized by fishing gears. The analysis will only evaluate fishing gears that have had an effort of more than 500 hours during the period under consideration.

## BEAM TRAWL

The beam trawl fishery is mainly characterized by the Dutch fishery. More than 68% (945.528 h) of the total effort is allocated to Dutch fishery. Belgium and Germany, with 10% and 15% respectively, also show significant shares of fishing effort. Their effort of less than 215,000 hours is substantially lower than the Dutch effort. All other nations are not important for beam trawl fishery in the Dutch EEZ (Table 16 and Figure 9).

Table 16: Distribution of the effort (in hours fished) for the international beam trawl fishery in the Dutch EEZ in the recent years.

| Effort in hours for beam trawl | | | | |
|---|---|---|---|---|
| **Country** | **2014** | **2015** | **2016** | **Total** |
| Belgium (BEL) | 45.005 | 48.449 | 48.800 | 142.254 |
| Germany (DEU) | 59.504 | 61.175 | 92.048 | 212.727 |
| Denmark (DNK) | - | - | - | - |
| England (ENG) | 28.246 | 25.875 | 22.766 | 76.887 |
| France (FRA) | 1.011 | 2.370 | 2.357 | 5.738 |
| Lithuania (LTU) | - | - | - | - |
| Northern Ireland (NIR) | - | - | - | - |
| Netherlands (NLD) | 325.874 | 306.909 | 312.745 | 945.528 |
| Scotland (SCO) | 1.469 | 2.663 | 1.648 | 5.780 |
| Sweden (SWE) | - | - | - | - |

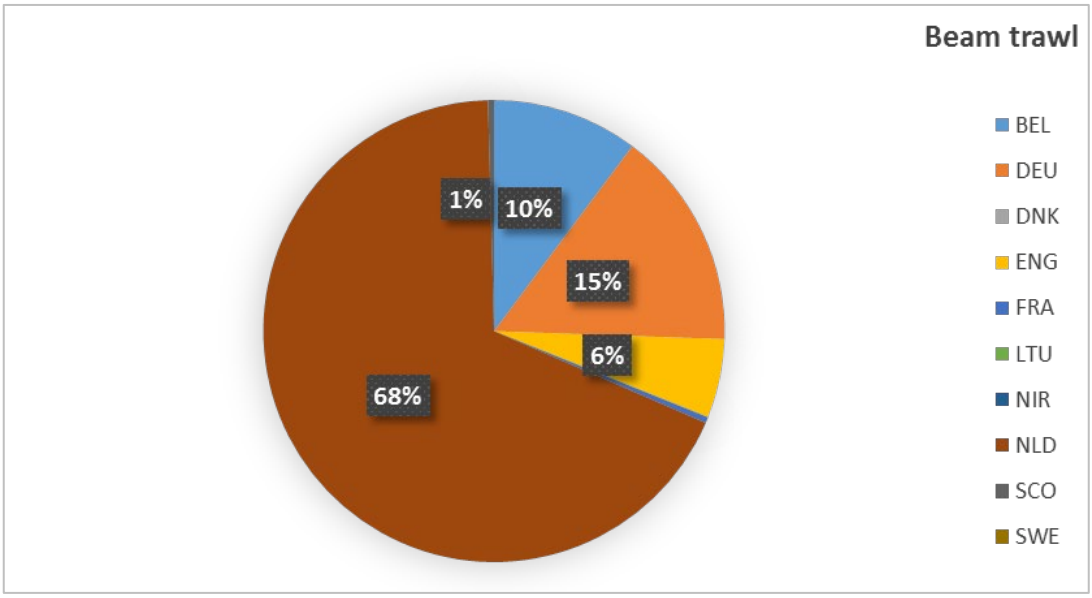



Figure 9: Overview of the distribution of effort for the international beam trawl fishery in the Dutch EEZ in the recent years.

## DEMERSAL SEINE

The fishery with demersal seiners is of minor importance compared to the total effort of all fishing gears. Dutch fishery reach about 50% of the effort. Denmark shows an effort share of 25%. The remaining proportions of maximum 10% are distributed between Belgium, England and France (Figure 10 and Table 17).

Table 17: Distribution of the effort (in hours fished) for the international demersal seine fishery in the Dutch EEZ in the recent years.

| Effort in hours for Demersal Seine | | | | |
|---|---|---|---|---|
| **Country** | **2014** | **2015** | **2016** | **Total** |
| Belgium (BEL) | 948 | 565 | 811 | 2.324 |
| Germany (DEU) | - | - | - | - |
| Denmark (DNK) | 4.440 | 3.636 | 1.640 | 9.716 |
| England (ENG) | 2.575 | 1.098 | 186 | 3.859 |
| France (FRA) | 608 | 817 | 2.643 | 4.068 |
| Lithuania (LTU) | - | - | - | - |
| Northern Ireland (NIR) | - | - | - | - |
| Netherlands (NLD) | 6.730 | 6.086 | 6.219 | 19.035 |
| Scotland (SCO) | - | - | - | - |
| Sweden (SWE) | - | - | - | - |

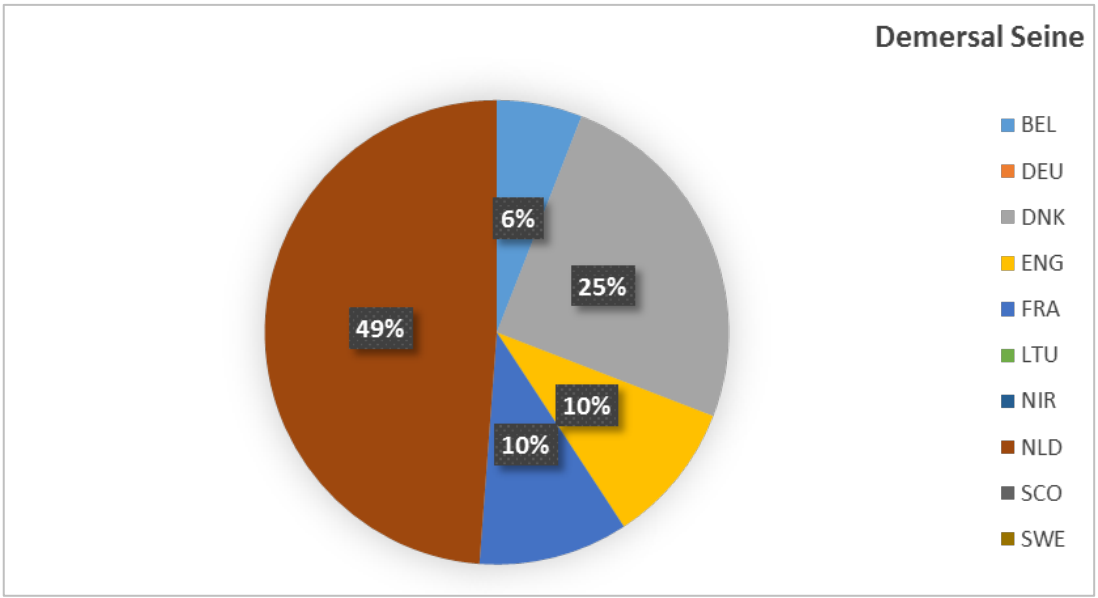



Figure 10: Overview of the distribution of effort for the international demersal seiner fishery in the Dutch EEZ in the recent years.

## DREDGE

Fishery with dredges are insignificant in relation to the total effort of all fishing gears. Dutch fishery is responsible for about 95% of the effort. The remaining shares of a maximum of 4% are distributed between Germany, England, France and Scotland (Table 18 and Figure 11).

Table 18: Distribution of the effort (in hours fished) for the international dredge fishery in the Dutch EEZ in the recent years.

| Effort in hours for Dredge | | | | |
|---|---|---|---|---|
| **Country** | **2014** | **2015** | **2016** | **Total** |
| Belgium (BEL) | - | - | - | - |
| Germany (DEU) | 64 | 64 | 71 | 199 |
| Denmark (DNK) | - | - | - | - |
| England (ENG) | - | 48 | 29 | 77 |
| France (FRA) | 853 | 19 | - | 872 |
| Lithuania (LTU) | - | - | - | - |
| Northern Ireland (NIR) | - | - | - | - |
| Netherlands (NLD) | 6.380 | 7.780 | 7.416 | 21.576 |
| Scotland (SCO) | - | - | 29 | 29 |
| Sweden (SWE) | - | - | - | - |

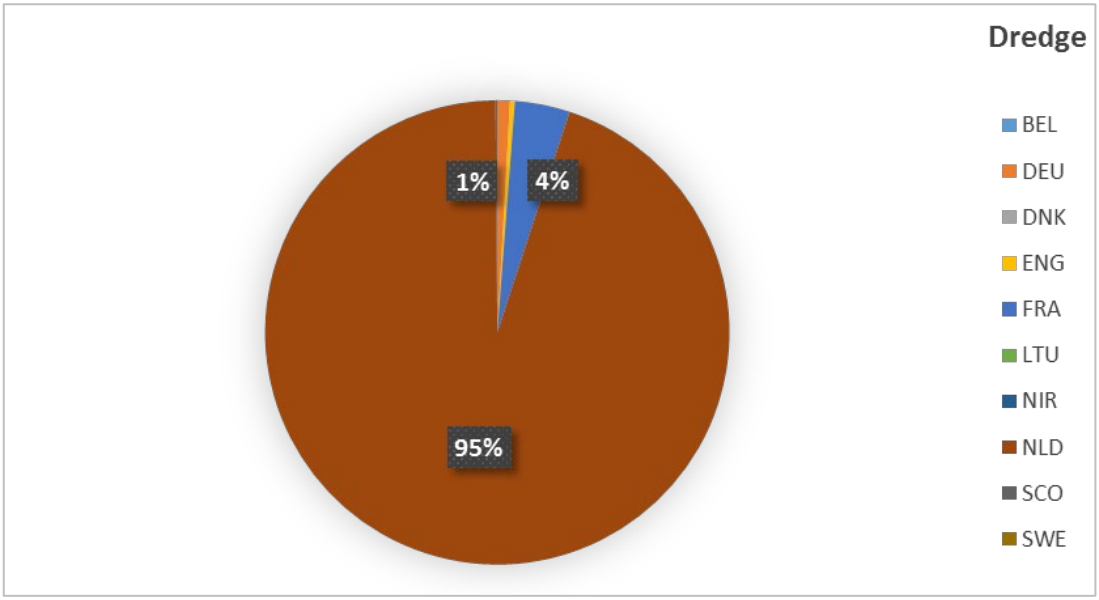



Figure 11: Overview of the distribution of effort for the international dredge fishery in the Dutch EEZ in the recent years.

## GILL NET

The Dutch fishery has a significant position in the set net fishery with a proportion of 53%. The Dutch fishery invested an effort of approx. 41,000 hours in the set net fishery. Germany and Denmark achieved significantly lower

ratios, with 13% and 22% respectively. All other nations showed insignificant efforts for fishery by gill net and are negligible (Figure 12 and Table 19).

Table 19: Distribution of the effort (in hours fished) for the international gill net fishery in the Dutch EEZ in the recent years.

| Effort in hours for Gill net | | | | |
|---|---|---|---|---|
| **Country** | **2014** | **2015** | **2016** | **Total** |
| Belgium (BEL) | 1.139 | 918 | 1.143 | 3.200 |
| Germany (DEU) | 4.401 | 3.385 | 2.371 | 10.157 |
| Denmark (DNK) | 3.625 | 9.270 | 3.625 | 16.520 |
| England (ENG) | 3.191 | 1.276 | 1.242 | 5.709 |
| France (FRA) | 15 | 17 | 50 | 82 |
| Lithuania (LTU) | - | - | - | - |
| Northern Ireland (NIR) | - | - | - | - |
| Netherlands (NLD) | 19.696 | 11.225 | 9.678 | 40.599 |
| Scotland (SCO) | - | - | - | - |
| Sweden (SWE) | - | - | - | - |

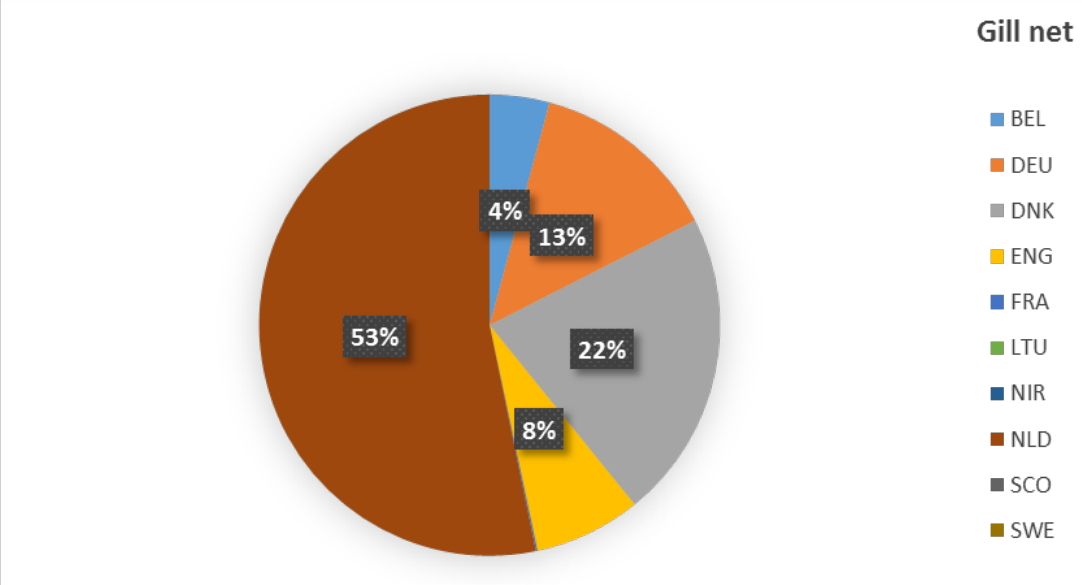



Figure 12: Overview of the distribution of effort for the international gill net fishery in the Dutch EEZ in the recent years.

## OTTER TRAWL

The otter trawl fishery is one of the most important fishery within the Dutch EEZ besides the beam trawl fishery. The overall effort is dominated by the Netherlands, with a share of 27% (Table 20 and Figure 13. However, other nations also have relatively high effort shares (10% to 18%).

Table 20: Distribution of the effort (in hours fished) for the international Otter trawl fishery in the Dutch EEZ in the recent years.

| Effort in hours for Otter trawl | | | | |
|---|---|---|---|---|
| **Country** | **2014** | **2015** | **2016** | **Total** |
| Belgium (BEL) | 11.328 | 12.062 | 11.603 | 34.993 |
| Germany (DEU) | 9.112 | 14.775 | 13.007 | 36.894 |
| Denmark (DNK) | 8.315 | 13.701 | 5.883 | 27.899 |
| England (ENG) | 16.394 | 16.301 | 19.493 | 52.188 |
| France (FRA) | 6.431 | 4.536 | 7.713 | 18.680 |
| Lithuania (LTU) | 20 | - | - | 20 |
| Northern Ireland (NIR) | 216 | - | 36 | 252 |
| Netherlands (NLD) | 26.912 | 29.557 | 22.322 | 78.791 |
| Scotland (SCO) | 8.876 | 10.186 | 20.394 | 39.456 |
| Sweden (SWE) | 94 | 163 | - | 257 |

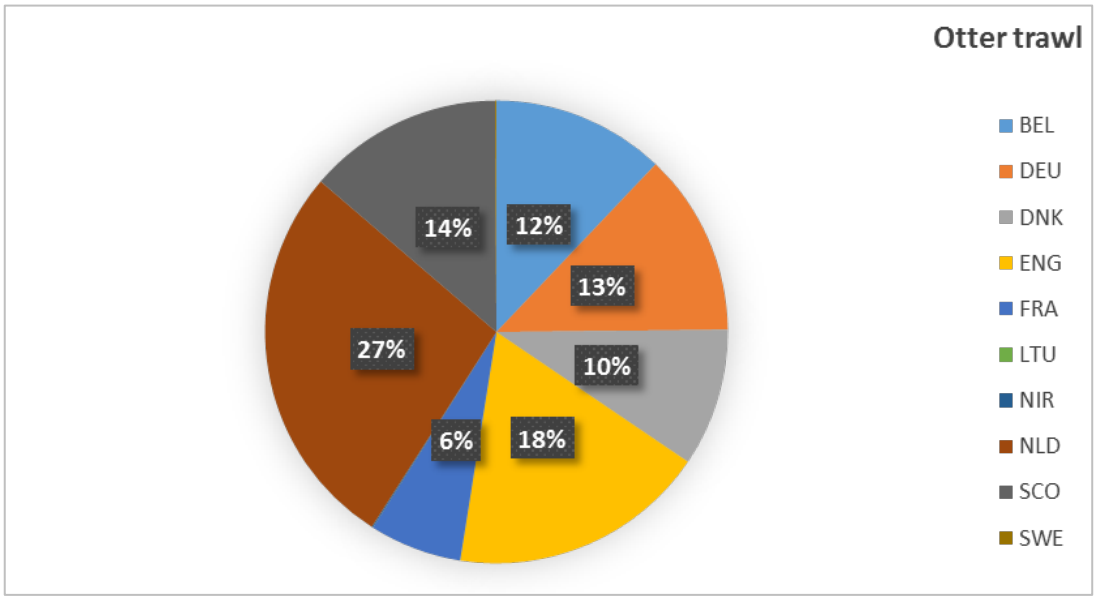



Figure 13: Overview of the distribution of effort for the international otter trawl fishery in the Dutch EEZ in the recent years.

## PELAGIC TRAWL

The pelagic trawl fishery is determined by the Danish fishery. Their contribution to the total effort was about 80% in the years considered. The Dutch fishery only accounts for 4% of the effort. Only the fishing nations Sweden and France still show remarkable shares of 3% and 4% respectively. All other nations are of no importance for pelagic fishery (Figure 14 and Table 21).

Table 21: Distribution of the effort (in hours fished) for the international pelagic trawl fishery in the Dutch EEZ in the recent years.

| Effort in hours for Pelagic trawl | | | | |
|---|---|---|---|---|
| **Country** | **2014** | **2015** | **2016** | **Total** |
| Belgium (BEL) | - | - | - | - |
| Germany (DEU) | 169 | 166 | 252 | 587 |
| Denmark (DNK) | 13.693 | 17.863 | 13.693 | 45.249 |
| England (ENG) | 160 | 53 | 112 | 325 |
| France (FRA) | 1.578 | 962 | 1.481 | 4.021 |
| Lithuania (LTU) | - | - | - | - |
| Northern Ireland (NIR) | - | - | - | - |
| Netherlands (NLD) | 732 | 401 | 1.002 | 2.135 |
| Scotland (SCO) | - | - | - | - |
| Sweden (SWE) | 164 | 438 | 909 | 1.511 |

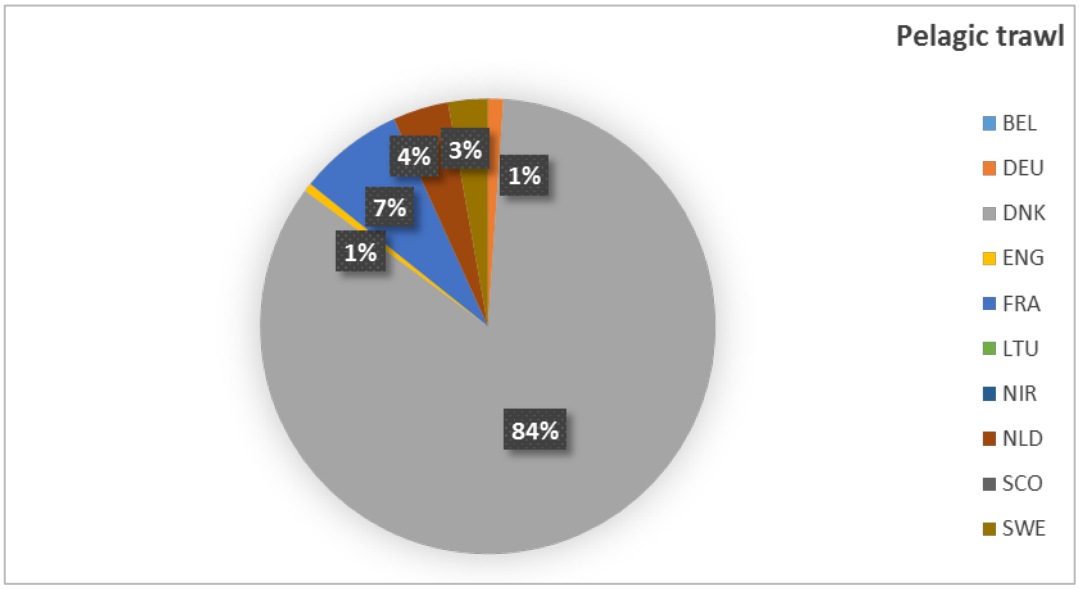



Figure 14: Overview of the distribution of effort for the international pelagic trawl fishery in the Dutch EEZ in the recent years.

## POTS

The pot or trap fishery is carried out by few nations in the Dutch EEZ. With more than 60% of the total effort, the Dutch fishery dominates this kind of fishery method. After all, English trap fishery still has a significant share of 30%. The remaining nations show only insignificant or no effort contributions (Table 22 and Figure 15).

Table 22: Distribution of the effort (in hours fished) for the international Pot fishery in the Dutch EEZ in the recent years.

| Effort in hours for Pots | | | | |
|---|---|---|---|---|
| **Country** | **2014** | **2015** | **2016** | **Total** |
| Belgium (BEL) | - | - | - | - |
| Germany (DEU) | 328 | 328 | - | 656 |
| Denmark (DNK) | - | - | - | - |
| England (ENG) | 1.252 | 5.779 | 5.675 | 12.706 |
| France (FRA) | 158 | 195 | 1.742 | 2.095 |
| Lithuania (LTU) | - | - | - | - |
| Northern Ireland (NIR) | - | - | - | - |
| Netherlands (NLD) | 10.007 | 8.604 | 8.837 | 27.448 |
| Scotland (SCO) | - | - | - | - |
| Sweden (SWE) | - | - | - | - |

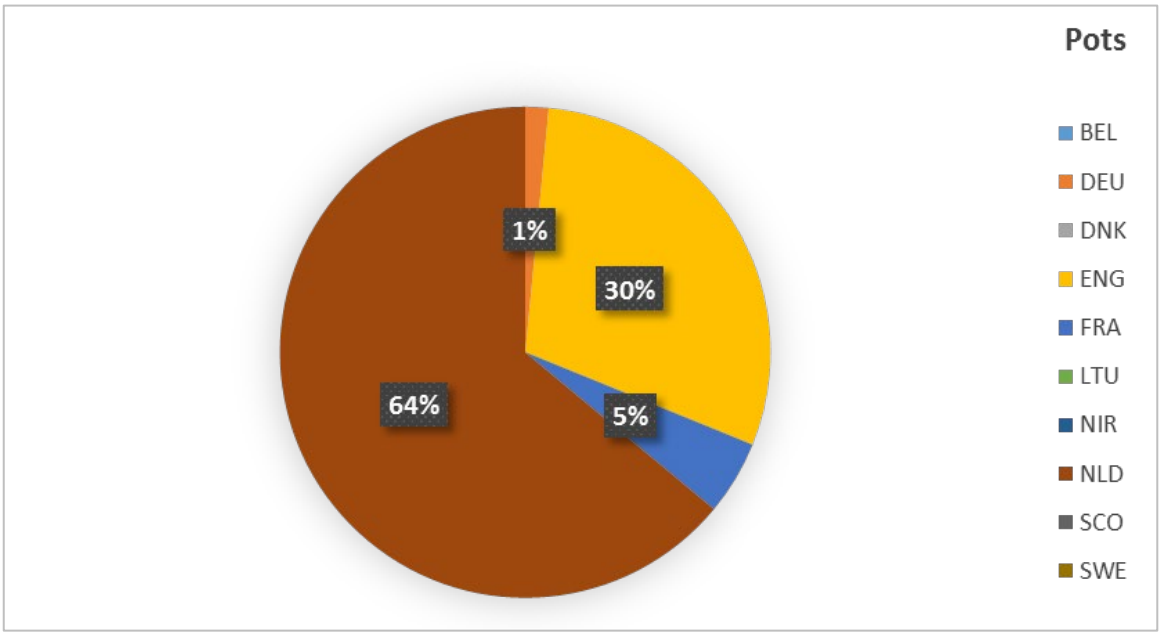



Figure 15: Overview of the distribution of effort for the international pot fishery in the Dutch EEZ in the recent years.

## TRAMMEL NET

The trammel net fishery is also carried out by few nations in the Dutch EEZ. With more than 95% of the total effort, the French fishery dominates this method. Dutch fishing accounts for only 3% of the total effort. The remaining fishing nations show only insignificant or no effort percentages (Figure 16 and Table 23).

Table 23: Distribution of the effort (in hours fished) for the international Trammel net fishery in the Dutch EEZ in the recent years.

| Effort in hours for Trammel net | | | | |
|---|---|---|---|---|
| **Country** | **2014** | **2015** | **2016** | **Total** |
| Belgium (BEL) | 122 | 324 | 703 | 1.149 |
| Germany (DEU) | - | - | - | - |
| Denmark (DNK) | 504 | 120 | 48 | 672 |
| England (ENG) | - | - | 24 | 24 |
| France (FRA) | 25.711 | 25.887 | 30.306 | 81.904 |
| Lithuania (LTU) | - | - | - | - |
| Northern Ireland (NIR) | - | - | - | - |
| Netherlands (NLD) | 496 | 962 | 720 | 2.178 |
| Scotland (SCO) | - | - | - | - |
| Sweden (SWE) | - | - | - | - |

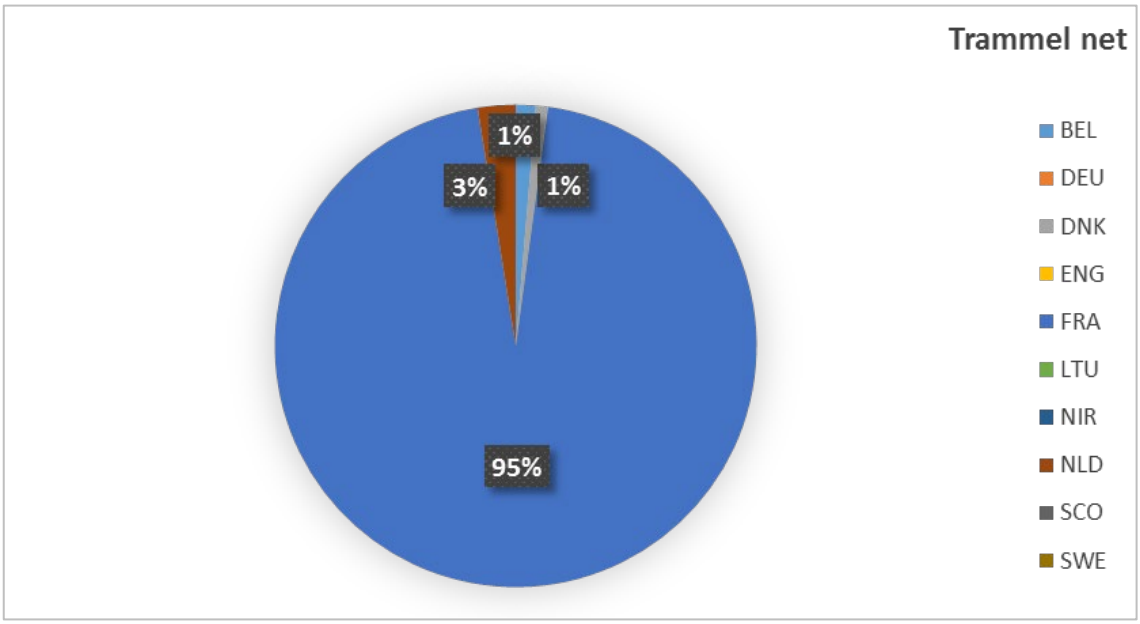



Figure 16: Overview of the distribution of effort for the international trammel net fishery in the Dutch EEZ in the recent years.

Overall, the beam trawl and otter trawl fishery dominates the fishery within the Dutch EEZ. In addition, gill net fishery is also important in the area under consideration. These types of fishery are generally dominated by the Dutch fishery.

### 4.2.2 Landings

The following chapter focuses exclusively on the Dutch fishery. The presented landing data of the most important commercial fish species were analyzed separately according to the different fishing gears. Only those fishing gears

have been analyzed where Dutch fishery have played a dominant role (compare chapter 4.2.1).

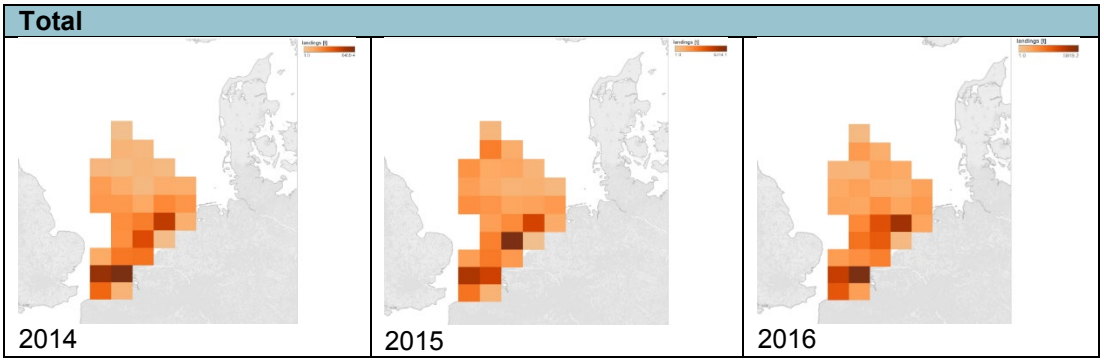
Table 24: Overview on landings per ICES-rectangle (in t) from the recent years for the Dutch fishery in the EEZ (colored ICES rectangles affected by the project).

| ICES-rectangle | year | | | Total |
|---|---|---|---|---|
| | 2014 | 2015 | 2016 | |
| 31F2 | 3.188,10 | 2.727,70 | 3.389,80 | 9.305,60 |
| 31F3 | 709,70 | 734,30 | 1.343,90 | 2.787,90 |
| 32F2 | 5.726,30 | 5.077,40 | 4.281,70 | 15.085,40 |
| 32F3 | 6.459,40 | 4.407,90 | 5.919,20 | 16.786,50 |
| 33F2 | 1.079,20 | 1.437,30 | 1.411,40 | 3.927,90 |
| 33F3 | 2.710,60 | 2.549,60 | 1.805,70 | 7.065,90 |
| 33F4 | 2.831,00 | 1.618,30 | 2.230,60 | 6.679,90 |
| 34F3 | 1.960,90 | 2.362,90 | 2.617,40 | 6.941,20 |
| 34F4 | 4.126,80 | 6.314,10 | 3.297,80 | 13.738,70 |
| 34F5 | 272,70 | 145,80 | 413,40 | 831,90 |
| 35F3 | 2.011,20 | 1.451,70 | 2.022,60 | 5.485,50 |
| 35F4 | 2.512,20 | 2.051,60 | 3.645,00 | 8.208,80 |
| 35F5 | 4.801,30 | 4.287,70 | 5.046,70 | 14.135,70 |
| 35F6 | 880,30 | 1.009,30 | 1.187,10 | 3.076,70 |
| 36F2 | 1.686,80 | 1.924,20 | 1.217,00 | 4.828,00 |
| 36F3 | 1.706,70 | 1.737,10 | 1.106,00 | 4.549,80 |
| 36F4 | 1.161,40 | 1.237,70 | 1.755,90 | 4.155,00 |
| 36F5 | 2.196,20 | 1.356,60 | 1.159,30 | 4.712,10 |
| 36F6 | 1.804,80 | 1.586,10 | 1.521,10 | 4.912,00 |
| 37F2 | 1.547,80 | 1.449,40 | 1.038,00 | 4.035,20 |
| 37F3 | 1.003,00 | 1.042,90 | 1.304,40 | 3.350,30 |
| 37F4 | 492,00 | 718,60 | 912,50 | 2.123,10 |
| 37F5 | 1.001,30 | 805,80 | 803,60 | 2.610,70 |
| 37F6 | 955,70 | 538,80 | 1.251,60 | 2.746,10 |
| 38F2 | 564,50 | 1.815,50 | 618,00 | 2.998,00 |
| 38F3 | 413,80 | 1.131,90 | 580,10 | 2.125,80 |
| 38F4 | 629,00 | 1.240,90 | 1.215,20 | 3.085,10 |
| 38F5 | 452,40 | 667,90 | 1.032,30 | 2.152,60 |
| 39F3 | 679,10 | 2.450,60 | 1.453,60 | 4.583,30 |
| 39F4 | 528,70 | 963,10 | 894,70 | 2.386,50 |
| 40F3 | 204,00 | 561,60 | 404,10 | 1.169,70 |

The total landings from the individual ICES rectangles of the recent years remained relatively constant. The maximum variation in landings was about 50% - 70% between the considered years (40F3; 38F4; 39F3; 37F4; 37F6; 34F5). The main ICES rectangles with the highest landings are near the coast (31F2; 32F2; 32F3; 34F4; 35F5). The landings from these rectangles

reached more than 10.000 t in the considered years (Table 24). The rectangles affected by the project showed significantly lower landings overall and ranged between 2,610 t and 8,208 t. However, a gradient can be seen which shows that the importance of ICES rectangles decreases from north-east to south-west (Table 25). Overall the southwestern rectangles show a high importance for the Dutch fishery (34F3; 35F3; 35F4). The north-eastern rectangles are of medium importance (36F4; 36F5; 37F5; 37F6).

Table 25: Distribution of Dutch landings in the EEZ in the recent years.




## BEAM TRAWL

Within the beam trawl fishery the landings are dominated by common shrimps (total 42.992 t and 35%) and flatfish (Table 26 and Figure 17). Concerning flatfish, plaice and common sole dominates the landings with a proportion of 34% (42.239 t) and 19% (19.447 t).

Table 26: Overview on landings (in t) from the recent years for the Dutch beam trawl fishery in the EEZ.

| Species | 2014 | 2015 | 2016 | Total |
|---|---|---|---|---|
| Common shrimps | 17.106,60 | 13.164,30 | 12.721,50 | 42.992,40 |
| Common dab | 1.569,70 | 1.256,00 | 1.321,50 | 4.147,20 |
| Gurnard | 719,70 | 881,60 | 1.167,20 | 2.768,50 |
| European plaice | 13.566,90 | 14.812,80 | 13.859,30 | 42.239,00 |
| Common sole | 6.704,60 | 5.858,30 | 6.884,10 | 19.447,00 |
| Turbot | 933,50 | 933,90 | 1.157,70 | 3.025,10 |
| Others | 3.110,80 | 3.222,50 | 3.443,40 | 9.776,70 |

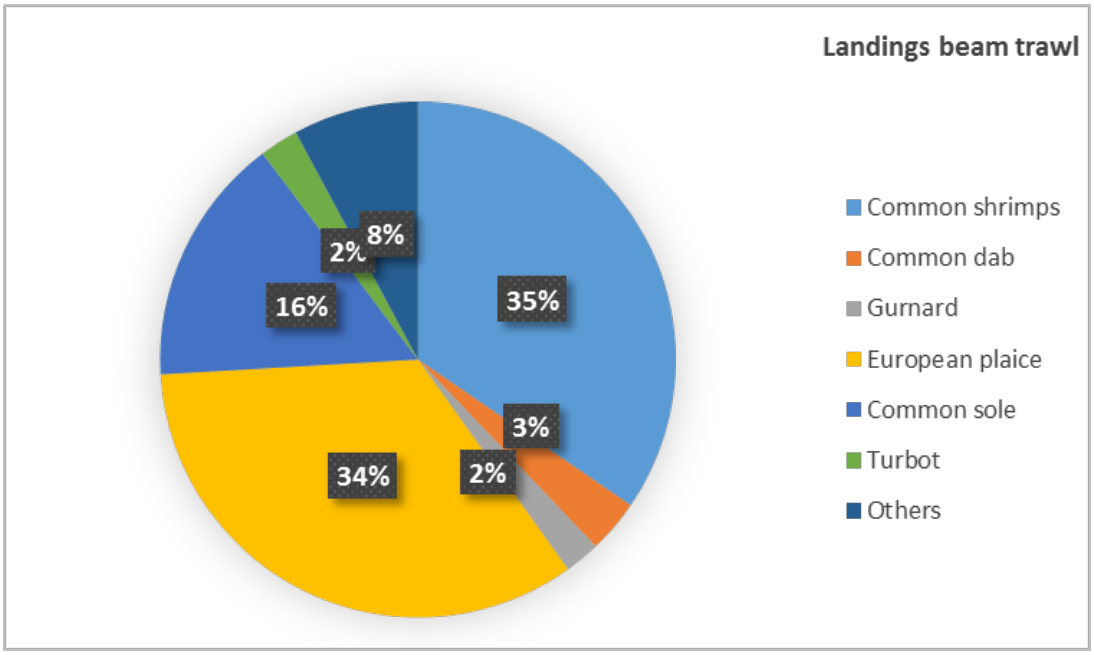
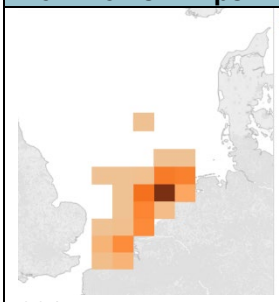
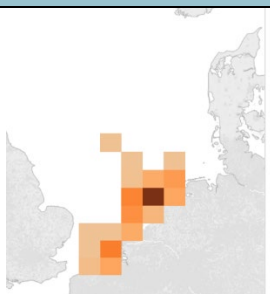



Figure 17: Overview on the most important commercial fish species for the Dutch beam trawl fishery in the EEZ.

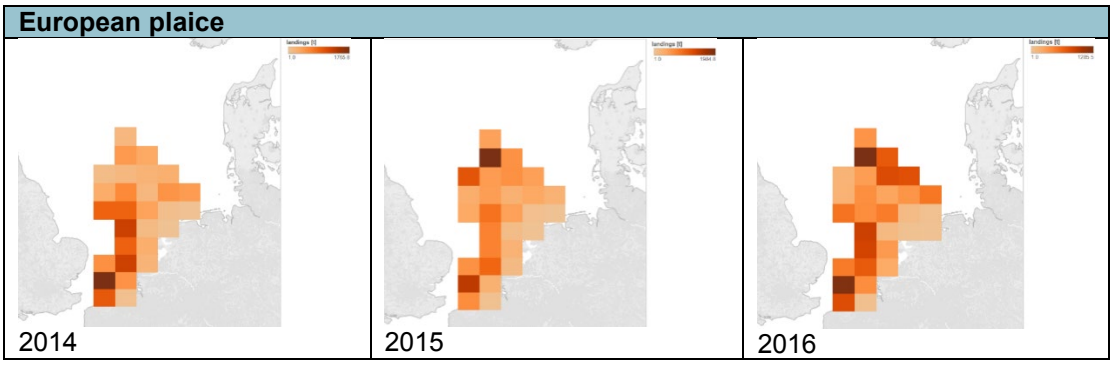
The main fishing grounds for common shrimps are located within the ICES rectangles on the coast. In contrast, the offshore rectangles are rarely fished. The rectangles 35F4, 36F5 and 37F6, which represent the cable route, are intensively used for common shrimp fishery (Table 27).

Table 27: Overview on the most important fishery areas for Common shrimps in the recent years within Dutch EEZ (landings in t).

| Common shrimps | | |
|---|---|---|
|  2014 | 2015 |  2016 |

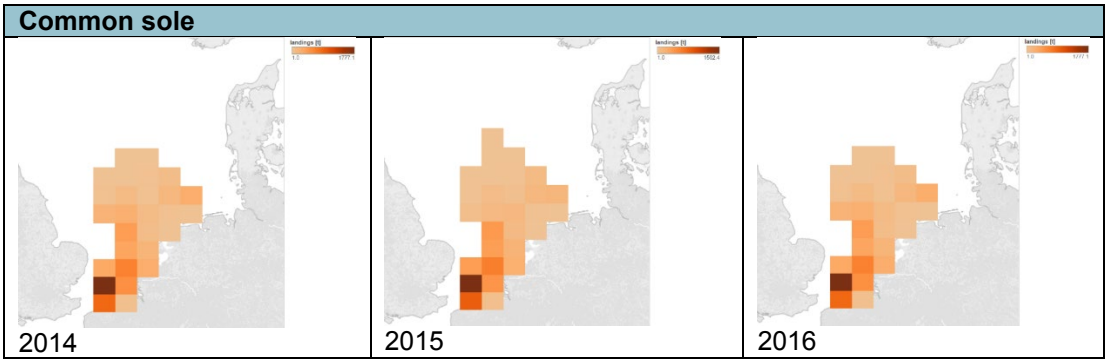
The fishing grounds of plaice are concentrated in the offshore areas of the Dutch EEZ. From the rectangles on the coast fewer landings are detected. Along the entire cable route an intensive fishing on plaice takes place (Table 28).

Table 28: Overview on the most important fishery areas for European plaice in the recent years within Dutch EEZ (landings in t).




The highest landings of sole have been recorded for the southern ICES rectangles at the entrance to the English Channel. Here the main fishing areas are located within the Dutch EEZ. Overall, the sole fishery is conducted throughout the entire EEZ. In the ICES rectangles affected by the project a fishing of medium intensity is carried out (Table 29).

Table 29: Overview on the most important fishery areas for Common sole in the recent years within Dutch EEZ (landings in t).




## DREDGE

The landings with the Dredge are determined by the mussel fishery. The Pod razor shell accounts for 98% or 9,841 t of the landings (Table 30 and Figure 18).

Table 30: Overview on landings (in t) from the recent years for the Dutch Dredge fishery in the EEZ.

| Species | 2014 | 2015 | 2016 | Total |
|---|---|---|---|---|
| Pod razor shell | 4.583,30 | 5.257,70 | 5.789,20 | 9.841,00 |
| Solen razor clams | 182,70 | 20,00 | 0,50 | 202,70 |
| Ostrich egg sponge | - | 20,00 | 0,50 | 20,00 |

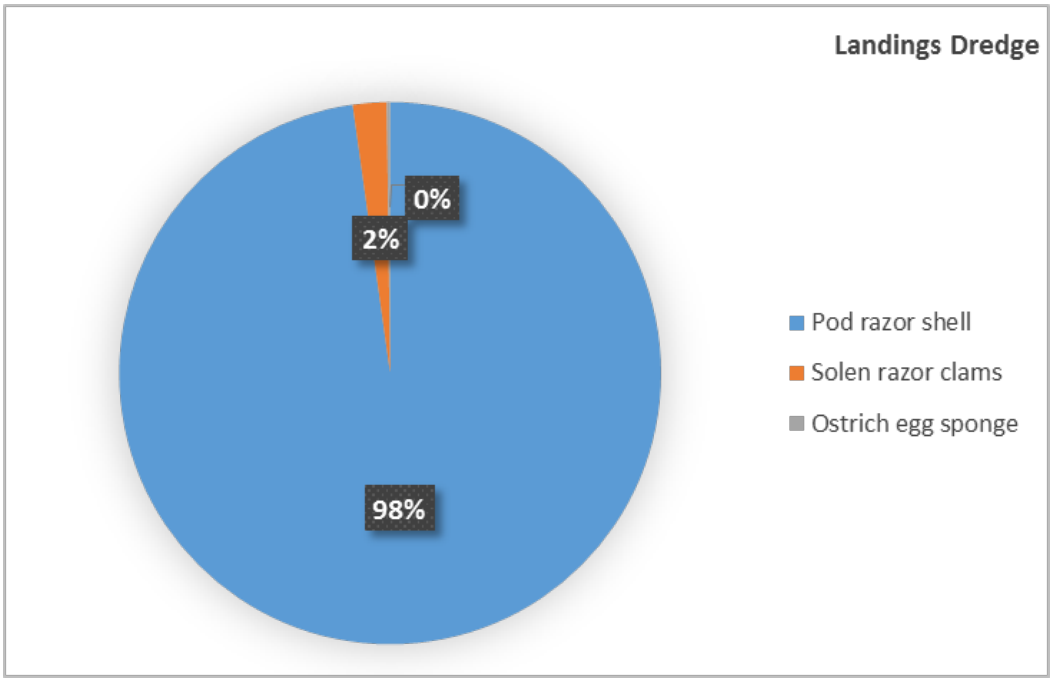
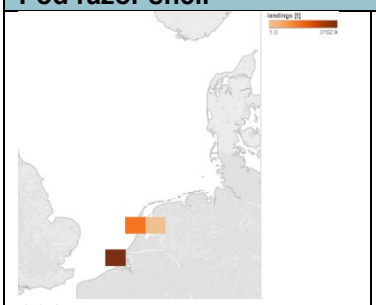
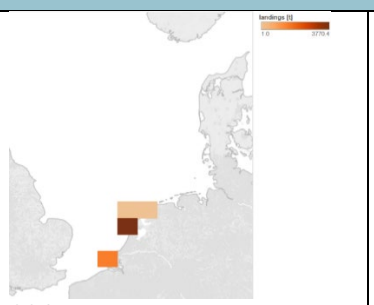
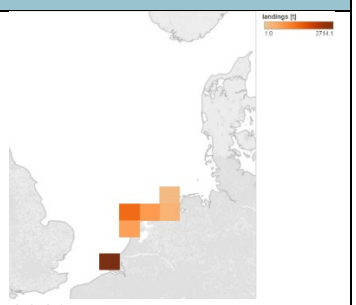



Figure 18: Overview on the most important commercial fish species for the Dutch dredge fishery in the EEZ.

The main fishery of the commercial species Pod razor Shell is located near the coast. There is no fishery in the offshore rectangles on this species. The planned cable route crosses the ICES rectangle 35F4. This rectangle is part of the main fishing areas. Here, an intensive mussel fishery takes place (Table 31).

Table 31: Overview on the most important fishery areas for Pod razor shell in the recent years within Dutch EEZ (landings in t).

| Pod razor shell | | |
|---|---|---|
|  2014 |  2015 |  2016 |

## GILL NET

The bottom-set net fishery is particularly characterized by the landings of sole with 60% share of landings (348 t). Other flatfish species such as Dab (12%) and Flounder (3%), or Seabass (5%) and Grey mullet (5%) are also important for fishing with gill nets (Table 32 and Figure 19).

Table 32: Overview on landings (in t) from the recent years for the Dutch Gill net fishery in the EEZ.

| Species | 2014 | 2015 | 2016 | Total |
|---|---|---|---|---|
| European seabass | 9,40 | 9,70 | 8,30 | 27,40 |
| Atlantic cod | 5,00 | 3,80 | 3,10 | 11,90 |
| Common dab | 24,40 | 21,80 | 21,40 | 67,60 |
| European flounder | 8,00 | 5,30 | 3,60 | 16,90 |
| Grey mullet | 13,30 | 8,80 | 8,70 | 30,80 |
| Pacific oyster | 0,00 | 0,90 | 33,90 | 34,80 |
| Common sole | 174,60 | 100,50 | 73,60 | 348,70 |
| Others | 12,70 | 16,30 | 10,80 | 39,80 |

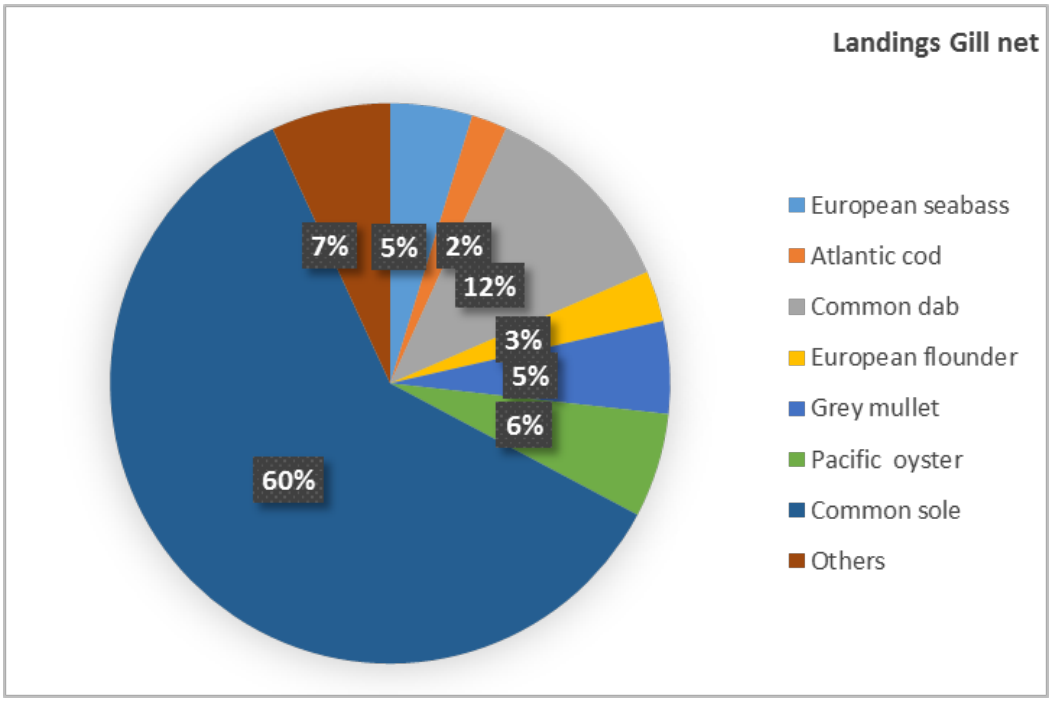
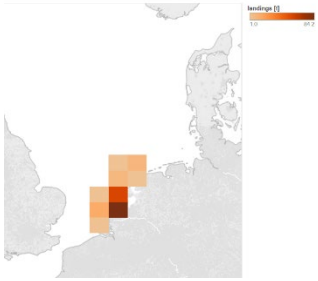
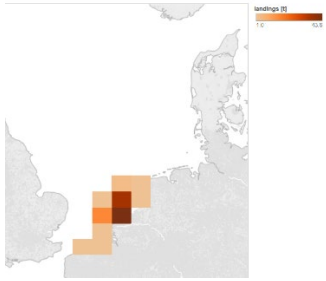
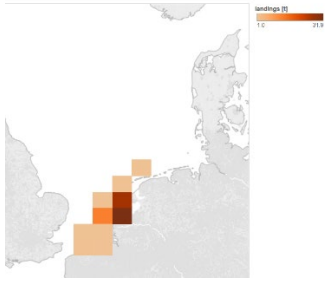



Figure 19: Overview on the most important commercial fish species for the Dutch gill net fishery in the EEZ.

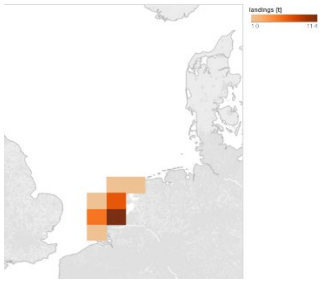
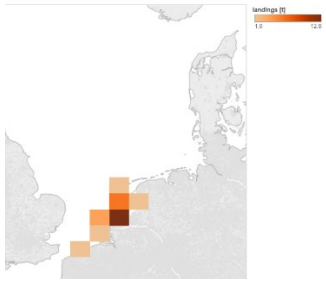
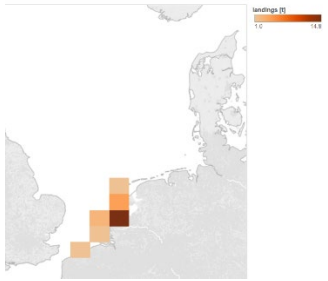
The exercise of sole fishery takes place exclusively in the coastal waters. The marine areas around the offshore islands are of particular importance. Along the cable route, the ICES rectangles 34F3 and 35F4 are exercised by a sole fishery of medium intensity (Table 33).

Table 33: Overview on the most important fishery areas for Common sole in the recent years within Dutch EEZ (landings in t).

| Common sole | | |
|---|---|---|
|  2014 |  2015 |  2016 |

As in the case of sole, the most important fishing areas for the dab are located in the coastal waters. In the area of the route alignment, the ICES rectangle 35F4 contains a low intensity of dab fishery (Table 34).

Table 34: Overview on the most important fishery areas for Common dab in the recent years within Dutch EEZ (landings in t).

| Common dab | | |
|---|---|---|
|  2014 |  2015 |  2016 |

## OTTER TRAWL

The catches from the Otter Trawl fishery are determined with 48% and approx. 80 t by Common shrimps. In addition, the landings from the plaice fishery are also significant with 38% and 50 t (Table 35 and Figure 20).

Table 35: Overview on landings (in t) from the recent years for the Dutch otter trawl fishery in the EEZ.

| Species | 2014 | 2015 | 2016 | Total |
|---|---|---|---|---|
| Common shrimps | 80,10 | 0,00 | 0,20 | 80,30 |
| Norway lobster | 0,00 | 0,10 | 15,90 | 16,00 |
| European plaice | 0,00 | 41,20 | 9,50 | 50,70 |
| Others | 2,70 | 10,10 | 7,40 | 20,20 |

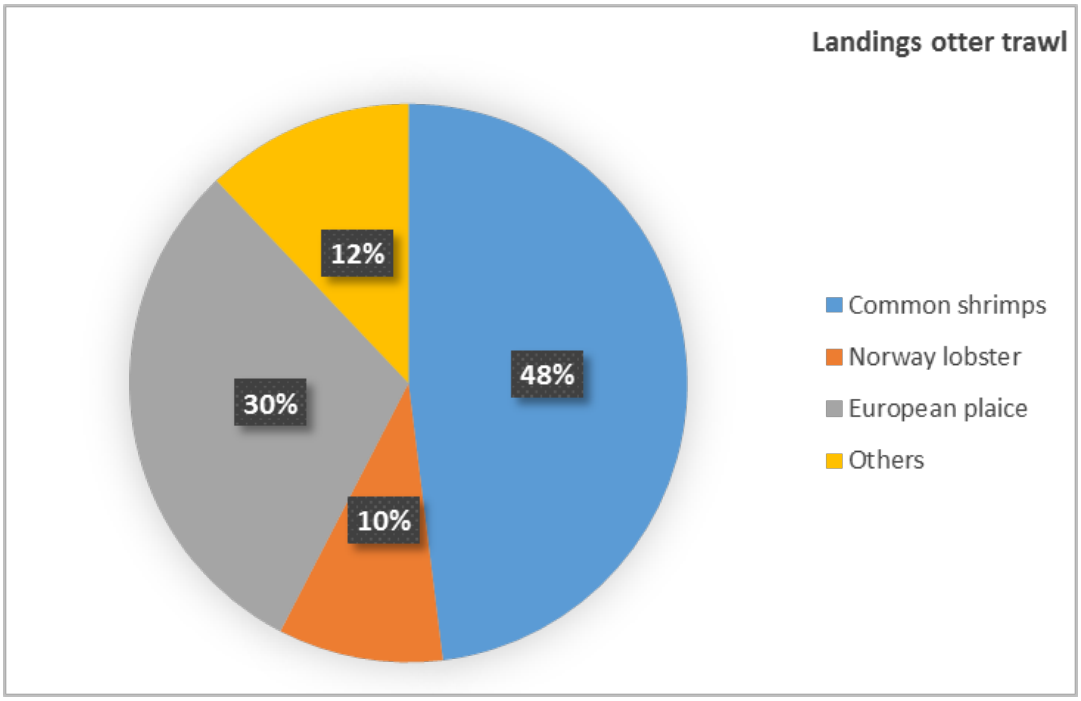
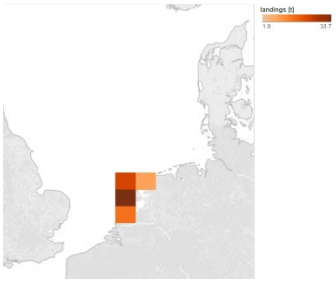
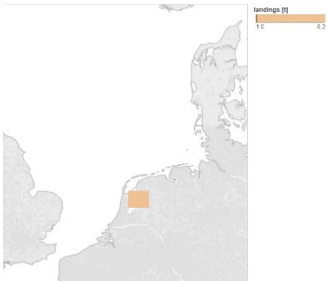



Figure 20: Overview on the most important commercial fish species for the Dutch otter trawl fishery in the EEZ.

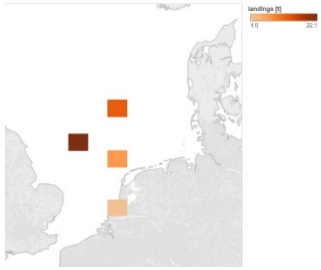
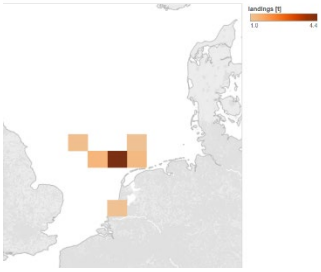
The catches of shrimps were very irregular in the years considered. Nevertheless, this species dominated the percentage of catches. Only in 2014 the rectangle 34F3 was as part of the cable route characterized by a fishery of medium intensity on Common shrimps (Table 36).

Table 36: Overview on the most important fishery areas for Common shrimps in the recent years within Dutch EEZ.

| Common shrimps | | |
|---|---|---|
|  2014 | No landings 2015 |  2016 |

The catches of plaice were also very irregular. Specific fishing areas cannot be mapped. Nevertheless, in 2015 and 2016, this species showed medium catch intensities in the area of the route alignment (Table 37).

Table 37: Overview on the most important fishery areas for European plaice in the recent years within Dutch EEZ.

| European plaice | | |
|---|---|---|
| 2014 |  2015 |  2016 |

## POTS

Trap fishing is particularly characterized by the crab species Edible crab and Lobster (Table 38 and Figure 21). Both species are responsible for about 70% of all landings (>100 t).

Table 38: Overview on landings (in t) from the recent years for the Dutch pot fishery in the EEZ.

| Species | 2014 | 2015 | 2016 | Total |
|---|---|---|---|---|
| Edible crab | 23,60 | 10,40 | 20,50 | 54,50 |
| European lobster | 10,40 | 19,50 | 18,80 | 48,70 |
| European plaice | 0,00 | 23,10 | 0,00 | 23,10 |
| Others | 3,60 | 11,10 | 8,70 | 23,40 |

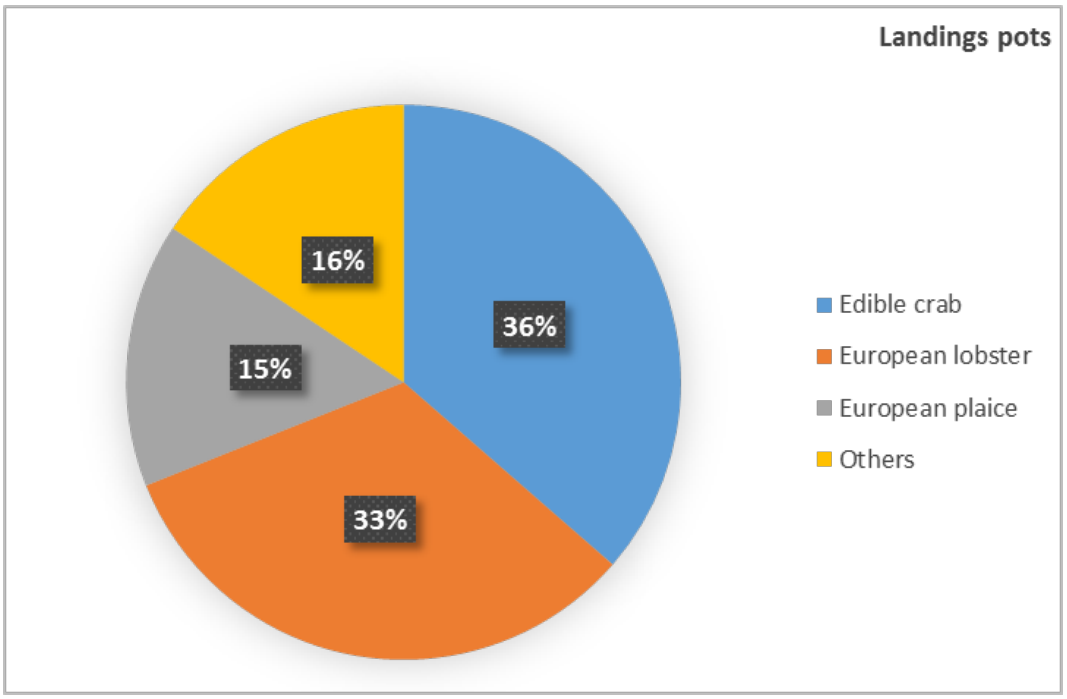
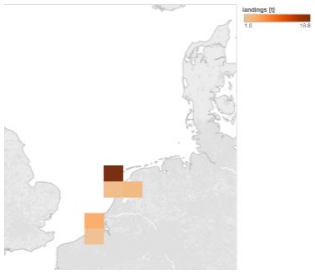
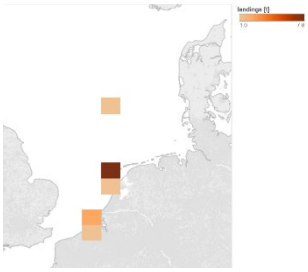
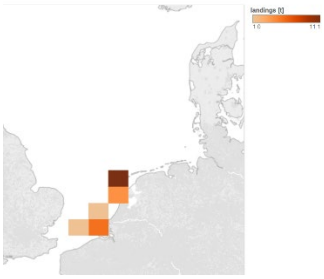



Figure 21: Overview on the most important commercial fish species for the Dutch pot fishery in the EEZ.

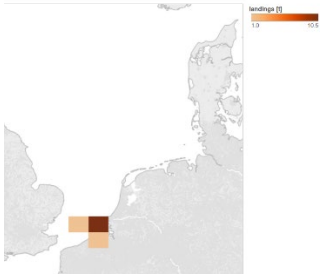
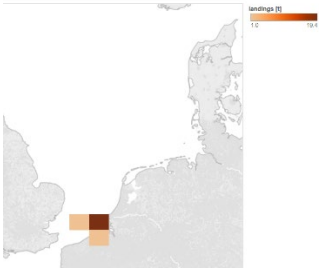
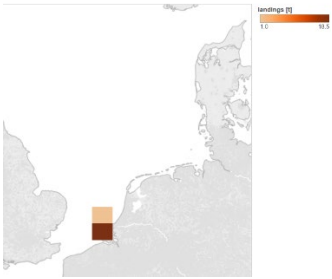
The main fishing areas for the edible crab are close to the Dutch coast. The ICES rectangles 34F3 and 35F3 show an importance for the pot fishery on the edible crab in the affected area of the planned project (Table 39).

Table 39: Overview on the most important fishery areas for Edible crab in the recent years within Dutch EEZ.

| Edible crab | | |
|---|---|---|
|  2014 |  2015 |  2016 |

The highest landings for the European lobster were recorded in the southern part of the Dutch coast. There is no significant fishing area along the planned cable route (Table 40).

Table 40: Overview on the most important fishery areas for European lobster in the recent years within Dutch EEZ.

| European lobster | | |
|---|---|---|
|  2014 |  2015 |  2016 |

## 4.3 Competition to other spatial uses

In the following chapter the Dutch fishery is analyzed in comparison to the other stakeholders which use the Dutch EEZ in a socio-economic manner.

In general, the economic growth has declined significantly since 2008, more significantly and longer than in the surrounding countries, the OECD and the EU on average. This is mainly due to sluggish domestic demand (STECF, 2015).

Table 41 contains an overview of the development of the socio-economic importance in terms of production value, added value and employment for the period 2005-2011 for sectors in the Dutch part of the North Sea as well as land-based sectors that have a direct relationship with the sea. The table

shows that oil and gas extraction, ports and shipping are of great economic importance to the Netherlands.

The total added value of the use of the Dutch part of the North Sea (including its coastal zone and seaports) amounted to over 23 billion euros in 2011. That is a decrease of more than 3.5 billion euros compared to 2008. The added value of the activities in the North Sea in 2011 amounted to an approximate total of 5.4 billion euros. That is a decrease of over 2.5 billion euros compared to 2008. The decrease is largely due to the financial and economic crisis. Oil and gas extraction has the highest added value of all designated uses in the Dutch part of the North Sea (over 4.7 billion euros in 2011). Although the production of oil and gas fell between 2005 and 2011, the production value and added value did not. The rise in oil prices in 2008 offset the decrease in production volume. Employment in this sector remained fairly stable between 2005 and 2011. The shipping industry is also of great economic importance to the Netherlands; however, the industry's added value dropped significantly between 2008 and 2010. The prices for shipping services have been under pressure since 2009, as has the volume of the activity (less volume to be transported). There was, after all, less international trade as a result of the economic crisis. In 2011 the added value of the shipping sector came to 616 million euros.
Sand extraction, fishery and wind energy are of relatively little economic significance compared to oil and gas extraction and shipping. Sand is extracted for coastal defence purposes and for infrastructure and/or land reclamation projects. The economic crisis has had no apparent impact on the demand for sand for coastal defence purposes; however, the demand for fill sand has dropped, as projects have been delayed or postponed as a consequence of the economic crisis. The Dutch fishing industry is highly regulated by the European Common Fishery Policy (CFP). Sole, plaice, herring and mackerel are of particular importance to Dutch fishermen. The added value of the commercial fishery sector has decreased compared to 2005 (STECF, 2015). This is partly due to higher fuel prices, social pressure to fish sustainably and competition from cheaper, imported fish. Wind energy has increased slightly in economic importance in recent years. This sector is expected to grow rapidly in the coming years (Table 41).

The total added value of directly sea-related land-based economic activities amounted to approximately 17.8 billion euros in 2011. This is a decrease of approximately 1 billion euros compared to 2008. The economic importance rose again after 2010. Of all land-based activities directly related to the North Sea, the seaports are of major economic interest. Just over half the added value of seaport-based activities is generated in the port of Rotterdam. Moreover, the Dutch seaports are hubs for international goods flows and a seat for industry and services.

The economic importance of other activities in the coastal zone, such as tourism and recreation (Vuik & Van Rossum, 2011), has also declined in recent years. There were fewer international tourists, and hotels, restaurants and

cafés saw a drop in sales. The economic crisis did not impact the number of beach visits or the recreational fishing industry. Many economic activities are more directly dependent on the North Sea, particularly inland shipping and other transport activities, but also the fish processing industry, the trade in ship components, and so on.

Table 41: Economic importance of the Dutch part of the North Sea (2005-2027). Employment x 1,000 FTE, production value and added value x 1,000,000 €.

| | 2005 | 2008 | 2010 | 2011 | 2015 | 2021 | 2027 |
|---|---|---|---|---|---|---|---|
| Shipping | | | | | | | |
| Employment | 8.0 | 7.7 | 8.7 | 8.6 | 5.5 | 5.0-5.4 | 4.6-5.4 |
| Production value | 4913 | 4876 | 3885 | 3885 | 3134 | 3098-3604 | 3002-4048 |
| Added value | 1337 | 1211 | 727 | 616 | 602 | 595-693 | 577-778 |
| Fishery | | | | | | | |
| Employment | 0.61 | 0.56 | 0.54 | 0.52 | 0.4 | 0.4 | 0.3-0.4 |
| Production value | 100.4 | 105.7 | 93.4 | 90.3 | 100 | 85-93 | 75-85 |
| Added value | 41.5 | 32.5 | 26.3 | 23.0 | 23 | 19-22 | 17-21 |
| Oil and gas extraction | | | | | | | |
| Employment | 2.5 | 2.9 | 2.3 | 2.7 | 2.5 | 2.1-2.2 | 1.5-1.8 |
| Production value | 5673 | 8477 | 5389 | 6004 | 5409 | 4483-4694 | 3186-3857 |
| Added value | 4196 | 6834 | 4099 | 4748 | 4277 | 3546-3711 | 2519-3050 |
| Sand extraction | | | | | | | |
| Employment | TBD | TBD | TBD | TBD | 0.2 | 0.2 | 0.2-0.6 |
| Production value | TBD | TBD | TBD | TBD | 133 | 91 | 91-314 |
| Added value | TBD | TBD | TBD | TBD | 31 | 21 | 21-72 |
| Wind energy | | | | | | | |
| Employment | - | 0.1 | 0.1 | 0.2 | 0.5 | 1.5 | 2.2 |
| Production value | - | 54 | 55 | 66 | 254 | 779 | 1146 |
| Added value | - | 31 | 29 | 35 | 76 | 233 | 343 |
| Total sea-based | | | | | | | |
| Employment | 11 | 11 | 12 | 12 | - | - | - |
| Production value | 10686 | 13512 | 9423 | 10046 | - | - | - |
| Added value | 5575 | 8109 | 4882 | 5422 | - | - | - |
| Seaports | | | | | | | |
| Employment | 118 | 126 | 118 | 120 | - | - | - |
| Production value | 63199 | 85761 | 82592 | 95904 | - | - | - |
| Added value | 15857 | 17305 | 15017 | 16436 | - | - | - |
| Coastal zone | | | | | | | |
| Employment | 32 | 35 | 34 | 34 | - | - | - |
| Production value | 2537 | 2946 | 2755 | 2745 | - | - | - |
| Added value | 1318 | 1451 | 1367 | 1350 | - | - | - |
| Total land-based | | | | | | | |
| Employment | 150 | 161 | 151 | 154 | - | - | - |
| Production value | 65736 | 88707 | 85348 | 98649 | - | - | - |
| Added value | 17175 | 18756 | 16384 | 17786 | - | - | - |
| Total sea- and land-based | | | | | | | |
| Employment | 161 | 172 | 163 | 166 | - | - | - |
| Production value | 76422 | 102219 | 94770 | 108695 | - | - | - |
| Added value | 22749 | 26865 | 21266 | 23208 | - | - | - |

Ecorys has made an estimate of the expected socio-economic developments between 2015 and 2027 and looked ahead to 2050 based on the latest information on the national socio-economic developments and on the basis of four long-term scenarios drawn up by the Netherlands Bureau for Economic Policy Analysis (CPB) (Ecorys, 2013). Between 2012 and 2027 the economy is expected to grow by 11% to 36%. Productivity linked to technological improvements will contribute the most to that expected growth. By 2027 employment in the Netherlands will have changed by -5% to +4% compared to 2012.

The oil and gas sector will be of less socio-economic importance in the future. Expectations are that most extractions will cease between 2020 and 2050 as fields become depleted, whereas much is expected of offshore wind energy in the coming years. The Energy Agreement stipulates that by 2023 4,450 MW of offshore wind energy will be operational (DHR, 2014) (by way of comparison: off-shore operational capacity in 2012 was 228 MW). Furthermore, several Dutch companies are actively developing and testing other forms of 'Ocean Energy', such as tidal power, wave power and osmotic energy. These kinds of energy production could be economically viable in the long term. The importance of the shipping sector can both rise and fall between 2012 and 2027. This uncertainty has to do with the large margin in the expected development of the transshipment of goods in the Dutch seaports. It is assumed that the transshipment of goods in Dutch seaports will keep pace with the global transit. The port of Rotterdam expects to transship 575 to 740 million tons per year by 2030. Especially the transshipment of containers is expected to increase substantially as a result of Maasvlakte 2 (50 to 200% growth up to the year 2040). In the coming years shipping will also need to adapt to measures aimed at reducing operational pollution, such as more stringent limits on emissions (such as nitrogen and sulphur oxides) from ships. The transport and the use of alternative fuels such as LNG and biofuel will increase.
The economic importance of sand extraction depends on the demand for sand for coastal sand replenishments and for infrastructure projects. The Delta Decision on Sand (Delta, 2014) proposes an annual coastal sand replenishment of 12 million $m^3$ for the coming years so as to maintain the basic coastline and to conduct additional research into the necessity of letting the coastal foundation rise as well. A required increase of up to 25 million $m^3$ per year of sea sand as fill sand is also taken into account. Meanwhile, technical developments have enabled the extraction of sand from deeper lying beds.

# 5 DISCUSSION

## 5.1 Trans-regional importance

For the North Sea as a whole, Dutch fishery represent only a small proportion (4%) of the total effort. Scottish, English and French fishery had the highest proportions of the total effort. The main fishing areas for international fishery are located in the coastal areas of the neighboring countries. In particular, the

English Channel and the coastal areas of Great Britain, Holland and Germany show the highest fishing activities.
The area along the route alignment in the Dutch EEZ is characterized by Dutch fishery in particular. The Belgian and German fishery also exhibit high fishery intensities.

The pelagic fish species herring, mackerel and sprat represent the main target species of commercial fishery in the North Sea. These species collectively account for more than 50% of the analyzed landings. Flatfishes, such as plaice, as well as lobster and shrimps are further important target species in the coastal areas of the North Sea. The temporal variations of the landings are related to the dependency on the stock situation and thus on the quotation. All commercial fish stocks are subject to strict control by the European Union and are monitored through a targeted fish stock management. The establishment of total allowable catches (TACs) for all commercially exploited fish stocks in the North Sea is a key tool in this context.

The analysis of the effort data for the ICES rectangles 34F3, 35F3, 35F4, 36F4, 36F5, 37F5, 37F6 which are concerned by the project, showed a high importance for the Dutch fishery. Overall, a high importance can be identified for the coastal areas for the flatfish fishery and the fishery on shrimps for trans-regional fishery in the North Sea.

## 5.2 Local and regional importance

The fishing effort in the Dutch EEZ is mainly dominated by the Dutch fishery. Overall considered through the years, the Dutch fishery showed with more than 50% the highest percentage of the total effort (>1,000,000 hours fished). The analysis confirms the importance of the EEZ for the Belgian and German fishery. The most important fishing grounds are located along the coastal areas of the Dutch EEZ. The ICES rectangles, which are affected by the cable project, show a medium fishery effort compared to the ICES rectangles along the coast. On the other hand, the rectangles of the northern Dutch EEZ reveal a lower fishery effort in all.

The Dutch EEZ is dominated by ground-hitting fishery. The beam trawl fishery plays an outstanding role (>900,000 hours fished). Furthermore, the fishery with Dredge, Gill net, otter trawl and traps are also of a high importance for the Dutch fishery within the EEZ. However, this fishery represent only a small proportion of the total effort when compared to beam trawl fishery. When looking at the landings from these fishing techniques, it can be seen that flatfishes, shrimps and lobsters are mainly constituting the catches. Within the flatfish fishery, the fishery on plaice is particularly significant. However, dab and sole also form an important part of the commercially exploited target fish species in the Dutch EEZ. The flatfish fishery does not show any specific fishing areas but was evenly distributed over the entire EEZ over the years under consideration. For the shrimps and lobster species, the coastal areas represent an important fishing area. The coastal areas play a major role in

regional fishery. The fishing areas in the coastal areas result in a lower investment in both time and technical effort (e.g. fuel, etc.) while maintaining good catch levels.

The rectangles affected by the project showed lower landings than the rectangles on the coast. However, a gradient can be seen which shows that the importance of ICES rectangles decreases from north-east to south-west. Overall the southwestern rectangles show a high importance for the Dutch fishery (34F3; 35F3; 35F4). The north-eastern rectangles are of medium importance (36F4; 36F5; 37F5; 37F6).

For local and regional fishery, in summary a high importance of flatfish and shrimp fishery in coastal areas can be derived. Overall, the results in the area of the project show a medium importance for Dutch fishery.

## 5.3 Competition to other spatial uses

In addition to internal competition on fish as a resource, there are also other stakeholder groups that are competing for the use of the space available. In many places the territorial claims already overlap. In the meantime, the use of the sea is becoming increasingly space-intensive including: Maritime transport, trade, coastal industries, offshore facilities, conventional and alternative energy generation, nature conservation areas, aquaculture, marine research and tourism all compete with fishery (Kafemann & Ehrich 2007). The problem here is that fishing is a dynamic process and therefore it is difficult to define its boundaries in connection with the national spatial planning in the Dutch EEZ and territorial waters (Ehrich et al. 2006). By developing new fishing strategies and techniques, it would be possible to protect and reinforce the Dutch fishery and used fish stocks (Ehrich et al. 2006). However, it should be kept in mind that Dutch fishery only have limited alternatives.

The future of the Dutch fishing industry is highly uncertain due to the many changes awaiting the sector (Table 41). A further decline in the sector's economic importance should be taken into consideration. The fishing industry is currently transitioning to a high sustainability level. The sector faces huge challenges to become more sustainable, especially with regard to reducing discards and developing new techniques such as pulse and sumwing fishing, which will continue to supplant traditional beam trawling in the coming years (Kuhlman & Van Oostenbrugge, 2014). Furthermore, the development of the main fish stocks in the North Sea will influence the importance of the sector in the future. Climate change figures in this respect as well. The warming of the North Sea is shifting populations to the north, causing some species to migrate away (cod, plaice) and others to potentially increase in number (mullet, sea bass). Market developments also affect the sector's economic significance. The vast majority of the fish caught in Dutch waters is exported to countries within the EU. Competition from farmed fish has increased sharply in recent years. In addition, the use of space especially by wind farms and protected areas in the North Sea is increasing substantially. That might lead

to displacement effects on the fishery at the traditional and available fishing grounds (AEI, 2012)

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# Memo

**Aan:** Lara Mielke (Altenburg & Wymenga Ecologisch Onderzoek)

**Van:** Floor Heinis

**CC:**

**Datum:** 3 februari 2021

**Betreft:** Effecten onderwatergeluid door geofysisch onderzoek voor NeuConnect-kabel

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## 1 Inleiding

De NeuConnect Interconnector is een hoogspanningskabel die in de zeebodem wordt aangelegd en de uitwisseling van elektriciteit tussen Duitsland en het Verenigd Koninkrijk mogelijk gaat maken. Rond de aanleg van deze zeekabel wordt op een aantal momenten geofysisch onderzoek uitgevoerd om de bodemgesteldheid in verschillende lagen in kaart te brengen en eventuele aanwezigheid van oude munitie te identificeren. Deze surveys beslaan een corridor met een breedte van ca. 500 m rond het tracé waarlangs de kabel wordt gelegd (Figuur 2-1).

Dit memo bevat een inschatting van de mogelijke effecten op populaties zeezoogdieren in het Nederlandse deel van de Noordzee (NCP) van het onderwatergeluid dat tijdens het geofysisch onderzoek wordt geproduceerd rond het geplande tracé voor de zeekabel. De lengte van het tracé op het NCP bedraagt ca. 265 km. Bij het bepalen van de effecten wordt uitgegaan van de aanpak die eerder is gevolgd voor het Kader Ecologie en Cumulatie 3.0 (Heinis *et al.* 2019)[1].

## 2 Bepaling effecten van onderwatergeluid op het zeeleven

### 2.1 Afbakening

Op het NCP en dus ook in het plangebied voor de NeuConnect kabel komen verschillende soorten zeezoogdieren voor. Van die soorten zijn alleen de aantallen van de bruinvis *Phocoena phocoena* dermate hoog dat effecten van het met de aanleg van de kabel gepaard gaande onderwatergeluid niet bij voorbaat kunnen worden uitgesloten. Gewone zeehonden *Phoca vitulina* en grijze zeehonden *Halichoerus grypus* komen weliswaar veel voor in de Noordzee, maar zijn sterk aan de kust gebonden. De dichtheid langs het tracé van de kabel is zeer laag en ligt tussen 0 en ca. 0,05 dieren per km$^2$ (Aarts *et al.* 2016). De kans dat een zeehond tijdens een van seismische surveys in de nabijheid is en effecten zou kunnen ondervinden, is daarom verwaarloosbaar klein. Andere soorten die sporadisch op het NCP worden aangetroffen zijn witsnuitdolfijn *Lagenorhynchus albirostris*, tuimelaar *Tursiops truncatus* en dwergvinvis *Balaenoptera acutorostrata* (zie bijvoorbeeld Geelhoed *et al.* 2020, Geelhoed *et al.* 2018 en eerdere rapportages). De aanwezigheid in het plangebied van deze soorten is dermate incidenteel dat effecten van de seismische surveys met zekerheid kunnen worden uitgesloten.

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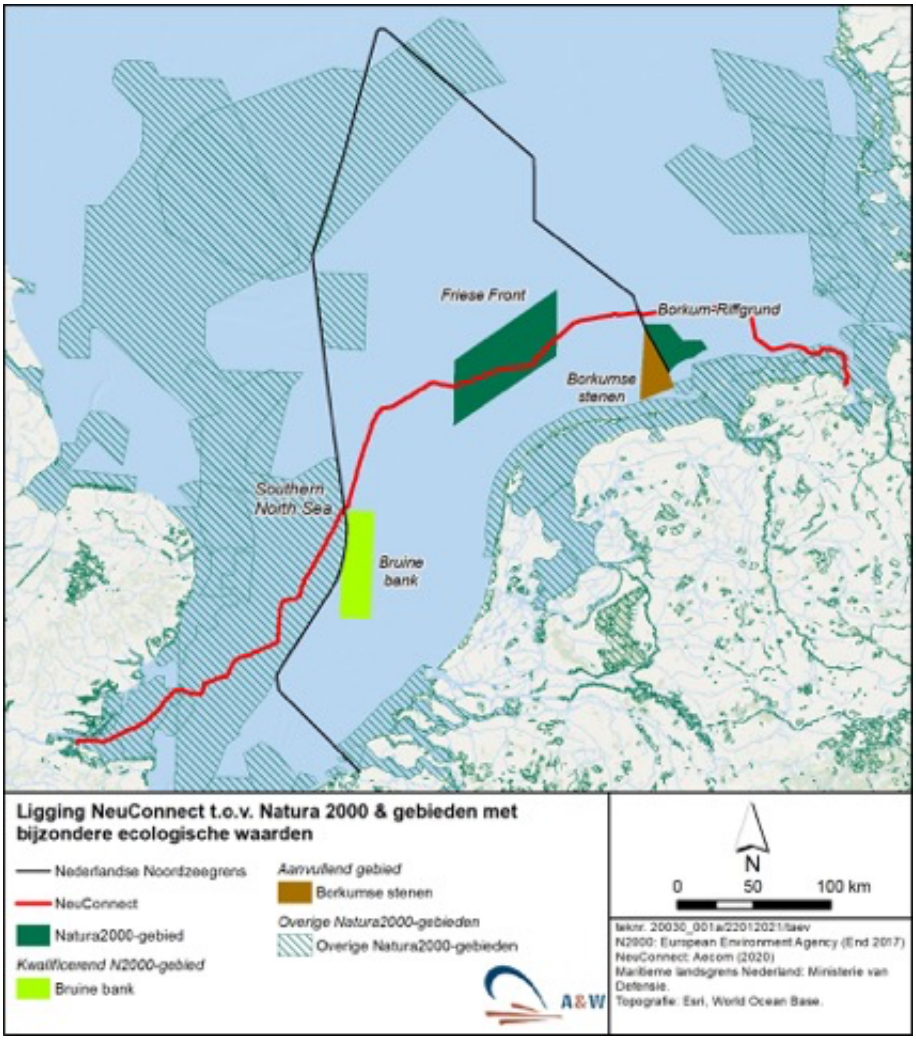
[1] Voor het Kader Ecologie en Cumulatie 3.0 (KEC 3.0) zijn de cumulatieve effecten onderzocht op o.a. bruinvissen van de aanleg van windparken op het NCP in de periode 2016 – 2030, inclusief de aanleg van de zeekabels tussen de windparken en het land. Op grond van de resultaten van het onderzoek zijn geluidsnormen afgeleid die bij de constructie van windparken niet mogen worden overschreden, zodat ontoelaatbare effecten op de bruinvispopulatie kunnen worden voorkomen.

Ook vissen kunnen een negatieve invloed van onderwatergeluid ondervinden, met name soorten die over een zwemblaas beschikken. Vissen zijn echter aanmerkelijk minder gevoelig voor onderwatergeluid dan zeezoogdieren (hogere gehoordrempel) en bovendien alleen gevoelig voor frequenties die lager liggen dan de frequenties van het door seismische apparatuur geproduceerde geluid. In combinatie met het gegeven dat het plangebied voor de NeuConnect kabel niet van specifieke betekenis is voor bepaalde vissoorten kan worden geconcludeerd dat effecten op vissen kunnen worden uitgesloten.




*Figuur 2-1 Tracé van de NeuConnect hoogspanningsgelijkstroomkabel*

## 2.2 Redeneerlijn

Bij het bepalen van de (cumulatieve) effecten van impulsief onderwatergeluid zijn in het Kader Ecologie en Cumulatie de volgende stappen onderscheiden (zie ook Heinis *et al.* 2015 en Heinis *et al.* 2019)[2]:

1. Berekenen van een realistische worst case in de verspreiding van het onderwatergeluid als gevolg van de activiteit;
2. Berekenen van de oppervlakte door het geluid verstoorde gebied;

[2] Bij het bepalen van de mogelijke doorwerking van effecten van impulsief onderwatergeluid op bruinvissen is ervan uitgegaan dat de effecten op het gedrag daarvoor maatgevend zijn. Dit heeft te maken met het feit dat het gebied waarin bruinvissen TTS en PTS kunnen oplopen veel kleiner is dan het gebied waarbinnen gedragseffecten kunnen optreden. Bovendien is onwaarschijnlijk dat bruinvissen die tijdens de pre-engineering survey in het plangebied aanwezig zijn lang genoeg aan het geluid van de seismische apparatuur worden blootgesteld om TTS of PTS op te lopen (zie ook rapportage voor NorthConnect kabel).

3. Berekenen van het aantal door het geluid verstoorde dieren uit de berekende verstoorde oppervlakten vermenigvuldigd met de lokale dichtheid van de dieren;
4. Berekening van het aantal dierverstoringsdagen uit het aantal verstoorde dieren per dag vermenigvuldigd met het aantal verstoringsdagen;
5. Schatten van het mogelijke effect op de populatie; voor bruinvissen is daarvoor gebruik gemaakt van het Interim PCoD model (versie 2019);
6. Beoordelen van de geschatte populatieafname en toetsen aan de, door de overheid gestelde ecologische doelstelling.

Deze stappen zijn voor het berekenen van de effecten van de seismische surveys voor de aanleg van de NeuConnect kabel doorlopen en beschreven in Sectie 3.

# 3 Berekening effecten

## 3.1 Door onderwatergeluid beïnvloed gebied door seismisch onderzoek

Rond de aanleg van de 2 hoogspanningsgelijkstroomkabels voor de NeuConnect Interconnector worden de volgende surveys met bijbehorende apparatuur uitgevoerd:

- Pre-engineering survey met inzet van multibeam echosounder (MBES), Side Scan Sonar (SSS) en Sub-Bottom Profiler (SBP), gedurende 23,5 werkdagen;
- Survey voor het opsporen van 'unexploded ordnance' (UXO's), met inzet van MBES en SSS, gedurende 17,5 werkdagen;
- Pre-installatie survey voor de bathymetrie (MBES en wellicht ook SSS), gedurende 17,5 dagen;
- Post-installatie survey (MBES, kabeltracering), gedurende 16,5 dagen;
- Survey nadat de kabel is ingegraven (MBES), gedurende 1 dag.

Tabel 3-1 bevat een overzicht van de apparatuur die bij het geofysische onderzoek zal worden gebruikt met een indicatie van verstoringsafstanden (specificaties overgenomen uit Heinis et al. 2019).

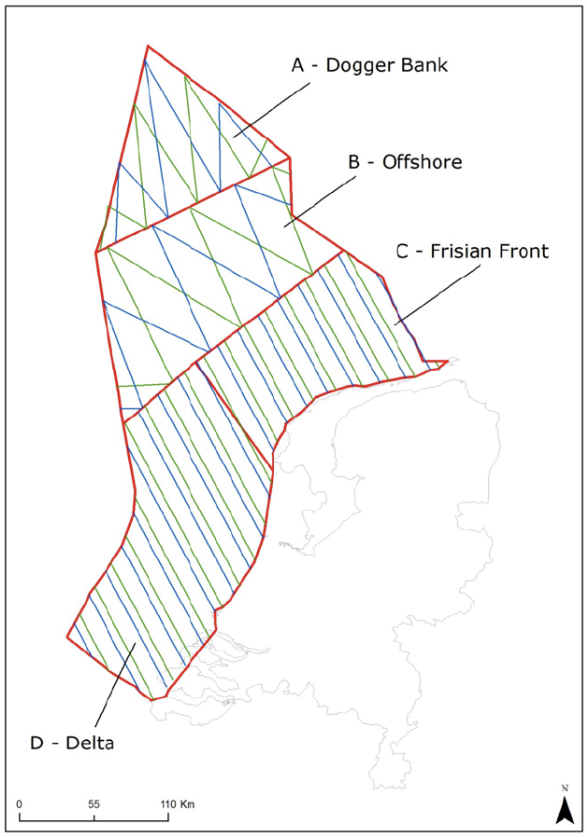
*Tabel 3-1 Typische systemen die tijdens het geofysische onderzoek rond het kabeltracé worden gebruikt en een inschatting van verstoringsafstanden*

| Type systeem | Voorbeeld systeem | Geschatte effectafstand |
|---|---|---|
| MBES: | Kongsberg EM2040 Dual Head, Dual Swath / Dual Ping – Frequency 400 kHz | Frequentie boven gehoorgrens vissen en zeezoogdieren; geen significante sub-harmonischen; verwachte effect afstanden (verwaarloosbaar) klein |
| SSS: | Edgetech 4200 300/600 – Frequency: 239 kHz (LF) and 555 kHZ (HF) | Frequentie boven gehoorgrens vissen en zeezoogdieren; geen significante sub-harmonischen; verwachte effect afstanden (verwaarloosbaar) klein |
| SBP: | Innomar SES 2000 Standard parametric sub-bottom profiler – Power: > 50kW; Frequency: 8 – 100 kHz | Verwachte verstoringsafstanden voor bruinvissen tussen 1 en 2 km (zie Bijlage 3 in Heinis et al. 2019) |

Uit het overzicht blijkt dat het grootste deel van het geofysisch onderzoek wordt uitgevoerd met apparatuur waarvan vanwege de gebruikte (zeer) hoge frequenties niet is te verwachten dat enig effect op zeezoogdieren zal optreden. De enige apparatuur die tot verstoring kan leiden, is de sub-bottom profiler (SBP). Deze wordt uitsluitend ingezet tijdens de pre-engineering survey. Voor de berekeningen is er *worst case* van uitgegaan dat deze apparatuur gedurende alle dagen van deze survey wordt ingezet. Omdat geen zeer diepe bodempenetratie nodig is, is voor de berekeningen conform Heinis et al. (2019) voor de sub-bottom profiler uitgegaan van een maximale verstoringsafstand van 1 km. Voor een rechthoekig scangebied en ervan uitgaande dat voor de pre-engineering survey 23,5 werkdagen nodig zijn, komt dat overeen met een verstoringsoppervlak van ~33 $km^2$ per dag.

## 3.2 Aantal verstoorde bruinvissen

Het aantal mogelijk verstoorde bruinvissen wordt berekend door de oppervlakte van het verstoorde oppervlak te vermenigvuldigen met de lokale bruinvisdichtheid. De lokale dichtheid is bepaald op basis van de gegevens van vliegtuigtellingen over de periode 2010 – 2019 en die zijn gerapporteerd door Geelhoed *et al.* (2018) en Geelhoed *et al.* (2020). In deze rapporten zijn op het NCP 4 deelgebieden onderscheiden (Figuur 3-1), waarvan er twee door de NeuConnect kabel worden doorsneden, te weten deelgebied C (~ 160 km) en deelgebied D (~ 105 km). De over de periode 2010 – 2019 gemiddelde dichtheid van bruinvissen bedraagt 0,87 ind/km$^2$ voor deelgebied C en 0,67 ind/km$^2$ voor deelgebied B.




*Figuur 3-1 Uit Geelhoed et al. (2018) overgenomen kaart van het NCP met onderscheiden deelgebieden A (Doggersbank), B (Offshore), C (Friese Front) en D (Delta). De lijnen geven de gevlogen transecten weer en de kleuren de verschillende surveys.*

## 3.3 Bruinvisverstoringsdagen en effecten op de populatie

Het totale aantal bruinvisverstoringsdagen is berekend door het aantal mogelijk verstoorde bruinvissen te vermenigvuldigen met het aantal verstoringsdagen. De resultaten van de schatting en de daaruit volgende berekening van het aan tal bruinvisverstoringsdagen zijn opgenomen in Tabel 3-2.

Voor de doorvertaling naar effecten op de bruinvispopulatie is voor het KEC gekozen gebruik te maken van het Interim PCoD model van SMRU/University St. Andrews (Harwood *et al.* 2013). De benaderingswijze die aan dit model ten grondslag ligt, wordt internationaal gebruikt (NRC, 2005; New *et al.* 2014) wat betekent dat niet alleen de werkwijze, maar ook de verkregen uitkomsten internationaal vergelijkbaar zijn[3]. In het Interim PCoD model wordt een kwantitatieve relatie gelegd tussen gedragsverandering en factoren als overlevingskans en reproductiesucces (*vital rates*). De

[3] Een ander model, DEPONS (Disturbance Effects on the harbour POrpoise population in the North Sea), waarmee effecten van verstoring door heigeluid op de bruinvispopulatie kunnen worden geschat, was ten tijde van het KEC 1.0 nog niet beschikbaar (Van Beest e.a., 2015, Nabe-Nielsen e.a., 2014). Een eerste versie voor algemene toepassing kwam in april 2017 beschikbaar. Er is inmiddels van die versie een update verschenen die is te downloaden via depons.au.dk. De Nederlandse overheid heeft ervoor gekozen om voor het KEC 3.0 van het volledige geüpdatete iPCoD model uit te gaan, omdat hiermee de internationale vergelijkbaarheid van berekeningen beter is gewaarborgd.

relatie is afgeleid door het raadplegen van deskundigen volgens een formeel *expert elicitation* proces, aangezien voor veel soorten meetgegevens voor het draaien van een 'full' PCoD model cf. New e.a. (2014) ontbreken. Daarbij zijn diverse technieken toegepast om de meningen van experts onafhankelijk te wegen en een numerieke schatting van de onzekerheid in de relatie te kunnen geven. In 2018 zijn een tweetal workshops gehouden waarin via *expert elicitation* op basis van nieuwe kennis en verbeterde inzichten voor bruinvissen en zeehonden opnieuw relaties zijn afgeleid (Booth & Heinis, 2018; Booth e.a. 2019). De resultaten zijn verwerkt in versie 5.0 van het iPCoD model, die in maart 2019 voor algemeen gebruik is vrijgegeven (http://www.smruconsulting.com/release-ipcod-version-5/).

*Tabel 3-2 Worst case schatting van verstoring van bruinvissen door het uitvoeren van de pre-engineering survey en het daaruit berekende aantal bruinvisverstoringsdagen.*

| Deelgebied | Inschatting lengte tracé (km) | Breedte tracé (km | Dagen survey (inschatting) | Km survey per dag | Verstoord oppervlak per dag ($km^2$) | Dichtheid bruinvissen (ind/$km^2$) | bruinvisverstoringsdagen |
|---|---|---|---|---|---|---|---|
| C (Friese Front) | 159,6 | 0,5 (2 kabels) | 14,2 | 11,3 | 33,2 | 0,87 | 408 |
| D (Delta) | 105,4 | 0,5 (2 kabels) | 9,3 | 11,3 | 33,2 | 0,67 | 209 |
| | | | | | | **Totaal** | **617** |

Voor het KEC 3.0 zijn verschillende scenario's voor de ontwikkeling van wind op zee, inclusief de effecten van de benodigde seismische surveys, doorgerekend. De uitkomsten laten zien dat er een verband bestaat tussen het aantal bruinvisverstoringsdagen en de reductie van de populatie bruinvissen op de Noordzee. De volgende benaderingsformule geeft het verband weer als van een 95% zekerheid wordt uitgegaan (maximaal 5% kans dat de berekende populatiereductie groter is en daarmee zou worden onderschat):

$$Populatiereductie = 1{,}06 \times 10^{-4} \times bvvd^{1{,}17}$$

De populatiereductie is daarbij uitgedrukt in het aantal individuen en bvvd staat voor het aantal bruinvisverstoringsdagen.

Uit de benaderingsformule volgt dat het berekende aantal bruinvisverstoringsdagen van 617 leidt tot een 5% kans op en een populatiereductie van minder dan 1 bruinvis (0,19). Dit is een verwaarloosbaar effect, ook in cumulatie met de effecten van de constructie van windparken op het NCP in de periode 2016 – 2030.

# 4 Conclusie

Tijdens de seismische surveys rond de aanleg van de NeuConnect kabel wordt impulsief onderwatergeluid geproduceerd. Alleen de apparatuur die wordt gebruikt voor de pre-engineering survey (sub-bottom profiler) produceert geluid dat tot verstoring van bruinvissen kan leiden. Effecten op zeehonden en andere soorten zeezoogdieren kunnen op voorhand worden uitgesloten, omdat zij (zeer) sporadisch in het plangebied voor de zeekabel voorkomen. Uit de *worst case* effectberekening blijkt dat ook voor bruinvissen de effecten verwaarloosbaar zijn: de berekende populatiereductie bedraagt minder dan 1 bruinvis. Op een geschatte gemiddelde populatie op het NCP van 51.000 individuen is dat verwaarloosbaar.

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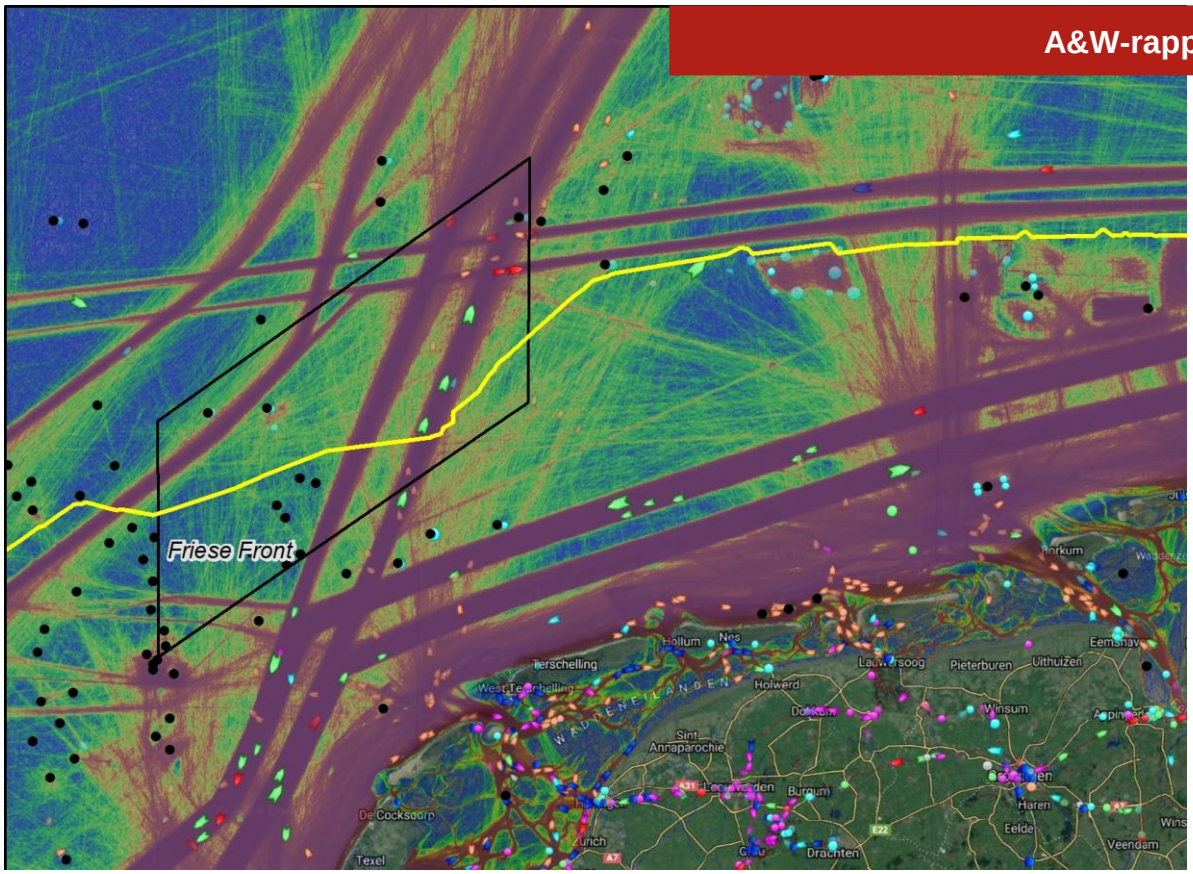
# Bijlage 13: Ecologische beoordeling NC-kabel, inclusief passende beoordeling,

## Altenburg & Wymenga, 15 maart 2021

Altenburg & Wymenga
ECOLOGISCH ONDERZOEK

# Ecologische beoordeling Neuconnect kabel, inclusief passende beoordeling

A&W-rapport 2550




in opdracht van

Bio Consult SH

# Ecologische beoordeling Neuconnect kabel, inclusief passende beoordeling

**A&W-rapport 2550**

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Lara Mielke
Anneke Rippen
Eddy Wymenga

**Afbeelding Voorplaat**
Route van het kabeltracé NeuConnect in geel ten opzichte van scheepvaartroutes

**Lara Mielke, Anneke Rippen, Eddy Wymenga 2021**
Ecologische beoordeling NeuConnect kabel, inclusief passende beoordeling. A&W-rapport 2550.
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|---|---|---|
| goedgekeurd | **Joris Latour** | 17 maart 2021 |

**Kwaliteitscontrole**

E. Wymenga

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# 1 Inleiding

## 1.1 Aanleiding

NeuConnect[1] heeft het voornemen om het Britse en Duitse energienetwerk met elkaar te verbinden door een hoogspanningskabel aan te leggen tussen het vasteland van Duitsland en Groot-Brittannië. Het gaat hier om een zogenaamde 1.400 MegaWatt (MW) hoogspanningsgelijkstroomverbinding (High Voltage Direct Current, HVDC). Deze interconnector (verbindingskabel) zal bestaan uit onderzeese hoogspanningkabels van in totaal circa 720 km tussen Duitsland en Groot-Brittannië, waarbij het traject ook door Nederlandse territoriale wateren gaat (over een afstand van circa 265 km).

Voor de aanleg van NeuConnect door het Nederlandse deel van de Noordzee (de Nederlandse Exclusieve Economische Zone, EZZ) wordt een milieueffectrapportage (m.e.r.)- procedure doorlopen. De m.e.r. maakt deel uit van de vergunningsaanvraag in het kader van de Waterwet, die benodigd is voor de bouw, exploitatie en ontmanteling van onderzeese kabels. Voor de m.e.r. is een Notitie Reikwijdte en Detail opgesteld (ingediend op 1 februari 2019, Schuttinga & Nijmeijer 2019). In het kader van de m.e.r.-procedure en ten behoeve van de benodigde vergunningen of ontheffingen (Wet natuurbescherming - Wnb) is het nodig de voorgenomen plannen ecologisch te beoordelen. De voorliggende ecologische beoordeling voorziet hierin. Daarnaast richt deze ecologische beoordeling zich op overige ecologisch waardevolle gebieden, zoals het gebied 'Borkumse Stenen', en beschermde soorten in het kader van internationale beschermingsregimes (i.e. KRM, OSPAR en ASCOBANS).

## 1.2 Doelstelling

De doelstelling van deze ecologische beoordeling is het toetsen van de voorgenomen aanleg, exploitatie en buitenbedrijfstelling van de onderzeese hoogspanningsgelijkstroomkabel NeuConnect in de EEZ aan de Wnb en, voor zover aan de orde, aan andere ecologisch relevante beschermingskaders (en natuurwaarden). Voor wat betreft Natura 2000 gaat het hier om een Voortoets in het kader van gebiedsbescherming, om na te gaan welke mogelijk relevante effecten passend beoordeeld moeten worden. Omdat significante negatieve effecten niet op voorhand kunnen worden uitgesloten is een passende beoordeling nodig. De passende beoordeling is ook onderdeel van deze rapportage. Voor wat betreft de soortbescherming (art. 3.5 en 3.10 Wnb) wordt beoordeeld of er al dan niet een ontheffing nodig is voor de uitvoering van het initiatief.

## 1.3 Aanpak

In deze ecologische beoordeling wordt gestart met een beschrijving van de voorgenomen activiteit, 'het initiatief', in hoofdstuk 2. Daarbij wordt ingegaan op de aanleg- en gebruiksfase en de eventuele buitenbedrijfstelling op langere termijn. In dit hoofdstuk wordt ook beschreven welke soort effecten te verwachten zijn. In hoofdstuk 3 wordt ingegaan op het wettelijk kader en de relevante regelgeving (Wet natuurbescherming, internationale beschermingsregimes, en

[1] NeuConnect verwijst hier naar het consortium NeuConnect Great Britain Limited (NCGBL) dat gevormd is door de groep van investeerders om de aanleg van de kabel mogelijk te maken. In de verdere tekst wordt met ‘NeuConnect’ de gelijknamige kabel bedoeld.

overige relevante regelgeving), en welke aspecten voor de beoordeling relevant zijn (instandhoudingsdoelen, beschermde gebieden en soorten e.d.). Vervolgens worden het beoordelingskader en de uitgangspunten daarvoor opgesteld. Als referentie voor de beoordeling is vervolgens in hoofdstuk 4 een beschrijving gemaakt van de relevante natuurwaarden in de bestaande situatie. Dit betreft zowel beschermde gebieden als (internationaal) beschermde soorten en habitats. De ecologische beoordeling valt in twee delen uiteen (hoofdstuk 5 en 6), de gebiedsbescherming en de bescherming van relevante soorten en habitats (inclusief soortbescherming). De gebiedsbescherming heeft betrekking op Natura 2000-gebieden en overige ecologisch waardevolle gebieden.

De Voortoets voor de gebiedsbescherming (Natura 2000) wordt in hoofdstuk 5 behandeld en daarin wordt ook ingegaan op andere ecologisch relevante gebieden. De daaruit voortvloeiende passende beoordeling is opgenomen in paragraaf 5.2: deze beschrijft de verwachte effecten op de natuurwaarden van de kabelaanleg in meer detail en beoordeelt deze op basis van Natura 2000 instandhoudingsdoelstellingen voor de relevante Natura 2000-gebieden. De mogelijke effecten op beschermde soorten, vallend onder de soortenbescherming Wnb worden op basis van de Wet Natuurbescherming in hoofdstuk 6 beschreven. Ook mogelijke effecten op beschermde soorten of habitats, vallend onder internationale beschermingsregimes, worden hier beschreven. De beschrijving van natuurwaarden en effectanalyses zijn gebaseerd op eerdere onderzoeken of monitoring-rapporten over de Noordzee en aanvullende gegevens in de literatuur. Voor de zeebodem is voor het Neuconnect voorkeurstracé een aanvullend veldonderzoek gedaan (Orbicon 2019a&b).

In Hoofdstuk 5 en 6 worden eventuele cumulatieve effecten besproken. Hierbij worden voor zover relevant de projecten in de omgeving meegenomen, waarover reeds bestuurlijke besluitvorming heeft plaatsgevonden (i.e. vergunningverlening), maar die nog niet zijn uitgevoerd. Het rapport sluit af in hoofdstuk 7 met conclusies en enkele aanbevelingen (leemten in kennis).

# 2 Voorgenomen activiteit

De voorgenomen activiteit betreft de aanlegfase, de exploitatiefase en de eventuele toekomstige buitenbedrijfstelling van een hoogspannings-gelijkstroomverbinding met een capaciteit van 1400 MW en een spanning van 500 kV, waarmee energie zal worden overgedragen tussen de transportsystemen van Groot-Brittannië en Duitsland. Om het elektriciteitsnetwerk van beide landen met elkaar te verbinden is een onderzeese kabel nodig van ongeveer 720 km in de zuidelijke Noordzee, waarvan circa 265 km door de Nederlandse Exclusieve Economische Zone (EEZ) zal gaan. De informatie in dit hoofdstuk is gebaseerd op de Notitie Reikwijdte en Detailniveau (Schuttinga & Nijmeijer 2019) en aanvullende informatie in het MER (AECOM 2021).

In de volgende paragrafen presenteren wij een samenvatting van de werkzaamheden. Voor nadere en meer gedetailleerde informatie verwijzen wij naar de MER (AECOM 2021).

## 2.1 Aanleg van de kabel

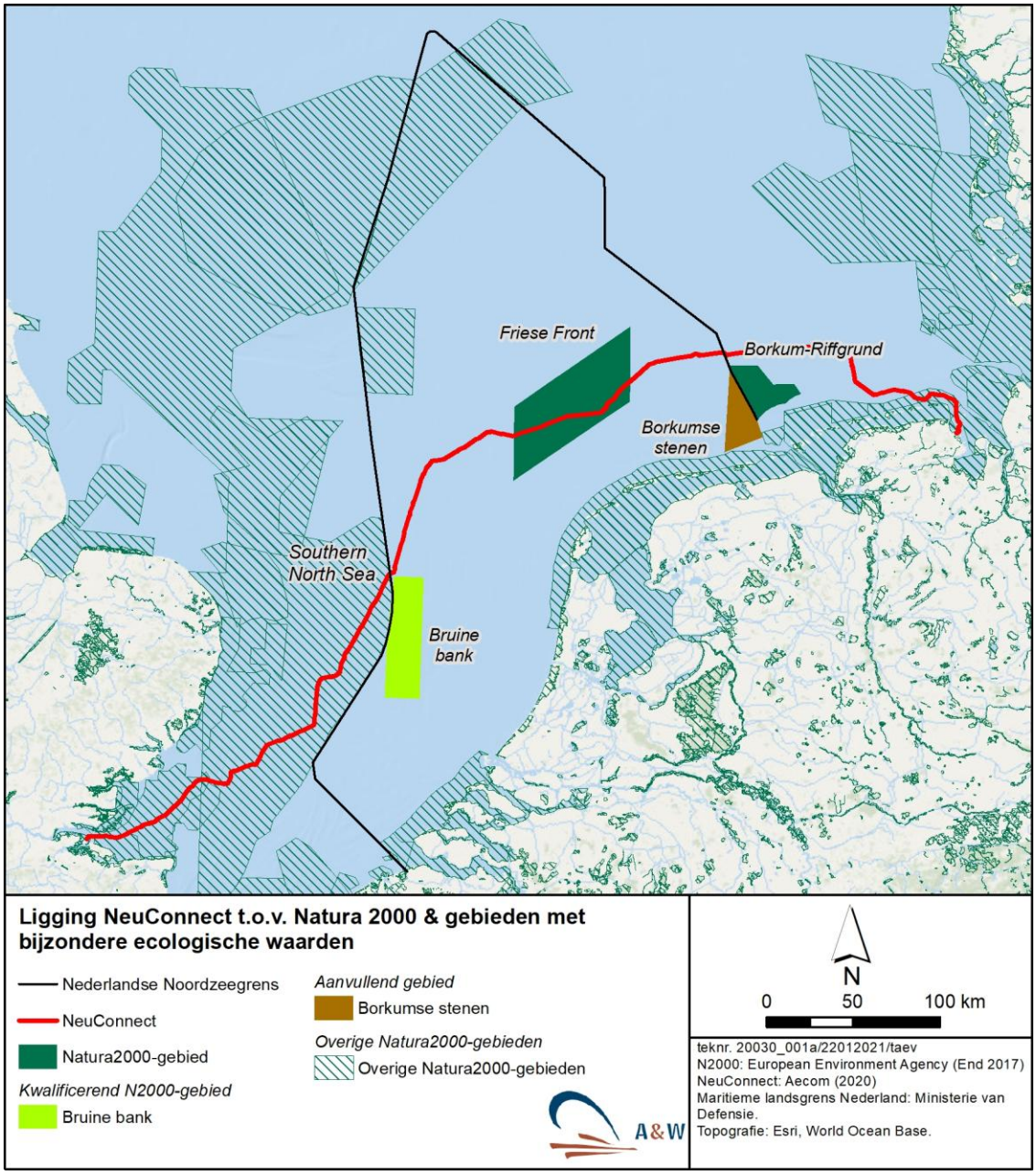
### *2.1.1 Route*

De NeuConnect verbinding doorkruist de wateren van Groot-Brittannië, Nederland en Duitsland. Het voorgestelde (voorkeurs)kabeltracé loopt van Isle of Grain (Groot-Brittannië) naar Fedderwarden, vlakbij Wilhelmshaven (Duitsland) (Figuur 2-1). De kabel loopt over een lengte van circa 265 km door de Nederlandse Exclusieve Economische Zone (EZZ), en loopt over een afstand van circa 78 km door het Natura 2000-gebied Friese Front. Op een afstand van circa 2,3 km loopt de kabel ten noorden van het kandidaat Natura 2000-gebied Bruine Bank. In het oosten zal de kabel op een afstand van ongeveer 7,3 km ten noorden van het ecologisch waardevolle gebied Borkumse Stenen liggen. De voorkeursroute is vastgesteld op basis van een studie (4C Offshore 2017), waarbij zeven route-alternatieven zijn beschouwd. De locatie van de grensovergang tussen Duitsland en Nederland is door de Duitse autoriteiten gefixeerd. Op basis hiervan is de route bepaald. Na een hernieuwde discussie met de Duitse autoriteiten zijn drie nieuwe alternatieve routes beschouwd. Uiteindelijk is de oorspronkelijke route als voorkeursroute bepaald (AECOM 2021).

Het Nederlandse deel van NeuConnect loopt door een deel van de Noordzee met een diepte van circa 30-40 m, waarbij in het westelijke deel noord-zuid lopende zandgolven lopen en in het oostelijke deel oost-west gerichte zandgolven. Het middendeel is relatief vlak (zie ook H-4).

### *2.1.2 Kabelsysteem*

Het gaat om een zogenoemd tweefasenkabelsysteem (i.e. elektriciteit wordt door twee hoogspanningsgeleiders met tegengestelde polariteit getransporteerd), waarbij de twee kabels naast elkaar worden gelegd in één sleuf ('bundelen'). De breedte van een kabelsleuf is ongeveer 1 m, met een ‘voetafdruk’ voor de installatieapparatuur van 15 m en tot 40 m indien ‘pre-sweeping’ (voorvegen van zandgolven) nodig is (AECOM 2021). Op de locaties van de kabelkruisingen zal de onderzeese kabel moeten worden beschermd en zal gebruik worden gemaakt van steenbestorting (grindsteen) of betonnen blokkenmatten.




*Figuur 2-1 Voorgestelde route (voorkeursalternatief) van het offshore kabeltracé van Neuconnect (AECOM 2021; www.neuconnect.eu) met aanvullend de ligging van Natura-2000 gebieden, en andere ecologisch relevante gebieden.*

Er zijn momenteel twee soorten gelijkstroom hoogspanning onderzeekabels die gebruikt zouden kunnen worden: massa-geïmpregneerde en geëxtrudeerde kabels. Het basisontwerp van de kabels is vergelijkbaar, met een diameter van 150 millimeter, maar het voornaamste verschil zit in de gebruikte isolatie. Welk systeem voor de NeuConnect kabel wordt gebruikt wordt naar verwachting bekend zodra de tender is gegund (naar verwachting 2021-2022).

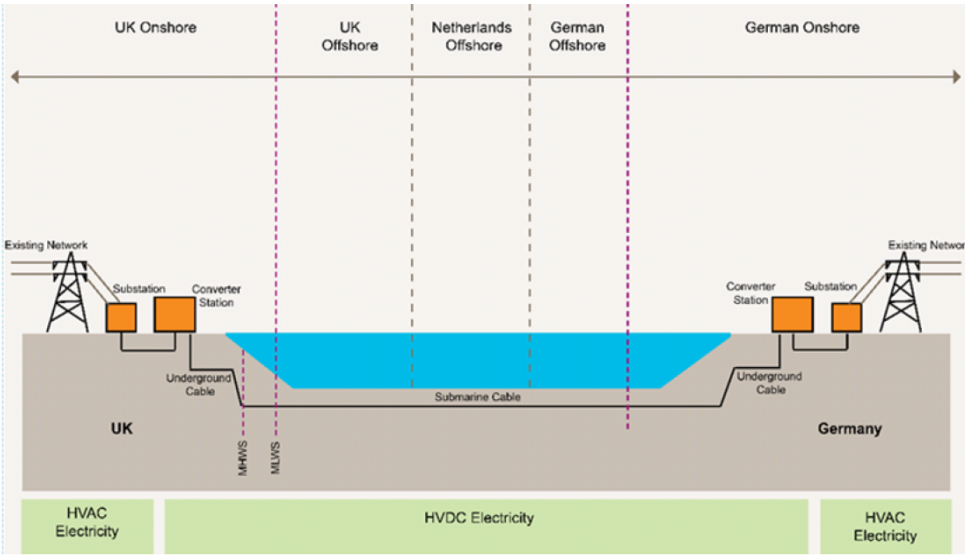
## 2.2 Werkzaamheden in de aanlegfase

Voorafgaand aan de aanleg van het zeekabelsysteem (Figuur 2-2) zullen verschillende voorbereidingswerkzaamheden op het tracé plaatsvinden, zoals pre-installatie onderzoeken en het vrijmaken van het kabeltracé, inclusief het verwijderen van obstakels.

Om informatie over de toestand van de zeebodem, de bathymetrie en andere kenmerken te bevestigen wordt voorafgaand aan de installatie van de kabel geofysisch onderzoek uitgevoerd. Daarvoor wordt gebruik gemaakt van bijvoorbeeld Side-scan sonar, Multi Beam echosounder, Sub-bottom profiler en magnetometer (AECOM 2021).

Daarnaast is het mogelijk dat specialistisch onderzoek wordt uitgevoerd naar niet-gesprongen explosieven (NGE) (Unexploded Ordnance (UXO) uit WO I en II). Mogelijke effecten door NGEs worden alleen voor de aanlegfase uitgewerkt, omdat de kans zeer klein is dat tijdens de exploitatiefase NGE worden aangetroffen. Ten aanzien van NGE is een risicobeoordeling uitgevoerd (1st Line Defence Limited 2018), waarbij geen exacte locaties van explosieven zijn bepaald. Er kan in deze fase nog niet worden uitgesloten dat er NGE aanwezig zijn. Eventueel langs de corridor aanwezige NGE moeten door middel van onderzoek worden gelokaliseerd en zo nodig worden opgeruimd. Het risico dat NGE tot ontploffing moeten worden gebracht wordt vooralsnog als laag geschat (AECOM 2021). Zorgvuldigheidshalve wordt in deze beoordeling uitgegaan van een worst case situatie waarbij NGE worden opgeruimd.

Onderdeel van de pre-installatie onderzoeken is een benthisch onderzoek, waarbij het voorgestelde traject is bemonsterd (met camera's en steekproefsgewijs met bodemmonsters) op de aanwezige benthische fauna en het voorkomen van bijzondere structuren (Orbicon 2019a; zie beschrijving resultaten in H4). Zandgolven langs de route worden indien mogelijk vermeden, waar dat niet mogelijk is zal de zeebodem aangepast moeten worden zodat de kabel effectiever begraven kan worden (bijvoorbeeld door te baggeren of de toppen van de zandgolven af te platten).




*Figuur 2-2 Schematische weergave van de NeuConnect interconnector, die een nieuwe verbinding vormt tussen de energienetwerken van Groot-Brittannië en Duitsland (www.neuconnect.eu).*

De kabels worden over de gehele lengte ingegraven, behalve op plekken waar dit onmogelijk is (door eigenschappen van de zeebodem, of bij kruising van bestaande kabels en leidingen). Binnen de Nederlandse EEZ ligt de voorgestelde aanlegdiepte (i.e. afstand tussen de bovenzijde van de kabels en het onberoerde zeebodemoppervlak) van het kabelsysteem tussen de 1,5 m en 2 m.

Er zijn verschillende typen installatiemethodes, te weten:

- Ploegen: waarbij een smalle sleuf in de zeebodem wordt gemaakt, die lang genoeg open wordt gehouden zodat de kabel erin gelegd kan worden voordat de zeebodem zich weer sluit. Ploegen is mogelijk in alle zeebodems (m.u.v. rotsachtige zeebodems).

- 'Jet trenching': waarbij water wordt gebruikt om het zand te verstoren en een vloeibare zandlaag te creëren, waarna de kabel op basis van eigen gewicht door de vloeibare zandlaag in de sleuf zinkt, of er mechanisch wordt ingeduwd. De sleuf vult zichzelf op natuurlijke wijze weer aan. Deze methode is het meest kosteneffectief in zandige gronden.

- Mechanisch graven: waarbij een sleuf wordt uitgegraven door middel van een snijmachine en het vrijgekomen materiaal aan weerszijden van de sleuf terechtkomt. De kabel wordt dan in de sleuf geplaatst waarna het materiaal wordt aangevuld of achtergelaten en natuurlijke processen het verplaatsen.

De exacte methode die zal worden toegepast hangt af van de resultaten van het pre-installatie onderzoek, waaruit moet blijken of er gevoelige gebieden aanwezig zijn en er een specifieke methode moet worden gebruikt. Ook zal de keuze afhangen van de uitvoerder van het project. Er wordt rekening gehouden met maximaal 9 verschillende soorten schepen tijdens de aanlegfase (Voets 2021a, AECOM 2021). Naar verwachting zal de vaarsnelheid van de schepen in de aanlegfase 20-125 m/uur bedragen (de schepen zullen zich voortbewegen met een snelheid van 0,5 km tot 3 km per dag). Deze snelheden zijn echter een globale inschatting, in de praktijk is de snelheid afhankelijk van de ondergrond en de 'trencher'. Wanneer er bij het leggen van de kabel geen gelijktijdige begraving plaatsvindt kan mogelijk een snelheid van circa 500 m/uur worden gehaald. De methode die gebruikt wordt voor het leggen van kabels zal te zijner tijd worden bevestigd in overeenstemming met wettelijke vereisten en aanvullende vergunningseisen. In deze beoordeling gebruiken we, waar relevant, beide vaarsnelheden.

Bij het kabelleggen zijn in ieder geval vijf schepen gelijktijdig betrokken (Voets 2021a, AECOM 2021), namelijk een kabellegger (die de lange, zware elektriciteitskabels transporteert en verwerkerkt) en vier veiligheids- of wachtschepen (die rond de kabellegger de wacht houden om te zorgen dat andere schepen uit de buurt van de installatie blijven). Tijdens de wisseling van de wachtschepen zullen er echter zes schepen tegelijkertijd op één plaats aanwezig zijn. In deze beoordeling wordt daarom uitgegaan van maximaal zes werkschepen (aanleg- en onderhoudsschepen) tijdens de aanlegfase.

De aanlegfase kan leiden tot verschillende effecten. Deze worden in paragraaf 2.6 nader besproken.

## 2.3 Gebruiksfase: exploitatie

De kabel en de installatie ervan worden zodanig ontworpen dat eventuele onderhoudsvereisten tot een minimum worden beperkt. Wel dient er beheer in de vorm van het meten van de diepte

van de kabel onder de zeebodem en de hoogte van de zeebodem (bathymetrie) te worden uitgevoerd. De reden daarvoor is dat de diepte van de kabel of de hoogte van de zeebodem kunnen veranderen doordat de mobiele zeebodem (zandgolven) zich verplaatsen door de stroming of een storm ervoor zorgt dat de toplaag van de zeebodem wegspoelt. Wanneer de diepte van de kabel of de hoogte van de zeebodem wijzigt, kan dit tot gevolg hebben dat de kabel ‘bloot’ komt te liggen. In dat geval ontstaat er een verhoogd risico dat er schade aan de kabel wordt veroorzaakt doordat bijvoorbeeld een ‘bloot’ liggende kabel wordt geraakt door een anker of vissersgerei. Dit wordt gezien als een calamiteit. In het ontwerp en tijdens de aanlegfase van de kabel is extra rekening gehouden met het voorkomen van dit soort schade aan de kabel. Onder andere wordt de kabel extra diep gelegd om te voorkomen dat deze eventueel bloot komt te liggen. Ook wordt ter plaatse van de mobiele zeebodem pre-sweeping toegepast waardoor de kabel wordt aangelegd onder de onderliggende niet-mobiele zeebodem. Dergelijke calamiteiten zijn zeldzaam en het risico dat de kabel bloot komt te liggen wordt als verwaarloosbaar geacht. (AECOM 2021, Voets 2021b). Kabelreparaties tijdens de exploitatiefase worden in deze ecologische beoordeling daarom niet in detail beschouwd.

De werkzaamheden voor beheer- en onderhoudsactiviteiten zijn vergelijkbaar met de aanleg van de kabels, maar dan op een kleinere en gelokaliseerde schaal.

De gebruiksfase leidt tot verschillende emissies, namelijk Elektromagnetisch (EM-)velden, Warmte-emissies en Geluid. Deze worden in paragraaf 2.6 nader besproken.

## 2.4 Werkzaamheden bij eventuele buitenbedrijfstelling (ontmanteling)

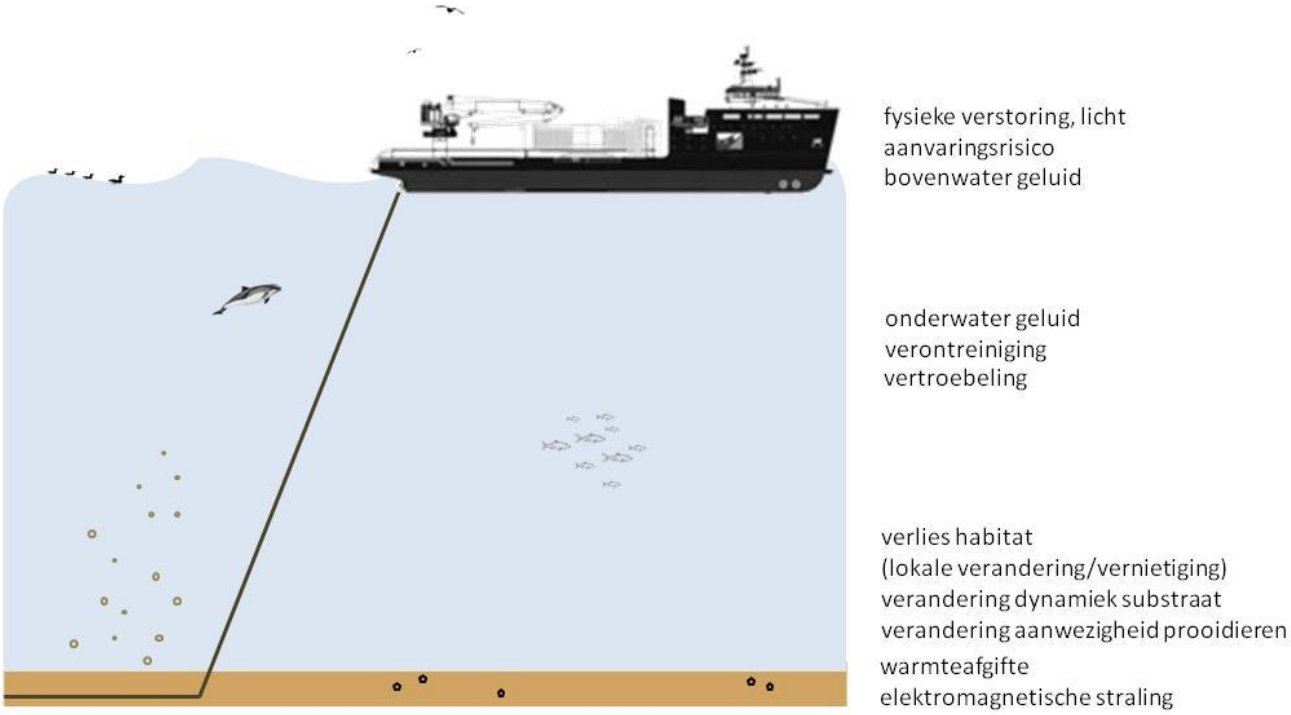
De verwachte levensduur van de kabel is ongeveer 40 jaar, maar deze 'leeftijd' kan in werkelijkheid ook overschreden worden. Zodra de kabel het einde van zijn levensduur bereikt, zal een beslissing worden genomen over de manier waarop de kabel buiten bedrijf wordt gesteld.

## 2.5 Planning

In 2018 heeft projectontwikkeling plaatsgevonden over milieubeoordeling en vergunningverlening. In 2019, 2020 en 2021 gaat deze projectontwikkeling verder en zullen vergunningaanvragen worden ingediend bij het bevoegd gezag. In 2021 wordt vergunningverlening verwacht, waarna er kan worden gestart met de kabelaanleg. Er wordt verwacht dat dit doorloopt in 2022. In 2023 zal de kabel naar verwachting in gebruik zijn.

## 2.6 Mogelijke effecten

**Soort van effecten**
Mogelijke effecten als gevolg van kabelaanlegwerkzaamheden kunnen worden ingedeeld in effecten boven water, in de waterkolom en op/in de zeebodem (Figuur 2-3). Daarbij kan onderscheid worden gemaakt in de verschillende fasen.




*Figuur 2-3 Vereenvoudigde visualisatie van potentiële effecten bij de kabelaanlegwerkzaamheden, op te delen in effecten boven water, in de waterkolom en op/in de zeebodem. Effecten ter plaatse tijdens de aanlegfase zijn tijdelijk ; de schepen hebben naar verwachting een werksnelheid van 0,5 tot 3 km per dag.*

*Aanlegfase*

In de aanlegfase zijn boven water potentieel effecten mogelijk van de aanwezigheid en zichtbaarheid van de schepen; deze zijn sterk vergelijkbaar met reguliere scheepvaart of vissersschepen omdat boven het normale niveau van scheepsmotoren en handelingen op het schip geen additioneel geluid wordt geproduceerd. Er zal waarschijnlijk sprake zijn van verlichting op het schip voor werkzaamheden ’s nachts. De belangrijkste effecten hangen samen met eventuele verstoring door verlichting en de fysieke aanwezigheid van de schepen (zes schepen: een kabellegger en vijf wachtschepen ). De verstoring is tijdelijk en hangt samen met de periode en de snelheid waarmee de kabel wordt aangelegd. Er is altijd sprake van een risico op aanvaring, ook al is dat in deze situatie gering door de aanwezigheid van een veiligheidsschip om dat te voorkomen.

In de waterkolom wordt de kabel neergelaten. Onderwatergeluid in deze situatie, buiten het onderwatergeluid dat varende schepen produceren, heeft betrekking op geluid als gevolg van graafwerk, afhankelijk van de fysieke eigenschappen van het specifieke deel van de zeebodem waar gewerkt wordt. Voorts kan in de onderwaterkolom sprake zijn van vertroebeling en verontreiniging als gevolg van het lokaal omwoelen van de zeebodem.

Op de zeebodem is sprake van fysieke beroering van de zeebodem van naar verwachting 3-15 m (lokaal tot 20 m of 40 m) en een lengte, over het Nederlandse deel van het traject, van 265 km (AECOM 2021). Fysieke beroering begint in de pre-installatie fase met het verwijderen van obstakels. Bij de feitelijke aanleg wordt de kabel ingegraven en wordt ter plaatse de zeebodem omgewoeld. Effecten betreffen lokale verandering en verplaatsing van de zeebodem en

verstoring van de daar aanwezige habitats en soorten. Dit leidt lokaal tevens tot kortstondige vertroebeling.

*Exploitatiefase*
In de exploitatiefase hangen effecten samen met geluid, de warmteafgifte van de kabel en elektromagnetische straling, lokaal in of boven de zeebodem. Daarnaast kan er sprake zijn van tijdelijke effecten door 'beheer en onderhoud' voor het meten van de diepte van de kabel en de bathymetrie van de zeebodem, alsmede tijdens calamiteiten (bijv. als de kabel bijvoorbeeld bloot komt te liggen).

*Buitenbedrijfstelling*
De effecten bij buitenbedrijfstelling zijn sterk vergelijkbaar met de aanlegfase. Ook hier zijn enkele schepen (tegelijkertijd) actief om de kabel te ontmantelen, en is opnieuw sprake van omwoeling van de zeebodem over dezelfde breedte en lengte van het traject.

Samenvattend
De te verwachten effecten door de aanleg van de kabel zullen op hoofdlijnen afhangen van:
1. het seizoen wanneer de kabel wordt aangelegd;
2. de duur van de aanleg van de kabel;
3. de verstoringsafstanden (gevoeligheid) van de aanwezige soorten;
4. de lengte, breedte en diepteligging van de kabel;
5. de frequentie van beheer en onderhoud;
6. opwarmingseffecten van de kabel;
7. magnetische straling rond de kabel.

De effecten die mogelijk kunnen voortkomen uit de aanleg van NeuConnect zijn samengevat in Tabel 2-1. In Hoofdstuk 3 wordt een beoordelingskader gegeven van de potentiële effecten door de kabelaanlegwerkzaamheden.

**Relevante effecten en gevoeligheid**
In een overzicht van relevante drukfactoren voor de offshore industrie van het ministerie van LNV (2008, aanvulling op Broekmeijer 2006) worden de volgende soorten effecten als potentieel relevant beschouwd:

1 Oppervlakteverlies;
2 Verontreiniging;
3 Verandering dynamiek substraat;
4 Vertroebeling;
5 Verstoring door geluid, licht, trilling en visuele verstoring

Voor de aanleg van NeuConnect zijn vooral het tijdelijke verlies van zeebodem habitat (maanden tot max. een jaar) en het kwaliteitsverlies door tijdelijke (uren tot max. een dag) verstoring van belang. Kwaliteitsverlies door fysische factoren (vertroebeling en trilling van de kabel) en door chemische verontreiniging wordt ook meegenomen in de effectanalyse. In tabel 2-1 geven we een overzicht van de boven beschreven effecten en de relevantie voor de verdere effectbepaling. De beoordeling van de effecten houdt - naast de locatie van Natura 2000-gebieden (en de daarbij aangewezen natuurwaarden) ten opzichte van het kabeltracé - rekening met de invloedszone van de mogelijke effecten (verschillende effecten hebben verschillende invloedzones), die door de aanleg, exploitatie & onderhoud en buitengebruikstelling van de NeuConnect kabel kunnen ontstaan. De te verwachten invloedszone voor de mogelijke effecten is ook in tabel 2-1 aangegeven.

Hieronder wordt nader op deze effecten ingegaan en beschreven op welke natuurwaarden deze effecten mogelijk een invloed kunnen hebben. De effecten zijn opgedeeld in effecten in de aanlegfase en buitenbedrijfstelling en effecten in de exploitatiefase.

## AANLEGFASE EN BUITENBEDRIJFSTELLING

***Visuele verstoring***
Visuele verstoring vindt voornamelijk boven water door de fysieke aanwezigheid van schepen en verlichting plaats en kan zeezoogdieren, vogels en vleermuizen betreffen. Op de zeebodem zijn geen effecten door visuele verstoring te verwachten.

***Aanvaringsrisico***
Tijdens de aanlegfase en eventueel toekomstige buitenbedrijfstelling is sprake van een beperkte toename van het scheepvaartverkeer. Voor zeezoogdieren kan dit leiden tot een grotere kans op aanvaringen met vaartuigen; het risico hierop is mede gezien de lage vaarsnelheid gering.

***Onderwatergeluid***
Door onderwatergeluid tijdens de aanlegfase en buitenbedrijfstelling kunnen soorten in de waterkolom worden verstoord, zoals vissen, duikende zeevogels en zeezoogdieren. Er wordt onderscheid gemaakt tussen geluid dat ontstaat door schepen en apparatuur, tijdens pre-installatie onderzoeken (geofysisch onderzoek) en geluid dat ontstaat door het opruimen van NGE.

*Geluid van schepen en apparatuur*
Onafhankelijk onderzoeksorgaan COWRIE (Nedwell *et al.* 2003, 2012) heeft onder andere onderzoek gedaan naar het geluid dat ontstaat bij het leggen van zeekabels. Tijdens het aanleggen van het offshore windpark North Hoyle (Groot-Brittannië) zijn metingen gedaan van de geluidsniveaus die ontstonden bij het ingraven van kabels in de zeebodem. De niveaus werden opgenomen met een hydrofoon (op 2 m diepte) op een afstand van 160 m van de graafwerkzaamheden. Het geluidsdrukniveau van de opnames was 123 dB re 1 µPa en bestond uit een combinatie van breedbandgeluid, tonaal machinegeluid en overgangsgeluiden. Er werd opgemerkt dat het geluid tijdens het onderzoek sterk variabel was en afhankelijk van de fysieke eigenschappen van het te bewerken deel van de zeebodem. Uit de analyse van de gegevens blijkt dat bij een verondersteld transmissieverlies van 22 log (R) sprake is van een bronniveau van 178 dB re 1 µPa @ 1 m. Met deze bron verrichte geluidsmodellering wijst vervolgens uit dat voor afstanden tot 5 km van de bron alle metingen lager zijn dan 70 dB (met één specifieke uitzondering, veroorzaakt door de hoge variabiliteit in geluid) (Nedwell *et al.* 2003*).*

*Geofysisch onderzoek*
Voorafgaand aan de aanlegfase wordt met behulp van geofysisch onderzoek (zoals bijvoorbeeld Side-scan sonar, Multi Beam echosounder, Sub-bottom profiler of magnetometer) de zeekabelcorridor opnieuw in kaart gebracht wordt. Het geluid dat door geofyfische onderzoeken ontstaat kan een effect hebben op zeezoogdieren (walvisachtigen en zeehonden). Voor de ontwikkeling van het Kader Ecologie en Cumulatie (KEC) is recent een onderzoek naar ‘Cumulatieve effecten van impulsief onderwatergeluid op zeezoogdieren’ uitgevoerd (Heinis *et al.* 2019). Daarbij is een schatting gemaakt van verstoringsafstanden voor

verschillende type systemen die gebruikt kunnen worden voor geofysisch onderzoek. Daaruit blijkt dat de effectafstanden door het gebruik van Side-scan sonar en Multi Beam echosounder (verwaarloosbaar) klein zijn. Door het gebruik van de Sub-bottom profiler en de magnetometer kunnen effectafstanden tussen 1 en 2 km (veroorzaakt door primaire frequentie van de bron op 100 kHz) optreden.

*Niet-gesprongen explosieven (NGE)*
Indien potentiële NGE's niet kunnen worden vermeden door microroutering binnen de toegestane route worden deze onderzocht en tot ontploffing gebracht. Door het ontploffen van NGE komt impulsgeluid vrij. De afstand vanaf het explosief waarop zeezoogdieren gehoorschade kunnen oplopen, is afhankelijk van de grootte van het explosief. Deze afstand kan variëren van één tot enkele kilometers en eventueel nog verder bij hele grote explosieven (Von Benda Beckman *et al.* 2015).

*Tabel 2-1. Indicatief overzicht van mogelijke effecten als gevolg van de NeuConnect-kabel ( risico optreden: m = matig, g = gering , zg= zeer gering) inclusief de invloedszone van de NeuConnect-kabel op basis van de geïdentificeerde mogelijke effecten (mede gebaseerd op Viking Link 2017a).*

| **Mogelijk effect** | | **Invloedszone** | **Onderbouwing** | **Risico op optreden** |
|---|---|---|---|---|
| **Aanlegfase en fase buitenbedrijfstelling** | | | | |
| Fysieke verstoring | Tijdelijke verstoring door aanwezigheid van zes schepen, vaarsnelheid naar verwachting 20-125 m/u | Omgeving van de schepen, kabelkoridor | In een zone van 200-1.000 m rond de schepen rekening te houden met mogelijke verplaatsing van vogels en/of zeezoogdieren | m |
| Aanvaringsrisico | Mogelijk aanvaringen met zeezoogdieren door toegenomen scheepsverkeer | Directe omgeving kabelcorridor | De aanwezigheid van vaartuigen blijft beperkt tot de kabelcorridor | zg |
| Onderwatergeluid | Tijdelijk onderwatergeluid door pre-installatie onderzoek, opruimen NGE, schepen, aanleg van kabel en apparatuur | Omgeving van de kabel, afhankelijk van de soort en het systeem | Effectafstanden door pre-installatie onderzoek tussen 1 en 2 km. Effectafstanden door opruimen van NGE afhankelijk van grootte van explosief (tussen 1 tot enkele km). Rekening houdend met ecologie van gevoelige soorten (verspreiding, migratie, reproductie etc.) | m |
| Verontreiniging | Lekkage van vervuilende stoffen door schepen, vrijkomen van verontreinigende stoffen in sediment door graafwerkzaamheden | Kabelcorridor + omgeving van de kabel | Negatieve effecten zullen zich tot een zone van 10km rond de kabel beperken, ook rekening houdend met de dispersie van gelekte brandstof (Viking Link 2017a) | g |
| Vertroebeling en hersedimentatie | Kortdurende en lokale stijging van concentraties van zwevende deeltjes | Kabelcorridor + directe omgeving | Gebaseerd op modellen met zwevende deeltjes voor aanleg VIKING kabel (Intertek 2016) | m |
| Directe verstoring habitat/flora/fauna | Tijdelijke verstoring van habitat/flora/fauna door obstakelverwijdering (pre-installatie) en graafwerkzaamheden/ankers | Directe omgeving kabel | Verstoring vindt alleen plaats binnen de directe omgeving van de kabel en de installatieapparatuur | m |
| Verlies van habitat | Habitatverlies door plaatsing van hard substraat op zeebodem (voor erosiebescherming of bescherming van kruisingen met | | | g |

| Mogelijk effect | | Invloedszone | Onderbouwing | Risico op optreden |
|---|---|---|---|---|
| | andere kabels, 13 locaties) | | | |
| Veranderingen aanwezigheid van prooidieren | Veranderingen in aanwezigheid van prooidieren door werkzaamheden en menselijke activiteiten | Kabelcorridor + directe omgeving | - effecten op visprooien worden alleen in de directe sonificatiezone verwacht, maar uit voorzorg wordt een ruimere zone aangehouden<br>- effecten op visprooien door vertroebeling worden verwacht in de zone waar sediment oplost en weer neerslaat (Intertek 2016) | m |
| **Exploitatie** | | | | |
| Elektromagnetische (EM-)velden | Door de kabel tijdens de exploitatiefase afgegeven EM-velden die het gedrag van mariene fauna kan beïnvloeden | Directe omgeving van de kabel | Emissies van EM-velden zwakken af tot achtergrondniveau of lager binnen 10 m van de kabel (Gill *et al.* 2005). | m |
| Warmteafgifte | Door de kabel tijdens de exploitatiefase afgegeven warmte die het gedrag van benthische soorten kan beïnvloeden | Directe omgeving van de kabel | In het direct omringende sediment spelen opwarmingseffecten (OSPAR 2012) | g |
| Onderwatergeluid | Verstoring door trillingen van kabel | Directe omgeving van de kabel | In de directe omgeving van de kabel (binnen 10m) kan onderwatergeluid optreden (OSPAR 2009) | zg |
| Verontreiniging | Lekkage/vrijkomen van verontreinigende stoffen door kabel | Directe omgeving van de kabel | Negatieve effecten beperken zich tot de directe omgeving van de kabel (Taormina *et al.* 2018) | zg |
| Tijdelijke onderhoudswerkzaamheden | Effecten vergelijkbaar met aanlegfase maar lokaal en kleiner van omvang | Langs de kabelcorridor | Effecten vergelijkbaar met aanlegfase maar lokaal en kleiner van omvang | zg |

***Verontreiniging***

Door de aanleg van de NeuConnect kabel is er in beginsel een kleine kans dat onopzettelijk vervuilende stoffen vrijkomen. Dit kan komen door het lekken van schepen of het vrijkomen van vervuilende stoffen in de sediment. Lekken vanuit schepen en materiaal wordt zoveel als mogelijk voorkomen. Ook kunnen tijdens werkzaamheden aan de sediment vervuilende stoffen vrijkomen. Daarbij kan het gaan om zware metalen en koolwaterstoffen (Taormina *et al.* 2018). Verontreiniging kan gevolgen hebben voor soorten in alle onderdelen van het water, maar de mate van gevoeligheid voor verontreiniging is echter soortafhankelijk. Omdat vervuilende stoffen van nature voorkomen in sediment en pas door menselijke activiteiten significante concentraties worden bereikt, worden hoogste concentraties verontreinigende stoffen in de sediment in kustgebieden en daarom niet in het plangebied verwacht (Taormina *et al.* 2018). Er zijn door Orbicon (2019b) sedimentmonsters genomen langs de voorgestelde kabelroute en geanalyseerd op vervuilende stoffen, en uit de sedimentchemie blijkt dat er geen bijzondere verontreinigingen zijn in het onderzoeksgebied.

***Vertroebeling en hersidementatie***

Vertroebeling kan als gevolg van activiteiten in de aanlegfase en buitenbedrijfstelling, voornamelijk tijdens graafwerkzaamheden, optreden. Dit leidt tot een tijdelijke stijging van concentraties van zwevende deeltjes. Deze sedimentdeeltjes kunnen zich verspreiden onder de invloed van wind, stroming en getij. In de tijdsperiode dat de deeltjes in suspensie zijn, nemen ze licht weg voor fytoplankton en remmen daarmee de primaire productie, de basis van

de voedselketen in het gebied. Met name zwevende deeltjes die zich bevinden nabij het wateroppervlak vangen licht weg. Na verloop van tijd bezinken deze deeltjes, en gaan wederom opwervelen en uiteindelijk op luwe locaties permanent gaan bezinken. Sedimentatie van grote omvang kan leiden tot nadelige gevolgen voor het bodemleven en vervolgens op de voedselketen in het gebied. Aangezien het over het algemeen zandige habitats betreft (Orbicon 2019b) en zand snel bezinkt, is vertroebeling lokaal en kortstondig van aard (gedurende het fysieke werk, en naar verwachting maximaal een aantal uren daarna).

***Directe verstoring van habitat/flora/fauna***
Door graafwerkzaamheden en ankers in verband met de aanlegfase en buitenbedrijfstelling kan tijdelijke verstoring van habitat/flora/fauna optreden. Dit effect betreft soorten op de zeebodem.

***Verlies van habitat***
Door plaatsing van hard substraat op de zeebodem (voor erosiebescherming of bescherming van kruisingen met andere kabels) kan ter plaatse van het hard substraat habitatverlies optreden. Dit effect betreft habitattypes.

***Veranderingen in aanwezigheid van prooidieren***
Effecten zoals onderwatergeluid, verontreiniging, vertroebeling of elektromagnetische velden kunnen leiden tot veranderingen in de aanwezigheid van vis-, schaaldier- en schelpdierpopulaties (Taormina *et al.* 2018, Viking Link 2017). Dit kan indirect effecten hebben op de hele voedselketen en op alle onderdelen van het water.

## EXPLOITATIEFASE

***Elektromagnetische (EM-)velden***
De aanwezigheid van elektromagnetische velden door een hoogspanningskabel in de zeebodem kan worden opgemerkt door organismen die hiervoor gevoelig zijn, zoals ongewervelde, vissen en zeezoogdieren.

Wanneer de kabel in gebruik is verplaatst elektrische stroom zich door de kabels waardoor er elektrische en magnetische velden (EMF) worden gegenereerd. Door de aanwezigheid van een metalen omhulsel zullen de kabels zelf geen elektrische velden creëren. Wel worden elektrische velden opgewekt door het zeewater dat door het aardmagnetische veld stroomt. Lokaal en in de achtergrond zal er een klein elektrisch veld aanwezig zijn (AECOM 2021).

Het magnetisch veld dat door de kabels wordt geproduceerd zal plaatselijk varieeren omdat het afhankelijk is van de elektrische stroom die door de kabels gaat, de manier waarop de kabels gescheiden zijn en de afstand tussen de kabels. Volgens Schuttinga & Nijmeijer (2019) worden de NeuConnect kabels gebundeld. Door de wederzijdse opheffing van de positieve en negatieve polen en de zich in tegengestelde richting verplaatsende stromen zullen de magnetische velden zwak zijn. In geringere mate kan ook de gronddekking het effectbereik van EM-velden beperken. Conform de Nederlandse wetgeving zal de ingraafdiepte van de NeuConnect kabel tussen 1,5 m tot 2 m liggen. Een mogelijke interferentie met andere elektromagnetische velden zal alleen bij kruisingen ontstaan. Hiermee wordt rekening gehouden in het ontwerp van de kruisingen (AECOM 2021). Elektromagnetische interferentie wordt daarom niet verwacht.

***Warmteafgifte***
De hoogspanningskabels zullen ook zorgen voor kleine temperatuursverschillen, die normaal gesproken beperkt zijn tot het oppervlak van de kabel en lokaal verwarmingseffecten veroorzaken. Bij het inschatten van de hoeveelheid afgegeven warmte boven de kabel (en hoe diep de kabel moet liggen om geen effect te geven op bodemfauna) wordt vaak het '2K criterium' aangehouden, zoals in Duitsland wordt gebruikt (nationale regelgeving, voorzorgsmaatregel om bodemfauna te beschermen). Bij het 2K criterium wordt gesteld dat, afhankelijk van het kabelontwerp, gebundelde kabels een sedimentdekking nodig hebben van 0,7 m tot 1,15 m voordat aan het 2K criterium is voldaan (i.e. temperatuurstijging van <2°C bij 0,2 m bodemdiepte).

Uit modelleringen voor de Viking Link blijkt dat het dan gaat om een lokale temperatuurstijging op 20 cm onder zeebodemniveau van 1-2°C (voor een op 1 m diepte begraven kabel) (Brakelman & Stammen 2017). Aangezien de ingraafdiepte van de NeuConnect kabel 1,5 m tot 2 m is en de zeer hoge warmtecapaciteit van het water, is het niet waarschijnlijk dat opwarmingseffecten optreden van de waterkolom en het bovenste deel van de zeebodem (AECOM 2021). Dit effect heeft daarom alleen betrekking op ingravende fauna en op bepaalde habitattypen.

***Onderwatergeluid***
Ook tijdens de exploitatiefase kan door trillingen van de kabel onderwatergeluid optreden. Vergeleken met het onderwatergeluid tijdens de aanlegfase en buitenbedrijfstelling is de intensiteit van dit geluid laag, maar permanent aanwezig (Taormina *et al.* 2018). Dit betreft vissen, vogels en zeezoogdieren.

***Verontreiniging***
Verontreiniging kan ook tijdens de exploitatie optreden. Dit kan komen door het vrijkomen van vervuilende stoffen, zoals zware metalen, die zijn verwerkt in de kabel zelf (Meißner *et al.* 2006). Dit effect kan soorten en habitats op en in de zeebodem betreffen.

***Tijdelijke beheer- en onderhoudswerkzaamheden***
De mogelijke effecten van onderhoudswerkzaamheden zijn vergelijkbaar met de effecten van aanlegwerkzaamheden, maar zullen waarschijnlijk lokaler optreden, korter duren en daarom beperkter van omvang zijn. Tijdelijke onderhoudswerkzaamheden kunnen effect hebben op alle onderdelen van het water.

*Figuur 2-4 & 2-5: Zeekoet(en) op de Noordzee (bron: C. Burger, BioConsultSH).*

# 3 Wettelijk kader en regelgeving

## 3.1 Wettelijk kader

In dit hoofdstuk wordt een overzicht gegeven van de internationale, Europese en Nederlandse, ecologische wet- en regelgeving. Er wordt nader ingegaan op de bescherming van natuurwaarden, die mogelijk beïnvloed worden door de aanleg van de onderzeese hoogspanningskabel. Verschillende natuurwaarden vallen onder verschillende nationale en internationale beschermingsregimes. Een gedetailleerde weergave van de aanwezigheid van natuurwaarden in ruimte en tijd wordt gegeven in hoofdstuk 4.

Per 1 januari 2017 is de Wet natuurbescherming (Wnb) van kracht. Deze wet vervangt drie oude wetten: de Natuurbeschermingswet, de Flora- en Faunawet en de Boswet. De Wet natuurbescherming kent twee pijlers: gebiedsbescherming (hoofdstuk 2 van de Wnb) en soortbescherming (hoofdstuk 3 van de Wnb). Hieronder wordt nader ingegaan op deze twee kaders. Daarnaast wordt ingegaan op overige beschermingsregimes.

## 3.2 Gebiedsbescherming - Wet natuurbescherming

**Natura 2000- gebieden**
Natura 2000 is een Europees ecologisch netwerk van beschermde natuurgebieden, die zijn aangewezen op grond van de Vogelrichtlijn en Habitatrichtlijn. De Vogelrichtlijn richt zich op in het wild levende vogelsoorten. De Habitatrichtlijn richt zich op overige dier- en plantensoorten en op habitattypen. Voor de natuurwaarden worden speciale beschermingszones, zogenaamde Natura 2000-gebieden, aangewezen.

Voor Natura 2000-gebieden gelden instandhoudingsdoelen. Het netwerk moet de betrokken natuurlijke habitattypen, habitats van soorten inclusief de leefgebieden van vogels in een gunstige staat van instandhouding behouden of herstellen. Deze bescherming wordt ten uitvoer gebracht met gebiedsspecifieke maatregelen, zoals afsluiting en gericht beheer van gebieden. De essentie van het beschermingsregime voor deze gebieden is dat deze instandhoudingsdoelen niet in gevaar mogen worden gebracht. Om dit toetsbaar te maken kent de Wet natuurbescherming voor projecten, en andere handelingen die negatieve gevolgen voor soorten en habitats van de betreffende gebieden zouden kunnen hebben, een vergunningplicht.

Een vergunning voor een plan of project wordt alleen verleend wanneer zeker is dat de beoogde, te vergunnen activiteit geen significante gevolgen heeft voor de natuurwaarden waarvoor het gebied als Natura 2000-gebied is aangewezen. Met behulp van een Voortoets wordt bepaald of er wel of geen negatieve effecten te verwachten zijn. Op basis van de Voortoets zijn drie uitkomsten mogelijk:

1. Er zijn zeker geen negatieve effecten te verwachten;
2. Er is een kans op negatieve effecten, maar deze leiden zeker niet tot een significante aantasting van de instandhoudingsdoelen van het Natura 2000-gebied;
3. Er is kans op significant negatieve effecten, die kunnen leiden tot aantasting van de instandhoudingsdoelstellingen van het Natura 2000-gebied.

Wanneer significante gevolgen op voorhand – en zonder mitigerende maatregelen mee te wegen - niet kunnen worden uitgesloten, is een Passende beoordeling van de gevolgen nodig.

Op basis van de Passende beoordeling moet met zekerheid vastgesteld kunnen worden dat de natuurlijke kenmerken van het gebied (*in casu* de instandhoudingsdoelen) niet worden aangetast. Daarbij mag de inzet van mitigerende maatregelen worden meegewogen. Wanneer er wel negatieve effecten zijn maar deze blijkens de beoordeling niet significant negatief zijn, kan een vergunning worden verleend onder voorwaarden (in de Natuurbeschermingswet 1998 was dit een zogenaamde verstorings-verslechteringstoets). Indien dit niet met zekerheid kan worden vastgesteld, is een zogenaamde ADC-toets (A: geen alternatieve oplossing; D: dwingende reden van openbaar belang; C: compenserende maatregelen) nodig. Indien deze toets met succes wordt doorlopen, kan het project alsnog worden vergund.

**Relevante Natura 2000-gebieden**
In het kader van Natura 2000 richt deze beoordeling zich voornamelijk op twee gebieden: het Natura 2000-gebied Friese Front en de Bruine Bank (zie ook 4.3). De Bruine Bank is nog niet aangewezen maar staat wel op nominatie om aangewezen te worden (planning en termijn niet bekend), daarom wordt het gebied in deze ecologische beoordeling meegenomen als ware het een reeds aangewezen Natura 2000-gebied. Volgens de plannen (Voorkeurstracé) zal de kabel over een afstand van ongeveer 78 km door het Friese Front lopen en op een afstand van 2,3 km ten noorden van de Bruine Bank. De Borkumse stenen wordt niet als Natura 2000-gebied aangewezen; volgens informatie van het ministerie van LNV wordt het meest zuidelijk puntje toegevoegd aan het Natura 2000-gebied Noordzeekustzone. Dit is op een afstand van ongeveer 60 km van de Neuconnect kabel.

**Externe werking op Natura 2000-gebieden**
Het beschermingsregime van Natura 2000 kent de externe werking. Dat betekent dat activiteiten buiten beschermde gebieden die negatieve gevolgen kunnen hebben voor Natura 2000-gebieden in de omgeving ook mede beoordeeld moeten worden. Activiteiten op korte afstand van een Natura 2000-gebied kunnen kwalificerende soorten in het Natura 2000-gebied verstoren. Ook activiteiten op grotere afstand van een Natura 2000-gebied kunnen gevolgen hebben voor Natura 2000-gebieden. Verstoring treedt ook op wanneer kwalificerende soorten vanuit het Natura 2000-gebied gebruik maken van de omgeving en dat gebruik door ruimtelijke ontwikkelingen minder mogelijk wordt. In dit geval betreft het in potentie voornamelijk zeezoogdieren en vogelsoorten, die vanuit Natura 2000-gebieden gebruik van de Noordzee maken om te foerageren.

Natura 2000-gebieden buiten het Nederlandse deel en in de directe omgeving van NeuConnect zijn 'Borkum Riffgrund' in Duitsland en 'Southern North Sea' in Groot-Brittannië (Fig. 2-1). Het kabeltracé loopt door Southern North Sea en ligt op een afstand van circa 7 km van Borkum Riffgrund. Beide gebieden grenzen direct aan de Nederlandse Noordzeegrens en zijn aangewezen voor de Bruinvis. Borkum Riffgrund is daarnaast aangewezen voor de Fint, de Gewone zeehond, de Grijze zeehond en de habitattypes H1110 (‘permanent overstroomde zandbanken’) en H1170 (‘riffen’).

Het betreft ook gebieden in de wijdere omgeving zoals 'Duinen Vlieland' of 'Waddenzee'. Deze gebieden zijn aangewezen voor broedvogels met een grote maximale foerageerafstand vanaf de broedlocatie zoals Kleine mantelmeeuw (100 km), Aalscholver (70km) of Grote stern (40km) (Arcadis 2008). De activiteiten kunnen in potentie gevolgen hebben voor Natura 2000-gebieden die liggen op een grote afstand tot het plangebied en zijn aangewezen voor habitats of soorten

die grote afstanden af kunnen leggen zoals bijv. de Jan-van-gent (Poot *et al.* 2010). De Natura 2000-gebieden 'Östliche Deutsche Bucht' en 'Seevogelschutzgebiet Helgoland' in Duitsland liggen op een afstand van <150km en zijn aangewezen voor deze soort.

Voor Natura 2000-gebieden geldt dat mogelijk effecten van de activiteit en daarmee ook de mogelijk gewijzigde stikstofuitstoot op Natura 2000-gebieden inzichtelijk gemaakt dienen te worden. De dichtstbijzijnde voor stikstofdepositie gevoelige habitattypen (zoals 'zilte pionierbegroeiingen', 'schorren en zilte graslanden', 'embryonale duinen', 'grijze duinen', 'vochtige duinvalleien') liggen in de Natura 2000-gebieden Waddenzee (circa 45km), Duinen Terschelling (circa 45km), Duinen Ameland (circa 55km), Duinen Vlieland (circa 55km) en Noordzeekustzone (circa 60km).

Op 29 mei 2019 heeft de Raad van State een uitspraak gedaan over het beoordelingskader 'Programatische Aanpak Stikstof (PAS), dat werd gebruikt voor voorgenomen projecten in Nederland waarbij een toename in stikstofdepositie optreedt in stikstofgevoelige habitats in Natura 2000-gebieden. De RvS heeft het PAS vernietigd, en momenteel wordt door het ministerie van LNV gewerkt aan een herzien beoordelingskader.

## 3.3 Overige gebiedsbescherming

We beschouwen in deze paragraaf ook andere waardevolle gebieden, of gebieden die een speciale status hebben en relevant zijn in het kader van deze beoordeling.

**Marine Protected Areas (MPA's)**
Marine Protected Areas is een term om 'beschermde gebieden' aan te duiden. Binnen OSPAR worden MPA's gedefinieerd als: "*areas for which protective, conservation, restorative or precautionary measures have been instituted for the purpose of protecting and conserving species, habitats, ecosystems or ecological processes of the marine environment*" (OSPAR 2019). In het Nederlandse deel van de Noordzee vallen de zes officieel aangewezen Natura 2000-gebieden onder de MPA's, dit zijn Doggersbank, Klaverbank, Friese Front, Noordzeekustzone, Voordelta en Vlakte van de Raan (zie ook Figuur 4-4).

**Overige ecologisch waardevolle gebieden**
Het gebied Borkumse Stenen wordt in deze beoordeling nader behandeld, omdat het ecologisch waardevol is (Bos & Paijmans 2012). In Nederland heeft dit gebied geen beschermde status en dus geen officiële status. Het staat ook niet op nominatie om te worden aangewezen als Natura 2000-gebied. Wel zal er sprake zijn van een gedeeltelijke sluiting van de Borkumse Stenen met de omvang van circa 108 $km^2$ (zuidelijke punt). De exacte locatie van de te beschermen zone zal nog worden bepaald, en worden toegevoegd aan het huidige Natura 2000-gebied Noordzeekustzone (Bron Kamerbrief 32670-115, min EZ, dd. 9 juni 2017). Het aangrenzende Duitse gebied Borkum Riffgrund is beschermd onder de Habitatrichtlijn en daarom een Natura 2000-gebied.

**Zoekgebied bodembeschermende maatregelen**
De gebieden Friese Front en 'Centrale Oestergronden' zijn aangewezen als 'zoekgebied bodembeschermende maatregelen' onder de Kaderrichtlijn Mariene Strategie (zie nadere uitleg KRM hieronder bij 3.5). Voor het Friese Front houdt dat in dat er een voorstel ligt om een gebied van 1.000 $km^2$ te sluiten voor bodemberoerende visserij. Ook wordt het gehele Friese Front onder de Vogelrichtlijn gedurende de helft van het jaar (1 juni t/m/ 30 november) gesloten voor staandwantvisserij. In de huidige situatie is visserij nog toegestaan. Voor de Centrale

Oestergronden betreft het voorstel om 1.000 $km^2$ te sluiten voor alle vormen van bodemberoerende visserij. Deze voorstellen moeten nog op Europees niveau worden goedgekeurd (Vrooman *et al.* 2018); dit proces kan een aantal jaren in beslag nemen.

**Natuurnetwerk Nederland (NNN)**
Het Natuurnetwerk Nederland (NNN) is een Nederlands netwerk van bestaande en nieuw aan te leggen natuurgebieden. Het netwerk heeft als doel natuurgebieden beter met elkaar verbinden om zo de achteruitgang van het areaal aan natuur en van de biodiversiteit te stoppen. Dit wordt o.a. gedaan door natuurgebieden te vergroten. Bij nieuwe ontwikkelingen in het NNN moet getoetst worden of er sprake is van significante aantasting van de wezenlijke waarden en kenmerken van het NNN. Daarbij geldt het 'Nee, tenzij …' principe'. Dit houdt in dat er geen toestemming mag worden verleend aan activiteiten die per saldo leiden tot een significante aantasting van de wezenlijke kenmerken en waarden, of tot een significante vermindering van de oppervlakte van of samenhang tussen die gebieden. Toestemming voor dergelijke activiteiten kan wel worden gekregen indien (1) er sprake is van een groot openbaar belang, (2) er geen reële alternatieven zijn en (3) de negatieve effecten op de wezenlijke kenmerken en waarden, de oppervlakte en de samenhang worden beperkt en de overblijvende effecten gelijkwaardig worden gecompenseerd.

Alle Natura 2000-gebieden vallen onder dit netwerk, evenals alle rijkswateren inclusief het Nederlandse deel van de Noordzee. Ten aanzien van NNN op de Noordzee zijn geen duidelijke kaders gesteld. Er is alleen vermeld dat de Noordzee en grote wateren tot het NNN behoren en onder de verantwoordelijkheid van het Rijk vallen. Voor delen in de Noordzee, die ook zijn aangewezen als Natura 2000- gebied, geldt het regime uit de Wet natuurbescherming. De overige delen van de Noordzee kennen geen specifiek planologisch regime en vallen onder het integrale Noordzeebeleid en -beheer (uitgewerkt in het Nationaal Waterplan). Hier is wel de soortbescherming van de Wnb van kracht en geldt een Zorgplicht (bijvoorbeeld ten aanzien van Rode Lijst soorten en soorten genoemd in internationale verdragen). Er wordt vanuitgegaan dat daarmee de wezenlijke waarden van de NNN Noordzee worden meegenomen.

## 3.4 Soortbescherming - Wet natuurbescherming

Soortbescherming is in Nederland sinds 1 januari 2017 vastgelegd in de Wet natuurbescherming (Wnb). Aan de Wet natuurbescherming zijn drie lijsten met soorten gekoppeld. Het gaat om artikel 3.1 waar soorten van de Europese Vogelrichtlijn onder vallen, artikel 3.5 waar soorten van de Europese Habitatrichtlijn onder vallen, bijlage II bij het Verdrag van Bern en bijlage I bij het Verdrag van Bonn en artikel 3.10 voor overige soorten. De beschermde soorten die mogelijk in het plangebied kunnen voorkomen en daarom relevant zijn voor de beoordeling staan genoemd in tabel 3-2.

<u>Artikel 3.1 Wnb: soorten van de Europese Vogelrichtlijn</u>
Deze categorie omvat alle vogelsoorten vermeld in artikel 1 van de Europese Vogelrichtlijn. Alle van nature in het wild levende vogelsoorten in Nederland vallen onder de bescherming van artikel 3.1. Daarbij zijn de volgende verbodsbepalingen van toepassing:

- een verbod om opzettelijk vogels te doden of te vangen;
- een verbod om opzettelijk hun nesten en eieren te vernielen of te beschadigen of hun nesten weg te nemen;
- een verbod om in de natuur eieren van deze vogels te rapen en deze in bezit te hebben;

• een verbod om deze vogels, met name gedurende de broedperiode, opzettelijk te storen;

Het laatstgenoemde verbod is niet van toepassing indien de storing niet van wezenlijke invloed is op de staat van instandhouding van de betreffende soort.

Artikel 3.5 Wnb: soorten van de Europese Habitatrichtlijn
Artikel 3.5 omvat soorten van de Europese Habitatrichtlijn, bijlage II bij het Verdrag van Bern en bijlage I bij het Verdrag van Bonn. Daarbij zijn de volgende verbodsbepalingen van toepassing:

• een verbod om deze dieren opzettelijk te doden of te vangen;
• een verbod om deze dieren opzettelijk te verstoren;
• een verbod om hun eieren in de natuur opzettelijk te vernielen of te rapen;
• een verbod om hun voortplantings- of rustplaatsen te beschadigen of te vernielen;
• een verbod op het opzettelijk plukken, verzamelen, afsnijden, ontwortelen of vernielen van planten in de natuur, in hun natuurlijke verspreidingsgebied.

Artikel 3.10 Wnb: overige of nationaal beschermde soorten
Artikel 3.10 omvat alle soorten vermeld in Bijlage A en B bij de Wet natuurbescherming. Daarbij zijn de volgende verbodsbepalingen van toepassing:

• een verbod om deze dieren opzettelijk te doden of te vangen;
• een verbod om hun voortplantings- of rustplaatsen te beschadigen of te vernielen.
• een verbod op het opzettelijk plukken, verzamelen, afsnijden, ontwortelen of vernielen van planten in de natuur, in hun natuurlijke verspreidingsgebied.

Soorten uit de eerste twee artikelen zijn dus Europees beschermd, soorten van artikel 3.10 zijn nationaal beschermd.

Rode Lijst soorten
In deze beoordeling worden ook eventuele effecten op (niet wettelijk beschermde) soorten op de Rode Lijst beschreven. Het Ministerie van Economische Zaken (i.e. Landbouw, Natuur en Voedselkwaliteit) heeft zogenaamde Rode Lijsten opgesteld van verschillende bedreigde plant- en diersoorten in Nederland. Er zijn Rode Lijsten voor onder andere vissen, vogels en zoogdieren (https://minez.nederlandsesoorten. nl/content/rode-lijsten). Een vermelding op een Rode Lijst betekent niet dat de betreffende soort wettelijk beschermd is. Dit is alleen het geval als artikel 3.1, 3.5 of 3.10 van de Wet natuur-bescherming eveneens van toepassing is op de soort. Soorten op Rode Lijsten fungeren als indicator-soorten die goede aanwijzingen geven voor de ecologische kwaliteit van een bepaald gebied, omdat ze relatief gevoelig zijn voor verstoring en andere effecten.

## 3.5 Internationale beschermingsregimes

Op de Noordzee zijn enkele internationale beschermingsregimes van kracht relevant voor de bescherming van de ecologische waarden van het gebied. Het gaat om de Kaderrichtlijn Mariene Strategie (KRM), de Oslo and Paris Convention (OSPAR) en de Agreement on the Conservation of Small Cetaceans of the Baltic and the North Seas (ASCOBANS).

**Kaderrichtlijn Mariene Strategie**
De Europese Kaderrichtlijn Mariene Strategie (KRM) is in 2008 van kracht geworden en verplicht de lidstaten om voor hun mariene wateren een strategie op te stellen voor het bereiken en/of behouden van een goede milieutoestand in 2020, om een duurzaam gebruik

mogelijk te maken. De goede milieutoestand wordt door de KRM beschreven aan de hand van 11 descriptoren (zie ook www.noordzeeloket.nl):

1 Biodiversiteit, 2 Exoten, 3 Commerciële visbestanden, 4 Voedselweb, 5 Eutrofiering, 6 Bodemintegriteit, 7 Hydrografische eigenschappen, 8 Gevaarlijke stoffen, 9 Gevaarlijke stoffen in vis, 10 Zwerfvuil, 11 Energietoevoer, o.m. onderwatergeluid

Met behulp van een monitoringsprogramma wordt het behalen van de doelstellingen en de goede milieutoestand gevolgd, zoals bijvoorbeeld door het monitoren van indicatorsoorten die fungeren als graadmeter voor de ontwikkeling van het bodemecosysteem. Voor het Friese Front zijn zeven bodemsoorten aangewezen: Draadarmige slangster (*Amphiura filiformis*), Moddergarnaal (*Callianassa subterranea),* Harige molkreeft (*Upogebia deltaura),* Bolle papierschelp (*Thracia convexa)*, Trapeziumkrab (*Goneplax rhomboides)*, Helmkrab (*Corystes cassivelaunus)* en de borstelworm *Nephtys incisa* (Wijnhoven *et al.* 2013).

De KRM is geen beschermingsregime, maar wel een toetsingskader en verplicht de EU-lidstaten tot een regionale aanpak met een coördinerende rol voor bestaande regionale zeeconventies, zoals OSPAR (zie toelichting hieronder) en ICES (International Council for the Exploration of the Sea; een groot netwerk van internationale wetenschappers dat marien onderzoek coördineert en bevordert), waarvoor al een breed scala aan gezamenlijke indicatoren en/of criteria is ontwikkeld. In Nederland wordt de KRM geïmplementeerd via de Waterregeling die is gebaseerd op de Waterwet.

De Europese Kaderrichtlijn Water (KRW) heeft als doel alle oppervlaktewateren en grondwatersystemen in 'een goede toestand' te brengen en zo 'natte' natuur te beschermen en te verbeteren. De KRW overlapt met de KRM, want naast het zoete water geldt de KRW ook voor het zoute water in kust- en overgangsgebieden, een zone tot 1 zeemijl vanaf de basiskustlijn. Dat betekent dat het Nederlandse deel van NeuConnect niet binnen de werkingssfeer van de KRW valt.

**OSPAR (Oslo and Paris Convention)**
De OSPAR Conventie (Convention for the Protection of the Marine Environment of the North-East Atlantic – www.ospar.org) heeft tot doel het beschermen van het mariene milieu in de Noord-Oost Atlantische Oceaan. Aan deze overeenkomst is een lijst (Initial OSPAR List of Threatened and/or Declining Species and Habitats) gekoppeld voor de bescherming van bepaalde soorten en habitats. OSPAR is een belangrijk platform voor de vereiste internationale afstemming voor de Noordzee. Er zijn verschillende thematische werkgroepen binnen OSPAR die o.a. zorgen voor de afstemming van implementatie van de KRM op regionaal niveau. In Tabel 3-1 zijn OSPAR soorten aangegeven, die relevant zijn voor deze beoordeling. Niet relevant zijn soorten, die niet in het plangebied worden verwacht (gebaseerd op Bos *et al.* 2012; OSPAR 2021).

**ASCOBANS**
ASCOBANS is een internationale overeenkomst, die voortvloeit uit de Bonn-conventie en staat voor Agreement on the Conservation of Small Cetaceans of the Baltic and the North Seas. Het doel van de overeenkomst is om een gunstige staat van instandhouding van tandwalvissen (met uitzondering van de Potvis) in de Noordzee en de Baltische zeeën te bereiken en te behouden. Aan de overeenkomst is een lijst met soorten gekoppeld. De volgende ASCOBANS-soorten kunnen mogelijk in het plangebied voorkomen en zijn daarom voor deze beoordeling relevant: Bruinvis (*Phocoena phocoena*), Tuimelaar (*Tursiops truncatus*), Witsnuitdolfijn (*Lagenorhynchus albirostris*).

*Tabel 3-1 OSPAR soorten die mogelijk in het plangebied kunnen voorkomen en daarom relevant zijn voor de beoordeling (Bos et al. 2012, OSPAR 2021).*

| Soort | Beslissing / aanbeveling OSPAR |
|---|---|
| **Ongewervelden** | |
| Noordkromp (*Arctica islandica*) | Bescherming en herstel (2013/5) |
| **Vogels** | |
| Kleine mantelmeeuw (*Larus fuscus*) | Bescherming en behoud (2011/01) |
| Vale pijlstormvogel (*Puffinus mauretanicus*) | Bescherming en behoud (2011/4) |
| Drieteenmeeuw (*Rissa tridactyla*) | Bescherming en behoud (2011/5) |
| **Vissen** | |
| Steur (*Aciper sturio*) | Bescherming en herstel (2014/11) |
| Elft (*Alosa alosa*) | Bescherming en behoud (2015/04) |
| Paling (Anguilla anguilla) | Bescherming en herstel (2014/15) |
| Houting (*Coregonus oxyrinchus*) | Openstaande aanbeveling |
| Vleet (*Dipturus batis*) | Bescherming en herstel (2010/06) |
| Gevlekte rog (*Raja montagui*) | Bescherming en behoud (2014/7) |
| Kabeljauw (*Gadus morhua*) | Bescherming en herstel (2014/14) |
| Langsnuitzeepaardje (*Hippocampus guttulatus*) | Bescherming en behoud (2012/3) |
| Kortsnuitzeepaardje (*Hippocampus hippocampus*) | Bescherming en behoud (2012/2) |
| Zeeprik (*Petromyzon marinus*) | Bescherming en behoud (2015/03) |
| Stekelrog (*Raja clavata*) | Bescherming en behoud (2014/8) |
| Zalm (*Salmo salar*) | Bescherming en behoud (2014/2) |
| Doornhaai (*Squalus acanthias*) | Bescherming en behoud (2014/2) |
| **Zeezoogdieren** | |
| Bruinvis (*Phocoena phocoena*) | Bescherming en herstel (2013/11) |
| **Habitats** | |
| Oesterbanken (*Ostrea edulis)* | Bescherming en behoud (2013/4) |
| Paardenmosselbanken (*Modiolus modiolus*) | Bescherming en herstel (2013/3) |
| *Sabellaria spinulosa* riffen | Bescherming en behoud (2013/2) |
| Zeeveer (*Pennatulacea*) & gravende infauna communities | Bescherming en herstel (2010/11) |

## 3.6 Beoordelingskader

### Relevante natuurwaarden

Voor een beoordeling van de effecten van een plan of project moet bekend zijn welk soort van effecten is te verwachten en welke relevant zijn voor de beoordelen natuurwaarden. In paragraaf 2.2 is dat aangegeven, en in tabel 3-2 is aangegeven welke soorten of soortgroepen onder welk beschermingsregime vallen. De Wet natuurbescherming heeft een directe beschermende werking met een bijbehorende stelsel van vergunningen en ontheffingen. Voor de NNN geldt het ‘nee, tenzij ...’ principe (zie paragraaf 3.3), terwijl het bij de andere beschermingsregimes gaat om internationale afspraken.

In het kader van het voorgenomen project zijn in potentie verschillende effecten denkbaar op de beschermde natuurwaarden. De bepaling van effecten is gebaseerd op de potentieel relevante effecten zoals aangegeven in paragraaf 2.6. Er wordt vooral gekeken naar aantasting, beschadiging of sterfte van habitats en/of soorten door:

- Oppervlakteverlies (ha) beschermde gebieden, van habitats of leefgebied van soorten;
- Verstoring door geluid, licht, trilling en visuele verstoring;
- Kwaliteitsverlies (habitats)/beschadiging van soorten door verontreiniging;
- Kwaliteitsverlies (habitats)/beschadiging soorten door verandering dynamiek substraat;
- Kwaliteitsverlies (habitats) of beschadiging van soorten door vertroebeling;

- Kwaliteitsverlies (habitats)/beschadiging soorten door magnetische velden of warmte-afgifte.

**Beoordelingskader**

De effecten worden zoveel als mogelijk gekwantificeerd. Waar dat niet mogelijk is wordt een kwalita-tieve inschatting gemaakt op basis van bestaande situaties (literatuurbronnen). Daarbij wordt opge-merkt, dat er relatief weinig ervaringen met ecologische effecten bij reeds uitgevoerde offshore projecten zijn gepubliceerd, De effecten worden uiteindelijk aan de hand van een 5-punts schaal (++, +, 0, -, - -) geduid (en samengevat in tabel 6-1). De scores geven vooral de richting van het effect aan; in de beoordeling wordt meegenomen in hoeverre het effect ook werkelijk van betekenis is in relatie tot de te beoordelen aspecten.

Het kader voor de beoordeling van de effecten wordt gevormd door de wet- en regelgeving. In Tabel 3-2 is aangegeven hoe effecten op beschermde natuurwaarden worden beoordeeld, en welke natuurwaarden relevant zijn.

*Tabel 3-2 Criteria en indicatoren voor effectbepaling en de wettelijke kaders (Gebiedsbescherming, Soortbescherming, Kaderrichtlijn Mariene Strategie en Internationale beschermingsregimes).*

| Toetsingskader | Relevante natuurwaarden | Toetsing/norm |
|---|---|---|
| Natura 2000 – gebiedsbescherming Wnb paragraaf 3.2 | Instandhoudingsdoelen aangewezen Natura 2000-gebieden : Friese Front - Zeekoet<br><br>Kwalificerende waarden mogelijk aan te wijzen Natura 2000-gebieden : Bruine Bank - Zeekoet, Alk<br><br>Stikstofgevoelige habitats in Natura 2000-gebieden | (Significant) negatieve effecten op instand-houdingsdoelen dan wel kwalificerende waarden (aan te wijzen) Natura 2000-gebieden |
| Soortbescherming Wnb Artikel 3.1, 3.5 en 3.10 Wnb paragraaf 3.4 | Vogels – diverse soorten (art. 3.1)<br>Zoogdieren - Ruige Dwergvleermuis, Rosse Vleermuis, Tweekleurige Vleermuis, Bruinvis, Gewone zeehond, Grijze zeehond, Dwergvinvis, Tuimelaar, Witsnuitdolfijn | Mogelijke overtreding verbodsbepalingen Wnb. Gunstige staat van instandhouding van betrokken soorten mag niet in gevaar komen |
| NNN paragraaf 3.3 | Wezenlijke waarden en kenmerken (niet nader gedefinieerd maar in elk geval alle beschermde soorten, Rode lijstsoorten e.d.) | Al dan niet aantasting wezenlijke waarden en kenmerken - voor het deel dat NNN is. Beoordeling conform het 'Nee, tenzij …' principe |
| OSPAR paragraaf 3.5 | Ongewervelden – Noordkromp<br>Vissen – Steur, Elft, Paling, Houting, Vleet, Gevlekte rog, Kabeljauw, Langsnuitzeepaardje, Kortsnuitzeepaardje, Zeeprik, Stekelrog, Zalm, Doornhaai<br>Vogels - Kleine mantelmeeuw, Vale pijlstormvogel, Drieteenmeeuw<br>Zoogdieren – Bruinvis<br>Habitats – Oesterbanken, Paardenmosselbanken, *Sabellaria spinulosa* riffen, Zeeveer & gravende infauna communities | Al dan niet negatieve invloed op specifiek aangewezen soorten (zie toelichting bij de Bruinvis) |

| Toetsingskader | Relevante natuurwaarden | Toetsing/norm |
|---|---|---|
| ASCOBANS paragraaf 3.5 | Zeezoogdieren – Bruinvis, Tuimelaar, Witsnuitdolfijn | Al dan niet negatieve invloed op specifiek aangewezen soorten (zie toelichting bruinvis) |
| KRM paragraaf 3.5 | Ongewervelden – Draadarmige slangster, Moddergarnaal, Harige molkreeft, Bolle papierschelp, Trapeziumkrab, Helmkrab, Borstelworm | Al dan niet negatieve invloed op specifiek aangewezen soorten |
| Rode lijst-soorten | Diverse soorten | Zorgplicht |

Vanuit de Wnb staat centraal de vraag voor de gebiedsbescherming of effecten kunnen leiden tot een negatieve invloed op de instandhoudingsdoelen van de aangewezen Natura 2000-gebieden. Voor de soortbescherming wordt nagegaan of de uitvoering van werkzaamheden leidt tot een overtreding van de verbodsbepalingen in de Wnb. Relevant voor de beoordeling is de vraag of de gunstige staat van instandhouding al dan niet in gevaar komt. Voor het NNN wordt beoordeeld of het initiatief, en de effecten die daarvan uitgaan, kunnen leiden tot aantasting van de wezenlijke waarden en kenmerken.

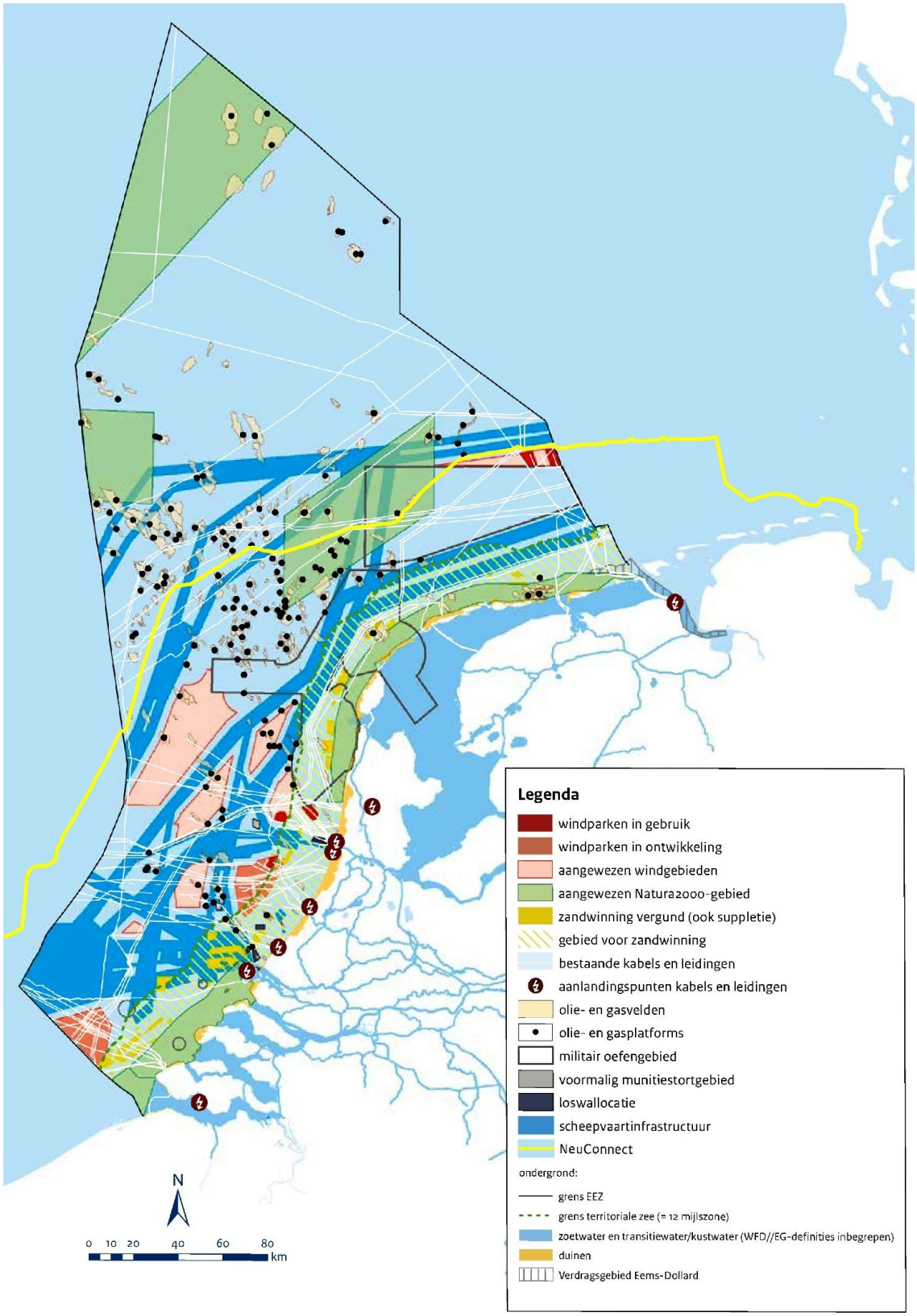
De internationale beschermingsregimes zijn in de Nederlandse wetgeving verankerd. Voor de beoordeling wordt nagegaan of de betreffende natuurwaarden negatieve effecten ondervinden. Voor OSPAR en ASCOBANS gaat het om specifieke soorten (tabel 3-2).

Van de soorten, die onder de bescherming van ASCOBANS vallen en mogelijk in het plangebied voorkomen, wordt aangenomen dat de bruinvis binnen de groep van de zeezoogdieren verreweg de meest gevoelige soort is (KEC, Rijkswaterstaat 2019). Uit het ASCOBANS-verdrag komt voor de bruinvis een norm voort die leidt tot een inspanningsverplichting. Het interim doel van ASCOBANS voor Bruinvissen is om de populatie op minimaal 80% van de draagkracht te houden. Wat deze populatieomvang is, is niet nader gedefinieerd. Daarom wordt vooralsnog uitgegaan van de omvang van de huidige populatie op het Nederlandse deel van de Noordzee. Volgens Geelhoed *et al.* (2020) werd de populatie in 2019 op 38.911 dieren geschat. Uitgangspunt bij de toetsing van de effecten op de Bruinvispopulatie is dat met grote zekerheid (95%) moet kunnen worden vastgesteld dat de huidige bruinvispopulatie als gevolg van de aanleg van de kabel met niet meer dan 5% afneemt (dan wel in cumulatie). Omdat de precieze omvang van de populatie bruinvissen niet bekend is en een vermindering van de populatie daarom niet rechtstreeks kan worden getoetst, volstaat deze toetsing met een uitgebreide beschrijving en beoordeling van effecten.

## 3.7 Cumulatie

Volgens de Wnb moeten effecten die door een project optreden, worden beoordeeld in samenhang met de effecten van andere projecten. Als de effecten van een project namelijk niet zelfstandig leiden tot significante gevolgen voor een instandhoudingsdoel van een Natura 2000-gebied, kan dit in cumulatie met de effecten van andere projecten wel het geval zijn.

De Wnb spreekt nadrukkelijk van cumulatie met andere projecten. De cumulatietoets wordt daarom uitgevoerd voor projecten die 'bestendig' zijn. Dat betreft projecten, waarvoor al een vergunning is verleend of een officieel besluit is genomen. Van onbestendige projecten zijn de effecten nog niet bekend en deze kunnen daarom ook niet worden beoordeeld. De cumulatietoets is niet van toepassing op projecten die al zijn uitgevoerd, en niet meer na-ijlen. De activiteiten en de effecten in verband met de aanleg van NeuConnect zijn niet direct vergelijkbaar met de activiteiten en effecten ten opzichte van windenergie op zee. Voor zover relevant zal ook voor de kabelaanleg het KEC worden gevolgd (Rijkswaterstaat 2019).




*Figuur 3-1 Route van het Nederlandse deel van het kabeltracé NeuConnect (Schuttinga & Nijmeijer 2019). De route is weergegeven met als achtergrond het ruimtegebruik in het Nederlandse deel van de Noordzee; bron Rijksoverheid, Mariene Strategie dl.1 (2018).*

# 4 Natuurwaarden

## 4.1 Het Noordzee ecosysteem in een notendop

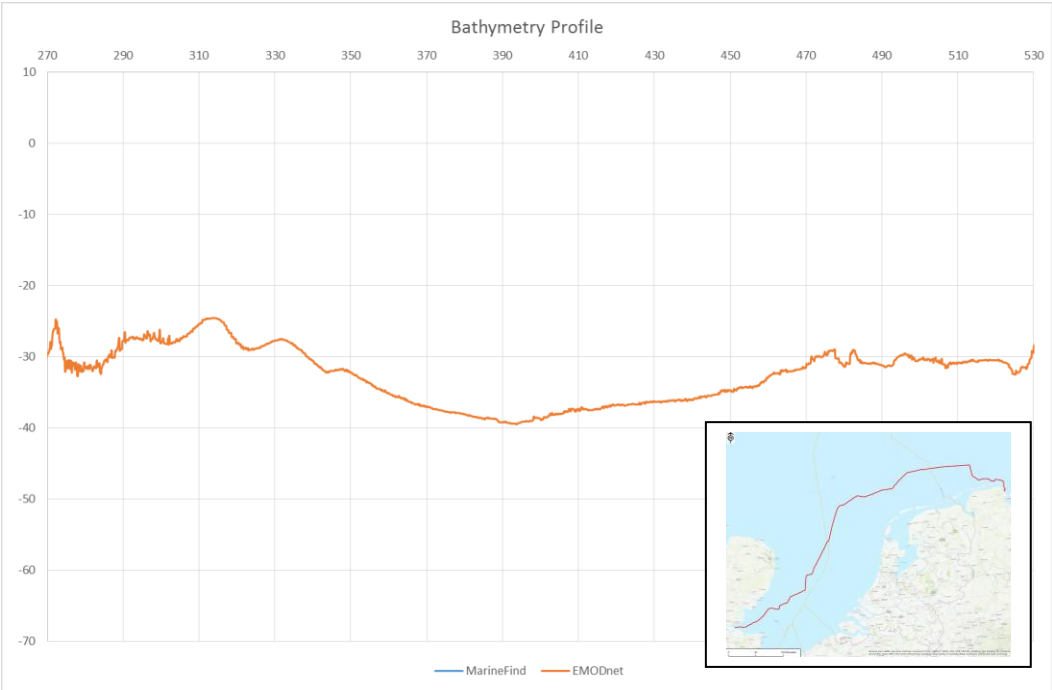
**Algemeen**
De NeuConnect route loopt over een relatief ondiep deel van de Noordzee, waarbij het diepste deel iets meer dan 60 m diep is. Het grootste deel van de route is tussen de 25 m en 40 m diep (4C Offshore 2017, Figuur 4-1).

Vanuit het westen loopt de kabel door het Theems Estuarium, waar de bathymetrie (i.e. topografische hoogte van de zeebodem) gedomineerd wordt door grote zandbanken en geulen. Het gebied is veelal ondiep (minder dan 20 m). Aan de rand van het Theems-gebied zijn er talrijke zandgolven aanwezig op de zeebodem, van noord naar zuid lopend. Het Nederlandse deel van NeuConnect, waar deze ecologische beoordeling betrekking op heeft, loopt door een deel van de Noordzee met een diepte van circa 30-40 m, waarbij in het westelijk deel noord-zuid lopende zandgolven lopen en in het oostelijke deel oost-west gerichte zandgolven. Het middendeel is relatief vlak. Langs het Duitse deel van de route wordt de zeebodem gekarakteriseerd door noord-noordwest / zuid-zuidoost lopende zandgolven tot de route de monding van de Jade rivier nadert, waar geulen (geassocieerd met het estuarium) domineren. De zeebodem op deze locatie staat erom bekend sterk dynamisch te zijn, al bestaat er een vaste regelmatige afname in diepte tot aan land (4C Offshore 2017).

Het Nederlandse deel van de Noordzee loopt vanaf de kust tot de grens van het Nederlands Continentaal Plat. Nederland deelt de zuidelijke Noordzee met Groot-Brittannië, Frankrijk, België, Duitsland en Denemarken. Aan de noordzijde vormt de relatief ondiepe Doggersbank een natuurlijk grensgebied met de diepere en centrale Noordzee. Door de beperkte diepte is er een relatief sterke interactie tussen fysische en chemische processen en het leven in/op de bodem en in de waterkolom. Het water in de Noordzee beweegt volgens een vast patroon; in de noordelijke helft staat het water onder invloed van de stroming uit de Atlantische Oceaan, in de zuidelijke helft is de stroming afkomstig uit Het Kanaal en trekt langs de Waddeneilanden in noordoostelijke richting verder (zie document Mariene Strategie voor het Nederlandse deel van de Noordzee; ministerie I&M 2012).

De Noordzee is een complex en open marien ecosysteem met specifieke habitats, te onderscheiden op basis van verschillen in bodemsamenstelling (slib en fijn zand tot grind en stenen) en diepte. De basis van de productiviteit van de Noordzee wordt gevormd door fytoplankton, waarbij de 'bloeien' (korte periodes van massale groei van algen) typerend zijn voor het fytoplankton van de Noordzee. Een deel van dit fytoplankton wordt door zoöplankton begraasd, maar een groot deel bereikt uiteindelijk de bodem en vormt daar de basis voor de bodemfauna.

Er zijn grote verschillen in soortsamenstelling van bodemfauna tussen soorten die op harde ondergrond leven, op/in zandbodems en op/in slibrijke bodems, waarbij zandbodems worden gekenmerkt door een relatief lage soortenrijkdom en lage biomassa. Het gebied Borkumse Stenen (aan de grens met de Duitse Noordzee) is een uniek gebied in de overwegend zandige Noordzee: naast zand (waaruit het grootste gedeelte van het gebied bestaat) vormen grind, keien en velden van schelpkokerwormen een natuurlijk Noordzee-rif, waartoe vele andere soorten worden aangetrokken (Bos *et al.* 2012). Het Friese Front daarentegen vormt een




*Figuur 4-1 Bathymetrie van de voorgestelde route over het Nederlandse deel van het offshore kabeltracé van NeuConnect, van ZW naar NO (4C Offshore 2017). Inzet : NeuConnect voorkeurstracé (zie figuur 2-1).*

Overgangszone tussen de ondiepe zandgronden van de zuidelijke Noordzee en de diepere slibbodems van de Oestergronden (www.synbiosys.alterra.nl). Het Friese Front is van belang voor het bodemleven vanwege de relatief hoge biomassa van bodemdieren, met een grote soortenrijkdom en -dichtheid, en relatief veel kwetsbare (bedreigde) langlevende en grote soorten (zie ook 4.2.1).

De Noordzee is een belangrijke schakel in het internationale systeem van trekroutes, leef- en foerageergebieden van vogels, vissen en zeezoogdieren (zoals zeehonden en bruinvissen). De Bruine Bank is een voorbeeld van een gebied dat een paaigrond vormt voor Bot en Schol. Bruinvissen komen er voor en er wordt een groot aantal zee- en kustvogels aangetrokken tot deze relatief ondiepe plek (omgeven door een diepere zeebodem; Stichting De Noordzee 2018). De totale biodiversiteit van het Nederlandse deel van de Noordzee wordt geschat op circa 1300 soorten (Mariene Strategie - actualisatie 2018).

De afgelopen eeuw hebben menselijk handelen en klimaatverandering de natuur van de Noordzee veranderd en beschadigd. Permanente fysische verstoring van de bodem heeft het bodemecosysteem doen verarmen, populaties van langlevende soorten zijn in omvang afgenomen, soorten zijn verdwenen en biogene riffen zijn zeldzaam geworden. Bodem-beroerende visserij, de introductie van exoten, eutrofiëring en klimaatverandering hebben hier een rol in gespeeld.

**Bestaand gebruik**

Het Nederlandse deel van de Noordzee heeft verschillende gebruiksfuncties (zie Figuur 3-1). Het is een van de meest intensief gebruikte zeeën ter wereld, samenhangend met het intensieve scheepvaartgebruik. De voorplaat van dit rapport geeft daarvan een indruk, waar de scheepvaart is te zien op 19 augustus 2019 rond een uur of 10.00, met als achtergrond de cumulatieve dichtheidskaart van schepen, zoals te raadplegen op www.marinetraffic.com.

Voor de energievoorziening is de Noordzee van (groeiend) belang. Er staan platforms voor olie- en gaswinning, windparken bezetten een groeiend oppervlak en in de bodem liggen veel pijpleidingen en kabels. Er wordt daarnaast ook ruimte gevraagd door zandwinning, natuurbescherming en militaire activiteiten. Ten slotte is er vanouds een intensieve visserij.

In Figuur 3-1 is de voorgestelde kabelroute in gele kleur over de kaart met gebruiksfuncties heen geplot, waarbij te zien is dat de kabel vanuit het zuidwesten het Nederlands Continentale Plat (NCP) binnenkomt en richting het noorden parallel loopt aan de scheepvaartinfrastructuur. De voorgestelde route kruist bestaande kabels en leidingen en buigt vervolgens af naar het oosten, waarbij de kabel langs olie- en gasplatforms loopt en scheepvaartinfrastructuur kruist. De route doorkuist het midden van het Natura 2000-gebied Friese Front, en loopt daarbij ook door militair oefengebied, waarna de kabel het NCP weer verlaat richting het Duitse deel van de Noordzee. Het kabeltracé bevindt zich in een deel van het NCP waar sprake is van een relatief hoge scheepvaartintensiteit, ook buiten de scheepvaartroutes (zie Figuur 3-1).

*Bestaand gebruik in Natura 2000-gebieden*

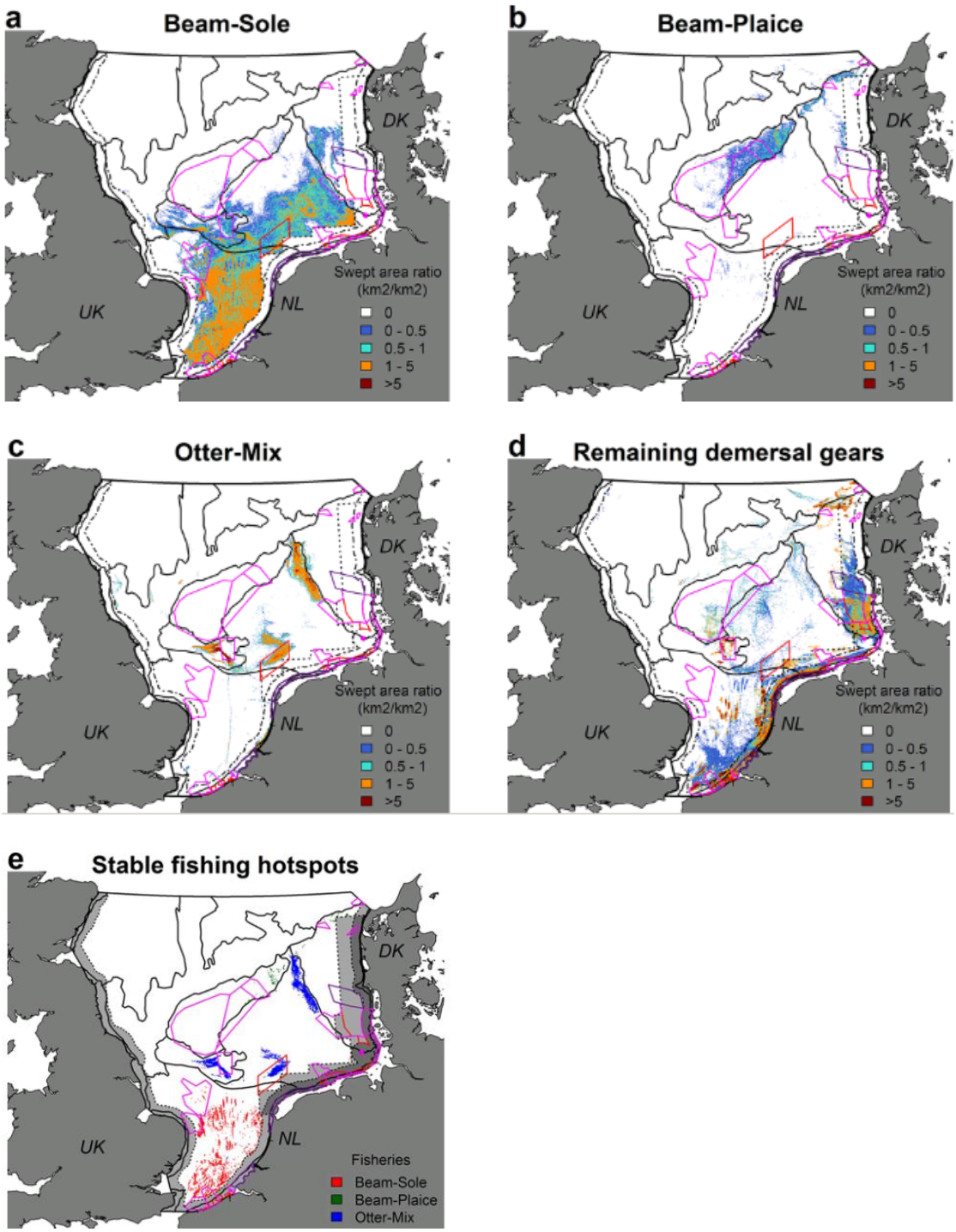
Het Friese Front is in juni 2016 aangewezen als Natura 2000-gebied. Binnen drie jaar na definitieve aanwijzing moet officieel een beheerplan zijn opgesteld (www.rwsnatura2000.nl). In dit beheerplan komt te staan op welke manier activiteiten in de gebieden mogelijk zijn, zonder dat dit ten koste gaat van de natuur. Rijkswaterstaat (als grootste beheerder van de Noordzee) werkt momenteel aan het opstellen van een beheerplan voor het Friese Front (evenals voor de Doggersbank en Klaverbank).

De aanwijzing van Natura 2000-gebieden op de Noordzee leidt niet automatisch tot bodembescherming. Bodembeschermingsmaatregelen worden tot nu toe maar in een (klein) gedeelte van de aangewezen natuurgebieden getroffen. Zo mag in het overgrote deel van de gebieden nog worden gevist. Voor het Friese Front ligt er wel een voorstel om een deel van het gebied te sluiten voor bodemberoerende visserij, en het gehele gebied een gedeelte van het jaar te sluiten voor staandwantvisserij (zie ook H-3). Echter, deze voorstellen moeten nog op Europees niveau worden goedgekeurd.

*Friese Front*

In het Friese Front wordt veel gevist (zie bijvoorbeeld de dichtheid van vaarbewegingen buiten de vaarroutes in Figuur 4-2). De studie van Van der Reijden *et al.* (2018) laat zien dat in het Friese Front hotspots zijn gesitueerd voor visserij met borden ('otter-trawling'). Op een raster van 1 km2 werd het totaal beroerde oppervlak bekeken om de jaarlijkse visserij intensiteit te berekenen. Het gaat om diepere, modderige gebieden waar de Noorse kreeft (*Nephrops norvegicus*) veel voorkomt, en waar ook een hoge benthische biodiversiteit is. In Figuur 4-2 is ter illustratie de gemiddelde visserijintensiteit weergegeven van verschillende typen bodemberoerende visserij, zoals boomkorvisserij op Tong, boomkorvisserij op Schol en visserij met boren op een mix van soorten.

Van der Reijden *et al.* (2018) concluderen dat de verschillende typen bodemberoerende visserij voorkeur hebben voor gebieden om in te vissen met condities die overeenkomen met gebieden waar doelsoorten graag voorkomen, maar dat dit ook vaak de zeldzamere habitats betreft. Ze adviseren dat voor een duurzaam beheer van benthische habitats de ruimtelijke verspreiding van zowel de benthische habitats als de visserij daarop meegenomen moeten worden in het beheer van visserij. Naast visserij wordt het Friese Front gebruikt voor olie- en gaswinning (middels 11 platforms), er lopen bestaande kabels en leidingen door het gebied, er is scheepvaartinfrastructuur in het gebied aanwezig en ruim een derde van het Friese Front ligt in militair oefenterrein (zie ook Figuur 3-1).




*Figuur 4-2 Gemiddelde visserijintensiteit van A) boomkorvisserij op Tong, B) boomkorvisserij op Schol, C) visserij met borden op een mix van soorten en D) resterende bodemberoerende vistuigen in de Nederlandse vloot over de periode 2008-2015. Voor de drie typen vistuig zijn de stabiele 'visserij hotspots' afgebeeld in E). De visserijintensiteit is berekend als het gemiddelde geviste gebied in km2 per jaar. Zwarte lijnen geven het 'zeelandschap' weer, de onderbroken lijn toont nationale territoriale wateren. Een visserijintensiteit van 0 betekent dat er gedurende de onderzoeksperiode geen visserijactiviteit is waargenomen. Van de huidige Natura 2000-gebieden worden beschermde gebieden volgens de Vogelrichtlijn met rode lijnen weergegeven en beschermde gebieden volgens de Habitatrichtlijn met roze lijnen (paarse lijnen schetsen beschermde gebieden onder zowel de Vogel- als de Habitatrichtlijn). (Van der Reijden et al. 2018).*

*Bruine Bank*
De Bruine Bank wordt nu (nog) o.a. gebruikt als visgrond door de Nederlandse vloot en omringende landen. De visserij met staandwant (kieuwnetten) kan een mogelijke oorzaak zijn van sterfte van de Zeekoet en Alk, omdat ze tijdens het foerageren onder water verstrikt kunnen raken in de netten (Jongbloed *et al.* 2015). Er lopen bestaande kabels en leidingen door het gebied, evenals scheepvaartinfrastructuur (zie ook Figuur 3-1).

## 4.2 Gebiedsbescherming in het kader van de Wnb

Op het Nederlandse deel van de Noordzee, het NCP, zijn zes gebieden aangewezen als Natura 2000-gebied. Aangewezen Natura 2000-gebieden zijn: Doggersbank, Klaverbank, Friese Front, Noordzeekustzone, Voordelta en Vlakte van de Raan (zie Figuur 2-1). De Bruine Bank staat op nominatie om ook als Natura 2000-gebied te worden aangewezen. Voor de Borkumse stenen is dat niet het geval; wel wordt de zuidelijke punt toegevoegd aan het Natura 2000-gebied Noordzeekustzone. Hieronder worden de afzonderlijke gebieden nader toegelicht.

### *4.2.1 Friese Front*

**Beschrijving systeem**
Het Friese Front is een zeegebied van ongeveer 2.880 km$^2$ groot ten noorden van de Waddeneilanden (ongeveer 75 km ten noorden van Den Helder) en vormt een overgangszone tussen de ondiepe zandgronden van de zuidelijke Noordzee en de diepere slibbodems van de Oestergronden (centrale Noordzee). Zoals de naam al zegt is het gebied een 'front', een overgangszone waar verschillende watermassa's samenkomen. Het Friese Front wordt gekenmerkt door sterke gradiënten in de waterkolom en in de bodemgesteldheid.

De bodem van de zuidrand van het gebied, ongeveer op 30 m diepte, bestaat uit zand. Naar het noorden toe wordt de bodemsamenstelling steeds fijner. De overgang in sedimenttype ontstaat door de afnemende snelheid van de getijdenstroom in noordelijke richting, waar het gebied steeds dieper wordt. Hier bezinkt fijn zwevend materiaal. Centraal in het front ligt hierdoor een 'tong' van fijn sediment met hoge slibgehalten. Verder naar het noorden, waar het Friese Front overgaat in de Centrale Oestergronden, daalt het percentage slib en wordt de bodem weer zandiger (www.synbiosys.alterra.nl).

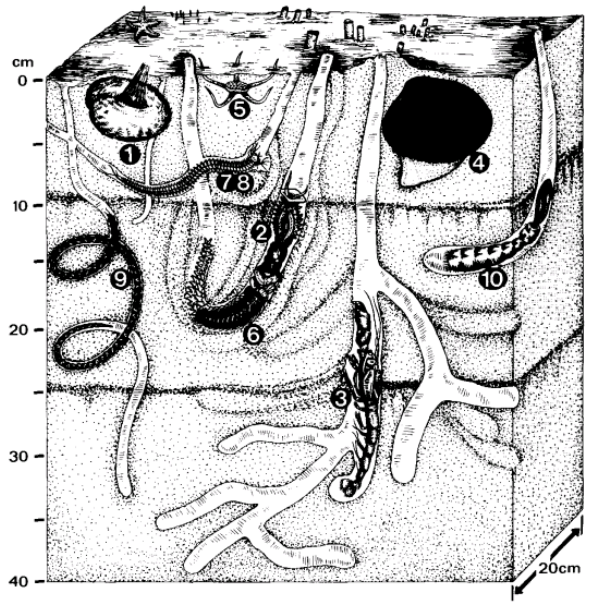
De overgangszone tussen verschillende watermassa's verhoogt plaatselijk de primaire productie, doordat bepaalde voedingsstoffen beschikbaar komen. Deze verhoogde primaire productie werkt door in de rest van de voedselketen, en zorgt voor een hoge biomassa en hoge diversiteit van het bodemleven. Het Friese Front is hierdoor een belangrijk foerageergebied voor vogels, maar ook veel vissen en zeezoogdieren worden aangetrokken tot dit gebied.

**Natuurwaarden**
In het Friese Front is over een relatief korte afstand een aantal uiteenlopende habitattypen te vinden met elk een specifieke fauna. Het gebied vormt de natuurlijke scheiding in het voorkomen van zuidelijke en noordelijke soorten, hetgeen terug te zien is in de soorten zoöplankton, de benthossoorten en de visfauna.

Er komt een aantal schelpdieren massaal in het gebied voor zoals de Korfschelp (*Corbula gibba*), die langs de noordrand van het Friese Front leeft in dichtheden tot boven de 3000 dieren per m$^2$. De tweekleppige *Nucula turgida* is juist langs de zuidrand met vergelijkbare

aantallen aanwezig. De Penhoren (*Turritella communis*) is ook een soort die in hoge dichtheden voorkomt in het Friese Front. De oude, traag groeiende tweekleppige Noordkromp (*Arctica islandica*) is een indicatorsoort voor het gebied (zie ook 4.4.1) (www.synbiosys.-alterra.nl).

Tot de meest karakteristieke soorten benthos op het Friese Front behoort o.a. de Draadarmige slangster (*Amphiura filiformis*), een kleine fragiele zeester die zich voedt met in het water zwevende deeltjes. De Brokkelster (*Ophiothrix fragilis*) kwam rond 1980 nog algemeen voor in het meest slikkige deel van het Friese Front (met dichtheden tot 2000 individuen per $m^2$) terwijl het er tegenwoordig ongeveer 200 per $m^2$ zijn (reden achteruitgang is nog onduidelijk). Gravende kreeftjes, zoals *Callianassa subterranea* en *Upogebia deltaura*, spelen met hun gegraaf (verschillende soorten graven hun gangenstelsels op verschillende diepten) een belangrijke rol bij de uitwisselingsprocessen tussen water en bodem, evenals vele wormensoorten die in de bodem hun gangenstelsels maken (zie ook Figuur 4-3; www.synbiosys.-alterra.nl).




1. Zeeklit - *Echinocardium cordatum*
2. Perkamentworm - *Chaetopteris variopedatus*
3. Moddergarnaal - *Callianassa subterranea*
4. Noordkromp - *Arctica islandica*
5. Slangster - *Amphiura filiformis*
6. Gekroesde zeerups - *Gatteana cirrosa*
7. *Glycerra rouxii*
8. Zager spp. - *Nereis* spp.
9. *Notomastus latericeus*
10. Zandworm - *Echiurus echiurus*

*Figuur 4-3 Een illustratie van een stuk bodem uit het gebied Friese Front / Centrale Oestergronden, met daarin weergegeven de meest karakteristieke dieren en de wijze waarop ze in die bodem voorkomen (bron: Wilde et al. 1984.)*

De visfauna in het Friese Front bestaat onder andere uit Noorse grondel (*Pomatoschistus norvegicus*), Dwergbolk (*Trisopterus minutus*) en Steenbolk (*Trisopterus luscus*) die langs de noordelijke, diepe rand van het gebied voorkomen. De Kleine pieterman (*Echiichthys vipera*) en verschillende soorten grondeltjes komen in het zuiden voor, op de meer zandige gronden. Van Schar (*Limanda limanda*), Dwergtong (*Buglossidium luteum*), Pitvis (*Callionymus lyra*) en Wijting (*Merlangius merlangus*) zijn de aantallen en biomassa op het Friese Front relatief hoog. Haring (*Clupea harengus*) en Sprot (*Sprattus sprattus*) (pelagische soorten) profiteren als jonge vis van de verhoogde productie zoöplankton in de waterkolom. Deze twee soorten vis vormen op hun beurt weer een belangrijke voedselbron voor de Zeekoeten (in augustus / september). (www.synbiosys.alterra.nl).

**Instandhoudingsdoelstelling voor het Natura 2000-gebied**

Het Friese Front is in 2016 aangewezen als speciale beschermingszone onder de Vogelrichtlijn en als Natura 2000-gebied, met een instandhoudingsdoelstelling voor de Zeekoet (*Uria aalge*), zie ook Tabel 4-1. Het gebied is gedefinieerd als 'samenhangend zoutwater gebied' dat voorziet in de beschermingsbehoefte van de Zeekoet.

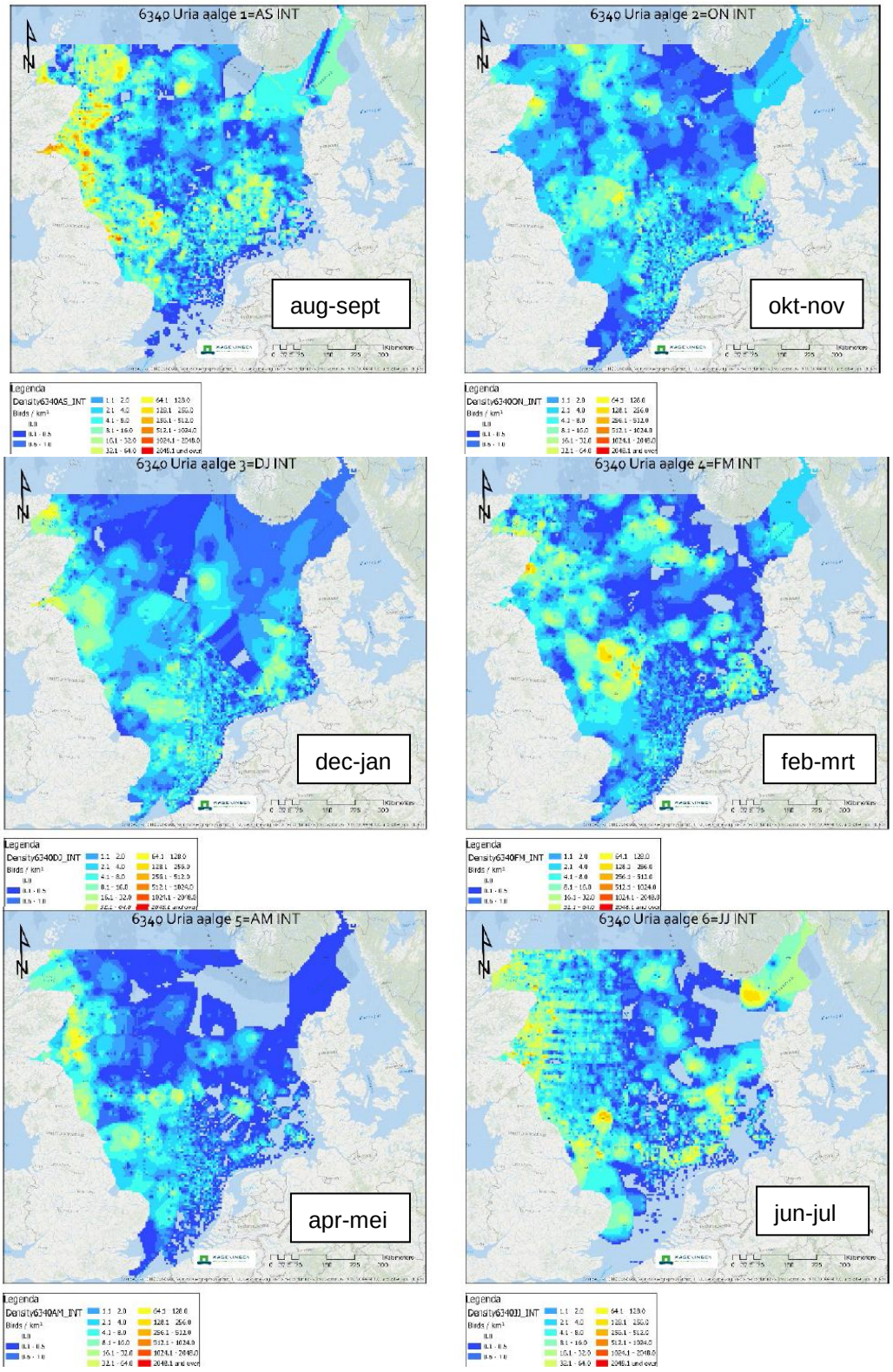
*Tabel 4-1 Kwalificerende soort die is aangewezen voor het Natura 2000-gebied Friese Front. SVI = landelijke staat van instandhouding, waarbij deze is weergegeven als gunstig (+), matig gunstig (-) en zeer ongunstig (- -). Opp = doelstelling omvang leefgebied, Kwal = doelstelling kwaliteit leefgebied. Pop = instandhoudingsdoel populatie. De instandhoudingsdoelen zijn weergegeven als behoud (=) en verbetering/uitbreiding (>). Er is (nog) geen populatieaantal aan de populatiedoelstelling toegevoegd, omdat de data hiervoor nog onvoldoende consistent zijn. Dit is de tabel met de formele instandhoudingsdoelen (Didderen* et al*. 2017; www.synbiosis.alterra.nl).*

| Code | Naam | SVI | Opp. | Kwal. | Pop. | Draagkracht |
|---|---|---|---|---|---|---|
| *Niet-broedvogel* | | | | | | |
| A199 | Zeekoet | + | = | = | | |

Het gebied heeft een bijzondere functie tijdens een belangrijk deel van de levenscyclus van de Zeekoet: ruiende ouderdieren trekken zwemmend met hun nog niet vliegvlugge jongen van broedgebied in Groot-Brittannië naar het Friese Front. Deze jonge vogels zijn kwetsbaar (o.a. voor olievlekken; Lindeboom *et al.* 2005). Het Friese Front wordt in de late zomer (juli, augustus en september) gebruikt als foerageergebied voor de Zeekoet met haar jongen en als rust- en ruigebied (Aanwijzingsbesluit Natura 2000 Friese Front – ministerie van EZ 2016). Het Friese Front voldoet aan het zogenaamde 1% criterium, wat inhoudt dat geregeld tenminste 1% van de biogeografische populatie gebruikt maakt van het gebied. De 1% norm voor zeekoet is 15.600. Volgens het aanwijzingsbesluit komt gemiddeld circa 2% van de Noordzeepopulatie hiervoor (gemiddelde over de jaren 2005-2012). Vliegtuigtellingen bevestigen het belang van het Friese Front voor zeekoeten: bij twee van de vier tellingen werden >20.000 zeekoeten vastgesteld (Leopold & van Bemmelen 2014). Didderen *et al*. (2017) geven aan, dat de populatieschattingen varieren van minimaal 3.867 vogels in augustus 2014 tot 21.990 in augustus 2016. Volgens deze auteurs zijn de gegevens onvoldoende om een betrouwbare schatting te maken.

**Verspreiding kwalificerende soort**

De hoogste aantallen Zeekoeten worden in augustus waargenomen (met een gemiddelde dichtheid van 2,0 individuen per $km^2$; Fijn *et al.* 2015), wanneer in het gebied regelmatig meer dan 1% van de Europese populatie verblijft. In Figuur 4-4 is te zien dat de Zeekoet een duidelijk seizoenspatroon vertoont. De verspreiding internationaal van de Zeekoet in de Noordzee concentreert zich in wateren van Groot-Brittannië tijdens en vlak na het broedseizoen, met een uitloper langs het Friese Front richting Duitsland. In de winter is de verspreiding meer homogeen tot in de zuidelijke Noordzee, waarbij het gebied rond de Bruine Bank van belang is. (Fijn *et al.* 2015; Wal *et al.* 2018). De instandhoudingsdoelstelling voor de Zeekoet houdt in dat de omvang en kwaliteit van het leefgebied behouden moeten blijven voor behoud van de populatie. Er is (nog) geen populatieaantal aan de populatiedoelstelling toegevoegd, omdat de data hiervoor nog onvoldoende consistent zijn (Didderen *et al*. 2017; Aanwijzingsbesluit Natura 2000 Friese Front).



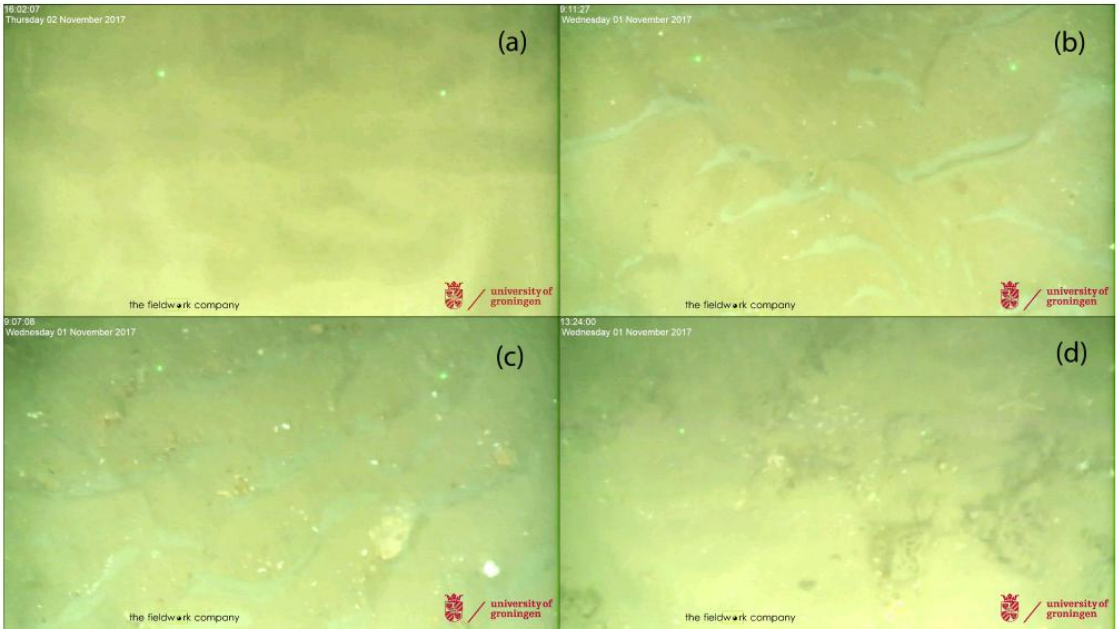

*Figuur 4-4 Verspreiding internationaal van de Zeekoet op de Noordzee in augustus/september, oktober/november, december/januari, februari/maart, april/mei en juni/juli, van linksboven naar rechtsonder op het totale NCP (Wal et al. 2018).*

Naast de Zeekoet zijn er nog vele andere soorten vogels die in het gebied voorkomen, vooral buiten het broedseizoen. Dat geldt bijvoorbeeld voor de Alk (*Alca torda*) die – buiten de ruiperiode - in vergelijkbare dichtheden voorkomt als de Zeekoet (Wal *et al.* 2018). De aantallen zeevogels zijn op het Friese Front twee tot drie keer hoger dan in de directe omgeving. In de broedtijd zijn vooral onvolwassen Noordse stormvogels en Kleine mantel-meeuwen aanwezig.

### *4.2.2 Bruine Bank*

De Bruine Bank is een permanent overstroomde zandbank van ruim 1280 km2 groot, gelegen in de Noordzee op ongeveer 80 km ten westen van IJmuiden. Het gebied is een relatief ondiepe plek (omgeven door een diepere zeebodem) en vormt een paaigrond voor Bot en Schol, Bruinvissen komen er voor en er komt een groot aantal zee- en kustvogels voor.

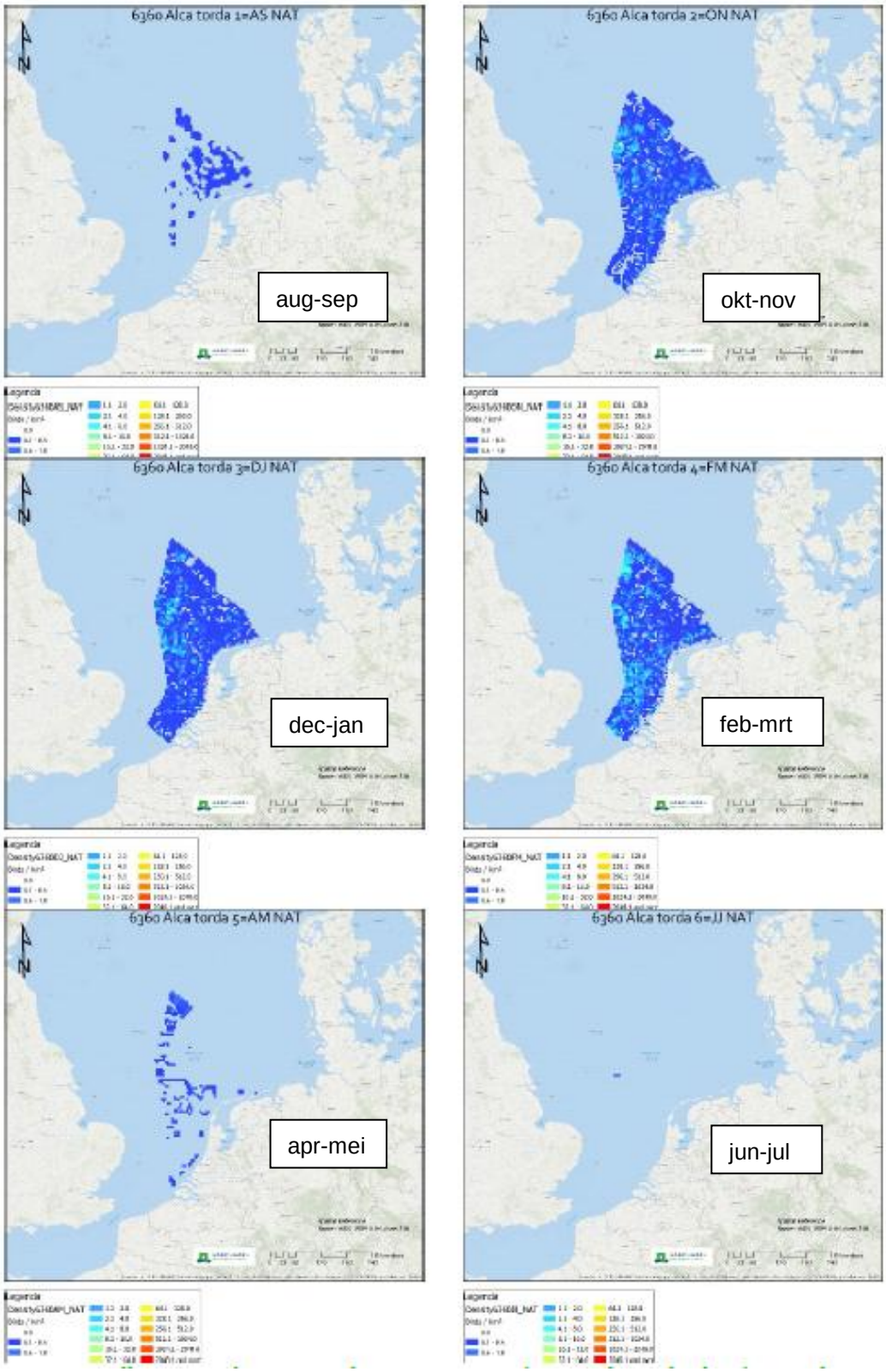
**Natuurwaarden**
De bodem van de Bruine Bank bestaat uit relatief grof substraat en er heersen dynamische omstandigheden in de omgeving van de Bruine Bank. Recentelijk zijn er riffen van de worm (*Sabellaria spinulosa*) aangetroffen in delen van de Bruine Bank (Stichting De Noordzee 2018; Koop *et al.* 2019, Van der Reijden *et al.* 2019). Figuur 4-5 toont een impressie van recente video-opnamen.




*Figuur 4-5 Videoframes van de Bruine Bank, geclassificeerd als (a) Zand met nauwelijks schelpfragmenten, (b) Zand met enkele schelpfragmenten, (c) Zand met kleine stenen en incidenteel grotere stenen, en (d) Zand met Sabellaria-fragmenten en incidenteel grotere stenen (Koop et al. 2019).*

Vanwege het belang van het gebied voor de vogelsoorten Zeekoet (*Uria aalge*) en Alk (*Alca torda*), is de Bruine Bank een kandidaat Natura 2000-gebied onder de Vogelrichtlijn. Beide soorten zeevogels voldoen aan de 1% norm, wat inhoudt dat de soort geregeld voorkomt in aantallen gelijk of groter dan 1% van de relevante biografische populatie (Leopold & Van der

Wal 2015). Met name in de wintermaanden trekt het gebied de grote aantallen Zeekoeten en Alken aan met in januari de hoogste aantallen Zeekoeten en in februari de hoogste aantallen




*Figuur 4-6 Verspreiding van alken in augustus/september, oktober/november, december/januari, februari/maart, april/mei en juni/juli, van linksboven naar rechtsonder op het totale NCP (Wal et al. 2018).*

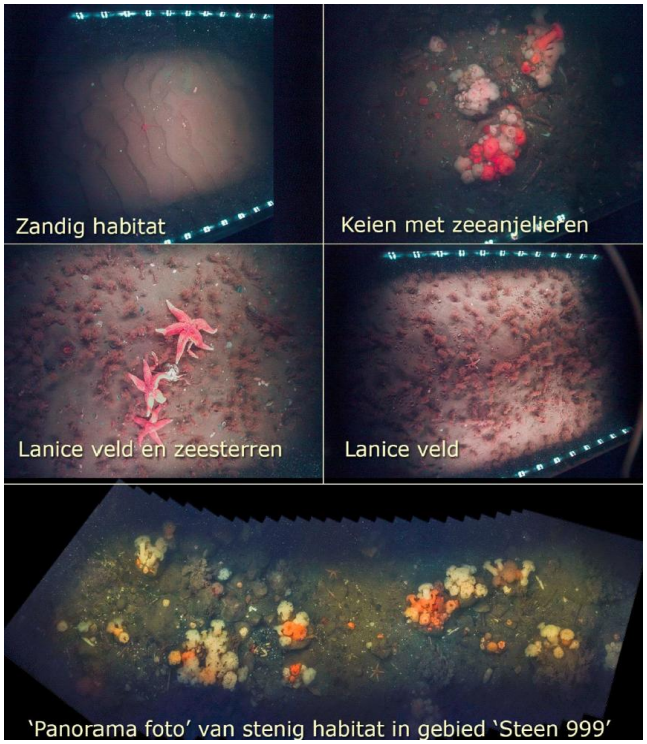
Alken (Figuur 4-6) Fijn *et al.* 2015). De herkomst van Zeekoeten is waarschijnlijk uit kolonies aan de Schotse oostkust. De herkomst van Alken in het gebied is onbekend. De zeevogels foerageren in het gebied Bruine Bank op Zandspiering, Glasgrondel, Haring en Sprot. Deze potentiële prooivissen zijn in het gehele gebied aanwezig, veelal in de bovenste meters van de waterkolom, goed zichtbaar voor foeragerende alkachtigen (Geelhoed *et al.* 2014).

## 4.3 Overige ecologisch waardevolle gebieden: Borkumse Stenen

Het gebied Borkumse Stenen wordt hier beschreven, omdat het ecologisch waardevol is (Bos & Paijmans 2012). Gezien de grote afstand (7,3 km) tussen het kabeltracé en dit gebied worden geen effecten verwacht. In Nederland heeft de Borkumse Stenen geen bescherming en geen officiële beschermde status (het is geen Marine Protected Area). Wel wordt door het ministerie van LNV overwogen om de zuidelijke punt van het gebied – met de hoogste waarden - toe te voegen aan het Natura 2000-gebied Noordzeekustzone (zie paragraaf 3.3, blz 18).

**Beschrijving systeem**

Op de grens van Nederland en Duitsland ligt in de Noordzee het bijzondere gebied Borkumse Stenen, ten noorden van Schiermonnikoog en Borkum. Het gebied heeft een oppervlak van 600 km$^2$ en de bodem bestaat o.a. uit grind en grote stenen, achtergelaten door gletsjers in de ijstijd. Het gebied grenst aan het Nederlandse Natura 2000-gebied Noordzeekustzone en het Duitse Natura 2000-gebied Borkum Riffgrund. Het Duitse deel is (onder andere) aangewezen vanwege de aanwezigheid van habitattype H1170 ('riffen').

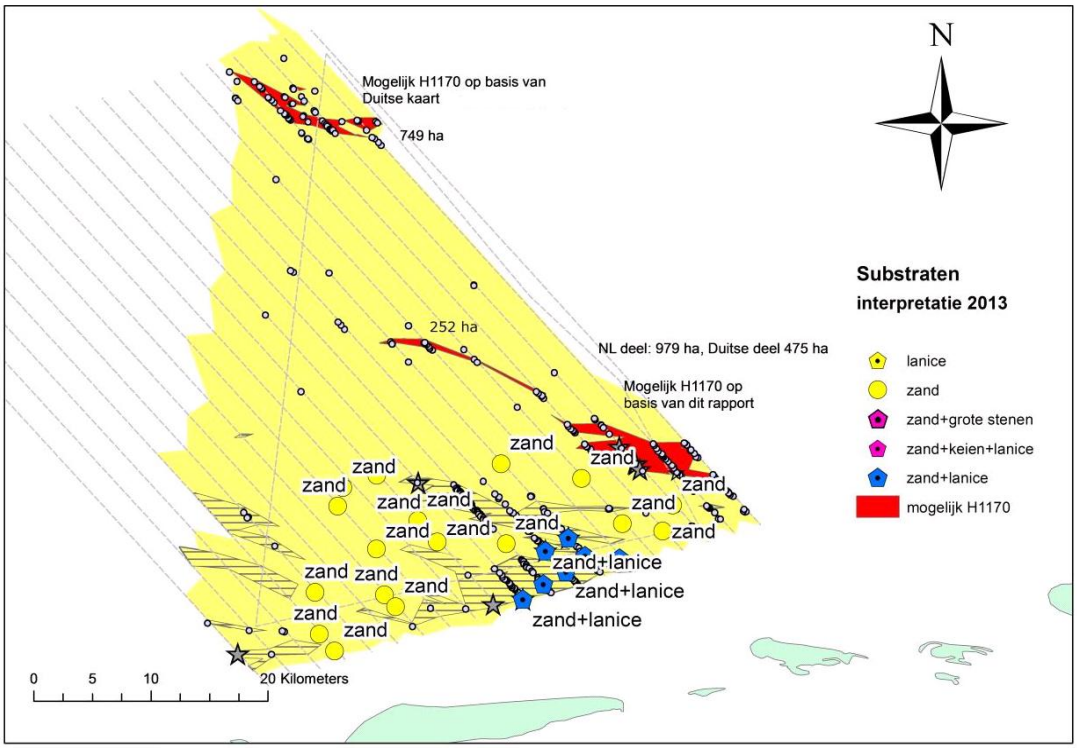



*Figuur 4-7 Verschillende substraten in het Borkumse Stenen gebied. Elke foto komt overeen met circa 0,33 m$^2$. De onderste foto is samengesteld uit overlappende foto's en geeft een gebied van ~ 2 x 0,5 m weer (uit: Bos et al. 2014).*

**Natuurwaarden**

Inmiddels is (door duikexpedities en bodemonderzoek met video's en bemonsteringen) duidelijk dat het gebied Borkumse Stenen een uniek gebied is in de overwegend zandige Noordzee: naast zand (waaruit het grootste gedeelte van het gebied bestaat) vormen grind, keien en velden van schelpkokerwormen een natuurlijk Noordzee-rif (zie Figuur 4-7 voor een impressie van de verschillende substraten).

Naast zandige soorten komen er door de aanwezigheid van hard substraat ook soorten in het gebied voor die hard substraat nodig hebben om op te groeien, zoals zakpijpen, anemonen en sponzen. Hard substraat dat volledig begroeid is lijkt vooral aanwezig in een klein gebied nabij Duitsland (zie inschatting door Bos *et al.* 2014 in Figuur 4-8). In dit gebied met hard substraat is een hoge biodiversiteit gevonden (i.e. hoge dichtheden van soorten en een grote soortenrijkdom). Bos *et al.* (2014) spreken van het aanwezig zijn van 'een abiotisch rif begroeid met een uitgebreide rifgemeenschap van hard substraat soorten', hetgeen neerkomt op habitattype H1170.




*Figuur 4-8 Potentiële riffen in het gebied Borkumse Stenen(Nederlandse deel) (uit: Bos et al. 2014). Het tracé loopt 7 km ten noorden van de Borkumse Stenen.*

Een aanzienlijk deel van het gebied de Borkumse Stenen bestaat ook uit dichte velden van de schelpkokerworm *Lanice conchilega*, die op zandige ondergrond een koker bouwt van zandkorrels en fijne stukjes schelp. *Lanice*-velden, waarbij meer dan 500 ind/m$^2$ voorkomen, vormen een driedimensionaal habitat met een hogere lokale biodiversiteit dan de 'kale' zandbodem in de rest van het gebied (Bos *et al.* 2014).

Als typische soorten voor hard substraat (H1170 'riffen') op de Borkumse Stenen stellen Bos *et al.* (2014) de primaire indicatoren Dodemansduim, (structuurvormende) sponzen en Hydroïdpoliepen voor. Naaktslakken (of eieren daarvan) en Hooiwagenkrab als secondaire indicatoren. En de Driekantige kalkkokerworm en Slakdolf als registratiesoorten. Deze soorten zijn

bruikbaar als indicator van een goede abiotische toestand of goede biotische structuur, zijn meetbaar en geen exoot.

**Herintroductie Platte oester**
Naast het substraat dat van nature aanwezig is in de Borkumse Stenen, is er in 2018 6000 kilogram Noorse Platte oesters in het gebied geplaatst, onder meer op 3D geprinte rifstructuren. Dit is gedaan in het kader van een natuurherstelproject van WNF & ARK Natuurontwikkeling (www.ark.eu). Platte oesterbanken kwamen vroeger ook van nature in het gebied voor, maar zijn grotendeels verdwenen door overbevissing, ziektes en koude winters. Een oesterbank (i.e. hard substraat) staat erom bekend veel soorten aan te trekken, haaien en roggen zetten bijvoorbeeld eieren af op een oesterbank en kleinere vissen en garnalen kunnen er schuilen en opgroeien (kraamkamerfunctie). Hogerop in de voedselketen vormen oesterbanken een belangrijke voedingsbodem voor roofvissen, zeevogels en zeezoogdieren. Omdat (wereldwijde) ervaring leert dat schelpdierbanken niet uit zichzelf terugkeren, is ook bij de Borkumse Stenen sprake van actief herstel en bescherming (in het gebied wordt vrijwillig niet meer gevist).

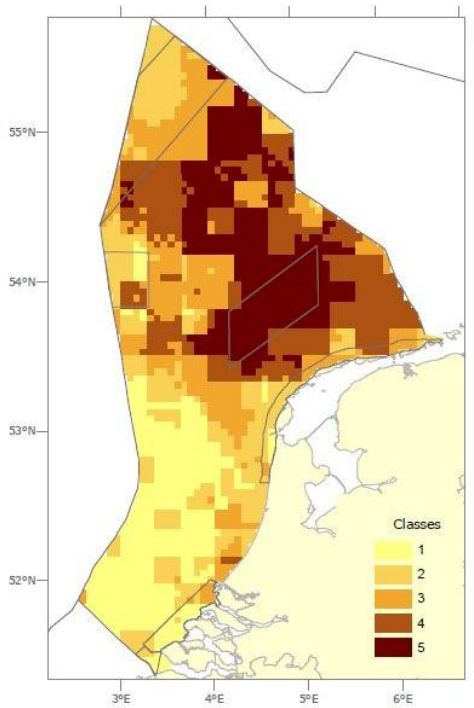
## 4.4 Relevante soorten en habitats

Veel soorten in het plangebied – dus het kabeltracé en omgeving - vallen niet onder een beschermingsregime. Deze worden dan ook niet in de toetsing meegenomen. Wel geldt voor alle soorten de Zorgplicht in het kader van de Wnb. Dit houdt in dat werkzaamheden, die nadelig kunnen zijn voor dieren en planten, in redelijkheid zo veel mogelijk worden voorkomen of maatregelen worden genomen om onnodige schade aan dieren en planten te voorkomen.

### *4.4.1 Ongewervelden / bodemdieren*

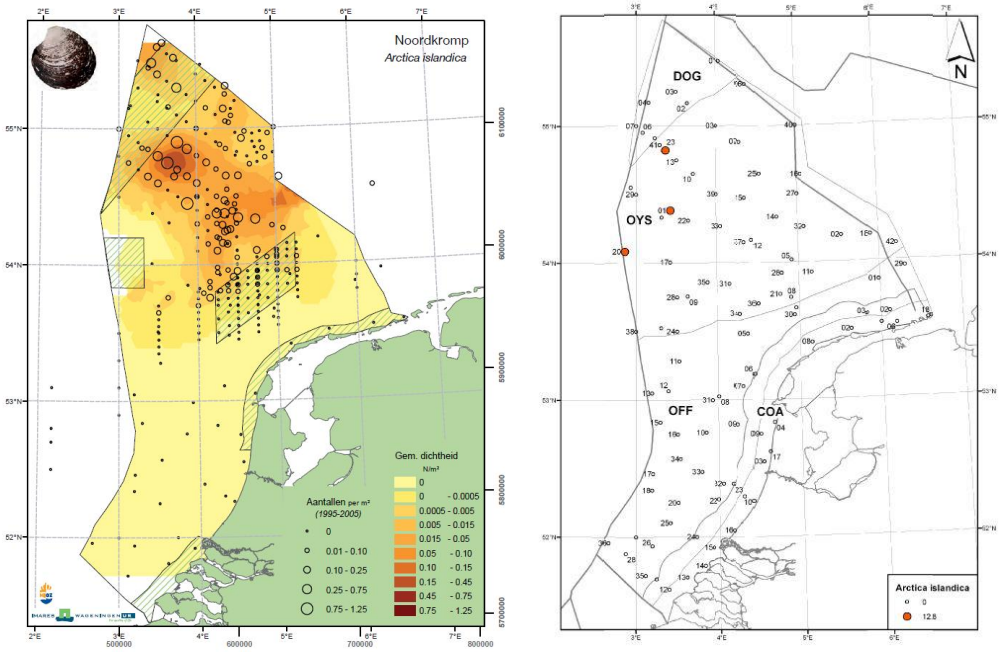
Vooral op het noordelijk deel van het NCP is een hoge biodiversiteit aan benthos in de vorm van soortenrijkdom, soortendichtheid, totale biomassa en aantallen kwetsbare soorten te vinden (Figuur 4-9). Dit betreft gebieden zoals het Friese Front of de Oestergronden. Overige biodiverse gebieden zijn de kustzone, Doggerbank en Klaverbank. Het zuidelijk deel van het NCP is relatief gezien minder divers (Bos *et al.* 2011, Bos & van Bemmelen 2012).

**Noordkromp**
De Noordkromp (*Arctica islandica*) is een tweekleppig schelpdier, dat ondiep ingegraven in de zeebodem leeft en wordt gezien als een indicatorsoort voor een goede milieutoestand (Witbaard & Bergman 2003). De Noordkromp is een langlevende soort met een trage groeisnelheid. Populaties bevatten exemplaren van 40-80 jaar oud, maar vaak zijn individuen meer dan 100 jaar oud, waarmee dit schelpdier een van de langstlevende mariene tweekleppigen is (OSPAR 2009a). In OSPAR documenten wordt de Noordkromp genoemd als een te beschermen soort die herstel behoeft. Noordkrompen worden sinds het begin van de jaren '70 op het NCP bemonsterd door het NIOZ met behulp van verschillende schepen en technieken, waarbij er vanaf 1995 consistent met de Triple-D bodemschaaf bemonsterd is (Lindeboom *et al.* 2008). In Figuur 4-10 zijn de verspreiding van de tweekleppige in de periode 1995-2005 en dichtheden op basis van een in 2010 uitgevoerde bemonstering van de MWTL stations te zien (Lindeboom *et al.* 2008, Verduin *et al.* 2011). Het Friese Front vormt onderdeel van de zuidrand van het verspreidingsgebied van de Noordkromp. De soort is in de noordelijke helft van het Friese Front aanwezig (overgaand in hoge dichtheden in het aangrenzende gebied Centrale Oestergronden). Bij de beomonstering van de MWTL stations in 2010 zijn alleen in de Centrale Oestergronden exemplaren van de Noordkromp vastgesteld (Verduin *et al.* 2012). Ook langs de kabelroute is de soort niet aangetroffen (paragraaf 4.4.3).




*Figuur 4-9 Benthos hotspots op het NCP (uit: Bos et al. 2011).*

De Noordkromp is gevoelig voor bodemberoering. Directe en indirecte effecten van bodemberoerende visserij hebben ervoor gezorgd dat de populatie van volwassen schelpdieren de laatste decennia is gedecimeerd (Witbaard & Bergman 2003). Andere bedreigingen zijn verstoring van de zeebodem door zand- en grindwinning, en directe en indirecte effecten van olie- en gaswinning (OSPAR 2009a).




*Figuur 4-10 Links: verspreiding van de Noordkromp in de periode 1995-2005 op het NCP (uit: Lindeboom et al. 2008), rechts: dichtheden (n/m$^2$) van de Noordkromp op basis van de bemonstering van de MWTL stations in 2010 (uit: Verduin et al. 2012).*

**Overige soorten**

Ten behoeve van het Nederlandse monitoringsprogramma van de KRM zijn indicatorsoorten aangewezen die fungeren als graadmeter voor de ontwikkeling van het bodemecosysteem. De soorten zijn eenvoudig te monitoren met bestaande methodes en worden relatief vaak in bodemmonsters aangetroffen over meerdere jaren. Voor het Friese Front zijn de volgende zeven soorten aangewezen (Wijnhoven *et al.* 2013):

- Draadarmige slangster (*Amphiura filiformis*), leeft ingegraven in de zeebodem en is gevoelig voor veranderingen in het leefgebied (zoals in zuurstofgehalte of veranderingen in de bodem). De soort komt niet voor in Europese richtlijnen of Nederlandse wet- en regelgeving.

- Moddergarnaal (*Callianassa subterranea):* gravende moddergarnaal die hoort bij de levensgemeenschap 'Sea-pen & burrowing megafauna communities' (zie beschrijving onder 15.4.2).

- Harige molkreeft (*Upogebia deltaura)*: gravende moddergarnaal die hoort bij de levensgemeenschap 'Sea-pen & burrowing megafauna communities' (zie beschrijving onder 15.4.2).

- Bolle papierschelp (*Thracia convexa)*: leeft ingegraven in modderige bodems met een tot twee individuen per vierkante meter. De tweekleppige is gevoelig voor bodemberoerende visserij, vanwege de tere (breekbare) schelp en het feit dat de soort weinig mobiel is. De soort komt niet voor in Europese richtlijnen of Nederlandse wet- en regelgeving (Fey-Hofstede & Witbaard 2013).

- Trapeziumkrab (*Goneplax rhomboides)*: leeft ingegraven in de zeebodem in complexe gangenstelsels, en staat erom bekend dat hij hard kan 'wegrennen' bij gevaar. De soort komt niet voor in Europese richtlijnen of Nederlandse wet- en regelgeving.

- Helmkrab (*Corystes cassivelaunus):* speelt evenals gravende moddergarnalen een belangrijke rol in het vermengen en verplaatsen van de zeebodem doordat ze zich achteruit in de bodem ingraven. De Helmkrab is gevoelig voor bodemberoerende visserij. De soort komt niet voor in Europese richtlijnen of Nederlandse wet- en regelgeving.

- De borstelworm *Nephtys incisa:* leeft in dunne gangen in de bovenste 10 cm van modderige bodems met enkele individuen per vierkante meter (in het Friese Front; Fey-Hofstede & Witbaard 2013). De soort komt niet voor in Europese richtlijnen of Nederlandse wet- en regelgeving.

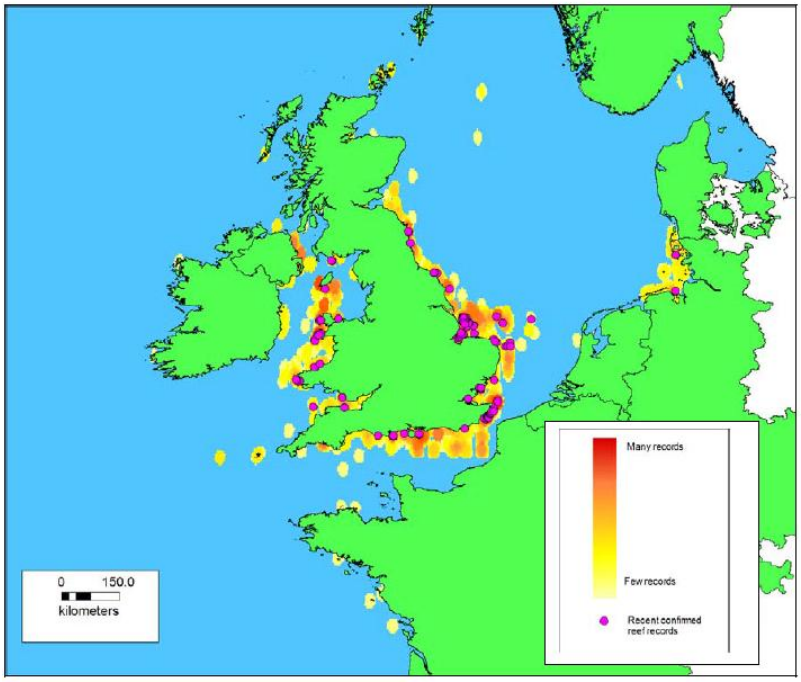
### *4.4.2 Habitats*

**Oesterbanken**
Banken van de Platte oester *(Ostrea edulis)* worden gedefinieerd als habitat wanneer vijf of meer individuen voorkomen per $m^2$. Er kan een aanzienlijke hoeveelheid dode oesterschelpen deel uitmaken van het substraat. De (levende en dode) oesterschelpen kunnen als substraat dienen voor bijvoorbeeld zakpijpen (*Ascidiacea*). Ook verschillende soorten borstelwormen en zeewieren komen op de oesterbanken voor. In het Nederlandse deel van de Noordzee kwamen vroeger grote oesterbedden van *Ostrea edulis* voor, maar deze zijn verdwenen o.a. door bodemberoerende visserij en ziekten (zie ook 4.2.2) (OSPAR 2009b). Gevoeligheden voor dit type habitat, waar ook rekening mee moet worden gehouden bij eventuele herintroductieprogramma's, zijn bedreigingen door een variëteit aan menselijke invloeden, zoals overbevissing, (introductie van) invasieve soorten, mechanische schade, vervuiling en klimaatverandering.

**Paardenmosselbanken**
De Paardenmossel *(Modiolus modiolus)* kan banken vormen, die een riffunctie met een hoge biodiversiteit vervullen (Bos *et al.* 2019). Per definitie worden banken waarvan meer dan 30% bedekt is met deze soort gezien als Paardemosselbank (OSPAR 2009c). In het Nederlandse deel van Noordzee worden plaatselijk losse individuen aangetroffen maar het belangrijkste gebied voor deze soort is het noordelijke deel van de Noordzee waar ook banken te vinden zijn, onder andere aan de noordrand van de Doggersbank (Bos *et al.* 2019). Langs het tracé van NeuConnect wordt het voorkomen van dit habitattype daarom uitgesloten (Bos & Tamis 2020).

***Sabellaria spinulosa*-riffen**
*S. spinulosa* is een kleine kokerworm, die in een groot deel van het verspreidingsgebied geen riffen vormt maar solitair leeft of met enkele individuen bij elkaar. Wanneer omstandigheden gunstig zijn kunnen dichte aggregaties voorkomen van kokerwormen, riffen vormend tot 60 centimeter hoogte en zich over verscheidene hectares uitstrekkend. Sabellaria-riffen kunnen vele jaren in een gebied aanwezig zijn, hoewel individuele groepjes kokerwormen regelmatig uit elkaar vallen (afsterven) en er ook weer nieuwe delen van het rif aangroeien (OSPAR 2013). Door de eigenschappen van het rif (o.a. consolidatie van onderliggend sediment) geeft de kolonie van kokerwormen stabiliteit, waardoor geassocieerde soorten zich kunnen vestigen. Het gaat hier om infaunasoorten als borstelwormen die tussen of in lege kokers leven, samen met tweekleppige schelpdieren en gravende vlokreeftjes. Tot de epifauna behoren Kalkkoker-wormen, Zeespinnen, Heremietkreeften, Vlokreeftjes, Hydroïdpolipen, Bryozoa, Sponzen en Zakpijpen (OSPAR 2013).

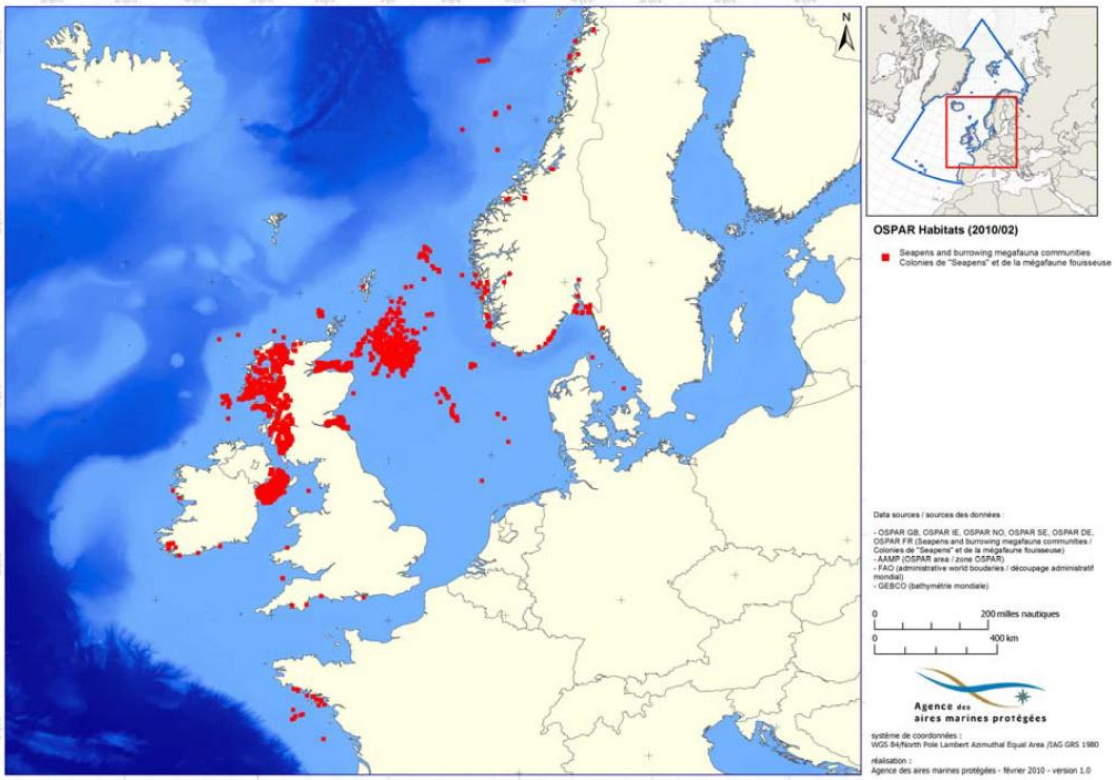
De verspreiding van *S. spinulosa* (voor zover bekend) is weergegeven in Figuur 4-11, waarbij te zien is dat de meldingen niet zozeer uit het Nederlandse deel van de Noordzee komen, maar wel in de kustzone van Groot-Brittannië en van Duitsland. Wel zijn er in 2017 *Sabellaria spinulosa*-riffen aangetroffen in delen van de Bruine Bank (zie paragraaf 4.2.2). Dit type habitat is gevoelig voor mechanische schade (zoals bodemberoerende visserij), zandwinning-activiteiten en verlies van substraat en bedekt / bedolven worden door sedimentatie, als gevolg van bijvoorbeeld aanleg van leidingen of kabels (OSPAR 2013).




*Figuur 4-11 Verspreiding van Sabellaria spinulosa, weergegeven als concentratie van meldingen in het OSPAR gebied, weergegeven in kleurgradatie. (NB. een klein deel van de data kan als historisch worden beschouwd, de cirkels geven een rif aan, van de overige data is niet zeker of ze aan het criterium 'rif' voldoen; OSPAR 2013).*

**Zeeveer *(Pennatulacea)* & gravende megafauna communities**

Dit type habitat ('Sea-pen and burrowing megafauna communities') bestaat uit vlakten met fijne modder, waarbij de bodem door elkaar gewerkt en verplaatst wordt door gravende megafauna. Op de bodem, die gekarakteriseerd wordt door glooiing van holen en heuvels, staan Zeeveren (*Pennulata phosphorea*), een soort koraal (OSPAR 2010). Tot de gravende kreeftachtigen behoren onder andere *Callianassa subterranea, Nephrops norvegicus* en *Upogebia deltaura*. Door de graafwerkzaamheden van de garnalen wordt een complex habitat gecreëerd, waarbij zuurstof tot diep in de bodem kan doordringen. De voorlopige verspreiding van dit type habitat is weergegeven in Figuur 4-12, waarbij te zien is dat er vooral meldingen zijn uit de meer noordelijke delen van de Noordzee en niet langs het tracé van NeuConnect. Dit habitattype is gevoelig voor bodemverstoring door bodemberoerende visserij en andere menselijke activiteiten die het habitat aantasten (omdat hun gangen, of de kreeftjes zelf dan beschadigen) en klimaatverandering (Fey-Hofstede & Witbaard 2013; Narberhaus *et al.* 2012).



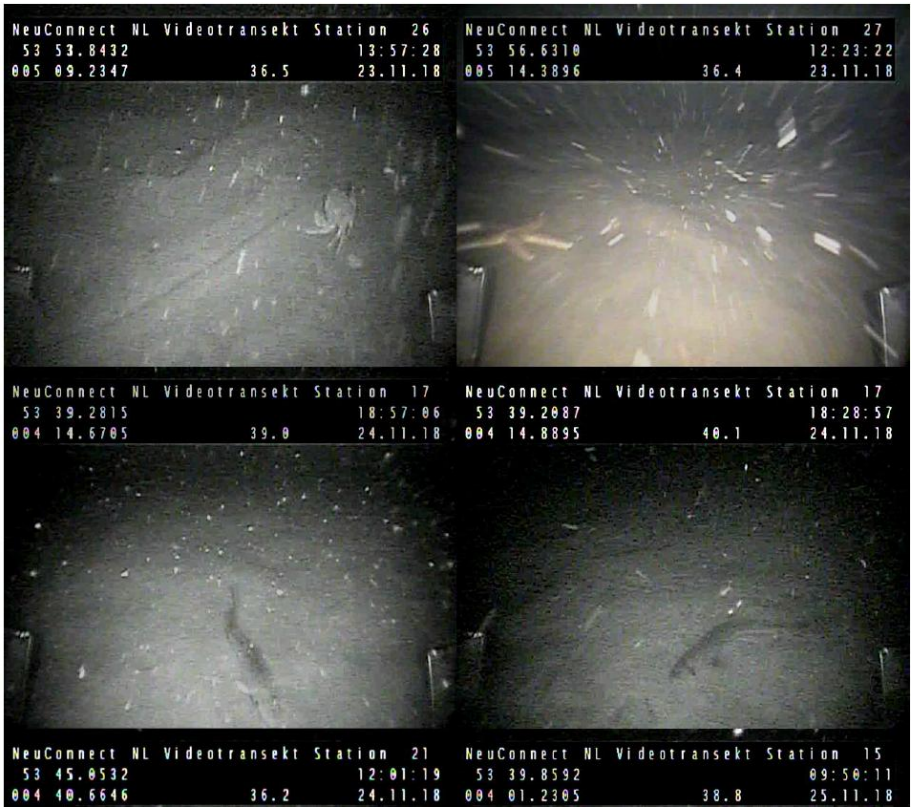

*Figuur 4-12 Voorlopige verspreiding van Zeeveer & gravende megafauna communities in het OSPAR-zeegebied (op basis van gegevens die de overeenkomstsluitende partijen tot oktober 2009 hebben verstrekt; OSPAR 2010).*

### *4.4.3 Resultaten van het benthosonderzoek langs de kabelroute*

Hieronder worden de resultaten van het benthosonderzoek langs de kabelroute besproken (Oribicon 2019a). Vervolgens worden soorten en habitats beschreven, die onder een beschermingsregime vallen en daarom relevant zijn voor deze ecologische beoordeling.

De resultaten van het benthosonderzoek, dat in de herfst van 2018 is uitgevoerd langs het Nederlandse deel van de kabelroute, beschrijven de huidige toestand van de mariene biotopen (inclusief sedimentkenmerken) en de benthische faunasoorten rond de voorgestelde kabelroute (Orbicon 2019a). Op het Nederlandse deel van de route waren 34 monsterpunten, met een afstand van ongeveer 7,7 km tussen elk punt. Er is gebruik gemaakt van video-onderzoek, de van Veen happer en een boomkor (sleepnet); verschillende methodes om soorten met verschillende levenswijzen te ontdekken.

Uit de beelden van de onderwater videocamera blijkt dat op alle bemonsteringspunten langs het Nederlandse deel van de kabelroute homogene zandbodem aanwezig was, met overwegend slibrijk fijn zand tot fijn zand (met een gemiddelde korrelgrootte tussen 0,085 en 0,2 mm). Op videobeelden was te zien dat wanneer er ongelijkmatigheid in de bodemstructuur te zien was, dit vaak een biogene oorsprong heeft, zoals 'constructies' van de Zeeklit (*Echinocardium cordatum*), sifonopeningen van mosselen, velden van kokerwormen en koraalachtigen die in het sediment leven (zie figuur 4-13).




*Figuur 4-13 Beelden van de onderwater videocamera, met linksboven (en met de klok mee) de Gewone zwemkrab, de Gewone zeester en verschillende vissoorten (niet op soort gebracht; uit Orbicon 2019)*

Naar de indeling van bodemhabitats volgens het European Nature Information System (EUNIS) kunnen er twee biotopen worden vastgesteld langs het Nederlandse deel van de kabelroute. Het eerste is 'ondiep tot matig diep slibrijk zand', gekenmerkt door een bodemgemeenschap met verschillende soorten borstelwormen, tweekleppigen zoals Witte dunschaal (*Abra alba*) en Driehoekige parelmoerneut (*Nucola nitidosa*), en stekelhuidigen zoals slangsterren van het geslacht Amhiura en Ophiura, evenals kamsterren (*Astropecten irregularis*). Het tweede is 'ondiep tot matig diep fijn zand', gekenmerkt door een verscheidenheid aan stekelhuidigen (met in sommige gebieden het Zeeboontje, *Echinocyamus pusillus*), borstelwormen en tweekleppigen.

Met de boomkor zijn 64 soorten epifauna (soorten die op de zeebodem leven) gevonden langs het Nederlandse deel van de kabelroute. In aantallen domineerden de soorten Kleine slangster (*Ophiura albida*), Penhoren (*Turritella communis*), Gewone slangster (*Ophiura ophiura*), Kamster (*Astropecten irregularis*), Zeeklit (*Echinocardium cordatum*), Gewone zwemkrab (*Liocarcinus holsatus*), Groefstaartgarnaal (*Crangon allmani*) en de Gewone zeester (*Asterias rubens*). De biomassa werd gedomineerd door de Gewone zeester, Zeeklit, Kleine slangster, Gewone zwemkrab en Kamster.

Er zijn in totaal 118 soorten infauna gevonden langs het Nederlandse deel van de kabelroute. De groep van borstelwormen heeft de hoogste diversiteit aan soorten. In aantallen domineerden de soorten Draadarmige slangster (*Ampiura filiformis*), de borstelworm *Lumbrineris gracilis*, Korfschelp (*Corbula gibba*), de borstelworm *Scalibregma inflatum*, en de borstelworm *Spiophanes bombyx*. De biomassa werd gedomineerd door de soorten Zeeklit, Draadarmige slangster en Harige molkreeft (*Upogebia deltaura*), en op een bemonsteringspunt

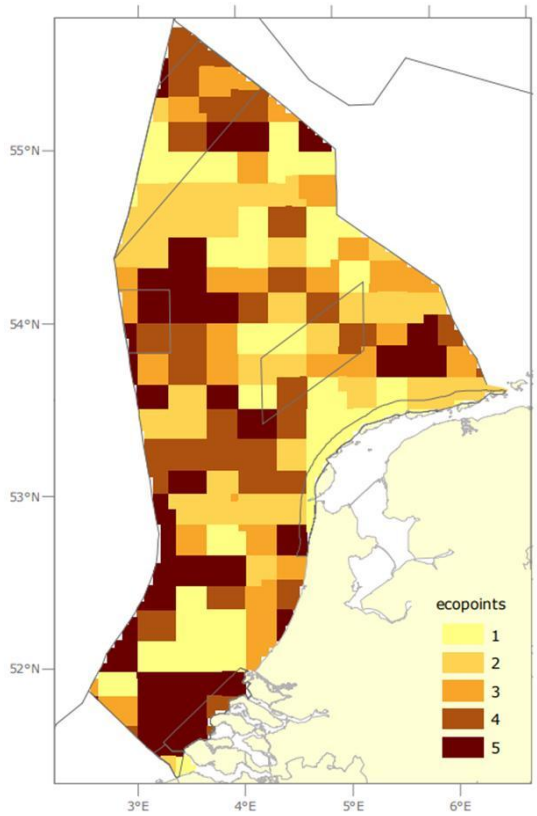
(ook het enige punt waar deze soort werd aangetroffen) door de Gedoornde hartschelp (*Acanthocardia echinata*).

Beschermingsregimes van benthos
Bij het benthosonderzoek langs het Nederlandse deel van de kabelroute zijn er geen individuen van de Noordkromp (*Arctica islandica*) aangetroffen, die op de OSPAR lijst staat van Bedreigde en/of Afnemende Soorten & Habitats. Van de aangewezen habitats zijn er geen oesterbanken aangetroffen tijdens de bemonstering. Wel zijn er individuen van *Sabellaria spinulosa* aangetroffen (met OSPAR bescherming & behoudsdoel), die met een aantal andere soorten een subgroep van epifauna domineerde in aantallen. Het habitat 'Zeeveer *(Pennatulacea)* & gravende megafauna communities' (met OSPAR bescherming en hersteldoel), is niet aangetroffen. Wel zijn de gravende kreeftjes Moddergarnaal (*Callianassa subterranea),* en Harige molkreeft (*Upogebia deltaura*) in de bemonstering langs het Nederlandse deel van de kabelroute aangetroffen. De zeven aangewezen indicatorsoorten van de KRM (zie paragraaf 3.5) zijn allemaal in meerdere of mindere mate aangetroffen in de bemonstering (Orbicon 2019a).

### *4.4.4 Vissen*

De Noordzee is van origine rijk aan vis (Heessen *et al.* 2015). De verschillende soorten vis kunnen worden onderverdeeld in pelagische soorten, vissen van het open water, waarvan de haring het meest talrijk is. Demersale soorten leven op of nabij de bodem en zijn onder te verdelen in rondvissen (zoals kabeljauwachtigen) en platvissen. Daarnaast zijn er trekvissen, die een deel van hun levenscyclus in de Noordzee leven, bijvoorbeeld als adult, en rivieren opzoeken om zich voort te planten (anadroom), of juist vanuit het zoete water de zee op trekken om te paaien (katadroom). Door verlies van paaigebieden, verontreiniging van rivieren en overbevissing zijn deze diadrome soorten zeldzaam geworden of verdwenen. Het herstel wordt o.a. beperkt door de barrièrewerking van dijken en kunstwerken, al worden er ook herintroductieprogramma's opgezet om bepaalde soorten te helpen (Mariene Strategie voor het Nederlandse deel van de Noordzee 2012).

In Tabel 4-2 zijn de vissoorten weergegeven die op de OSPAR lijst staan voor bescherming en behoud of herstel en mogelijk in het plangebied voorkomen. De Houting en de Steur zijn tevens beschermd volgens artikel 3.5 van de Wnb. Verspreidingskaarten van individuele soorten zijn weergegeven in Heessen *et al.* (2015). Voor wat betreft hotspots geldt voor Noordzee vissen dat er duidelijke patronen te zien zijn qua verspreiding in ruimte en tijd, met over het algemeen het hoogste aantal soorten in het zuid(west)elijk deel en in het noordelijk deel van de Noordzee (zie Figuur 4-14; Bos *et al.* 2011).




*Figuur 4-14 Hotspots voor vissen op het NCP (uit: Bos et al. 2011).*

De meeste soorten van de OSPAR lijst zijn in lage aantallen in de Noordzee waargenomen. Onder meer overbevissing (in het verleden) is een van de oorzaken. Vanuit OSPAR is het streven deze daling te stoppen, en te zorgen dat vissen ook in gebieden zonder (bodem-beroerende) visserij kunnen opgroeien. Naast de soorten van de OSPAR lijst zijn er uiteraard vele andere vissoorten die veel voorkomen in de Noordzee en kunnen worden aangetroffen in of nabij het tracé.

*Tabel 4-2 Vissoorten die op de OSPAR lijst staat voor bescherming en behoud of herstel, en tevens verwacht worden mogelijk in het plangebied voor te komen (anadroom = soort trekt vanuit zee de rivieren op om te paaien. katadroom = soort trekt vanuit het zoete water naar zee om te paaien).*

| **Soort** | **Leefwijze** | **Voedsel** | **Voorkomen / trend** |
|---|---|---|---|
| Steur (*Aciper sturio*) | Anadroom, pelagisch (maar zoekt voedsel op de bodem) | Benthische dieren | Afwezig (enkel in Gironde, Frankrijk, populatie), herintroductieprogramma opgezet |
| Elft *(Alosa alosa)* | Anadroom, pelagisch (scholen vormend) | Plankton | Zeldzaam |
| Paling *(Anguilla anguilla)* | Katadroom, demersaal | Macrofauna en vissen | Relatief kleine populatie, met neergaande trend, voorkomen in kustwateren |
| Houting *(Coregonus oxyrinchus)* | Anadroom, pelagisch (maar zoekt voedsel op de bodem) | Kreeftachtigen, schelpdieren, kleine vis | Zeldzaam, herintroductie |

| | | | |
|---|---|---|---|
| Vleet *(Dipturus batis)* | Demersaal | Kreeftachtigen, vissen, wormen, inktvis | Afwezig |
| Gevlekte rog *(Raja montagui)* | Demersaal | Kreeftachtigen, vissen, wormen | Relatief kleine populatie, toenemende trend, ruimtelijk verspreid over centrale Noordzee |
| Kabeljauw *(Gadus morhua)* | Demersaal | Allerlei soorten vis, zwemkrabben en ander dierlijk bodemleven | Relatief kleine populatie |
| Langsnuitzeepaardje *(Hippocampus guttulatus)* | Demersaal | (larven van) kreeftachtigen, (larven van) vissen | Lage aantallen |
| Kortsnuitzeepaardje *(Hippocampus hippocampus)* | Demersaal | Kleine kreeft-achtigen, kleine visjes | Lage aantallen |
| Zeeprik *(Petromyzon marinus)* | Anadroom, pelagisch | Adult:: meereizend als parasiet op o.a. kabeljauw, zalm. | Lage aantallen |
| Stekelrog *(Raja clavata)* | Demersaal | Kreeftachtigen, wormen, slakken | Lage aantallen |
| Zalm *(Salmo salar)* | Anadroom | Adult: Kreeftachtigen, krabben, vis | Herintroductie, lage aantallen |
| Doornhaai *(Squalus acanthias)* | Pelagisch | Zandspiering, Inktvis, Haring | Relatief kleine populatie, met neergaande trend. |

Referenties: Vis & de Bruin (2012), synbiosys.alterra.nl (profielendocumenten), Bos *et al. (*2012), soortenbank.nl, Stichting Anemoon; Heessen *et al.* (2015).

### *4.4.5 Vleermuizen*

Over het algemeen is de kennis over vleermuizen op zee heel beperkt (Rijkswaterstaat 2019). Bekend is dat vleermuizen gebruik maken van de Noordzee als doortrekgebied (Boonman 2018). Er zijn drie migrerende soorten vleermuizen, die lange afstanden kunnen afleggen en op de Noordzee kunnen voorkomen: de Ruige Dwergvleermuis (*Pipistrellus nathusii*), de Rosse Vleermuis (*Nyctalus noctula*) en de Tweekleurige Vleermuis (*Vespertilio murinus*) (Janssen *et al.* 2016). De Ruige Dwergvleermuis is de soort die het vaakst op de Noordzee wordt aangetroffen (Boshamer & Bekker 2008), waarbij het gaat om trek naar Groot-Brittannië om daar te overwinteren of te baltsen.

De meeste waarnemingen op zee worden tijdens de trekperiodes waargenomen, vanaf eind maart - eind juni en vanaf eind augustus - eind september. Belangrijkste aantallen zijn tijdens de najaarstrek aan te treffen ( Lagerveld *et al.* 2017). Op een hoogte van 3-20m hoogte vliegen vleermuizen boven het water (Boshamer & Bekker 2008). De hoogste vleermuisactiviteit op zee is vastgesteld in windstille en relatief warme nachten (Boonman 2018, Lagerveld *et al.* 2017).

### *4.4.6 Vogels*

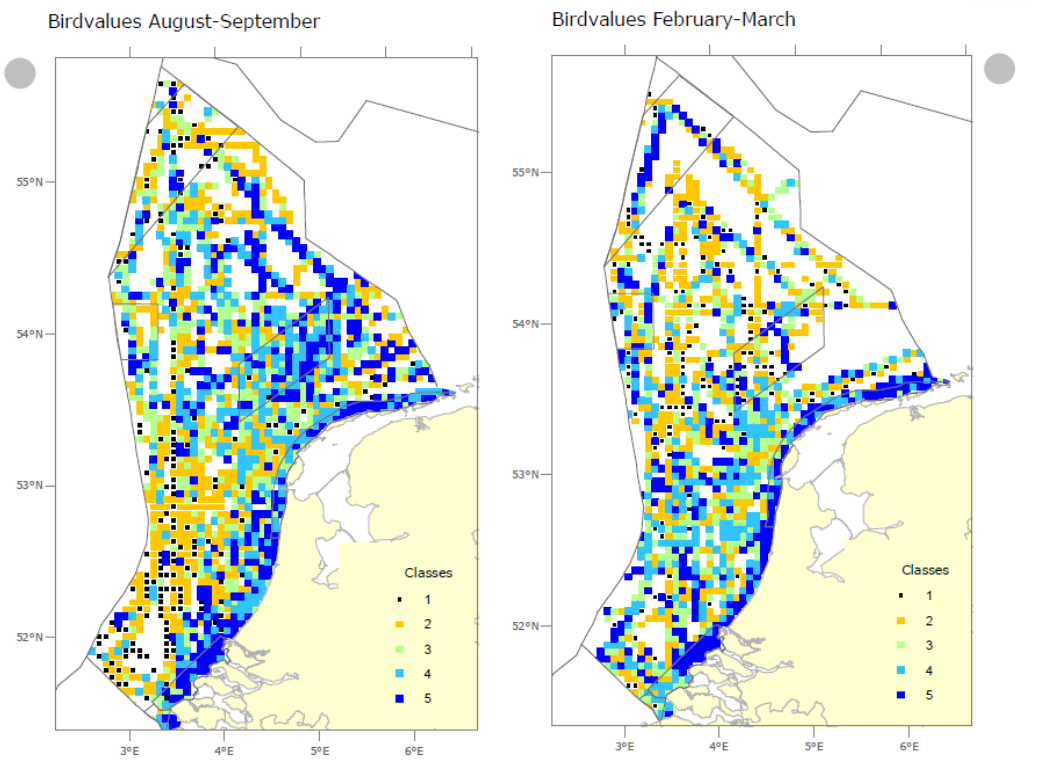
Alle in Nederland voorkomende vogelsoorten zijn opgenomen in bijlage I van de Vogelrichtlijn en dus beschermd volgens artikel 3.1 Wnb. In de Nederlandse Noordzee komen diverse vogels met een verschillende verspreiding in ruimte en tijd voor. De hoogste concentraties vogels

bevinden zich langs de kust. Ver uit de kust valt vooral het Natura 2000-gebied Friese Front als gebied met hoge vogelwaarden in de zomer en herfst op (zie Figuur 4-15) (Bos *et al.* 2014). Het gaat dan vooral om zeekoeten.

In het algemeen kunnen de op het NCP voorkomende vogels in twee groepen worden ingedeeld: kustgebonden vogels en zeegebonden vogels (pelagische soorten). Kustgebonden zeevogels foerageren op zee, maar zijn minder goed aangepast aan het leven op zee en komen meestal dagelijks aan land (m.u.v. duikers). De zeegebonden soorten zijn goed aangepast aan het leven op zee en zijn alleen in het broedseizoen voor kortere of langere tijd aan land.

Kustgebonden vogels, die op het NCP voorkomen, zijn onder andere meeuwen en sterns, zoals Grote mantelmeeuw, Grote stern, Kleine mantelmeeuw, Stormmeeuw, Visdief en Zilvermeeuw. De talrijkste pelagische soorten op het NCP zijn Alk, Drieteenmeeuw, Jan-van-gent, Noordse stormvogel en Zeekoet (Fijn *et al.* 2015, 2018). Tabel 4-3 geeft een overzicht van verschillende groepen vogels en de daarbij horende soorten, die mogelijk in het plangebied kunnen voorkomen.

In Tabel 4-4 is aangegeven in welke periode de hoogste aantallen van voor deze beoordeling belangrijke soorten op het NCP voorkomen. Het voorkomen en de verspreiding van deze soorten zijn in Bijlage 2 Relevante vogelsoorten beschreven. Soorten, die in voor de populatie belangrijke aantallen op het NCP voorkomen zijn Dwergmeeuw, Eidereend, Kleine mantel-meeuw, Zwarte zee-eend, Zilvermeeuw, Grote jager en Roodkeelduiker (Tabel 4-4).




*Figuur 4-15 Vogelwaarden op het Nederlandse deel van de Noordzee, nazomer en winter. Bron: Bos et al. 2014.*

*Tabel 4-3 Groepen en soorten vogels, die mogelijk in het plangebied kunnen voorkomen.*

| Groep | Kustgebonden soorten | Zeegebonden soorten |
|---|---|---|
| **Visetende vogels** | Aalscholver, Fuut, Parelduiker, Roodkeelduiker | Alk, Vale Pijlstormvogel, Jan-van-gent, Kleine en Grote jager, Noordse stormvogel, Papegaaiduiker, Zeekoet |
| **Schelpdier etende vogels** | Eider, Topper, Zwarte zee-eend | |
| **Meeuwen en sterns** | Dwergmeeuw, Dwergstern, Grote mantelmeeuw, Grote stern, Kleine mantelmeeuw, Kokmeeuw, Noordse stern, Stormmeeuw, Visdief, Zilvermeeuw | Drieteenmeeuw |

*Tabel 4-4 Overzicht van de soorten, die mogelijk in het plangebied kunnen voorkomen inclusief maximum aantal individuen op het NCP en de periode met de hoogste aantallen. Bron: Bos et al. 2014, Birdlife International 2019.*

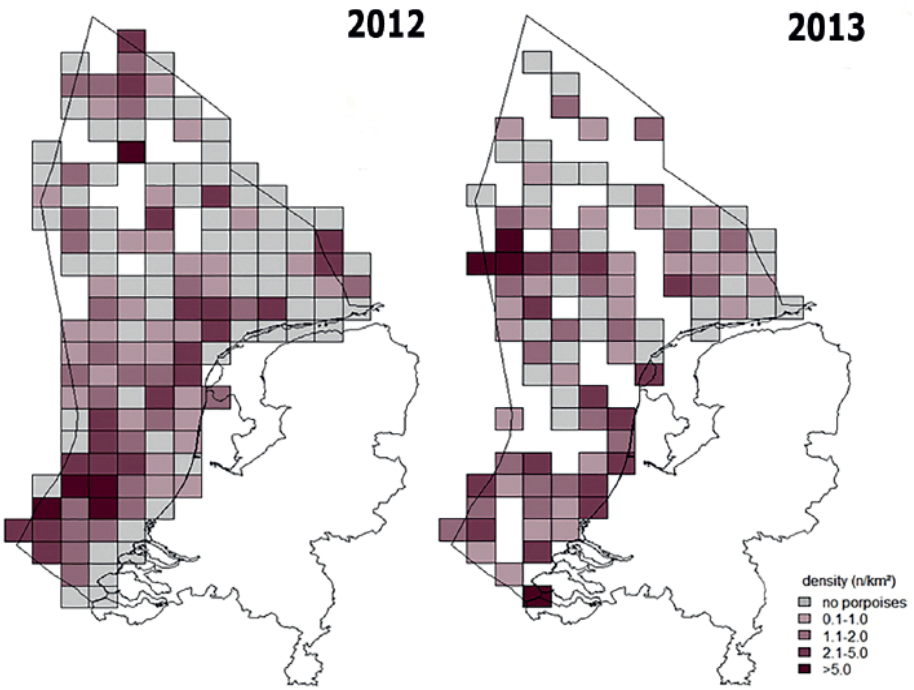
| Soort | Totale populatiegrootte (x1.000) | Maximum aantal op het NCP | Max % | Seizoen met maximum aantallen op het NCP |
|---|---|---|---|---|
| Aalscholver (*Phalacrocorax carbo*) | 276-342 | 4.000 | 1.3 | zomer |
| Dwergmeeuw (*Hydrocoloeus minutus*) | 66-102 | 14.200 | 16.9 | migratie |
| Dwergstern (*Sterna albifrons*) | 31-32 | 500 | 1.6 | lente |
| Eidereend (*Somateria mollissima*) | 850-1.200 | 70.000 | 6.8 | winter |
| Fuut (*Podiceps crustatus)* | 370-580 | 21.100 | 4.4 | winter |
| Grote mantelmeeuw (*Larus marinus*) | 420-510 | 36.000 | 7.7 | winter |
| Grote stern (*Thalasseus sandvicensis*) | 159-171 | 7.000 | 4.1 | lente/zomer |
| Kleine mantelmeeuw (*Larus fuscus*) | 525 | 82.900 | 15.8 | lente/zomer |
| Kokmeeuwen (*Chroicocephalus ridibundus*) | 5.600-7.300 | 24.900 | 0.4 | winter |
| Noordse sterns (*Sterna paradisaea*) | 1.320-2.280 | 1.000 | 0.1 | zomer |
| Visdief (*Sterna hirundo*) | 500-1.000 | 10.600 | 1.4 | augustus - september |
| Parelduiker (*Gavia arctica*) | 360-690 | 400 | 0.1 | winter/migratie |
| Roodkeelduiker (*Gavia stellata*) | 183-420 | 9.800 | 5.4 (19.6) | winter |
| Stormmeeuw (*Larus canus*) | 1.300-2.100 | 61.500 | 3.6 | winter |
| Topper (*Aythya marila)* | 310 | 5.000 | 1.6 | winter |
| Zwarte zee-eend (*Melanitta nigra*) | 1.600 | 110.000 | 6.9 | winter |
| Zilvermeeuw (*Larus argentatus*) | 1.090 | 139.200 | 12,8 | winter |
| Alken (*Alca torda*) | 2.400 | 24.215 | 1.0 | winter |
| Drieteenmeeuw (*Rissa tridactyla*) | 8.400 | 155.700 | 1.9 | winter |
| Grote jager (*Stercorarius skua*) | 27 | 1.500 | 5.5 | augustus - september |
| Jan-van-gent (*Morus bassanus*) | 892 | 25.600 | 2.9 | herfst |
| Kleine jagers (*Stercorarius parasiticus*) | 55 | 300 | 0.5 | herfst |
| Noordse stormvogel (*Fulmarus glacialis*) | 10.000 | 95.800 | 1.0 | augustus - september |
| Papegaaiduiker (*Fratercula arctica grabae*) | 12.000 | 820 | 0.0 | winter |
| Vale pijlstormvogel (*Puffinus mauretanicus)* | 19 | - | - | juli - oktober |
| Zeekoet (*Uria aalge*) | 8.000 | 133.185 | 1.7 | herfst |

### *4.4.7 Zeezoogdieren*

De Bruinvis, de Gewone zeehond en de Grijze zeehond zijn de meest voorkomende zeezoogdieren op het NCP (Bos *et al.* 2011). Van de andere walvisvachtigen komt de Witsnuitdolfijn het meest frequent in Nederlandse wateren voor (Lindeboom *et al.* 2005, 2008). Alle walvisachtigenzijn opgenomen in bijlage IV van de Habitatrichtlijn en dus beschermd volgens artikel 3.5 Wnb.

**Bruinvis**

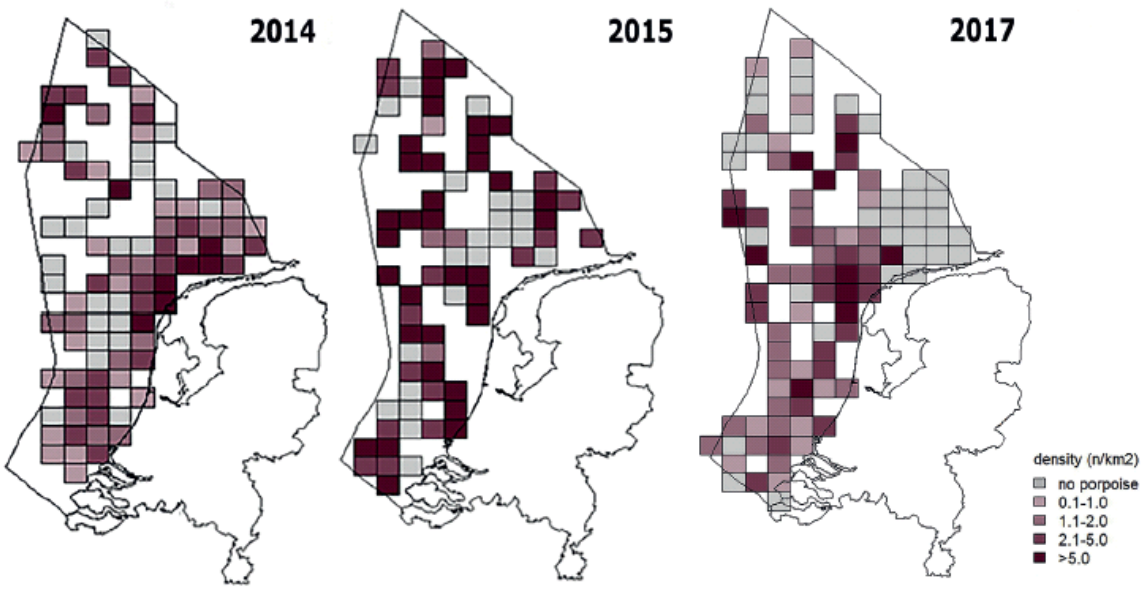
De Bruinvis (*Phocoena phocoena*) is de meest voorkomende walvisachtige in de Noordzee (Reid *et al.* 2003, Hammond *et al.* 2013, 2017, Ministry of Agriculture, Nature and Food Quality, 2020). De meest recente gegevens uit SCANS II en III, een meerjarig boot- en vliegtuigonderzoek naar de populatieomvang en verspreiding van bruinvissen, dolfijnen en walvissen, laten zien dat de centrale en zuidelijke delen van de Europese Noordzee belangrijke gebieden voor de Bruinvis zijn (Hammond *et al.* 2013, 2017). Het hele NCP valt binnen de zuidelijke Noordzee. In 2017 werd de Bruinvis populatie hier op ongeveer 47,000 dieren geschat, in de zomer van 2019 op ongeveer 39.000 dieren (Geelhoed *et al.* 2018, 2020). Beide aantallen vallen binnen het bereik van eerder gemaakte schattingen sinds 2010 met een minimum van circa 26.000 dieren in 2010 en een maximum van bijna 77.000 dieren in 2014. De aantallen bruinvissen in Nederlandse wateren nemen sinds de laatste decennia significant toe (Camphuysen & Siemensma 2011). De reden hiervoor lijkt echter een verandering in de verspreiding te zijn dan een toename van de populatie (Camphuysen 2004).




*Figuur 4-16 Verspreiding van de dichtheden van bruinvissen (dieren/km²) per 1/9 ICES grid cell, lente 2012 en 2013. Bron: Geelhoed & Scheidat 2018.*

Voor de Bruinvis zijn tot nu toe geen duidelijke hotspots gedefinieerd en is aan te nemen dat de Bruinvis evenredig op het NCP verspreid is (Bos *et al.* 2011, Camphuysen & Siemensma 2011). Wel kunnen er grote lokale, seizoensgebonden en jaarlijkse verschillen in aantallen en dichtheden zijn (Bos & Paijmans 2012, Geelhoed & Scheidat 2018, Gilles *et al.* 2016). Volgens Scheidat *et al. (*2012) komen de hoogste dichtheden in Nederlandse wateren voor in de winter en vroege lente (februari en maart), laagste dichtheden in de zomer. Geelhoed & Scheidat (2018) laten echter zien, dat dit veranderd is en de dichtheden in de lente en zomer tussen 2012 - 2017 marginaal verschillen. Het gaat dan om jaarlijkse dichtheden op het NCP tussen 1.07-1.12 dieren/km² in de lente en 0.7 - 1.29 dieren/km² in de zomer. Hogere dichtheden in de zomer gaan samen met hogere percentages moeder-kalf paren en suggereren een groeiend belang van het NCP voor de reproductie van de Bruinvis. De geboorteperiode loopt van mei tot augustus. In zowel de lente als in de zomer is er een band van hogere dichtheden van het zuidelijke deel van het NCP naar het gebied ten noorden van de westelijke Waddeneilanden te zien (Figuur 4-16 en Figuur 4-17). De gemiddelde dichtheden in de delen van het NCP waar de kabel loopt bedroeg over de periode 2010 – 2019 0,67-0,87 ind/km$^2$ (Geelhoed *et al*. 2020).

In het Duitse deel van de Borkumse Stenen worden relatief hoge dichtheden bruinvissen in het voorjaar aangetroffen (Gilles *et al.* 2009). Ondanks hoge fluctuaties in de abundantie lijken de aantallen bruinvissen hier in het afgelopen decennium te stijgen (Nachtsheim *et al.* 2021). Dergelijk verhoogde dichtheden konden echter niet in het Nederlandse deel van de Borkumse Stenen worden vastgesteld (Bos *et al.* 2011, Bos & Paijmans 2012). De Borkumse Stenen lijken wel bij een brede band langs de Nederlandse Waddenzee en kust te horen, waar bruinvissen in het voorjaar doortrekken en foerageren en in hogere dichtheden voorkomen (Bos & Paijmans 2012). Bruinvissen worden ook in en rond het Friese Front aangetroffen, maar er zijn geen aanwijzingen dat dit gebied van specifiek belang is voor de soort (Camphuysen & Siemensma 2011). Op de Bruine Bank werden in september en december 2011 hogere dichtheden bruinvissen met relatief hoge percentages moeder-kalf paren aangetroffen (Bos & van Bemmelen 2012). Het wordt aangenomen dat de Bruine Bank bij een ruimer gebied hoort dat voor de Bruinvis van belang binnen het NCP is.




*Figuur 4-17 Verspreiding van de dichtheden van bruinvissen (dieren/km²) per 1/9 ICES grid cell, zomer 2014, 2015 en 2017. Bron: Geelhoed & Scheidat 2018.*

**Andere walvisachtigen**

Naast de bovengenoemde soorten worden volgens Geelhoed & Polanen Petel (2011) ook de Dwergvinvis (*Balaenoptera acutorostrata*), de Tuimelaar (*Tursiops truncatus*) en de Witsnuitdolfijn (*Lagenorhynchus albirostris*) als inheemse soorten beschouwd.

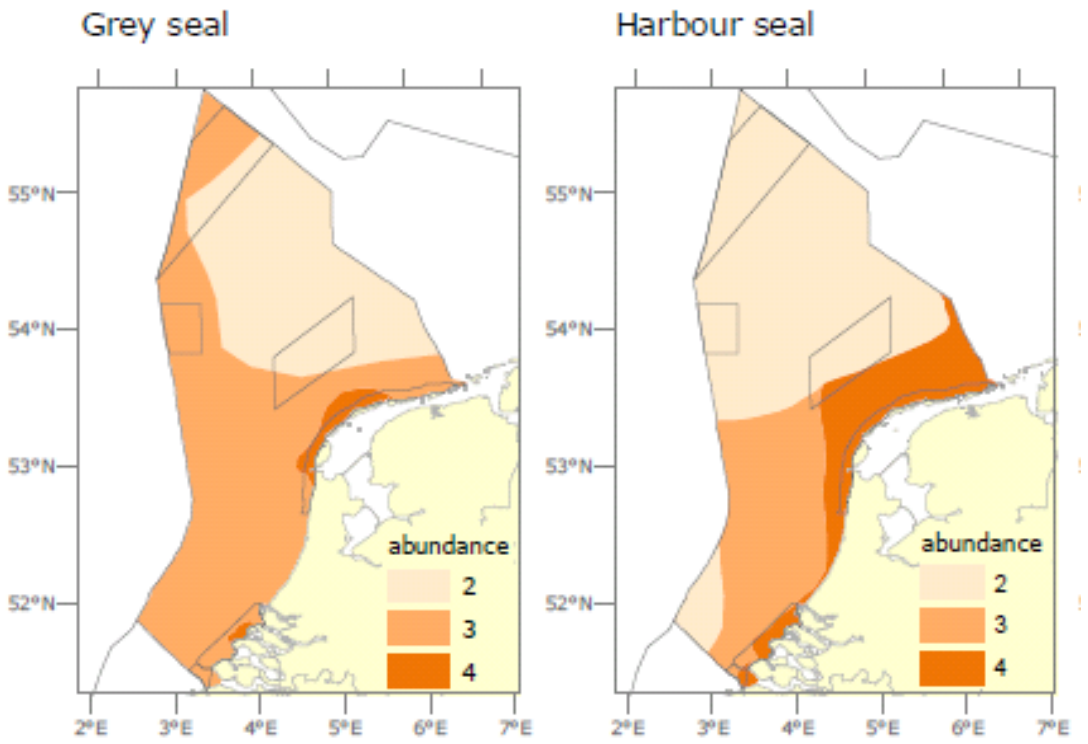
De Dwergvinvis heeft een wereldwijde verspreiding en komt voornamelijk in relatief ondiep water (< 200 m) voor. Op het NCP is het voorkomen van deze soort beperkt tot het noordwesten, maar de verspreiding lijkt zuidwaarts te verschuiven. De meeste waarnemingen worden in het late voorjaar en in de vroege zomer (mei-juli) gedaan (Geelhoed & Polanen Petel 2011). Voor de Tuimelaar ligt de Noordzee aan de noordgrens van het verspreidingsgebied. Onregelmatig wordt deze soort in lage aantallen waargenomen (Geelhoed & Polanen Petel 2011). De Witsnuitdolfijn komt voornamelijk in de noordwestelijke Noordzee voor en dringt waarschijnlijk ter hoogte van de Doggersbank en Klaverbank in Nederlandse wateren (Lindeboom *et al.* 2005, 2008). In 2017 werden tijdens twee surveys in januari 16 witsnuitdolfijnen op de Bruine Bank waargenomen (Geelhoed *et al.* 2018). Volgens Lindeboom *et al. (*2005) komt de Witsnuitdolfijn echter onregelmatig verspreid op het NCP voor en zijn geen speciale, beschermingswaardige gebieden aan te wijzen voor deze soort. Andere walvisachtigen, zoals de Bultrug, kunnen ook incidenteel op het NCP voorkomen, maar het zwaartepunt van de verspreiding ligt buiten Nederlandse wateren (Lindeboom *et al.* 2008).

**Zeehonden**

Op het NCP komen twee soorten zeehonden voor, de Grijze zeehond (*Halichoerus grypus*) en de Gewone zeehond (*Phoca vitulina*). De Gewone zeehond is talrijker dan de Grijze zeehond (Aarts *et al.* 2016). Beide soorten leven en foerageren op zee, maar komen regelmatig naar ligplaatsen op wad- en zandplaten in de Waddenzee en de Delta. In de voortplantingstijd en tijdens de verharingsperiode worden de grootste aantallen zeehonden op land aangetroffen. Bij gewone zeehonden is dit de periode juni tot september, bij grijze zeehonden van december-januari en maart-april (Cremer *et al.* 2017).

Volgens Aarts *et al.* (2016) besteden gewone zeehonden in de wintermaanden meer tijd op zee, leggen grotere afstanden vanuit de ligplaatsen af en gebruiken ligplaatsen die dichter bij de Noordzee gelegen zijn. In het algemeen blijken de dichtheden ver uit de kust lager te zijn. Van de Grijze zeehond is bekend dat de soort langere tochten maakt dan de Gewone zeehond (Figuur 4-18). Grijze zeehonden bewegen veel tussen de Waddeneilanden en Groot-Brittannië en in mindere mate andere aangrenzende gebieden (Deltagebied en Frankrijk) (Cremer *et al.* 2017). Daarbij is er sprake van grote individuele verschillen tussen dieren (Brasseur *et al.* 2017).

Beide soorten zullen dus langs de aanlegroute voorkomen. Uit onderzoek op het Friese Front en de Bruine Bank zijn waarnemingen van beide soorten bekend (Geelhoed & Leopold 2017). Het gebied Borkumse Stenen wordt intensief door de Gewone zeehond gebruikt als leefgebied en als uiterst waardevol voor deze soort beschouwd. Ook de Grijze zeehond gebruikt dit gebied om te foerageren en er doorheen te trekken (Bos & Paijmans 2012).




*Figuur 4-18 Jaarlijkse gemiddelde verspreiding van de Grijze zeehond (links) en de Gewone zeehond (rechts) op het NCP.Bron: Bos et al. 2014.*

### *4.4.8 Rode Lijst soorten*

Een beschrijving van alle soorten die op de Rode Lijst staan (zie ook paragraaf 6.4) is te vinden op de website van het Ministerie van Landbouw, Natuur en Voedselkwaliteit (https://minez.-nederlandsesoorten.nl/content/rode-lijsten). De Rode Lijst soorten worden in deze beoordeling niet afzonderlijk behandeld, maar meegenomen in de beoordeling van de andere kaders. Voor het mariene milieu zijn de Rode lijsten van Vissen, Zoogdieren en Vogels van belang. Op de Rode lijst staan 19 soorten vissen die in de Noordzee voorkomen. De Vissen in de Noordzee kennen geen bescherming volgens de Wnb, er geldt wel een Zorgplicht. Van de zeezoogdieren staan Bruinvis (kwetsbaar), Gewone zeehond (kwetsbaar), Grijze zeehond (gevoelig), en Tuimelaar (in het wild verdwenen uit Nederland) op de Nederlandse Rode lijst, en daarnaast zijn de vleermuizen Rosse vleermuis (kwetsbaar) en Tweekleurige vleermuis (gevoelig) relevant. Op deze soorten zijn ook artikel 3.1, 3.5 of 3.10 van de Wnb van toepassing. Relevante Rode lijstsoorten onder vogels zijn Grote mantelmeeuw en Drieteenmeeuw. Voor de vogels geldt dat alle in Nederland voorkomende vogelsoorten beschermd zijn volgens artikel 3.1 van de Wnb; deze komen daar aan de orde.

## 4.5 Voorkeurstracé en ecologische hotspots

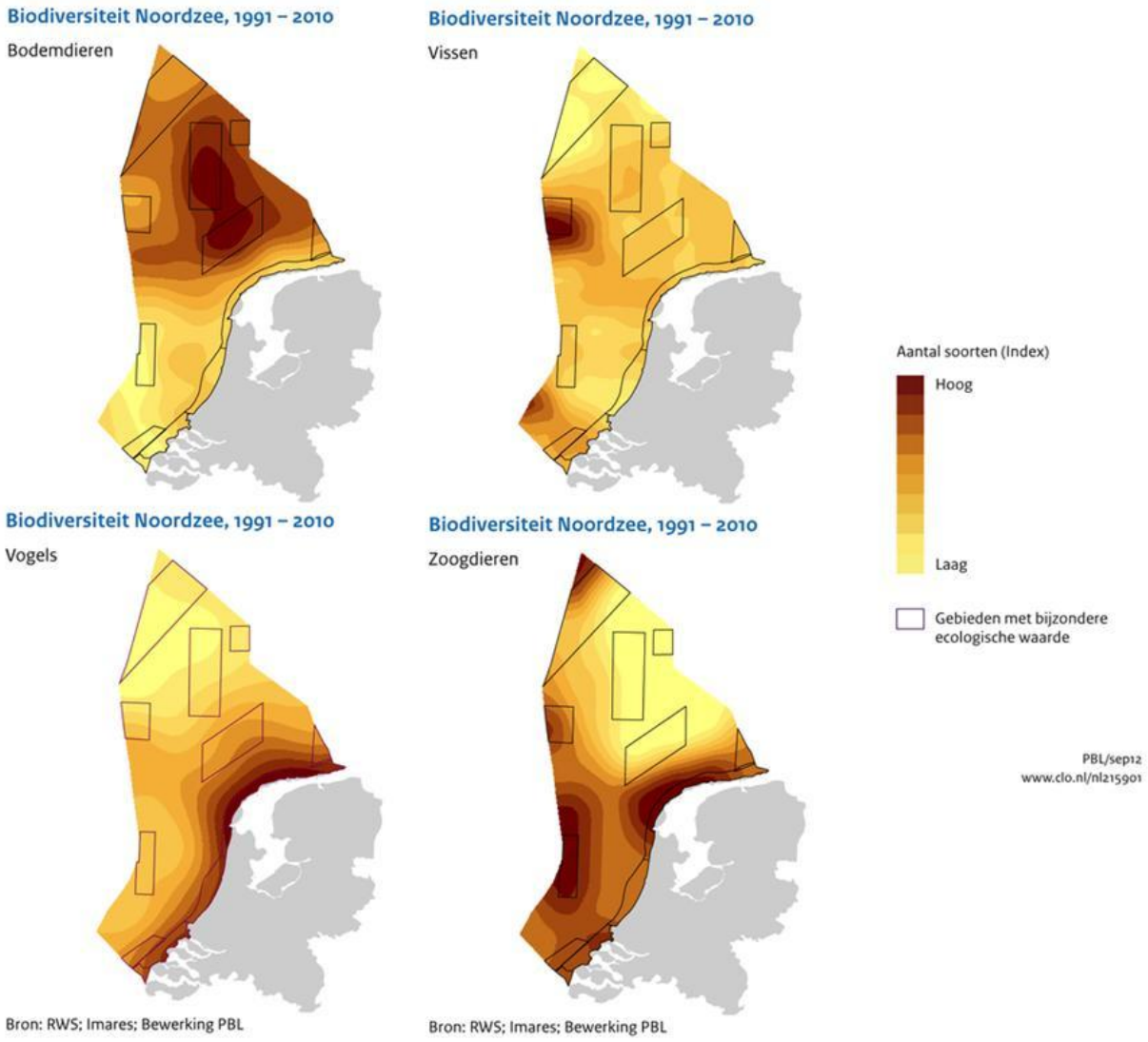
Op basis van de voorgaande beschrijving kan aangegeven worden dat in het Noordzee ecosysteem verschillende beschermde en belangwekkende soorten voorkomen. Voor veel pelagische soorten geldt, dat er vrij homogene verspreiding is, maar ook komen er hotspots voor (zie figuur 4-19). Dat geldt zeker ook voor benthische soorten. Op basis van de beschik-bare informatie kan met betrekking tot het voorkeurstracé van Neuconnect het volgende worden aangegeven over ecologische hotspots:

- **Benthische hotspots**: vooral op het noordelijk deel van het NCP is een hoge biodiversiteit aan benthos in de vorm van soortenrijkdom, soortendichtheid, totale biomassa en aantallen kwetsbare soorten te vinden. Dit betreft gebieden zoals het Friese Front of de Oestergronden.

- **Vissen hotspots**: voor vissen geldt dat er duidelijke patronen te zien zijn qua verspreiding in ruimte en tijd, met over het algemeen het hoogste aantal soorten in het zuid(west)elijk deel en in het noordelijk deel van de Noordzee.

- **Vogels hotspots**: diverse vogels komen met een verschillende verspreiding in ruimte en tijd voor op het NCP. De hoogste concentraties vogels bevinden zich langs de kust. Ver uit de kust valt vooral het Natura 2000-gebied Friese Front als gebied met hoge vogelwaarden in de zomer en herfst op, het gaat dan vooral om zeekoeten.

- **Zeezoogdieren hotspots:** voor de Bruinvis zijn voor zover bekend geen hotspots gedefinieerd, en het is aan te nemen dat de Bruinvis evenredig op het NCP verspreid is. Er kunnen wel lokale, seizoensgebonden en jaarlijkse verschillen in aantallen en dichtheden zijn. De Gewone en Grijze zeehond zijn vooral in de kustzone te vinden, maar er zijn ook waarnemingen vanuit het hele NCP bekend. De verschillende soorten zeezoogdieren kunnen langs de kabelroute voorkomen.




*Figuur 4-19 Overzicht van biodiversiteit op de Noordzee (1991-2010) en gebieden met een bijzondere ecologische waarde. Linksboven: bodemdieren, rechtsboven: vissen; linksonder: vogels, rechtsonder zoogdieren (www.clo.nl/indicatoren/nl2159). Voor de achterliggende bronnen zie de tekst.*

Ten aanzien van de meer verspreid voorkomende soorten geldt dat de gebieden waar sprake is van weinig beroerde bodems over het algemeen een hoge biodiversiteit hebben. Deze gebieden zijn over het algemeen als beschermde gebieden in de Noordzee aangewezen, hoewel er mogelijk op kleinere schaal nog meer bijzonderheden zijn. Voor deze ecologische beoordeling baseren we ons op de bestaande informatie, aangevuld met het gerichte onderzoek langs het tracé (Orbicon 2019a).

# 5 Gebiedsbescherming - Wet natuurbescherming

## 5.1 Voortoets

De Voortoets beschrijft de relevante Natura 2000-gebieden en de mogelijke impact van het project op de kwalificerende natuurwaarden van het Natura 2000-gebied, en weegt af of (significant) negatieve effecten al dan niet kunnen worden uitgesloten. Kan dat niet, dan is een (uitgebreide) Voortoets of een Passende beoordeling nodig.

### *5.1.1 Relevante Natura 2000-gebieden in Nederland*

De NeuConnect verbinding loopt over een afstand van circa 78 km door het Natura 2000-gebied Friese Front. De kabel loopt 2,3 km ten noorden van het (nog als aan te wijzen als Natura 2000-)gebied Bruine Bank. De Bruine Bank wordt dus niet doorkruist door de kabel, maar mogelijk is in dit gebied sprake van externe werking. Activiteiten op (korte) afstand van een Natura 2000-gebied kunnen kwalificerende soorten in het Natura 2000-gebied verstoren. Ook kunnen kwalificerende soorten vanuit het Natura 2000-gebied gebruik maken van de omgeving en dat gebruik kan door ruimtelijke ontwikkelingen minder mogelijk worden. De Natura 2000-gebieden Friese Front en Bruine Bank worden in deze Voortoets verder beoordeeld.

De dichtstbijzijnde Natura 2000-gebieden, naast de hierboven genoemde, zijn Waddenzee en Duinen Terschelling. Beide gebieden liggen op een afstand van ongeveer 45 km van de NeuConnect kabel. Gezien de grote afstand is de verwachting dat deze gebieden buiten de invloedszone van de activiteiten in verband met de NeuConnect kabel ligt (zie ook Tabel 2-1). Voor emmissie en depositie van stikstof (NOx) kan sprake zijn van een groter beinvloedingsgebied (zie daarvoor paragraaf 5.1.3).

### *5.1.2 Externe werking op Natura 2000-gebieden buiten de Nederlandse grenzen*

Relevante Natura 2000-gebieden buiten de Nederlandse grenzen zijn 'Borkum Riffgrund' in Duitsland en 'Southern North Sea' in Groot-Brittannië. Daarnaast zijn er gebieden die op een zodanige afstand van het kabeltracé liggen dat niet kan worden uitgesloten dat er een ecologische relatie tussen deze gebieden en het kabeltracé bestaat. Hieronder wordt nader op 'Borkum Riffgrund' en 'Southern North Sea' en overige gebieden ingegaan.

<u>Borkum Riffgrund en Southern North Sea</u>
‘Borkum Riffgrund’ ligt op een afstand van circa 7 km ten zuiden van het kabeltracé. Het gebied is aangewezen voor de Bruinvis, Gewone zeehond, Grijze zeehond en Fint. In het Britse deel van het tracé loopt de kabel door het Natura 2000-gebied ‘Southern North Sea’. Het gebied grenst daarmee direct aan de Nederlandse Noordzeegrens. ‘Southern North Sea’ is aangewezen voor de Bruinvis. In de Britse en Duitse beoordeling worden deze Natura 2000-gebieden behandeld. In deze beoordeling wordt alleen erop ingegaan of activiteiten in het Nederlandse deel van het tracé een invloed hebben op de instandhoudingsdoelen van 'Borkum Riffgrund' en 'Southern North Sea'.

Enerzijds kan verstoring optreden wanneer activiteiten buiten de Natura 2000-gebieden worden uitgevoerd maar door de uitstraling van effecten van deze activiteiten kwalificerende soorten in

de Natura 2000-gebieden worden verstoord. Anderzijds kan verstoring optreden wanneer kwalificerende soorten vanuit de Natura 2000-gebieden gebruik maken van de omgeving en dat gebruik door de effecten van activiteiten minder mogelijk wordt. Uit paragraaf 6 blijkt dat door onderwatergeluid tijdens de aanleg- en buitenbedrijfstellingsfase en door elektromagnetische straling tijdens de exploitatiefase mogelijk een (klein) negatief effect kan optreden op zeezoogdieren en vissen. Deze effecten zijn daarom ook relevant voor een mogelijke invloed op de instandhoudingsdoelen van de Natura 2000-gebieden. Voor een nadere beschrijving van deze effecten verwijzen we naar paragraaf 6. Hieronder wordt apart op de verschillende vormen van verstoring ingegaan.

*Verstoring door activiteiten buiten Natura 2000-gebieden*
Gezien de grote effectafstanden die het opruimen van NGE kan veroorzaken, kan een (incidentele en tijdelijke) invloed op de instandhoudinsdoelen van de Natura 2000-gebieden ‘Borkum Riffgrund’ en ‘Southern North Sea’ optreden. Ten aanzien van effecten op zeezoogdieren door het opruimen van NGE worden maatregelen genomen en voorschriften gevolgd. Een deel van deze maatregelen is ook van toepassing op vissen en daarom ook op de Fint. Gelet op deze voorzorgsmaatregelen en het zeer geringe risico dat NGE moeten worden opgeruimd, wordt echter niet verwacht dat de instandhoudingsdoelen van de Natura 2000 – gebieden ‘Borkum Riffgrund’ en ‘Southern North Sea’ in gevaar worden gebracht.

*Verstoring door het gebruik van de kabelzone door soorten vanuit Natura 2000-gebieden*
Gezien de mobiliteit van zeezoogdieren en vissen en de kleine afstand is het mogelijk dat er een ecologische relatie tussen de zone van de kabelroute en de aangewezen soorten van de Natura 2000-gebieden bestaat. Vergeleken met de Natura 2000-gebieden wordt verwacht dat de zone van het kabeltracé in het Nederlandse deel van het tracé van ondergeschikt belang voor de aangewezen soorten zijn. Het is wel mogelijk dat Bruinvis, zeehonden en de Fint sporadisch gebruik van het kabelzone maken. Daardoor zijn ook effecten met een minder grote uitstraling relevant. Het gaat hier om onderwatergeluid tijdens de aanleg- en buitenbedrijfstellingsfase en door elektromagnetische straling tijdens de exploitatiefase.

Ten aanzien van geluid dat ontstaat door schepen en apparatuur en door geofysisch onderzoek zullen effecten door onderwatergeluid naar verwachting niet leiden tot een wijziging van de referentiesituatie voor zeezoogdieren. Zekerheidshalve worden wel voorzorgsmaatregelen getroffen (zie Box 2, paragraaf 6). Zoals eerder beschreven dienen ook maatregelen te worden genomen en voorschriften te worden gevolgd ten aanzien van effecten op zeezoogdieren door het opruimen van NGE. Een deel van deze maatregelen is ook van toepassing op vissen en daarom ook op de Fint. Gelet op deze maatregelen, de kortdurende, lokale en voorbij-gaande aard van deze activiteiten, het grote verspreidingsgebied en de mobiliteit van de betrokken kwetsbare soorten worden echter geen negatieve effecten op de soorten verwacht waarvoor de Natura 2000-gebieden zijn aangewezen.

Ten aanzien van elektromagnetische straling zullen effecten op vissen en zeezoogdieren minimaal zijn, maar door een leemte in kennis kunnen deze niet volledig worden uitgesloten (zie paragraaf 6). Echter, het gebied waarop elektromagnetische velden mogelijk een effect hebben zal klein zijn en de veldsterkte waaraan zeezoogdieren en/of vissen worden blootgesteld beperkt blijven. Daarom worden geen negatieve effecten verwacht op de populaties zeezoogdieren en finten in 'Borkum Riffgrund' en bruinvissen in ‘Southern North Sea’.

*Overige gebieden*
De Natura 2000-gebieden 'Östliche Deutsche Bucht' en 'Seevogelschutzgebiet Helgoland' in Duitsland liggen op een afstand van <150km tot de kabelroute en zijn aangewezen voor de Jan-van-gent. De soort kan grote afstanden afleggen. Jan-van genten uit Duitse Natura 2000-gebieden kunnen daarom mogelijk gebruik van het NCP als foerageer- en rustgebied maken. Daarnaast is het NCP van groot belang als migratieroute voor zeevogels (Bruinzeel *et al.* 2009). Mogelijk zijn ook deze migrerende vogels afkomstig uit Natura 2000-gebieden. Gezien de grote afstand, de kortdurende, lokale en voorbijgaande aard van de werkzaamheden worden door externe werking geen negatieve effecten op Natura 2000-gebieden in de omgeving van het kabeltracé verwacht. Ook worden geen migratieroutes geblokkeerd (barrièrewerking).

### *5.1.3 Stikstofdepositie*

Een belangrijk aandachtspunt is, of door uitvoering van het voornemen een toename in stikstofdepositie veroorzaakt wordt in Natura 2000-gebieden met voor stikstofdepositie gevoelige habitats. Voor de aanleg van de NeuConnect kabel zijn meerdere schepen nodig, die op- en afvaren gedurende het project. De stikstofdepositie wordt veroorzaakt door de NOx emissie die schepen emitteren. Voor Natura 2000-gebieden die zijn aangewezen ter bescherming van stikstofgevoelige habitattypen kan stikstofdepositie schadelijk zijn. De dichtstbijzijnde voor stikstofdepositie gevoelige habitattypen (zoals 'zilte pionierbegroeiingen', 'schorren en zilte graslanden', 'embryonale duinen', 'grijze duinen', 'vochtige duinvalleien') liggen in de Natura 2000-gebieden Waddenzee (circa 45km), Duinen Terschelling (circa 45km), Duinen Ameland (circa 55km), Duinen Vlieland (circa 55km) en Noordzeekustzone (circa 60km). In op de Noordzee aangewezen Natura 2000-gebieden liggen geen voor stikstofdepositie gevoelige habitats.

De vraag is of de aanleg van Neuconnect leidt tot stikstofdepositie op genoemde natuurgebieden op de eilanden en het vasteland. Buiten de Natura 2000-gebieden geldt uiteraard ook dat stikstofdepositie relevant kan zijn voor habitats die gevoelig zijn voor vermesting en daarmee stikstofdepositie. Om deze vraag te kunnen beantwoorden is een berekening uitgevoerd van de emissie en de depositie met het AERIUS-model (www.aerius.nl; Voets 2021a&b).

In 2019 zijn de eerste berekeningen voor de stikstofemissie en -depositie uitgevoerd. Omdat op dat moment nog niet gespecificeerd was hoe de kabel aangelegd zou worden, is aanvankelijk uitgegaan van een worst-case situatie. In de loop van 2020 is nadere informatie beschikbaar gekomen over o.a. de in te zetten schepen, te verplaatsen zandvolumes, aanlegduur e.d. Aan de hand daarvan zijn in een iteratief proces vier uitvoeringsvarianten opgesteld die verschillen in o.a. de in te zetten schepen, uitvalsbasis (haven) e.d. Deze varianten zijn doorgerekend door Ingenia (Voets 2021a). Op basis van deze emmissie-analyses en AERIUS-berekeningen (met toepassing van de meest recente modellen), is een nadere beoordeling uitgevoerd van de stikstofeffecten van het project (Bijkerk *et al.* 2021, Voets 2021a&b). Hieronder wordt nader ingegaan op de resultaten daarvan.

**Uitgebreide voortoets Stikstofdepositie (Bijkerk *et al.* 2021)**
Voor de berekening van stikstofemissies door de NeuConnect kabel is een onderscheid gemaakt tussen de aanlegfase en de exploitatiefase. Voor meer details, incl. ruimtelijke beelden van de depositie, verwijzen wij naar Bijkerk *et al.* (2021).

*Aanlegfase*
Om stikstofeffecten in de aanlegfase van de NeuConnect kabel te bepalen zijn in het iteratief proces vier uitvoeringsvarianten beschouwd (Voets 2021a), waarbij de variant met de laagste stikstofemissie (1C) is gekozen als voorkeursvariant en gebruikt voor de verdere depositie analyse door Bijkerk *et al.* (2021).

De totale stikstofemissie van de aanleg (variant 1C) bedraagt volgens de berekeningen van Voets (2021a) 162.148 kg NOx. Uit de AERIUS-berekening hiervan volgt dat er sprake is van een projectdepositie van meer dan 0,00 mol N/ha/jr in 129 Natura 2000-gebieden met stikstofgevoelige habitattypen of leefgebieden. In veel van die gebieden wordt als gevolg van een hoge achtergronddepositie de Kritische Depositie Waarde (KDW) voor habitattypen en leefgebieden reeds overschreden. Bijkerk *et al*. (2021) hebben een gedetailleerde kwantificering gemaakt van deze depositie, tot op hexagoon niveau (tabel 5-1). Uit deze analyse blijkt, dat deze tijdelijke depositie (één jaar) uiteenloopt van minimaal 0,008 mol N/ha/jaar tot maximaal 0,091 mol N/ha/jaar. Om de verhoudingen aan te geven, dit betreft 0,000% tot 0,01% van de achtergronddepositie is. Een depositie van <0,1 mol/ha gedurende max 1 jaar komt neer op eenmalig <1,4 gr N per ha.

De depositie van stikstof door het project op de hiervoor gevoelige Natura 2000-habitattypen en -leefgebieden is nergens hoger dan 0,09 mol N/ha terwijl de doorlooptijd van het project niet langer duurt dan één jaar. Het project valt daarmee onder de mobiele werktuigenbenadering.

Bijkerk *et al.* (2021) concluderen het volgende:

- de aanleg van de kabel leidt niet tot verandering in omvang en ruimtelijke spreiding van de depositiedeken ten gevolge van de gebruikte mobiele werktuigen;
- de depositie ten gevolge van de aanleg van de kabel dusdanig gering en kortdurend is dat een effect op stikstofgevoelige habitattypen en leefgebieden van dit project niet is te duiden
- significant negatieve effecten op deze habitattypen en leefgebieden zijn uitgesloten vanwege inzet van mobiele werktuigen met een maximale depositie van 0,09 mol N/ha over een tijdspanne van minder dan een jaar.

Op grond van bovenstaande kan geconcludeerd worden dat de uitstoot en depositie van stikstof als gevolg van zowel de exploitatie- als de aanlegfase van de NeuConnect-kabel noch leidt tot de verplichting om een passende beoordeling te maken noch tot een vergunningplicht op grond van de Wet Natuurbescherming.

*Tabel 5-1. Het aantal Natura 2000-gebieden, het aantal hexagonen, en het aantal habitattypen en leefgebieden en hun oppervlakte waarop de projectdepositie tijdens de aanlegfase kleiner is dan 0,1 mol N/ha/jr. [1)] Varianten van habitat(sub)typen zijn afzonderlijk geteld. [2)] De oppervlakte is gecorrigeerd voor de gemiddelde bedekking per habitattype binnen een Natura 2000-gebied (Bijkerk et al. 2021).*

| | **>0,00 – <0,1 mol N/ha/jr** |
|---|---|
| Aantal Natura 2000-gebieden | 129 |
| Aantal hexagonen | 252.600 |

| | |
|---|---|
| Aantal habitat(sub)typen 1) | 71 |
| Aantal leefgebieden | 14 |
| Oppervlakte habitattypen en leefgebieden (ha) 2) | 171.841 |

Ten aanzien van gebieden in de NNN geldt, dat ook die te maken hebben met de deken aan depositie die aan de orde is. Deze is vergelijkbaar met de depositie op Natura 2000-gebieden, aangezien de depositie door Bijkerk *et al.* (2021) voor heel Nederland inzichtelijk is gemaakt.

*Exploitatiefase*
Voor de berekening van de stikstofdepositie tijdens de exploitatiefase van NeuConnect is uitgegaan van de eventueel uitgevoerde, jaarlijkse controles. De jaarlijkse controles leveren op geen enkel stikstofgevoelig habitattype een depositie van meer dan 0,00 mol N/ha/jr op (Voets 2021b). Significant negatieve effecten op stikstofgevoelige habitattypen en leefgebieden in Natura 2000-gebieden in Nederland als gevolg van de exploitatiefase van Neuconnect zijn daarom uit te sluiten. Dit geldt ook voor gebieden in de NNN.

Ten aanzien van onverwachte calamiteiten geldt dat deze vergelijkbaar of lager zijn dan die in de aanlegfase. Aangezien niet bekend is of en wanneer calamiteiten zich voordoen in de toekomst, wat de regelgeving op dat moment is, en de inzet van schepen met lagere emissies verwacht wordt, worden ook hiervan geen significant negatieve effecten op stikstofgevoelige habitattypen en leefgebieden in Natura 2000-gebieden verwacht.

### *5.1.4 Kwalificerende natuurwaarden per Natura 2000-gebied*

Het Friese Front is aangewezen als Natura 2000-gebied met een instandhoudingsdoelstelling voor de Zeekoet. Het gebied heeft een bijzondere functie tijdens een belangrijk deel van de levenscyclus van de Zeekoet: ruiende ouderdieren trekken aan het eind van de zomer zwemmend met hun nog niet vliegvlugge jongen van broedgebied in Groot-Brittannië naar het Friese Front (zie ook 4.3.1).

De Bruine Bank is een kandidaat Natura 2000-gebied onder de Vogelrichtlijn, vanwege het belang van het gebied voor de vogelsoorten Zeekoet en Alk (zie ook 4.3.2). Deze zeevogels gebruiken het gebied voor de rui van winterkleed naar zomerkleed en als foerageergebied om een goede conditie op te bouwen voorafgaand aan de trek naar de broedgebieden. Beide soorten zeevogels voldoen aan het criterium van de 1% norm[2], wat inhoudt dat de soort geregeld voorkomt in aantallen gelijk of groter dan 1% van de relevante biografische populatie (Leopold & Van der Wal 2015).

### *5.1.5 Mogelijke effecten op instandhoudingsdoelen*

De voorgenomen activiteit betreft de aanlegfase, de exploitatiefase en de eventuele toekomstige buitenbedrijfstelling van een hoogspanningsgelijk-stroomverbinding, waarmee energie zal worden overgedragen tussen de transportsystemen van Groot-Brittannië en Duitsland (zie voor meer details H-2).

[2] De 1%-norm is een international norm voor het aanwijzen van voor watervogels belangrijke wetlands (Ramsar Concentie, 1971). Wanneer 1% van een biogegrafische populatie geregeld van een gebied gebruikt maakt, kwalificeert dit gebied zich als internationaal belangrijke wetland.

Mogelijk optredende soorten van effecten als gevolg van kabelaanlegwerkzaamheden zijn beschreven in hoofdstuk 2 (Tabel 2-1) en kunnen worden ingedeeld in effecten boven water (fysieke aanwezigheid van schepen in de aanlegfase en in buitenbedrijfstellingfase, eventueel met verlichting) en effecten in de waterkolom (waar de kabel wordt neergelaten, met onderwatergeluid van varende schepen, verontreiniging en vertroebeling van het lokaal omwoelen van de zeebodem). Deze Voortoets richt zich op de instandhoudingsdoelen Natura 2000, in het bijzonder die voor de Zeekoet (Friese Front, Bruine Bank) en de Alk (Bruine Bank).

*Invloedszone*
Naast de locatie van Natura 2000-gebieden ten opzichte van het kabeltracé houdt de beoordeling van de effecten rekening met de invloedszone van de mogelijke effecten, die door de aanleg van de kabel kunnen ontstaan (zie Tabel 2-1). De NeuConnect kabel is ongeveer 720 km lang, en loopt over een afstand van ongeveer 265 km door de Nederlandse EEZ. De kabel loopt over een afstand van 78 km door het Friese Front en op een afstand van 2,3 km langs de Bruine Bank. De ruimtelijke impact van het project is relatief klein (ondanks de lengte van het traject), aangezien de kabel zelf betrekkelijk smal is.

Het kabeltracé loopt door het midden/zuidelijk deel van het Natura 2000-gebied Friese Front. Directe effecten (zoals fysieke aanwezigheid vaartuigen, habitatverstoring, introductie van hard substraat e.d.) zullen binnen de directe invloedzone van het kabeltracé optreden. De kabel loopt daarnaast op 2,3 km ten noorden van de Bruine Bank. Dit (kandidaat) Natura 2000-gebied bevindt zich buiten de invloedzone van het project voor effecten als fysieke verstoring en aanvaringsrisico (visuele en/of akoestische verstoring door vaartuigen heeft een maximale invloedzone van 200 – 1.000 m; zie Tabel 2-1), maar het gebied bevindt zich binnen de invloedzone van het project voor een effect als verontreiniging (potentiële invloedzone 10 km voor (onopzettelijke) lekkage en dispersie van verontreinigde stoffen).

**Beoordeling instandhoudingsdoelstelling Zeekoet en Alk**
Bij de Voortoets wordt rekening gehouden met het feit of een soort gevoelig is of niet voor de te verwachten soort effecten.

De Zeekoet brengt een belangrijk en kwetsbaar deel van de levenscyclus door in het Friese Front. Het gaat dan vooral om de zomer (juli, augustus en september). In deze periode wordt het Friese Front gebruikt door zeekoeten en hun jongen als foerageergebied en als rust- en ruigebied. De soort is in zekere mate gevoelig voor verstoring door geluid, licht en visuele verstoring als gevolg van de fysieke aanwezigheid van schepen. Dit kan in potentie resulteren in (tijdelijk) verlies van habitat. Tevens is er kans op kwaliteitsverlies van het habitat door vertroebeling in de waterkolom en veranderingen in aanwezigheid van prooidieren door de kabelaanlegwerkzaamheden, evenals vervuiling door (onopzettelijke) lekkage van verontreinigende stoffen (drijvende olie, vet of chemicaliën). Gezien echter het tijdelijke karakter van de werkzaamheden (werksnelheid 0,5-3 km per dag) en de kortdurende impact op de waterkolom verwachten we geen zodanige effecten door vertroebeling, verontreiniging en veranderingen in aanwezigheid van prooidieren (zie ook hoofdstuk 6), dat dit doorwerkt op de kwaliteit van het gebied voor zeekoeten. De gevoeligheid van de Zeekoet en de fysieke aanwezigheid van schepen in de voor zeekoeten kwetsbare periode – wanneer ze niet kunnen vliegen – kan mogelijk wel tot verstoring leiden. Daardoor kunnen (significant) negatieve effecten niet op voorhand worden uitgesloten.

De Alk is evenals de Zeekoet in zekere mate gevoelig voor verstoring door geluid, licht en visuele verstoring als gevolg van fysieke aanwezigheid van schepen. Echter deze effecten

liggen, zoals hierboven beschreven, buiten de invloedzone (200 – 1.000 m) van het project. Indien alken vanuit het Natura 2000-gebied Bruine Bank gebruik maken van het gebied langs het kabeltracé en dat gebruik door effecten in verband met de kabel minder mogelijk wordt, kan er in principe sprake zijn van externe werking. Anders dan de Zeekoet bevindt de Alk zich tijdens de kwetsbare ruiperiode echter niet in Nederland (Leopold & van der Wal 2015). Indien er overlap in ruimte en tijd bestaat tussen de werkzaamheden en de aanwezigheid van alken uit het Natura 2000-gebied Bruine Bank, is de soort mobiel genoeg om te vluchten. Ook zijn de werkzaamheden kortdurend en lokaal waardoor mogelijk verstoorde alken naar het gebied terug kunnen keren wanneer de werkzaamheden klaar zijn. Door een eventuele verstoring worden daarom geen negatieve effecten verwacht op alken afkomstig uit het Natura 2000-gebied Bruine Bank.

Alken kunnen wel in aanraking komen met verontreinigende stoffen afkomstig van werkzaamheden aan het kabeltracé, omdat de Bruine Bank binnen de invloedzone (van 10 km) valt. Echter, er zijn geen negatieve effecten te verwachten omdat de kabelaanlegwerkzaamheden tijdelijk en lokaal van aard zijn, de schepen slechts gedurende een korte periode in de buurt aanwezig zullen zijn en de kans heel klein wordt geacht dat een werkschip onopzettelijk verontreinigende stoffen lekt.

### *5.1.6 Conclusie Voortoets*

Voor het Natura 2000-gebied Friese Front is een instandhoudingsdoel bepaald voor de Zeekoet. Het betreft een voor verstoring gevoelige zeevogel. Zonder het nemen van mitigerende maatregelen kan niet op voorhand worden uitgesloten dat er (significant) negatieve effecten optreden door de aanwezigheid van werkschepen in de kwetsbare periode voor de soort. Hiervoor is derhalve een Passende beoordeling nodig (5.2).

Voor het nog als Natura 2000-gebied aan te wijzen Bruine Bank zijn de Alk en Zeekoet kwalificerende soorten. Omdat het gebied 2,3 km bij de kabel vandaan ligt valt het buiten de invloedzone voor effecten als visuele en/of akoestische verstoring door vaartuigen. Het gebied valt wel binnen de invloedzone als het gaat om de dispersie van onopzettelijke lekkage van verontreinigende stoffen, maar de kans wordt heel klein geacht dat deze lekkage plaatsvindt, waarbij de schepen bovendien maar gedurende een korte periode en lokaal aanwezig zullen zijn. Er worden daarom geen negatieve effecten verwacht op de kwalificerende soorten Alk en Zeekoet. Daarmee wordt met een hoge mate van ecologische zekerheid vastgesteld dat geen negatieve effecten zullen optreden op de kwalificerende soorten Alk en Zeekoet en bestaat geen aanleiding om de Bruine Bank passend te beoordelen.

Ten aanzien van de mogelijke externe werking van de depositie van stikstof is geconstateerd op basis van een AERIUS berekening, dat er sprake is van de aanvullende depositie van NOx als gevolg van Neuconnect op voor stikstofgevoelige habitats in Natura 2000-gebieden in Nederland. Een nadere analyse laat zien, dat de additionele depositie zowel absoluut als in vergelijking tot de jaarlijkse achtergronddepositie zo weinig is (eenmalig <0,1 mol/ha), dat ecologische effecten hiervan onmogelijk zijn te duiden. Wij concluderen op basis hiervan, dat geen vergunning nodig is. Hetzelfde geldt voor de exploitatiefase in de vorm van jaarlijkse controles, die niet leidt tot aanvullende depositie op stikstofgevoelige habitats.

## 5.2 Passende beoordeling instandhoudingsdoelen Friese Front

(Significante) negatieve effecten op het instandhoudingsdoel voor de Zeekoet voor het Friese Front kunnen niet op voorhand worden uitgesloten. Dit betreft met in bijzonder effecten als gevolg van verstoring door fysieke aanwezigheid van werkschepen. Effecten van kwaliteitsverlies van het habitat (door vertroebeling in de waterkolom en veranderingen in aanwezigheid van prooidieren), of vervuiling door (onopzettelijke) lekkage van verontreinigende stoffen (drijvende olie, vet of chemicaliën) worden niet als zodanig ingeschat, maar hier voor de volledigheid wel meegenomen. De focus ligt op de instandhoudingdoelen.

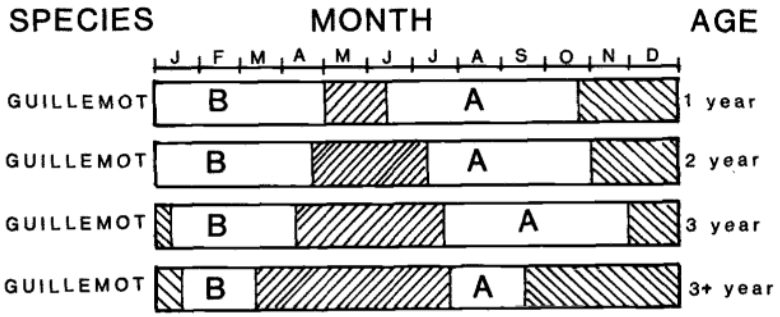
**Instandhoudingsdoel Friese Front**
Voor het Natura 2000-gebied Friese Front is de Zeekoet als niet-broedvogel aangewezen. Er zijn geen instandhoudingsdoelstellingen aangewezen voor habitattypen, habitatsoorten en/of broedvogels en deze kenmerken worden in dit hoofdstuk dan ook niet verder behandeld.

De instandhoudingsdoelstelling voor de Zeekoet houdt in dat de omvang en kwaliteit van het leefgebied behouden moeten blijven voor behoud van de populatie. Er is (nog) geen populatieaantal aan de populatiedoelstelling toegevoegd, omdat de data hiervoor nog onvoldoende consistent zijn (Aanwijzingsbesluit Natura 2000 Friese Front, Didderen *et al*. 2017). De huidige staat van instandhouding van de Zeekoet is gunstig (synbiosys.alterra.nl; www.sovon.nl). Op het moment van schrijven van dit rapport is een beheerplan Natura 2000, waarin de instandhoudingsdoelen verder worden uitgewerkt, voor het Friese Front in opstelling.

*Ecologie Zeekoet*
De Zeekoet (*Uria aalge*) behoort tot de familie van de Alken (Alcidae) en is een echte zeegebonden soort, die alleen aan land komt om te broeden (maart-juli). Het is een trekvogel zonder vaste migratieroutes, die van broedplekken naar omliggende zeeën trekt buiten het broedseizoen (augustus-februari) (Furness 2015). Op de Noordzee kunnen Zeekoeten overal voorkomen, op open zee en in de kustwateren, de soort stelt weinig eisen aan het mariene leefgebied.

De vogels broeden in kolonies op kliffen, zoals aan de oostkust van Groot-Brittannië. Het Schotse eiland Isle of May (Scottish Natural Heritage National Nature Reserve) is een bekende plek waar Zeekoeten broeden en worden geobserveerd. Nederland behoort niet tot het broedgebied. Na het broedseizoen zwemmen Zeekoetmannetjes eind juni, begin juli met hun jongen (die nog niet kunnen vliegen) vanuit de kolonies (veelal Britse en Ierse, van de noordoostkust van Schotland) naar zee, waaronder het gebied Friese Front, om te foerageren. Het vrouwtje van de Zeekoet volgt enkele weken later (Harris & Wanless 1990). Kort na vertrek van de broedplek ondergaan de volwassen vogels een complete rui ('post-breeding'), waarbij de vogels voor een bepaalde periode de capaciteit verliezen om te vliegen. Het gaat om een complete rui, die eind juli begint en waarbij de vogels 45-50 dagen niet in staat zijn om te vliegen (BWPi 2006). Deze periode duurt derhalve van eind juli tot en met september.

De donkerbruine, zwarte veren in de nek en op de kop (typisch voor het zomer- of broedkleed) worden vervangen door witte veren (ofwel winterkleed). Aan het eind van de winter, of aan het begin van de lente is er een verdere gedeeltelijke rui ('pre-breeding'), waarbij de kop en de nek donker worden en de vogels hun broedkleed krijgen (Harris & Wanless 1990). Figuur 5-1 geeft een tijdlijn met een inschatting van de duur van de rui van zomer- of winterkleed. De duur van de periode in zomerkleed neemt toe naarmate de vogels ouder worden; de rui vindt derhalve in een kortere periode plaats (Harris & Wanless 1990, Birkhead & Taylor 1977).




*Figuur 5-1 Tijdstip van het hebben van een verenkleed (gearceerd vlak) en de rui (A = rui nà de broedperiode, B = rui voor de broedperiode). Guillemot = Zeekoet. Uit (Harris & Wanless 1990). Zie de tekst voor toelichting.*

De vogels zijn tijdens de maanden juli, augustus en september extra gevoelig voor verstoring, omdat ze tijdens de slagpenrui niet kunnen vliegen. Zeekoeten kunnen echter wel snel zwemmen en spreiden zich uit van kolonies bij de kust naar gebieden verder op zee, zodanig dat ze in lage dichtheden over grote gebieden te vinden zijn (Camphuysen 2002; zie voor verspreiding Figuur 4-4).

Zeekoeten zijn duikend jagende zeevogels (net als pinguïns), hetgeen ze voornamelijk overdag doen tot een maximum diepte van 170-230 m (Birdlife International 2019). Ze spotten daarbij hun prooi door herhaaldelijk hun kop in het water te steken (dompelen), voordat ze in het oppervlak gaan duiken (BWPi 2006). Scholende pelagische vissen, zoals Horsmakreel (*Trachurus trachurus*) en Sprot (*Sprattus sprattus*) vormen de belangrijkste voedselbron, echter benthische soorten, inktvis en incidenteel platvis kunnen ook op het menu staan (Camphuysen & Leopold 1994; Birdlife International 2019a). In het broedseizoen voeren Zeekoeten hun jongen in de kolonies vooral kleine haringachtigen en zandspieringen. Het is bekend van gezenderde Zeekoeten die op Isle of May broeden dat de meeste foerageerbewegingen (zowel zelfvoedend als voor het jong op het nest) plaatsvinden binnen een straal van 30 km van de kolonie (Thaxter *et al.* 2009). Tijdens het broedseizoen wordt het Friese Front dus niet door deze broedvogels gebruikt om te foerageren (omdat de broedlocaties enkele honderden km van het Friese Front verwijderd zijn). Het is voor het broedsucces van belang dat er voldoende vette prooivissen beschikbaar zijn. Als deze in onvoldoende mate rond de kolonies beschikbaar zijn, of als het vetgehalte van de geprefereerde prooivissen tijdens het broedseizoen te laag is, mislukt het broedseizoen (Profieldocument Zeekoet, 2014).

Nadat de kuikens de kolonie hebben verlaten krijgen ze op zee, op het Friese Front, ook veel kleine horsmakreel gevoerd. In het niet-broedseizoen worden er verschillende prooisoorten gegeten (minimaal 25 soorten vis), wat maakt dat Zeekoeten niet langer afhankelijk zijn van een of enkele prooisoorten. In de winter kan langdurig stormachtig weer resulteren in grootschalige sterfte (zogeheten *wrecks*) onder de Zeekoeten, hetgeen een relatief normaal fenomeen is en eens in de zoveel tijd plaatsvindt, zoals recent in de winter 2018/19 (Camphuysen 2019; Profieldocument Zeekoet, 2014).

**Effectbepaling en -beoordeling**

Hierna worden per projectfase de geconstateerde relevante storingsfactoren beschreven, waarbij is uitgegaan van een worst case situatie. Daarna wordt getoetst of de storingsfactoren (significant) negatieve effecten kunnen hebben op de instandhoudingsdoelstelling van het Natura 2000-gebied Friese Front. Eventueel cumulerende effecten komen in 5.3 ter sprake.

## AANLEGFASE EN BUITENBEDRIJFSTELLING

Wat betreft werkzaamheden voor de kabelaanleg en buitenbedrijfstelling kunnen (scheepvaart)activiteiten aan het wateroppervlak en in de waterkolom leiden tot verstoring van vogels. De verstoring zal afhankelijk zijn van de duur en locatie, en van de aanwezigheid van de vogels ter plaatse en wordt hierna nader gespecificeerd. Directe verstoring van bodemhabitat of verlies hiervan is niet relevant voor de beoordeling van effecten op de Zeekoet. Het gaat wel om de volgende typen verstoring:

***Fysieke verstoring***

Visuele en/of akoestische verstoring door vaartuigen kan optreden door de aanwezigheid van schepen die actief zijn in de aanlegfase en tijdens de buitenbedrijfstelling. Hierdoor kunnen de zeekoeten uit een bepaald gebied worden verdreven, hetgeen tijdelijk verlies van habitat betekent tijdens de periode van verstoring. Deze verstoring moet worden gezien in de context van bestaande bronnen van verstoring, zoals scheepvaart en visserij in het gebied.

Het bestaand gebruik van het Friese Front is beschreven in H-4, en houdt in dat er veel wordt gevist, en dat er veel schepen varen omdat er scheepvaartinfrastructuur door het gebied loopt (Fig 4-1), evenals bestaande kabels en leidingen. Ruim een derde van het gebied ligt in militair oefenterrein en er staan ook platforms voor olie- en gaswinning. Het kabeltracé loopt door een deel van het Friese Front waar in de huidige situatie relatief weinig scheepvaartroutes aanwezig zijn. In dit deel van het Friese Front is de mate van fysieke verstoring daarom relatief gering. Dit gebied wordt daarom in de huidige situatie als geschikt geacht voor zeekoeten. In verband met de aanleg van de NeuConnect kabel zullen er tijdelijk zes schepen op het Friese Front aanwezig zijn. Dit is een beperkte toename van fysieke verstoring ten opzichte van de huidige situatie (visserij, scheepvaartroutes).

In de periode juli-september komen er in het projectgebied ruiende adulte vogels en niet-vliegvlugge jonge Zeekoeten voor, die extra kwetsbaar zijn omdat ze niet kunnen wegvliegen bij verstoring. Volgens Jongbloed *et al.* (2010) hebben de meeste vogelsoorten op groot open water een verstoringsafstand van 500 m, die voldoende zekerheid biedt tegen verstoring door varende objecten op het water. Ook metingen aan Zwarte zee-eenden op de Noordzee (pers. observatie M. Sikkema, A&W 2019) laten een opvliegafstand van gemiddeld 500 m zien. Echter, uit Mendel *et al. (*2019) blijkt dat duikers bijzonder verstoringsgevoelig zijn en dichtheden in een zone tot 5 km rond schepen significant afnemen. Ook ruiende watervogels zijn extra gevoelig en hebben een verstoringsafstand tot circa 1.500m (Klop 2013).

Het is in principe mogelijk dat de kabelaanlegwerkzaamheden en de aanwezigheid van zeekoeten in ruimte en tijd overlappen. Gezien de lage vaarsnelheid van de werkschepen (20-125 m/uur) is de verwachting dat de zeekoeten en hun niet vliegvlugge jongen de werkschepen zullen ontwijken. Daarom zal er geen barrièrewerking ontstaan. Indien het leggen van de kabels zonder gelijktijdige begraving plaatsvindt kan mogelijk een snelheid van circa 500 m/uur worden gehaald. Een hogere werksnelheid kan ertoe leiden dat zeekoeten worden opgeschrikt wat negatieve energetische effecten kan hebben omdat de vogels moeten opschuiven om geschikt foerageer- en rustgebied te vinden. Deze effecten zijn tijdelijk en lokaal. De vogels kunnen naar het gebied terug wanneer de werkzaamheden klaar zijn (werksnelheid 0,5 tot 3 km per dag). Het aanbod van alternatief geschikt gebied in de directe omgeving is bovendien groot, wat ervoor zorgt dat een mogelijk effect beperkt is. Het deel van het Friese Front dat tijdelijk niet beschikbaar is wordt in Box 1 verder toegelicht.

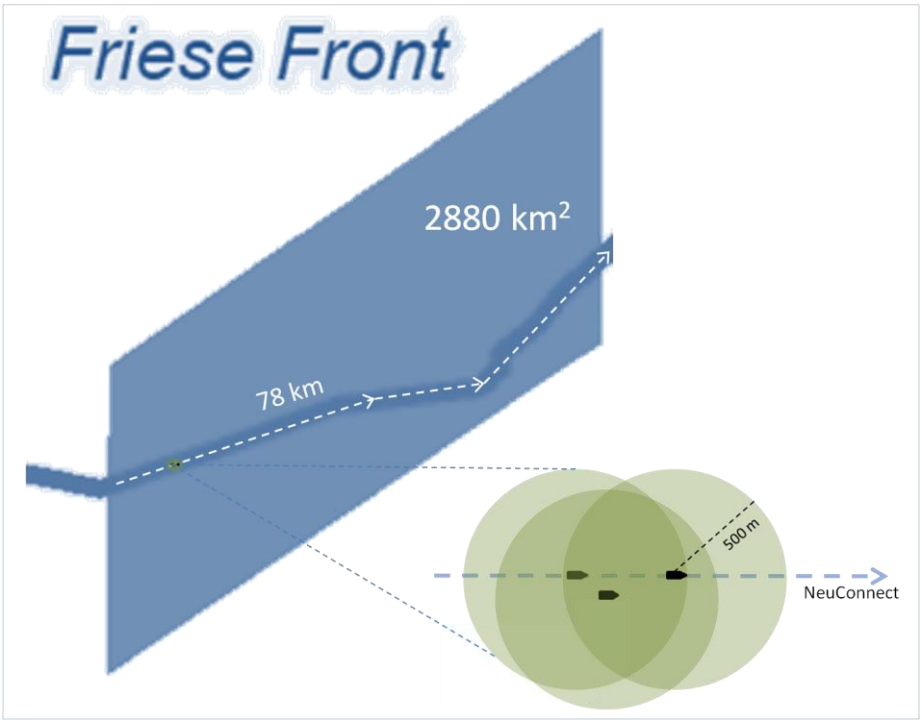
De gegevens uit Box 1 laten zien, dat de verstoringsinvloed van maximaal zes werkschepen bij een verstoringsafstand van 500 m in totaal 0,16% van de oppervlakte van het Friese Front beslaat, en bij 1.500 m 1,5%. Opgemerkt moet worden, dat niet alle zeevogels over die oppervlakten worden verstoord, maar dat  een invloed van verstoring merkbaar is. De verstoring is gradueel en dichtbij de bron maximaal. Bij het bepalen van verstoring is het ook belang rekening te houden met bestaande verstoring als gevolg van bestaand gebruik.

**Box 1. Oppervlakteverlies door aanwezigheid werkschepen**

Het Friese Front heeft een oppervlak van 2.880 km$^2$. De kabel zal over een lengte van 78 km door het gebied gaan. De verwachting is dat er maximaal zes werkschepen (aanleg- en onderhouds-schepen) tegelijkertijd in het gebied aanwezig zijn, en dat deze zich met een snelheid van 0,5 – 3 km per dag (20-125 m/uur) langs het tracé verplaatsen (AECOM). Dit zou betekenen dat de schepen maximaal ongeveer 156 dagen in het gebied aan het werk zijn, en minimaal 26 dagen.

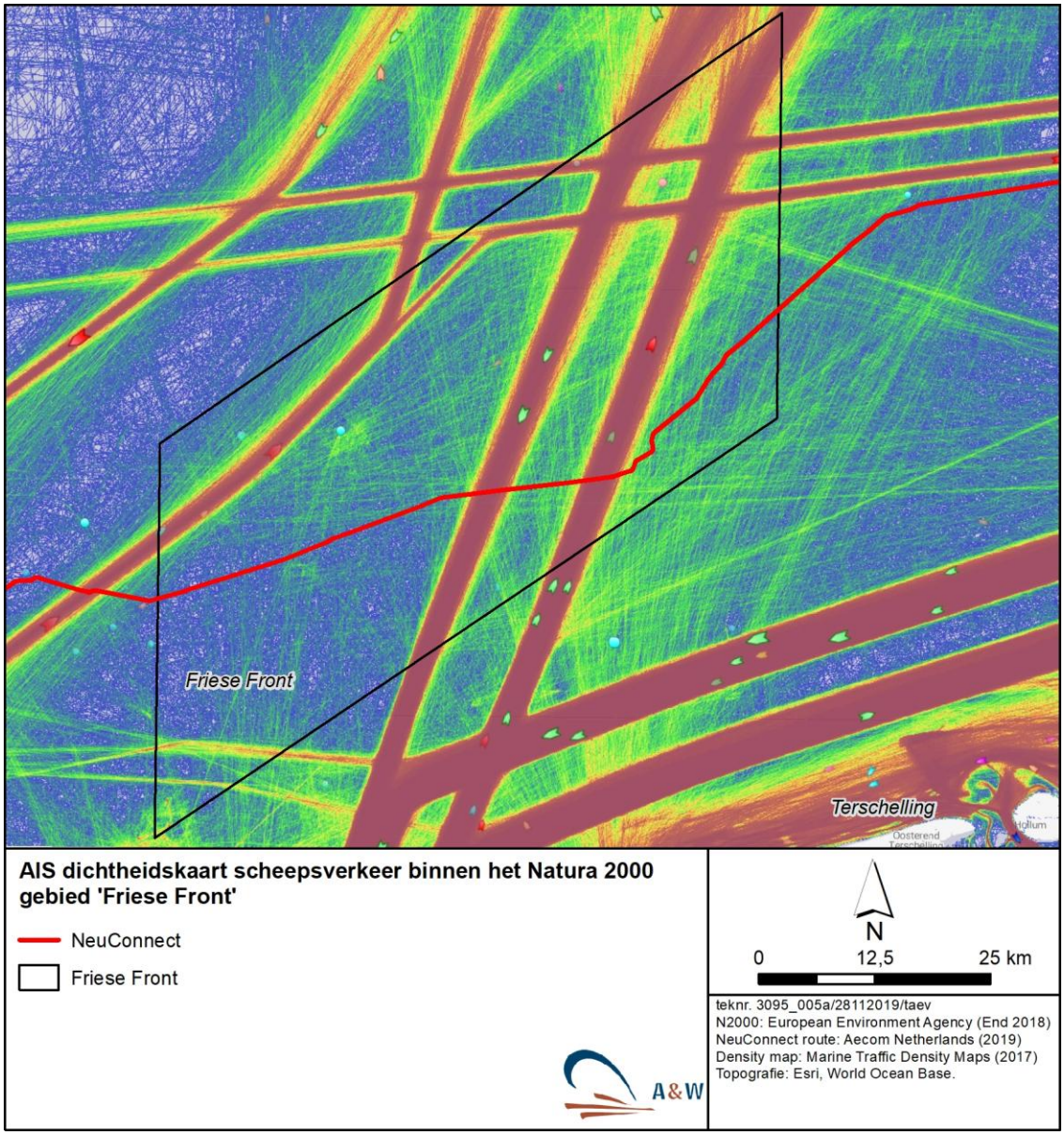
Wanneer er rekening wordt gehouden met een verstoringsafstand van schip tot Zeekoet van 500 m, is er sprake van een verstoord oppervlak van 0,79 km$^2$ rondom een schip. Deze waarde maal zes schepen (van maximale verstoring uitgaande, waarbij de verstoringsbuffers niet over elkaar heen liggen) komt uit op 4,7 km$^2$. Dit is 0,16% van het totale oppervlak van het Friese Front. [In werkelijkheid lager, omdat de verstoringbuffers gedeeltelijk overlappen].

In de ruiperiode is de Zeekoet gevoeliger voor verstoring en wordt een verstoringsafstand van 1.500 m aangehouden. In dit geval is er rond een werkschip een verstoringsbuffer met een oppervlak van 7,1 km$^2$. Wanneer er zes schepen tegelijkertijd aanwezig zijn komt dit neer op 42,4 km$^2$ verstoord oppervlak. Dit is 1,5% van het totale oppervlak van het Friese Front.




*Figuur 5-2 Impressie verstoringsbuffer rondom werkschepen. Weergegeven is het Friese Front, de Neu-Connect kabel en de aanname van max. 6 aanwezige werkschepen, met een uitsnede om de verstoringsbuffer rondom de aanwezige werkschepen te illustreren (in dit geval is rekening gehouden met een verstoringsafstand van 500 m).*

Samenvattend zijn er in het Friese Front minimaal 26 tot maximaal 156 dagen werkschepen aan de slag, afhankelijk van de vaarsnelheid (die wordt geschat op 20-125 m/uur). Deze schepen verstoren een zone van 4,7 km$^2$, die opschuift langs het tracé (0,16% van het oppervlak van het Friese Front), bij een verstoringsafstand van 500 m. Er wordt een - zich langs het tracé verplaatsende- zone van 42,4 km$^2$ verstoord (1,5% van het oppervlak van het Friese Front), bij een verstoringsafstand van 1.500 m.




*Figuur 5-3. Kaartbeeld van scheepvaartbewegingen op 16 juli 2019 om 10.00 uur. De kleine bruine boten zijn vissersschepen, de grote boten horen tot de grotere scheepvaart (paars, groen, rood). Platforms als blauwe cirkels weergegeven, maar niet alle platforms geven locaties door. Achtergrond: dichtheidskaart scheepvaartverkeer. Bron: www.marinetraffic.com.*

Voor de zeekoeten is het relevant, dat ook rekening wordt gehouden met het oppervlak dat autonoom al wordt verstoord door aanwezige boorplatforms en varende schepen (scheepvaart en visserij). Op het Friese Front zijn 11 platforms aanwezig[3] die bij een verstoringsafstand van 1500 m leiden tot een verstoringsoppervlak van 77,7 km$^2$. Op basis van de actuele vaardata geregisteerd via Automatic Identifcation System (AIS) (marinetraffic.com) kan bepaald worden hoeveel schepen ongeveer in het Friese Front varen. Hierbij moet opgemerkt worden dat AIS alleen voor grotere schepen verplicht is (Herrmannsen *et al.* 2019). Echter, omdat het Friese Front ver uit de kust ligt zijn hier ook voornamelijk grote schepen met AIS te verwachten. Dat zijn gemiddeld over de waargenomen dagen (juni, juli 2019) circa 10-15. Bij 15 schepen en eenzelfde verstoringafstand is dat een oppervlak van 106,5 km$^2$.

[3] Op basis van de structuurvisiekaart (zie figuur 3-1). We hebben 1500 m als maximumafstand aangehouden, maar hierbij geen rekening gehouden met helikoptervluchten. Daarvoor ontbreken voldoende kwantitatieve data.

In de autonome situatie is op het Friese Front op enig moment bij aanwezigheid van 15 schepen en 11 platforms derhalve sprake van een oppervlak van 184 $km^2$ (bij een worst case afstand van 1.500 m) waar sprake is van verstoringsinvloed; dat is op 6,4% van de oppervlakte. Bij aanleg van het kabeltracé is die oppervlakte tijdelijk 226 $km^2$, ofwel 8,0% van de oppervlakte (tabel 5-2).

In een worstcase situatie worden de scheepvaartroutes zo druk bevaren, dat de zeekoeten niet terugkeren voor er weer een schip is. Dat is dan het geval op de meest intensief bevaren routes, in bruin te zien op de dichtheidskaart (zie figuur 5-3). Deze zijn 7-8 km breed. In dat geval zouden alle bruine delen permanent onder invloed van verstoring staan. Samen met de platforms (77,8 $km^2$) gaat dat om een oppervlakte van 677,8 $km^2$ ofwel 24,03% onder invloed van verstoring staan. Inclusief de werkschepen van Neuconnect is dat een oppervlak van 25,5%. Nogmaals moet benadrukt worden, dat deze oppervlakte niet geheel verstoord is, maar dat invloed van verstoring merkbaar is.

In de kwetsbare periode voor zeekoeten is derhalve nu al sprake van een relatief groot deel van het Friese Front waar sprake is van een verstoringsinvloed; de relatieve bijdrage daarin van de aanleg van de kabel is beperkt. Dit additionele effect is evenwel goed te vermijden door de kabel niet aan te leggen in de kwetsbare periode.

Voor zeekoeten is specifiek de situatie in het Friese Front van belang in de kwetsbare periode. In het geval van een worstcase situatie (scheepvaartroutes continu verstoord) is in de autonome situatie sprake van een invloed van verstoring over bijna een kwart van het gebied. De tijdelijke extra bijdrage van het project beslaat 42,4 $km^2$ ofwel 1,5% van het Friese Front. Daarbij geldt evenwel, dat de kabel wordt aangelegd in een deel van het Friese Front waar de scheepvaartintensiteit minder hoog is. Hoewel sprake is van een geringe bijdrage aan de verstoring kan er daarmee wel een negatief effect vanuit gaan.

*Tabel 5-2. Oppervlakte onder verstoringsinvloed op het Friese Front door platforms (11), schepen (15 aangehouden op enig moment) of scheepvaartroutes, en de tijdelijke bijdrage daarin van het Neuconnect project. In het winterhalfjaar is hier als overal 500 m verstoringszone aangehouden, ook voor platforms.*

| **Situatie** | **Platforms 11 locaties** | **Scheepvaart Schepen / routes** | **Aanleg Neuconnect max. 6 schepen** | **Totaal** |
|---|---|---|---|---|
| Winterhalfjaar 500 m | 8,6 km2 | 11,8 km2 15 schepen | 4,7 km2 | 25,1 km2 0,9% opp |
| Kwetsbare periode 1.500 m | 77,8 km2 | 106,0 km2 15 schepen | 42,4 km2 | 226 km2 8,0% opp |
| Worst case 1.500 m, scheepvaart-routes verstoord | 77,8 km2 | 600 km2 scheepvaartroutes | 42,4 km2 | 720,1 km2 25,5% opp |

Samenvattend: ‘Significant’ negatieve effecten op de instandhoudingsdoelstelling van de Zeekoet door fysieke verstoring kunnen worden uitgesloten. Reden hiervoor is dat de verstoring door de aanleg van de kabel ten opzichte van de huidige verstoring zeer klein is. Wel is er sprake van een beperkte toename van de verstoring van de Zeekoet. Deze verstoring

kan worden voorkomen door de werkzaamheden in het Friese Front uit te voeren buiten de kwetsbare ruiperiode van de Zeekoet. Deze periode loopt van juli t/m september.

***Onderwatergeluid***

Op het gehele NCP worden regelmatig niet-gesprongen explosieven (NGE) gevonden en tot ontploffing gebracht. Op basis van de risicobeoordeling (1st Line Defence Limited 2018) zijn geen exacte locaties van explosieven vastgesteld. Hoewel in deze fase niet kan worden uitgesloten dat er NGE's langs het kabeltracé aanwezig zijn is het risico dat ontploffingen vereist zijn vooralsnog laag (AECOM 2021). Het is onduidelijk of en hoeveel zeekoeten effecten ondervinden van het tot ontploffing brengen van explosieven. Volgens het Ministerie van Defensie vindt het ruimen van explosieven zo mogelijk buiten Natura 2000-gebieden plaats. In dat geval is er geen direct effect op zeekoeten in het Friese Front. Indien het niet mogelijk is om een explosief te verplaatsen en het vanwege veiligheidsrisicos toch geruimd moet worden, zal dat zoveel mogelijk buiten de periode juli tot en met september geschieden. Daarnaast zal het Ministerie van Defensie (in overleg met de Kustwacht) met Rijkswaterstaat afstemmen of en op welke voorwaarden dat gebeurt.

*'Significante' negatieve effecten op de instandhoudingsdoelstelling van de Zeekoet door onderwatergeluid kunnen daarom worden uitgesloten.*

***Vertroebeling en hersedimentatie***

Verandering in de dynamiek van de zeebodem kan als gevolg van activiteiten in de aanlegfase en buitenbedrijfstelling optreden, voornamelijk bij mechanische activiteiten zoals graafwerkzaamheden. Ter plaatse wordt hierdoor de zeebodem verstoord, waarbij het water vertroebeld wordt. Dit leidt tot een tijdelijke, lokale stijging van de concentratie van zwevende deeltjes. Deze sedimentdeeltjes kunnen zich verspreiden onder de invloed van stroming. Door de relatief zwakke stromingen en getijdenenergie is de kans op veranderingen in sedimenttransportpatronen zeer klein.

In het kader van de Viking-kabel zijn modellen opgesteld om de beweging van verstoord sediment te voorspellen (Intertek 2016). Naar verwachting zijn deze resultaten ook toepasbaar op de aanleg van de NeuConnect kabel. Uit voorzorg wordt een verspreidingsafstand van 0,7 km aangehouden voor zwevend sediment, dat naar verwachting grotendeels in de directe nabijheid van het kabeltracé zal neerslaan. Omdat in het projectgebied over het algemeen zandige habitats aangetroffen zijn (Orbicon 2019a) en zand snel bezinkt is de verwachting dat mogelijke effecten lokaal en kortdurend van aard (gedurende het fysieke werk, en naar verwachting maximaal een aantal uren daarna, paragraaf 2.6) zullen zijn. Hoewel zeekoeten zichtjagers zijn (BWPi 2006) is het niet de verwachting dat daarmee het foerageersucces van de soort wordt beïnvloed. De reden daarvoor is dat gewerkt wordt op een diepte van enkele tientallen meters en omdat zeekoeten niet in de directe omgeving van de schepen foerageren.

Ook is er sprake van een beperkte zone van vertroebeling (zie ook Tabel 2-1) rondom de locatie waar op dat moment gewerkt wordt en deze zone verplaatst zich langs de kabel. De kortdurende vertroebeling heeft naar verwachting geen invloed op de primaire productie, en werkt daardoor niet door op systeemniveau en op prooidieren. Deze vertroebeling is daarmee tijdelijk en lokaal van aard. Doorwerking van deze kortdurende vertroebeling op de aanwezige populatie zeekoeten is daarom niet te verwachten.

*'Significante' negatieve effecten op de instandhoudingsdoelstelling van de Zeekoet door vertroebeling en hersidementatie kunnen daarom worden uitgesloten.*

***Verontreiniging***
Door de aanleg van de NeuConnect kabel bestaat de mogelijkheid dat onopzettelijk vervuilende stoffen vrijkomen, zoals drijvende olie, vet en chemicaliën. Dit kan komen door het lekken van schepen of het vrijkomen van vervuilende stoffen in de sediment (Taormina *et al.* 2018).

Zeekoeten zijn gevoelig voor olievervuiling, des te meer omdat het zeevogels zijn die veel tijd zwemmend op zee doorbrengen, vaak in grote groepen. In het verleden was olievervuiling de belangrijkste doodoorzaak bij Zeekoeten die in Nederland strandden (Camphuysen 2018). In de jaarlijkse rapportage 'Vaststelling van het percentage met olie besmeurde Zeekoeten in Nederland' geeft Camphuysen (2018) aan dat er een sterk dalende trend zichtbaar is in het aantal olieslachtoffers, en dat OSPAR doelstellingen binnen bereik liggen: er wordt nauwelijks nog serieuze olievervuiling op gestrande vogels waargenomen.

De onopzettelijke lekkage van verontreinigende stoffen (drijvende olie, vet of chemicaliën), tijdens aanleg-, onderhouds- en buitenbedrijfstellingswerkzaamheden, kan leiden tot directe effecten omdat de stoffen het verenkleed kunnen aantasten en ervoor zorgen dat de zeevogels hun isolatie verliezen en sterven aan onderkoeling, of immobiel worden of stikken (in geval van zwaardere vervuiling) (Profielendocument N2000). Er kunnen daarnaast indirecte effecten optreden op zeevogels, door bioaccumulatie. Er zal tijdens de werkzaamheden alles aan worden gedaan ter voorkoming van onopzettelijke lekkage (middels protocollen, verdragen en scheepsnoodplannen; blz 70). De kabelaanlegwerkzaamheden zijn tijdelijk van aard en de schepen zullen slechts gedurende een korte periode in het gebied aanwezig zijn.

*‘Significant’ negatieve effecten op de instandhoudingsdoelstelling van de Zeekoet door verontreiniging kunnen daarom worden uitgesloten.*

***Veranderingen in aanwezigheid van prooidieren***
Effecten zoals onderwatergeluid, verontreiniging, vertroebeling kunnen leiden tot veranderingen in de aanwezigheid van de vis-, schaal- en schelpdierpopulaties (Taormina *et al.* 2018, Viking Link 2017a).

Het mogelijke verlies van prooidieren als gevolg van de aanleg van de NeuConnect kabel is naar verwachting minimaal. De mogelijke effecten die op vissoorten zijn geïdentificeerd, zullen lokaal, kortdurend en omkeerbaar zijn. Daarbij speelt ook, dat er geen werkzaamheden plaatsvinden in de kwetsbare periode voor de Zeekoet. Rekening houdend met het bovenstaande zou een eventuele, met veranderingen in de prooibeschikbaarheid samenhangende impact op de Zeekoet minimaal zijn, en wordt geen negatief effect verwacht.

*‘Significante’ negatieve effecten op de instandhoudingsdoelstelling van de Zeekoet door veranderingen in aanwezigheid van prooidieren als gevolg van de NeuConnect kabelaanleg kunnen daarom worden uitgesloten.*

## EXPLOITATIE

Van de mogelijke effecten die tijdens de exploitatiefase kunnen optreden is de Tijdelijke verstoring door beheer- en onderhouswerkzaamheden relevant. Door de andere mogelijke effecten wordt geen invloed op de Zeekoet verwacht.

***Tijdelijke verstoring door beheer- en onderhoudswerkzaamheden***
De mogelijke effecten van onderhoudswerkzaamheden zijn vergelijkbaar met de effecten van aanlegwerkzaamheden, maar zullen waarschijnlijk lokaler optreden, korter duren en daarom beperkter van omvang zijn.

*Rekening houdend met de bovenstaande overwegingen voor de aanlegfase kan worden geconcludeerd dat de effecten van tijdelijke onderhoudswerkzaamheden niet zullen leiden tot negatieve effecten op de Zeekoet*. 'Significant' negatieve effecten op de instandhoudings-doelstelling van de Zeekoet tijdens de exploitatiefase kunnen daarom worden uitgesloten.

**Conclusie Passende beoordeling**
Op grond van de analyse worden 'significante' negatieve effecten op de instandhoudings-doelstellingen van het Friese Front uitgesloten. Reden hiervoor is dat de verstoring door de aanleg van de kabel ten opzichte van de huidige verstoring zeer klein is. Wel is er sprake van een beperkte toename van de verstoring van de Zeekoet. Deze verstoring kan worden voorkomen door de werkzaamheden in het Friese Front uit te voeren buiten de kwetsbare ruiperiode van de Zeekoet. Deze periode loopt van juli t/m september.

## 5.3 Cumulatieve effecten

Deze paragraaf beschrijft de cumulatieve effecten met andere relevante projecten in de omgeving. Hierbij worden de projecten meegenomen, waarover reeds bestuurlijke besluit-vorming heeft plaatsgevonden, maar die nog niet zijn uitgevoerd.

**Relevante projecten en effecten**
In het kader van de Passende Beoordeling dienen niet alleen de effecten in beeld gebracht te worden die worden veroorzaakt door de in dit rapport beschreven activiteit, maar ook de cumulatieve effecten van toekomstige ontwikkelingen in en rond het Friese Front. Een belang-rijke vraag is welke initiatieven in de cumulatieve beoordeling dienen te worden meegenomen. Jurisprudentie schrijft voor dat bij cumulatie alleen vergunde, nog niet gerealiseerde projecten hoeven te worden meegenomen (laatste RWE uitspraak NB-wet september 2015). Plannen die nog niet zijn vergund kunnen dus buiten beschouwing blijven, evenals reeds gerealiseerde initiatieven. Daarbij dient het uitsluitend te gaan om die ontwikkelingen die voldoende concreet zijn en waarover reeds een besluit is genomen. In (de ruime omgeving van) het Friese Front betreft het op dit moment (juli 2019) de projecten die zijn samengevat in Tabel 5-3.

*Tabel 5-3. Projecten in de wijde omgeving van het Friese Front.*

| | Activiteit / project | Status | Relevant voor cumulatie |
|---|---|---|---|
| 1 | Hollandse Kust Noord | Voorbereiding aanleg | Ja |
| 2 | Platform Olie en gaswinning F17 (2, ten noorden FF) | In procedure | Nee |
| 3 | Aardgaswinning D12 en A en B blokken (ten nw FF) | In procedure | Nee |
| 4 | Viking Kabel | Voorbereiding aanleg | Ja |
| 5 | Windpark Ten noorden van de Waddeneilanden | In procedure | Nee |
| 6 | Zandwinning | Besluitvorming is afgerond (2018 t/m 2027) | Ja |

Uit bovenstaand overzicht komen enkele projecten naar voren, die op grond van de aangegeven criteria moeten worden verkend op cumulatieve effecten met de aanleg van de NeuConnect Kabel. Het betreft:

**Windpark Hollandse Kust Noord en Ten Noorden van de Waddeneilanden**
Op het NCP is een aantal nieuwe windparken gepland, waaronder het windpark Hollandse kust Noord, in aansluiting op het bestaand Windpark Amalia. Voor de fasen V en IV is een m.e.r. procedure doorlopen (Pondera 2018) en is de besluitvorming afgerond. De aanleg van dit park is in voorbereiding, met als doel om de kavel voor 2023 te realiseren.

Het windpark Hollandse Kust Noord ligt op een afstand van 150 km van het Friese Front. Effecten hebben vooral te maken met onderwater geluid (bruinvissen) tijdens de aanlegfase en aanvaringsslachtoffers onder vogels tijdens de exploitatiefase. Deze effecten cumuleren niet met de aanlegfase van de kabel Neuconnect, vanwege de grote afstand (tenminste 150 km), geen of geringe overlap met de aanlegfase en het andersoortige effect.

Overige windparken waarvoor de besluitvorming is afgerond liggen op nog grotere afstand (Hollandse Kust Zuid). Voor het windpark Ten noorden van de Waddeneilanden is de procedure opgestart, maar is de besluitvorming nog niet afgerond.

**Platform Olie- en gaswinning F17 en aardgaswinning D12, A-B blokken**
In het kader van de gaswinning op het NCP worden nieuwe velden geëxploiteerd of geoptimaliseerd. In dat kader worden nieuwe locaties gezocht. Voor drie nieuwe locaties (F17, D12, A-B blokken) zijn m.e.r. procedures opgestart. Voor deze locaties zijn die procedures nog niet voltooid en is de besluitvorming derhalve nog niet afgerond.

**Vinking Link**
Voor de Viking Link kabel is de besluitvorming afgerond en de aanleg is in voorbereiding; de aanleg is voorzien tussen 2019-2020. De Viking kabel loopt door het noordelijk deel van het NCP op een (kortste) afstand van 103 km van het Friese Front. De effecten zijn vergelijkbaar met die van de Neuconnect kabel, met dit verschil dat de Viking kabel niet door het Friese Front loopt (wel door de noordelijk punt van de Klaverbank). Belangrijke aspecten zijn de fysieke verstoring van vogels en effecten op de zeebodem. Ten aanzien van de instandhoudingsdoelen van het Friese Front en bestaande migratieroutes is geen cumulatie aan de orde. Dit heeft te maken met het tijdelijke karakter van de werkzaamheden en het verschil in fasering van de aanleg (Viking 2019-2020, Neuconnect 2021) alsmede met de grote afstand tussen beide projecten. Daarnaast worden door geen van de projecten migratieroutes geblokkeerd (barrièrewerking).

**Zandwinning**
Voor onder andere kustveiligheid en infrastructuur is jaarlijks een grote hoeveelheid zand nodig. Het gaat hier om zandwinning door Rijkswaterstaat ten behoeve van reguliere kustsuppleties en commerciële winning van ophoogzand. Het zand wordt gewonnen in de Noordzee tussen de doorgaande NAP -20 m dieptelijn en de 12-mijlsgrens, buiten het kustfundament en buiten Natura 2000-gebieden. Ten behoeve van de zandwinningen zijn in het verleden verschillende MER-en opgesteld. De meest recente en nog vigerende MER-en zijnopgesteld voor de periode 2018 t/m 2027 (Van Duin *et al.* 2017a, b). Een deel van deze initatieven is vergund, een deel nog niet. Ook zijn in de huidige situatie niet alle locaties binnen de zandwinningszone bekend. Bij effecten door zandwinning gaat het om het ontgraven van de zeebodem, de verandering van het slibgehalte in het water en verstoring door geluid, licht of

beweging. In de MER-en is onderbouwd dat effecten op Natura 2000-gebieden die verder op de Noordzee liggen, zoals het Friese Front, kunnen worden uitgesloten.

Het tijdelijke areaalverlies en de verstoring die optreedt bij de aanleg van de kabel is zeer klein in verhouding tot de gebieden waar verstoring door zandwinning plaatsvindt. Daarnaast is de afstand van het voornemen tot de zo ver bekende vergunde zandwinningsgebieden groot (tenminste 50km, Noordzeeloket 2019) zodat een cumulatie van effecten niet te verwachten is.

**Conclusie beoordeling cumulatieve effecten**

Er spelen in het NCP en in de wijde omgeving van het Friese Front verschillende projecten waarvan de effecten in combinatie met die van de aanleg van de Neuconnect kabel dienen te worden verkend op mogelijke significantie. Uit de analyse blijkt, dat er geen interferentie is met de aanleg van windparken door vooral de grote afstanden tussen de projectgebieden en het verschil in aard van effecten. Voor de nieuwe platforms in de omgeving van het Friese Front die voorzien zijn om olie- en/of gasvelden te exploiteren, is de besluitvorming nog niet afgerond; deze zijn derhalve niet relevant voor de cumulatietoets. Ten aanzien van zandwinning op de Noordzee en de Viking kabel geldt, dat ook daar geen cumulatie van effecten optreedt vanwege de grote afstand en verschil in fasering.

De conclusie van deze Passende Beoordeling is, dat de aanleg van de Neuconnect kabel – ook in cumulatie – geen significante effecten heeft op de instandhoudingsdoelen van het Friese Front. Met inbegrip van het treffen van mitigerende maatregelen in de kwetsbare periode voor zeekoeten kunnen ook negatieve effecten worden uitgesloten.

# 6 Soortbescherming - Wet natuurbescherming

In dit hoofdstuk wordt ingegaan op de effecten van kabelaanlegwerkzaamheden op beschermde natuurwaarden in het kader van de Wet natuurbescherming (vleermuizen, vogels en zeezoogdieren) en Internationale beschermingsregimes (habitats, ongewervelden en vissen). Het gaat hier vooral om de beschermde soorten en habitats; de bescherming van gebieden vanuit Natura 2000 is in het vorige hoofdstuk reeds behandeld.

De mogelijke effecten zijn voor resp de aanlegfase en buitenbedrijfstelling (paragraaf 6.1) en de exploitatiefase (paragraaf 6.2) beschreven. In effectbeoordeling (paragraaf 6.3) is per beschermingsregime een beoordeling gemaakt of het projecct een negatief effect heeft in het kader van het beschermingsregime waaronder de betreffende natuurwaarde valt.

Voor details ten aanzien van de werkzaamheden en uitvoering in de aanleg- en buitenbedrijf-stellingsfase en de exploitatiefase, bijvoorbeeld type schepen, type isolatiemateriaal kabels of een toelichting van de planning, verwijzen wij naar de MER (AECOM 2021).

## 6.1 Effectbepaling in de aanleg- en buitenbedrijfstellingsfase

### *6.1.1 Visuele verstoring*

Visuele verstoring kan de volgende natuurwaarden betreffen: vleermuizen, vogels, zeezoog-dieren en vissen. Op deze soortgroepen wordt hieronder nader ingegaan.

***Vleermuizen***
Op de zuidelijke Noordzee komen geregeld vleermuizen voor, vooral tijdens de migratieperiode in april en september-oktober. De dichtheden zijn wel lager dan op het land (Lagerveld 2019). Op zee kunnen vleermuizen door de aanwezigheid van schepen incidenteel worden aangetrokken (Boshamer & Bekker 2008, Leopold *et al.* 2014). Bijvoorbeeld doordat ze ’s nachts aangetrokken worden door het licht van de schepen. Duidelijk lichtgevoelige soorten zoals de Watervleermuis en de Meervleermuis worden niet offshore aangetroffen (Lagerveld *et al.* 2017). De Ruige dwergvleermuis is verreweg de belangrijkste soort, blijkt uit onderzoek met batdetectoren (Lagerveld 2019), en deze soort wordt ook het vaakst op schepen aangetroffen, waarschijnlijk om tijdens ongunstige weersomstandigheden te rusten (Boshamer & Bekker 2008). De vlieghoogte van trekkende vleermuizen is over het algemeen hoog, veel hoger dan schepen. Of schepen een negatief verstorend effect op vleermuizen kunnen hebben zoals offshore windparken, die de trekbanen van vleermuizen kunnen verstoren, is niet duidelijk (Rijkswaterstaat 2019); aanvarings-slachtoffers zijn minder waarschijnlijk. Hoewel uit onderzoek gebleken is dat vleermuizen op zee meer voorkomen dan eerder werd aangenomen, schijnen de meeste vleermuizen de trek langs de kust te prefereren (Lagerveld *et al.* 2017, Rijkswaterstaat 2019). Als al sprake is van (tijdelijke) verstoring van vleermuizen door de werkschepen, dan zal het om individuen gaan en is geen sprake van doorwerking op populatieniveau. In het kader van de Zorgplicht dient echter ’s nachts aan boord van schepen de minimaal benodigde verlichting (veilig werken) te worden toegepast.

*Voor vleermuizen op de Noordzee geldt dat er geen negatieve effecten worden verwacht als gevolg van visuele verstoring door schepen bij de aanleg van de NeuConnect kabel. In het*

*kader van de Zorgplicht dient 's nachts aan boord van schepen de minimaal benodigde verlichting worden toegepast.*

***Vogels***

Voor effecten op vogels kan onderscheid worden gemaakt tussen de fysieke aanwezigheid van de schepen en verlichting. Hieronder wordt nader daarop ingegaan.

Fysieke aanwezigheid schepen

De aanwezigheid van schepen kan een verstorende werking hebben op vogels en hun verspreidingspatronen beïnvloeden (Bellebaum *et al.* 2006, Schwemmer *et al.* 2011). De mate van verstoring is soortspecifiek en afhankelijk van onder andere de afstand, het seizoen en of de betreffende vogel in rui is (Klop 2013). Volgens Jongbloed *et al.* (2010) hebben de meeste vogelsoorten op groot open water een verstoringsafstand van 500 m, die voldoende zekerheid biedt tegen verstoring door varende objecten op het water. Ruiende watervogels zijn extra gevoelig en hebben een verstoringsafstand tot circa 1.500 m (Klop 2013). In de periode eind juli tot en met september komen er in het projectgebied ruiende adulte vogels en niet-vliegvlugge jonge Zeekoeten voor, die extra kwetsbaar zijn omdat ze niet kunnen wegvliegen bij verstoring. Op deze soort wordt in Hoofdstuk 5 nader ingegaan. Op overige, bijzonder verstoringsgevoelige soorten zoals de Zwarte zee-eend, duikers, aalscholvers en Jan-van-genten wordt hieronder nader ingegaan.

Zwarte zee-eenden zijn verstoringsgevoelig; de gevoeligheid schijnt onder andere afhankelijk te zijn van de groepsgrootte (Kaiser *et al.* 2006, Schwemmer *et al.* 2011). Met verstorings-afstanden van 1.000 - 2.000 m zijn grote groepen gevoeliger dan kleine groepen met verstoringsafstanden van < 1.000 m (Kaiser *et al.* 2006). Schwemmer *et al.* (2011) hebben verstoringsafstanden van zwarte zee-eenden van ongeveer 800 m gemeten. Tijdens metingen met de rangefinder aan de Zwarte zee-eend op de Noordzee (ten noorden van de Wadden-eilanden) werden gemiddelde verstoringsafstand van ongeveer 500 m gemeten, vanaf een langzaam varend schip op een kalme zee (pers. observatie M. Sikkema, A&W). Een recente studie naar de verstoring van zeevogels door scheepvaart heeft voor zwarte zee-eenden gemiddelde verstoringsafstanden van 1.600m vastgesteld (Fliessbach *et al.* 2019).

Bijzonder verstoringsgevoelige zeevogels zijn duikers. Deze soort vlucht op grote afstand weg voor schepen. Uit Mendel *et al. (*2019) blijkt dat de dichtheden van duikers in een zone tot 5 km rond schepen significant afnemen. Fijn *et al.* (2015) geven aan dat naast soorten zoals duikers ook aalscholvers en jan-van-genten bijzonder verstoringsgevoelig zijn bij vaartuigen. De verstoringsgevoelige soorten Aalscholver en Jan-van-gent zijn alleen in lage aantallen langs het kabeltracé te verwachten. Duikers en zwarte zee-eenden kunnen in principe langs het kabeltracé voorkomen. Omdat dit meer kustgebonden soorten zijn die alleen in de winter-maanden op het NCP voorkomen, zullen zich mogelijke effecten beperken op individueel niveau. Voor overige soorten, die gedurende het hele jaar in het plangebied kunnen voorkomen, is het mogelijk dat deze worden opgeschrikt en moeten opschuiven om geschikt foerageer- en rustgebied te vinden.

Voor de aanleg van de kabel varen er zes schepen langs het tracé met een lage snelheid (20-125 m/uur). Indien het leggen van de kabels zonder gelijktijdige begraving plaatsvindt kan mogelijk een snelheid van circa 500 m/uur worden gehaald. Het gaat hier om een tijdelijk kleine toename van het scheepvaartverkeer vergeleken met de huidige situatie, waarin op het NCP gemiddeld 390 schepen per dag varen (Noordzeeloket 2019). Een mogelijk effect zal tijdelijk en lokaal zijn (zie Box 1. voor een toelichting van het oppervlakteverlies op het Friese Front door

de aanwezigheid van werkschepen). Ook kunnen mogelijk verstoorde vogels naar het gebied terugkeren wanneer de werkzaamheden klaar zijn. Het aanbod van alternatief geschikt gebied in de directe omgeving is groot. Een mogelijk effect op populatieniveau is daarom niet te verwachten.

Voor zeevogels op de Noordzee in het algemeen geldt dus dat er geen negatieve effecten worden verwacht als gevolg van visuele verstoring door schepen bij de aanleg en buiten-bedrijfstelling van de NeuConnect kabel. Voor de Zeekoet is een aparte Passende beoordeling uitgevoerd, en kan in de kwetsbare zomerperiode – en zonder mitigatie - wel sprake zijn van een negatief effect, voor details zie hoofdstuk 5 (paragraaf 5.2).

Verlichting

Vooral zeevogels zijn sterk visueel georiënteerd en kunnen worden aangetrokken door verlichting (Poot *et al.* 2008, Rebke *et al.* 2019). Ook kan kunstmatige verlichting in de nacht hun oriëntatie verstoren (Poot *et al.* 2008). Naar verwachting zullen de werkschepen ook ’s nachts verlichting voeren. Gezien de aantallen schepen die dagelijk op de Noordzee varen, ook in de zone van de kabelroute zal een mogelijk additioneel effect van verlichting vanuit de enkele schepen van Neuconnect minimaal zijn. In het kader van de Zorgplicht dient echter ’s nachts aan boord van schepen de minimaal benodigde verlichting worden toegepast.

*Rekening houdend met bovenstaande overwegingen kan worden geconcludeerd dat verlichting van de werkschepen geen effect heeft op de populatie zeevogels in het gebied van het kabeltracé. In het kader van de Zorgplicht dient ’s nachts aan boord van schepen de minimaal benodigde verlichting worden toegepast.*

***Zeezoogdieren***

Vaarbewegingen kunnen een verstorende invloed hebben op zeezoogdieren. Voor walvis-achtigen zijn de effecten van onderwatergeluid echter zwaarwegende dan visuele impulsen. Verstoring op walvisachtigen door visuele impulsen wordt hier daarom niet nader beschouwd.

Bij zeehonden is vastgesteld dat langsvarende baggerschepen tot circa 700m een verstorende werking kunnen hebben (Bouma *et al.* 2010). Zeehonden zijn vooral gevoelig voor verstoring nabij ligplaatsen tijdens de kraamperiode en tijdens de verharingsperiode. Belangrijke ligplaatsen van zeehonden zijn Razende bol, het wadplaten in het Eierlandse Gat, weerszijden van de instroom van het Vlie (inclusief Richel), de platen onder oost Terschelling aan het Borndiep en rondom Blauwe balg, Simonszand, Zuid-oost Lauwers en Rottumeroog (Ens *et al.* 2017). Gezien de grote afstand tussen het kabeltracé en de ligplaatsen zullen deze geen effect ondervinden van de beoogde werkzaamheden.

*Rekening houdend met de bovenstaande overwegingen kan worden geconcludeerd dat er geen negatieve effecten te verwachten zijn op zeezoogdieren als gevolg van visuele verstoring door schepen bij de kabelaanlegwerkzaamheden en buitenbedrijfstelling.l.*

***Vissen***

Vaarbewegingen kunnen een verstorende invloed hebben op vissen, maar de effecten van onderwatergeluid worden als maatgevend boven die van visuele impulsen beschouwd (de Robertis & Handegard 2013). Verstoring op vissen door visuele impulsen wordt hier daarom niet nader beschreven.

### *6.1.2 Aanvaringsrisico*

Aanvaringsrisico kan zeezoogdieren betreffen. Op deze soortgroep wordt hieronder nader ingegaan.

***Zeezoogdieren***
Bij zeezoogdieren kan een toename aan scheepvaartsverkeer in beginsel leiden tot een grotere kans op aanvaringen met vaartuigen (Van Waerebeek 2006). Over het algemeen is de kennis over het risico op aanvaringen met walvisachtigen beperkt. Incidenten van aan-varingen van schepen met zeehonden zijn bekend, maar vergeleken met walvisachtigen wordt het risico op aanvaringen met zeehonden lager ingeschat dan bij walvisachtigen (Jones *et al.* 2017). Volgens Evans *et al.* (2011) hebben grote walvisachtigen een hoger risico op aan-varingen dan kleine walvisachtigen. In het plangebied kunnen naast de Bruinvis voornamelijk kleine walvisachtigen zoals Tuimelaar en Witsnuitdolfijn incidenteel voorkomen. Voor bruin-vissen wordt het risico op aanvaringen over het algemeen als relatief laag ingeschat. Dit risico hangt voor een groot deel van de grootte en de snelheid van vaartuigen af (Camphuysen & Siemensma 2011). Ook Crum *et al.* (2019) hebben recentelijk vastgesteld, dat de snelheid van vaartuigen een invloed op aanvaringsrisico heeft: hoe lager de snelheid, hoe lager de kans op aanvaring

Het gaat bij de aanleg van de Neuconnect kabel om een kleine en tijdelijke toename van het scheepvaartverkeer vergeleken met de huidige, dagelijkse situatie (zes versus dagelijks circa 390 schepen NCP). De kabellegger en een aantal hulpschepen zullen zich langs het tracé met een lage snelheid (20-500 m/uur) verplaatsen waardoor het aanvaringsrisico laag is. Ook zal de werklocatie voortdurend langs de zeekabelcorridor verschuiven. Daardoor heeft elk gebied slechts korte tijd te maken met een verhoogd aanvaringsrisico. Gezien de kortdurende, lokale en voorbijgaande aard van de kabelaanlegwerkzaamheden en het grote verspreidingsgebied van zeezoogdieren zal het risico op aanvaringen naar verwachting minimaal zijn.

*Rekening houdend met de bovenstaande overwegingen kan worden geconcludeerd dat er geen negatieve effecten zijn op zeezoogdieren als gevolg van een risico op aanvaringen door de aanleg van de kabel en tijdens de buitenbedrijfstelling.*

### *6.1.3 Onderwatergeluid*

Onderwatergeluid kan de volgende natuurwaarden betreffen: vogels, zeezoogdieren en vissen. Op deze soortgroepen wordt hieronder nader ingegaan.

***Vogels***
Zeevogels kunnen worden verstoord door geluid van schepen en apparatuur. Hansen *et al.* (2017) hebben recentelijk vastgesteld, dat aalscholvers onder water kunnen horen. Het wordt aangenomen dat aalscholvers, en ook andere soorten, hun gehoor gebruiken om onder water te kunnen foerageren en daarom gevoelig zijn voor onderwatergeluid. Onderwatergeluid kan ontstaan door geluid van schepen en apparatuur, geofysisch onderzoek of het opruimen van NGE. Voor effecten door onderwatergeluid worden voorzorgsmaatregelen ten aanzien van zeezoogdieren getroffen. Deze worden in de volgende paragraaf nader beschreven. Omdat door deze maatregelen ook effecten op duikende vogels worden voorkomen, wordt hier alleen ingegaan op geluid dat ontstaat door schepen. Het is onwaarschijnlijk dat het geluid door schepen aan het zeeoppervlak zo sterk is dat het leidt tot fysiologische schade bij duikende vogels. Het geluid kan echter sterk genoeg zijn om verstoring in de buurt van het schip te veroorzaken. De mate van akoestische verstoring is afhankelijk van het type schepen dat wordt

ingezet. Op dit moment is nog niet duidelijk welk type schepen wordt gebruikt. Omdat het hier gaat om een kleine en tijdelijke toename van het scheepvaartverkeer vergeleken met de huidige situatie zullen mogelijke effecten van onderwatergeluid op vogels naar verwachting minimaal zijn.

*Rekening houdend met het bovenstaande worden door de effecten van onderwatergeluid geen negatieve effecten verwacht op vogels.*

***Zeezoogdieren***

Walvisachtigen zijn afhankelijk van echolocatie om zich te oriënteren en te foerageren (Tyack & Clark 2000). Daarom zijn ze bijzonder gevoelig voor geluid (Richardson *et al.* 1995). Langs het kabeltracé kunnen mogelijk de Tuimelaar, de Witsnuitdolfijn en de Dwergvinvis voorkomen, maar de Bruinvis is de meest voorkomende soort. Alle genoemde walvisachtigen, die mogelijk in het plangebied kunnen voorkomen, zijn gevoelig voor geluid (Narberhaus *et al.* 2012). Het daadwerkelijk hoorbare frequentiebereik is soortspecifiek. Omdat de Bruinvis, de Gewone zeehond en de Grijze zeehond de meest voorkomende zeezoogdieren op het NCP zijn wordt hieronder voornamelijk op deze soorten ingegaan (Bos *et al.* 2011). De Bruinvis heeft het beste gehoor in de range van 13 tot 140 kHz, waarbij de hoogste gevoeligheid ligt tussen 100 en 140 kHz (bij 33 dB re 1 µPa) (Kastelein *et al.* 2002, 2015). Ook al wordt aangenomen dat walvisachtigen gevoliger zijn worden ook zeehonden als gevoelig ingeschat voor operationeel onderwatergeluid (KEC, Rijkswaterstaat 2019). Onderwater reageren zeehonden op geluiden tussen de 0,1 en 128 kHz, in de lucht is het functioneel bereik 0,1-30 kHz (Narberhaus *et al.* 2012).

Voor de beoordeling van effecten op zeezoogdieren (walvisachtigen en zeehonden) door de aanleg van de kabel is het geluid dat ontstaat door schepen en apparatuur (1) en door geofysisch onderzoek (2) van belang. Daarnaast wordt op effecten door de opruiming van NGE ingegaan (3). Hieronder worden effecten door deze geluidsbronnen apart besproken.

*(1) Geluid van schepen en apparatuur*

Volgens Dyndo *et al.* (2015) kunnen bruinvissen door het hoogfrequent geluid op laag niveau van schepen tot op meer dan een km afstand worden verstoord. Uit Wisniewska *et al.* (2018) blijkt ook dat hoog geluidsniveau bij bruinvissen tot een verminderd aantal pogingen om prooi te vangen leidt.

De schepen die bij het proces betrokken zijn en het meeste geluid veroorzaken, zijn vermoedelijk baggerschepen die de kabel in de zeebodem aanleggen. Uit onderzoek naar het geluid dat ontstaat bij het leggen van zeekabels en de effecten op verschillende soorten zeezoogdieren (Tuimelaar, bruinvis en zeehonden) blijkt dat bij een verondersteld transmissieverlies van 22 log (R) sprake is van een bronniveau van 178 dB re 1 µPa @ 1 m. Op basis van de hoge variabiliteit in geluid geven Nedwell *et al.* (2003) aan dat deze waardes niet als betrouwbare inschatting voor transmissieverlies en bronniveau gebruikt kunnen worden. Wel geven deze metingen een goede indicatie. Geluidsmodellering wijzen vervolgens uit dat voor afstanden tussen 100 m tot 5 km van de bron alle metingen lager zijn dan 70 dB (met één specifiece uitzondering), en daarmee onder het niveau blijven waarop gedragsveranderingen van zeezoogdieren zouden worden verwacht (Nedwell *et al.* 2003).

Heinis *et al.* (2013) beschrijven dat bij een (theoretische) 24-uurs blootstelling aan geluid door baggerschepen een zeehond op een diepte van 16 m en op 90 m afstand van een baggerschip, mogelijk TTS (*Temporary Threshold Shift*) zal ondervinden. Bij een langdurige blootstelling is het mogelijk dat PTS (*Permanent Threshold Shift*) optreedt. De afstand waarbij

gehoorschade kan optreden zal kleiner zijn bij dieren die dichter bij het wateroppervlak zwemmen en bij minder lange blootstelling (bijvoorbeeld doordat de dieren van de geluidsbron wegzwemmen).

Een vervolgonderzoek van Nedwell *et al*. (2012) naar geluidsniveaus en frequenties geproduceerd bij de installatie van elektriciteitskabels voor het Beatrice windmolenpark voor de kust van Schotland geeft aan dat er effecten zijn maar dat de werkzaamheden niet zullen leiden tot gehoorschade bij mobiele zeezoogdieren. Dit komt mede doordat deze over de mogelijkheid beschikken om het geluid te ontvluchten. Ook Taormina *et al.* (2018) stellen vast dat er geen duidelijke aanwijzingen zijn dat het geluid in verband met de aanleg van een kabel effecten op zeezoogdieren heeft.

*(2) Geofysisch onderzoek*

Voorafgaand aan de aanlegwerkzaamheden wordt de zeekabelcorridor in kaart gebracht met behulp van geofysisch onderzoek. Daarbij wordt gebruik gemaakt van Side-scan sonar, Multi Beam echosounder en Sub-bottom profiler.

Uit de recent door Heinis *et al.* (2019) gemaakte schatting van verstoringsafstanden voor verschillende type systemen geofysisch onderzoek blijkt dat effectafstanden door het gebruik van Side-scan sonar en Multi Beam echosounder (verwaarloosbaar) klein zijn. De reden hiervoor is dat deze systemen zeer hoge frequenties (tussen 170 kHz en 400 kHz) produceren en daarmee boven de gehoorgrens van de bruinvis liggen (Heinis *et al.* 2019, Nehls 2019).

Door het gebruik van de Sub-bottom profiler kunnen in potentie effect-afstanden tussen 1 en 2 km optreden. De reden hiervoor zijn primaire frequenties van de bron op 100 kHz (Heinis *et al.* 2019). Gezien de korte duur van geofysisch onderzoek worden de risico's over het algemenen als zeer lokaal ingeschat (JNCC, 2008). In 2019 zijn geluids-metingen aan de sub-bottom profiler in de Waddenzee uitgevoerd. Uit deze veldproef blijkt dat de sterkte van de geluidspuls (van 238 dB) enkel in een scherp gebundelde puls wordt uitgezonden en weinig horizontale uitstraling heeft. De maximum geluidsdruk van 138 dB ligt op 10-15 m afstand van de geluidsbron, en wordt daarna snel lager dan de achtergrondwaarde van onderwatergeluid (op 300 m is 90 dB waarneembaar) (Brinkkemper 2019). Het totale bloot-stellingsniveau voor een Bruinvis of een Zeehond is ook afhankelijk van de tijdsduur waarin het dier wordt blootgesteld aan deze geluidspieken. Een Bruinvis of Zeehond zal daarom enkel hinder ondervinden als hij precies onder de meetapparatuur en door de geluidspuls heen zwemt. De kans op een dergelijke confrontatie in de praktijk is erg klein, ook omdat bruinvissen en zeehonden een groot verspreidingsgebied hebben (lage dichtheid op volle zee).

Om de effecten van onderwatergeluid door geofysisch onderzoek voor de aanleg van de NeuConnect kabel op zeezoogdieren te kunnen kwantificeren is een separaat onderzoek uitgevoerd (Heinis 2021, zie bijlage 1). Bij het onderzoek werd uitgegaan van de aanpak voor het Kader Ecologie en Cumulatie 3.0 waarbij bruinvisverstoringsdagen als gevolg van de aanleg van offshore windparken worden berekend en worden gebruikt als maat voor het berekende effect op de bruinvispopulatie (Heinis *et al.* 2019). De conclusie van dit onderzoek was dat alleen de voor de pre-engineering survey gebruikte sub-bottom profiler geluid produceert dat tot verstoring van bruinvissen kan leiden. Gezien het sporadisch voorkomen van zeehonden en andere soorten zeezoogdieren langs het kabeltracé worden effecten op deze soorten op voorhand uitgesloten. Uit de worst case effectberekening voor effecten op bruinvissen bleek dat de berekende populatiereductie minder dan 1 bruinvis bedraagt. Bij een geschatte gemiddelde bruinvispopulatie op het NCP van 51.000 individuen zijn de effecten op bruinvissen verwaarloosbaar (Heinis 2021, zie bijlage 1).

Omdat het geluid dat geproduceerd wordt door de sub-bottom profiler wel tot verstoring van bruinvissen kan leiden en er ten aanzien van de te verwachten geluidsdruk-niveaus door schepen, apparatuur (1) en geofysisch onderzoek (2) nog leemte in kennis bestaat, dienen zekerheidshalve voorzorgsmaatregelen te worden getroffen. Het gaat dan om de volgende maatregelen, zie ook Box 2:

- toepassen van een Acoustic Deterrent Device (ADD)
- beginnen met geofysisch onderzoek met een soft start
- aanwezigheid van een Marine mammal observer (MMO) tijdens werkzaamheden

**Box 2. Voorzorgsmaatregelen in verband met effecten door onderwatergeluid**

In verband met een leemte in de kennis over de te verwachten geluidsdrukniveaus door schepen, apparatuur en geofysisch onderzoek is het nodig dat zekerheidshalve voorzorgsmaatregelen worden getroffen. Als borging worden deze maatregel in de tendervoorwaarden voor de aanbesteding opgenomen. Hieronder worden deze maatregelen beschreven.

*Acoustic Deterrent Device (ADD)*
Om gehoorbeschadiging van zeezoogdieren nabij de activiteiten (geofysisch onderzoek en/of de installatie van de kabels) te voorkomen worden zoals gebruikelijk bij dit type werkzaamheden maatregelen getroffen, waaronder de toepassing van een ADD vanaf een half uur voor de start vanaf de activiteiten. ADDs produceren onderwatergeluid met als doel zeezoogdieren uit het gebied te verdrijven voor aanvang van de activiteiten. Op basis van onderzoek wordt gekozen voor de inzet van de Sealscarer Lofitech (Brandt *et al.* 2012, 2013).

*Soft start*
Het geofysisch onderzoek begint met een soft start. Dat betekent dat de energie van de geofysische meetapparaturen in 25% stappen gedurende 20 minuten wordt opgevoerd.

*Marine mammal observer (MMO)*
Tijdens de werkzaamheden (geofysisch onderzoek en/of de installatie van de kabels) dient een Marine mammal observer (MMO) aanwezig te zijn. Dit sluit aan bij de voorzorgmaatregelen die ook in het Duitse deel worden getroffen (Nehls 2019). De MMO dient de omgeving van de werkschepen in een radius van 100 m te monitoren naar de aanwezigheid van zeezoogdieren. De monitoring dient 30 minuten voor aanvang van de werkzaamheden te beginnen. Indien een zeezoogdier wordt waargenomen geldt het volgende:

- Indien een zeezoogdier tijdens de 30 minuten voor aanvang van de de werzaamheden en binnen de radius van 100 m wordt waargenomen dienen de werkzaamheden te worden uitgesteld tot het dier de radius van 100 m verlaten heeft.
- Indien tijdens de werkzaamheden in een radius van 100 m een zeezoogdier waargenomen wordt dienen de werkzaamheden te worden gestopt. De werkzaamheden kunnen worden vervolgd indien voor een tijdvak van 30 minuten na de stop geen zeezoogdier wordt gezien.

*(3) Niet-gesprongen explosieven (NGE)*
Op het gehele NCP worden regelmatig NGE gevonden en tot ontploffing gebracht. Per jaar worden gemiddeld ongeveer 120 explosieven geruimd op het NCP (Von Benda-Beckmann *et al.* 2015). Op basis van de risicobeoordeling (1st Line Defence Limited 2018) zijn geen exacte

locaties van explosieven vastgesteld. Hoewel in deze fase niet kan worden uitgesloten dat er NGE's langs het kabeltracé aanwezig zijn is het risico dat ontploffingen vereist zijn vooralsnog laag (AECOM 2021). Volgens Geneis (2011) kan het laten ontploffen van niet gesprongen explosieven geluidsniveaus opleveren van 272-287dB re 1µPa@1m (0-piek). Explosies genereren lage frequenties 2 -1.000Hz en hebben een zeer korte duur. Door de hoge geluids-druk afkomstig van deze explosieven kunnen bruinvissen permanente gehoorschade oplopen of zelfs overlijden. De afstand vanaf het explosief waarop zeezoogdieren gehoor-schade kunnen oplopen, is afhankelijk van de grootte van het explosief en kan variëren van één tot enkele kilometers en eventueel nog verder bij hele grote explosieven (Von Benda Beckman *et al.* 2015). Het is niet duidelijk of en hoeveel zeehonden effecten ondervinden van het tot ontploffing brengen van deze explosieven.

In Nederland is het ruimen van munitie een taak van het ministerie van Defensie. Om schade bij zeezoogdieren, veroorzaakt door de hoge geluidsdruk afkomstig van explosieven, te vermijden, worden volgens het Ministerie van Defensie de volgende mitigerende maatregelen genomen:

- Bij het vernietigen van explosieven moeten mitigerende maatregelen worden genomen om het effect van onderwaterexplosies zoveel mogelijkte beperken.
- De volgende voorschriften dienen opgevolgd te worden bij het ruimen van munitie op de Noordzee: 'Gedragscode Springen van munitie op de Noordzee' (Koninklijke Marine 2005) en de 'Bekendmaking 01/18 Groepsoudste KBW en Mijnendienst' (KBW en Mijnendientst 2018). Deze voorschriften hebben ook betrekking op de bescherming van dieren.
- In het kader van de monitoring van onderwatergeluid worden door Rijkswaterstaat de ruimingen jaarlijks opgenomen in het (openbare) ICES Impulsive Noise Register.

*Samenvattende conclusie*
*Ten aanzien van geluid dat ontstaat door schepen en apparatuur (1) en door geofysisch onderzoek (2) zullen effecten door onderwatergeluid naar verwachting niet leiden tot een wijziging van de referentiesituatie voor zeezoogdieren. De redenen hiervoor zijn de kort-durende, lokale en voorbijgaande aard van deze activiteiten, het grote verspreidingsgebied en de mobiliteit van de betrokken kwetsbare soorten. Dit blijkt ook uit een separaat onderzoek waarbij effecten door geofysisch onderzoek op de bruinvispopulatie werden berekend. Zekerheidshalve worden wel voorzorgsmaatregelen getroffen (zie Box 2.). Ten aanzien van effecten op zeezoogdieren door het opruimen van NGE (3) worden volgens het Ministerie van Defensie voorschriften gevolgd en mitigerende maatregelen genomen. Gelet op deze maatregelen wordt uitgegaan van de mogelijkheid van een klein negatief effect.*

***Vissen***
Onderwatergeluid kan ontstaan door geluid van schepen en apparatuur, geofysisch onderzoek of het opruimen van NGE. Voor effecten door onderwatergeluid worden voorzorgsmaatregelen ten aanzien van zeezoogdieren getroffen. Deze zijn in de vorige paragrafen nader beschreven. Omdat door een deel van deze maatregelen (Soft start,) ook effecten op vissen worden voorkomen, wordt hier alleen ingegaan op geluid dat ontstaat door schepen en apparatuur. Vissen kunnen gebruik maken van geluid voor communicatie of oriëntatie (Taormina *et al.* 2018). Er bestaat echter nog een grote kennisleemte over de gedragsrespons van verschillende vissoorten op geluid (Hawkings & Popper, 2014, Hawkings *et al.* 2015). Taormina *et al.* (2018) stellen vast dat er geen duidelijke aanwijzingen zijn dat het geluid in verband met de aanleg van een kabel effecten op vissen heeft. Nedwell *et al.* (2003) hebben ook onderzoek

gedaan naar het geluid dat ontstaat bij het leggen van zeekabels en de effecten op verschillende soorten vissen (zalm, schar, kabeljauw). Daaruit blijkt dat bij een veronder-steld transmissieverlies van 22 log (R) sprake is van een bronniveau van 178 dB re 1 µPa @ 1 m. Geluidsmodellering wijzen vervolgens uit dat voor afstanden tot 5 km van de bron alle metingen lager zijn dan 70 dB, en daarmee onder het niveau blijven waarop gedrags-veranderingen van vissen worden verwacht.

Een vervolgonderzoek van Nedwell *et al*. (2012) naar geluidsniveaus en frequenties geproduceerd bij de installatie van elektriciteitskabels voor een windmolenpark geeft aan dat de invloedszone bij vissen kleiner is dan bij zeezoogdieren. Dit komt waarschijnlijk omdat zeezoogdieren gevoeliger voor onderwatergeluid zijn dan vissen. Omdat de studie ook vaststelt dat er effecten zijn maar dat de werkzaamheden niet zullen leiden tot gehoorschade bij mobiele zeezoogdieren, wordt dit ook niet bij vissen verwacht.

Voor vissen is vooral het geluid dat ontstaat bij de scheepvaart van belang. Het geluid dat bij de scheepvaart ontstaat kan een invloed hebben op het gedrag van vissen (Popper & Hastings 2009). Gezien de kortdurende, lokale en voorbijgaande aard van de werkzaamheden en het grote verspreidingsgebied en de mobiliteit van betreffende vissoorten zal het verstorende effect van onderwatergeluid naar verwachting minimaal zijn. Ook zullen vissen naar verwachting snel terugkeren naar het gebied en hun normale gedrag hervatten wanneer de activiteiten, die geluidsoverlast produceren, zijn opgehouden.

*In vergelijking met de referentiesituatie wordt de kans daarom verwaarloosbaar klein geacht dat negatieve effecten als gevolg van onderwatergeluid door de aanleg van de kabel op vissen ontstaan.*

### *6.1.4 Verontreiniging*

Verontreiniging betreft de onopzettelijke lekkage van verontreinigende stoffen (drijvende olie, vet of chemicaliën) van vaartuigen tijdens aanleg- en buitenbedrijfstellingswerkzaamheden of graafwerkzaamheden die kunnen leiden tot het vrijkomen van eventueel aanwezige verontreinigingen in het sediment (zoals zware metalen en koolwaterstoffen). Verontreiniging kan een invloed op alle in of op de zee levende natuurwaarden hebben, namelijk vogels, zeezoogdieren, habitats, ongewervelden en vissen.

Over het algemeen zijn soorten in de top van de voedselpiramide, zoals vogels, zeezoogdieren of vissen, gevoelig als gevolg van accumulatie van verontreinigingen (Broekmeyer 2006, Lahr *et al.* 2007). Zeezoogdieren, vissen en filtervoeders kunnen deze stoffen opnemen en dit kan doorwerken in het systeem. Bij vogels kunnen verontreinigende stoffen van vaartuigen ook leiden tot aantasting van het verenkleed in de vorm van het verlies van isolatie, onderkoeling of immobiliteit (Profielendocument N2000). Het betreft vooral zeevogels, die veel tijd zwemmend op zee doorbrengen. Hieronder wordt nader op de twee vormen van verontreiniging ingegaan.

<u>*Onopzettelijke lekkage van verontreinigende stoffen van vaartuigen*</u>
Het risico op verontreiniging wordt over het algemeen als laag ingeschat (Taormina *et al.* 2018). De vaartuigen zijn slechts gedurende een korte periode in het plangebied aanwezig. Onopzettelijke lekkages zullen dan ook kleinschalig en lokaal van aard zijn. Daarnaast houden alle vaartuigen die betrokken zijn bij de aanlegwerkzaamheden zich aan de bepalingen van het Internationaal Verdrag ter voorkoming van verontreiniging door schepen (MARPOL). Deze zijn gericht op het voorkomen van verontreiniging als gevolg van ongevallen en routinewerkzaam-

heden. Daarnaast beschikken alle betrokken vaartuigen over een scheepsnoodplan voor olieverontreinigingen (Shipboard Oil Pollution Emergency Plan, SOPEP).

*Vrijkomen van eventueel aanwezige verontreinigingen in het sediment*
Zoals onder 2.6 Mogelijke effecten beschreven zijn hoge concentraties verontreinigingen in de sediment niet in het plangebied te verwachten en blijkt ook uit het onderzoek door Orbicon (2019b) dat er geen grote verontreinigingen aanwezig zijn in het onderzoeksgebied.

*In vergelijking met de referentiesituatie wordt de kans daarom verwaarloosbaar klein geacht dat negatieve effecten door verontreiniging ontstaan en worden geen negatieve effecten verwacht op de betreffende soortgroepen.*

### *6.1.5 Vertroebeling en hersidementatie*

Vertroebeling kan de volgende natuurwaarden betreffen: vogels, zeezoogdieren, habitats, ongewervelden en vissen. Samenvattend voor alle natuurwaarden wordt hieronder nader op vertroebeling ingegaan.

In het kader van de Viking kabel zijn modellen opgesteld om de beweging van verstoord sediment te voorspellen (Intertek 2016). Naar verwachting zijn deze resultaten ook toepasbaar op de aanleg van de NeuConnect kabel. Uit voorzorg wordt een verspreidingsafstand van 0,7 km aangehouden voor zwevend sediment, dat naar verwachting grotendeels in de directe nabijheid van het kabeltracé zal neerslaan. Omdat in het projectgebied over het algemeen zandige habitats aangetroffen zijn (Orbicon 2019a) en zand snel bezinkt is de verwachting dat mogelijke effecten lokaal en kortdurend van aard (gedurende het fysieke werk, en naar verwachting maximaal een aantal uren daarna) zullen zijn. Door de over het algemeen zwakke stromingen en getijdenenergie is de kans op veranderingen in sedimenttransportpatronen zeer klein. Naar verwachting zullen effecten op bovenstaande soort(-groepen) door vertroebeling en hersidementatie daarom minimaal zijn.

Vertroebeling kan een effect op ongewervelden en op habitats hebben. Het kan o.a. zorgen voor vertraagde groei van individuen door vertraagde filtratiesnelheden en geredu-ceerde vestiging van larven (Narberhaus *et al.* 2012) van ongewervelden. Het type habitat *Sabbelaria spinulosa* is gevoelig voor bedekt/bedolven worden door sedimentatie (OSPAR 2013). Op het tracé is dit habitat niet aangetroffen, maar wel individuen van *Sabellaria spinulosa* die met een aantal andere soorten een subgroep van epifauna domineerde in aantallen. Ook het gevoelige habitat 'Zeeveer *(Pennatulacea)* & gravende megafauna communities' is niet aangetroffen. Wel zijn de gravende kreeftjes Moddergarnaal en Harige molkreeft in de bemonstering langs het Nederlandse deel van de kabelroute aangetroffen. Moddergarnalen zijn enigszins bestand tegen troebel water en lage zuurstofgehaltes, maar ook gevoelig wanneer 'troebelheidspluimen' ontstaan.

Doorwerking van kortdurende vertroebeling op de aanwezige populatie vogels en zeezoog-dieren is niet te verwachten. Voor visetende vogels, die in het bovenste deel van de water-kolom foerageren kan vertroebeling leiden tot een afname van het vangstsucces (Baptist & Leopold 2010), maar hier wordt gewerkt op een diepte van enkele tientallen meters. Voor zeehonden kan sprake zijn van een direct effect door een mogelijk tijdelijke vermindering van doorzicht in het water waardoor het foerageersucces kan worden beïnvloed. Hetzelfde geldt voor zichtjagende vissen. Dit is vooral lokaal en tijdelijk aan de orde. Naar verwachting is dit effect niet groter dan dat wat uitgaat van de fysieke aanwezigheid van de schepen en werk-

zaamheden. Voor walvisachtige is geluid maatgevend boven het visuele zintuig (Wahlberg *et al.* 2017). Mogelijke effecten op walvisachtigen door vertroebeling worden daarom niet nader beschouwd.

*In vergelijking met de referentiesituatie wordt de kans daarom klein geacht dat negatieve effecten door kortdurende vertroebeling ontstaan en worden geen negatieve effecten verwacht op primaire productie en de betreffende soortgroepen.*

### *6.1.6 Verlies en directe verstoring van habitat/flora/fauna op de zeebodem*

Directe verstoring van habitat/flora/fauna kan de volgende natuurwaarden betreffen: habitats en ongewervelden. Samenvattend voor deze natuurwaarden wordt hieronder nader daarop ingegaan.

Door de aanleg van de kabel zal de zeebodem langs de voorgestelde zeekabelcorridor tijdelijk worden verstoord. De kabel zal op een diepte tussen 1,5 m en 2 m worden ingegraven. Daarom is te verwachten dat de organismen in de directe omgeving van de kabel ten minste zullen worden verplaatst of vernietigd. Het merendeel van de organismen zal worden beschadigd, of door de graafwerkzaamheden of door een toegenomen kwetsbaarheid voor roofdieren. Ook kan het, afhankelijk van de methode waarmee de kabel wordt ingegraven en de stromings- en de getijdenenergie, enkele maanden duren voordat de gegraven sleuf volledig bijgevuld is. Dit effect beperkt zich echter tot de directe omgeving van de kabel.

Het Friese Front hoort bij de gebieden met een hogere biodiversiteit. Zoals in Hoofdstuk 4 is beschreven hoort het merendeel van het tracé bij de minder diverse gebieden wat betreft soortenrijkdom, soortendichtheid, totale biomassa en aantallen kwetsbare soorten. Ook was de conclusie van het benthosonderzoek dat er geen bijzondere habitattypes zijn aangetroffen (Orbicon 2019a). Wel zijn bepaalde soorten aangetroffen, die in principe deel uit kunnen maken van bepaalde habitattypes en/of bij de aangewezen indicatorsoorten van de KRM horen. De soort *Sabbelaria spinulosa* is gevoelig voor mechanische schade (zoals bodem-beroerende visserij), zandwinningactiviteiten en verlies van substraat. Ook de aangetroffen moddergarnalen zijn gevoelig voor bodemverstoring door bodemberoerende visserij en andere menselijke activiteiten die het habitat aantasten (omdat hun gangen, of de kreeftjes zelf dan beschadigen) (Fey-Hofstede & Witbaard 2013; Narberhaus *et al.* 2012). Er zijn voorts geen individuen van de Noordkromp (*Arctica islandica*) aangetroffen. Dit komt ook overeen met de verspreiding van deze soort. Het Friese Front vormt onderdeel van de zuidrand van het verspreidingsgebied van de Noordkromp. De soort wordt voornamelijk in de noordelijke helft van het Friese Front aangetroffen. Langs de zuidrand van het Friese Front zijn de dichtheden sterk afgenomen, hoogstwaarschijnlijk door de toegenomen boomkorvisserij (Lindeboom *et al.* 2008). In combinatie met het benthosonderzoek waarbij de Noordkromp niet is aangetroffen is de kans zeer klein dat de Noordkromp alsnog in de omgeving van het kabeltracé voorkomt.

Slechts een klein deel van de zeebodem zal worden verstoord. Andrulewicz *et al.* (2003) stelden één jaar na de installatie van een zeekabel geen significante effecten op de diversiteit, abundantie of biomass van macrofauna op de kabelroute of in de directe omgeving vast.. Het herstelvermorgen heeft met meerdere factoren te maken en volledig herstel van habitat/flora/fauna kan meerdere jaren duren (Taormina *et al.* 2018). De tijdelijke verstoring van habitat als gevolg van het project zal daarom leiden tot een klein negatief effect voor de zeebodemdieren ten opzichte van de referentiesituatie.

*In vergelijking met de referentiesituatie is door de tijdelijke verstoring van habitat als gevolg van het project daarom een klein negatief effect voor het zeebodemdierenleven te verwachten.*

### *6.1.7 Verlies van habitattypes*

Als gevolg van de plaatsing van hard substraat op de zeebodem (voor erosiebescherming of bescherming van kruisingen met andere kabels) kan verlies van habitattypes optreden. In totaal zal in het Nederlandse deel van het traject sprake zijn van 13 kabelkruisingen (AECOM 2021), waardoor een geschat oppervlak van 32.000 $m^2$ veranderd in hard substraat (steenbestorting). Uit het benthosonderzoek bleek dat er geen bijzondere en/ of volledige habitattypes zijn aangetroffen (zie Hoofdstuk 4, Orbicon 2019a). Omdat er alleen soorten, die in principe deel uit kunnen maken van bepaalde habitattypes en/of bij de aangewezen indicatorsoorten van de KRM horen, zijn aangetroffen en het betroffen gebied beperkt blijft tot de directe omgeving van de zeekabel, worden geen negatieve effecten op habitattypes verwacht.

*Rekening houdend met het bovenstaande worden door de effecten van verlies van habitat geen negatieve effecten verwacht op habitattypes.*

### *6.1.8 Veranderingen in aanwezigheid van prooidieren*

Veranderingen in aanwezigheid van prooidieren kunnen een invloed op alle in of op de zee levende natuurwaarden hebben. Dit betreft: vogels, zeezoogdieren, habitats, ongewervelden en vissen. Samenvattend voor alle natuurwaarden wordt hieronder nader op veranderingen in de aanwezigheid van prooidieren ingegaan.

De gezamenlijke effecten van onderwatergeluid, verontreiniging, vertroebeling of directe verstoring kunnen leiden tot directe of indirecte veranderingen in de aanwezigheid van de vis-, schaal- en schelpdierpopulaties (Taormina *et al.* 2018). Dit kan gevolgen hebben voor de voedselbeschikbaarheid van vogels, zeezoogdieren, ongewervelden, vissen en ook op de dynamiek van habitats. Op basis van de beoordeling betreffende de bovengenoemde effecten en de lokale en/of voorbijgaande aard van de kabelaanlegwerkzaamheden zullen samenhangende effecten naar verwachting minimaal zijn.

*Rekening houdend met het bovenstaande zou een eventuele, met veranderingen in de prooibeschikbaarheid samenhangende effect op de natuurwaarden minimaal zijn. Negatieve effecten worden niet verwacht.*

## 6.2 Effectbepaling in de exploitatiefase

### *6.2.1 Elektromagnetische (EM-)velden*

De voorgestelde diepte waarop de NeuConnect kabels zal worden ingegraven ligt tussen de 1,5 m en 2 m. Het aanleggen van twee kabels in één sleuf en een ingraafdiepte van ten minste 1 m zorgt ervoor dat de veldsterktes beperkt blijven en dat de meeste soorten niet worden beïnvloed door de krachtigste velden direct aan de kabel (Gill *et al.* 2005, Snoek *et al.* 2016). Volgens modelleringen zwakken opgewekte magnetische velden binnen circa 10 meter af tot een sterkte die minder bedraagt dan het aardmagnetisch veld (circa 49 µT, AECOM 2021, Fichtner 2018). De kennis over de effecten van elektromagnetische (EM-)velden op mariene dieren is evenwel heel beperkt. Er is bekend dat veranderingen in het aardmagnetische veld

een effect kunnen hebben op o.a. het gedrag, de oriëntatie/navigatie of indirecte effecten op predator-prooi-relaties (Taormina *et al.* 2018). Hieronder wordt nader op het effect van elektromagnetische velden op de natuurwaarden zeezoogdieren, ongewervelden en vissen ingegaan.

***Ongewervelden***

Ten aanzien van ongewervelden hebben enkele studies kleine tot niet significante effecten gevonden wat betreft de invloed van elektromagnetische velden op deze soortgroep. Gebaseerd op verschillende studies zijn er ook geen aanwijzingen dat elektromagnetische velden van zeekabels een barrièrewerking voor mariene dieren hebben (Snoek *et al.* 2020). Dezelfde studie concludeert echter ook dat er nog een grote leemte in kennis is en dat negatieve effecten niet uit te sluiten zijn. Een onderzoek heeft laten zien dat de Amerikaanse zeekreeft een subtiele gedragsverandering als reactie op elektromagnetische velden door een zeekabel toont (Hutchison *et al.* 2018, 2020). Ook Scott *et al.* (2018) heeft aangetoond dat elektromagnetische velden significante effecten op de Noordzeekrab hebben in de vorm van veranderingen in gedrag en fysiologie. Een andere, recent uitgevoerde studie kon echter geen significante veranderingen in gedrag bij juveniele zeekreeften vaststellen (Taormina *et al.* 2020). Ten aanzien van de NeuConnect kabel verwachten we dat het effect door elektromagnetische velden op ongewervelden verwaarloosbaar klein zal zijn. De redenen daarvoor zijn de kleine omvang van de zone waarin elektromagnetische velden effect hebben, de ingraafdiepte van 1.5-2 m, en het feit dat de sterkte van de velden waaraan organismen worden blootgesteld beperkt zal blijven. Dit is tevens geconcludeerd in de milieueffectenanalyse voor het Britse en het Duitse deel van de NeuConnect kabel (AECOM 2019, Schütte 2020). Door de boven beschreven leemte in kennis over dit effect wordt echter uitgegaan van een klein negatief effect.

*Rekening houdend met de bovenstaande overwegingen kan worden geconcludeerd dat met elektromagnetische straling samenhangende effecten op ongewervelden minimaal zullen zijn. Door de leemte in kennis wordt uitgegaan van een klein negatief effect.*

***Vissen***

Vissen zijn gevoelig voor elektromagnetische velden. Elasmobranchen - vooral haaien en roggen – zijn electroreceptief en kunnen hele lage elektrische (tot 0,5 µV/m) en elektromagnetische velden (20-75 µT) waarnemen en in hun mobiliteit worden beïnvloed (Taormina *et al.* 2018). De gedragsrespons kan soortspecifiek zijn en zelfs tussen individuen verschillen (Gill *et al.* 2009, Hutchison *et al.* 2018). Er is waargenomen dat Elasmobranchs door EMV op verschillende sterkten worden aangetrokken en afgeschrikt. Laboratoriumstudies hebben aangetoond dat de Gevlekte hondshaai aangetrokken wordt tot 10 µV/m op 0,1 m van de bron, vergelijkbaar met die geproduceerd door hun prooi, terwijl ze vermijdingsgedrag vertonen bij constante DC elektrische velden van 1.000 µV/m (Gill & Taylor 2001). Op basis van gepubliceerde drempels voor detectie, aantrekking en vermijding, is het waarschijnlijk dat demersale elasmobranchen in eerste instantie aangetrokken kunnen worden door de onderzeese kabel, maar afgeschrikt worden vanuit het gebied in de directe (< 1m) omgeving (Gill & Taylor 2001, Peters *et al.* 2007, Kimber *et al.* 2008). Een recent uitgevoerde studie heeft laten zien dat kleine roggen significant meer verkennend en foeragerend gedrag tonen wanneer deze blootgesteld zijn aan elektromagentische velden van HVDC kabels (Hutchison *et al.* 2020). Er zijn geen aanwijzingen dat verhoogde EMV's kunnen leiden tot fysiologische veranderingen in elasmobranchen. De mogelijkheid bestaat echter, dat elektrische velden die verband houden met het project het jachtgedrag kunnen verstoren, waarbij individuen meer tijd en energie moeten besteden aan het zoeken naar bio-elektrische velden die verband houden

met hun prooi. Bovenstaande studies geven tevens aan dat er meer onderzoek moet worden verricht naar de efecten van EMV, dat betreft ook eventuele effecten op populatieniveau. Vanwege de kleine omvang van de zone waarin elektromagnetische velden effect hebben, de diepteligging van de kabel en de lage sterkten wordt verwacht dat effecten verwaarloosbaar klein zullen zijn. Dit is tevens geconcludeerd in de milieueffectenanalyse voor het Britse en het Duitse deel van de NeuConnect kabel (AECOM 2019, Schütte 2020).Gezien de leemten in kennis gaan we wel uit van een klein negatief effect op vissen.

*Rekening houdend met de bovenstaande overwegingen kan worden geconcludeerd dat met elektro-magnetische straling samenhangende effecten op vissen minimaal zullen zijn. Door de leemte in kennis wordt uitgegaan van een klein negatief effect.*

***Zeezoogdieren***

Er zijn momenteel geen aanwijzingen dat zeehonden direct worden beïnvloed door of gevoelig zijn voor magnetische velden of gebruikmaken van deze velden (Gill *et al.* 2005). Bij walvisachtigen kunnen magnetische velden leiden tot tijdelijke veranderingen in de zwemrichting of omwegen tijdens migraties (Gill *et al.* 2005). Arcadis (2015) geeft aan, dat een Bruinvis het veld van een 1 m diep in de zeebodem ingegraven hoogspanningskabel kan waarnemen tot op een afstand van ongeveer 15 meter. Door de voorgestelde ingraafdiepte van de NeuConnect kabel van 1,5 m tot 2 m zal de afstand waarop zeezoogdieren de kabel waar zullen nemen iets kleiner zal zijn. Het gebied waarop de elektromagnetische velden effect hebben zal klein zijn en de veldsterkte waaraan organismen worden blootgesteld beperkt blijven (zie Tabel 4-4, AECOM 2021). Daarom is geconcludeerd dat verstoring veroorzaakt door elektromagnetische velden als gevolg van de aanwezige kabels niet zal leiden tot een wijziging van de referentiesituatie voor zeezoogdieren. Dit is tevens geconcludeerd in de milieueffectenanalyse voor het Britse en het Duitse deel van de NeuConnect kabel (AECOM 2019, Schütte 2020). Door de eerder beschreven leemte in kennis over dit effect wordt echter uitgegaan van een klein negatief effect.

*Rekening houdend met de bovenstaande overwegingen kan worden geconcludeerd dat met elektromagnetische straling samenhangende effecten op zeezoogdieren minimaal zullen zijn. Door de leemte in kennis wordt uitgegaan van een klein negatief effect.*

### *6.2.2 Warmteafgifte*

Warmteafgifte kan de volgende natuurwaarden betreffen: habitats en ongewervelden. Samenvattend wordt hieronder nader op deze natuurwaarden ingegaan.

Als zeekabels worden begraven, kan het omringende sediment worden verwarmd. Gezien de kleine invloedszone (directe omgeving van de kabel) en de te verwachten geringe warmte-straling worden over het algemeen kleine effecten door warmteafgifte verwacht (Taormina *et al.* 2018). Zoals in paragraaf 2.6. is aangegeven is het niet waarschijnlijk dat opwarmings-effecten optreden van de waterkolom en het bovenste deel van de zeebodem gezien de ingraafdiepte tussen 1,5 m en 2 m en enorme warmtecapaciteit van het waterlichaam. Op demersale en epibenthische organismen zijn daarom geen effecten te verwachten. Alleen zich ingravende fauna lopen risico op dergelijke effecten, waarbij soorten die zich diep ingraven mogelijk blootstaan aan relatief grotere effecten. Dit betreft bijvoorbeeld de Harige molkreeft, die burchten tot een diepte van 68 cm graaft (Hall-Spencer *et al.*1999). Deze soort is onder andere in het plangebied aangetroffen (Orbicon 2019a).

Uit modelleringen van Meißner & Sordyl (2006) dat bij een ingraafdiepte van minimaal 1 m in de meeste gevallen aan het 2K criterium wordt voldaan, wat betekent dat de temperatuurstijging op een bodemdiepte van 0,2 m <2°C bij zal bedragen (zie 2.6 Mogelijke effecten voor een uitgebreide beschrijving). Daarmee worden grote en directe temperatuureffecten op benthische fauna voorkomen. De ingraafdiepte van de NeuConnect kabel ligt tussen 1,5 m en 2 m. Ook betreft een mogelijke verwarming slechts een kleine oppervlakte. Voor de Viking Link zijn modellen van de kabelverwarmingsefecten opgesteld, die mogelijk ook toepasbar zijn op de aanleg van de NeuConnect kabel (Brakelman & Stammen 2017). Daaruit blijkt dat de temperatuurstijging – zelfs in het meest ongunstige scenario van gebundelde kabels – waarschijnlijk beperkt zal blijven tot een smalle strook boven de kabels, met een verwaarloosbare zijdelingse warmteoverdracht. De voetafdruk van een eventueel verwarmingseffect zal beperkt blijven tot een smalle strook van minder dan 10 m boven de kabel. Een mogelijke verwarming van het sediment zal daarom naar verwachting verwaarloosbaar zijn.

*Rekening houdend met de bovenstaande overwegingen kan worden geconcludeerd dat met warmteafgifte samenhangende effecten op habitats en ongewervelden minimaal zullen zijn. Negatieve effecten worden niet verwacht.*

### *6.2.3 Onderwatergeluid*

Bij onderwatergeluid in de exploitatiefase gaat het met name om trillingen van de kabel. De intensiteit van het geluid tijdens de exploitatiefase is naar verwachting veel lager dan tijdens de aanlegfase en buitenbedrijfstelling (voor een beschrijving van het effect van onderwatergeluid zie aanlegfase en buitenbedrijfstelling - onderwatergeluid). Ook zal naar verwachting een gewenning aan de permanentie van het geluid door een zeekabel plaatsvinden. Effecten door onderwatergeluid op de betreffende soorten tijdens de exploitatiefase zullend daarom minimaal zijn.

*In vergelijking met de referentiesituatie wordt de kans daarom verwaarloosbaar klein geacht dat negatieve effecten door onderwatergluid ontstaan en worden geen negatieve effecten verwacht op de betreffende soortgroepen.*

### *6.2.4 Verontreiniging*

Verontreiniging kan ook tijdens de exploitatie optreden. Dit kan komen door het vrijkomen van vervuilende stoffen, zoals zware metalen, die zijn verwerkt in de kabel zelf (Meißner *et al.* 2006). Het is aan te nemen dat dergelijke effecten alleen een invloed op de directe omgeving van de kabel hebben. Het risico op verontreiniging over het algemeen als laag ingeschat (Taormina *et al.* 2018). Zoals in paragraaf 2.1.2 is beschreven is op dit moment nog niet duidelijk welke soort kabel gebruikt gaat worden. Beide soorten kabels zijn zodanig omhuld dat het risico op verontreiniging tijdens de exploitatiefase als laag wordt ingeschat.

*In vergelijking met de referentiesituatie wordt de kans daarom verwaarloosbaar klein geacht dat negatieve effecten door verontreiniging ontstaan en worden geen negatieve effecten verwacht op de betreffende soortgroepen.*

### *6.2.5 Tijdelijke onderhoudswerkzaamheden*

De mogelijke effecten van onderhoudswerkzaamheden zijn vergelijkbaar met de effecten van aanlegwerkzaamheden, maar zullen waarschijnlijk lokaler optreden, korter duren en daarom beperkter van omvang zijn. Echt onderhoud met fysieke beroering van de zeebodem is alleen

aan de orde wanneer kabels bloot komen te liggen of er andere bodemverstoringen zijn; het ligt in de rede dat dit heel weinig voorkomt. Rekening houdend met de bovenstaande overwegingen voor de aanlegfase kan worden geconcludeerd dat de effecten van tijdelijke onderhoudswerkzaamheden niet zullen leiden tot negatieve effecten op de betreffende soortgroepen en habitats.

*In vergelijking met de referentiesituatie wordt de kans daarom verwaarloosbaar klein geacht dat negatieve effecten door tijdelijke onderhoudswerkzaamheden ontstaan en worden geen negatieve effecten verwacht op de betreffende soortgroepen.*

### *6.2.6 Samenvattend overzicht van effecten*

Op basis van de voorgaande effectbepaling volgt in Tabel 6-1 een samenvattend overzicht van de effecten en een vergelijking met de referentiesituatie, per projectfase. Er zijn vijf mogelijke uitkomsten. Een van het NeuConnect initiatief uitgaand effect kan sterk negatief (--), licht negatief (-), neutraal (0), licht positief (+) of sterk positief (++) zijn.

Grotendeels zal het NeuConnect initiatief tot neutrale (0) effecten leiden in vergelijking met de huidige situatie. Licht negatieve effecten zijn te verwachten door verlies en directe verstoring van habitat op en in de zeebodem op ongewervelden. Negatieve effecten zijn (mogelijk) te verwachten door visuele verstoring op vogels, in het bijzonder op de Zeekoet in de voor deze soort kwetsbare zomerperiode. Daarnaast is er een (klein) negatief effect dat samenhangt met effecten door onderwatergeluid op zeezoogdieren en door elekotromagnetische velden op ongewervelden, vissen en zeezoogdieren in de exploitatiefase, ook gezien de leemten in kennis op dat punt.

*Tabel 6-1 Samenvattend overzicht van de effecten, die kunnen optreden tijdens de aanlegfase, buitenbedrijfstelling en exploitatiefase van de NeuConnect kabel. Deze effectinschatting heeft betrekking op effecten zonder mitigerende maatregelen.*

| **Effecten/ Natuurwaarden** | **Risico op optreden** | **Habitat** | **Ongewervelden** | **Vissen** | **Vleermuizen** | **Zeezoogdieren** | **Vogels** |
|---|---|---|---|---|---|---|---|
| ***Aanlegfase en buitenbedrijfstelling*** | | | | | | | |
| Verlies en directe verstoring van habitat op en in de zeebodem | g/m | 0 | - | | | | |
| Visuele verstoring (overige vogels/ Zeekoet) | m | | | | 0 | 0 | 0 / - |
| Aanvaringsrisico | zg | | | | | 0 | |
| Onderwatergeluid (installatie kabel) | m | | | 0 | | 0 / - | 0 |
| Vertroebeling | m | 0 | 0 | 0 | | 0 | 0 |
| Veranderingen in aanwezigheid van prooidieren | m | 0 | 0 | 0 | | 0 | 0 |
| Verontreiniging | g | 0 | 0 | 0 | | 0 | 0 |
| ***Exploitatie*** | | | | | | | |
| Onderwatergeluid | m | | | 0 | | 0 | 0 |
| Elektromagnetische velden | g | | - | - | | - | |
| Warmteafgifte | zg | 0 | 0 | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| Verontreiniging | zg | 0 | 0 | 0 | 0 | 0 |
| Tijdelijke onderhoudswerkzaamheden | zg | 0 | 0 | 0 | 0 | 0 |

## 6.3 Beoordeling per beschermingsregime

Uit de effectbepaling en de beoordeling volgen de conclusies in het kader van de beschermingsregimes Soortbescherming (Wnb), NNN, OSPAR, ASCOBANS en KRM zoals beschreven in 3.6 Beoordelingskader.

### *6.3.1 Soortbescherming - Wet natuurbescherming*

In het kader van de soortbescherming in de Wnb zijn verbodsbepalingen van kracht om soorten te beschermen. Dit is in deze situaite van toepassing op vleermuizen, vogels en zeezoogdieren. Indien sprake is van een overtreding van de verbodsbepaling(en) dient een ontheffing te worden aangevraagd.

***Vleermuizen***
Ten aanzien van de onder artikel 3.5 van de Wet natuurbescherming vallende vleermuizen geldt dat door effecten in verband met de aanleg, buitenbedrijfstelling en de exploitatie van de NeuConnect kabel geen van de verbodsbepaling overtreden zal worden. Wel dient in het kader van de Zorgplicht ’s nachts aan boord van schepen alleen de minimaal benodigde verlichting worden toegepast.

***Vissen***
De Steur en de Houting zijn beschermd onder artikel 3.5 van de Wet natuurbescherming. In de effectbepaling is geconcludeerd dat door de leemte in kennis wat betreft elektromagnetische straling uitgegaan wordt van een klein negatief effect tijdens de exploitatiefase. Aangezien het hier gaat om zeer zeldzame soorten en het zeer onwaarschijnlijk is dat de soorten langs het kabeltracé voorkomen geldt dat door effecten in verband met de aanleg, buitenbedrijfstelling en de exploitatie van de NeuConnect kabel de verbodsbepaling uit artikel 3.5 Wnb niet wordt overtreden. Wel geldt ten aanzien van alle vissen de Zorgplicht in het kader van de Wnb.

***Zeezoogdieren***
Zoals in paragraaf 9.6 aangegeven wordt uitgegaan van een klein negatief effect op zeezoogdieren door elektromagnetische velden en door onderwatergeluid dat ontstaat door de installatie van kabels en geofysisch onderzoek. Op basis van een separaat onderzoek ten aanzien van onderwatergeluid door geofysisch onderzoek worden effecten op de bruinvispopulatie verwaarloosbaar geacht. Omdat bruinvissen in principe kunnen worden verstoord door het geluid van de sub-bottom profiler en er ten aanzien van onderwatergeluid nog leemte in kennis bestaat, worden zekerheidshalve voorzorgsmaatregelen getroffen in de vorm van Acoustic Deterrent Devices, Soft Starts en het gebruik van Marine mammal observers (Box 2). Door het nemen van deze maatregelen worden eventuele effecten door onderwatergeluid (installatie van kabels/geofysisch onderzoek) verwaarloosbaar geacht. Een overtreding van de verbodsbepalingen uit artikel 3.5 Wnb ten aanzien van bruinvissen is daarom niet te verwachten. Onderwatergeluid als gevolg van het opruimen van NGE kan letsel bij zeezoogdieren veroorzaken. Daarmee worden in principe de verbodsbepalingen uit artikel 3.5 Wnb overtreden. Echter, doordat het Ministerie van Defensie voorschriften volgt en mitigerende maatregelen neemt worden effecten door het opruimen van NGE tot een aanvaardbaar niveau teruggebracht.

Gezien de kortdurende, lokale en voorbijgaande aard van de kabelaanlegwerkzaamheden en het grote verspreidingsgebied van zeezoogdieren geldt dat door overige effecten in verband met de aanleg, buitenbedrijfstelling en de exploitatie van de NeuConnect kabel de verbodsbepaling uit artikel 3.5 Wnb niet wordt overtreden.

***Vogels***
Volgens Artikel 3.1 is het verboden om vogelsoorten vermeld onder de Europese Vogelrichtlijn, met name gedurende de broedperiode, opzettelijk te storen. Dit verbod is niet van toepassing indien de storing niet van wezenlijke invloed is op de staat van instandhouding van de betreffende soort. Uit de effectbepaling blijkt dat er geen negatieve effecten worden verwacht als gevolg van visuele verstoring door schepen bij de aanleg en buitenbedrijfstelling van de NeuConnect kabel. De verbodsbepaling uit artikel 3.1 Wnb wordt daarom niet overtreden ten aanzien van vogels. Wel dient in het kader van de Zorgplicht's nachts aan boord van schepen alleen de minimaal benodigde verlichting worden toegepast. Voor de Zeekoet is een aparte Passende beoordeling uitgevoerd, en kan in de kwetsbare zomerperiode – en zonder mitigatie - wel sprake zijn van een negatief effect. Voor overige effecten in verband met de aanleg, buitenbedrijfstelling en de exploitatie van de NeuConnect kabel is de kans verwaarloosbaar klein dat negatieve effecten op vogels ontstaan.

### *6.3.2 NNN*

Voor het NNN is het relevant voor de beoordeling of het initiatief, en de effecten die daarvan uitgaan, kunnen leiden tot aantasting van de wezenlijke waarden en kenmerken. Uit de effectanalyse komt naar voren dat – buiten het mogelijk tijdelijke effect op de Zeekoet in het Friese Front – het niet te verwachten is dat er belangrijke negatieve effecten op soorten en habitats zijn. Voor de mogelijke invloed – hoewel gering (hoofdstuk 5) – op de Zeekoet vindt mitigatie plaats door niet in de kwetsbare periode werkzaamheden in het Friese Front uit te voeren. De conclusie is derhalve, dat de aanleg van de Neuconnect kabel, en de tijdelijke beperkte effecten die daarvan uitgaan, niet leiden tot een aantasting van de wezenlijke waarden en kenmerken op het NNN-gebied Noordzee.

### 6.3.3 Internationale beschermingsregimes

**OSPAR**

*Ongewervelden*
De door OSPAR als kwetsbare soort met de aanbeveling 'Bescherming en herstel' aangewezen Noordkromp is niet langs het kabeltracé aangetroffen (Orbicon 2019a). Negatieve effecten door de aanleg, buitenbedrijfstelling en de exploitatie van de NeuConnect kabel op deze soort worden daarom niet verwacht.

*Habitats*
De door OSPAR aangewezen habitattypes (Oesterbanken, *Sabellaria spinulosa* riffen, Zeeveer & gravende infauna communities) zijn niet langs het kabeltracé aangetroffen (Orbicon 2019a). Negatieve effecten door de aanleg, buitenbedrijfstelling en de exploitatie van de NeuConnect kabel op habitattypes worden daarom niet verwacht, zie paragraaf 9.6 voor een uitgebreide beschrijving.

*Vissen*

Voor de dertien vissoorten, die door OSPAR aangewezen en relevant voor de voorliggende beoordeling zijn, geldt voor de Steur, de Paling en de Vleet de aanbeveling 'Bescherming en herstel'. Voor de overige soorten (Elft, Houting, Gevlekte rog, Kabeljauw, Langsnuitzee-paardje, Kortsnuitzeepaardje, Zeeprik, Stekelrog, Zalm, Doornhaai) geldt de aanbeveling 'Bescherming en behoud' (Tabel 9-1). Zoals in paragraaf 9.6 aangegeven wordt uitgegaan van een klein negatief effect op vissen door elektromagnetische velden omdat hier nog een leemte in kennis bestaat. Overige negatieve effecten worden niet verwacht door de aanleg, buiten-bedrijfstelling en de exploitatie van de NeuConnect kabel. Er kan daarom worden geconcludeerd dat het voorliggende initiatief niet de bescherming van bovengenoemde soorten in het kader van OSPAR in gevaar zal brengen.

*Zeezoogdieren*
Voor de door OSPAR als kwetsbare soort aangewezen Bruinvis geldt de aanbeveling 'Bescherming en herstel'. Zoals in paragraaf 9.6 aangegeven wordt uitgegaan van een klein negatief effect op zeezoogdieren door elektromagnetische velden en door onderwatergeluid (installatie van kabels/geofysisch onderzoek). Op basis van een separaat onderzoek ten aanzien van onderwatergeluid door geofysisch onderzoek worden effecten op de bruinvispopulatie verwaarloosbaar geacht. Omdat bruinvissen in principe kunnen worden verstoord door het geluid van de sub-bottom profiler en er ten aanzien van onderwatergeluid nog leemte in kennis bestaat, worden zekerheidshalve voorzorgsmaatregelen getroffen (Box 2). Eventuele effecten door onderwatergeluid (installatie van kabels/ geofysisch onderzoek) worden daarom verwaarloosbaar geacht. Onderwatergeluid als gevolg van het opruimen van NGE kan letsel bij zeezoogdieren veroorzaken en in principe de bescherming van de Bruinvis in het kader van OSPAR in gevaar brengen. Echter, met passende voorzorgs-maatregelen kunnen effecten door het opruimen van NGE tot een aanvaardbaar niveau worden teruggebracht.

Gezien de kortdurende, lokale en voorbijgaande aard van de kabelaanlegwerkzaamheden en het grote verspreidingsgebied van zeezoogdieren worden geen overige negatieve effecten in verband met de aanleg, buitenbedrijfstelling en de exploitatie van de NeuConnect kabel verwacht. Naar verwachting zal het voorliggende initiatief niet de bescherming van boven-genoemde soorten in het kader van OSPAR in gevaar brengen.

*Vogels*
Ten aanzien van de door OSPAR aangewezen vogelsoorten die relevant voor de voorliggende beoordeling zijn (Kleine mantelmeeuw, Vale pijlstormvogel en Drieteenmeeuw) geldt de aanbeveling 'Bescherming en behoud'. Uit de effectbepaling blijkt dat er geen negatieve effecten worden verwacht als gevolg van visuele verstoring door schepen bij de aanleg en buitenbedrijfstelling van de NeuConnect kabel. Voorn de Zeekoet is een aparte beoordeling uitgeveord. Voor overige effecten in verband met de aanleg, buitenbedrijfstelling en de exploitatie van de NeuConnect kabel is de kans verwaarloosbaar klein dat negatieve effecten op vogels ontstaan. Het voorliggende initiatief zal daarom niet de bescherming van bovengenoemde soorten in het kader van OSPAR in gevaar brengen.

**ASCOBANS**
Zoals in paragraaf 9.6 aangegeven wordt uitgegaan van een klein negatief effect op zeezoog-dieren door elektromagnetische velden en door onderwatergeluid (installatie van kabels/ geofysisch onderzoek). Op basis van een separaat onderzoek ten aanzien van onderwatergeluid door geofysisch onderzoek worden effecten op de bruinvispopulatie verwaarloosbaar geacht. Omdat bruinvissen in principe kunnen worden verstoord door het geluid van de sub-bottom profiler en er ten aanzien van onderwatergeluid nog leemte in kennis

bestaat, worden zekerheidshalve voorzorgsmaatregelen getroffen (Box 2). Eventuele effecten door onderwatergeluid (installatie van kabels/ geofysisch onderzoek) worden daarom verwaarloosbaar geacht. Onderwatergeluid als gevolg van het opruimen van NGE kan letsel bij zeezoogdieren veroorzaken. Daarmee kan in principe het interim doel van ASCOBANS voor Bruinvissen (houden van de populatie op minimaal 80% van de draagkracht) in gevaar worden gebracht. Echter, doordat het Ministerie van Defensie passende voorzorgsmaatregelen treft worden effecten door het opruimen van NGE tot een aanvaardbaar niveau worden teruggebracht.

Gezien de kortdurende, lokale en voorbijgaande aard van de kabelaanlegwerkzaamheden en het grote verspreidingsgebied van zeezoogdieren geldt dat door overige effecten in verband met de aanleg, buitenbedrijfstelling en de exploitatie van de NeuConnect kabel de verbodsbepaling uit artikel 3.5 Wnb niet wordt overtreden.

KRM
Voor de KRM zijn een aantal descriptoren van belang, die we hier aangeven, en wat de mogelijk invloed hierop is van de aanleg van de NeuConnect kabel. Voor de KRM zijn, zoals in paragraaf 9.3 aangegeven, de descriptoren D1, D4, D6, D7, D8 en D11 van belang voor de beoordeling van effecten.

*D1: Biodiversiteit:*
Door de aanleg van de kabel (i.e. graven sleuf) zal de zeebodem langs het voorgestelde tracé tijdelijk worden verstoord, waarbij er ook slib vrij in de waterkolom komt. De organismen in de directe omgeving van de kabel zullen worden verplaatst of vernietigd. Het gaat hier ook om de zeven indicatorsoorten van de KRM die als bodemsoorten voor het Friese Front zijn aangewezen (zie paragraaf 9.2). De achteruitgang van de habitat zal tijdelijk zijn: de sleuf wordt deels weer opgevuld en zal binnen een jaar na installatie weer opnieuw door zeebodemfauna worden gekoloniseerd (volledig herstel van de infauna in het projectgebied kan meerdere jaren duren); het opgeloste slib zal weer bezinken. Bovendien is het getroffen oppervlak verwaarloosbaar ten opzichte van het totale habitat dat in de Noordzee beschikbaar is. De tijdelijke verstoring van habitat als gevolg van het project zal daarom leiden tot een klein negatief effect voor de zeebodemdieren ten opzichte van de referentiesituatie. Maar op de langere termijn is er geen risico dat de goede milieutoestand wordt aangetast

*D4: Voedselweb*
De mariene voedselketen kan worden aangetast omdat er tijdelijk minder prooidieren beschikbaar kunnen zijn door een gezamenlijke effect van onderwatergeluid, verontreiniging, vertroebeling, directe verstoring of elektromagnetische velden. Op basis van de beoordeling betreffende de genoemde effecten en de kortdurende, lokale en voorbijgaande aard van de kabelaanlegwerkzaamheden zullen samenhangende effecten naar verwachting minimaal zijn.

*D6: Bodemintegriteit*
Het graven van de sleuf heeft effect op de zeebodem en daarmee op de organismen die op en in de zeebodem leven. De integriteit van de zeebodem zal worden aangetast door de kabelbescherming die wordt aangebracht waar kabels elkaar kruisen. Maar vanwege het relatief kleine oppervlak en de tijdelijke aard van de werkzaamheden zullen de structuur en functies van de bodem en benthische ecosystemen niet negatief worden beïnvloed.

*D7: Hydrografische eigenschappen*
De hydrografische eigenschappen van de bodem zullen veranderen, omdat het waarschijnlijk een tijd duurt voordat de sleuf weer volledig is opgevuld met sediment. Effecten zullen alleen

lokaal zijn. Ook zal de troebelheid toenemen als gevolg van het graven van de sleuf, waardoor hydrografische kenmerken zullen veranderen. Dit effect zal lokaal en tijdelijk zijn. Voor deze descriptor zal er daarom geen effect zijn op de goede milieutoestand.

*D8: Gevaarlijke stoffen*
Wanneer de werkzaamheden, die vereist zijn om de kabel te leggen, zorgvuldig en volgens internationale regels worden uitgevoerd, wordt verwacht dat er geen vervuilende / gevaarlijke stoffen in de omgeving vrijkomen. De goede milieutoestand zal daarom niet worden beïnvloed door vrijkomende vervuilende stoffen.

*D11: Energietoevoer, o.m. onderwatergeluid*
*1. Elektromagnetische velden*
Ten aanzien van het effect van elektromagnetische velden op ongewervelden, vissen, of zeezoogdieren langs het tracé (zie paragraaf 9.6 effectbepaling in de exploitatiefase) zijn er nog steeds leemten in kennis. Een recent uitgevoerd onderzoek heeft significante gedragsveranderingen bij de Amerikaanse zeekreeft en de Kleine rog door de blootstelling aan elektromagnetische velden vastgesteld (Hutchison *et al* 2020). Daarentegen hebben Taormina *et al.* (2020) geen significante gedragsveranderingen bij juveniele amerikaanse zeekreeften vastgesteld. Andere studies tonen aan dat gedragsrespons soortspecifiek zijn of zelfs tussen individuen verschillen (Gill *et al.* 2009, Hutchison *et al.* 2018). In het kader van het Wind op Zee Ecologisch Programma (WOZEP) worden de effecten van elektromagnetische velden op dit moment onderzocht (Snoek *et al.* 2016, 2020). Eerste resultaten geven aan dat zwakke elektromagnetische velden in sommige gevallen meer effecten kunnen hebben dan sterke velden, omdat ze meer lijken op biologische magnetische velden die van nature voorkomen. Ook geven deze onderzoeken aan, dat er nog veel onzekerheden over de effecten van elektromagnetische velden zijn maar dat effecten niet uit te sluiten zijn. In de komende periode wordt hierover meer informatie verzameld. Aangezien er nog steeds leemten in kennis zijn, worden de effecten als licht negatief beoordeeld ten opzichte van de referentiesituatie.

*2. Impulsgeluid en voortdurend geluid onderwater*
De goede milieutoestand kan tijdelijk worden verstoord door meer onderwatergeluid als gevolg van extra scheepsverkeer, baggerwerkzaamheden en het aanbrengen van kabelbescherming op kabelkruisingen. Daarnast wordt geofysisch onderzoek uitgevoerd. Gezien de leemte in kennis over te verwachten geluidsdrukniveaus die ontstaan als gevolg van de installatie van kabels worden als voorzorg mitigerende maatregelen genomen (Box 2). Onderwatergeluid als gevolg van het opruimen van NGE kan letsel bij zeezoogdieren veroorzaken. Met passende voorzorgsmaatregelen worden effecten door het opruimen van NGEs tot een aanvaardbaar niveau worden teruggebracht. Vanwege de tijdelijke aard van het werk worden de werkzaamheden vanuit de KRM niet als schadelijk gezien. Door extra onderwatergeluid worden daarnaast ook descriptoren 1 (behoud van biodiversiteit) en 4 (voedselketens) aangetast, omdat sommige soorten het gebied tijdelijk zullen mijden (zie ook 9.6). Dat zal geen permanent effect op de goede milieutoestand hebben, aangezien deze soorten in het gebied zullen terugkeren wanneer de werkzaamheden zijn afgerond. Samenvattend leidt de voorgestelde activiteit niet tot een verandering met betrekking tot de referentiesituatie.

Concluderend voor wat betreft de effectbeoordeling KRM geldt dat op bovengenoemde descriptoren beperkte en tijdelijke effecten worden verwacht. Er zijn geen effecten op de overige descriptoren. Mogelijke effecten van elektromagnetische velden zijn nog veelal onduidelijk, omdat empirische effectstudies - naar de gevolgen van elektromagnetische velden in de Noordzee- ontbreken.

### *6.3.4.* Rode Lijst soorten

Voor alle soorten van de Rode Lijst geldt de Zorgplicht in het kader van de Wnb. Dit houdt in dat werkzaamheden, die nadelig kunnen zijn voor dieren en planten, in redelijkheid zo veel mogelijk worden voorkomen of maatregelen worden genomen om onnodige schade aan dieren en planten te voorkomen.

## 6.4 Cumulatieve effecten

In hoofdstuk 5.3. is ingegaan op de cumulatieve effecten voor het Natura 2000-gebied Friese Front. Voor eventuele cumulatie van effecten voor het kabeltracé in het overige deel van de Noordzee wordt dezelfde benadering gevolgd.

**Relevante projecten**
Relevante projecten voor de cumulatie zijn geïdentificeerd in tabel 5-3. Analoog aan de cumulatie beoordeling voor de passende beoordeling (paragraaf 5.3) zijn enkele projecten relevant, nl. het Windpark Hollandse Kust Noord (deels aanleg in voorbereiding), de Viking Kabel (aanleg in voorbereiding) en Zandwinning (in procedure). Overige projecten zijn niet relevant voor cumulatie omdat ofwel nog geen definitieve besluitvorming heeft plaatsgevonden (platforms olie- en gaswinning, windpark Ten Noorden van de Waddeneilanden, zie tabel 5-3), ofwel vanwege de grote afstand (niet in tabel).

**Mogelijke cumulatie van effecten**
Analoog aan de beschrijving voor het Friese Front (paragraaf 5.3) geldt dat een eventuele cumulatie met de aanleg van de windparken bij de Hollandse kust erg onwaarschijnlijk is, door 1) de grote afstand, 2) de andersoortige effecten (bij windpark vooral het onderwatergeluid bij de aanleg en tijdens de exploitatiefase de kans op aanvaring voor vogels). Voor de Viking kabel geldt, dat het type effecten grotendeels vergelijkbaar is, ook al gaat de Viking door andere gebieden en structuren in de Noordzee dan Neuconnect. De kans op cumulatie van effecten met Viking is evenwel klein. Dit heeft te maken met 1) het tijdelijke karakter van de aanleg en de kortdurende tijdsspanne van effecten, 2) het niet overlappen van de aanlegfase, en 3) de grote afstand tussen kabels waardoor geringe effecten direct rond de kabel (magnetisch veld, warmte) niet cumuleren. Ten aanzien van zandwinning geldt dat ook hier geen cumulatie van effecten te verwachten is. De reden hiervoor zijn 1) de grote afstand, 2) het tijdelijk karakter van de aanleg en de kortdurende tijdsspanne van effecten, 3) de beperkte uitstraling van effecten.

**Conclusie beoordeling cumulatieve effecten**
Er spelen op het NCP verschillende projecten waarvan de effecten in combinatie met die van de aanleg van de Neuconnect kabel dienen te worden verkend op mogelijke significantie. Uit de analyse blijkt, dat er geen interferentie is met de aanleg van windparken door vooral de grote afstanden tussen de projectgebieden en het verschil in aard van effecten. Voor de nieuwe platforms in de wijde omgeving van het kabeltracé die voorzien zijn om olie- en/of gasvelden te exploiteren, is de besluitvorming nog niet afgerond; deze zijn derhalve niet relevant voor de cumulatietoets. Ten aanzien van de Viking kabel geldt, dat ook daar geen cumulatie van effecten optreedt vanwege de grote afstand en verschil in fasering.

De conclusie is dan ook, dat bij de aanleg van de Neuconnect kabel geen cumulatie van effecten met andere projecten op treedt.

# 7 Aanbevelingen

In deze rapportage is op enkele punten geconstateerd, dat er leemten in kennis zijn of dat er beperkt informatie aanwezig is. Ook zijn aanbevelingen gedaan voor nadere verkenningen. Deze worden hieronder kort benoemd.

**Delen van ervaringen met andere kabeltracé's**
Op het NCP zijn in de loop der jaren verschillende kabel gelegd (zie bijvoorbeeld Figuur 3-1). Er is heel weinig gepubliceerde informatie over monitoring en de ervaring met deze aanleg en de effecten op het milieu. Dit punt geldt bijvoorbeeld voor de te verwachten geluiddrukniveaus en elektromagnetische velden die spelen bij kabelaanleg.

Het is in zijn algemeenheid aan te bevelen, dat monitoringgegevens die beschikbaar komen bij aanleg van kabels en andere projecten publiekelijk beschikbaar te maken. Nieuwe projecten en plannen kunnen dan daar nuttig gebruik van maken.

**Populatieschatting Zeekoet**
Er is (nog) geen populatieaantal aan de populatiedoelstelling toegevoegd, omdat de data hiervoor nog onvoldoende consistent zijn (Aanwijzingsbesluit Natura 2000 Friese Front, Didderen *et al*. 2017). De huidige staat van instandhouding van de Zeekoet is gunstig (synbiosys.alterra.nl; www.sovon.nl). Het is aan te bevelen om via gestandaardiseerde monitoring tot dergelijke schattingen te komen.

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Bezochte websites:

- www.synbiosys.alterra.nl
- www.noordzeeloket.nl
- www.ospar.org
- www.sovon.nl

# Bijlage 1 Memo – berekening effecten onderwatergeluid

HWE onderzoek en advies in waterbeheer en ecologie

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# Memo

**Aan:** Lara Mielke (Altenburg & Wymenga Ecologisch Onderzoek)

**Van:** Floor Heinis

**CC:**

**Datum:** 3 februari 2021

**Betreft:** Effecten onderwatergeluid door geofysisch onderzoek voor NeuConnect-kabel

## 1 Inleiding

De NeuConnect Interconnector is een hoogspanningskabel die in de zeebodem wordt aangelegd en de uitwisseling van elektriciteit tussen Duitsland en het Verenigd Koninkrijk mogelijk gaat maken. Rond de aanleg van deze zeekabel wordt op een aantal momenten geofysisch onderzoek uitgevoerd om de bodemgesteldheid in verschillende lagen in kaart te brengen en eventuele aanwezigheid van oude munitie te identificeren. Deze surveys beslaan een corridor met een breedte van ca. 500 m rond het tracé waarlangs de kabel wordt gelegd (Figuur 2-1).

Dit memo bevat een inschatting van de mogelijke effecten op populaties zeezoogdieren in het Nederlandse deel van de Noordzee (NCP) van het onderwatergeluid dat tijdens het geofysisch onderzoek wordt geproduceerd rond het geplande tracé voor de zeekabel. De lengte van het tracé op het NCP bedraagt ca. 265 km. Bij het bepalen van de effecten wordt uitgegaan van de aanpak die eerder is gevolgd voor het Kader Ecologie en Cumulatie 3.0 (Heinis *et al.* 2019)[1].

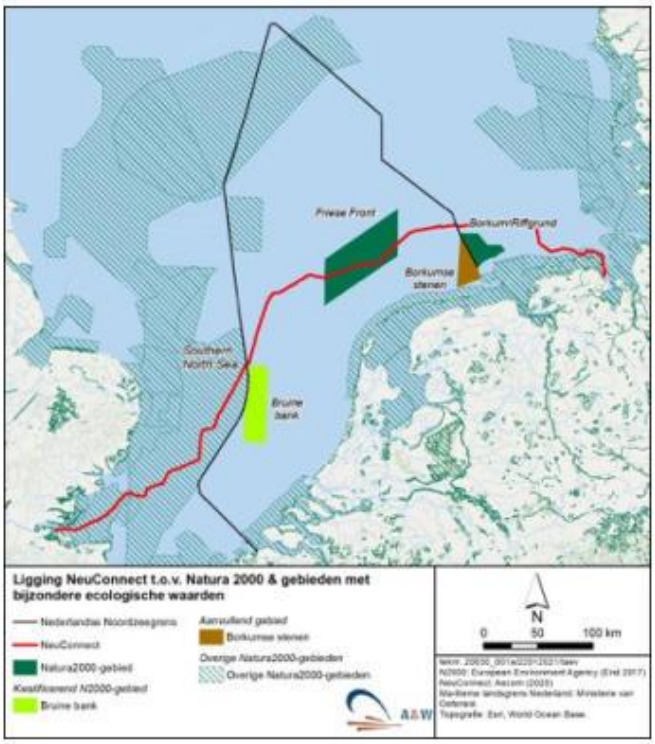
## 2 Bepaling effecten van onderwatergeluid op het zeeleven

### 2.1 Afbakening

Op het NCP en dus ook in het plangebied voor de NeuConnect kabel komen verschillende soorten zeezoogdieren voor. Van die soorten zijn alleen de aantallen van de bruinvis *Phocoena phocoena* dermate hoog dat effecten van het met de aanleg van de kabel gepaard gaande onderwatergeluid niet bij voorbaat kunnen worden uitgesloten. Gewone zeehonden *Phoca vitulina* en grijze zeehonden *Halichoerus grypus* komen weliswaar veel voor in de Noordzee, maar zijn sterk aan de kust gebonden. De dichtheid langs het tracé van de kabel is zeer laag en ligt tussen 0 en ca. 0,05 dieren per km$^2$ (Aarts *et al.* 2016). De kans dat een zeehond tijdens een van seismische surveys in de nabijheid is en effecten zou kunnen ondervinden, is daarom verwaarloosbaar klein. Andere soorten die sporadisch op het NCP worden aangetroffen zijn witsnuitdolfijn *Lagenorhynchus albirostris*, tuimelaar *Tursiops truncatus* en dwergvinvis *Balaenoptera acutorostrata* (zie bijvoorbeeld Geelhoed *et al.* 2020, Geelhoed *et al.* 2018 en eerdere rapportages). De aanwezigheid in het plangebied van deze soorten is dermate incidenteel dat effecten van de seismische surveys met zekerheid kunnen worden uitgesloten.

[1] Voor het Kader Ecologie en Cumulatie 3.0 (KEC 3.0) zijn de cumulatieve effecten onderzocht op o.a. bruinvissen van de aanleg van windparken op het NCP in de periode 2016 – 2030, inclusief de aanleg van de zeekabels tussen de windparken en het land. Op grond van de resultaten van het onderzoek zijn geluidsnormen afgeleid die bij de constructie van windparken niet mogen worden overschreden, zodat ontoelaatbare effecten op de bruinvispopulatie kunnen worden voorkomen.

Ook vissen kunnen een negatieve invloed van onderwatergeluid ondervinden, met name soorten die over een zwemblaas beschikken. Vissen zijn echter aanmerkelijk minder gevoelig voor onderwatergeluid dan zeezoogdieren (hogere gehoordrempel) en bovendien alleen gevoelig voor frequenties die lager liggen dan de frequenties van het door seismische apparatuur geproduceerde geluid. In combinatie met het gegeven dat het plangebied voor de NeuConnect kabel niet van specifieke betekenis is voor bepaalde vissoorten kan worden geconcludeerd dat effecten op vissen kunnen worden uitgesloten.




*Figuur 2-1 Tracé van de NeuConnect hoogspanningsgelijkstroomkabel*

## 2.2 Redeneerlijn

Bij het bepalen van de (cumulatieve) effecten van impulsief onderwatergeluid zijn in het Kader Ecologie en Cumulatie de volgende stappen onderscheiden (zie ook Heinis *et al.* 2015 en Heinis *et al.* 2019)[2]:

1. Berekenen van een realistische worst case in de verspreiding van het onderwatergeluid als gevolg van de activiteit;
2. Berekenen van de oppervlakte door het geluid verstoorde gebied;

[2] Bij het bepalen van de mogelijke doorwerking van effecten van impulsief onderwatergeluid op bruinvissen is ervan uitgegaan dat de effecten op het gedrag daarvoor maatgevend zijn. Dit heeft te maken met het feit dat het gebied waarin bruinvissen TTS en PTS kunnen oplopen veel kleiner is dan het gebied waarbinnen gedragseffecten kunnen optreden. Bovendien is onwaarschijnlijk dat bruinvissen die tijdens de pre-engineering survey in het plangebied aanwezig zijn lang genoeg aan het geluid van de seismische apparatuur worden blootgesteld om TTS of PTS op te lopen (zie ook rapportage voor NorthConnect kabel).

3. Berekenen van het aantal door het geluid verstoorde dieren uit de berekende verstoorde oppervlakten vermenigvuldigd met de lokale dichtheid van de dieren;
4. Berekening van het aantal dierverstoringsdagen uit het aantal verstoorde dieren per dag vermenigvuldigd met het aantal verstoringsdagen;
5. Schatten van het mogelijke effect op de populatie; voor bruinvissen is daarvoor gebruik gemaakt van het Interim PCoD model (versie 2019);
6. Beoordelen van de geschatte populatieafname en toetsen aan de, door de overheid gestelde ecologische doelstelling.

Deze stappen zijn voor het berekenen van de effecten van de seismische surveys voor de aanleg van de NeuConnect kabel doorlopen en beschreven in Sectie 3.

# 3 Berekening effecten

## 3.1 Door onderwatergeluid beïnvloed gebied door seismisch onderzoek

Rond de aanleg van de 2 hoogspanningsgelijkstroomkabels voor de NeuConnect Interconnector worden de volgende surveys met bijbehorende apparatuur uitgevoerd:

- Pre-engineering survey met inzet van multibeam echosounder (MBES), Side Scan Sonar (SSS) en Sub-Bottom Profiler (SBP), gedurende 23,5 werkdagen;
- Survey voor het opsporen van 'unexploded ordnance' (UXO's), met inzet van MBES en SSS, gedurende 17,5 werkdagen;
- Pre-installatie survey voor de bathymetrie (MBES en wellicht ook SSS), gedurende 17,5 dagen;
- Post-installatie survey (MBES, kabeltracering), gedurende 16,5 dagen;
- Survey nadat de kabel is ingegraven (MBES), gedurende 1 dag.

Tabel 3-1 bevat een overzicht van de apparatuur die bij het geofysische onderzoek zal worden gebruikt met een indicatie van verstoringsafstanden (specificaties overgenomen uit Heinis et al. 2019).

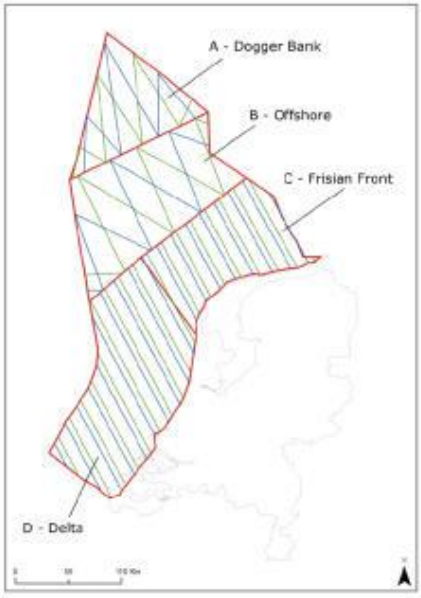
*Tabel 3-1 Typische systemen die tijdens het geofysische onderzoek rond het kabeltracé worden gebruikt en een inschatting van verstoringsafstanden*

| Type systeem | Voorbeeld systeem | Geschatte effectafstand |
|---|---|---|
| MBES: | Kongsberg EM2040 Dual Head, Dual Swath / Dual Ping – Frequency 400 kHz | Frequentie boven gehoorgrens vissen en zeezoogdieren; geen significante sub-harmonischen; verwachte effect afstanden (verwaarloosbaar) klein |
| SSS: | Edgetech 4200 300/600 – Frequency: 239 kHz (LF) and 555 kHZ (HF) | Frequentie boven gehoorgrens vissen en zeezoogdieren; geen significante sub-harmonischen; verwachte effect afstanden (verwaarloosbaar) klein |
| SBP: | Innomar SES 2000 Standard parametric sub-bottom profiler – Power: > 50kW; Frequency: 8 – 100 kHz | Verwachte verstoringsafstanden voor bruinvissen tussen 1 en 2 km (zie Bijlage 3 in Heinis et al. 2019) |

Uit het overzicht blijkt dat het grootste deel van het geofysisch onderzoek wordt uitgevoerd met apparatuur waarvan vanwege de gebruikte (zeer) hoge frequenties niet is te verwachten dat enig effect op zeezoogdieren zal optreden. De enige apparatuur die tot verstoring kan leiden, is de sub-bottom profiler (SBP). Deze wordt uitsluitend ingezet tijdens de pre-engineering survey. Voor de berekeningen is er *worst case* van uitgegaan dat deze apparatuur gedurende alle dagen van deze survey wordt ingezet. Omdat geen zeer diepe bodempenetratie nodig is, is voor de berekeningen conform Heinis et al. (2019) voor de sub-bottom profiler uitgegaan van een maximale verstoringsafstand van 1 km. Voor een rechthoekig scangebied en ervan uitgaande dat voor de pre-engineering survey 23,5 werkdagen nodig zijn, komt dat overeen met een verstoringsoppervlak van ~33 km² per dag.

## 3.2 Aantal verstoorde bruinvissen

Het aantal mogelijk verstoorde bruinvissen wordt berekend door de oppervlakte van het verstoorde oppervlak te vermenigvuldigen met de lokale bruinvisdichtheid. De lokale dichtheid is bepaald op basis van de gegevens van vliegtuigtellingen over de periode 2010 – 2019 en die zijn gerapporteerd door Geelhoed *et al.* (2018) en Geelhoed *et al.* (2020). In deze rapporten zijn op het NCP 4 deelgebieden onderscheiden (Figuur 3-1), waarvan er twee door de NeuConnect kabel worden doorsneden, te weten deelgebied C (~ 160 km) en deelgebied D (~ 105 km). De over de periode 2010 – 2019 gemiddelde dichtheid van bruinvissen bedraagt 0,87 ind/km$^2$ voor deelgebied C en 0,67 ind/km$^2$ voor deelgebied B.




*Figuur 3-1 Uit Geelhoed et al. (2018) overgenomen kaart van het NCP met onderscheiden deelgebieden A (Doggersbank), B (Offshore), C (Friese Front) en D (Delta). De lijnen geven de gevlogen transecten weer en de kleuren de verschillende surveys.*

## 3.3 Bruinvisverstoringsdagen en effecten op de populatie

Het totale aantal bruinvisverstoringsdagen is berekend door het aantal mogelijk verstoorde bruinvissen te vermenigvuldigen met het aantal verstoringsdagen. De resultaten van de schatting en de daaruit volgende berekening van het aan tal bruinvisverstoringsdagen zijn opgenomen in Tabel 3-2.

Voor de doorvertaling naar effecten op de bruinvispopulatie is voor het KEC gekozen gebruik te maken van het Interim PCoD model van SMRU/University St. Andrews (Harwood *et al.* 2013). De benaderingswijze die aan dit model ten grondslag ligt, wordt internationaal gebruikt (NRC, 2005; New *et al.* 2014) wat betekent dat niet alleen de werkwijze, maar ook de verkregen uitkomsten internationaal vergelijkbaar zijn[3]. In het Interim PCoD model wordt een kwantitatieve relatie gelegd tussen gedragsverandering en factoren als overlevingskans en reproductiesucces (*vital rates*). De

[3] Een ander model, DEPONS (Disturbance Effects on the harbour POrpoise population in the North Sea), waarmee effecten van verstoring door heigeluid op de bruinvispopulatie kunnen worden geschat, was ten tijde van het KEC 1.0 nog niet beschikbaar (Van Beest e.a., 2015, Nabe-Nielsen e.a., 2014). Een eerste versie voor algemene toepassing kwam in april 2017 beschikbaar. Er is inmiddels van die versie een update verschenen die is te downloaden via deponc.au.dk. De Nederlandse overheid heeft ervoor gekozen om voor het KEC 3.0 van het volledige geüpdatete iPCoD model uit te gaan, omdat hiermee de internationale vergelijkbaarheid van berekeningen beter is gewaarborgd.

relatie is afgeleid door het raadplegen van deskundigen volgens een formeel *expert elicitation* proces, aangezien voor veel soorten meetgegevens voor het draaien van een 'full' PCoD model cf. New e.a. (2014) ontbreken. Daarbij zijn diverse technieken toegepast om de meningen van experts onafhankelijk te wegen en een numerieke schatting van de onzekerheid in de relatie te kunnen geven. In 2018 zijn een tweetal workshops gehouden waarin via *expert elicitation* op basis van nieuwe kennis en verbeterde inzichten voor bruinvissen en zeehonden opnieuw relaties zijn afgeleid (Booth & Heinis, 2018; Booth e.a. 2019). De resultaten zijn verwerkt in versie 5.0 van het iPCoD model, die in maart 2019 voor algemeen gebruik is vrijgegeven (http://www.smruconsulting.com/release-ipcod-version-5/).

*Tabel 3-2 Worst case schatting van verstoring van bruinvissen door het uitvoeren van de pre-engineering survey en het daaruit berekende aantal bruinvisverstoringsdagen.*

| Deelgebied | Inschatting lengte tracé (km) | Breedte tracé (km | Dagen survey (inschatting) | Km survey per dag | Verstoord oppervlak per dag (km²) | Dichtheid bruinvissen (ind/km²) | bruinvisverstoringsdagen |
|---|---|---|---|---|---|---|---|
| C (Friese Front) | 159,6 | 0,5 (2 kabels) | 14,2 | 11,3 | 33,2 | 0,87 | 408 |
| D (Delta) | 105,4 | 0,5 (2 kabels) | 9,3 | 11,3 | 33,2 | 0,67 | 209 |
| | | | | | | **Totaal** | **617** |

Voor het KEC 3.0 zijn verschillende scenario's voor de ontwikkeling van wind op zee, inclusief de effecten van de benodigde seismische surveys, doorgerekend. De uitkomsten laten zien dat er een verband bestaat tussen het aantal bruinvisverstoringsdagen en de reductie van de populatie bruinvissen op de Noordzee. De volgende benaderingsformule geeft het verband weer als van een 95% zekerheid wordt uitgegaan (maximaal 5% kans dat de berekende populatiereductie groter is en daarmee zou worden onderschat):

$$Populatiereductie = 1{,}06 \times 10^{-4} \times bvvd^{1{,}17}$$

De populatiereductie is daarbij uitgedrukt in het aantal individuen en bvvd staat voor het aantal bruinvisverstoringsdagen.

Uit de benaderingsformule volgt dat het berekende aantal bruinvisverstoringsdagen van 617 leidt tot een 5% kans op en een populatiereductie van minder dan 1 bruinvis (0,19). Dit is een verwaarloosbaar effect, ook in cumulatie met de effecten van de constructie van windparken op het NCP in de periode 2016 – 2030.

## 4 Conclusie

Tijdens de seismische surveys rond de aanleg van de NeuConnect kabel wordt impulsief onderwatergeluid geproduceerd. Alleen de apparatuur die wordt gebruikt voor de pre-engineering survey (sub-bottom profiler) produceert geluid dat tot verstoring van bruinvissen kan leiden. Effecten op zeehonden en andere soorten zeezoogdieren kunnen op voorhand worden uitgesloten, omdat zij (zeer) sporadisch in het plangebied voor de zeekabel voorkomen. Uit de *worst case* effectberekening blijkt dat ook voor bruinvissen de effecten verwaarloosbaar zijn: de berekende populatiereductie bedraagt minder dan 1 bruinvis. Op een geschatte gemiddelde populatie op het NCP van 51.000 individuen is dat verwaarloosbaar.

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# Bijlage 2 Relevante vogelsoorten

***Kustgebonden soorten***

**Aalscholver**
Aalscholvers (*Phalacrocorax carbo*) werden in het verleden vooral langs de kust aangetroffen, maar met stijgende aantallen sinds 1970 stijgt ook het aantal foeragerende aalscholvers op het NCP. Hoogste aantallen worden in de zomer nabij de kust waargenomen. Maar de soort is een jaarvogel op het NCP en kan overal worden aangetroffen, ook ver uit de kust (Leopold *et al.* 2014, Poot *et al.* 2011).

**Dwergmeeuw**
De Dwergmeeuw (*Hydrocoloeus minutus*) wordt voornamelijk tijdens de najaarstrek (oktober) en de voorjaarstrek (april) in de kustzone op het NCP waargenomen. De verspreiding op het NCP is onregelmatig. In lagere dichtheden is de Dwergmeeuw ook een wintergast. Overwinterende dwergmeeuwen worden ook in het Duitse deel van de Borkumse stenen aangetroffen. Dit gebied is aangewezen voor de Dwergmeeuw (BfN 2011). In de maanden juni tot september is deze soort gewoonlijk afwezig (Arts 2015).

**Dwergstern**
De Dwergstern (*Sterna albifrons*) wordt vooral tijdens de voorjaarstrek langs de kust aangetroffen. De aantallen dwergsterns op het NCP pieken in mei. Voor de najaarstrek lijkt de Noordzee een minder belangrijke rol te spelen (Leopold *et al.* 2014).

**Eidereend**
Zoals de meeste schelpdieretende soorten wordt de Eidereend (*Somateria mollissima*) vaak in ondiepe wateren langs de kust aangetroffen. In de winter kan deze soort echter ook ver uit de kust voorkomen (Camphuysen & Leopold 1994, Leopold *et al.* 2014).

**Fuut**
Hoewel de Fuut meer als vogel van zoet water wordt beschouwd, stijgen sinds deze eeuw de aantallen futen, die op de Noordzee overwinteren. Hoogste aantallen worden van december - maart waargenomen (Leopold *et al.* 2014). De soort wordt voornamelijk langs de kust aangetroffen, maar ook op de Bruine Bank en het Friese Front zijn waarnemingen bekend (Geelhoed & Leopold 2018). In de zomermaanden is de soort meestal afwezig op het NCP.

**Grote mantelmeeuw**
De Grote mantelmeeuw (*Larus marinus*) komt het hele jaar op het NCP voor (Arts 2015). In het algemeen is het voorkomen van de Grote mantelmeeuw verspreid over een brede zone (>100km) langs de Nederlandse kust, waarbij hoogste dichtheden dicht bij de kust worden aangetroffen. Op de Bruine Bank en het Friese Front worden hoogste dichtheden in de maanden augustus tot januari waargenomen (Poot *et al.* 2010). Het Duitse deel van de Borkumse Stenen is ook aangewezen voor deze soort, hier worden overwinterende Grote mantelmeeuwen aangetroffen (BfN 2011).

**Grote stern**
Ongeveer 17.000 paren Grote sterns (*Thalasseus sandvicensis*) broeden in Nederland, voornamelijk in kolonies in de Waddenzee en het Deltagebied (Boele *et al.* 2018). De soort wordt vanaf april/mei in een brede zone (25-30 km) langs de Nederlandse kust waargenomen

(Arts 2015). In het begin van oktober vertrekt de Grote stern naar de overwinteringsplekken in West-Afrika (Poot *et al.* 2010). Op volle zee is de soort schaars. Het Duitse deel van de Borkumse Stenen is ook aangewezen voor deze soort, grote sterns trekken in lage aantallen door het gebied (BfN 2011).

**Kleine mantelmeeuw**

Het aantal broedpaar van de Kleine mantelmeeuw (*Larus fuscus*) in Nederland bedraagt ongeveer 80.000 (Boele *et al.* 2018). Het merendeel van de kolonies is langs de Waddenkust te vinden (Poot *et al.* 2010). Op het NCP wordt deze soort vanaf februari t/m september met een piek in juni/juli aangetroffen (Arts 2013, 2015). Hoewel de grootste aantallen kleine mantelmeeuwen nabij de kust worden gezien, kan deze soort overal op het NCP worden waargenomen. Opvallende concentraties worden ook op het Friese Front en Bruine Bank waargenomen (Poot *et al.* 2010). Het Duitse deel van de Borkumse Stenen is ook aangewezen voor deze soort, het gebied wordt gebruikt als doortrekplaats (BfN 2011).

**Kokmeeuw**

Kokmeeuwen (*Chroicocephalus ridibundus*) broeden in Nederland. De soort is in het algemeen meer kustgebonden. Groepen Kokmeeuwen kunnen tijdens het hele jaar offshore worden aangetroffen, maar vooral in de winter (Leopold *et al.* 2014).

**Noordse stern en Visdief**

Bijna 800 paren Noordse sterns (*Sterna paradisaea*) broeden in Nederland. Daarnaast zijn er ongeveer 13.000 paren visdieven (*Sterna hirundo*) (Boele *et al.* 2018). Beide soorten zijn in het zomerhalfjaar aanwezig met hoogste dichtheden op het NCP in augustus/september en april/mei. In juni en juli worden deze sterns voornamelijk nabij de kust gezien, in de voorjaars- en najaarstrek komen ze ver uit de kust voor (Arts 2013, 2015). Het Duitse deel van de Borkumse Stenen is aangewezen voor beide soorten, in lage aantallen trekken noordse sterns en visdieven door dit gebied (BfN 2011).

**Parelduiker en Roodkeelduiker**

De Parelduiker (*Gavia arctica*) en de Roodkeelduiker (*Gavia stellata*) overwinteren in de Noordzee. De Roodkeelduiker is de meest voorkomende duikersoort, daarnaast is het aandeel Parelduikers vrijwel klein (Camphuysen & Leopold 1994). Deze soorten zijn in het zomerhalfjaar afwezig. In de maanden oktober - maart worden parel- en roodkeelduikers in de kustzone aangetroffen (Arts 2015). Enkele dieren worden ook verder uit de kust, op het Friese Front en de Bruine Bank waargenomen (Geelhoed & Leopold 2017, Poot *et al.* 2010). Van december tot april gebruiken grotere aantallen roodkeel- en parelduikers het gebied Borkumse stenen als doortrekplaats (Bos *et al.* 2011, Poot *et al.* 2010). Het Duitse deel van de Borkumse Stenen is aangewezen voor beide soorten (BfN 2011).

**Stormmeeuw**

De Stormmeeuw (*Larus canus*) heeft broedkolonies in de Waddenzee, Noord-Holland en het deltagebied (Poot *et al.* 2010). In de broedperiode wordt de soort gewoonlijk niet op het NCP aangetroffen (Arts 2015). In de periode oktober tot februari worden de meeste dieren in een brede kustzone aangetroffen, maar hogere aantallen zijn dan ook ver uit de kust te vinden (Arts 2015, Poot *et al.* 2010, 2011). Stormmeeuwen komen ook op het Friese Front en de Bruine Bank voor. Het Duitse deel van de Borkumse Stenen is ook aangewezen voor deze soort, stormmeeuwen komen hier in lagere aantallen voor (BfN 2011, Geelhoed & Leopold 2017).

**Topper**
Toppers (*Aythya marila*) uit Noord-Europe en Siberië overwinteren in belangrijke aantallen op het NCP (Vogelbescherming 2018). De Waddenzee, het IJsselmeergebied en de Voordelta vormen de belangrijkste overwinteringsgebieden. Maar vooral bij strenge winters wordt de soort ook op open zee aangetroffen (Camphuysen & Leopold 1994, Sovon 2018).

**Zwarte zee-eend**
In hoge aantallen kan de Zwarte zee-eend (*Melanitta nigra*) in de wintermaanden in Nederlandse wateren worden aangetroffen. De aantallen pieken meestal in de maanden februari en maart. In de overige maanden is de soort in lagere aantallen aanwezig. Hoewel de Zwarte zee-eend in het algemeen meer kustgebonden is, kan ze overal op het NCP voorkomen (Poot *et al.* 2010).

**Zilvermeeuw**
Ongeveer 34.000 paren Zilvermeeuwen (*Larus argentatus*) broeden in Nederland (Boele *et al.* 2018). Deze soort is het hele jaar op het NCP aanwezig met hoogste dichtheden in de wintermaanden en een piek in december/januari (Arts 2015). In deze maanden zijn ook de meeste dieren ver uit de kust aan te treffen, in de overige maanden wordt de Zilvermeeuw voornamelijk nabij de kust waargenomen (Arts 2015, Poot *et al.* 2010). Ook op het Friese Front en de Bruine Bank komt deze soort voor (Geelhoed & Leopold 2017).

***Zeegebonden soorten***

**Alk**
Alken (*Alca torda*) zijn het hele jaar verspreid over het Nederlandse Continentaal Plat (NCP) aan te treffen (Arts 2015, Camphuysen 1998, Poot *et al.* 2010). Hoogste dichtheden worden in het winterhalfjaar waargenomen, in 2013/2014 waren dit de maanden november, januari en februari (Arts 2015, Poot *et al.* 2010). Aan het einde van de lente vertrekken de grootste aantallen alken. Anders dan bij de Zeekoet zijn in Nederland slechts weinig juveniele alken aanwezig (Camphuysen & Leopold 1994). Alken zijn voornamelijk offshore aan te treffen, maar steeds meer dieren worden ook in de kustzone gezien (Arts 2015). Daarnaast worden ook grotere aantallen ten noordwesten van de Waddeneilanden waargenomen (Berrevoets & Arts 2002). De Alk is één van de meest voorkomende vogelsoorten op de Bruine Bank en het Friese Front (Geelhoed & Leopold 2017).

**Drieteenmeeuw**
De Drieteenmeeuw (*Rissa tridactyla*) is de meest voorkomende meeuwsoort op het NCP. De soort wordt het hele jaar met hoogste dichtheden in het winterhalfjaar waargenomen. In de maanden oktober tot januari wordt de soort verspreid over het hele NCP aangetroffen. Ook op de Bruine Bank en het Friese Front wordt de Drieteenmeeuw aangetroffen en het Duitse deel van de Borkumse Stenen is aangewezen voor deze soort (BfN 2011, Geelhoed & Leopold 2017). Alleen geringe aantallen drieteenmeeuwen worden in kustgebieden gezien (Arts 2015).

**Grote jager**
De Grote jager (*Stercorarius skua*) komt breed verspreid op het NCP voor, zowel in offshore gebieden als langs de kust (Poot *et al.* 2010, 2011). Opvallende concentraties worden nabij de Bruine Bank en op het Friese Front waargenomen (Bos *et al.* 2011, Poot *et al.* 2011). In het algemeen worden relatief lage aantallen aangetroffen, dit komt mede door het feit dat de totale populatie met niet meer dan 16.000 broedparen relatief klein is (Leopold 2017, Poot *et al.*

2010). De Grote jager wordt op het NCP voornamelijk in de herfst waargenomen met hoogste aantallen in augustus en september (Bos *et al.* 2011, Poot *et al.* 2011).

**Jan-van-gent**

De Jan-van-gent (*Morus bassanus*) is het hele jaar in lage dichtheden op het NCP aanwezig. Hoge aantallen worden in de late zomer en herfst met een piek in oktober/november waargenomen (Arts 2015). In het algemeen is de Jan-van-gent verspreid over het hele NCP te zien (Poot *et al.* 2010). Opvallende aantallen werden tijdens de wintermaanden op de Bruine Bank waargenomen (Geelhoed & Leopold 2017). Het Duitse deel van de Borkumse Stenen is ook aangewezen voor de Jan-van-gent, in lage aantallen overwintert de soort in dit gebied (BfN 2011).

**Kleine jager**

Tijdens een korte periode in de herfst trekt een groot deel van de Europese populatie kleine jagers (*Stercorarius parasiticus*) langs de Nederlandse kust. Hogere concentraties kleine jagers worden dan ook meestal nabij de kust aangetroffen. Op zee komt de soort verspreid voor en is in lagere aantallen te verwachten (Leopold *et al.* 2014).

**Noordse stormvogel**

De Noordse stormvogel (*Fulmarus glacialis*) is een soort, die het hele jaar onregelmatig verspreid in de offshore gebieden van het NCP aanwezig is (Arts 2015, Poot *et al.* 2011). Hoogste aantallen worden in augustus en september, maar soms ook in februari en maart waargenomen (Bos *et al.* 2011, Camphuysen & Leopold 1994). Op het Friese Front en de Bruine Bank werden hogere aantallen Noordse stormvogels in de herfst waargenomen (Geelhoed & Leopold 2017). De soort wordt weinig in de kustzone aangetroffen (Arts 2013, Poot *et al.* 2010).

**Papegaaiduiker**

Van de drie ondersoorten papegaaiduiker komt de *Fratercula arctica grabae* het meest in de zuidelijke Noordzee voor. Hoogste aantallen worden in de winter wijd verspreid over het noordelijk deel van het NCP aangetroffen (Leopold *et al.* 2014).

**Vale pijlstormvogel**

Enkele individuen Vale pijlstormvogels (*Puffinus mauretanicus*) worden jaarlijks op het NCP gezien. Deze waarnemingen zijn beperkt tot de periode juli-oktober, wanneer de soort doortrekkend langs de kust wordt gezien (Sovon 2018).

**Zeekoet**

De Zeekoet (*Uria aalge*), hoort bij de in de zuidelijke Noordzee meest voorkomende soorten en wordt het hele jaar op het NCP aangetroffen. De aantallen bereiken een piek in de late zomer en herfst wanneer adulte dieren met hun jongens vanaf de broedkolonies rustige plekken op zee opzoeken (Poot *et al.* 2010). Een belangrijke rustplaats is het Friese Front (Bos *et al.* 2011). Daarnaast worden ook hoge aantallen zeekoeten op de Bruine Bank aangetroffen (Geelhoed & Leopold 2017). In de wintermaanden nemen de dichtheden weer geleidelijk af. Het Duitse deel van de Borkumse Stenen kan door hoge aantallen zeekoeten worden gebruikt als overwinteringsplaats (BfN 2011). In het algemeen worden de meeste zeekoeten ver uit de kust aangetroffen, minder dieren zijn nabij de kust te vinden (Poot *et al.* 2010).

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# Bijlage 12: Ecologische beoordeling stikstofdepositie NC, voortoets ecologische effecten,

## Altenburg &Wymenga, 17 maart 2021

Altenburg & Wymenga
ECOLOGISCH ONDERZOEK

# Beoordeling stikstofdepositie NeuConnect
## Voortoets ecologische effecten

A&W-rapport 20-030

in opdracht van

Bio Consult SH

# Beoordeling stikstofdepositie NeuConnect
Voortoets ecologische effecten

**A&W-rapport 20-030**

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| Projectnummer | Projectleider | Status |
|---|---|---|
| 20-030 | E. Wymenga | Eindrapport |

| Autorisatie | Paraaf | Datum |
|---|---|---|
| Goedgekeurd | **W. Altenburg** | 15 maart 2021 |

**Kwaliteitscontrole**

M. Brongers

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# 1 Inleiding

NeuConnect is een consortium van Meridiam, Allianz Group en Kansai Electronic Power. NeuConnect is voornemens de energienetwerken van Duitsland en Groot-Brittannië met elkaar te verbinden door middel van een hoogspanningskabel (High Voltage Direct Current, HVDC) van 1.400 MegaWatt (MW). Deze interconnector (verbindingskabel) zal bestaan uit onderzeese hoogspanningskabels van in totaal ongeveer 706 km tussen Duitsland en Groot-Brittannië, waarbij het traject ook door de Nederlandse territoriale wateren loopt (over een afstand van ongeveer 261 km).

Voor de aanleg, exploitatie en buitenbedrijfstelling van de kabel in het Exclusieve Economische Zone (EEZ) in het Nederlandse deel van de Noordzee wordt een milieueffectbeoordelingsprocedure (m.e.r.) doorlopen en een MER opgesteld. Het MER maakt deel uit van de vergunningaanvraag in het kader van de Waterwet, die vereist is voor de aanleg, exploitatie en buitenbedrijfstelling van onderzeese kabels. Voor het MER is een notitie reikwijdte en detailniveau opgesteld (ingediend op 1 februari 2019, Schuttinga & Nijmeijer 2019). In het kader van de m.e.r.-procedure en de Wet Natuurbescherming is het noodzakelijk om het voorgenomen project ecologisch te beoordelen. Hiervoor is een ecologische beoordeling opgesteld (Mielke *et al*. 2021). Onderdeel van deze beoordeling is het effect van stikstofemissies die bij het project vrijkomen en kunnen leiden tot stikstofdepositie op de habitattypen en leefgebieden binnen de beschermde Natuur 2000-gebieden. Mielke *et al*. (2021) hebben geconcludeerd dat het project kan leiden tot toename van de stikstofdepositie op één of meerdere Natura 2000-gebieden. Om die reden is een nadere kwantificering nodig.

In deze rapportage wordt die nadere kwantificering gegeven. Hieruit blijkt dat de depositie van stikstof door het project op de hiervoor gevoelige Natura 2000-habitattypen en -leefgebieden nergens hoger is dan 0,09 mol N/ha terwijl de doorlooptijd van de aanlegfase van het project korter is dan één jaar. In de exploitatiefase blijkt geen sprake te zijn van stikstofdepositie als gevolg van het project. Het project valt daarmee onder de mobiele werktuigenbenadering, zodat geen Natuurvergunning in verband met stikstofeffecten is benodigd.

Volledigheidshalve is ervoor gekozen om in deze rapportage inzicht te geven in de habitattypen, leefgebieden en Natura 2000-gebieden waar een depositie optreedt als gevolg van de aanleg van de hoogspanningskabel ook al is deze nergens hoger dan 0,09 mol N/ha. Hierbij is nagegaan of de stikstofdepositie ten gevolge van de aanleg en de exploitatiefase van de kabel significante negatieve effecten kan hebben op de habitattypen en leefgebieden in Natura 2000-gebieden in Nederland.

## 1.1 Emissie en depositie

**Voortraject**
Na de keuze voor een tracévoorkeursalternatief, zijn binnen deze tracévariant vier uitvoeringsvarianten onderzocht. De variant met de hoogste emissie is in eerste instantie gebruikt als worstcasescenario voor de AERIUS-berekeningen en de eerste ecologische toetsing. Vanuit de wens om de stikstofimpact van de aanleg op realistische wijze in kaart te brengen en een zo beperkt mogelijke stikstofimpact te veroorzaken, heeft voor het in kaart brengen van de stikstofimpact een iteratief proces plaatsgevonden. In het najaar van 2020 is in het kader van inschrijvingen op de tender voor het project gedetailleerde informatie beschikbaar gekomen over de voor de aanleg benodigde activiteiten. Op basis van deze gedetailleerde

informatie zijn in samenwerking met Primo Marine, expert op het gebied van onderwaterinfrastructuur, de nieuwe, realistische uitgangspunten vastgesteld voor de emissieberekeningen. Een belangrijk verschil met de voorgaande uitgangspunten is dat er veel minder zand van de mobiele zeebodem afgegraven hoeft te worden. Op basis hiervan zijn naast de basisvariant nog drie uitvoeringsvarianten opgesteld (zie ook Voets 2021a). De variant 1C, een combinatie van twee andere uitvoeringsvarianten, is gekozen als voorkeursvariant en gebruikt voor de stikstofdepositieberekeningen die in dit rapport getoetst worden.

**Uitvoeringsvariant 1C**
De modellering van stikstofemissie en projectdepositie is uitgevoerd door Ingenia met behulp van de AERIUS-calculator (Voets 2021a, Voets 2021b, www.aerius.nl).

Afhankelijk van de weersomstandigheden zal de aanleg van de kabel in uitvoeringsvariant 1C maximaal 313-357 dagen in beslag nemen indien alle activiteiten achter elkaar zouden worden uitgevoerd. Aangezien diverse activiteiten naast elkaar uitgevoerd gaan worden zal de totale doorlooptijd minder zijn. De door AERIUS gegenereerde rapportages voor zowel de aanlegfase (met uitvoeringsvariant 1C) als de exploitatiefase zijn bijlagen bij Voets (2021a en 2021b) en geven de waarden van de maximale stikstofdeposities door aanleg van de kabel en tijdens de exploitatiefase op habitattypen en leefgebieden binnen Natura 2000-gebieden in Nederland.

Open source data van het Nationaal Georegister (https://www.nationaalgeoregister.nl/) zijn gebruikt voor informatie over achtergronddepositie per hexagoon (versie 16-9-2019, gebaseerd op de depositie in 2018) en de verdeling van habitattypen en leefgebieden binnen de hexagonen (versie 16-9-2019). In deze laatste zijn ook de Kritische Depositiewaarde (KDW) per habitattype of leefgebied (van Dobben *et al*. 2012) opgenomen.

## 1.2 Werkstappen beoordeling

Om te beoordelen of aanleg en de exploitatie van de kabel kunnen leiden tot significant negatieve effecten op stikstofgevoelige habitattypen en leefgebieden, zijn de volgende werkstappen gevolgd:

- Bepalen van de stikstofemissie van de voorgenomen activiteit, waarbij onderscheid wordt gemaakt tussen de aanlegfase en de exploitatiefase.
- Vaststellen van de stikstofdepositie door de voorgenomen activiteit op stikstofgevoelige habitat(sub)typen en leefgebieden in Natura 2000-gebieden in Nederland. Ook hierbij zijn aanlegfase en exploitatiefase onderscheiden.
- Vaststellen waar deze depositie meer bedraagt dan 0,005 mol N/ha/jr (afgerond meer dan 0,00 mol N/ha/jr).
- Uitvoeren van een ecologische voortoets om vast te stellen of significant negatieve effecten uitgesloten kunnen worden.
- Indien significant negatieve effecten niet kunnen worden uitgesloten volgt een Passende Beoordeling in het licht van de instandhoudingsdoelen van de Natura 2000-gebieden.

Deze werkstappen komen overeen met de werkstappen 1 t/m 4 uit het stappenplan “Toestemmingsverlening stikstofdepositie bij nieuwe activiteiten” van de Rijksoverheid. De eerste twee werkstappen zijn beschreven in Voets (2021a) en Voets (2021b) voor respectievelijk de aanlegfase en de exploitatiefase. In deze beide rapportages is aangegeven wat de maximale depositie is op het ruimtelijk niveau van Natura 2000-gebieden en stikstofgevoelige habitattypen en leefgebieden hierbinnen.

In de analyse die aan voorliggende rapportage ten grondslag ligt, is dit ruimtelijk niveau sterker gedetailleerd tot op 1 ha grote hexagonen en de hierbinnen aanwezige stikstofgevoelige habitattypen en leefgebieden. Deze data zijn de basis voor de in voorliggend rapport gepresenteerde ecologische voortoets.

# 2 Projectdepositie en totale depositie

## 2.1 Projectdepositie

**Exploitatiefase**
Na ingebruikname van kabel wordt jaarlijks de diepte van de kabel onder de zeebodem en de hoogte van de zeebodem gemeten. Bij dergelijke controles worden schepen ingezet, wat leidt tot een jaarlijkse stikstofuitstoot. In de door Ingenia uitgevoerde AERIUS-berekeningen (Voets 2021b) is bepaald dat de stikstofuitstoot tijdens de exploitatiefase 2.933 kg $NO_x$ per jaar bedraagt. Dat leidt nergens tot een toename van de stikstofdepositie groter dan 0,00 mol N/ha/jaar op stikstofgevoelige habitattypen en leefgebieden.

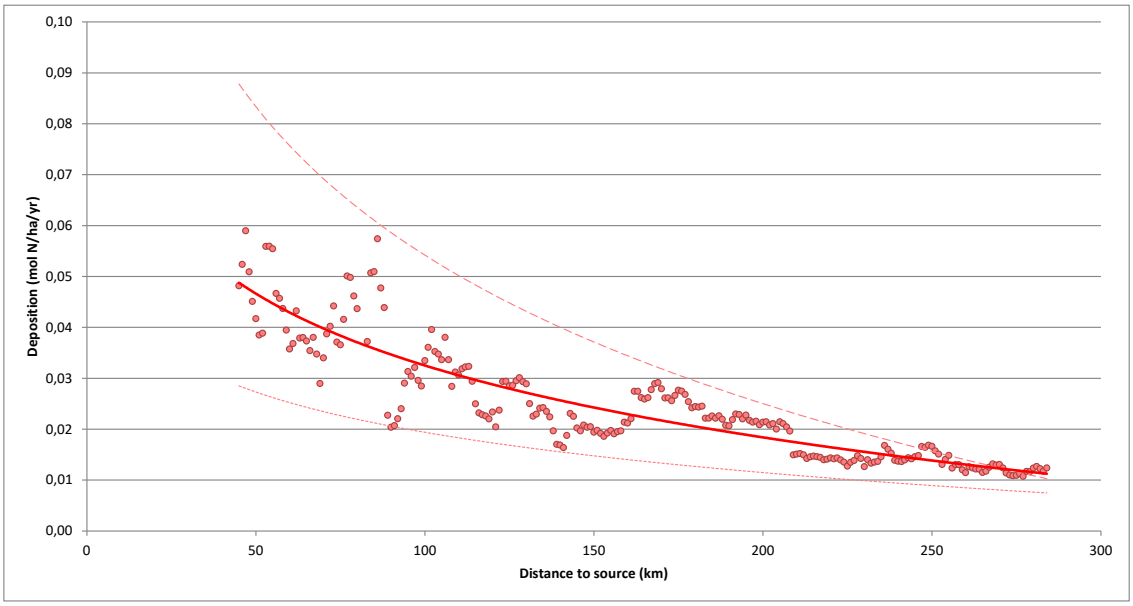
In uitzonderlijke gevallen kunnen zich noodsituaties voordoen waarbij de kabel bloot is komen te liggen. Bij het ontwerp en de aanleg van de kabel is hier echter rekening mee gehouden door een begravingsdiepte van 1,5 tot 2 m aan te houden en door pre-sweeping toe te passen bij een mobiele zeebodem. Als gevolg hiervan is het risico dat de kabel komt bloot te liggen verwaarloosbaar. Mocht dit toch gebeuren dan betreft het een calamiteit en is daarom niet opgenomen in de ecologische beoordeling.

**Conclusie**: In de exploitatiefase is de stikstofdepositie door de geplande activiteit nergens hoger dan 0,00 mol N/ha/jaar.

**Aanlegfase**
De totale uitstoot aan stikstof tijdens de aanlegfase bedraagt 162.148 kg NOx (Voets 2021a). Op basis van de door Ingenia uitgevoerde AERIUS-berekeningen voor de aanlegfase (Voets 2021a) zijn de projectgebonden stikstofdeposities per hexagoon weergegeven in figuur 2.2. Hieruit blijkt dat de projectdepositie snel afneemt met de afstand tot de bron. Maar nog steeds is in het uiterste zuidoosten van Nederland de projectdepositie plaatselijk hoger dan 0,005 mol N/ha/jr. Een grafiek met de relatie tussen stikstofdepositie en afstand tot de bron is weergegeven in figuur 2.1, gebaseerd op de AERIUS-berekeningen voor uitvoeringsvariant 1C.

Dat het verband tussen projectdepositie en afstand niet een mooie kromme is, komt omdat de depositie ook afhankelijk is van de windrichting en de ruwheid van het terrein. Figuur 2.1 laat goed zien dat bij grotere afstand tot de bron de gemiddelde stikstofdepositie slechts zeer langzaam verder afneemt.

De eerste stap in het stappenplan “Toestemmingsverlening stikstofdepositie bij nieuwe activiteiten” is het vaststellen of de geplande activiteit leidt tot een extra stikstofdepositie (verderop aangeduid als projectdepositie) groter dan 0,00 mol N/ha/jaar. In de Aerius-rapportages worden de deposities afgerond op twee decimalen. In de Aerius-output per hexagon worden deposities afgerond tot op (maximaal) vijf decimalen. Een projectdepositie van meer dan 0,00 mol N/ha/jr betekent daarbij dat de depositie hoger dan of gelijk is aan 0,005 mol N/ha/jr. Aerius genereert alleen output voor hexagonen met stikstofgevoelige habitattypen en leefgebieden waarop de projectdepositie 0,005 mol N/ha/jr is of meer.




*Figuur 2.1 Stikstofdepositie in relatie tot de afstand tot de bron van de bouwwerkzaamheden voor de NeuConnect-kabel in de Nederlandse EZZ (uitvoeringsvariant 1C). De stippen geven de gemiddelde depositie per kilometer afstand weer. De dikke en niet-onderbroken lijn is de (logaritmisch bepaalde) trendlijn voor deze gemiddelde deposities. De stippellijnen geven de trendlijnen weer voor de maximale en de minimale depositie per kilometer afstand. De afzonderlijke maxima en minima zijn voor de overzichtelijkheid niet in de figuur opgenomen.*

In totaal is sprake van een projectdepositie van meer dan 0,00 mol N/ha/jr in 129 Natura 2000-gebieden met stikstofgevoelige habitattypen of leefgebieden. Dat betreft meer dan 252 duizend hexagonen van 1 ha (tabel 2.1). Aangezien de stikstofgevoelige habitattypen of leefgebieden vaak slechts een deel van deze hexagonen beslaan, is de totale beïnvloede oppervlakte 171.841 ha. In totaal gaat het om 71 verschillende stikstofgevoelige habitat(sub)typen en 14 leefgebieden (incl. eventueel corresponderend zoekgebied).

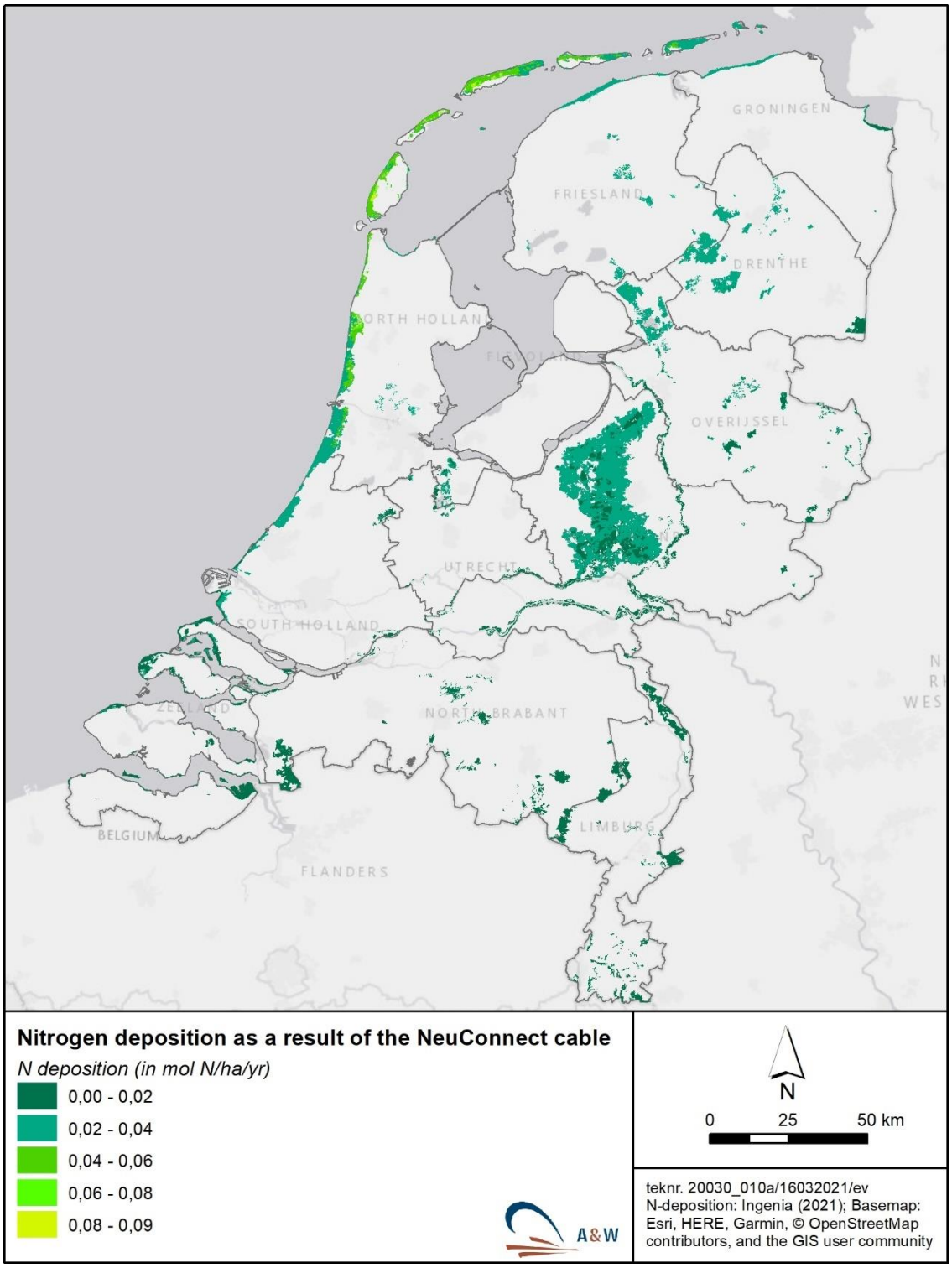
*Tabel 2.1 Overzicht van het aantal Natura 2000-gebieden, het aantal hexagonen en het aantal habitattypen en leefgebieden en hun oppervlakte waarop de projectdepositie hoger is dan 0,00 mol N/ha/jr.[1)] De oppervlakte is gecorrigeerd voor de gemiddelde dekking per habitattype binnen een Natura 2000-gebied. Zoekgebieden zijn bij de desbetreffende habitattypen of leefgebieden meegerekend.*

| | |
|---|---|
| Aantal Natura 2000-gebieden | 129 |
| Aantal hexagonen | 252.600 |
| Aantal habitat(sub)typen | 71 |
| Aantal leefgebieden | 14 |
| Oppervlakte habitattypen en leefgebieden [1)] | 171.841 ha |

De hoogste projectdepositie is berekend voor het Natura 2000-gebied 'Duinen Vlieland', waar de stikstofdepositie als gevolg van het project maximaal 0,091 mol N/ha/jaar bedraagt (Voets 2021a). De laagste bijdrage (0,008 mol N/ha/jaar) is berekend voor het Natura 2000-gebied ‘Maas bij Eijsden’.

In Voets (2021a) is een overzicht gegeven van de maximale projectdeposities door de aanleg op de verschillende Natura 2000-gebieden. Bijlage 1 van voorliggend rapport geeft een overzicht

van alle habitattypen en leefgebieden die te maken krijgen met een projectdepositie in de aanlegfase groter dan 0,00 mol N/ha.




*Figuur 2.2 Stikstofdepositie van > 0,00 mol N/ha/jr op hexagonen met stikstofgevoelige habitattypen en leefgebieden ten gevolge van de aanleg van de NeuConnect-kabel (uitvoeringsvariant 1C).*

## 2.2 Totale depositie en KDW

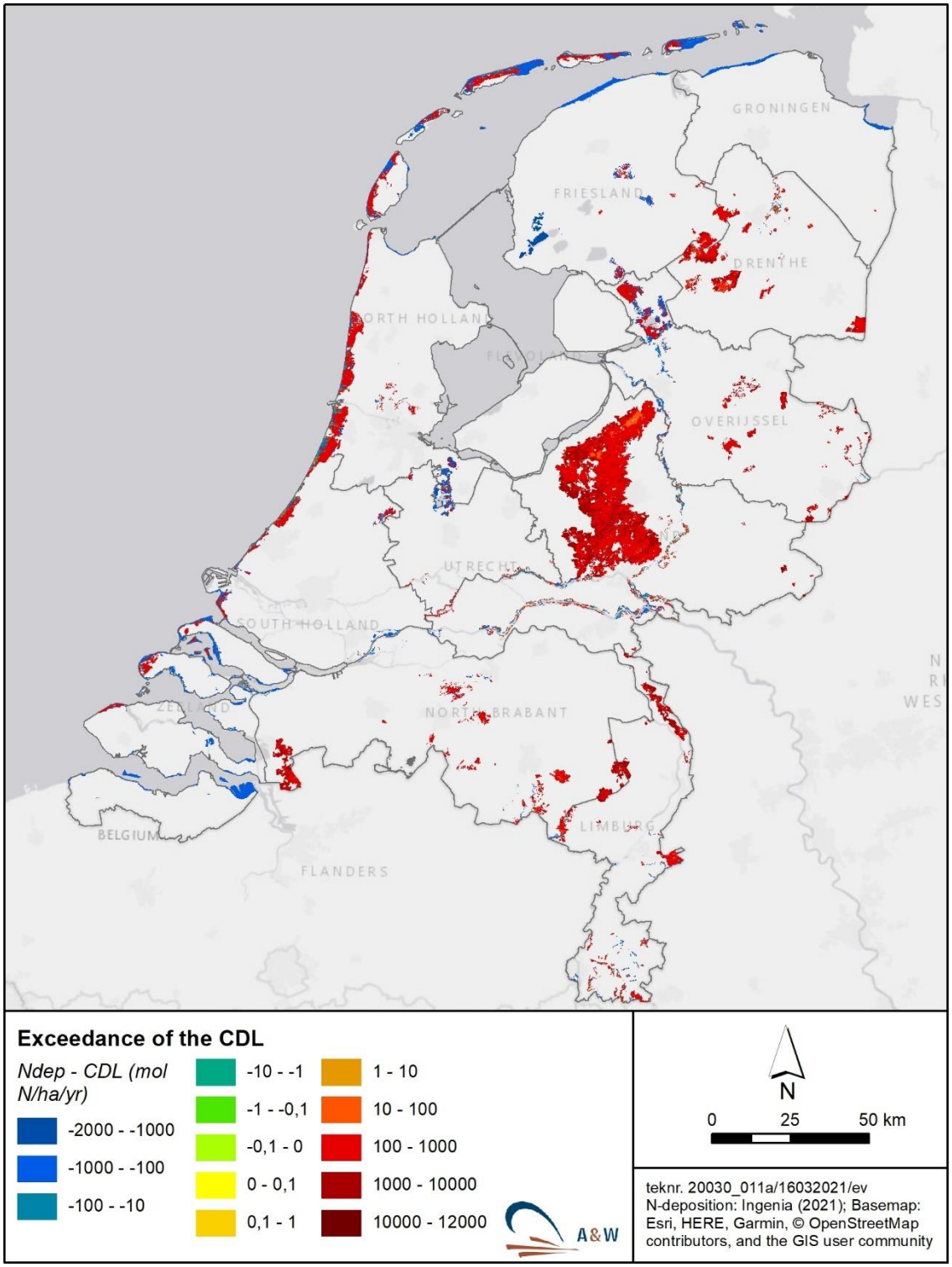
Voor de ecologische beoordeling van de effecten is (mede) van belang hoe de achtergronddepositie in de bestaande situatie zich verhoudt tot de Kritische Depositie Waarde (KDW) van de betreffende habitattypen en leefgebieden en vervolgens wat de bijdrage hierop is van de projectdepositie als gevolg van de aanleg van de NeuConnect-kabel.

De achtergronddepositie op de hexagonen met een projectdepositie van meer dan 0,00 mol N/ha/jr varieert in de bestaande situatie van 396,26 tot 12.116,40 mol N/ha/jr. Als gevolg van deze achtergronddepositie wordt de KDW voor de betreffende habitattypen en leefgebieden in de bestaande situatie op veel plaatsen al ruim overschreden. Deze achtergronddepositie is orden hoger dan de projectdepositie die ligt tussen 0,008 tot 0,091 mol N/ha/jr. De bijdrage van de projectdepositie aan de totale depositie (= achtergronddepositie + projectdepositie) varieert van zodoende tussen 0,000 tot 0,010%.

Als gevolg van de hoge achtergronddepositie wordt de KDW voor habitattypen en leefgebieden op veel locaties overschreden. In figuur 2.3 is het verschil tussen de totale depositie en de KDW per hexagoon weergegeven. Waar binnen een hexagoon meerdere habitattypen voorkomen, is steeds de KDW van het meest kritische type gebruikt. Bij een positieve waarde (rode tinten) wordt de KDW overschreden. Bij een negatieve waarde (blauwe tinten) wordt de KDW niet overschreden en is er dus nog ruimte voor depositie totdat de KDW wordt bereikt. Uit figuur 2.3 kan geconcludeerd worden dat in het merendeel van de relevante hexagonen de KDW met (ruim) meer dan 100 mol N/ha/jr wordt overschreden. Deels loopt de overschrijding op tot meer dan eenmaal de KDW. In een kleiner deel van de hexagonen is er nog stikstofruimte over (deels >100 mol N/ha/jr).

Tevens blijkt uit figuur 2.3 dat de klasse 0,0 – 0,1 ontbreekt. Dat betekent dat de projectdepositie niet leidt tot het (net) overschrijden van de KDW. Nadere analyse laat zien dat er drie hexagonen zijn waarbij door de projectdepositie de KDW net wordt overschreden, maar die zijn op de schaal van de kaart niet zichtbaar. Hierbij moet worden aangemerkt dat het aandeel van de projectdepositie ten opzichte van de achtergronddepositie op die drie hexagonen minder is dan 0,005%.

Een depositie boven de KDW kan een significant negatief effect hebben, maar dat is niet per definitie het geval (van Dobben *et al*. 2012). Van een depositie onder de KDW wordt gesteld dat deze geen significant negatief effect heeft op een habitattype of een leefgebied tenzij door een andere oorzaak de kwaliteit reeds sterk is verslechterd en deze door de extra stikstof verder achteruit gaat. Voorzichtigheidshalve en om eventuele cumulatieve effecten te voorkomen, wordt vaak de term ‘naderende overschrijding van de KDW’ als drempelwaarde gebruikt. Deze wordt vastgesteld op een waarde van 70 mol N/ha/jr onder de KDW (mondelinge med. Helpdesk Stikstof en Natura 2000, Prov. Noord-Holland 2020, www.aerius.nl).




*Figuur 2.3 Overschrijding van KDW (CDL) in hexagonen met stikstofgevoelige habitattypen en leefgebieden. Waarden > 0 geven een overschrijding van de KDW aan. Bij waarden < 0 is totale stikstofdepositie lager dan de KDW.*

In bijlage 2 is per Natura 2000-gebied aangegeven wat de achtergrond- en projectdeposities zijn op de habitattypen/leefgebieden die binnen het Natura 2000-gebied het meest stikstofgevoelig zijn (d.w.z. de types met de laagste KDW per gebied). Daarbij is uitsluitend gekeken naar die locaties waarop de projectdepositie door de aanlegfase hoger is dan 0,00 mol N/ha/jr en waarbij

sprake is van (naderende) overschrijding van de KDW. Dit geeft inzicht in hoe, binnen de meest gevoelige delen van een Natura 2000-gebied, de variatie (gemiddelde, minimum en maximum) in projectdepositie zich verhoudt tot de variatie in de achtergronddepositie en wat de variatie in de mate van overschrijding van de KDW is.

Uit bijlage 2 blijkt dat de KDW, gemiddeld genomen, in vrijwel alle van die meest kritische habitattypen wordt overschreden. Ook blijkt hieruit dat het maximale aandeel van de projectdepositie op de totale depositie varieert tussen 0,001% en 0,007%.

# 3 Beoordeling

## 3.1 Exploitatie- en aanlegfase

Op basis van de berekeningen met Aerius (Voets 2021b) blijkt dat de exploitatiefase nergens leidt tot een depositie hoger dan 0,00 mol N/ha/jr (zie ook par. 2.1). De exploitatiefase leidt daarom niet tot significant negatieve effecten op stikstofgevoelige habitattypen en leefgebieden en wordt verder buiten beschouwing gelaten.

Tijdens de aanlegfase is er wel sprake van deposities hoger dan 0,00 mol N/ha/jr (Voets 2021a) en deze fase is daarom nader beschouwd.

## 3.2 Beschouwingen over het tijdelijke aspect en de inzet van mobiele werktuigen

Bij het beoordelen van het effect van de projectdepositie tijdens de aanlegfase dient een aantal zaken in overweging te worden genomen:

- De duur van de aanlegfase is beperkt tot maximaal 313 tot 357 dagen. Aangezien diverse activiteiten tegelijkertijd worden uitgevoerd zal de doorlooptijd nog beduidend minder zijn.
- Tijdens de aanlegfase worden mobiele werktuigen en ander materieel gebruikt die voordien voor andere projecten en op diverse locaties zijn ingezet. Na de aanlegfase wordt dit materieel wederom voor andere projecten ingezet verspreid over de Nederlandse wateren. Het zijn bestaande bronnen die al sinds voor de aanwijzing van de Natura 2000-gebieden deel uitmaken van de bestaande achtergronddepositie.
- Inzet van deze mobiele apparatuur op een nieuwe locatie in Nederland kan op zichzelf leiden tot een minimale lokale tijdelijke toename van de depositie. Een dergelijke zeer beperkte tijdelijke toename kan echter niet van invloed zijn op de omvang en de ruimtelijke spreiding van de depositiedeken die het gevolg is van de jaarlijkse stationering van alle mobiele apparatuur die zich in Nederland bevindt. Bovendien zijn de door dit materieel veroorzaakte emissies in de loop der jaren gestaag gedaald als gevolg van de steeds schonere motoren. Voor Neuconnect worden dan ook voor de activiteiten die de meeste emissies veroorzaken de schonere schepen ingezet die voldoen aan de emissieklasse TIER II van de Internationale Maritieme Organisatie (Voets 2021a).
- Gezien de korte doorlooptijd van de aanlegfase en het feit dat gebruik wordt gemaakt van mobiele werktuigen waarvan de emissie al sinds vele jaren bijdraagt aan de achtergronddepositie en hiertoe gerekend wordt, ligt het voor de hand om de projectdepositie vanuit dit gebruik van bestaande mobiele werktuigen te benaderen.
- Vanwege de inzet van deze mobiele werktuigen kan ervan worden uitgegaan dat een depositie kleiner of gelijk aan 0,05 mol N/ha/jaar gedurende maximaal 2 jaar, of een equivalent hiervan (c.q. kleiner dan 0,1 mol N/ha/jaar gedurende 1 jaar) niet leidt tot een significant negatief effect op stikstofgevoelige habitattypen.
- De stikstofemissie van het project veroorzaakt een beperkte en tijdelijke projectdepositie over een groot gebied van stikstofgevoelige habitattypen en leefgebieden binnen de beschermde Natura 2000-gebieden in Nederland. Dat blijkt uit de figuren 2.1 en 2.2. Ten gevolge van de totale emissie van 167.264 kg $NO_x$ leidt dit tot een maximale projectdepositie van 0,09 mol N/ha.
- Een depositie van maximaal 0,09 mol N/ha verspreid over een tijdspanne korter dan een jaar komt overeen met een eenmalige depositie van maximaal 1,3 gram N/ha. Dat is zowel absoluut als in vergelijking tot de achtergronddepositie een dusdanig geringe hoeveelheid

dat de ecologische effecten die dit heeft op stikstofgevoelige habitattypen en leefgebieden niet te duiden zijn.

### 3.3 Conclusies

Bovenstaande beschouwingen leiden tot de conclusies dat:

- de aanleg van de kabel niet leidt tot verandering in omvang en ruimtelijke spreiding van de depositiedeken ten gevolge van de gebruikte mobiele werktuigen
- de depositie ten gevolge van de aanleg van de kabel dusdanig gering en kortdurend is dat een effect op stikstofgevoelige habitattypen en leefgebieden van dit project niet is te duiden
- significant negatieve effecten op deze habitattypen en leefgebieden zijn uitgesloten vanwege inzet van mobiele werktuigen met een maximale depositie van 0,09 mol N/ha over een tijdspanne van minder dan één jaar.

Op grond van bovenstaande kan geconcludeerd worden dat de uitstoot en depositie van stikstof als gevolg van zowel de exploitatie- als de aanlegfase van de NeuConnect-kabel noch leidt tot de verplichting om een passende beoordeling te maken noch tot een vergunningplicht op grond van de Wet Natuurbescherming.

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Voets, N. 2021b. Stikstofdepositie onderzoek t.b.v. de exploitatiefase van de NeuConnect kabel in Nederlandse EEZ. Ingenia-rapportnr. 1958639-RAP-0004-03. Ingenia Consultants & Engineers BV, Eindhoven.

**Websites**

Naderende overschrijding van de KDW: https://www.aerius.nl/nl/factsheets/onderscheid-hexagonen-met-en-zonder-naderende-overbelasting/03-04-2020

Stappenplan Toestemmingsverlening stikstofdepositie bij nieuwe activiteiten: https://aerius-hulp.nl/aerius-hulp-nl/beleid-stikstof/

# Bijlage 1 Stikstofgevoelige habitattypen met projectdepositie > 0,00 mol N/ha/jr

Onderstaande tabel geeft een overzicht van de stikstofgevoelige habitattypen en leefgebieden waarop de projectdepositie tijdens de aanlegfase groter is dan 0,00 mol N/ha. Naast de habitattypen en leefgebieden zijn in deze tabel ook eventuele zoekgebieden voor habitattypen (ZGH…) en leefgebieden (ZGL…) opgenomen die stikstofgevoelig zijn. Deze zoekgebieden zijn gegroepeerd ten behoeve van de overzichtelijkheid van de tabel. Dat geldt ook voor de delen waarvan het habitattype onbekend is en waarvoor in AERIUS derhalve rekent met het meest kritische habitattype of leefgebied binnen het Natura 2000-gebied (H9999).

Per habitattype/leefgebied is de kritische depositiewaarde (KDW) weergegeven evenals het aantal Natura 2000-gebieden en het totale oppervlak waarin dit habitattype een projectdepositie ontvangt hoger dan 0,00 mol N/ha/jr.

| (Sub)Habitattype of Leefgebied | | KDW | N2000-gebieden | Oppervlak |
|---|---|---|---|---|
| Code | Naam | (mol N/ha/jr) | (aantal) | (ha) |
| H1310A | Zilte pionierbegroeiingen (zeekraal) | 1643 | 13 | 2.892,81 |
| H1310B | Zilte pionierbegroeiingen (zeevetmuur) | 1500 | 9 | 117,77 |
| H1320 | Slijkgrasvelden | 1643 | 6 | 841,54 |
| H1330A | Schorren en zilte graslanden (buitendijks) | 1571 | 11 | 8.420,81 |
| H1330B | Schorren en zilte graslanden (binnendijks) | 1571 | 8 | 706,68 |
| H2110 | Embryonale duinen | 1429 | 12 | 528,92 |
| H2120 | Witte duinen | 1429 | 20 | 2.133,70 |
| H2130A | Grijze duinen (kalkrijk) | 1071 | 18 | 3.858,49 |
| H2130B | Grijze duinen (kalkarm) | 714 | 16 | 4.556,79 |
| H2130C | Grijze duinen (heischraal) | 714 | 9 | 144,72 |
| H2140A | Duinheiden met kraaihei (vochtig) | 1071 | 7 | 154,44 |
| H2140B | Duinheiden met kraaihei (droog) | 1071 | 8 | 1.337,81 |
| H2150 | Duinheiden met struikhei | 1071 | 11 | 153,13 |
| H2160 | Duindoornstruwelen | 2000 | 21 | 4.447,97 |
| H2170 | Kruipwilgstruwelen | 2286 | 14 | 364,58 |
| H2180A | Duinbossen (droog), berken-eikenbos | 1071 | 6 | 2.166,36 |
| H2180Abe | Duinbossen (droog), berken-eikenbos | 1071 | 10 | 718,82 |
| H2180Ao | Duinbossen (droog), overig | 1429 | 4 | 563,10 |
| H2180B | Duinbossen (vochtig) | 2214 | 14 | 654,60 |
| H2180C | Duinbossen (binnenduinrand) | 1786 | 12 | 1.421,43 |
| H2190A | Vochtige duinvalleien (open water) | 1000 | 4 | 157,10 |
| H2190Ae | Vochtige duinvalleien (open water), (matig) eutrofe vormen | 2143 | 3 | 39,55 |
| H2190Aom | Vochtige duinvalleien (open water), oligo- tot mesotrofe vormen | 1000 | 13 | 85,46 |
| H2190B | Vochtige duinvalleien (kalkrijk) | 1429 | 20 | 927,44 |
| H2190C | Vochtige duinvalleien (ontkalkt) | 1071 | 13 | 164,75 |
| H2310 | Stuifzandheiden met struikhei | 1071 | 19 | 2.393,59 |
| H2320 | Binnenlandse kraaiheibegroeiingen | 1071 | 10 | 297,25 |
| H2330 | Zandverstuivingen | 714 | 16 | 2.764,37 |
| H3110 | Zeer zwakgebufferde vennen | 429 | 5 | 69,65 |
| H3130 | Zwakgebufferde vennen | 571 | 26 | 308,58 |
| H3140 | Kranswierwateren | 571 | 2 | 96,70 |
| H3140hz | Kranswierwateren, op hogere zandgronden | 571 | 4 | 7,46 |
| H3140lv | Kranswierwateren, in laagveengebieden | 2143 | 6 | 184,30 |
| H3150 | Meren met krabbenscheer en fonteinkruiden, buiten afgesloten zeearmen | 2143 | 4 | 353,74 |
| H3150baz | Meren met krabbenscheer en fonteinkruiden, buiten afgesloten zeearmen | 2143 | 8 | 293,74 |
| H3160 | Zure vennen | 714 | 21 | 367,69 |
| H4010A | Vochtige heiden (hogere zandgronden) | 1214 | 36 | 1.466,87 |
| H4010B | Vochtige heiden (laagveengebied) | 786 | 10 | 162,80 |
| H4030 | Droge heiden | 1071 | 34 | 17.227,84 |
| H5130 | Jeneverbesstruwelen | 1071 | 15 | 240,72 |

| (Sub)Habitattype of Leefgebied | | KDW | N2000-gebieden | Oppervlak |
|---|---|---|---|---|
| Code | Naam | (mol N/ha/jr) | (aantal) | (ha) |
| H6110 | Pionierbegroeiingen op rotsbodem | 1429 | 4 | 0,73 |
| H6120 | Stroomdalgraslanden | 1286 | 11 | 67,05 |
| H6130 | Zinkweiden | 1071 | 1 | 2,11 |
| H6210 | Kalkgraslanden | 1500 | 5 | 95,35 |
| H6230 | Heischrale graslanden | 714 | 6 | 346,02 |
| H6230dka | Heischrale graslanden, droog kalkarm | 857 | 1 | 0,53 |
| H6230dkr | Heischrale graslanden, droog kalkrijk | 857 | 3 | 7,31 |
| H6230vka | Heischrale graslanden, vochtig kalkarm | 714 | 24 | 82,45 |
| H6410 | Blauwgraslanden | 1071 | 41 | 167,29 |
| H6430C | Ruigten en zomen (droge bosranden) | 1857 | 5 | 3,32 |
| H6510A | Glanshaver- en vossenstaarthooilanden (glanshaver) | 1429 | 12 | 400,00 |
| H6510B | Glanshaver- en vossenstaarthooilanden (grote vossenstaart) | 1571 | 4 | 191,15 |
| H7110A | Actieve hoogvenen (hoogveenlandschap) | 500 | 10 | 7,58 |
| H7110B | Actieve hoogvenen (heideveentjes) | 786 | 13 | 57,07 |
| H7120 | Herstellende hoogvenen | 500 | 2 | 930,38 |
| H7120ah | Herstellende hoogvenen, actief hoogveen | 500 | 11 | 6.000,83 |
| H7140A | Overgangs- en trilvenen (trilvenen) | 1214 | 17 | 128,09 |
| H7140B | Overgangs- en trilvenen (veenmosrietlanden) | 714 | 16 | 1.238,93 |
| H7150 | Pioniervegetaties met snavelbiezen | 1429 | 25 | 178,93 |
| H7210 | Galigaanmoerassen | 1571 | 15 | 57,37 |
| H7220 | Kalktufbronnen | 2399 | 3 | 0,82 |
| H7230 | Kalkmoerassen | 1143 | 10 | 6,40 |
| H9110 | Veldbies-beukenbossen | 1429 | 1 | 367,07 |
| H9120 | Beuken-eikenbossen met hulst | 1429 | 22 | 7.209,63 |
| H9160A | Eiken-haagbeukenbossen (hogere zandgronden) | 1429 | 9 | 69,46 |
| H9160B | Eiken-haagbeukenbossen (heuvelland) | 1429 | 8 | 766,52 |
| H9190 | Oude eikenbossen | 1071 | 11 | 1.990,15 |
| H91D0 | Hoogveenbossen | 1786 | 24 | 1.046,03 |
| H91E0B | Vochtige alluviale bossen (essen-iepenbossen) | 2000 | 3 | 24,26 |
| H91E0C | Vochtige alluviale bossen (beekbegeleidende bossen) | 1857 | 33 | 973,13 |
| H91F0 | Droge hardhoutooibossen | 2071 | 3 | 30,05 |
| Lg01 | Permanente bron & Langzaam stromende bovenloop | 2399 | 4 | 16,72 |
| Lg02 | Ge´soleerde meander en petgat | 2143 | 11 | 676,46 |
| Lg03 | Zwakgebufferde sloot | 1786 | 8 | 11,57 |
| Lg04 | Zuur ven | 1214 | 7 | 316,03 |
| Lg05 | Grote-zeggenmoeras | 1714 | 9 | 1.063,27 |
| Lg06 | Dotterbloemgrasland van beekdalen | 1429 | 3 | 22,92 |
| Lg07 | Dotterbloemgrasland van veen en klei | 1429 | 9 | 488,28 |
| Lg08 | Nat, matig voedselrijk grasland | 1571 | 14 | 1.438,08 |
| Lg09 | Droog struisgrasland | 1000 | 9 | 1.399,79 |
| Lg10 | Kamgrasweide & Bloemrijk weidevogelgrasland van het zand- en veengebied | 1429 | 10 | 702,60 |
| Lg11 | Kamgrasweide & Bloemrijk weidevogelgrasland van het rivieren- en zeekleigebied | 1429 | 5 | 2.307,04 |
| Lg12 | Zoom, mantel en droog struweel van de duinen | 1643 | 7 | 428,23 |
| Lg13 | Bos van arme zandgronden | 1071 | 7 | 36.879,51 |
| Lg14 | Eiken- en beukenbos van lemige zandgronden | 1429 | 7 | 29.755,58 |
| ZGH…. | Zoekgebied voor diverse habitattypen | - | - | 4.451,41 |
| ZGL…. | Zoekgebied voor diverse leefgebieden | - | - | 4.999,81 |
| H9999 | Habitattype onbekend/onzeker, KDW op basis meest kritische binnen gebied | | 19 | 643,49 |
| | **Totaal** | | **129** | **171.840,90** |

# Bijlage 2 Achtergrond- en projectdeposities op de meest gevoelige habitattypen/leefgebieden

Deze tabel geeft per Natura 2000-gebied weer wat de achtergrond- en projectdeposities zijn op de habitattypen/leefgebieden die binnen het Natura 2000-gebied het meest stikstofgevoelig zijn (d.w.z. de types met de laagste KDW per gebied). Daarbij is uitsluitend gekeken naar die locaties waarop de projectdepositie door de aanlegfase hoger is dan 0,00 mol N/ha/jr en waarbij sprake is van (naderende) overschrijding van de KDW. Per habitattype is de KDW, het betreffende oppervlak en het aantal hexagonen weergegeven. Ook is per habitattype de variatie (gemiddelde, minimum en maximum) weergegeven in de achtergronddepositie, de projectdepositie ten gevolge van de aanlegfase en de mate van overschrijding van de KDW. In de laatste kolom is het maximale aandeel (als percentage) weergegeven van de projectdepositie op de totale depositie (totale depositie = achtergronddepositie + projectdepositie).

| Natura 2000-gebied | Habitattype / Leefgebied | | | | | Achtergronddepositie | | | Projectdepositie | | | Overschrijding KDW | | | Aandeel project |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Naam | Code | Naam | KDW | #hex | Opp (ha) | Gem | Min | Max | Gem | Min | Max | Gem | Min | Max | tov totaal |
| | ZGH7120ah | Herstellende hoogvenen, actief hoogveen | 500,00 | 8 | 0,11 | 1.952,46 | 1.666,07 | 2.119,08 | 0,02 | 0,02 | 0,02 | 1.452,48 | 1.166,09 | 1.619,10 | 0,001% |
| | H7120ah | Herstellende hoogvenen, actief hoogveen | 500,00 | 102 | 44,47 | 1.806,86 | 1.472,39 | 2.398,10 | 0,02 | 0,02 | 0,02 | 1.306,87 | 972,41 | 1.898,12 | 0,001% |
| Aamsveen | H7110A | Actieve hoogvenen (hoogveenlandschap) | 500,00 | 1 | 0,09 | 1.512,48 | 1.512,48 | 1.512,48 | 0,02 | 0,02 | 0,02 | 1.012,50 | 1.012,50 | 1.012,50 | 0,001% |
| Achter de Voort, Agelerbroek & Voltherbroek | H3130 | Zwakgebufferde vennen | 571,00 | 2 | 0,15 | 2.376,49 | 2.261,36 | 2.491,62 | 0,02 | 0,02 | 0,02 | 1.805,51 | 1.690,38 | 1.920,64 | 0,001% |
| Alde Feanen | H7140B | Overgangs- en trilvenen (veenmosrietlanden) | 714,00 | 470 | 58,20 | 1.278,24 | 978,82 | 1.931,68 | 0,03 | 0,03 | 0,05 | 564,28 | 264,85 | 1.217,72 | 0,003% |
| Bakkeveense Duinen | H3130 | Zwakgebufferde vennen | 571,00 | 6 | 0,40 | 1.833,46 | 1.464,82 | 2.071,69 | 0,03 | 0,03 | 0,04 | 1.262,50 | 893,85 | 1.500,72 | 0,002% |
| | ZGH7120ah | Herstellende hoogvenen, actief hoogveen | 500,00 | 372 | 32,81 | 1.509,97 | 1.222,72 | 3.453,30 | 0,02 | 0,02 | 0,03 | 1.009,99 | 722,74 | 2.953,32 | 0,002% |
| | H7120ah | Herstellende hoogvenen, actief hoogveen | 500,00 | 1988 | 1.486,74 | 1.415,37 | 1.202,72 | 3.453,30 | 0,02 | 0,02 | 0,03 | 915,39 | 702,74 | 2.953,32 | 0,002% |
| Bargerveen | H7110A | Actieve hoogvenen (hoogveenlandschap) | 500,00 | 14 | 0,96 | 1.307,44 | 1.222,98 | 1.465,91 | 0,02 | 0,02 | 0,02 | 807,46 | 723,00 | 965,93 | 0,002% |
| | H9160A | Eiken-haagbeukenbossen (hogere zandgronden) | 1429,00 | 23 | 3,19 | 2.510,28 | 1.850,18 | 2.832,39 | 0,02 | 0,01 | 0,02 | 1.081,29 | 421,19 | 1.403,41 | 0,001% |
| Bekendelle | H9120 | Beuken-eikenbossen met hulst | 1429,00 | 60 | 18,05 | 2.564,82 | 1.940,63 | 2.832,39 | 0,02 | 0,02 | 0,02 | 1.135,84 | 511,65 | 1.403,41 | 0,001% |
| Bemelerberg & Schiepersberg | H6230dkr | Heischrale graslanden, droog kalkrijk | 857,00 | 20 | 2,23 | 1.304,56 | 1.194,08 | 1.560,44 | 0,01 | 0,01 | 0,01 | 447,57 | 337,09 | 703,45 | 0,001% |
| Bergvennen & Brecklenkampse Veld | H3110 | Zeer zwakgebufferde vennen | 429,00 | 39 | 13,52 | 2.056,83 | 1.604,83 | 2.635,45 | 0,02 | 0,02 | 0,02 | 1.627,84 | 1.175,85 | 2.206,47 | 0,001% |
| Biesbosch | H6120 | Stroomdalgraslanden | 1286,00 | 13 | 7,55 | 1.236,05 | 1.219,55 | 1.245,21 | 0,02 | 0,02 | 0,02 | -49,93 | -66,43 | -40,77 | 0,001% |
| Binnenveld | H7140B | Overgangs- en trilvenen (veenmosrietlanden) | 714,00 | 8 | 0,38 | 1.697,52 | 1.570,26 | 1.852,69 | 0,02 | 0,02 | 0,02 | 983,53 | 856,28 | 1.138,71 | 0,001% |
| | ZGH3130 | Zwakgebufferde vennen | 571,00 | 1 | 0,02 | 2.628,57 | 2.628,57 | 2.628,57 | 0,03 | 0,03 | 0,03 | 2.057,60 | 2.057,60 | 2.057,60 | 0,001% |
| Boetelerveld | H3130 | Zwakgebufferde vennen | 571,00 | 5 | 0,14 | 2.131,15 | 1.885,06 | 2.524,51 | 0,02 | 0,02 | 0,02 | 1.560,17 | 1.314,08 | 1.953,53 | 0,001% |
| | H3160 | Zure vennen | 714,00 | 2 | 0,08 | 1.399,74 | 1.335,62 | 1.463,86 | 0,02 | 0,02 | 0,02 | 685,76 | 621,64 | 749,88 | 0,001% |
| | H6230vka | Heischrale graslanden, vochtig kalkarm | 714,00 | 7 | 0,33 | 1.964,79 | 1.528,81 | 2.404,05 | 0,02 | 0,02 | 0,02 | 1.250,81 | 814,83 | 1.690,07 | 0,001% |
| Borkeld | H2330 | Zandverstuivingen | 714,00 | 9 | 0,70 | 1.395,02 | 1.333,11 | 1.657,56 | 0,02 | 0,02 | 0,02 | 681,04 | 619,13 | 943,58 | 0,001% |
| Boschhuizerbergen | H3130 | Zwakgebufferde vennen | 571,00 | 7 | 1,43 | 1.640,69 | 1.387,02 | 1.810,03 | 0,01 | 0,01 | 0,01 | 1.069,70 | 816,03 | 1.239,04 | 0,001% |
| Botshol | H7140B | Overgangs- en trilvenen (veenmosrietlanden) | 714,00 | 128 | 34,90 | 1.430,78 | 1.184,58 | 1.827,29 | 0,02 | 0,02 | 0,03 | 716,80 | 470,60 | 1.113,31 | 0,002% |
| Brabantse Wal | H3130 | Zwakgebufferde vennen | 571,00 | 44 | 12,70 | 1.423,40 | 1.102,66 | 2.212,88 | 0,01 | 0,01 | 0,02 | 852,42 | 531,67 | 1.641,90 | 0,001% |
| | H6230vka | Heischrale graslanden, vochtig kalkarm | 714,00 | 4 | 0,35 | 1.292,53 | 1.002,44 | 1.614,49 | 0,01 | 0,01 | 0,01 | 578,54 | 288,45 | 900,50 | 0,001% |
| Brunssummerheide | H3160 | Zure vennen | 714,00 | 2 | 0,01 | 1.367,03 | 1.283,44 | 1.450,62 | 0,01 | 0,01 | 0,01 | 653,04 | 569,45 | 736,63 | 0,001% |
| | H9160B | Eiken-haagbeukenbossen (heuvelland) | 1429,00 | 246 | 92,00 | 1.637,27 | 1.359,00 | 1.902,17 | 0,01 | 0,01 | 0,01 | 208,29 | -69,99 | 473,18 | 0,001% |
| | H9120 | Beuken-eikenbossen met hulst | 1429,00 | 40 | 10,52 | 1.665,35 | 1.427,65 | 1.870,99 | 0,01 | 0,01 | 0,01 | 236,36 | -1,34 | 442,00 | 0,001% |
| Bunder- en ElslooÙrbos | H6510A | Glanshaver- en vossenstaarthooilanden (glanshaver) | 1429,00 | 5 | 0,42 | 1.535,61 | 1.506,40 | 1.600,77 | 0,01 | 0,01 | 0,01 | 106,62 | 77,41 | 171,78 | 0,001% |
| | ZGH7120ah | Herstellende hoogvenen, actief hoogveen | 500,00 | 15 | 3,02 | 1.775,94 | 1.462,40 | 1.994,58 | 0,02 | 0,01 | 0,02 | 1.275,95 | 962,42 | 1.494,60 | 0,001% |
| | H7120ah | Herstellende hoogvenen, actief hoogveen | 500,00 | 444 | 312,57 | 1.729,25 | 1.425,82 | 2.884,63 | 0,02 | 0,01 | 0,02 | 1.229,27 | 925,83 | 2.384,65 | 0,001% |
| Buurserzand & Haaksbergerveen | H7110A | Actieve hoogvenen (hoogveenlandschap) | 500,00 | 22 | 2,55 | 1.597,88 | 1.466,47 | 1.845,10 | 0,01 | 0,01 | 0,02 | 1.097,90 | 966,49 | 1.345,12 | 0,001% |
| Coepelduynen | H2130A | Grijze duinen (kalkrijk) | 1071,00 | 196 | 109,77 | 1.129,79 | 1.001,89 | 1.672,69 | 0,03 | 0,02 | 0,03 | 58,82 | -69,09 | 601,72 | 0,003% |
| De Bruuk | H6230 | Heischrale graslanden | 714,00 | 2 | 0,01 | 1.569,06 | 1.552,05 | 1.586,06 | 0,01 | 0,01 | 0,01 | 855,07 | 838,06 | 872,07 | 0,001% |
| De Wieden | H9999:35 | Habitattype onbekend/onzeker, KDW obv: H7120 | 500,00 | 850 | 202,88 | 1.260,47 | 985,01 | 2.211,18 | 0,02 | 0,02 | 0,04 | 760,49 | 485,03 | 1.711,21 | 0,002% |
| | H7110A | Actieve hoogvenen (hoogveenlandschap) | 500,00 | 1 | 0,02 | 1.714,96 | 1.714,96 | 1.714,96 | 0,01 | 0,01 | 0,01 | 1.214,97 | 1.214,97 | 1.214,97 | 0,001% |
| | H7120ah | Herstellende hoogvenen, actief hoogveen | 500,00 | 2257 | 1.130,89 | 1.810,99 | 1.323,83 | 3.577,36 | 0,01 | 0,01 | 0,02 | 1.311,00 | 823,84 | 3.077,37 | 0,001% |
| | L7120 | Herstellende hoogvenen | 500,00 | 789 | 278,26 | 1.793,18 | 1.322,30 | 2.903,95 | 0,01 | 0,01 | 0,02 | 1.293,20 | 822,31 | 2.403,97 | 0,001% |
| Deumsche Peel & Mariapeel | ZGH7120ah | Herstellende hoogvenen, actief hoogveen | 500,00 | 248 | 42,58 | 1.851,41 | 1.354,99 | 2.834,23 | 0,01 | 0,01 | 0,02 | 1.351,43 | 855,00 | 2.334,25 | 0,001% |

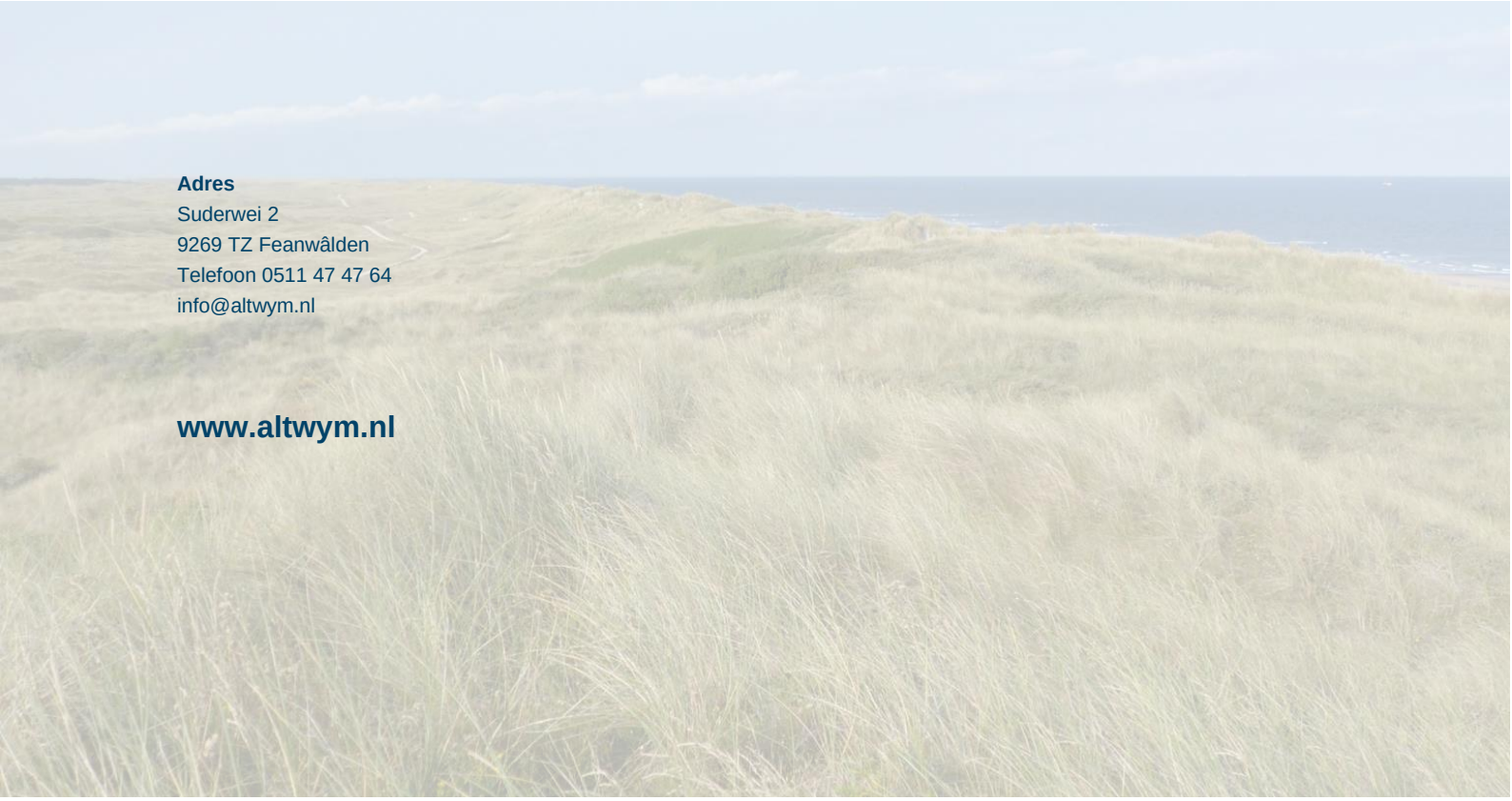
| Natura 2000-gebied | Habitattype / Leefgebied | | | | | Achtergronddepositie | | | Projectdepositie | | | Overschrijding KDW | | | Aandeel project |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Naam | Code | Naam | KDW | #hex | Opp (ha) | Gem | Min | Max | Gem | Min | Max | Gem | Min | Max | tov totaal |
| | H3130 | Zwakgebufferde vennen | 571,00 | 12 | 1,06 | 1.798,35 | 1.575,58 | 2.022,17 | 0,02 | 0,02 | 0,02 | 1.227,37 | 1.004,60 | 1.451,19 | 0,001% |
| Dinkelland | H9999:49 | Habitattype onbekend/onzeker, KDW obv: H3130 | 571,00 | 2 | 0,03 | 1.970,40 | 1.942,70 | 1.998,10 | 0,02 | 0,02 | 0,02 | 1.399,42 | 1.371,72 | 1.427,12 | 0,001% |
| | H2330 | Zandverstuivingen | 714,00 | 23 | 3,02 | 1.099,36 | 1.038,04 | 1.315,60 | 0,02 | 0,02 | 0,03 | 385,39 | 324,06 | 601,63 | 0,002% |
| | ZGH3160 | Zure vennen | 714,00 | 13 | 3,22 | 1.320,68 | 1.117,14 | 1.510,90 | 0,03 | 0,03 | 0,03 | 606,71 | 403,17 | 796,93 | 0,002% |
| | ZGH2330 | Zandverstuivingen | 714,00 | 3 | 0,69 | 1.303,32 | 1.269,88 | 1.324,48 | 0,03 | 0,03 | 0,03 | 589,35 | 555,91 | 610,51 | 0,002% |
| | H6230vka | Heischrale graslanden, vochtig kalkarm | 714,00 | 108 | 8,20 | 1.217,51 | 1.065,43 | 1.689,08 | 0,03 | 0,02 | 0,03 | 503,54 | 351,45 | 975,11 | 0,002% |
| Drentsche Aa-gebied | H3160 | Zure vennen | 714,00 | 14 | 1,40 | 1.360,16 | 1.206,07 | 1.633,24 | 0,03 | 0,02 | 0,03 | 646,19 | 492,09 | 919,27 | 0,002% |
| Drents-Friese Wold & Leggelderveld | H3110 | Zeer zwakgebufferde vennen | 429,00 | 4 | 0,01 | 1.150,76 | 1.035,05 | 1.402,43 | 0,03 | 0,02 | 0,03 | 721,78 | 606,07 | 973,46 | 0,002% |
| | ZGH2330 | Zandverstuivingen | 714,00 | 17 | 4,36 | 1.354,87 | 1.135,13 | 1.567,96 | 0,03 | 0,02 | 0,03 | 640,90 | 421,15 | 853,99 | 0,002% |
| | H2330 | Zandverstuivingen | 714,00 | 82 | 26,15 | 1.239,44 | 1.051,13 | 1.930,01 | 0,03 | 0,02 | 0,03 | 525,46 | 337,15 | 1.216,04 | 0,002% |
| Drouwenerzand | H6230vka | Heischrale graslanden, vochtig kalkarm | 714,00 | 5 | 1,06 | 1.358,52 | 1.289,88 | 1.428,36 | 0,03 | 0,03 | 0,03 | 644,54 | 575,91 | 714,39 | 0,002% |
| | ZGH6230vka | Heischrale graslanden, vochtig kalkarm | 714,00 | 10 | 1,83 | 1.305,25 | 1.220,92 | 1.390,55 | 0,04 | 0,04 | 0,04 | 591,29 | 506,96 | 676,59 | 0,003% |
| | H2130B | Grijze duinen (kalkarm) | 714,00 | 637 | 276,14 | 1.157,66 | 871,44 | 1.880,18 | 0,05 | 0,04 | 0,07 | 443,70 | 157,48 | 1.166,25 | 0,005% |
| | H2130C | Grijze duinen (heischraal) | 714,00 | 14 | 1,55 | 1.333,32 | 1.091,58 | 1.685,80 | 0,05 | 0,04 | 0,05 | 619,36 | 377,62 | 971,85 | 0,004% |
| | H9999:5 | Habitattype onbekend/onzeker, KDW obv: H2130C;H6230;H2130B | 714,00 | 517 | 126,26 | 1.073,33 | 816,21 | 1.525,51 | 0,04 | 0,03 | 0,06 | 359,37 | 102,24 | 811,57 | 0,004% |
| Duinen Ameland | ZGH2130B | Grijze duinen (kalkarm) | 714,00 | 775 | 334,62 | 1.107,13 | 778,96 | 1.919,22 | 0,04 | 0,03 | 0,07 | 393,18 | 64,99 | 1.205,29 | 0,005% |
| | H6230 | Heischrale graslanden | 714,00 | 2 | 0,05 | 1.330,70 | 1.299,15 | 1.362,24 | 0,06 | 0,06 | 0,06 | 616,75 | 585,21 | 648,30 | 0,004% |
| Duinen Den Helder-Callantsoog | H2130B | Grijze duinen (kalkarm) | 714,00 | 556 | 174,10 | 1.068,86 | 705,97 | 1.720,06 | 0,05 | 0,04 | 0,08 | 354,91 | -7,99 | 1.006,12 | 0,006% |
| | H2130B | Grijze duinen (kalkarm) | 714,00 | 2324 | 628,73 | 940,72 | 646,47 | 1.656,74 | 0,05 | 0,04 | 0,09 | 226,77 | -67,49 | 942,83 | 0,007% |
| | H2130C | Grijze duinen (heischraal) | 714,00 | 331 | 18,75 | 915,90 | 712,99 | 1.536,86 | 0,05 | 0,04 | 0,09 | 201,96 | -0,96 | 822,95 | 0,007% |
| | H6230 | Heischrale graslanden | 714,00 | 7 | 0,32 | 901,76 | 863,20 | 928,57 | 0,05 | 0,05 | 0,05 | 187,81 | 149,25 | 214,62 | 0,006% |
| Duinen en Lage Land Texel | H9999:2 | Habitattype onbekend/onzeker, KDW obv: H2130B;H2130C;H6230 | 714,00 | 2 | 0,16 | 1.282,91 | 1.187,59 | 1.378,23 | 0,08 | 0,07 | 0,08 | 568,99 | 473,66 | 664,31 | 0,006% |
| | H2130B | Grijze duinen (kalkarm) | 714,00 | 386 | 185,36 | 1.095,08 | 915,06 | 1.777,45 | 0,02 | 0,02 | 0,02 | 381,10 | 201,08 | 1.063,47 | 0,002% |
| Duinen Goeree & Kwade Hoek | H2130C | Grijze duinen (heischraal) | 714,00 | 142 | 15,29 | 1.062,67 | 915,06 | 1.423,78 | 0,02 | 0,02 | 0,02 | 348,69 | 201,08 | 709,80 | 0,002% |
| | H2130C | Grijze duinen (heischraal) | 714,00 | 103 | 10,64 | 1.350,02 | 805,91 | 2.963,87 | 0,04 | 0,03 | 0,06 | 636,06 | 91,94 | 2.249,91 | 0,004% |
| | ZGH2130B | Grijze duinen (kalkarm) | 714,00 | 319 | 88,22 | 1.342,54 | 840,85 | 3.372,55 | 0,04 | 0,03 | 0,06 | 628,58 | 126,88 | 2.658,59 | 0,004% |
| Duinen Schiermonnikoog | H9999:6 | Habitattype onbekend/onzeker, KDW obv: H2130B;H2130C;H2130B | 714,00 | 531 | 172,10 | 1.286,96 | 776,62 | 3.372,55 | 0,04 | 0,03 | 0,06 | 573,00 | 62,65 | 2.658,59 | 0,004% |
| | H6230vka | Heischrale graslanden, vochtig kalkarm | 714,00 | 43 | 9,40 | 1.017,90 | 882,74 | 1.208,00 | 0,05 | 0,04 | 0,06 | 303,95 | 168,79 | 494,06 | 0,006% |
| | ZGH2130C | Grijze duinen (heischraal) | 714,00 | 5 | 0,25 | 1.020,04 | 979,83 | 1.073,86 | 0,05 | 0,05 | 0,05 | 306,09 | 265,88 | 359,91 | 0,005% |
| Duinen Terschelling | H2130B | Grijze duinen (kalkarm) | 714,00 | 2092 | 650,92 | 1.043,14 | 654,23 | 2.191,06 | 0,05 | 0,04 | 0,09 | 329,19 | -59,72 | 1.477,13 | 0,007% |
| | H2130B | Grijze duinen (kalkarm) | 714,00 | 675 | 287,42 | 1.036,24 | 650,54 | 1.745,97 | 0,06 | 0,04 | 0,09 | 322,30 | -63,41 | 1.032,05 | 0,008% |
| Duinen Vlieland | H2130C | Grijze duinen (heischraal) | 714,00 | 42 | 3,62 | 942,40 | 747,08 | 1.409,33 | 0,05 | 0,05 | 0,07 | 228,45 | 33,13 | 695,40 | 0,007% |
| | H9999:30 | Habitattype onbekend/onzeker, KDW obv: H7120 | 500,00 | 223 | 40,19 | 1.486,63 | 1.087,15 | 2.392,79 | 0,03 | 0,02 | 0,04 | 986,66 | 587,17 | 1.892,83 | 0,002% |
| Dwingelderveld | H7120ah | Herstellende hoogvenen, actief hoogveen | 500,00 | 131 | 89,12 | 1.428,90 | 1.094,54 | 2.364,27 | 0,02 | 0,02 | 0,03 | 928,92 | 594,56 | 1.864,30 | 0,002% |
| Eilandspolder | H7140B | Overgangs- en trilvenen (veenmosrietlanden) | 714,00 | 5 | 0,18 | 1.148,27 | 1.106,65 | 1.171,83 | 0,03 | 0,03 | 0,03 | 434,30 | 392,68 | 457,86 | 0,002% |
| | H6230vka | Heischrale graslanden, vochtig kalkarm | 714,00 | 10 | 0,64 | 1.217,30 | 1.147,39 | 1.299,32 | 0,02 | 0,02 | 0,02 | 503,32 | 433,41 | 585,34 | 0,002% |
| Elperstroomgebied | H3160 | Zure vennen | 714,00 | 1 | 0,07 | 1.916,27 | 1.916,27 | 1.916,27 | 0,03 | 0,03 | 0,03 | 1.202,30 | 1.202,30 | 1.202,30 | 0,002% |
| | H7120ah | Herstellende hoogvenen, actief hoogveen | 500,00 | 921 | 617,79 | 1.668,52 | 1.282,15 | 2.753,08 | 0,02 | 0,02 | 0,03 | 1.168,54 | 782,17 | 2.253,11 | 0,001% |
| Engbertsdijksvenen | H7110A | Actieve hoogvenen (hoogveenlandschap) | 500,00 | 3 | 0,10 | 1.355,09 | 1.335,93 | 1.371,63 | 0,02 | 0,02 | 0,02 | 855,11 | 835,95 | 871,65 | 0,001% |

| Natura 2000-gebied | Habitattype / Leefgebied | | | | | Achtergronddepositie | | | Projectdepositie | | | Overschrijding KDW | | | Aandeel project |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Naam | Code | Naam | KDW | #hex | Opp (ha) | Gem | Min | Max | Gem | Min | Max | Gem | Min | Max | tov totaal |
| | ZGH7120ah | Herstellende hoogvenen, actief hoogveen | 500,00 | 298 | 78,59 | 1.434,21 | 895,04 | 2.315,30 | 0,03 | 0,02 | 0,04 | 934,24 | 395,06 | 1.815,34 | 0,002% |
| | H7120ah | Herstellende hoogvenen, actief hoogveen | 500,00 | 1857 | 1.440,21 | 1.251,51 | 990,01 | 2.221,19 | 0,03 | 0,02 | 0,04 | 751,54 | 490,03 | 1.721,23 | 0,002% |
| Fochteloërveen | H7110A | Actieve hoogvenen (hoogveenlandschap) | 500,00 | 4 | 0,38 | 1.150,66 | 1.144,10 | 1.162,45 | 0,03 | 0,03 | 0,03 | 650,69 | 644,13 | 662,48 | 0,002% |
| Geleenbeekdal | H7230 | Kalkmoerassen | 1143,00 | 8 | 0,99 | 1.446,52 | 1.243,19 | 1.700,70 | 0,01 | 0,01 | 0,01 | 303,53 | 100,20 | 557,71 | 0,001% |
| Geuldal | H6230dkr | Heischrale graslanden, droog kalkrijk | 857,00 | 29 | 4,98 | 1.355,69 | 1.045,45 | 1.746,75 | 0,01 | 0,01 | 0,01 | 498,70 | 188,46 | 889,76 | 0,001% |
| Grevelingen | H2130A | Grijze duinen (kalkrijk) | 1071,00 | 34 | 9,67 | 1.393,22 | 1.023,44 | 1.817,95 | 0,02 | 0,02 | 0,02 | 322,24 | -47,54 | 746,97 | 0,002% |
| | H7120ah | Herstellende hoogvenen, actief hoogveen | 500,00 | 1279 | 911,80 | 1.645,93 | 1.323,19 | 3.059,96 | 0,01 | 0,01 | 0,02 | 1.145,95 | 823,20 | 2.559,98 | 0,001% |
| | ZGH7120ah | Herstellende hoogvenen, actief hoogveen | 500,00 | 98 | 8,08 | 1.545,10 | 1.378,50 | 2.167,28 | 0,01 | 0,01 | 0,01 | 1.045,11 | 878,51 | 1.667,29 | 0,001% |
| Groote Peel | L7120 | Herstellende hoogvenen | 500,00 | 114 | 28,29 | 1.626,65 | 1.360,02 | 2.957,01 | 0,01 | 0,01 | 0,02 | 1.126,66 | 860,03 | 2.457,03 | 0,001% |
| Holtingerveld | H3130 | Zwakgebufferde vennen | 571,00 | 18 | 1,02 | 1.604,31 | 1.116,93 | 2.129,88 | 0,03 | 0,02 | 0,04 | 1.033,34 | 545,95 | 1.558,91 | 0,002% |
| IJsselmeer | H7140A | Overgangs- en trilvenen (trilvenen) | 1214,00 | 1 | 0,02 | 1.192,49 | 1.192,49 | 1.192,49 | 0,04 | 0,04 | 0,04 | -21,47 | -21,47 | -21,47 | 0,004% |
| | ZGH7140B | Overgangs- en trilvenen (veenmosrietlanden) | 714,00 | 12 | 1,05 | 1.131,88 | 1.039,52 | 1.255,33 | 0,03 | 0,02 | 0,03 | 417,91 | 325,54 | 541,36 | 0,002% |
| Ilperveld, Varkensland, Oostzanerveld & Twiske | H7140B | Overgangs- en trilvenen (veenmosrietlanden) | 714,00 | 498 | 54,22 | 1.160,40 | 996,43 | 1.595,81 | 0,02 | 0,02 | 0,03 | 446,43 | 282,45 | 881,84 | 0,002% |
| Kampina & Oisterwijkse Vennen | H3110 | Zeer zwakgebufferde vennen | 429,00 | 14 | 5,17 | 1.899,02 | 1.532,02 | 2.329,18 | 0,02 | 0,01 | 0,02 | 1.470,04 | 1.103,03 | 1.900,20 | 0,001% |
| | L3130 | Zwakgebufferde vennen | 571,00 | 3 | 0,16 | 2.406,22 | 2.363,91 | 2.427,72 | 0,02 | 0,02 | 0,02 | 1.835,24 | 1.792,93 | 1.856,74 | 0,001% |
| Kempenland-West | H3130 | Zwakgebufferde vennen | 571,00 | 191 | 59,27 | 1.582,36 | 1.148,06 | 2.293,00 | 0,01 | 0,01 | 0,02 | 1.011,37 | 577,07 | 1.722,02 | 0,001% |
| | H2130B | Grijze duinen (kalkarm) | 714,00 | 4261 | 817,70 | 1.194,41 | 761,33 | 2.099,40 | 0,04 | 0,02 | 0,08 | 480,45 | 47,36 | 1.385,44 | 0,005% |
| | H2130C | Grijze duinen (heischraal) | 714,00 | 20 | 1,29 | 1.077,28 | 961,90 | 1.183,11 | 0,03 | 0,03 | 0,03 | 363,31 | 247,92 | 469,14 | 0,003% |
| | H9999:88 | Habitattype onbekend/onzeker, KDW obv : H2130C;H7140B;H2130B | 714,00 | 9 | 1,91 | 929,66 | 854,62 | 1.019,88 | 0,03 | 0,03 | 0,03 | 215,69 | 140,64 | 305,91 | 0,003% |
| Kennemerland-Zuid | ZGH2130B | Grijze duinen (kalkarm) | 714,00 | 75 | 13,56 | 1.234,27 | 1.054,94 | 1.755,61 | 0,03 | 0,03 | 0,04 | 520,31 | 340,97 | 1.041,65 | 0,003% |
| Kolland & Overlangbroek | H91E0C | Vochtige alluviale bossen (beekbegeleidende bossen) | 1857,00 | 111 | 51,02 | 2.227,31 | 1.792,90 | 2.912,02 | 0,02 | 0,02 | 0,03 | 370,34 | -64,08 | 1.055,05 | 0,001% |
| | H2130C | Grijze duinen (heischraal) | 714,00 | 260 | 85,02 | 1.137,37 | 830,22 | 1.674,32 | 0,02 | 0,01 | 0,03 | 423,38 | 116,23 | 960,35 | 0,002% |
| | H2130B | Grijze duinen (kalkarm) | 714,00 | 969 | 283,30 | 1.131,08 | 764,00 | 1.872,37 | 0,02 | 0,01 | 0,03 | 417,10 | 50,01 | 1.158,40 | 0,002% |
| Kop van Schouwen | H9999:116 | Habitattype onbekend/onzeker, KDW obv : H2130B;H2130C | 714,00 | 3 | 0,55 | 1.580,00 | 1.386,69 | 1.710,15 | 0,02 | 0,02 | 0,02 | 866,02 | 672,71 | 996,17 | 0,001% |
| | H7110A | Actieve hoogvenen (hoogveenlandschap) | 500,00 | 4 | 0,15 | 2.251,34 | 2.030,99 | 2.428,00 | 0,02 | 0,02 | 0,02 | 1.751,35 | 1.531,01 | 1.928,02 | 0,001% |
| Korenburgerveen | H7120ah | Herstellende hoogvenen, actief hoogveen | 500,00 | 260 | 159,07 | 2.474,06 | 1.807,75 | 3.044,85 | 0,02 | 0,02 | 0,02 | 1.974,08 | 1.307,77 | 2.544,87 | 0,001% |
| Krammer-Volkerak | H2190B | Vochtige duinvalleien (kalkrijk) | 1429,00 | 48 | 9,44 | 1.529,94 | 1.367,34 | 2.218,78 | 0,02 | 0,01 | 0,02 | 100,96 | -61,64 | 789,80 | 0,001% |
| Kunderberg | H9160B | Eiken-haagbeukenbossen (heuvelland) | 1429,00 | 28 | 8,99 | 1.579,65 | 1.363,14 | 1.774,77 | 0,01 | 0,01 | 0,01 | 150,66 | -65,85 | 345,78 | 0,001% |
| | H3130 | Zwakgebufferde vennen | 571,00 | 27 | 3,62 | 1.763,69 | 1.330,03 | 2.146,77 | 0,02 | 0,02 | 0,02 | 1.192,71 | 759,05 | 1.575,79 | 0,001% |
| Landgoederen Brummen | ZGH3130 | Zwakgebufferde vennen | 571,00 | 6 | 1,20 | 1.412,92 | 1.308,21 | 1.501,58 | 0,02 | 0,02 | 0,02 | 841,94 | 737,23 | 930,60 | 0,001% |
| | H4030 | Droge heiden | 1071,00 | 3 | 0,50 | 2.159,31 | 1.857,07 | 2.355,23 | 0,02 | 0,02 | 0,02 | 1.088,33 | 786,09 | 1.284,25 | 0,001% |
| Landgoederen Oldenzaal | H9999:50 | Habitattype onbekend/onzeker, KDW obv : H4030 | 1071,00 | 2 | 0,29 | 1.957,60 | 1.801,07 | 2.114,12 | 0,02 | 0,02 | 0,02 | 886,61 | 730,09 | 1.043,14 | 0,001% |
| | H3140hz | Kranswierwateren, op hogere zandgronden | 571,00 | 61 | 1,29 | 1.478,79 | 1.234,05 | 2.320,58 | 0,02 | 0,01 | 0,02 | 907,80 | 663,06 | 1.749,60 | 0,001% |
| Langstraat | H3130 | Zwakgebufferde vennen | 571,00 | 11 | 0,42 | 1.410,13 | 1.282,37 | 1.561,38 | 0,02 | 0,01 | 0,02 | 839,15 | 711,38 | 990,40 | 0,001% |
| | H3140hz | Kranswierwateren, op hogere zandgronden | 571,00 | 8 | 0,39 | 1.298,71 | 1.215,59 | 1.406,94 | 0,01 | 0,01 | 0,01 | 727,72 | 644,60 | 835,95 | 0,001% |
| | H3130 | Zwakgebufferde vennen | 571,00 | 160 | 19,66 | 1.385,08 | 1.055,66 | 2.350,65 | 0,01 | 0,01 | 0,02 | 814,09 | 484,67 | 1.779,67 | 0,001% |
| Leenderbos, Groote Heide & De Plateaux | H9999:136 | Habitattype onbekend/onzeker, KDW obv : H3140;H3130 | 571,00 | 7 | 0,52 | 1.529,47 | 1.133,21 | 2.129,21 | 0,01 | 0,01 | 0,02 | 958,48 | 562,22 | 1.558,23 | 0,001% |
| Lemselermaten | H6230vka | Heischrale graslanden, vochtig kalkarm | 714,00 | 5 | 0,22 | 1.719,87 | 1.568,80 | 1.837,40 | 0,02 | 0,02 | 0,02 | 1.005,89 | 854,82 | 1.123,42 | 0,001% |
| | H9190 | Oude eikenbossen | 1071,00 | 6 | 0,32 | 2.059,86 | 1.898,01 | 2.215,19 | 0,01 | 0,01 | 0,02 | 988,87 | 827,02 | 1.144,21 | 0,001% |
| | H6410 | Blauwgraslanden | 1071,00 | 2 | 0,14 | 1.899,37 | 1.778,67 | 2.020,07 | 0,01 | 0,01 | 0,01 | 828,38 | 707,68 | 949,08 | 0,001% |
| Leudal | ZGH9190 | Oude eikenbossen | 1071,00 | 15 | 1,32 | 2.129,48 | 2.011,90 | 2.217,23 | 0,02 | 0,01 | 0,02 | 1.058,49 | 940,92 | 1.146,25 | 0,001% |

| Natura 2000-gebied | Habitattype / Leefgebied | | | | | Achtergronddepositie | | | Projectdepositie | | | Overschrijding KDW | | | Aandeel project |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Naam | Code | Naam | KDW | #hex | Opp (ha) | Gem | Min | Max | Gem | Min | Max | Gem | Min | Max | tov totaal |
| Lieftinghsbroek | H6410 | Blauwgraslanden | 1071,00 | 4 | 0,32 | 2.147,09 | 1.857,60 | 2.282,62 | 0,03 | 0,03 | 0,03 | 1.076,12 | 786,63 | 1.211,65 | 0,001% |
| | H7230 | Kalkmoerassen | 1143,00 | 6 | 1,34 | 1.831,32 | 1.739,07 | 1.924,70 | 0,02 | 0,02 | 0,02 | 688,33 | 596,09 | 781,72 | 0,001% |
| Lingegebied & Diefdijk-Zuid | H9999:70 | Habitattype onbekend/onzeker, KDW obv: H7230 | 1143,00 | 327 | 64,40 | 1.841,66 | 1.168,22 | 3.117,00 | 0,02 | 0,01 | 0,03 | 698,68 | 25,23 | 1.974,02 | 0,001% |
| Loevestein, Pompveld & Komsche Boezem | H6120 | Stroomdalgraslanden | 1286,00 | 4 | 0,40 | 1.291,60 | 1.242,71 | 1.410,24 | 0,01 | 0,01 | 0,02 | 5,61 | -43,28 | 124,26 | 0,001% |
| Lonnekermeer | H3130 | Zwakgebufferde vennen | 571,00 | 17 | 2,08 | 1.927,38 | 1.611,74 | 2.363,95 | 0,02 | 0,02 | 0,02 | 1.356,40 | 1.040,76 | 1.792,97 | 0,001% |
| Loonse en Drunense Duinen & Leemkuilen | H3130 | Zwakgebufferde vennen | 571,00 | 59 | 5,82 | 1.856,15 | 1.494,28 | 2.257,26 | 0,02 | 0,01 | 0,02 | 1.285,17 | 923,30 | 1.686,28 | 0,001% |
| | ZGH3130 | Zwakgebufferde vennen | 571,00 | 1 | 0,13 | 2.050,40 | 2.050,40 | 2.050,40 | 0,01 | 0,01 | 0,01 | 1.479,41 | 1.479,41 | 1.479,41 | 0,001% |
| | H3130 | Zwakgebufferde vennen | 571,00 | 169 | 55,44 | 1.640,43 | 1.165,61 | 2.498,40 | 0,01 | 0,01 | 0,02 | 1.069,45 | 594,62 | 1.927,41 | 0,001% |
| Maasduinen | L3130 | Zwakgebufferde vennen | 571,00 | 6 | 0,22 | 1.920,11 | 1.789,05 | 2.007,02 | 0,01 | 0,01 | 0,01 | 1.349,12 | 1.218,06 | 1.436,03 | 0,001% |
| | H2130B | Grijze duinen (kalkarm) | 714,00 | 438 | 110,66 | 1.305,64 | 875,86 | 1.784,43 | 0,02 | 0,01 | 0,02 | 591,66 | 161,87 | 1.070,45 | 0,002% |
| Manteling van Walcheren | H2130C | Grijze duinen (heischraal) | 714,00 | 23 | 0,62 | 1.293,71 | 1.067,59 | 1.752,83 | 0,02 | 0,02 | 0,02 | 579,72 | 353,61 | 1.038,85 | 0,001% |
| Mantingerbos | H9120 | Beuken-eikenbossen met hulst | 1429,00 | 31 | 15,09 | 1.851,48 | 1.407,72 | 2.496,70 | 0,03 | 0,02 | 0,03 | 422,51 | -21,26 | 1.067,73 | 0,002% |
| Mantingerzand | H3130 | Zwakgebufferde vennen | 571,00 | 38 | 8,40 | 1.330,69 | 1.219,45 | 1.590,54 | 0,02 | 0,02 | 0,02 | 759,71 | 648,47 | 1.019,56 | 0,002% |
| Meijendel & Berkheide | H3140 | Kranswierwateren | 571,00 | 97 | 15,84 | 1.079,97 | 964,34 | 1.536,43 | 0,03 | 0,02 | 0,03 | 508,99 | 393,37 | 965,46 | 0,002% |
| Meinweg | ZGH3130 | Zwakgebufferde vennen | 571,00 | 8 | 0,22 | 1.475,82 | 1.315,10 | 1.659,20 | 0,01 | 0,01 | 0,01 | 904,83 | 744,11 | 1.088,21 | 0,001% |
| | H9999:94 | Habitattype onbekend/onzeker, KDW obv: H3130;H3140 | 571,00 | 9 | 1,56 | 1.522,22 | 1.194,86 | 1.771,74 | 0,03 | 0,02 | 0,03 | 951,25 | 623,88 | 1.200,77 | 0,002% |
| Naardermeer | H3130 | Zwakgebufferde vennen | 571,00 | 5 | 0,25 | 1.421,77 | 1.255,71 | 1.649,74 | 0,02 | 0,02 | 0,02 | 850,79 | 684,73 | 1.078,76 | 0,002% |
| Nieuwkoopse Plassen & De Haeck | H7140B | Overgangs- en trilvenen (veenmosrietlanden) | 714,00 | 710 | 167,67 | 1.332,71 | 1.079,96 | 2.268,72 | 0,02 | 0,02 | 0,03 | 618,73 | 365,98 | 1.554,75 | 0,002% |
| Noorbeemden & Hoogbos | H9160B | Eiken-haagbeukenbossen (heuvelland) | 1429,00 | 8 | 0,88 | 1.464,38 | 1.366,06 | 1.619,88 | 0,01 | 0,01 | 0,01 | 35,39 | -62,93 | 190,89 | 0,001% |
| | H2130B | Grijze duinen (kalkarm) | 714,00 | 3000 | 475,72 | 1.205,22 | 766,26 | 2.145,73 | 0,04 | 0,03 | 0,07 | 491,27 | 52,29 | 1.431,79 | 0,004% |
| Noordhollands Duinreservaat | H2130C | Grijze duinen (heischraal) | 714,00 | 142 | 7,19 | 1.127,32 | 941,19 | 1.720,52 | 0,04 | 0,03 | 0,06 | 413,37 | 227,23 | 1.006,58 | 0,004% |
| Norgerholt | H9120 | Beuken-eikenbossen met hulst | 1429,00 | 38 | 23,62 | 1.934,28 | 1.412,02 | 2.323,16 | 0,04 | 0,03 | 0,04 | 505,31 | -16,95 | 894,20 | 0,002% |
| Oeffelter Meent | H6120 | Stroomdalgraslanden | 1286,00 | 9 | 3,32 | 1.428,73 | 1.374,32 | 1.518,71 | 0,01 | 0,01 | 0,01 | 142,75 | 88,33 | 232,72 | 0,001% |
| | H7140B | Overgangs- en trilvenen (veenmosrietlanden) | 714,00 | 63 | 2,89 | 1.403,53 | 1.213,13 | 1.700,77 | 0,02 | 0,02 | 0,03 | 689,55 | 499,15 | 986,79 | 0,002% |
| Olde Maten & Veerslootslanden | H6230 | Heischrale graslanden | 714,00 | 11 | 0,59 | 1.550,02 | 1.316,95 | 1.737,72 | 0,02 | 0,02 | 0,03 | 836,05 | 602,97 | 1.023,75 | 0,002% |
| Oostelijke Vechtplassen | H9999:95 | Habitattype onbekend/onzeker, KDW obv: H3140 | 571,00 | 26 | 3,80 | 1.481,18 | 1.140,70 | 1.820,99 | 0,02 | 0,02 | 0,03 | 910,20 | 569,72 | 1.250,02 | 0,002% |
| Oosterschelde | H7140B | Overgangs- en trilvenen (veenmosrietlanden) | 714,00 | 2 | 0,06 | 1.071,33 | 1.048,14 | 1.094,52 | 0,01 | 0,01 | 0,01 | 357,34 | 334,15 | 380,53 | 0,001% |
| Oudegaasterbrekken, Fluessen en omgeving | H7140B | Overgangs- en trilvenen (veenmosrietlanden) | 714,00 | 2 | 0,07 | 1.076,52 | 1.072,75 | 1.080,29 | 0,03 | 0,03 | 0,03 | 362,55 | 358,78 | 366,32 | 0,003% |
| | ZGH7140B | Overgangs- en trilvenen (veenmosrietlanden) | 714,00 | 3 | 0,09 | 1.198,05 | 1.174,72 | 1.236,10 | 0,03 | 0,03 | 0,03 | 484,08 | 460,75 | 522,13 | 0,002% |
| Polder Westzaan | H7140B | Overgangs- en trilvenen (veenmosrietlanden) | 714,00 | 218 | 14,70 | 1.191,45 | 1.056,29 | 1.960,40 | 0,03 | 0,02 | 0,04 | 477,48 | 342,32 | 1.246,43 | 0,003% |
| Regte Heide & Riels Laag | H3130 | Zwakgebufferde vennen | 571,00 | 56 | 3,41 | 1.506,72 | 1.215,62 | 2.337,28 | 0,01 | 0,01 | 0,02 | 935,74 | 644,63 | 1.766,30 | 0,001% |
| Rijntakken | H6120 | Stroomdalgraslanden | 1286,00 | 206 | 29,09 | 1.410,20 | 1.248,65 | 2.308,29 | 0,01 | 0,01 | 0,02 | 124,21 | -37,34 | 1.022,31 | 0,002% |
| | Lg06 | Dotterbloemgrasland van beekdalen | 1429,00 | 37 | 10,57 | 1.602,09 | 1.363,21 | 2.121,99 | 0,01 | 0,01 | 0,01 | 173,11 | -65,78 | 693,00 | 0,001% |
| | ZGH9120 | Beuken-eikenbossen met hulst | 1429,00 | 6 | 2,07 | 1.994,29 | 1.926,56 | 2.116,46 | 0,01 | 0,01 | 0,01 | 565,30 | 497,57 | 687,47 | 0,001% |
| | Lg10 | Kamgrasweide & Bloemrijk weidevogelgrasland van het zand- en veen | 1429,00 | 23 | 1,35 | 1.615,08 | 1.364,36 | 2.181,71 | 0,01 | 0,01 | 0,01 | 186,09 | -64,63 | 752,72 | 0,001% |
| | L6510A | Glanshaver- en vossenstaarthooilanden (glanshaver) | 1429,00 | 20 | 7,48 | 1.499,38 | 1.373,52 | 1.806,10 | 0,01 | 0,01 | 0,01 | 70,39 | -55,47 | 377,11 | 0,001% |
| Roerdal | H9120 | Beuken-eikenbossen met hulst | 1429,00 | 24 | 3,16 | 1.839,63 | 1.537,66 | 2.217,15 | 0,01 | 0,01 | 0,01 | 410,64 | 108,67 | 788,16 | 0,001% |
| | H6230 | Heischrale graslanden | 714,00 | 35 | 1,10 | 1.222,92 | 1.090,28 | 1.500,55 | 0,03 | 0,02 | 0,03 | 508,95 | 376,31 | 786,58 | 0,002% |
| Rottige Meenthe & Brandemeer | H7140B | Overgangs- en trilvenen (veenmosrietlanden) | 714,00 | 531 | 153,86 | 1.247,65 | 991,54 | 1.721,82 | 0,03 | 0,02 | 0,04 | 533,68 | 277,56 | 1.007,86 | 0,002% |

| Natura 2000-gebied | Habitattype / Leefgebied | | | | | Achtergronddepositie | | | Projectdepositie | | | Overschrijding KDW | | | Aandeel project |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Naam | Code | Naam | KDW | #hex | Opp (ha) | Gem | Min | Max | Gem | Min | Max | Gem | Min | Max | tov totaal |
| | H6230vka | Heischrale graslanden, vochtig kalkarm | 714,00 | 33 | 0,50 | 1.586,35 | 1.223,32 | 2.555,80 | 0,02 | 0,02 | 0,03 | 872,37 | 509,34 | 1.841,83 | 0,001% |
| Sallandse Heuvelrug | H9999:42 | Habitattype onbekend/onzeker, KDW obv: H6230;H2330;H3160 | 714,00 | 4 | 0,74 | 2.074,37 | 1.448,52 | 2.315,30 | 0,02 | 0,02 | 0,03 | 1.360,39 | 734,54 | 1.601,33 | 0,001% |
| Sarsven en De Banen | H3110 | Zeer zwakgebufferde vennen | 429,00 | 16 | 1,83 | 1.878,10 | 1.394,51 | 2.341,68 | 0,01 | 0,01 | 0,01 | 1.449,11 | 965,52 | 1.912,69 | 0,001% |
| | H6110 | Pionierbegroeiingen op rotsbodem | 1429,00 | 2 | 0,02 | 1.463,51 | 1.417,67 | 1.509,34 | 0,01 | 0,01 | 0,01 | 34,52 | -11,32 | 80,35 | 0,001% |
| | H9120 | Beuken-eikenbossen met hulst | 1429,00 | 114 | 27,45 | 1.618,19 | 1.375,39 | 1.840,70 | 0,01 | 0,01 | 0,01 | 189,20 | -53,60 | 411,71 | 0,001% |
| Savelsbos | H9160B | Eiken-haagbeukenbossen (heuvelland) | 1429,00 | 337 | 157,35 | 1.583,68 | 1.360,14 | 1.840,70 | 0,01 | 0,01 | 0,01 | 154,69 | -68,85 | 411,71 | 0,001% |
| | ZGH2130B | Grijze duinen (kalkarm) | 714,00 | 9 | 1,82 | 1.140,09 | 984,83 | 1.293,63 | 0,05 | 0,04 | 0,06 | 426,14 | 270,87 | 579,69 | 0,004% |
| Schoorlse Duinen | H2130B | Grijze duinen (kalkarm) | 714,00 | 539 | 103,35 | 1.166,27 | 792,08 | 1.799,23 | 0,05 | 0,04 | 0,07 | 452,32 | 78,12 | 1.085,29 | 0,005% |
| Sint Jansberg | H9120 | Beuken-eikenbossen met hulst | 1429,00 | 186 | 79,35 | 2.330,50 | 1.577,42 | 2.685,99 | 0,02 | 0,01 | 0,02 | 901,52 | 148,43 | 1.257,01 | 0,001% |
| Sint Pietersberg & Jekerdal | H6230dkr | Heischrale graslanden, droog kalkrijk | 857,00 | 2 | 0,10 | 1.209,35 | 1.101,49 | 1.317,21 | 0,01 | 0,01 | 0,01 | 352,36 | 244,50 | 460,22 | 0,001% |
| | H2130B | Grijze duinen (kalkarm) | 714,00 | 186 | 89,82 | 1.187,47 | 933,61 | 1.836,40 | 0,02 | 0,02 | 0,03 | 473,50 | 219,63 | 1.122,43 | 0,002% |
| Solleveld & Kapittelduinen | ZGH2130B | Grijze duinen (kalkarm) | 714,00 | 12 | 5,37 | 1.158,43 | 1.104,64 | 1.473,07 | 0,02 | 0,02 | 0,02 | 444,45 | 390,66 | 759,09 | 0,002% |
| | ZGH6230vka | Heischrale graslanden, vochtig kalkarm | 714,00 | 3 | 0,01 | 2.015,55 | 1.777,93 | 2.320,17 | 0,02 | 0,02 | 0,02 | 1.301,57 | 1.063,95 | 1.606,19 | 0,001% |
| | H6230vka | Heischrale graslanden, vochtig kalkarm | 714,00 | 47 | 2,36 | 1.896,98 | 1.499,21 | 2.680,91 | 0,02 | 0,02 | 0,02 | 1.183,00 | 785,23 | 1.966,93 | 0,001% |
| Springendal & Dal van de Mosbeek | H9999:45 | Habitattype onbekend/onzeker, KDW obv: H6230 | 714,00 | 10 | 0,95 | 2.351,56 | 1.972,84 | 2.676,28 | 0,02 | 0,02 | 0,02 | 1.637,58 | 1.258,86 | 1.962,30 | 0,001% |
| Stelkampsveld | H3130 | Zwakgebufferde vennen | 571,00 | 22 | 2,01 | 1.925,99 | 1.584,50 | 2.289,21 | 0,02 | 0,02 | 0,02 | 1.355,00 | 1.013,52 | 1.718,23 | 0,001% |
| Strabrechtse Heide & Beuven | H3110 | Zeer zwakgebufferde vennen | 429,00 | 69 | 49,12 | 1.240,28 | 1.126,80 | 1.615,95 | 0,01 | 0,01 | 0,01 | 811,29 | 697,81 | 1.186,96 | 0,001% |
| Swalmdal | H9999:148 | Habitattype onbekend/onzeker, KDW obv: H4030 | 1071,00 | 7 | 0,97 | 2.078,45 | 1.908,93 | 2.207,02 | 0,01 | 0,01 | 0,02 | 1.007,46 | 837,94 | 1.136,04 | 0,001% |
| Uiterwaarden Lek | H6120 | Stroomdalgraslanden | 1286,00 | 55 | 7,32 | 1.470,66 | 1.346,06 | 1.700,20 | 0,02 | 0,01 | 0,02 | 184,68 | 60,07 | 414,22 | 0,001% |
| Uiterwaarden Zwarte Water en Vecht | H6410 | Blauwgraslanden | 1071,00 | 2 | 0,27 | 1.432,87 | 1.412,67 | 1.453,06 | 0,02 | 0,02 | 0,02 | 361,89 | 341,69 | 382,08 | 0,001% |
| | H9120 | Beuken-eikenbossen met hulst | 1429,00 | 91 | 29,06 | 2.198,50 | 1.645,54 | 2.430,36 | 0,02 | 0,02 | 0,02 | 769,52 | 216,56 | 1.001,38 | 0,001% |
| Ulvenhoutse Bos | H9160A | Eiken-haagbeukenbossen (hogere zandgronden) | 1429,00 | 42 | 6,26 | 2.233,79 | 1.873,24 | 2.413,16 | 0,02 | 0,02 | 0,02 | 804,81 | 444,26 | 984,18 | 0,001% |
| Van Oordt's Mersken | H3130 | Zwakgebufferde vennen | 571,00 | 1 | 0,06 | 1.713,27 | 1.713,27 | 1.713,27 | 0,04 | 0,04 | 0,04 | 1.142,31 | 1.142,31 | 1.142,31 | 0,002% |
| | H7120ah | Herstellende hoogvenen, actief hoogveen | 500,00 | 95 | 44,14 | 1.561,85 | 1.313,58 | 2.024,50 | 0,02 | 0,02 | 0,02 | 1.061,87 | 813,60 | 1.524,52 | 0,001% |
| | H9999:39 | Habitattype onbekend/onzeker, KDW obv: H7120 | 500,00 | 3 | 0,31 | 2.361,13 | 2.231,17 | 2.432,33 | 0,03 | 0,03 | 0,03 | 1.861,16 | 1.731,20 | 1.932,36 | 0,001% |
| Vecht- en Beneden-Reggegebied | ZGH7120ah | Herstellende hoogvenen, actief hoogveen | 500,00 | 5 | 0,14 | 1.668,80 | 1.527,15 | 1.958,84 | 0,02 | 0,02 | 0,02 | 1.168,83 | 1.027,17 | 1.458,86 | 0,001% |
| Veluwe | H3130 | Zwakgebufferde vennen | 571,00 | 70 | 5,43 | 1.581,75 | 1.115,34 | 2.358,72 | 0,02 | 0,02 | 0,03 | 1.010,78 | 544,36 | 1.787,75 | 0,002% |
| Vlijmens Ven, Moerputten & Bossche Broek | H3140hz | Kranswierwateren, op hogere zandgronden | 571,00 | 12 | 0,19 | 1.654,25 | 1.300,70 | 1.981,34 | 0,02 | 0,01 | 0,02 | 1.083,27 | 729,71 | 1.410,36 | 0,001% |
| | ZGH2130B | Grijze duinen (kalkarm) | 714,00 | 5 | 1,08 | 1.465,38 | 1.424,76 | 1.542,26 | 0,02 | 0,02 | 0,03 | 751,40 | 710,78 | 828,29 | 0,002% |
| | H2130C | Grijze duinen (heischraal) | 714,00 | 49 | 1,40 | 1.295,94 | 1.141,01 | 1.744,51 | 0,02 | 0,02 | 0,03 | 581,96 | 427,03 | 1.030,54 | 0,002% |
| Voornes Duin | H2130B | Grijze duinen (kalkarm) | 714,00 | 1 | 0,07 | 1.428,79 | 1.428,79 | 1.428,79 | 0,02 | 0,02 | 0,02 | 714,81 | 714,81 | 714,81 | 0,002% |
| Waddenzee | H2130B | Grijze duinen (kalkarm) | 714,00 | 20 | 1,71 | 872,85 | 712,78 | 1.093,79 | 0,05 | 0,04 | 0,06 | 158,90 | -1,18 | 379,85 | 0,006% |
| Weerribben | H9999:34 | Habitattype onbekend/onzeker, KDW obv: H7120 | 500,00 | 143 | 25,08 | 1.292,03 | 1.054,11 | 1.821,00 | 0,03 | 0,02 | 0,04 | 792,06 | 554,13 | 1.321,04 | 0,002% |
| Weerter- en Budelerbergen & Ringselven | H3130 | Zwakgebufferde vennen | 571,00 | 137 | 34,24 | 1.704,13 | 1.144,11 | 2.415,35 | 0,01 | 0,01 | 0,02 | 1.133,14 | 573,12 | 1.844,37 | 0,001% |
| Westduinpark & Wapendal | H2130B | Grijze duinen (kalkarm) | 714,00 | 44 | 4,23 | 1.469,66 | 989,53 | 1.964,73 | 0,03 | 0,02 | 0,03 | 755,69 | 275,55 | 1.250,76 | 0,002% |
| | H7110A | Actieve hoogvenen (hoogveenlandschap) | 500,00 | 1 | 0,01 | 1.448,95 | 1.448,95 | 1.448,95 | 0,02 | 0,02 | 0,02 | 948,97 | 948,97 | 948,97 | 0,001% |
| Wierdense Veld | H7120ah | Herstellende hoogvenen, actief hoogveen | 500,00 | 458 | 382,58 | 1.495,48 | 1.282,10 | 2.631,66 | 0,02 | 0,02 | 0,03 | 995,50 | 782,12 | 2.131,69 | 0,001% |
| Wijnjeterper Schar | H3130 | Zwakgebufferde vennen | 571,00 | 5 | 0,21 | 1.423,35 | 1.303,07 | 1.480,08 | 0,03 | 0,03 | 0,03 | 852,38 | 732,10 | 909,11 | 0,002% |
| Willinks Weust | H6230vka | Heischrale graslanden, vochtig kalkarm | 714,00 | 10 | 0,98 | 2.198,56 | 1.899,84 | 2.483,05 | 0,02 | 0,02 | 0,02 | 1.484,57 | 1.185,86 | 1.769,07 | 0,001% |
| | H7120ah | Herstellende hoogvenen, actief hoogveen | 500,00 | 8 | 3,10 | 1.846,05 | 1.688,91 | 2.157,37 | 0,02 | 0,02 | 0,02 | 1.346,06 | 1.188,93 | 1.657,39 | 0,001% |
| Witte Veen | ZGH7120ah | Herstellende hoogvenen, actief hoogveen | 500,00 | 4 | 0,41 | 1.815,52 | 1.701,51 | 1.912,60 | 0,02 | 0,02 | 0,02 | 1.315,54 | 1.201,53 | 1.412,62 | 0,001% |

| Natura 2000-gebied | Habitattype / Leefgebied | | | | | Achtergronddepositie | | | Projectdepositie | | | Overschrijding KDW | | | Aandeel project |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Naam | Code | Naam | KDW | #hex | Opp (ha) | Gem | Min | Max | Gem | Min | Max | Gem | Min | Max | tov totaal |
| Witterveld | H7120ah | Herstellende hoogvenen, actief hoogveen | 500 | 419 | 278,77 | 1.286,55 | 1.061,32 | 1.887,21 | 0,03 | 0,02 | 0,03 | 786,58 | 561,34 | 1.387,24 | 0,002% |
| | H7110A | Actieve hoogvenen (hoogveenlandschap) | 500 | 11 | 3,08 | 1.186,40 | 1.115,77 | 1.289,56 | 0,02 | 0,02 | 0,03 | 686,42 | 615,79 | 789,59 | 0,002% |
| Wooldse Veen | H7120ah | Herstellende hoogvenen, actief hoogveen | 500 | 52 | 33,04 | 2.001,89 | 1.716,48 | 2.427,07 | 0,01 | 0,01 | 0,02 | 1.501,90 | 1.216,49 | 1.927,09 | 0,001% |
| | H7110A | Actieve hoogvenen (hoogveenlandschap) | 500 | 4 | 0,25 | 1.873,42 | 1.802,44 | 1.939,53 | 0,01 | 0,01 | 0,01 | 1.373,43 | 1.302,45 | 1.439,54 | 0,001% |
| Wormer- en Jisperveld & Kalverpolder | H7140B | Overgangs- en trilvenen (veenmosrietlanden) | 714 | 263 | 14,32 | 1.083,31 | 936,17 | 1.481,67 | 0,02 | 0,02 | 0,03 | 369,33 | 222,19 | 767,70 | 0,003% |
| Yerseke en Kapelse Moer | H1330B | Schorren en zilte graslanden (binnendijks) | 1571 | 2 | 0,02 | 1.584,67 | 1.522,62 | 1.646,72 | 0,01 | 0,01 | 0,01 | 13,68 | -48,37 | 75,73 | 0,001% |
| Zeldersche Driessen | H6120 | Stroomdalgraslanden | 1286 | 7 | 1,60 | 1.898,40 | 1.541,73 | 2.360,47 | 0,01 | 0,01 | 0,02 | 612,41 | 255,74 | 1.074,49 | 0,001% |
| Zouweboezem | H6410 | Blauwgraslanden | 1071 | 9 | 1,83 | 1.494,52 | 1.360,56 | 1.654,68 | 0,02 | 0,02 | 0,02 | 423,54 | 289,58 | 583,70 | 0,001% |
| Zwanenwater & Pettemerduinen | H6230vka | Heischrale graslanden, vochtig kalkarm | 714 | 122 | 6,68 | 1.039,12 | 649,46 | 1.453,06 | 0,05 | 0,03 | 0,06 | 325,17 | -64,50 | 739,12 | 0,005% |
| | H2130B | Grijze duinen (kalkarm) | 714 | 591 | 153,05 | 1.064,66 | 682,14 | 1.701,25 | 0,05 | 0,03 | 0,06 | 350,71 | -31,83 | 987,31 | 0,005% |
| | H9999:85 | Habitattype onbekend/onzeker, KDW obv H2130B;H6230 | 714 | 11 | 1,48 | 1.060,98 | 882,27 | 1.360,27 | 0,04 | 0,04 | 0,05 | 347,02 | 168,30 | 646,32 | 0,004% |
| | ZGH2130B | Grijze duinen (kalkarm) | 714 | 5 | 0,41 | 996,41 | 882,27 | 1.169,67 | 0,04 | 0,04 | 0,05 | 282,45 | 168,30 | 455,72 | 0,004% |
| Zwin & Kievittepolder | H2190A | Vochtige duinvalleien (open water) | 1000 | 11 | 0,20 | 1.184,85 | 1.091,24 | 1.400,27 | 0,01 | 0,01 | 0,01 | 184,86 | 91,25 | 400,28 | 0,001% |



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# Bijlage 14: Samenvattingen Engelse en Duitse studies

# NeuConnect

## Inleiding

In deze notitie zijn ten behoeve van het MER de milieueffecten van de NeuConnect verbinding in de Duitse en Britse wateren beschreven. Hieronder is eerst kort de in de drie landen benodigde besluitvorming beschreven, waarna de milieueffecten van de verbinding in de Britse wateren wordt beschreven, gevolgd door de effecten van de verbinding in de Duitse wateren. Zowel ten aanzien van de milieueffecten in de Britse als in de Duitse wateren wordt geconcludeerd dat – al dan niet na het nemen van mitigerende maatregelen – geen sprake is van belangrijke nadelige milieueffecten. Voor de Duitse kustzee moet als gevolg van een Duits nationaal beschermingsregime compensatie plaatsvinden voor het ruimtebeslag van de kabel en in het bijzonder het aanlandingspunt.

De informatie met betrekking tot de Britse wateren is afkomstig uit het opgestelde rapport “NeuConnect Great Britiain to Germany Interconnector, GB Offshore Scheme Non-Technical Summary”, opgesteld door AECOM UK Limited, augustus 2020 en ingediend bij de Britse overheid in september 2020. De informatie met betrekking tot de Duitse wateren is afkomstig uit het opgestelde rapport “NeuConnect Umweltfach-beitrag Abschnitt Niedersächsisches Küstenmeer“ door BioConsult SH, november 2020 (NC_EnWG_OFF_BIC_8-UFB_20201111_BV_R_01) en het rapport “NeuConnect Erläuterungsbericht für die Deutsche AWZ” , opgesteld door AECOM Deutschland GmbH, november 2020 en ingediend bij de Duitse overheid in december 2020.

## Benodige besluitvorming

Het NeuConnect kabeltracé gaat door drie rechtsgebieden (Groot-Brittannië, Nederland en Duitsland). Voor de gedeelten van de kabel die in het water worden aangelegd en voor de aansluiting en de convertorstations op land zijn er in ieder land bevoegde gezagen die verantwoordelijk zijn voor de in dat land van toepassing zijnde vergunningsprocedures, zoals aangegeven in Tabel 1-1. De vergunningprocedures en de eisen die aan onderliggende onderzoeken worden gesteld verschillen per land en de vergunningprocedures worden in ieder land afzonderlijk doorlopen. De aanvraag voor de mariene vergunning in Groot-Brittannië is ingediend in september 2020 en de aanvragen in Duitsland in december 2020.

**Tabel 1-1: Bevoegde gezagen per rechtsgebied**

| Rechtsgebied | Nationale bevoegde gezagen | Vergunning/toestemming |
|---|---|---|
| Groot-Brittannië onshore | Medway Council | Vergunning op grond van de Town and Country Planning Act 1990 |
| Groot-Brittannië offshore | Marine Management Organisation (MMO) | Mariene vergunning op grond van Marine and Coastal Access Act 2009 (MMO)<br>Coördinerend gezag TEN-E |
| Nederland offshore | Minister van Infrastructuur en Waterstaat (vertegenwoordigd door Rijkswaterstaat) | Watervergunning op basis van de Waterwet (inclusief MER) |
| | Minister van Landbouw, Natuur en Voedselkwaliteit (LNV) | Vergunning voor beschermde gebieden (Friese Front) op grond van de Wet natuurbescherming |
| | Ministerie van Economische Zaken en Klimaat | Coördinerend bevoegd gezag TEN-E en rijkscoördinatieregeling (RCR) |
| Duitsland onshore | Niedersächsische Landesbehörde für Straßenbau und Verkehr (NLStBV) | Vergunning op basis van de Energiewirtschaftsgesetz (EnWG) |
| | Gewerbeaufsichtsamt (GAA) Oldenburg | Vergunning op basis van de Bundesimmissionsschutzgesetz |
| Duitsland offshore | Bundesamt für Seeschifffahrt und Hydrographie (BSH) | Vergunning op basis van de Bundesberggesetz (BBergG) |
| | Landesamt für Bergbau, Energie und Geologie (LBEG) | Vergunning op basis van de Bundesberggesetz<br>Coördinerend bevoegd gezag TEN-E |

| Rechtsgebied | Nationale bevoegde gezagen | Vergunning/toestemming |
|---|---|---|
| | Bundernetzagentur fur Elektrizitat, Gas, Telekommunikation, Post und Eisenbahnen (BnetzA) | |

In Nederland zijn een watervergunning (inclusief het MER ten behoeve van besluitvorming over de watervergunning) en een vergunning op grond van de Wet natuurbescherming vereist (vergunning gebiedsbescherming) benodigd. De minister van Infrastructuur en Waterstaat, vertegenwoordigd door RWS, is bevoegd gezag voor de watervergunning. De minister van Landbouw, Natuur en Voedselkwaliteit is bevoegd voor het verlenen van een vergunning voor beschermde gebieden (Friese Front) op grond van de Wet natuurbescherming. De minister van Economische Zaken en Klimaat is het coördinerend bevoegd gezag voor de rijkscoördinatieregeling en de TEN-E Verordening.

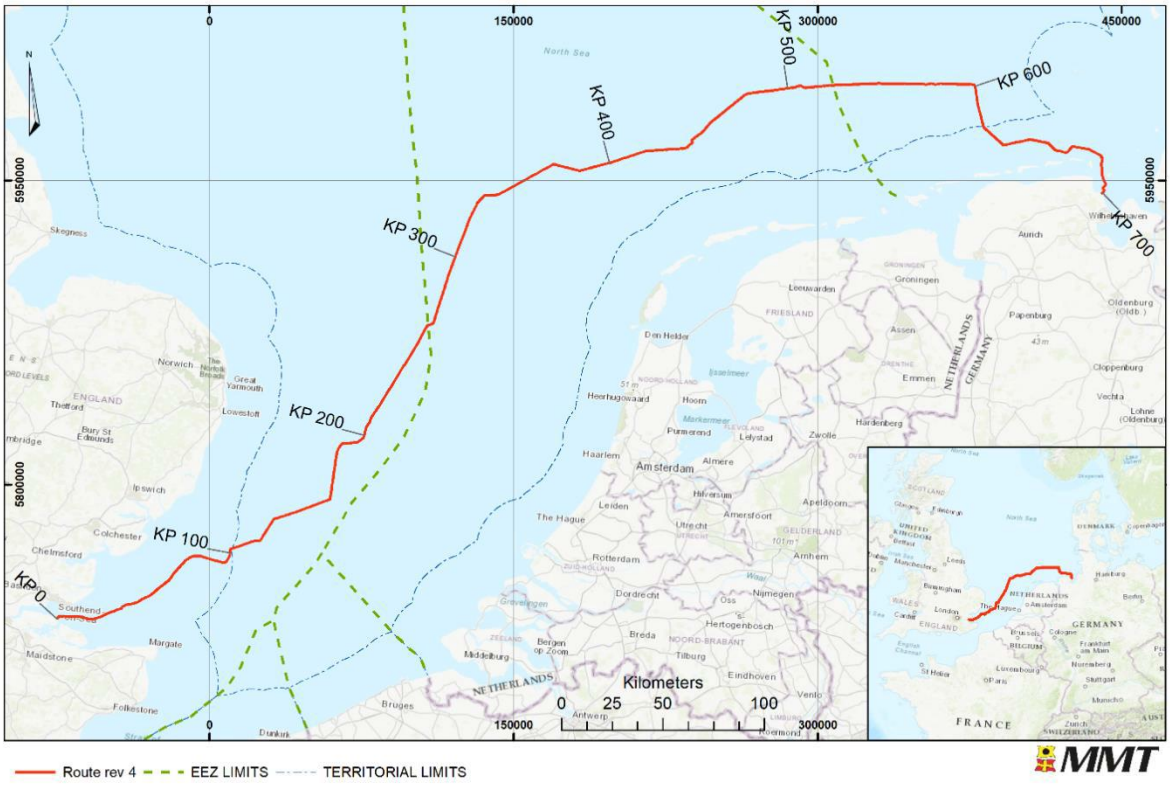
Een wettelijk verplichte MER is niet vereist voor de aanvraag voor het GB offshore gedeelte. Ter ondersteuning van de aanvraag voor de mariene vergunning zijn voor het GB Offshore gedeelte de milieueffecten in kaart gebracht in een milieueffectbeoordeling.

Ook voor het Duitse offshore gedeelte is een wettelijk verplicht MER niet vereist. Ter ondersteuning van de vergunningaanvragen zijn de milieueffecten in kaart gebracht. Ten aanzien van de Duitse kustwateren is conform de eisen van de Duitse natuurbeschermingswet (BNatSchG) aanvullend onderzoek verricht om de verenigbaarheid met de FFH-wet, de wet op de soortenbescherming, de wet op de biotoopbescherming en de aantastingsverordening in het kader van de natuurbeschermingswet te beoordelen. Daarom zijn een Natura 2000-effectbeoordeling, een beoordeling van de bescherming van soorten, een beoordeling van de bescherming van biotopen en een beoordeling van de waterwetgeving uitgevoerd en is een plan voor landschapsbehoud opgesteld.

# GB Offshore gedeelte

## Inleiding

Het GB Offshore gedeelte bevindt zich van MHWS aan de noordkust van de Isle of Grain, door de buitenste monding van de Theems en de zuidelijke Noordzee, alvorens de middellijn over te steken naar de Nederlandse wateren. Het GB Offshore gedeelte omvat een Project Route Corridor (PRC) met een lengte van ongeveer 270 km, van KP 0 tot KP 270, zoals weergegeven in Figuur 1-2, waarbinnen de onderzeese HVDC-kabels zullen worden geïnstalleerd.




Figuur 2-2 :Overzicht van de projectroute (GB Offshore)

## Overweging van alternatieven

Er is een reeks gespecialiseerde studies uitgevoerd om de haalbaarheid van het project te beoordelen. In het kader van deze studies is een reeks projectalternatieven bestudeerd.

### Technologie selectie

NeuConnect zal gebruik maken van gelijkstroomtechnologie (DC) omdat deze doeltreffender is om elektriciteit over langere afstanden te transporteren, hetgeen resulteert in lagere energieverliezen dan een gelijkwaardig wisselstroomsysteem (AC). Hoewel de elektriciteitstransmissiesystemen in Duitsland en GB met dezelfde frequentie werken, zijn ze niet gesynchroniseerd. Een HVDC-systeem maakt een einde aan de problemen die inherent zijn aan synchronisatie. Bovendien hoeven voor HVDC-systemen slechts twee transmissiekabels te worden geïnstalleerd, terwijl voor gelijkwaardige HVAC-systemen veelvouden van drie kabels nodig zouden zijn (d.w.z. één kabel per fase) om de hoeveelheid elektriciteit die wordt getransporteerd te kunnen verwerken. De fysieke voetafdruk van een HVDC-systeem is dus kleiner dan die van een gelijkwaardig HVAC-systeem, waardoor de ecologische voetafdruk van NeuConnect tot een minimum wordt beperkt.

### Route selectie en ontwerp

Bij de keuze van de PRC is rekening gehouden met een reeks milieu-, technische en commerciële factoren. Het resultaat is dat de voorgestelde corridor technisch haalbaar en economisch levensvatbaar is en de potentiële milieueffecten zo veel mogelijk zijn beperkt.

Een desktopstudie waarbij een breed scala van mogelijke beperkingen werd bekeken, werd in eerste instantie uitgevoerd om een corridor van ongeveer 500 m breed te identificeren, die vervolgens werd onderworpen aan een reeks onderzoeken van de zeebodem (geofysisch, geotechnisch en benthisch onderzoek). Bovendien had NeuConnect ontmoetingen met regelgevende instanties in Groot-Brittannië, Nederland en Duitsland om tracéopties te bespreken in belangrijke stadia voorafgaand aan en tijdens de desktopstudies en onderzoeken van de zeebodem, alsook vergaderingen in het kader van het vergunningsproces.

De 500 m brede (op bepaalde specifieke plaatsen variabele) corridor waarvoor nu toestemming wordt gevraagd, is aangewezen omdat:

- Dankzij de eigenschappen van de zeebodem de kabel kan worden ingegraven tot een veilige diepte van 1,5 à 2 m;
- Het gevaarlijke terrein op de zeebodem zoveel mogelijk wordt vermeden, zodat het risico dat de kabel na de installatie bloot komt te liggen, tot een minimum kan worden beperkt;
- Het ruimtebeslag in ecologisch beschermde gebieden, met name de speciale beschermingszone Margate and Long Sands (SAC) in de monding van de Theems, tot een minimum wordt beperkt, terwijl tegelijkertijd ook het ruimtebeslag in de aangrenzende drukke scheepvaartroutes en transitgebieden tot een minimum wordt beperkt;
- De interactie met bestaande offshore-infrastructuur, zoals andere kabels en pijpleidingen, offshore-windmolenparken, olie- en gasinstallaties en andere welomschreven mariene gebruiksdoeleinden, zoals ankergebieden, baggergebieden, wingebieden en militaire oefengebieden, tot een minimum wordt beperkt.

# Milieubeoordeling

## Methodologie voor de milieubeoordeling

De informatie in de milieueffectbeoordeling (EA) is afkomstig uit bestaande literatuur, overleg met plaatselijke deskundigen, (overheids)instanties en studies en onderzoeken ter plaatse. De EA is onderverdeeld in afzonderlijke thematische hoofdstukken die betrekking hebben op het fysische, biologische en menselijke milieu.

Het EA volgt de richtsnoeren van het Institute of Environmental Management and Assessment (IEMA) Guidelines for Environmental Impact Assessment (2004) en de Chartered Institute of Ecology and Environmental Management (CIEEM) Guidelines for Ecological Impact Assessment in Britain and Ireland: Marine and Coastal (2010).

Om de mogelijke effecten van het GB Offshore gedeelte te beoordelen, zijn de fysische, biologische en menselijke basisomstandigheden binnen de corridor vastgesteld. Vervolgens zijn de projectactiviteiten geïdentificeerd die een interactie kunnen hebben met geïdentificeerde milieuwaarden (bv. habitats, vissen, vogels) en tot een effect kunnen leiden. Voor elk potentieel effect is vervolgens gekeken naar de potentiële omvang van het effect (de mate van verandering die kan worden veroorzaakt) en de gevoeligheid van de ontvanger voor het effect. Vervolgens is het significantieniveau van het resulterende effect bepaald en zijn waar nodig mitigerende maatregelen vastgesteld om nadelige effecten te vermijden, te beperken of te voorkomen, of om de potentiële milieuvoordelen te maximaliseren. Eventuele resterende effecten, rekening houdend met alle mitigerende maatregelen, zijn in de EA beschreven.

In de volgende paragrafen worden de bevindingen van de EA samengevat.

## Fysieke processen

De bathymetrie in het Theems estuarium tussen KP0 en ongeveer KP75 van de corridor, wordt gedomineerd door afzettingen van grote zandbanken en bijbehorende geulen, waar de zeebodem bestaat uit zand en modderige zanden. Het gebied wordt beschouwd als actief met verschuivingen/migratie van de zandbanken en geulen. Van KP75 tot KP270, waar de corridor overgaat in Nederlandse wateren, wordt de zeebodem gekenmerkt door talrijke zandgolven en verscheidene grote noord-zuid verlopende zandbanken. Deze zijn waar mogelijk vermeden, hoewel de corridor door enkele kleine gebieden loopt die niet konden worden vermeden. De zeebodem bestaat over het algemeen uit zand of grindhoudend zand. De getijden zijn half-dagelijks met piekgetijden in het voorjaar rond 1,8 knopen (0,9 m/s). Onderzoek naar de verontreiniging van de sedimenten heeft geen verhoogde verontreinigingsniveaus aan het licht gebracht, met uitzondering van matige gehalten aan arseen, nikkel en bepaalde koolwaterstoffen in een klein aantal monsters.

Het GB Offshore gedeelte kan leiden tot plaatselijke veranderingen van de bathymetrie en kenmerken van de zeebodem, verstoring van de geologie en de sedimenten van de zeebodem, sedimenttransport, verontreiniging van de sedimenten en verandering van de waterkwaliteit, bv. door een sedimentpluim of lozingen van installatieschepen. Er zullen specifieke

installatiemethoden worden toegepast om de hoeveelheid zwevend sedimenten tot een minimum te beperken. In gebieden met zandgolven zal de kabel, voor zover mogelijk, worden ingegraven in de golftroggen onder de mobiele sedimentlaag om blootstelling te vermijden. Waar dit niet mogelijk is, zal een deel van de zandgolven onmiddellijk voor de installatie van de kabel worden geveegd en naar verwachting na de installatie terugkeren naar de staat van vóór de aanleg. Na de installatie zal het risico van uitslijting en veranderingen in het sedimenttransport als gevolg van de aanwezigheid van kabels tot een minimum worden beperkt, aangezien de kabels ten minste 1,5 tot 2 m onder de zeebodem zullen worden begraven. Deze effecten zullen naar verwachting van geringe omvang zijn, tijdelijk en plaatselijk van aard zijn en van geringe tot verwaarloosbare betekenis zijn.

# Benthische ecologie

Binnen de corridor zijn acht habitattypes geïdentificeerd.

- De twee habitats die in het intergetijdengebied van de corridor zijn geïdentificeerd, zijn representatief voor de habitat van bijlage I "slikwadden en zandplaten die bij eb niet onder water staan". Bovendien is intergetijdenzand en modderig zand een aangewezen kenmerk van de MCZ Medway Estuary, waarvan de grens over een lengte van ongeveer 500 m wordt doorkruist door de PRC. Van deze intergetijdenhabitats is bekend dat zij belangrijke foerageergebieden vormen voor in het wild levende vogels en steltlopers vanwege de macrofaunale gemeenschappen en flora die zij herbergen.
- Het subgetijdengebied omvat nog eens zes habitats. Verscheidene daarvan zijn opgenomen in bijlage I van de Habitatrichtlijn van de EG en zijn derhalve van Europees instandhoudingsbelang, met inbegrip van "zandbanken die te allen tijde licht met zeewater zijn bedekt" binnen de SAC Margate and Long Sands. Sommige zijn ook van nationaal instandhoudingsbelang en worden beschermd door nationale wetgeving en het UK Biodiversity Action Plan (BAP).

Het GB Offshore gedeelte kan leiden tot tijdelijke en/of permanente verstoring en/of verlies van habitats; tijdelijke toename van sedimenten in suspensie met verstikkingseffecten en verslechtering van de waterkwaliteit tot gevolg. Er is ook rekening gehouden met operationele verstoring als gevolg van plaatselijke warmte van de kabels die de omringende sedimenten aantast. Het belang van eventuele effecten werd beoordeeld als verwaarloosbaar tot gering, met uitzondering van de mogelijkheid van tijdelijke verstoring van habitats van zandgolven binnen Margate and Long Sands SAC. Het mogelijke significante effect op Margate and Long Sands SAC wordt nader besproken in de onderstaande paragraaf "aangewezen gebieden".

Het uitwerpen van ankers/ankerkettingen op de zeebodem door installatieschepen zal tot een minimum worden beperkt om verstoring van de zeebodem, met name in het intergetijdengebied, te beperken. De kabels zullen waar mogelijk in het intergetijdengebied worden geïnstalleerd met gebruikmaking van installatie vanaf schepen, waarbij een gering potentieel voor effecten op intergetijdenhabitats en -soorten door het ankeren, te verkiezen wordt geacht boven de potentiële verstoring als gevolg van installatie vanaf land. Na de installatie zal bentische ecologie worden gemonitord om na te gaan of het habitatherstel verloopt zoals verwacht.

# Vis en schaaldieren

De GB Offshore gedeelte loopt door paai- en kinderkamergebieden van verscheidene vissoorten die van commercieel en/of instandhoudingsbelang zijn, waaronder demersale en pelagische soorten, waaronder kabeljauw, haring, tongschar, Europese schol, zandspiering en wijting. De kweekgronden van andere soorten van economische waarde kunnen ook overlappen met of in de buurt liggen van de GB Offshore gedeelte, zoals Europese zeebaars en Europese sprot. De regio is ook belangrijk voor schelpdieren, met name kokkel, wulk en bruine krab. Andere vissoorten van nationaal en/of internationaal instandhoudingsbelang, zoals Europese paling, Atlantische zalm, zeeprik, elft en spiering, kunnen eveneens aanwezig zijn.

Mogelijke effecten zijn onder meer tijdelijke en/of permanente verstoring en/of verlies van habitats; verstikking van soorten (direct en indirect); verstoring of verwonding door onderwatergeluid; verandering van de kwaliteit van het zeewater door het gebruik van boorvloeistoffen (uitsluitend intergetijdengebied) of onbedoelde lozingen; en de mogelijkheid dat elektromagnetische velden die door de kabel worden geproduceerd het gedrag van vissen verstoren (bijv. foerageren en navigatie). In de meeste gevallen zullen de potentiële effecten gering of te verwaarlozen zijn. Tijdelijke verstoring van zandspiering en hun paaiplaatsen kan optreden, hoewel de ruimtelijke omvang van dit effect onbeduidend wordt geacht in de context van alternatieve equivalente habitats die in de Noordzee beschikbaar zijn. Hoewel het herstelvermogen van zandspiering over het algemeen als gering wordt beschouwd omdat paai- en volwassen habitats zich op dezelfde plaats bevinden en deze soort zeer plaatsgetrouw is, wordt op middellange termijn (1-5 jaar) een zeker herstel verwacht, waarbij geschikte substraten na de voltooiing van de kabelinstallatie opnieuw door individuen zullen worden gekoloniseerd.

Het GB Offshore gedeelte zal waar mogelijk in het intergetijdengebied worden geïnstalleerd met gebruikmaking van bootmethoden, waarbij een kleine kans op effecten op intergetijdenhabitats en -soorten door het stranden van de duwbak en het verankeren van het vaartuig te verkiezen wordt geacht boven de potentiële verstoring die kan optreden indien installatietechnieken op het land zouden worden gebruikt. Het uitwerpen van ankers/ankerkettingen op de zeebodem vanaf installatieschepen zal tot een minimum worden beperkt.

Het tijdstip van de werkzaamheden zal waar mogelijk zo worden gepland dat verstoring van het paaibestand van haring en zandspiering tot een minimum wordt beperkt en dat bekende paaigebieden tijdens de paaipieken worden vermeden. Indien nodig zullen ook seizoensgebonden beperkingen worden opgelegd voor geofysische onderzoeken om de effecten van onderwatergeluid op gevoelige vissen tot een minimum te beperken. Na de installatie zal het benthisch ecologisch onderzoek worden uitgevoerd om na te gaan of het herstel verloopt zoals verwacht.

## Zeezoogdieren

Van zeven soorten walvisachtigen is bekend dat zij regelmatig voorkomen in grote delen van de Noordzee: bruinvis, tuimelaardolfijn, witsnuitdolfijn, dwergvinvis, Rissodolfijn, gewone dolfijn en witflankdolfijn. Uit gegevens over waarnemingen blijkt dat bruinvissen de talrijkste walvisachtigen zijn in de wateren rond de GB Offshore gedeelte. Alle walvisachtigen zijn Europees beschermde soorten (EPS). Twee soorten vinpotigen (opgenomen in bijlage II van de EU Habitatrichtlijn) kunnen ook voorkomen in en grenzend aan de GB Offshore gedeelte: gewone zeehond en grijze zeehond.

Mogelijke effecten zijn onder meer verstoring door onderwatergeluid; EMV die het vermogen van zeezoogdieren om te navigeren verstoren; het risico van aanvaringen met installatieschepen; en het risico van lekkages en lozingen die leiden tot een wijziging van de waterkwaliteit. De potentiële effecten zijn beoordeeld als gering of verwaarloosbaar omdat de kans op een toevallige aanvaring of lekkage als gering is beoordeeld, omdat de kans daarop klein is.

Er zal een plan voor de beperking van de gevolgen voor zeezoogdieren (MMMP) worden opgesteld en indien nodig uitgevoerd. Dit zal worden opgesteld om alle potentiële effecten te beperken in overeenstemming met de meest recente geschikte JNCC-richtlijnen voor de betrokken activiteiten.

## Ornithologie

Het GB Offshore gedeelte overlapt met twee nationale en Europese gebieden die zijn aangewezen voor hun ornithologische waarde: The Thames Estuary and Marshes Ramsar/SPA/SSSI, en The Outer Thames Estuary SPA. Deze gebieden zijn aangewezen voor de bescherming van een aantal internationaal belangrijke vogelpopulaties, waaronder de grootste groep overwinterende roodkeelduikers in Groot-Brittannië. Binnen een straal van 10 km van het GB Offshore gedeelte zijn nog eens vier gebieden aangewezen voor hun ornithologische waarde. In 2018 is een onderzoek uitgevoerd naar watervogels die gebruik maken van het intergetijdengebied en daarbij zijn 24 soorten geregistreerd, waarvan er 18 als van instandhoudingsbelang werden beschouwd. Gebieden verder uit de kust in het estuarium van de Outer Thames en de zuidelijke Noordzee zijn belangrijk als foerageer- en foerageergebieden, en als trekroutes voor een breed scala aan zeevogels.

Mogelijke effecten zijn onder meer tijdelijke verstoring en verplaatsing in het subgetijden en het intergetijdengebied; en tijdelijke verstoring en verlies van habitat en bijbehorende prooibronnen die door watervogels in het intergetijdengebied worden gebruikt. Alle effecten werden als verwaarloosbaar beschouwd, met uitzondering van de verplaatsing van vogels in het intergetijdengebied, die als gering werd beoordeeld vanwege het grote belang in de Ramsar/SPA/SSSI van het Theems estuarium en de Marshes.

Het GB Offshore gedeelte omvat maatregelen ter voorkoming van potentiële effecten op ornithologische waarden. Deze omvatten installatiemethoden (HDD-boring) om het verlies en de verstoring van habitats die ornithologische waarden ondersteunen tot een minimum te beperken; de voorbereiding van het tracé wordt zo plaatselijk mogelijk uitgevoerd; en baggerspecie wordt gestort op een locatie die grenst aan de kabel, zodat de voetafdruk van verstoring tot een minimum wordt beperkt. Indien de bouwwerkzaamheden tijdens de wintermaanden tijdens hoogwaterperiodes moeten worden uitgevoerd, d.w.z. twee uur aan weerszijden van hoogwater, zal bovendien, indien passend en mogelijk, gebruik worden gemaakt van aanvullende mitigerende maatregelen, zoals afscherming ter hoogte van de MHWS-markering.

# Aangewezen gebieden

Het GB Offshore gedeelte loopt door de volgende beschermde gebieden:

- Het Greater Thames Estuary SPA Complex en Ramsar sites - ontworpen voor de bescherming van internationaal belangrijke vogelpopulaties;
- Outer Thames Estuary SPA - aangewezen voor de bescherming van de grootste aggregatie van overwinterende roodkeelduiker in het Verenigd Koninkrijk;
- Margate and Long Sands SAC - met inbegrip van de habitat van bijlage I "zandbanken die enigszins de hele tijd bedekt door zeewater";
- Zuidelijke Noordzee SAC - voorgesteld voor de bescherming van bruinvissen;
- Medway Estuary of Marine Conservation Zone (MCZ) - voorgesteld voor de bescherming van intergetijdenzand en modderig zand.

Binnen een straal van 10 km is nog een aantal andere gebieden geïdentificeerd. Het gaat onder meer om Ramsar-gebieden, mariene beschermingszones (MCZ's), gebieden van bijzonder wetenschappelijk belang (SSSI's), speciale beschermingszones (SPA's), speciale beschermingszones (SAC's), nationale natuurreservaten (NNR's) en plaatselijke natuurreservaten (LNR's).

Mogelijke effecten op de integriteit van beschermde gebieden als gevolg van kabelinstallatie, exploitatie en ontmanteling kunnen optreden als gevolg van tijdelijke of plaatselijke verstoring van gebiedscomponenten. Effecten op soorten / habitats van instandhoudingsbelang worden samengevat in elk afzonderlijk hoofdstuk van de waarden. Na beoordeling van de individuele gevoeligheid van de aan te wijzen kenmerken is nagegaan of de significantie van de effecten de integriteit van het gebied zou aantasten. Rekening houdend met de in het kader van het project genomen mitigerende maatregelen werden de effecten van geringe tot te verwaarlozen betekenis geacht.

Mitigatie- en controlemaatregelen, waaronder het minimaliseren van de plaatsing van rotsen of matrassen binnen de kwetsbare habitats die beschermd worden door de Margate and Long Sands SAC-aanduiding; controle na de aanleg van de Margate and Long Sands SAC-zandbanken; en ontwikkeling van een plan voor milieubeheer voor de bouw (CEMP) en 24-uurs installatiewerkzaamheden om de totale tijd van verstoring van vogels in de Thames Estuary and Marshes SPA/Ramsar/SSSI tot een minimum te beperken. Na toepassing van de mitigerende maatregelen zal het belang van de resterende effecten gering zijn.

# Commerciële visserij

Er zijn 351 vissersvaartuigen geregistreerd in de thuishavens langs de kustlijn van Kent, Essex en Suffolk, waarvan 86% een lengte van minder dan 10 m heeft. Binnen de kustwateren (6 nm uit de kust) overlapt het GB Offshore gedeelte gebieden die worden gebruikt door een verscheidenheid van vistuigen, waaronder: korren (kokkels), boomkorren (garnalen, kokkels), demersale trawls/zegens (meest waardevolle soorten tong en haring), vistuig met haken (zeebaars, tong) en korven en vallen (wulken, kreeften, krabben). De meest waardevolle vangst wordt behaald met dregvisserij, waarbij kokkels de meest waardevolle vangst vertegenwoordigt.

Mogelijke effecten zijn: verminderde toegang tot visgronden tijdens de installatiewerkzaamheden; tijdelijke verplaatsing van visserijactiviteiten; belemmering van de scheepvaart; indirecte effecten op commerciële vis- en schelpdiersoorten; verlies van visgronden op lange termijn; en verplaatsing van visserijactiviteiten op lange termijn. Het belang van de effecten zal verwaarloosbaar tot gering zijn, gezien de tijdelijke aard en het kleine oppervlak van eventuele beperkingsgebieden tijdens de installatie, en omdat de kabel in de zeebodem zal worden ingegraven.

Er is een visserijverbindingsfunctionaris (Fisheries Liaison Officer, FLO) aangesteld om te zorgen voor een doeltreffende voortdurende communicatie tussen het project en de belanghebbenden in de visserijsector. Waar nodig zullen tijdelijke veiligheidszones rond de installatie-infrastructuur worden ingesteld om het risico van interactie met vissersvaartuigen verder te beperken. Het overleg met de vissers is aan de gang en zal worden voortgezet om een goed inzicht te krijgen en te behouden in de belangrijkste visgronden voor de visserij met bodemdrijfnetten. Na de bouw zullen onderzoeken worden uitgevoerd op belangrijke primaire visgronden waar de belanghebbenden specifieke bezorgdheid hebben geuit. Er zullen ook regelmatig onderzoeken worden uitgevoerd om de diepte van de ingravingen in dergelijke belangrijke visgronden te controleren. Vissers zullen op de hoogte worden gebracht van de aanwezigheid en de locatie van het operationele kabelsysteem via de KIS-ORCA Cable Awareness Charts.

## Scheepvaart en navigatie

Het GB Offshore gedeelte loopt door de offshore Vessel Traffic Service (VTS)-grenzen van de Port of London Authority (PLA), met een klein deel dat ook door de inshore VTS-grens en de havengrenzen van Medway loopt. Sheerness is de dichtstbijzijnde grote haven, gelegen op 2 mijl ten zuidoosten van de aanlanding van de kabel. Er zijn meerdere ankergebieden in de nabijheid. Het GB Offshore gedeelte doorkruist ook het verkeersscheidingsstelsel "Sunk East", een gebied met veel scheepvaartverkeer dat door de Internationale Maritieme Organisatie wordt gereguleerd. Uit de verdeling van het scheepstype, geanalyseerd aan de hand van de databank van het Automatic Identification System (AIS), blijkt dat in het gebied vooral vracht- en tankerschepen varen.

Mogelijke effecten zijn onder meer verstoring van de route/tijdschema's van passerende schepen; verstoring van de scheepvaart van andere gebruikers van de zee, zoals vissers, recreatievaartuigen, militairen, stortplaatsen voor aggregaten en baggerschepen; mogelijke kompasafwijkingen als gevolg van de EMF van de werkende kabel; en incidentele gebeurtenissen, waaronder aanvaring met een passerend schip of windturbines, en het voor anker gaan op de kabels. Het belang van de effecten zal voor alle mogelijke effecten verwaarloosbaar tot gering zijn. Het risico op ongevallen wordt aanvaardbaar geacht, gezien de uiterst lage frequentie waarmee deze zich kunnen voordoen.

Elke verstoring van commerciële activiteiten zal tot een minimum beperkt worden door ervoor te zorgen dat relevante informatie over de installatie, in het bijzonder de locatie en de tijdstippen, meegedeeld wordt aan commerciële operatoren (bv. Ro-Ro scheepsexploitanten), lokale zeilclubs, ontwikkelaars van windmolenparken, enz. De bouwwerkzaamheden binnen de grenzen van de PLA-haven zullen in een zo kort mogelijk tijdsbestek worden uitgevoerd, teneinde de verstoring van andere activiteiten tot een minimum te beperken. Er zal ook vooraf een specifieke methodologie worden overeengekomen voor de kabelinstallatie via het verkeersscheidingsstelsel "Sunk East".

## Mariene Archeologie

Uit de gegevens van het geofysisch onderzoek zijn in totaal 397 zeebodemkenmerken naar voren gekomen die mogelijk van archeologisch belang zijn in het studiegebied. Hiervan zijn er 30 van antropogene oorsprong en van archeologisch belang, 10 zijn historisch bekend en van mogelijk archeologisch belang zonder een overeenkomstige geofysische anomalie, en de overige 357 zijn van onzekere oorsprong en van mogelijk archeologisch belang. Het gaat meestal om puin, donkere reflectoren en voorwerpen met magnetische eigenschappen. Het kan gaan om materiaal dat verband houdt met scheepswrakken of vliegtuigcrashes, maar het is ook mogelijk dat het gaat om elementen van niet-archeologisch belang.

Bij de beoordeling is rekening gehouden met zowel directe als indirecte verstoring van bekende en onbekende archeologische waarden, alsmede met indirecte verstoring als gevolg van bijvoorbeeld veranderingen in mariene processen. Directe verstoring heeft het potentieel om grote negatieve gevolgen te hebben voor de mariene archeologie, maar na toepassing van passende mitigatie zal het resterende effect gering, verwaarloosbaar of positief zijn.

Archeologische uitsluitingszones zullen worden ingesteld rond alle 30 elementen van antropogene oorsprong die van archeologisch belang zijn. Er zal een Protocol voor Archeologische Ontdekkingen (PAD) worden opgesteld en geïmplementeerd. In overleg met de Archeologische Curator zal een archeologisch 'Written Scheme of Investigation' (WSI) worden opgesteld, dat als vergunningsvoorwaarde door de MMO zal worden goedgekeurd, mochten ze worden uitgevoerd.

## Andere gebruikers van de zee

Andere gebruikers van het zeegebied waar het GB Offshore gedeelte doorheen zal lopen (met uitzondering van commerciële visserij, scheepvaart en navigatie, die afzonderlijk zijn bekeken) zijn onder meer windmolenparken, bagger- en stortplaatsen, militaire gebieden, activiteiten van de olie- en gasindustrie en verscheidene elektriciteits- en telecommunicatiekabels. Verscheidene windmolenparken, waarvan sommige reeds operationeel zijn en andere in aanbouw, vergund of in een vroege planningsfase, zijn geïdentificeerd binnen een straal van 10 km van het GB Offshore gedeelte. Het GB Offshore gedeelte doorkruist momenteel het gebied van de huurovereenkomst voor de Galloper-uitbreiding, waar de PRC-breedte breder is dan de standaardbreedte van 500 m om verdere lopende routingbesprekingen met dewindmolenparkontwikkelaar te vergemakkelijken. Daarnaast zijn ook twee baggerstortplaatsen in verband met aangelegde windmolenparken geïdentificeerd. Open stortplaatsen voor andere doeleinden en baggerstortplaatsen zullen naar verwachting niet worden doorsneden. Twee schietoefengebieden bevinden zich in de nabijheid, waarvan één een klein deel van de PRC doorsnijdt. In totaal zullen twintig pijpleidingen en kabels door het voorgestelde project worden gekruist: elf telecommunicatiekabels (waarvan er drie niet in gebruik zijn); één gaspijpleiding; zes onderzeese stroomkabels; en één kabel met een niet nader omschreven toepassing (niet in gebruik).

Mogelijke effecten zijn onder meer potentiële verstoring van geplande scheepsroutes en toegang tot werkgebieden, beschadiging of verstoring van externe activa, en mogelijke beperking van toekomstige ontwikkelingsopties. De besprekingen met de ontwikkelaars van het windmolenpark Galloper extension zijn momenteel gaande. Andere verwachte effecten op andere gebruikers van de zee worden verwaarloosbaar geacht na de vaststelling van mitigerende maatregelen.

Er is vroegtijdig overleg gepleegd met de betrokken contactpersonen om de verstoring van de geplande routes tot een minimum te beperken. Er zullen ook mededelingen aan zeegebruikers worden gedaan om een afstand van 500 m van kabelschepen te waarborgen tijdens installatie, exploitatie en buitenbedrijfstelling. Met de eigenaars van kabels en pijpleidingen zullen overeenkomsten over kruisingen worden gesloten, teneinde de rechten, verantwoordelijkheden en het ontwerp van de kruisingen overeen te komen. Met windmolenparken in de nabijheid zal een nabijheidsovereenkomst worden gesloten, overeenkomstig de richtsnoeren van de Renewables Sub-Group van Subsea Cables UK (2012).

## Potentieel voor cumulatieve effecten met andere projecten

Binnen het studiegebied dat door de EA voor het GB Offshore gedeelte in aanmerking is genomen, worden verschillende andere ontwikkelingsprojecten voorgesteld, waaronder: andere onderdelen van NeuConnect (met name het aangrenzende GB Onshore gedeelte en het Netherlands Offshore gedeelte; zowel de voorgestelde GridLink-interconnector als de bestaande BritNed-interconnector; een wingebied; en elf offshore windmolenparkprojecten.

Uit het onderzoek van de geïdentificeerde invloedzones van de geïdentificeerde potentiële effecten blijkt dat het GB Offshore gedeelte in de meeste gevallen ruimtelijk gescheiden zal zijn van andere voorgestelde ontwikkelingen en ook gescheiden zal zijn in de bouwperiodes waarin zij naar verwachting zullen worden uitgevoerd.

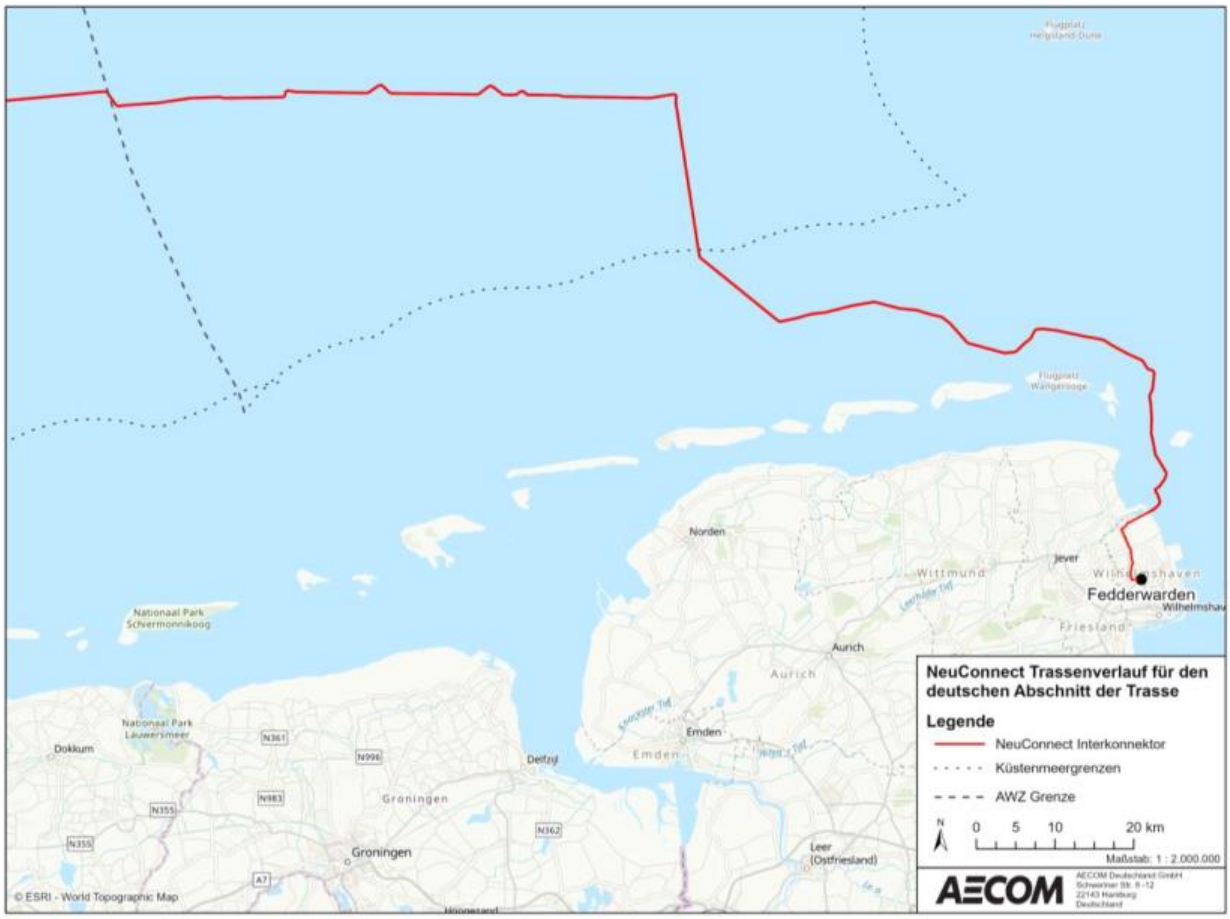
Er is een potentieel voor enige plaatselijke cumulatieve toename van de concentraties van zwevende sedimenten en de waterkwaliteit vastgesteld indien het GB Offshore gedeelte tegelijkertijd met de voorstellen voor de GridLink-interconnector voor aanleg wordt vrijgegeven. Ook de aanleg van het gedeelte van het GB-offshoreplan dat in de nabijheid ligt van de Longsands Aggregate Extraction site op hetzelfde moment dat actieve winning plaatsvindt, of in de nabijheid van andere voorstellen voor windmolenparken (East Anglia Three, Norfolk Vanguard, Galloper Extension of Greater Gabbard extension) kan leiden tot een plaatselijke cumulatieve toename van de sedimentconcentratie in de waterkolom (SSC). Waar de SSC toenemen, kan een overeenkomstig potentieel voor plaatselijke cumulatieve effecten op de bentische ecologie en op vis en commerciële visserij worden verwacht. Evenzo kunnen tijdelijke beperkingen van de toegang tot visgronden optreden wanneer op eenzelfde plaats tegelijkertijd meer dan één ontwikkeling plaatsvindt.

Waar mogelijk zal worden gestreefd naar een goede communicatie en coördinatie tussen de verschillende installatieprogramma's van de projecten, om ervoor te zorgen dat de activiteiten op verschillende tijdstippen worden geprogrammeerd, zodat eventuele cumulatieve effecten tot een minimum worden beperkt.

# Duitse Offshore gedeelte

## Inleiding

Het Duitse offshore gedeelte bestaat uit de tracédelen binnen de Duitse EEZ, en de Duitse territoriale zee (cf. figuur 2). De totale lengte van het tracé bedraagt circa 181 km. Binnen de kustzee van Nedersaksen bedraagt de lengte van de geplande route ongeveer 86 km. De kustzee van Niedersachsen wordt doorkruist in noordwestelijke richting, ten oosten en noorden van de Oostfriese eilanden Wangerooge, Spiekeroog, Langeoog (afstand van 5 tot 12 km). De toegang tot de Duitse EEZ verloopt via de N-III grenscorridor. Binnen de kustzee van Nedersaksen ligt het tracé gedeeltelijk binnen wettelijk beschermde gebieden overeenkomstig de federale natuurbeschermingswet, binnen het "Nationaal Park Nedersaksische Waddenzee" en binnen het FFH-gebied "Nationaal Park Nedersaksische Waddenzee" en het vogelreservaat "Nedersaksische Waddenzee en aangrenzende kustzee".




Figuur 3-2 : Overzicht Duitse tracédeel

## Overweging van alternatieven

Voor het geplande project zijn technische en ruimtelijke alternatieven overwogen. De technische haalbaarheid van dit soort projecten en de lengte van het tracé kunnen alleen zonder grote verliezen worden gerealiseerd door middel van een HVDC-kabelsysteem. Voor de aanleg van de interconnector van Groot-Brittannië naar Duitsland door de Noordzee zijn vooraf verschillende denkbare zeecorridors en verschillende aanlandingsmogelijkheden onderzocht.

### Technische alternatieven

De technische haalbaarheid en de economische levensvatbaarheid van transmissie via kabels en de aan te leggen trajectlengte kunnen alleen worden bereikt door gebruik te maken van een HVDC-kabelsysteem. Uit milieuoogpunt (thermische emissies, 2K-criterium) is het gebruik van een wisselstroomverbinding eveneens uitgesloten wegens de

hoge transmissieverliezen, waarvoor bovendien meer ruimte nodig zou zijn voor de geplande transmissiecapaciteit van 1.400 MW.

## Ruimtelijke alternatieven

Sinds 2017 heeft NeuConnect verschillende varianten voor het tracé van de interconnector onderzocht en in een meerstappenproces eerst een corridor en vervolgens een voorkeurstracé door de EEZ en de aangrenzende kustzee van Nedersaksen ontwikkeld, rekening houdend met de aanbevelingen van de autoriteiten en met inbegrip ruimtelijke planningsinstrumenten.

In een tracéstudie zijn verschillende corridorvarianten voor het Duitse deel van het project beoordeeld in het licht van ruimtelijke en planologische bepalingen, bundelingsopties, landgebruik, technische aspecten en milieuoverwegingen. Bovendien werden verschillende aanlandingsmogelijkheden overwogen. Uit de studie konden in eerste instantie de vanuit milieuoogpunt meest gunstige varianten voor het tracé door de EEZ en de kustzee worden afgeleid op basis van alle aspecten waarmee rekening moet worden gehouden, zoals natuurbehoud, bodem en andere gebruiksfuncties. Vervolgens werden deze varianten beoordeeld aan de hand van de criteria van technische haalbaarheid en toelaatbaarheid in het kader van de ruimtelijke ordening.

Voor het mariene zoekgebied zijn drie corridors ontwikkeld (varianten 1 tot en met 3). Voorts werden twee andere corridors die door het BSH ter discussie waren voorgelegd, onderzocht (varianten 4 en 5). Alleen het onderstation Fedderwarden was vooraf als doellocatie bepaald vanwege de toewijzing door TenneT. Bij de beoordeling van de alternatieven is rekening gehouden met het feit dat het mariene gebied wordt bepaald door zeer grootschalige aanwijzingen en gebruiksvormen, bijvoorbeeld voor natuurbehoud, scheepvaart, gebruik van windenergie of het leger. Zo werden specifieke voorschriften voor het doorkruisen van scheepvaartgebieden en bepaalde afstanden tot bestaand gebruik opgenomen. Uit de uitgevoerde analyses is gebleken dat variant 3 via de Jade (oost) de voorkeur geniet.

De door NeuConnect voorgestelde corridorvariant was in 2018 onderwerp van een toepassingsconferentie van het Bureau voor regionale ontwikkeling Weser-Ems (ArL-WE) om te onderzoeken of een regionale planningsprocedure vereist is voor het deel van de kustzee van Nedersaksen. Bij brief van 01.06.2018 heeft de ArL-WE specificaties gegeven voor de routering in de territoriale zee, die ook gevolgen hebben voor de routering in de aangrenzende Duitse EEZ en waarmee rekening is gehouden bij de verdere planning:

- De NeuConnect interconnector moet worden aangelegd in het oostelijke gebied van Gate N-III en er moet afstand worden gehouden tot de bestaande aardgaspijpleidingen in het verdere verloop in de territoriale zee om voldoende ruimte te laten voor OWP-verbindingskabels in de tussenliggende ruimte en om kabelkruisingen in de territoriale zee te vermijden.

- De kabels moeten zo worden gelegd dat eventuele verdere, parallelle kabeltracés zo weinig mogelijk worden gehinderd. In het belang van de aanleg van zoveel mogelijk parallelle kabelsystemen moeten de beschermingsafstanden tussen de NeuConnect interconnector en andere bestaande en in de toekomst aan te leggen kabelsystemen tot een minimum worden beperkt, ook al betekent dit in individuele gevallen kortstondige beperkingen van de exploitatie van de kabels. De afzonderlijke kabels moeten in bundels worden gelegd. Dit laat de technische en ruimtelijke mogelijkheid open om op een later tijdstip parallel met de NeuConnect interconnector nog meer kabelsystemen te leggen.

Na de tracéstudie en het besluit van de ArL werd het tracé in de Duitse EEZ grotendeels afgestemd met het BSH (hierbij heeft de grensovergang met Nederland nog ter discussie gestaan, zie paragraaf 3.5 van het MER). In de vroege zomer van 2019 is het overeengekomen tracé voor de NeuConnect-interconnector voor het eerst opgenomen in het FEP 2019. Het vastgestelde tracé komt over grote delen overeen met de voorkeursvariant "variant 3" van de tracéstudie van NeuConnect.

# Vergunningsvereisten BBergG

## Geen gevaar voor het leven of de gezondheid van personen

Er bestaat geen gevaar voor het leven of de gezondheid van personen als gevolg van het aangevraagde project. De genomen maatregelen zullen worden opgenomen in de veiligheids- en voorzorgsplannen, die zullen worden gespecificeerd in de individuele beschermings- en veiligheidsplannen van de uitvoerende bedrijven en schepen. De minimale installatiediepte van 1,5 m onder de zeebodem betekent ook dat elk risico voor personen tijdens de werking van de kabelbundel kan worden uitgesloten.

# Geen risico voor materiële activa

Eventuele risico's voor materiële activa als gevolg van het voorgestelde project worden doeltreffend tegengegaan door de veiligheids- en voorzorgsplannen en de individuele beschermings- en veiligheidsplannen van de uitvoerende bedrijven en vaartuigen.

Voorts waarborgt het gekozen tracé de vereiste minimumafstand van 500 m tot windturbines. De noodzakelijke oversteekstructuren zullen worden aangelegd in overleg met de respectieve eigenaars.

Mogelijke objecten voor de bescherming van monumenten zijn voldoende onderzocht en beschreven. Binnen 250 m van de route is bij de geofysische onderzoeken (2019) op KP 587 slechts één verdacht punt vastgesteld op een afstand van ongeveer 90 m ten noorden van de voorkeursroute-as, dat een keienveld of een wrak zou kunnen zijn. Een validatie van de geofysische gegevens in het voorjaar van 2020 heeft deze vondst daarentegen niet kunnen bevestigen. Bij wijze van voorzorgsmaatregel wordt het echter nog steeds als een verdacht punt behandeld. Bovendien strekt zich volgens de zeekaart van het BSH tussen de NeuConnect KP 611 tot 613 een puingebied (foul) uit, dat alleen in het uiterste randgebied ter hoogte van KP 613.0 tot 613.2 door de gekozen routing wordt doorsneden.

# Geen afbreuk aan dwingende openbare belangen

**Luchtvaart**

Binnen de Duitse EEZ zijn er twee militaire luchtvaartgebieden in de nabijheid van de route. Ten noorden van het geplande kabeltracé, op een afstand van ca. 16 km, ligt het militaire schiet- en vliegoefenterrein ED-D 46 (Fliegerschießgebiet Nordsee). Ten noordoosten van het kabeltracé, op een afstand van ca. 30 km, bevindt zich ook ED-D 41 A (schietterrein van de luchtmacht van Sylt). Gezien de grote afstand tot militaire vliegvelden en het ontbreken van aanwijzingen van bijzonder belang voor de burgerluchtvaart, zijn er geen nadelige effecten te verwachten van de bouw, de exploitatie of de operationele fase.

**Visserij en scheepvaart**

Over het geheel genomen domineert het vracht- en tankerverkeer, waarbij het vervoer van gevaarlijke stoffen een aparte positie inneemt. Dit verkeer is geconcentreerd in de verkeersscheidingsgebieden van VTG Terschelling en VTG Duitse Bocht. Binnen het niet-geleide verkeer moet het vissen worden beschouwd als dominant voor dit type verkeer, met belangrijke gebruikspunten langs de hele route. Bovendien worden de gebieden van de OWP-clusters N-1 tot N-3 intensief en regelmatig door bevoorradingsschepen aangedaan. In het algemeen heeft de scheepvaartstudie kunnen aantonen dat ondanks de hoge verkeersdichtheid de ongevallencijfers en dus het gevaar van scheepsongevallen over het algemeen zeer laag zijn.

De kans op risico's als gevolg van anker-kabelbundelcontacten is over het algemeen gering. Gevaren voor de installaties kunnen echter niet volledig worden uitgesloten, aangezien het onopzettelijk afdrijven van een ankerpositie, maar ook een noodankering als gevolg van motor- of stuurstoring, denkbaar is. Met deze verbinding moet vooral rekening worden gehouden bij de aanleg in de bouwfase. Met een minimale legdiepte tijdens bedrijf van 1,5 m, die voor kabeltracés is voorgeschreven, is er geen risico van beschadiging van de interconnector door ankers.

Een risico van visserijactiviteiten met trawlnetten die in contact komen met de bodem is denkbaar, maar onwaarschijnlijk tijdens de legwerkzaamheden, waarbij het kabelsysteem tijdelijk op het sediment rust, aangezien de legwerkzaamheden worden begeleid door een borgingsvaartuig. Zolang de kabel op een minimale legdiepte van 1,5 m blijft, is er geen algemeen risico op beschadiging.

Uit de risicoanalyse blijkt niet dat er tijdens de aanleg- en exploitatiefase van het kabelsysteem gevaren bestaan voor de veiligheid en het vlotte verloop van het scheepvaartverkeer.

De projectspecifieke bouwwerkzaamheden zullen resulteren in een tijdelijke toename van het aantal scheepsbewegingen langs het kabeltraject in vergelijking met het algemene scheepsverkeer. Alle vaartuigeenheden kunnen de normale doorvaart belemmeren van trawlvissers en andere vissersvaartuigen die op weg zijn naar of van visgronden, of die actief aan het slepen zijn. De extra vaartuigeenheden (b.v. lichters, leggerschepen en bevoorradingsschepen) vormen echter geen groter risico dan andere vaartuigen die reeds in het gebied opereren. Aangezien bouwschepen tijdens de aanlegwerkzaamheden als manoeuvreerschepen worden beschouwd, schrijven de internationale voorschriften van de Internationale Maritieme Organisatie (IMO) ter voorkoming van aanvaringen op zee (KVR) voor dat andere schepen de bouwschepen moeten vermijden. De KVR zijn risicobeperkend, omdat er duidelijke regels zijn voor de nautische omgang met schuivende schepen. Tegelijkertijd leidt dit ook tot potentieel gevaarlijke situaties. Dit risico kan echter tot een minimum worden beperkt door een bouwplaatsvoorziening met een verboden zone rond het bouwschip of een verkeersveiligheidsvaartuig.

De bouwgerelateerde effecten zijn lokaal en beperkt in de tijd. Aangezien het kabeltracé bovendien reeds door wateren loopt waar intensief commercieel maritiem verkeer plaatsvindt of waar een prioritair gebied voor de scheepvaart is en trawlvisserij derhalve slechts in beperkte mate mogelijk is, zullen de bijkomende nadelige gevolgen van het project voor de visserij verwaarloosbaar zijn.

Als gevolg van de werkzaamheden zal er een opwerveling van sedimenten optreden met de daarmee gepaard gaande vorming van troebelingspluimen. De korrelgrootte is bepalend voor de omvang en intensiteit van troebelingspluimen, waarbij het aandeel van de fijnkorrelige fracties en de installatiemethode sleutelfactoren zijn. Het kabelpaar is waarschijnlijk overwegend in het sediment geplaatst in een gelijktijdig leg- en begraafproces. Dit zal slechts resulteren in een geringe opwerveling van sediment in de omgeving. Derhalve wordt een snelle sedimentatie van het wervelende materiaal in de omgeving van het punt van oorsprong verwacht.

Aangezien de interconnector overal in de zeebodem zal worden ingegraven, behalve in de gebieden waar kabels en pijpleidingen worden gekruist, worden slechts geringe effecten op de visserij verwacht als gevolg van de installatieactiviteiten.

Tijdens de exploitatiefase zijn slechts geringe en tijdelijke nadelige gevolgen voor de visserij te verwachten, aangezien de NeuConnect-interconnector grotendeels zal worden aangelegd in prioritaire scheepvaartgebieden.

# Milieubeoordeling

Gelet op het Duitse beschermingsregime voor de kustzee, is een milieustudie uitgevoerd om de verwachte milieueffecten van het project, die zouden kunnen worden veroorzaakt door het geplande leggen van kabels in de kustwateren van Nedersaksen, te voorspellen en te beoordelen. Deze milieueffectbeoordeling omvat de volgende onderdelen:

- Beoordeling van bedreigingen voor het mariene milieu;
- Beoordeling van de bescherming van Natura 2000-gebieden;
- Biodiversiteitsbeoordeling;
- Beoordeling voor de bescherming van biotopen;
- Beoordeling voor waterbescherming;
- Plan voor landschapsbehoud incl. effectbeoordeling.

Op basis van een projectbeschrijving, waarin alle bekende technische kadergegevens van het geplande project, de nodige voorafgaande tracé-onderzoeken en werkzaamheden en de bouw-, installatie- en exploitatiegerelateerde maatregelen zijn samengebracht, werden voor het aangevraagde project 17 verschillende effecten vastgesteld.

In dit document wordt de huidige status van alle beschermde activa en andere voor het mariene milieu relevante aangelegenheden beschreven en beoordeeld. Op basis van de met het project samenhangende effecten is een effectprognose opgesteld. Daarnaast zijn een beoordeling van de projectgerelateerde effecten en een evaluatie van mogelijke cumulatieve effecten uitgevoerd.

De verwachte effecten zijn over het algemeen kleinschalig en van korte duur. Derhalve wordt verwacht dat op grotere schaal het voortbestaan van de relevante structuren en functies van de beschermde waarden en overige belangen gewaarborgd blijft na realisatie van het project. Een bedreiging van de beschermde waarden en andere belangen als gevolg van het project wordt uitgesloten.

Ook uit de effecttrajecten en de interacties van de beschermde belangen en andere belangen met elkaar blijkt geen risico voor de betrokken beschermde belangen of andere belangen. Uit de beoordeling is gebleken dat voor geen van de voor de beoordeling relevante beschermingsobjecten cumulatieve effecten te verwachten zijn met andere projecten die reeds zijn goedgekeurd of die zich in een wettelijk vastgesteld stadium van de procedure bevinden.

Overeenkomstig de habitatrichtlijn en de Duitse natuurbeschermingswet (BNatSchG) moet worden nagegaan of het voorgenomen project significante negatieve effecten kan hebben voor de instandhoudingsdoelstellingen of de beschermingsdoelstelling van een Natura 2000-gebied. Het traject in de Nedersaksische kustzee loopt door twee beschermde Natura 2000-gebieden. Het *Fauna-Flora-Habitatrichtijn*-gebied "Nationaal Park Nedersaksen Waddenzee" wordt op een kleine afstand van ca. 320 m van de gebiedsgrens door het kabeltracé geraakt, terwijl het Vogelbeschermingsgebied "Nedersaksische Waddenzee en aangrenzende kustzee" direct door het kabeltracé wordt doorkruist. Uit de beknopte beoordeling van de met het project samenhangende effecten, met inbegrip van cumulatieve effecten, is gebleken dat significante negatieve effecten overeenkomstig de BNatSchG op de componenten die relevant

zijn voor de instandhoudingsdoelstellingen of beschermingsdoeleinden van de Natura 2000-gebieden, evident afwezig zijn of met zekerheid kunnen worden uitgesloten.

Overeenkomstig BNatSchG moet worden onderzocht of het voorgenomen project voldoet aan de eisen voor soorten die speciaal en strikt worden beschermd. Bij de beoordeling van de soortenbescherming van het voor de Nedersaksische kustzee relevante soortenspectrum zijn geen overtredingen van de verbodsbepalingen inzake soortenbescherming overeenkomstig BNatSchG vastgesteld.

Overeenkomstig de federale wet op het natuurbehoud is een beoordeling uitgevoerd van de met het project samenhangende effecten op wettelijk beschermde biotopen. Uit de beoordeling is gebleken dat er, rekening houdend met de vermijdings- en verzachtende maatregelen, geen vernietiging of andere significante aantasting van wettelijk beschermde biotopen in de kustzee van Nedersaksen zal plaatsvinden .

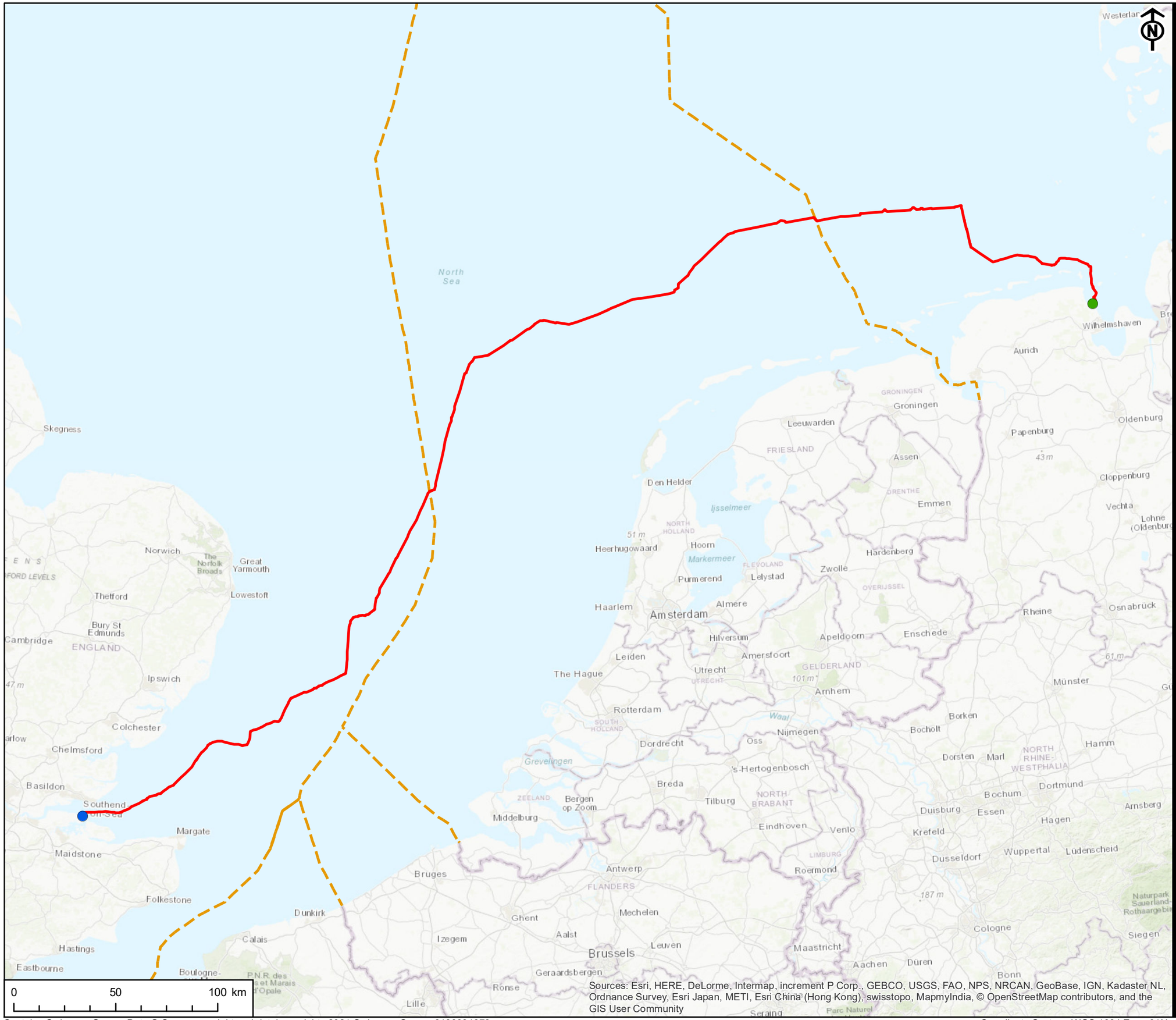
Overeenkomstig het Duitse '*Wasserhaushaltsgesetz*' (WHG) is een beoordeling uit hoofde van het waterrecht uitgevoerd overeenkomstig de Kaderrichtlijn water en de Kaderrichtlijn mariene strategie. De waterrechtelijke beoordeling komt tot de conclusie dat een projectgebonden verslechtering van de ecologische of chemische toestand en een aantasting van de huidige milieutoestand van de mariene wateren van de Duitse Noordzee op de relevante datum in de kustwateren van Nedersaksen en de mariene wateren van de Duitse Noordzee kan worden uitgesloten. Het geplande project is niet in strijd met de waterrechtelijke verplichting om de voor het project relevante kustwateren en de mariene wateren van de Duitse Noordzee te verbeteren. Er is geen projectgerelateerde bedreiging voor het bereiken van een goede milieutoestand en er is geen aantasting van de milieudoelstellingen en milieumaatregelen. Het geplande project voldoet ook aan de uitfaseringsverplichting.

Volgens BNatSchG moeten onvermijdelijke aantastingen van natuur en landschap in de kustzee worden gecompenseerd. Ondanks de in het Landschaftspflegerischer Begleitplan (plan voor landschapsbehoud) genoemde beschermings- en vermijdingsmaatregelen, zal het project tot ruimtebeslag in de kustzee leiden, in het bijzonder ter plaatse van de aanlanding van de kabel. Hieronder zijn de relevante onderdelen van het project opgesomd die tot (permanent) ruimtebeslag leiden:

- Kabelsleuf;
- PLGR (grenst aan beide zijden aan de kabelsleuf);
- Verstoringszone (grenst aan beide zijden aan PLGR);
- Interventiegebied van de kabelploeg (grenst aan beide zijden aan de interferentiezone);
- Sedimentatiegebied (grenst aan beide zijden aan het interventiegebied van de kabelploeg of de verstoringszone);
- Verwijdering van drie OOS-kabels (6 verzinkboren);
- Draagvlak van het ponton;
- Draagvlak van de trek- en positieankers;
- Oversteekstructuur;
- Kokerinstallatie;
- Methode voor het eerste uiteinde – graafmachine;
- Methode voor het eerste uiteinde;
- Wattside HDD bouwplaats;
- Damwandkast;
- Toegangsweg naar de HDD bouwplaats aan de wadzijde;
- Productie strook voor verbuizing.

Dit ruimtebeslag dient te worden gecompenseerd. De totale compensatiebehoefte voor het gedeelte van het traject in de Nedersaksische kustzee is bepaald rekening houdend met de projectspecifieke impactlengtes en -breedtes. Dit resulteert in een totale compensatiebehoefte van 128.396,345 $m^2$ (= 12,84 ha, incl. 10% toeslag).

Project Management Initials: DR Designer: LC Checked: RAS Approved: DR




Scale @ A3 1:1,750,000

0 50 100 km

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Coordinate System: WGS 1984 Zone 31N

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PROJECT
NEUCONNECT

CLIENT
NeuConnect Britain Ltd.

KEY
- NeuConnect RPL 09
- EEZ Boundary
- UK Landfall Location
- DE Landfall Location

TITLE
NEUCONNECT RPL

REFERENCE
NC_210210_P1_v7

SHEET NUMBER
1 of 1

DATE
10/02/21