NeuConnect

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Burial Assessment Study "Lite"

for the proposed

NEUCONNECT INTERCONNECTOR
(Bundled Cable Asset)

For

NeuConnect

By

primo marine
Independent Marine Infrastructure Expertise

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NeuConnect

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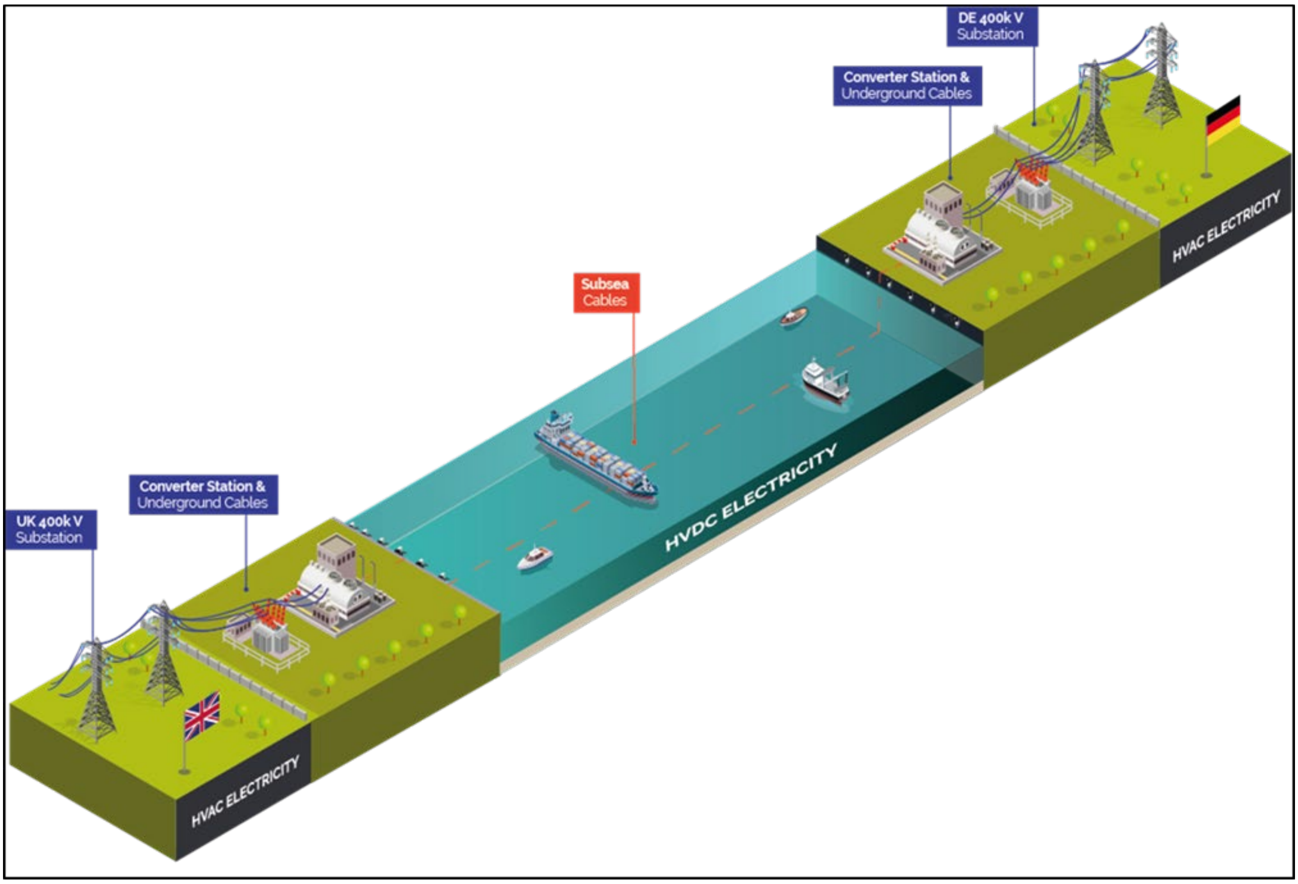
1. INTRODUCTION

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

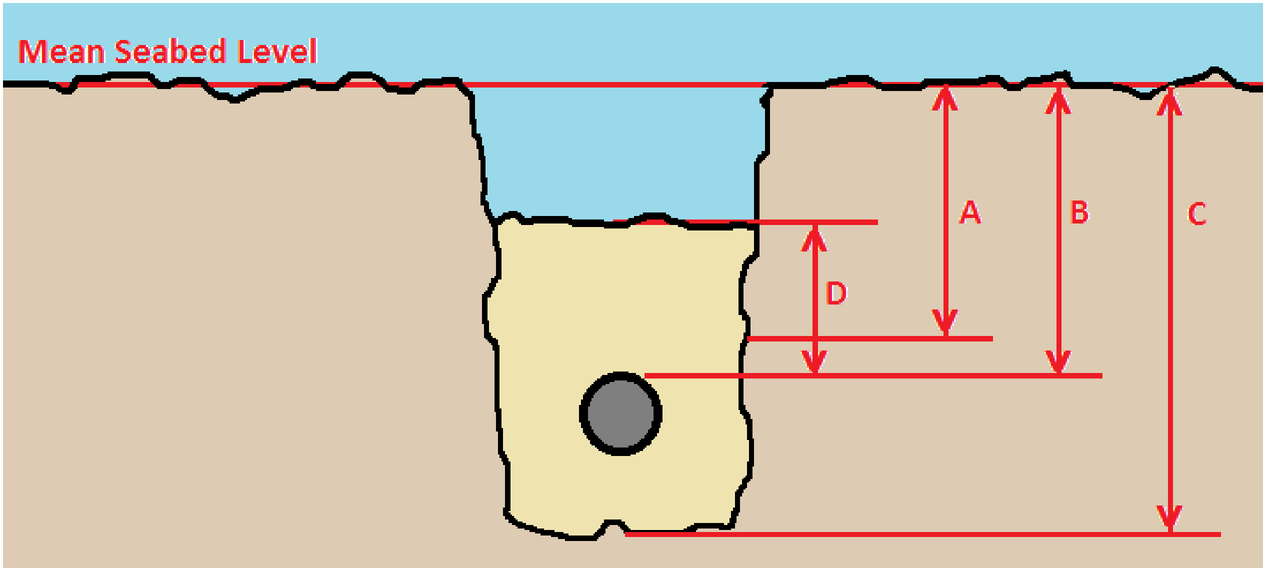
The particular definitions stated in the Carbon Trust Guidance Notes [/8/] are repeated here for ease for reference.

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

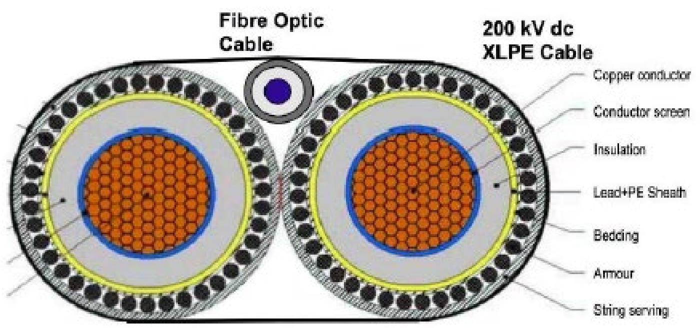
PRIMO assume that a typical bundle arrangement would be applicable as is shown in the three images shown below under Figure 5-1, and that the as-installed configuration involves the two HVDC cables, 700 MW each, positioned (buried) side by side.

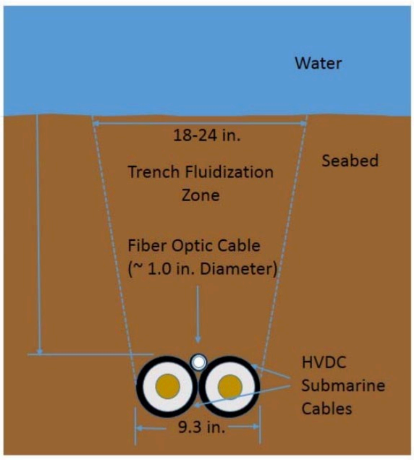
The cables are bundled using strapping of twine installed around the 2-3 cables at regular spacing or continuously on the deck of the cable laying vessel before it is let into the water over the chute.

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.

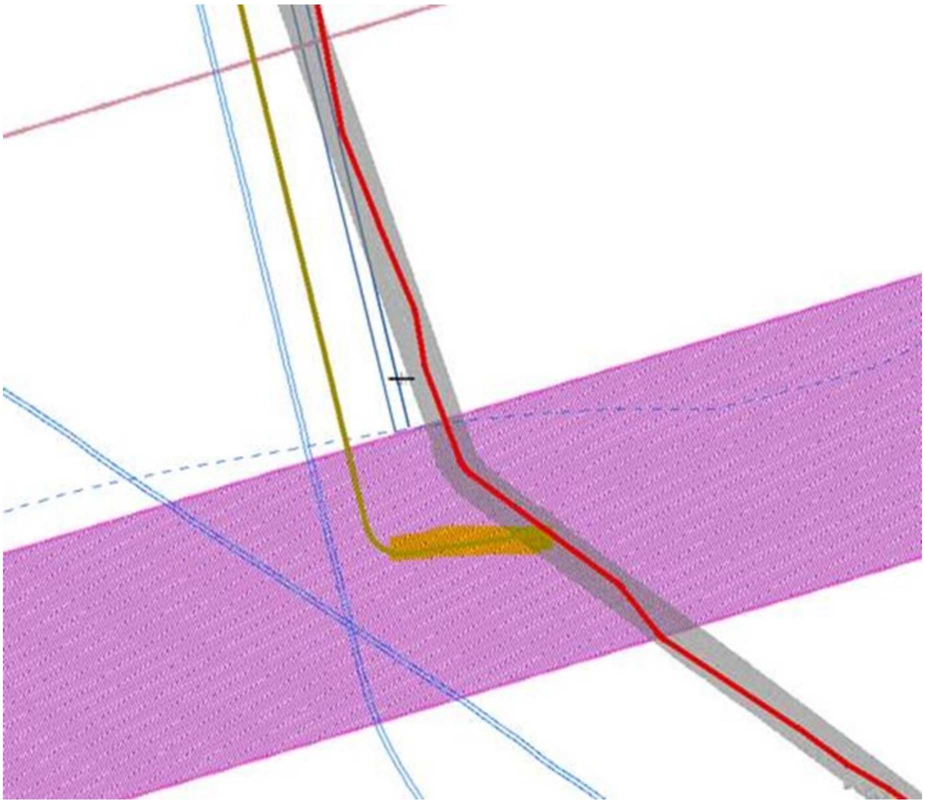
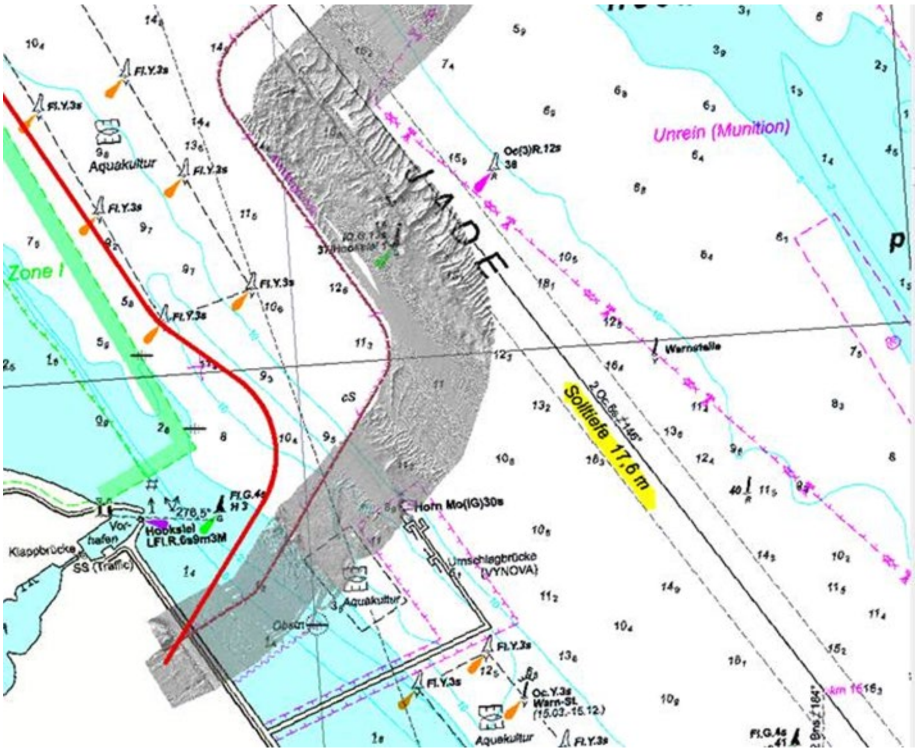


Figure 6-2: Option 2 (BSH?): Navigation Channel Depth

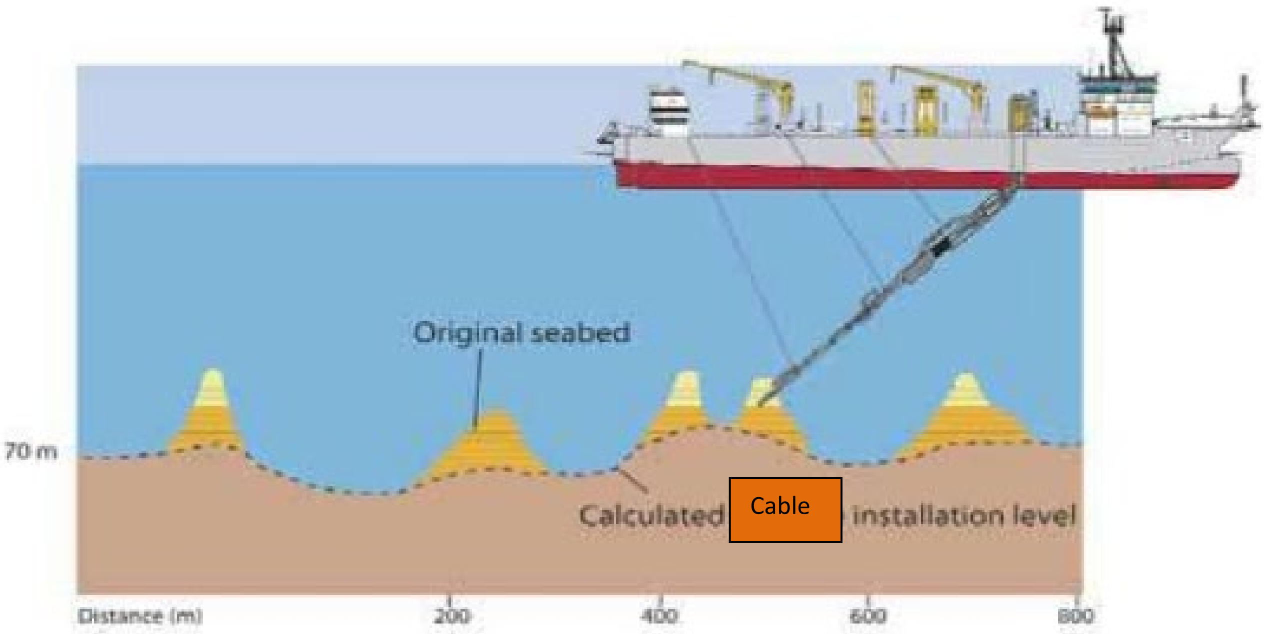


7. SEABED INTERVENTION TECHNIQUES

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

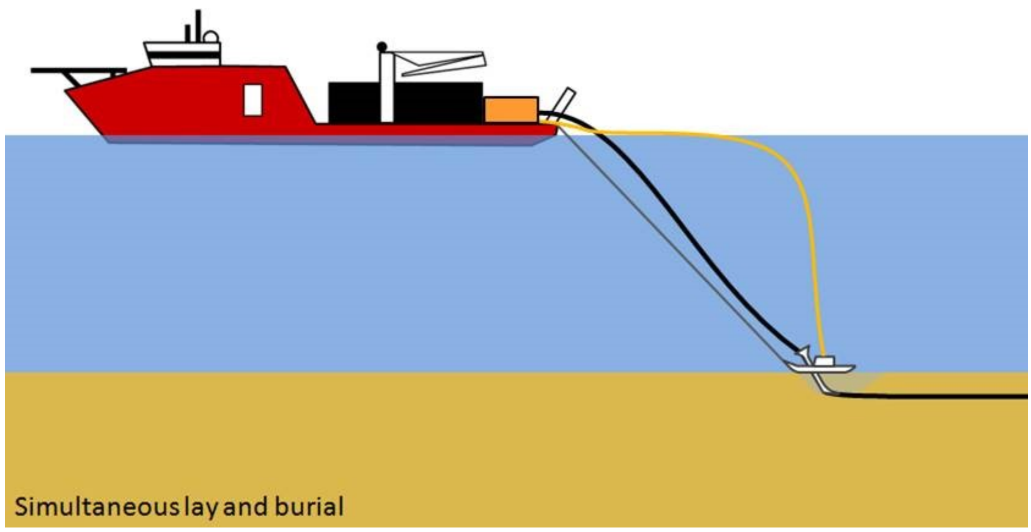
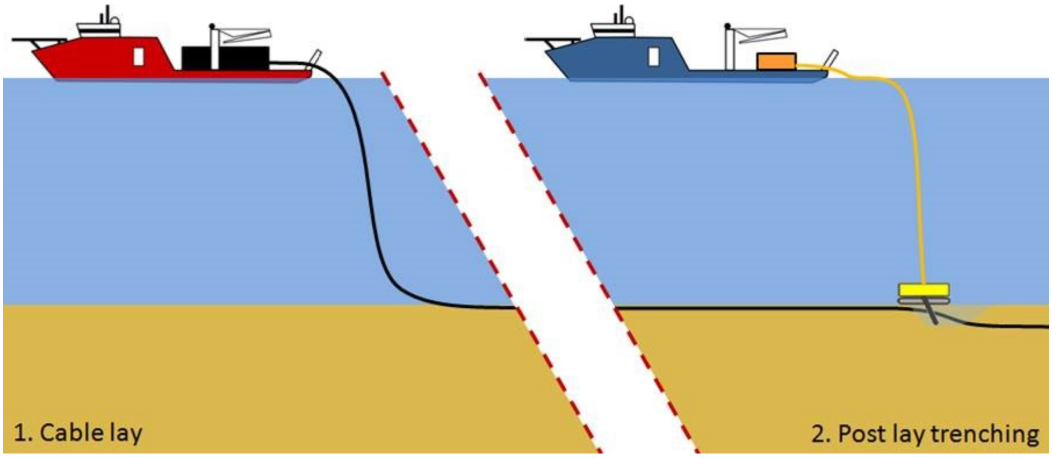


Figure 7-3: Cable Surface Lay, followed by PLB.



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.

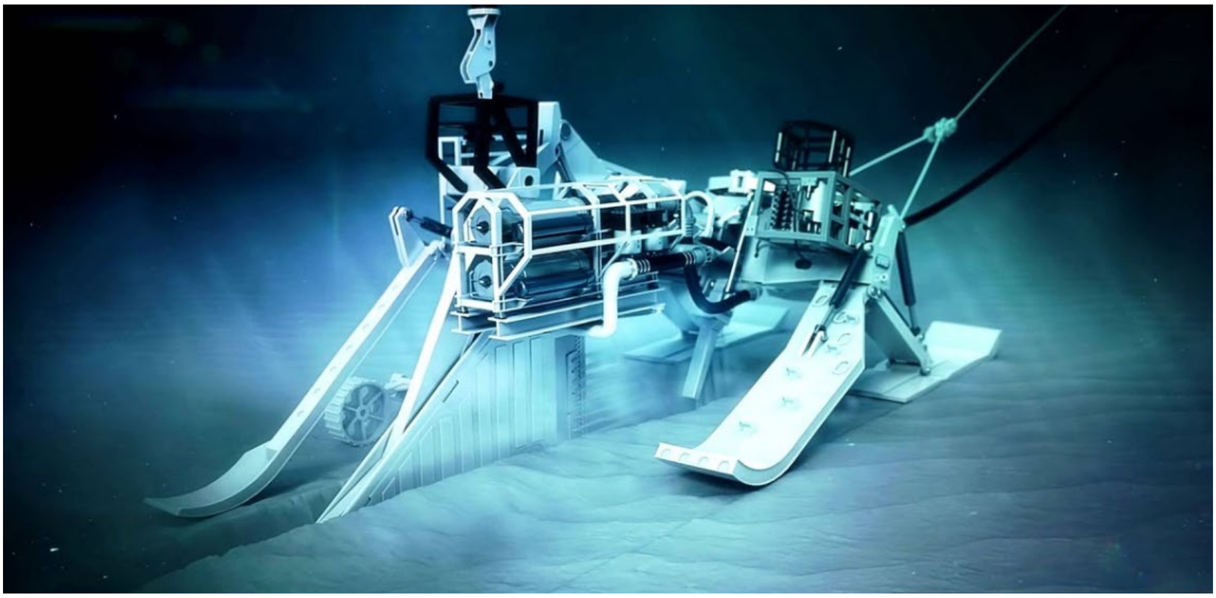
Modern ploughs can bury cables up to a depth of 3 metres below seafloor.

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.

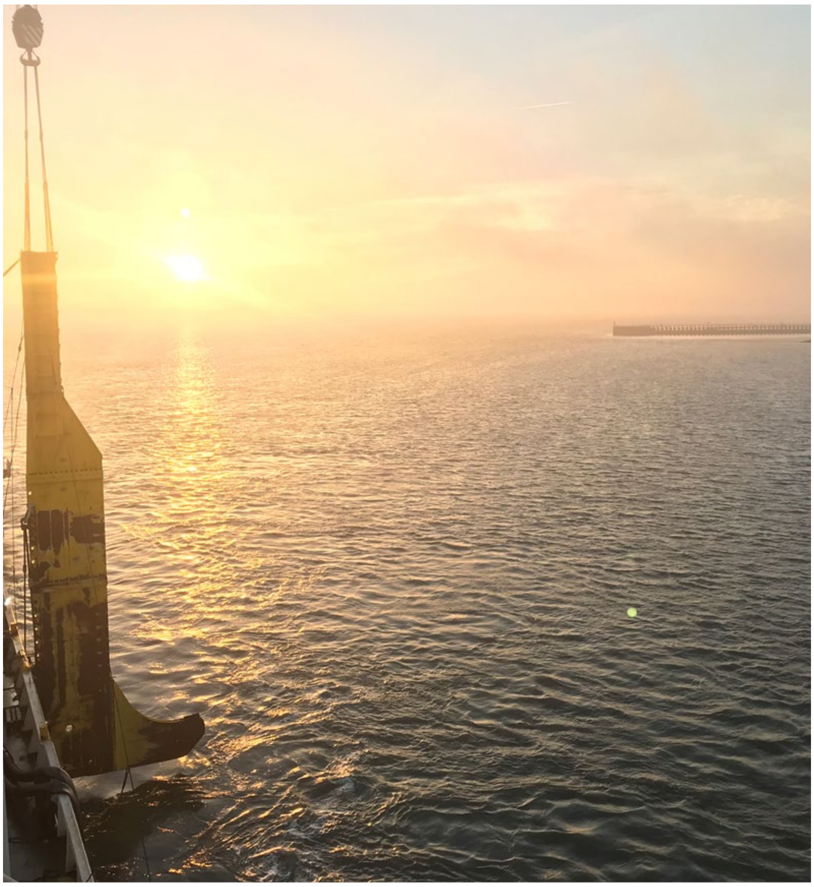
Ploughs can cope with material types and strengths ranging up to very dense sands, and firm to stiff clays, as well as weak (weathered, fractured) rock, in principle, depending on factors such as target trench depth.

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

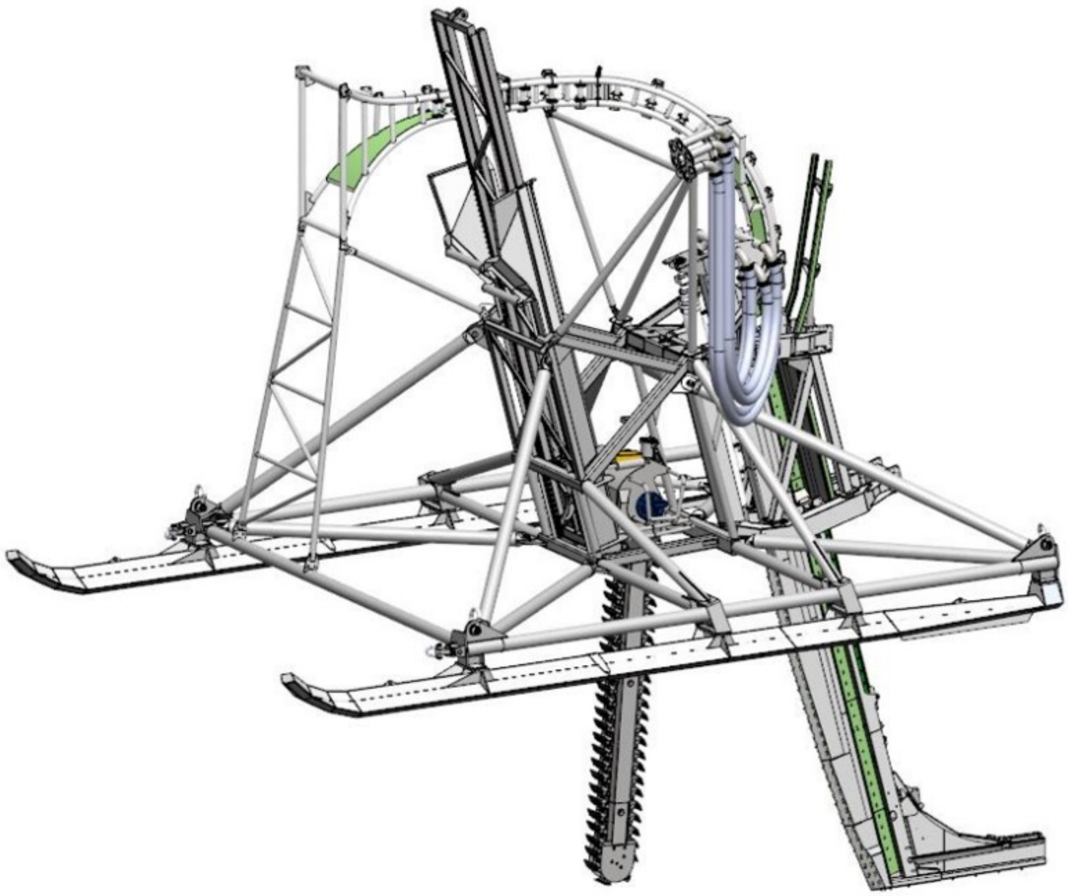


A Vertical Injector (VI) can be assisted by a dedicated mechanical chain cutter, if necessary, to pre-cut harder cohesive soils and rock, i.e. preceding the installation of the cables by the Vertical Injector (VI). For pre-cutting, the chain cutter will be passed along the selected route sections to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



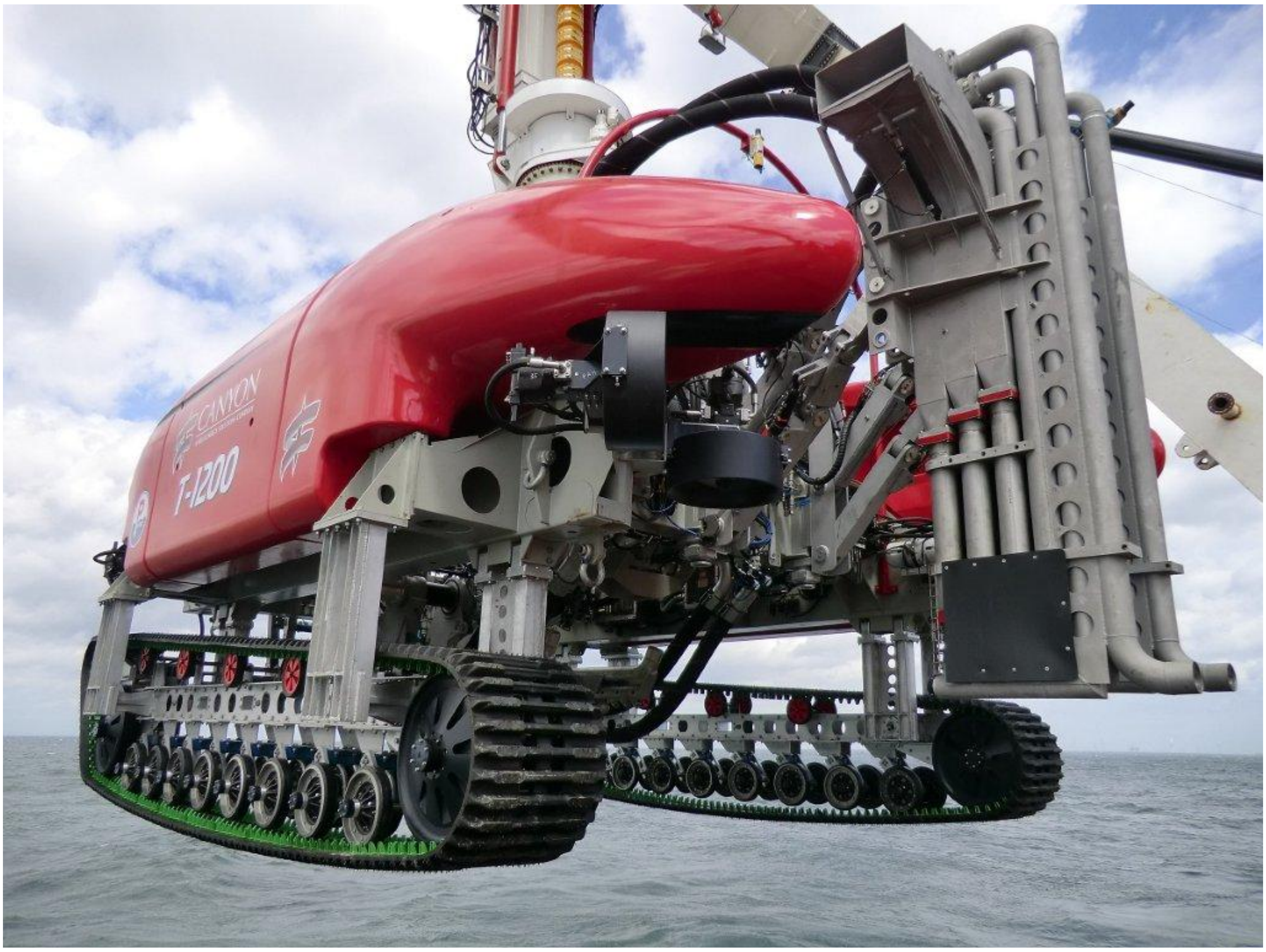
7.4. PLB Techniques

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.

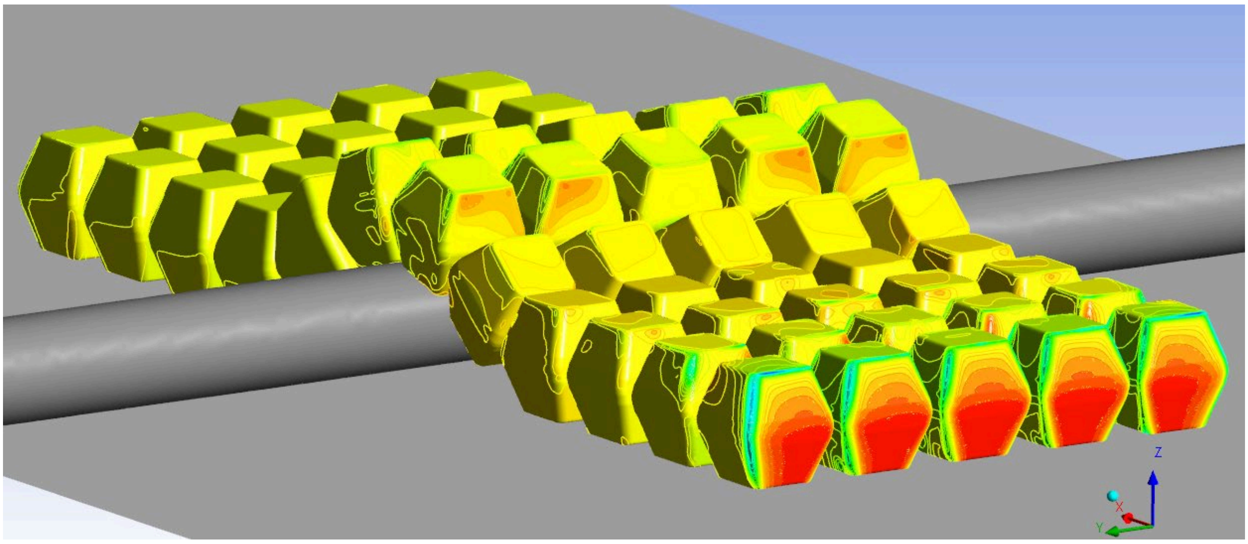
In some cases, other precautions are agreed with the service owner ("crossing agreements"), including applying cable protection on top of the service before it is crossed. Whilst burial of the cables is the common method for protecting the cables where hazards or risks exist, other protection methods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

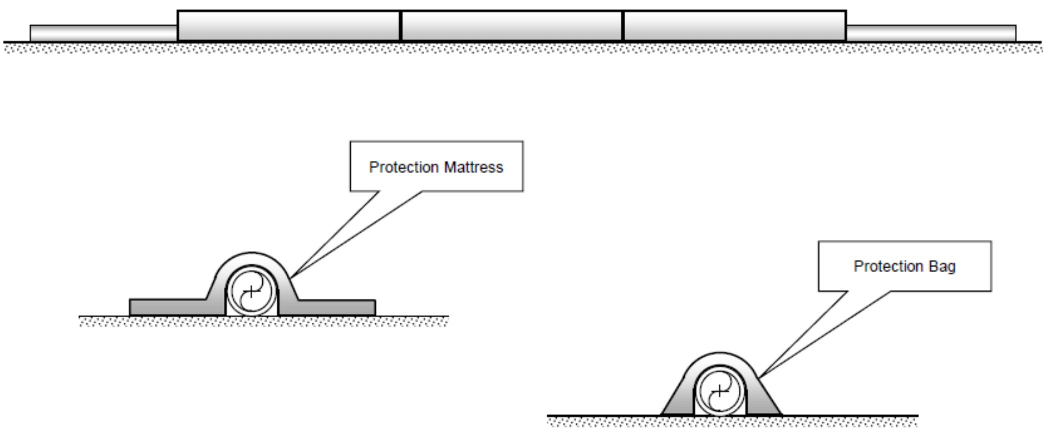
Figure 7-10: Rock Placement on Cable

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)

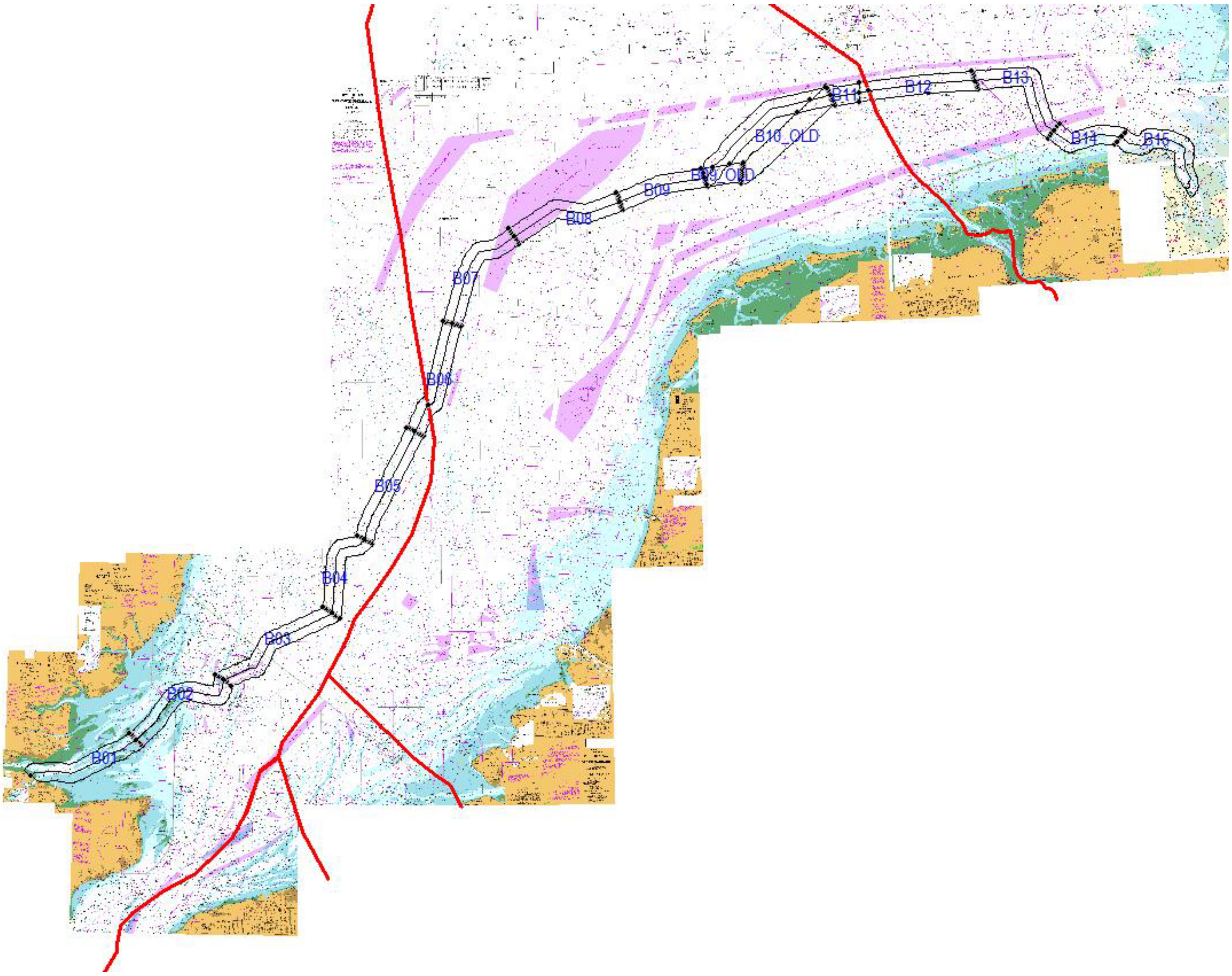
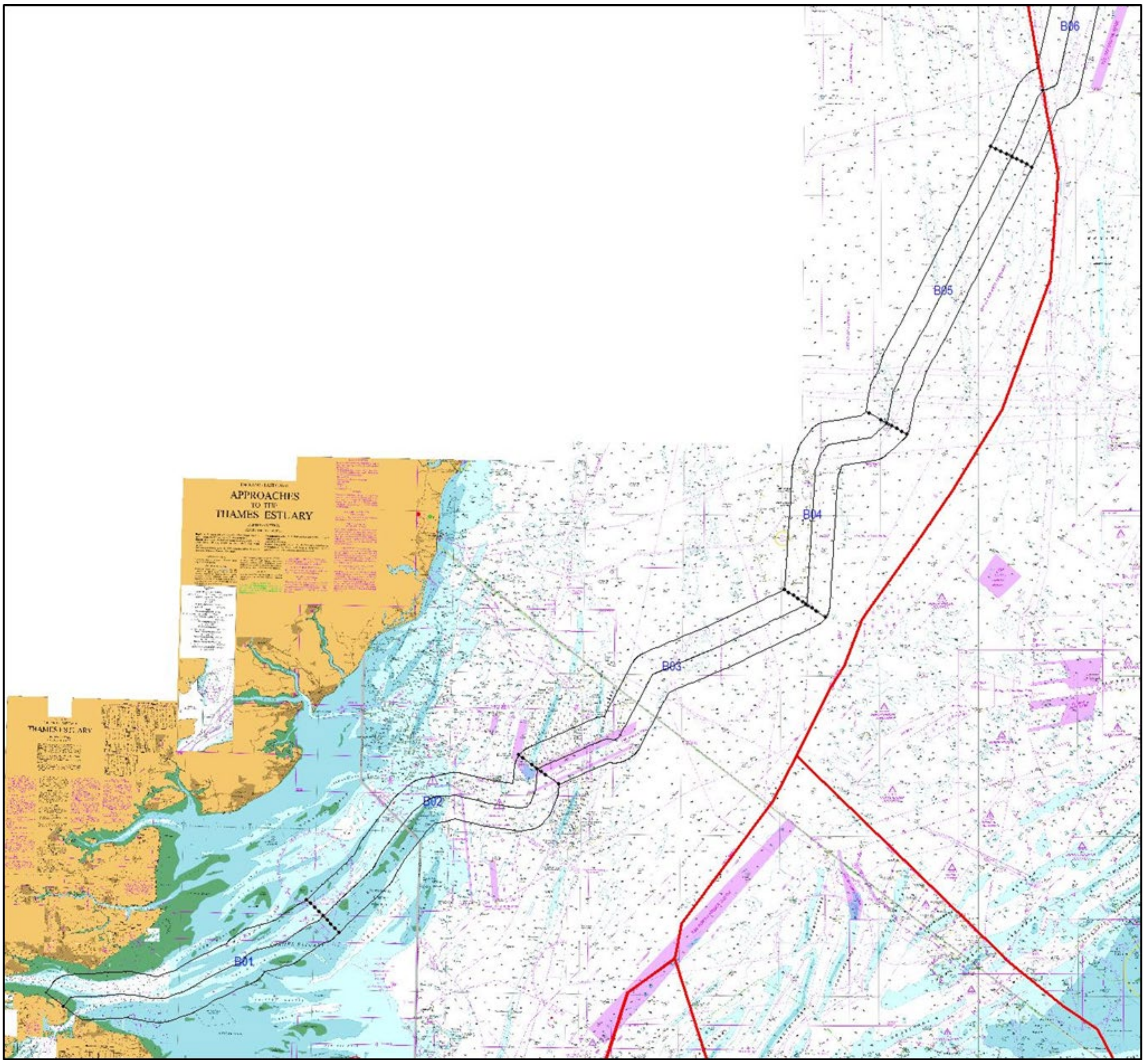


Table 8-1: Summary Details of EEZ sectors

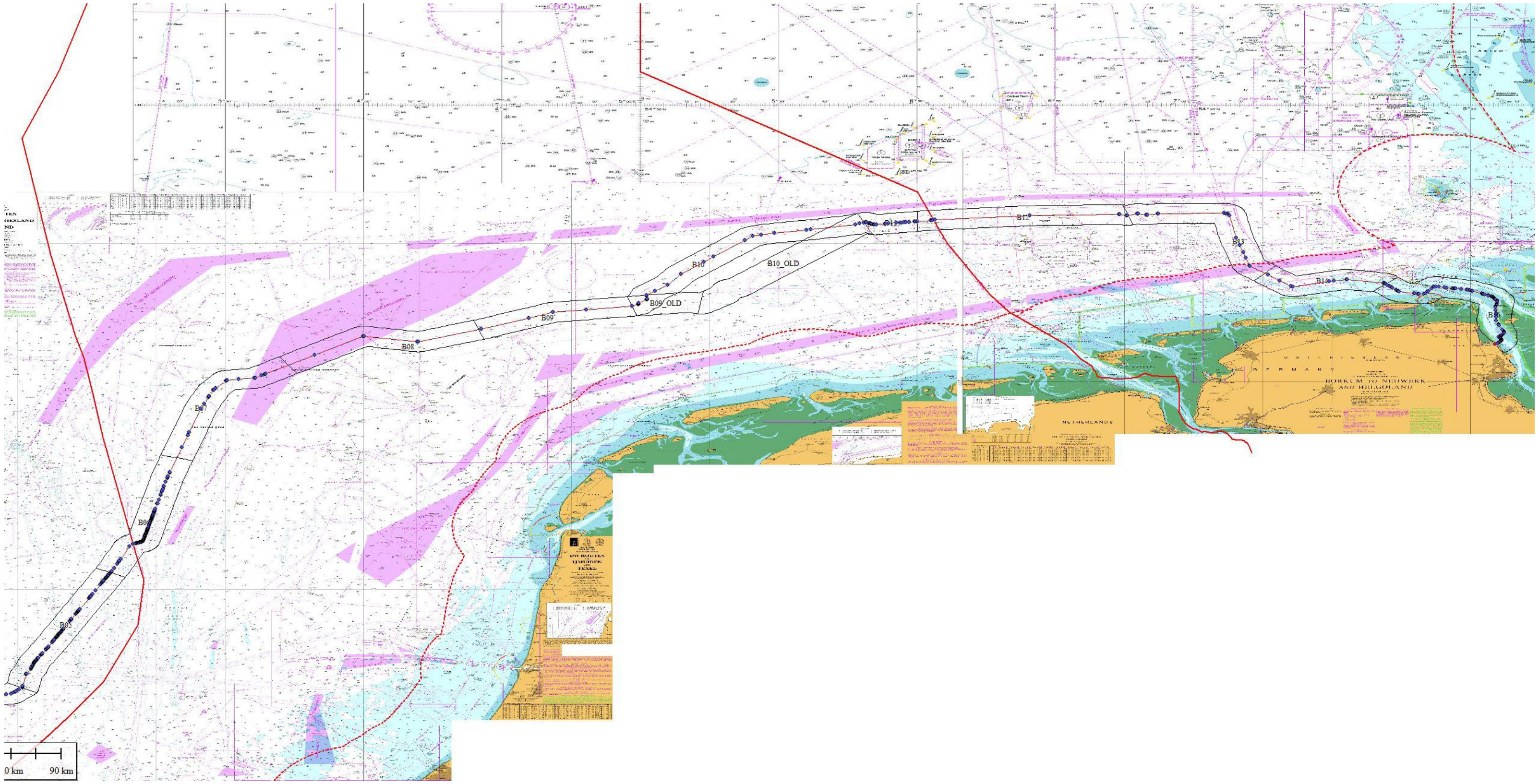
NeuConnect EEZ Sector	KP FROM (Appr.)	KP TO (Appr.)	Length (Appr.)
	[km]	[km]	[km]
EEZ United Kingdom	0.0	~262.850	~262.850
EEZ The Netherlands	~262.850	~522.900	~260.05
EEZ Germany	~522.900	~700.150	~177.25

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:

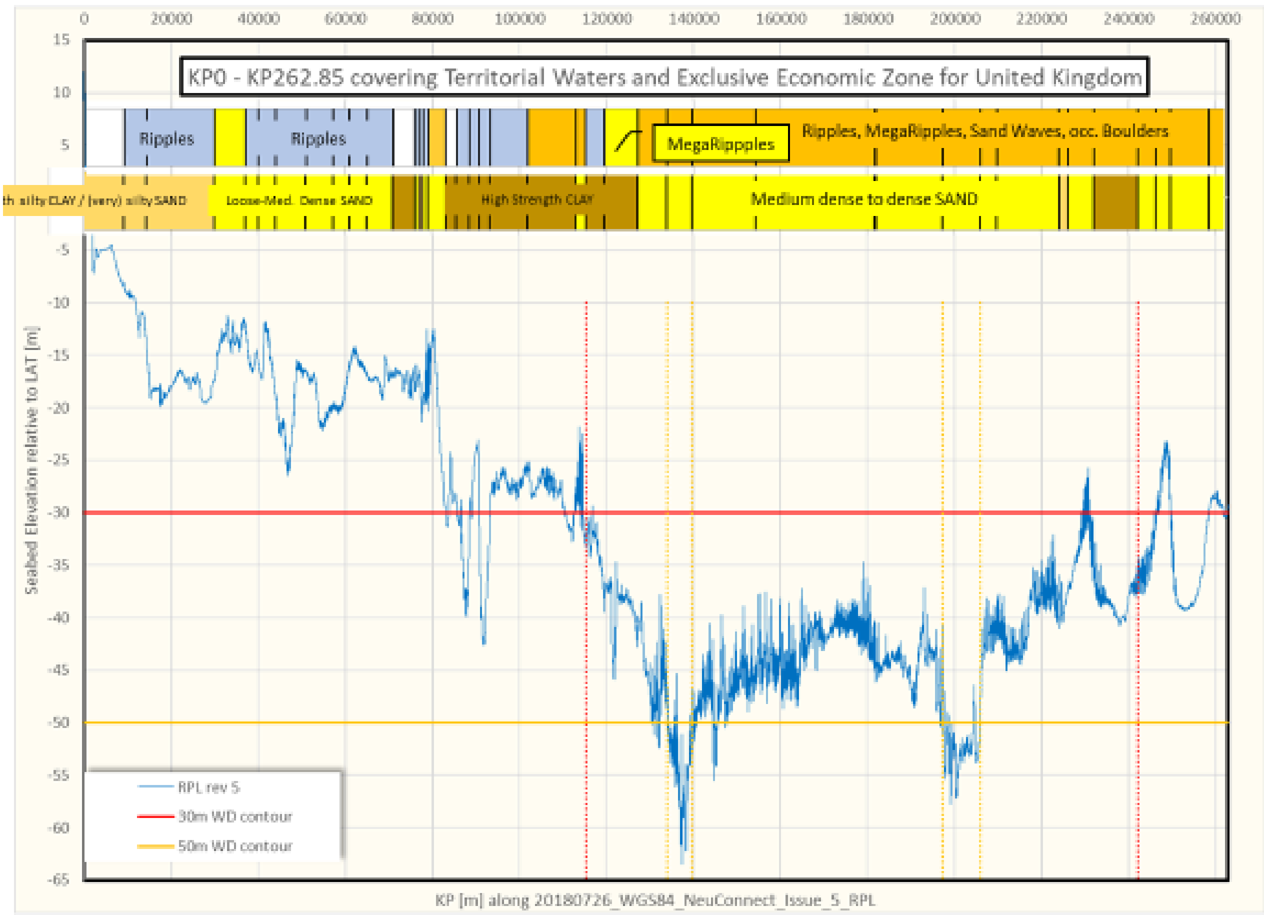
- Ripples between KP011 and KP304 (intermittently);
- Mega Ripples between KP108 and KP190 (intermittently);
- Sand Waves between KP078 and KP080 (intermittently);
  between KP106 and KP253 (intermittently);

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.

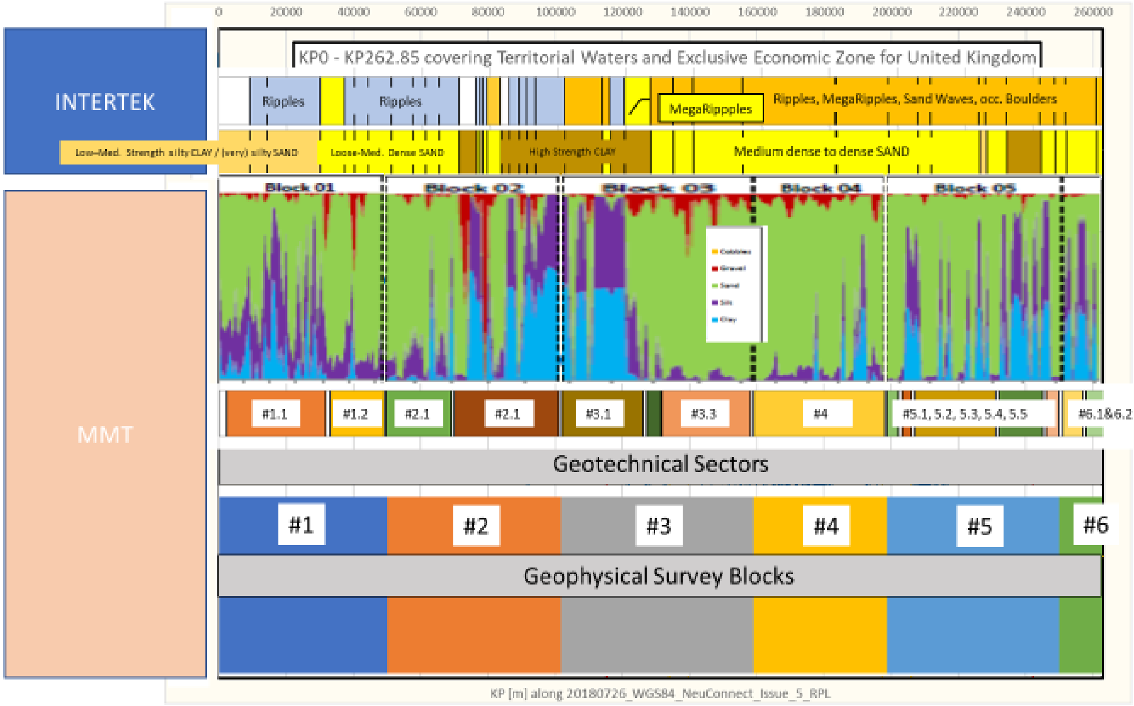
Enlarged versions of these figures are enclosed in Appendix B1 of this report.

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



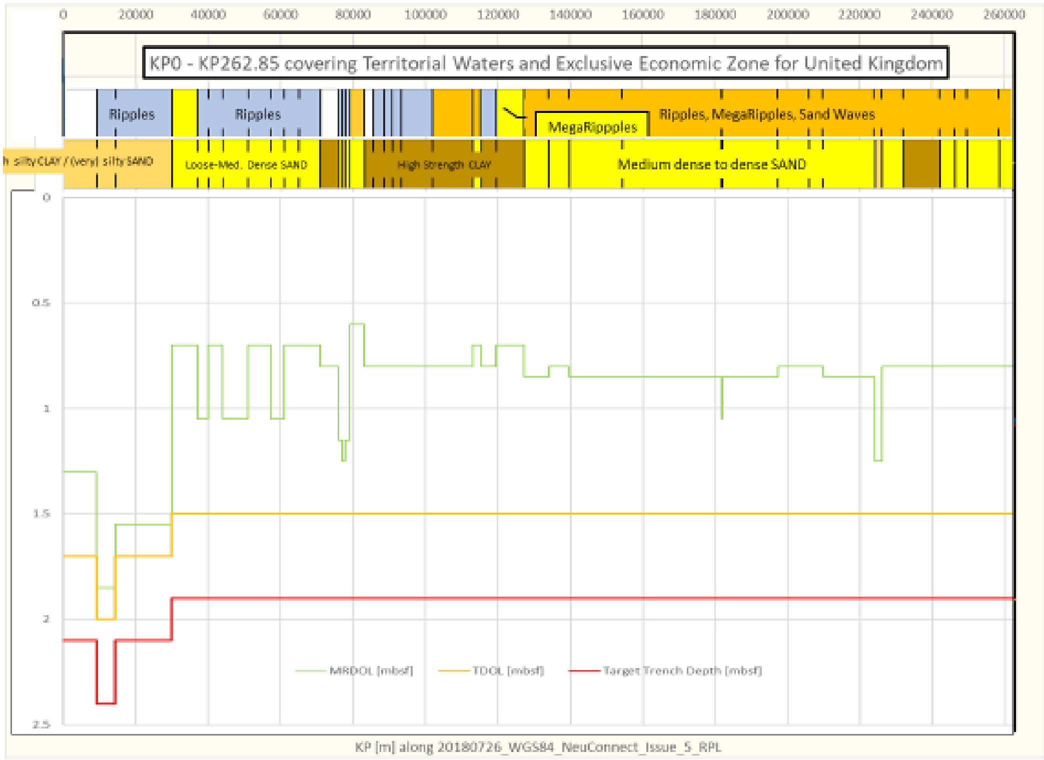
Comment: The chosen LAT 30m water depth segmentation at approximately KP 240+ to be re-considered.

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:

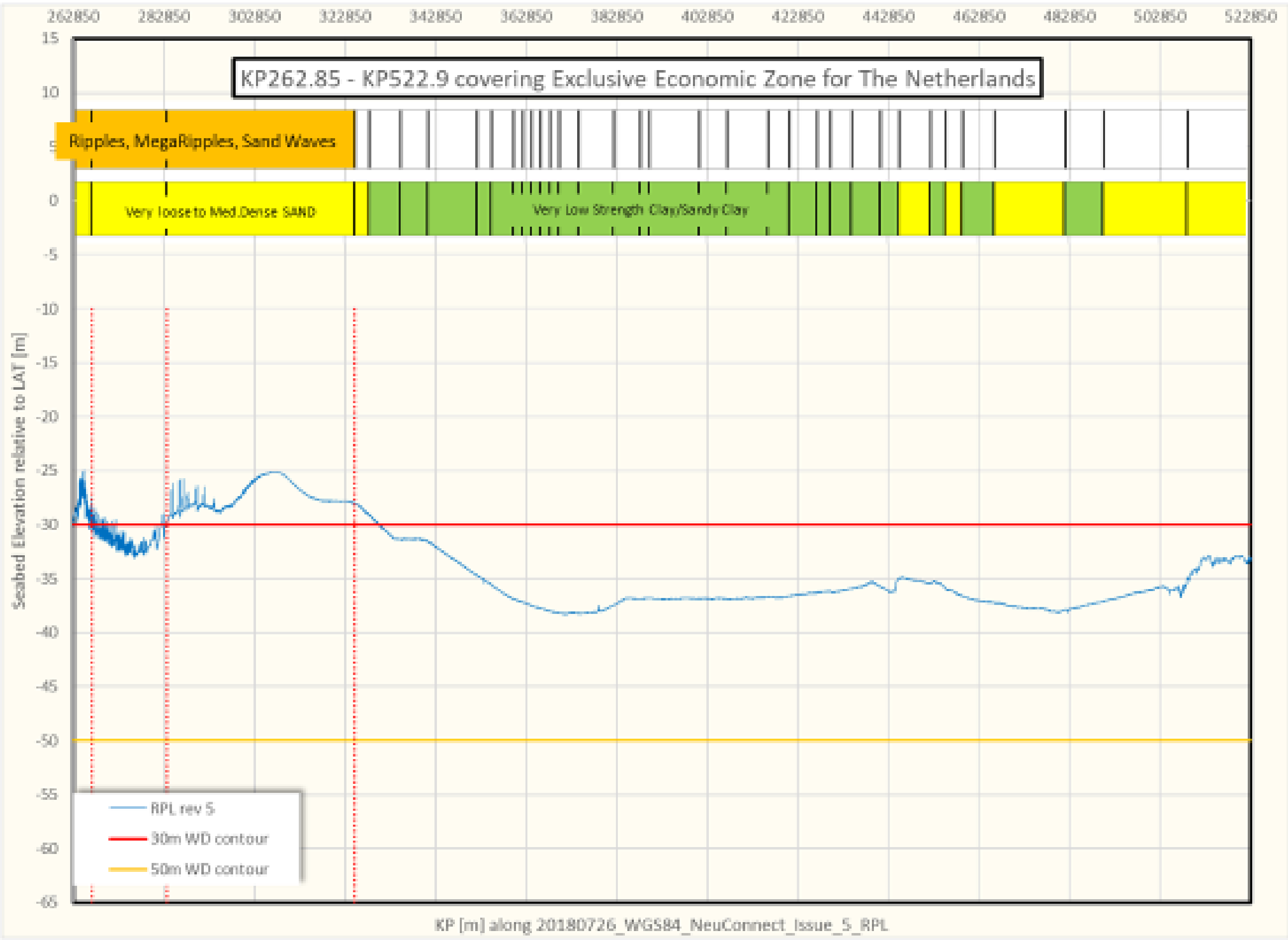
- Sand Waves between KP253 and KP294 (intermittently);

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.

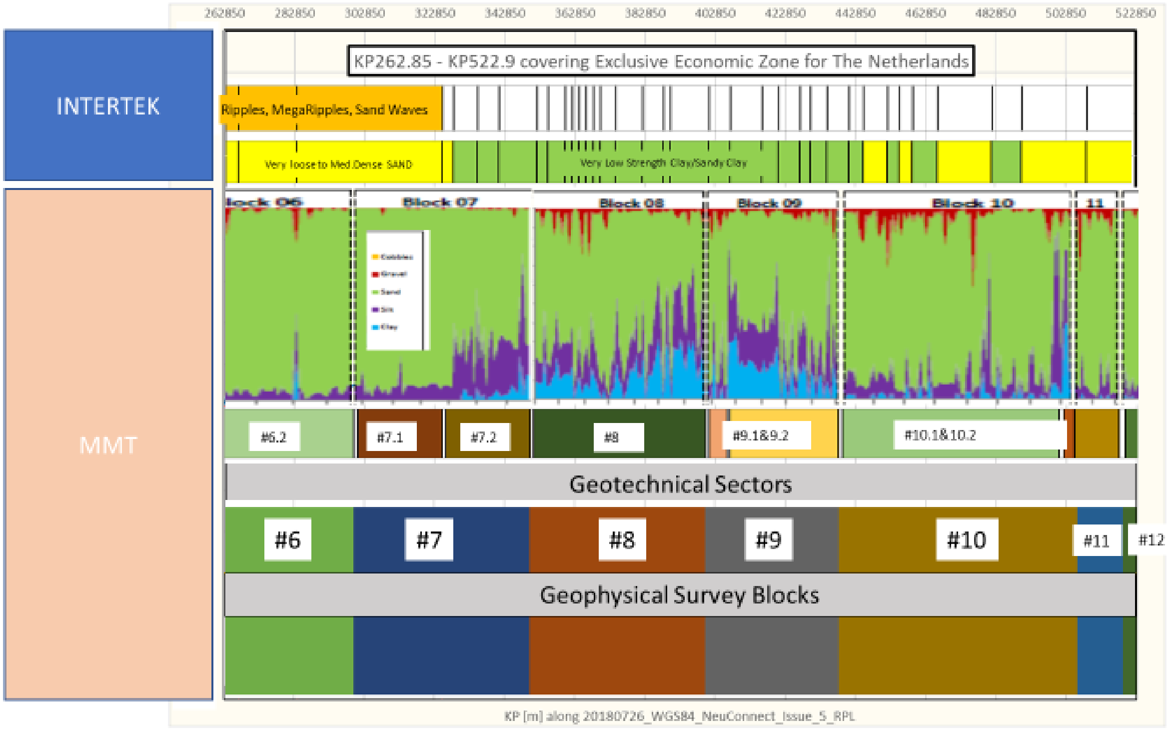
Enlarged versions of these figures are enclosed in Appendix B1 of this report.

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



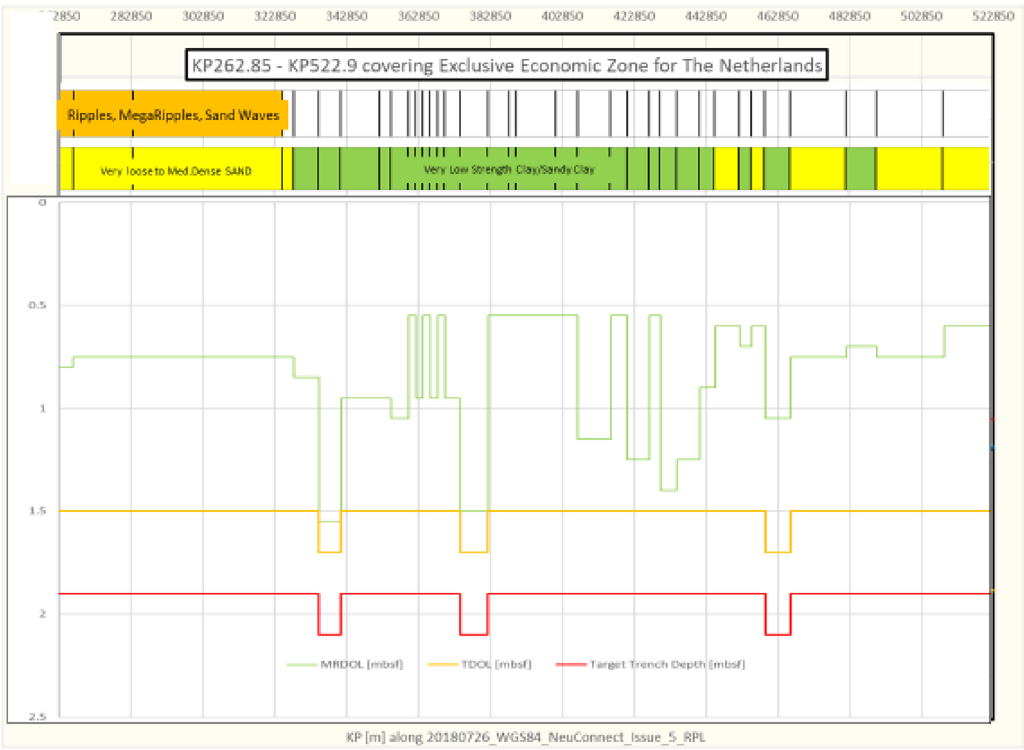
Comment: The chosen LAT 30m water depth segmentation at approximately KP 322.9 to be re-considered.

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:

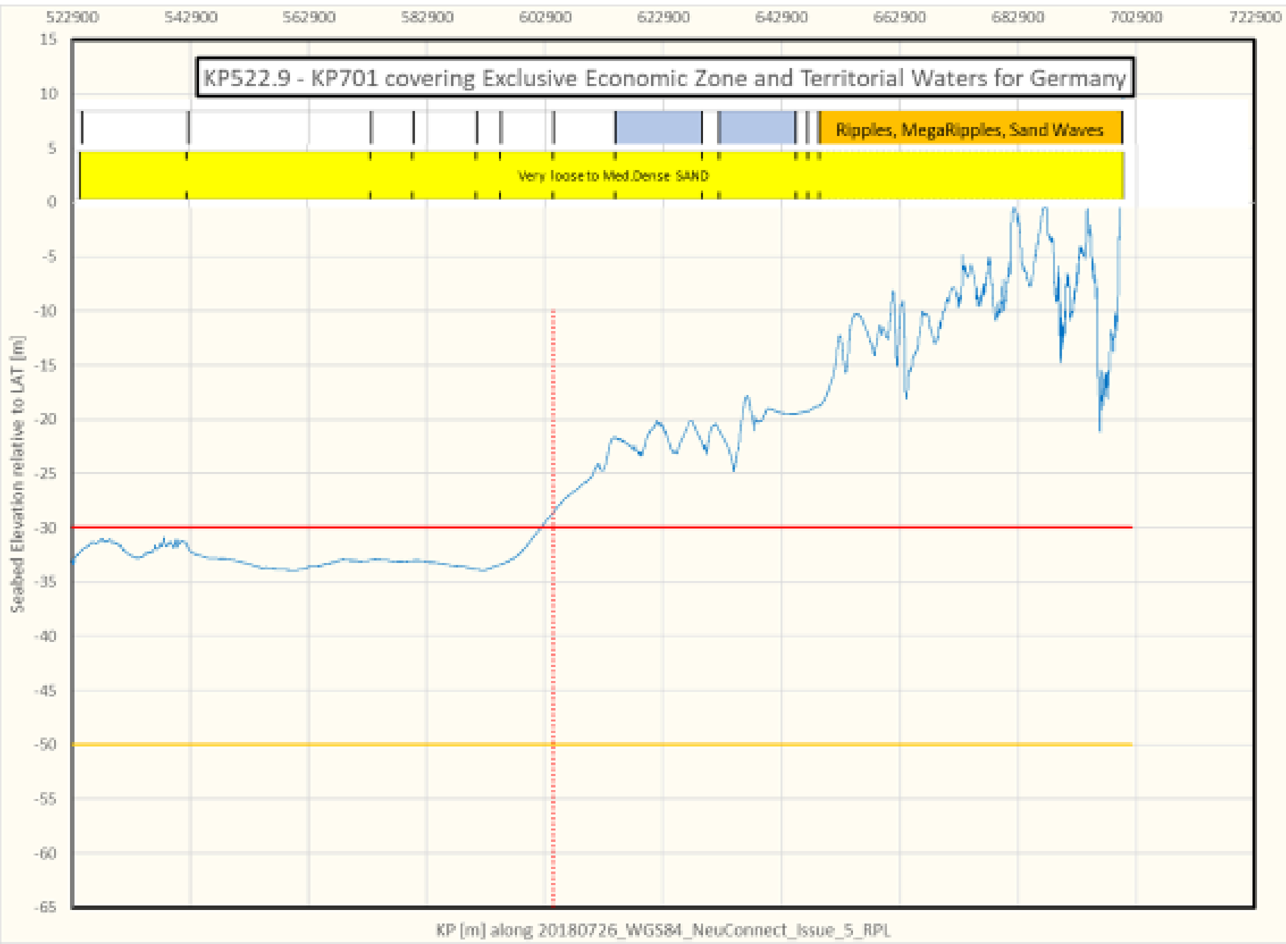
- Ripples between KP620 and KP700 (intermittently);
- Mega Ripples between KP669 and KP700 (intermittently);
- Sand Waves between KP673 and KP700 (intermittently);

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.

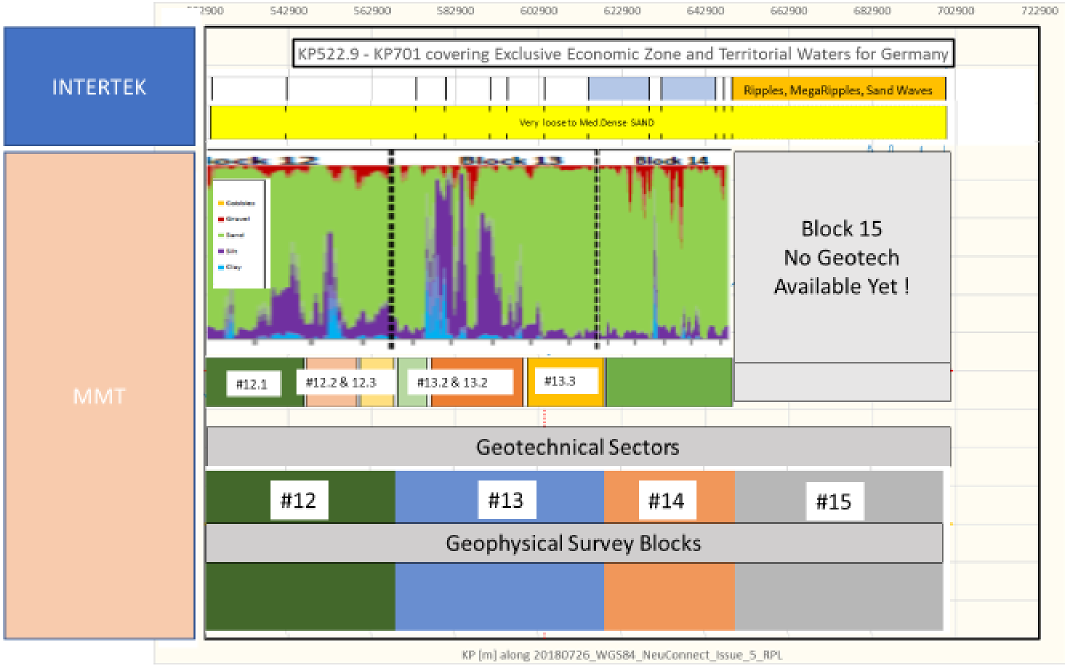
Enlarged versions of these figures are enclosed in Appendix B1 of this report.

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



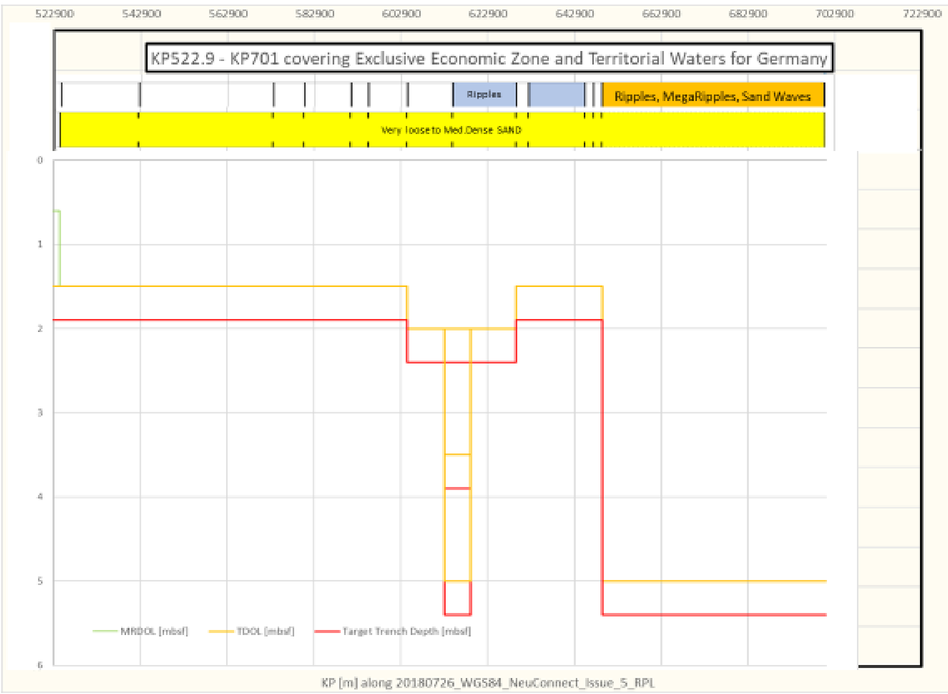
Comment: The chosen LAT 30m water depth segmentation at approximately KP 603 to be re-considered.

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) Several relatively small areas identified in UK Sector
		"Numerous Boulders" (> 20 boulders per 100 sqm) 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. 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)

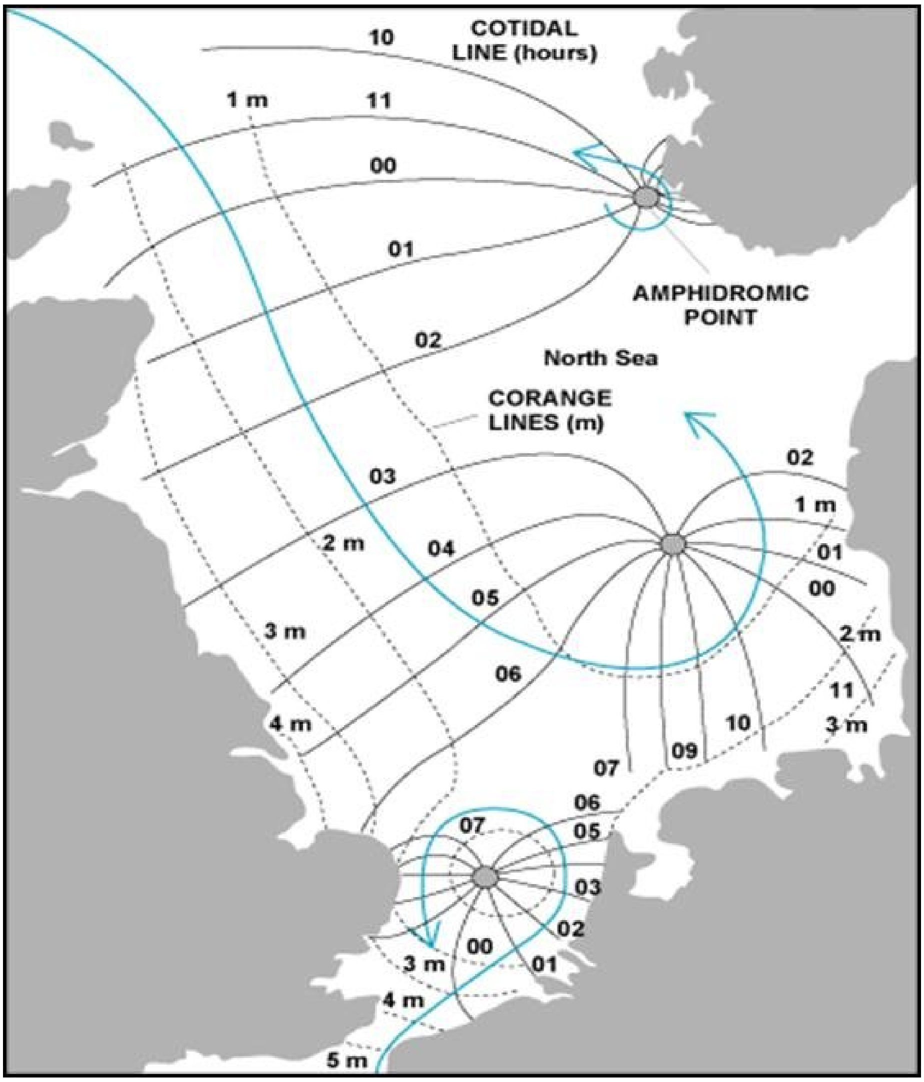
12.2. STEP1 – Bedform Segmentation

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



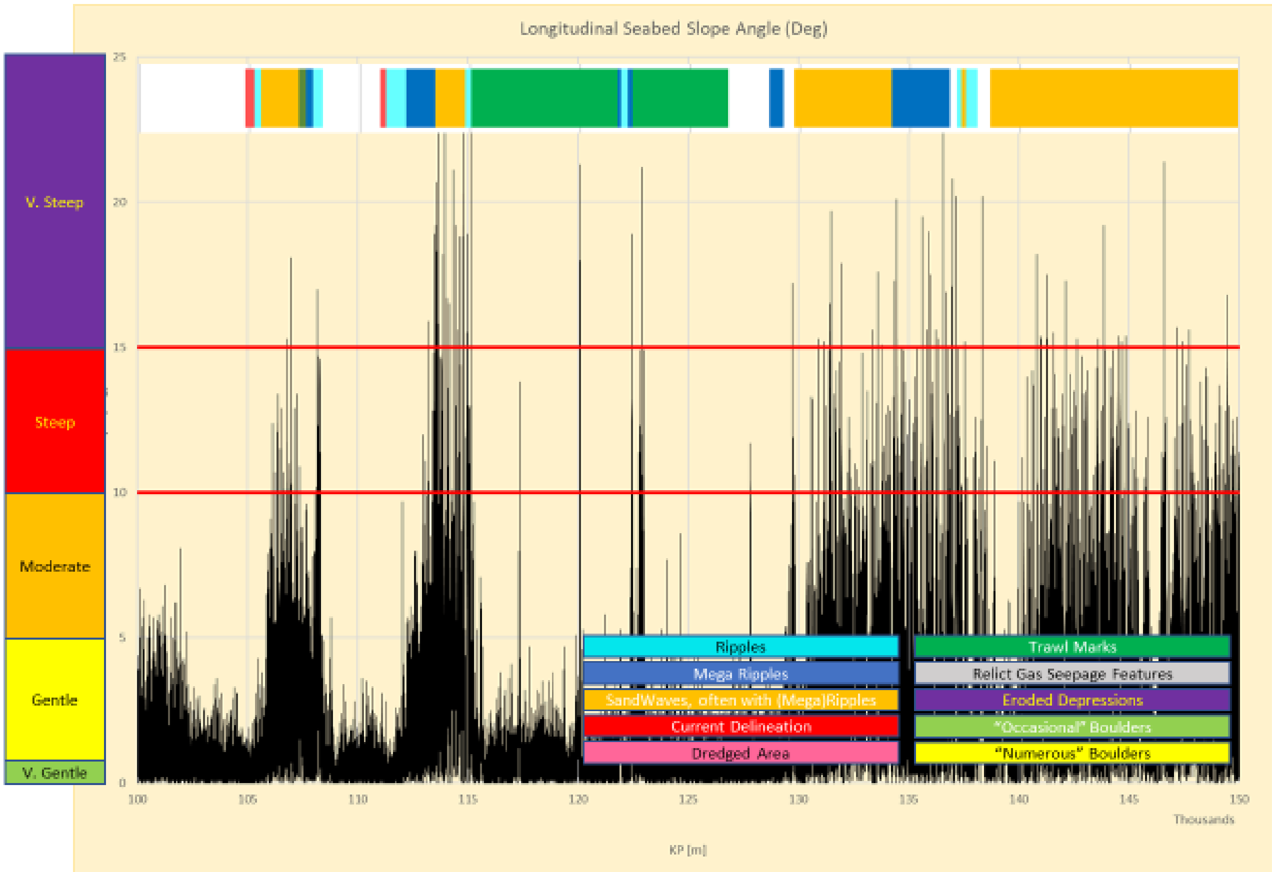
It should be noted that only mobile seabed features with a wave height, similar in magnitude to the target trench depth (TTD), should be of interest to pre-sweeping (mega ripples, sand waves) and only those that are (confirmed) mobile.

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

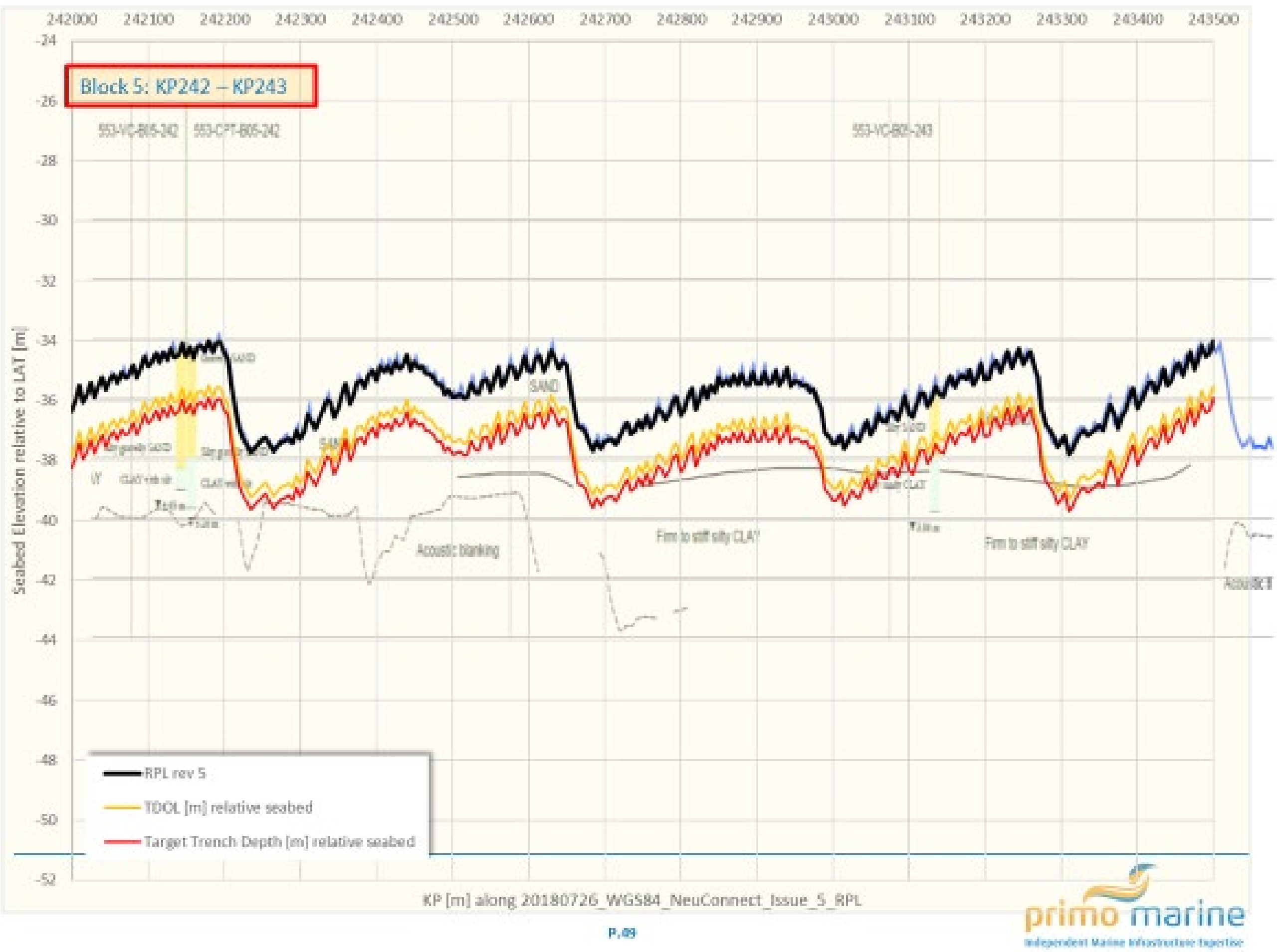
12.3. STEP 2 - Shallow Geology Segmentation

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	KP TO	SHALLOW GEOLOGY within TARGET TRENCH DEPTH zone
	[km]	[km]	
1	0.0	9.2	MIXED MATERIALS - SANDS, SILTS, CLAYS …. Typically: Layer of very low to medium strength silty CLAY of varying thickness ….overlying … 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 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 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 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	KP TO	SHALLOW GEOLOGY within TARGET TRENCH DEPTH zone
	[km]	[km]	
			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 Steep Slopes	Ripples ($w_L < 15m$, $w_H < 1m$)
		Mega Ripples ($15m < w_L < 50m$, $1m < w_H < 3m$) None identified in NETHS Sector.
		Sand Waves ($50m < w_L < 200m$, $w_H > 3m$) 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) None identified in NETHS Sector.
		"Numerous Boulders" (> 20 boulders per 100 sqm) 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. NETHS Sector: total 36x crossings. 13x active, 22x OOS, 1x planned.
	Dredging	Shipping channels in shallow areas with mobile sediments have their depth maintained via dredging.
	Other	Trawl Marks

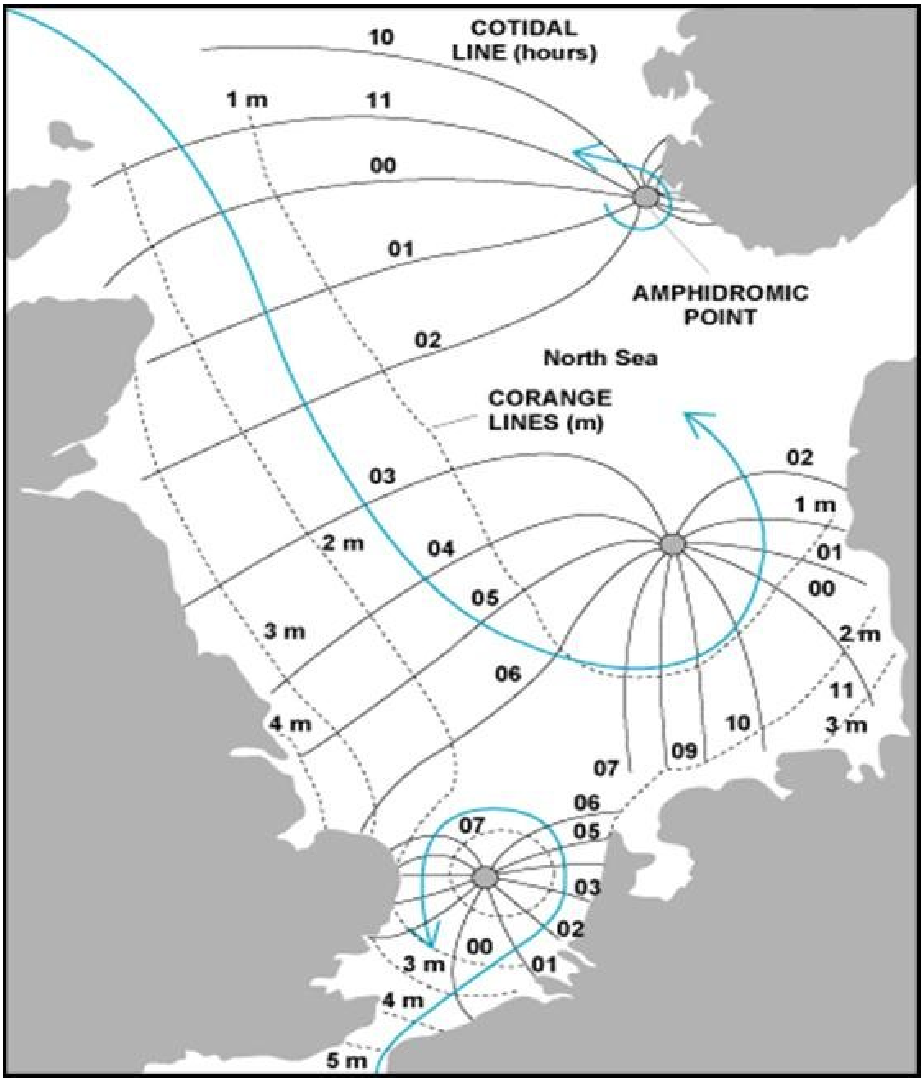
13.2. STEP1 – Bedform Segmentation

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



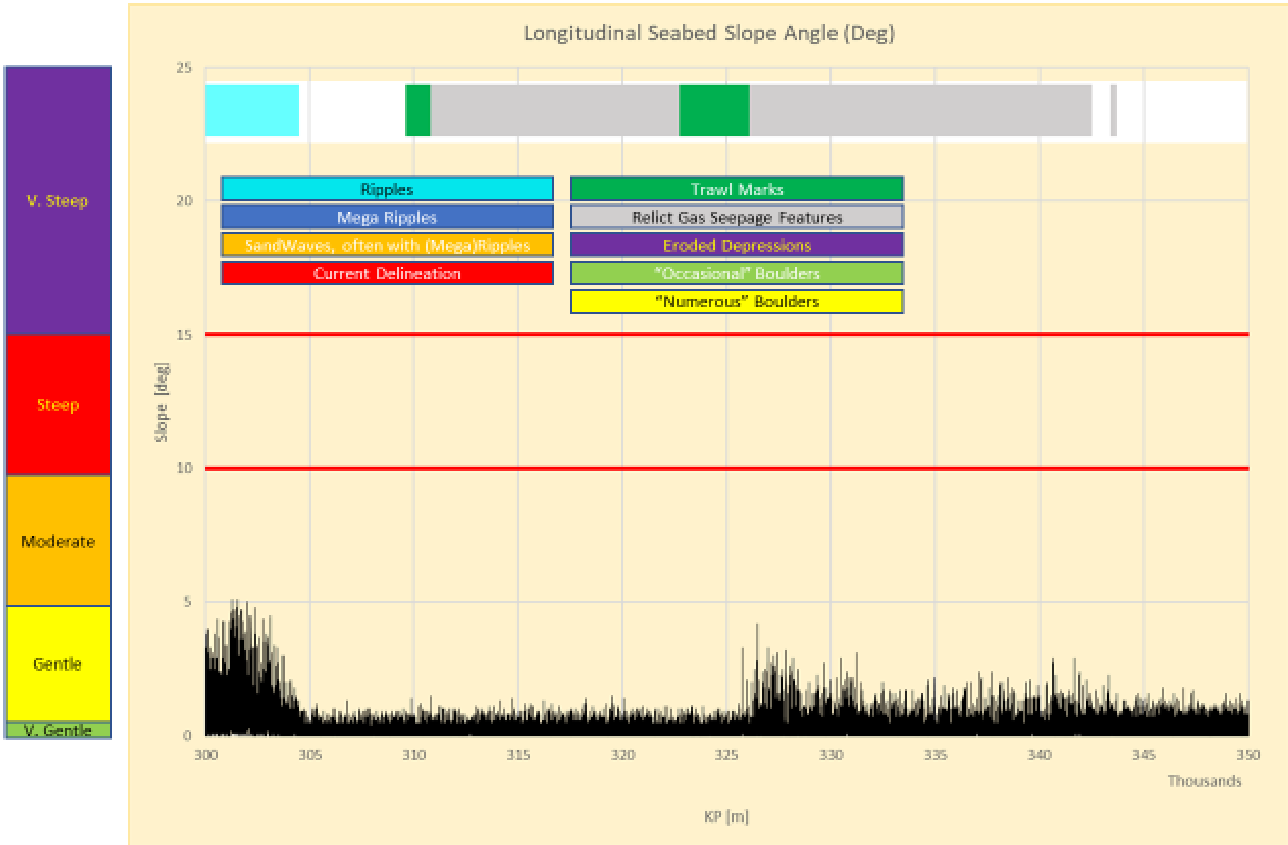
It should be noted that only mobile seabed features with a wave height, similar in magnitude to the target trench depth (TTD), should be of interest to pre-sweeping (mega ripples, sand waves) and only those that are (confirmed) mobile.

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

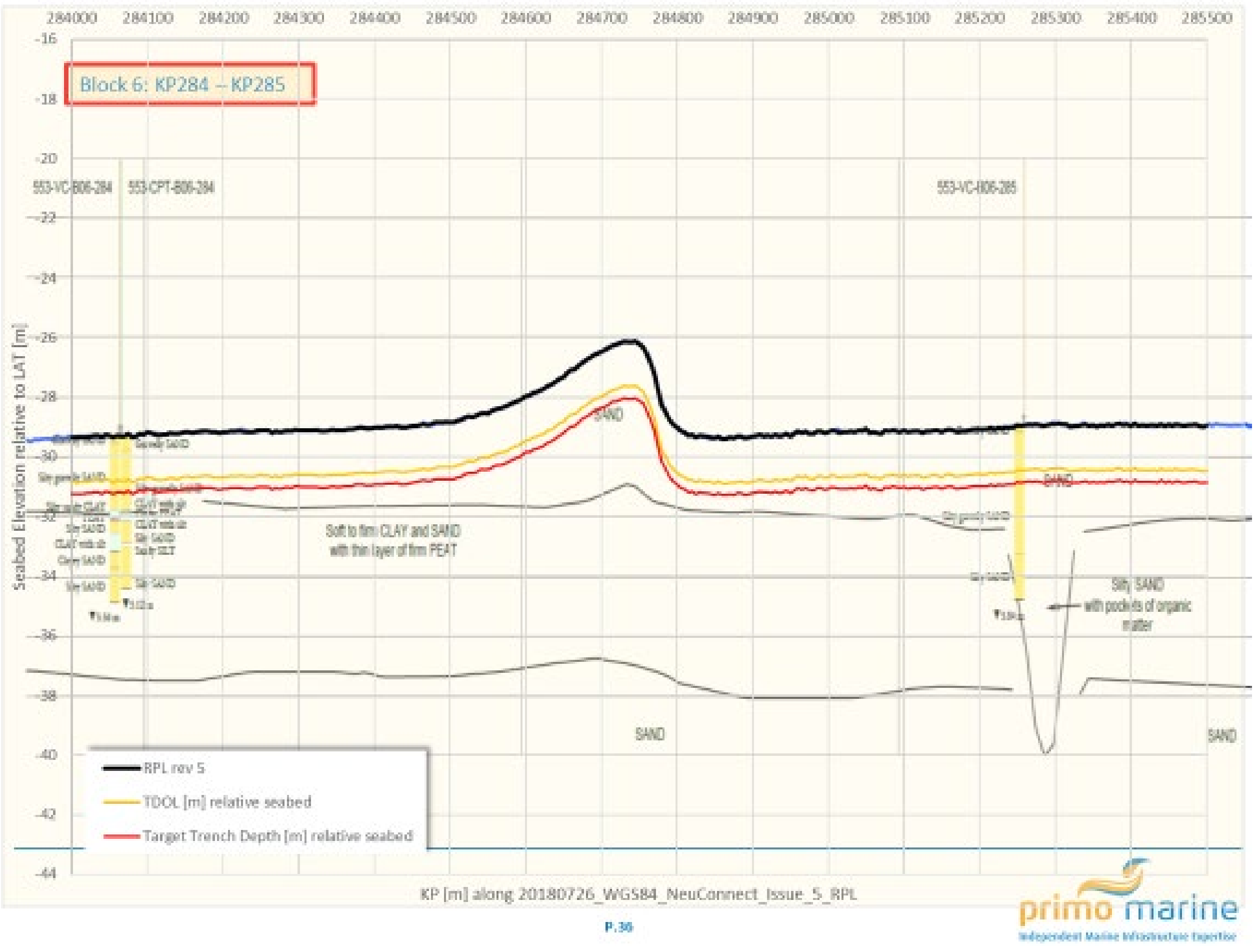
13.3. STEP 2 - Shallow Geology Segmentation

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	KP TO	SHALLOW GEOLOGY within TARGET TRENCH DEPTH zone
	[km]	[km]	
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 Steep Slopes	Ripples $(w_L < 15m, w_H < 1m)$
		Mega Ripples $(15m < w_L < 50m, 1m < w_H < 3m)$
		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) Several areas identified in GERMANY Sector
		"Numerous Boulders" (> 20 boulders per 100 sqm) 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. GERMANY Sector: 20x crossings 9x active, 10x OOS, 1x planned
	Dredging	Shipping channels in shallow areas with mobile sediments have their depth maintained via dredging.

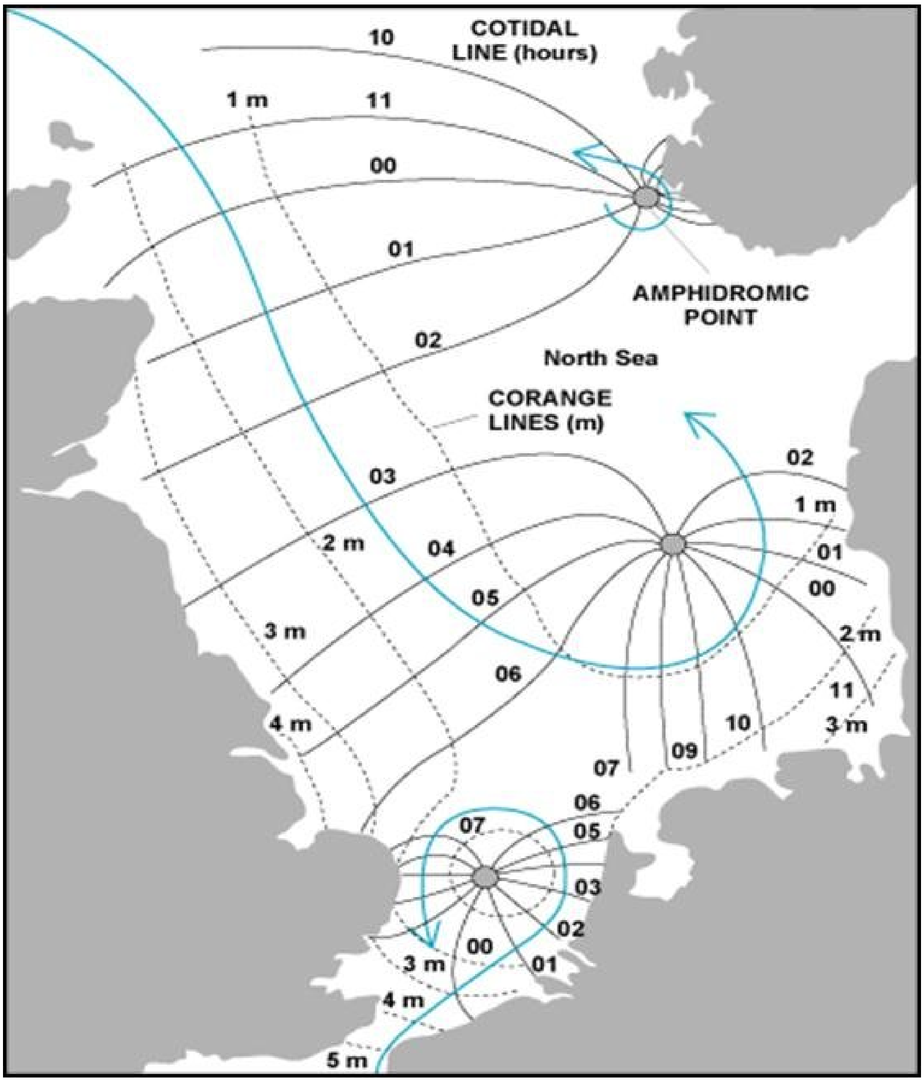
14.2. STEP1 – Bedform Segmentation

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



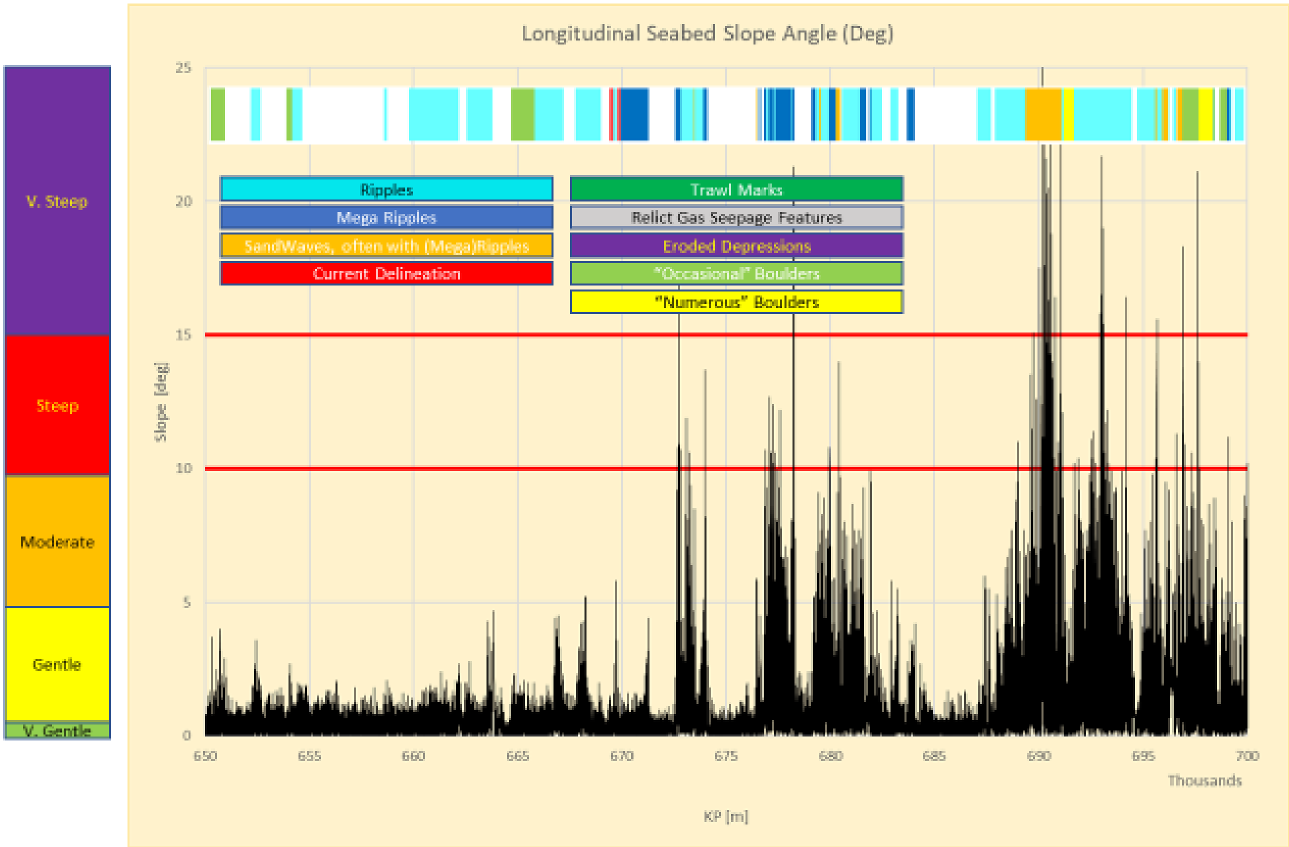
It should be noted that only mobile seabed features with a wave height, similar in magnitude to the target trench depth (TTD), should be of interest to pre-sweeping (mega ripples, sand waves) and only those that are (confirmed) mobile.

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

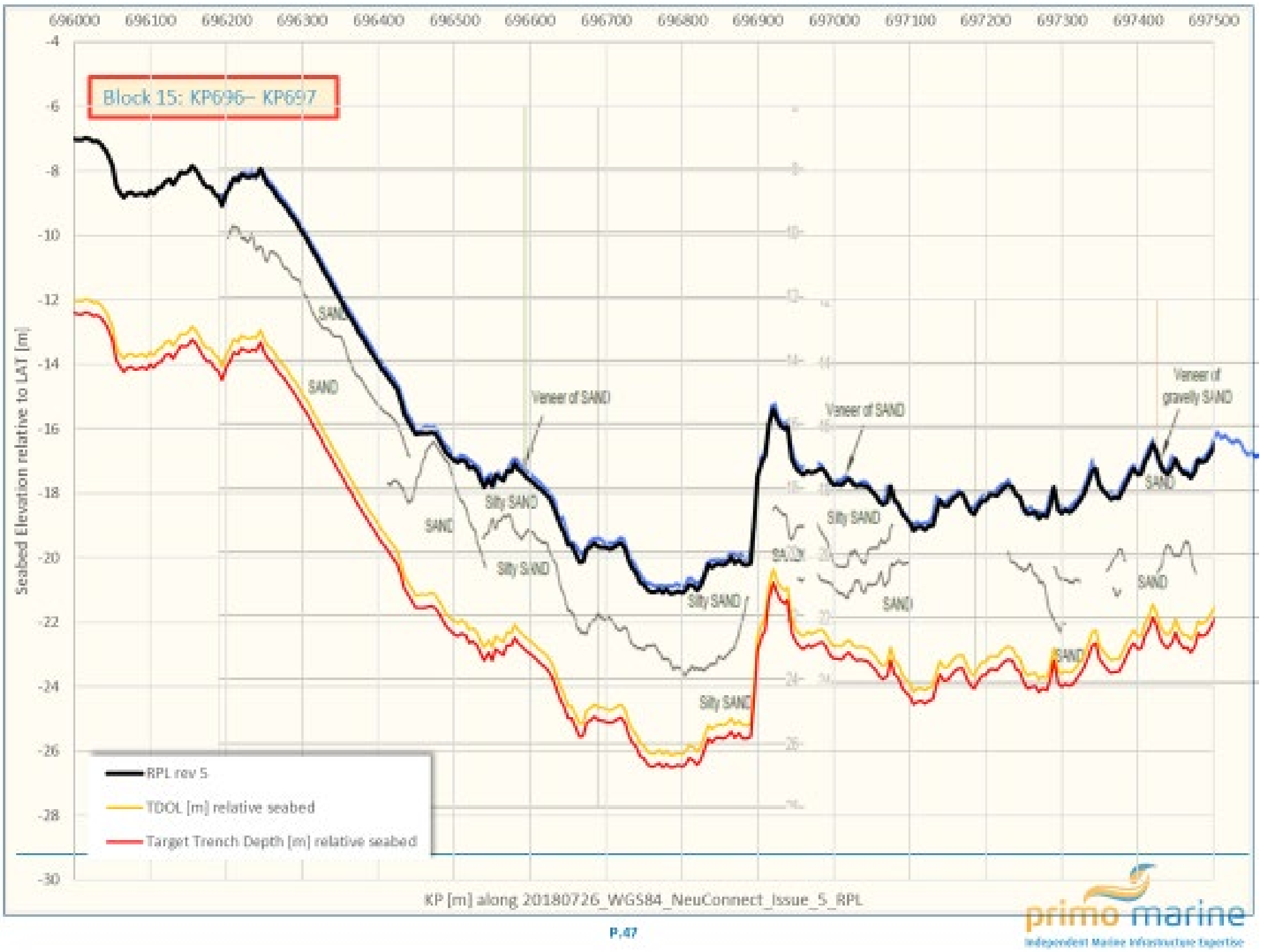
14.3. STEP 2 - Shallow Geology Segmentation

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	KP TO	SHALLOW GEOLOGY within TARGET TRENCH DEPTH zone
	[km]	[km]	
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.

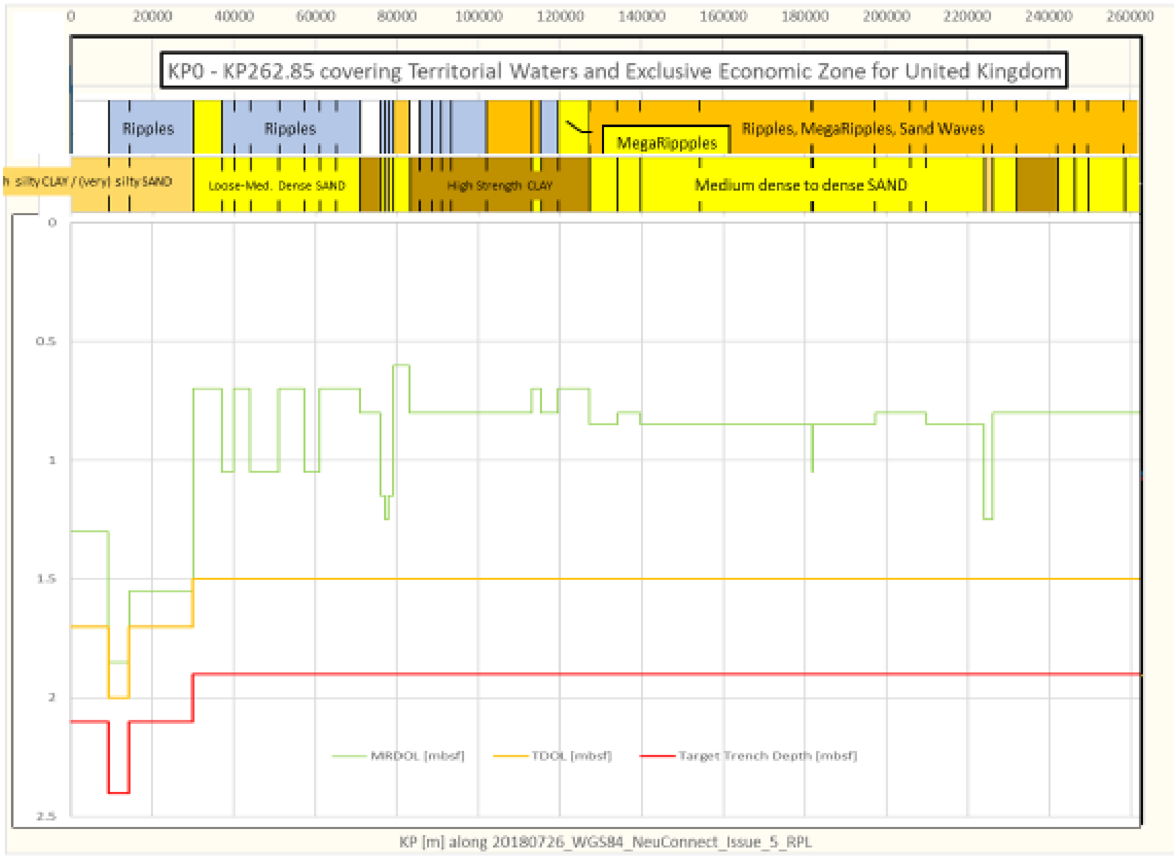
No rock, and no peat was encountered in this sector, at least not within the zone of interest (TTD).

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.

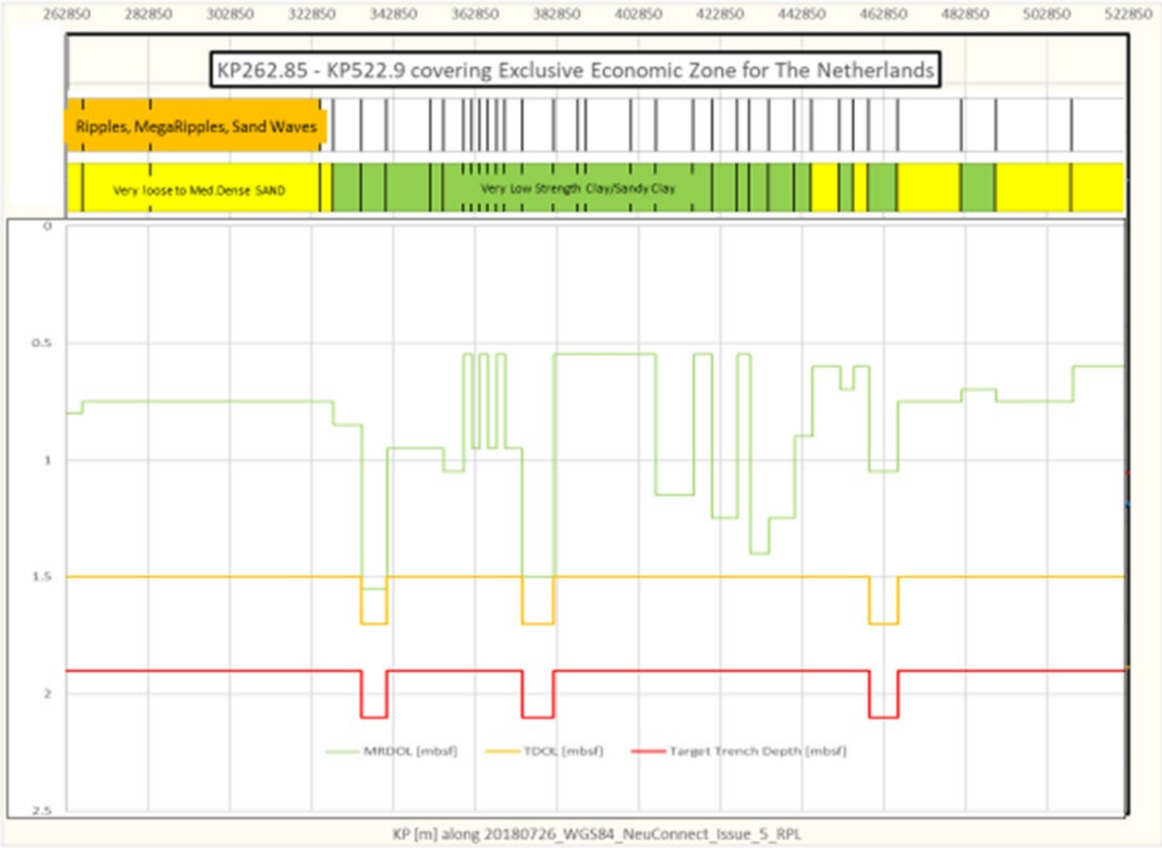
      Pre-sweeping should be carried out using Trailer Suction Hopper Dredging techniques.

   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.

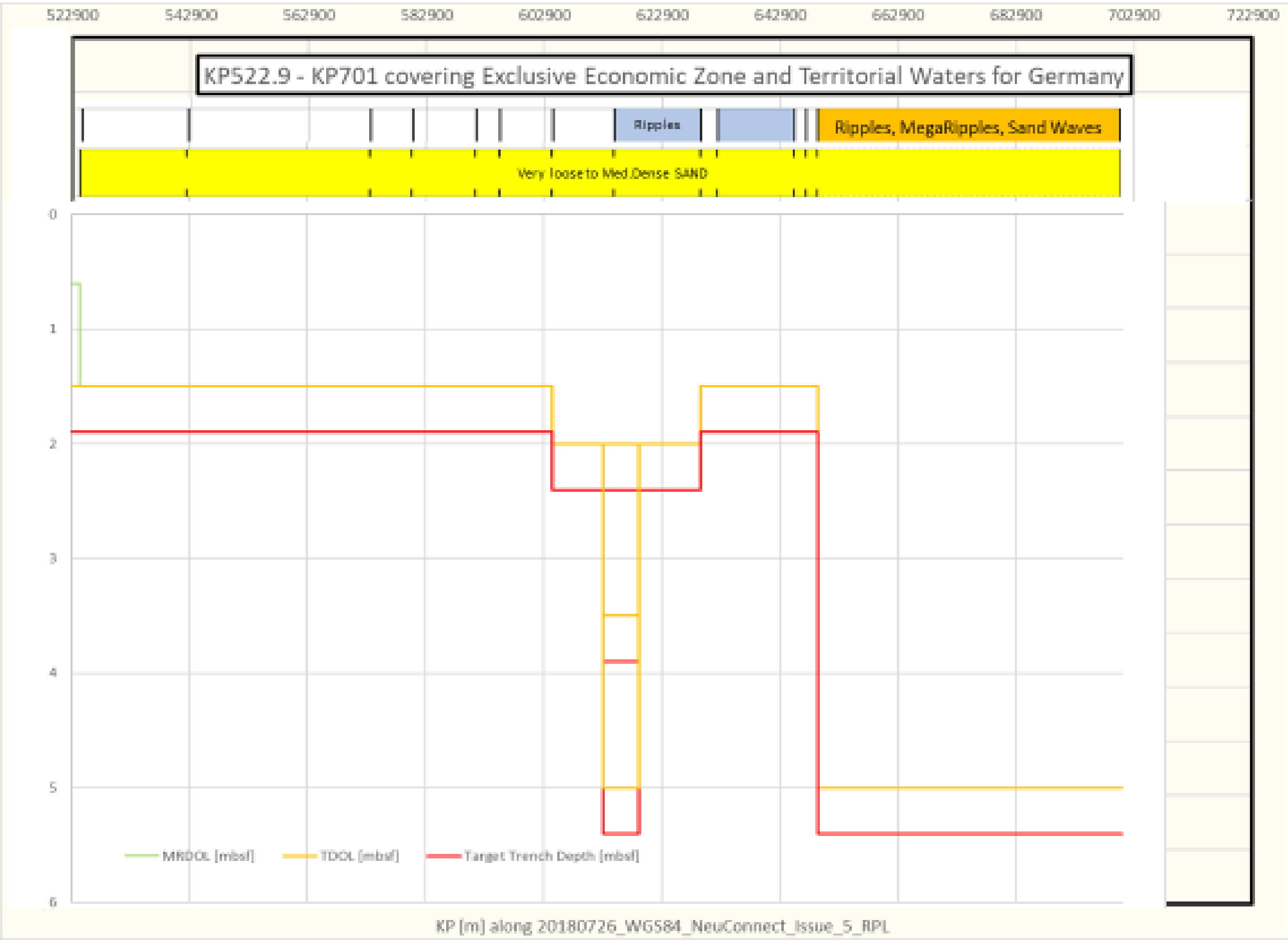
   The Figure 20-1 below provides a useful summary of the CBRA results showing segmentation of bedforms, shallow geology and burial requirements in one snapshot. Note however that PRIMO's shallow geology segmentation is shown in detail in Appendix C3 (GERMANY Sector) and considered a refinement of the one 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

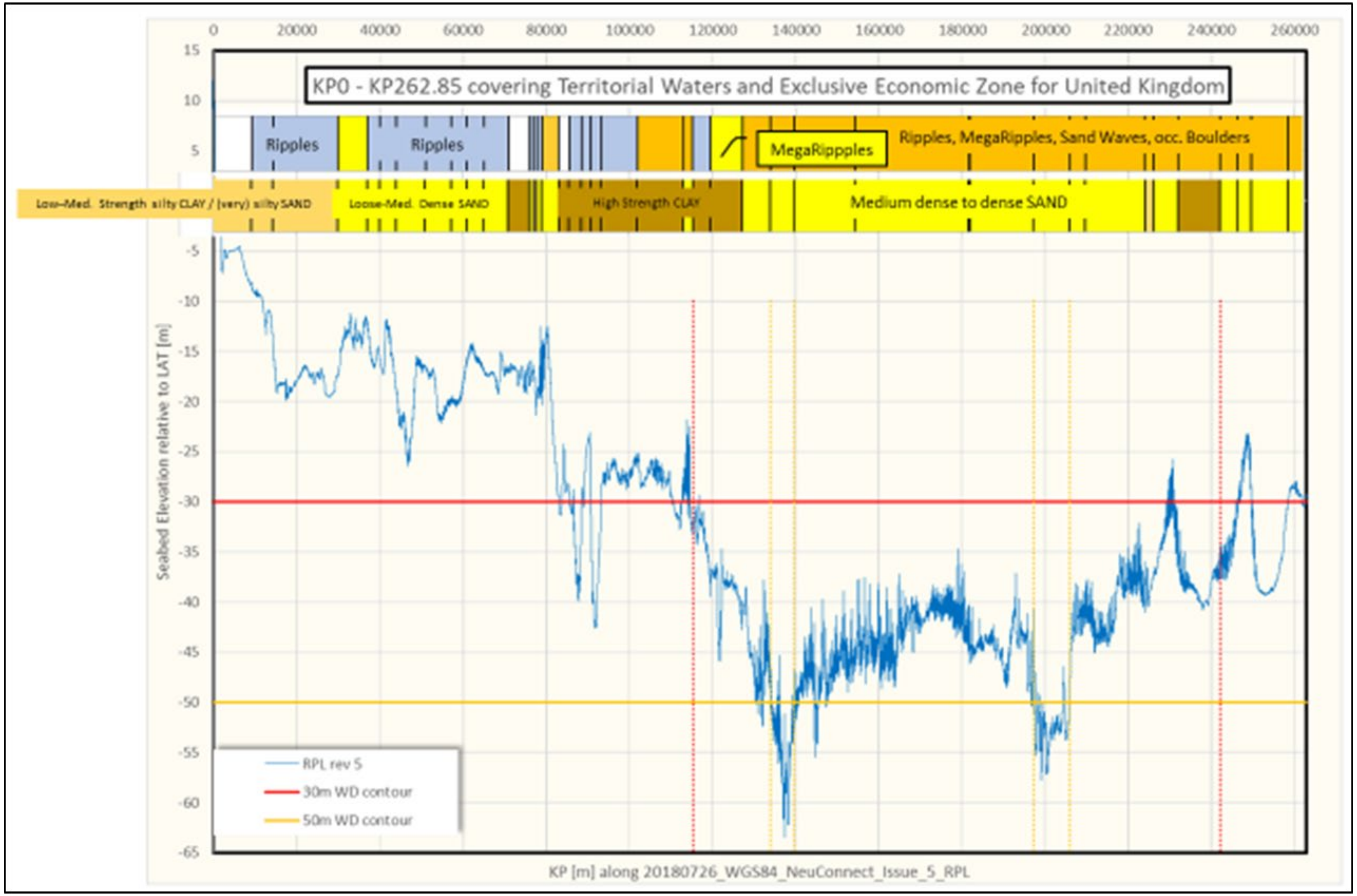


Figure B1- 2: UK SECTOR CBRA RESULTS SUMMARY - Blocks, Sections + Bedforms & Shallow Geology

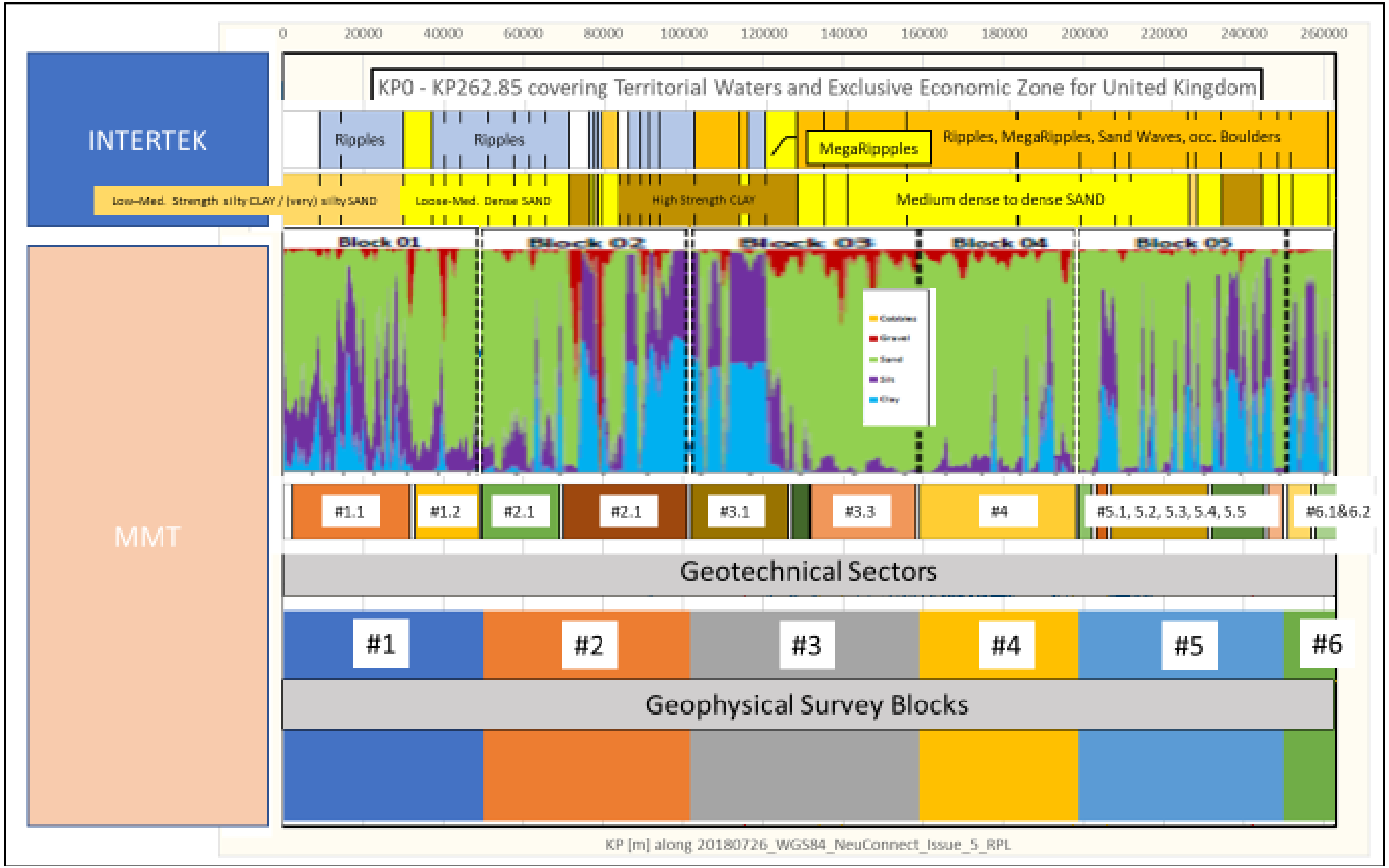
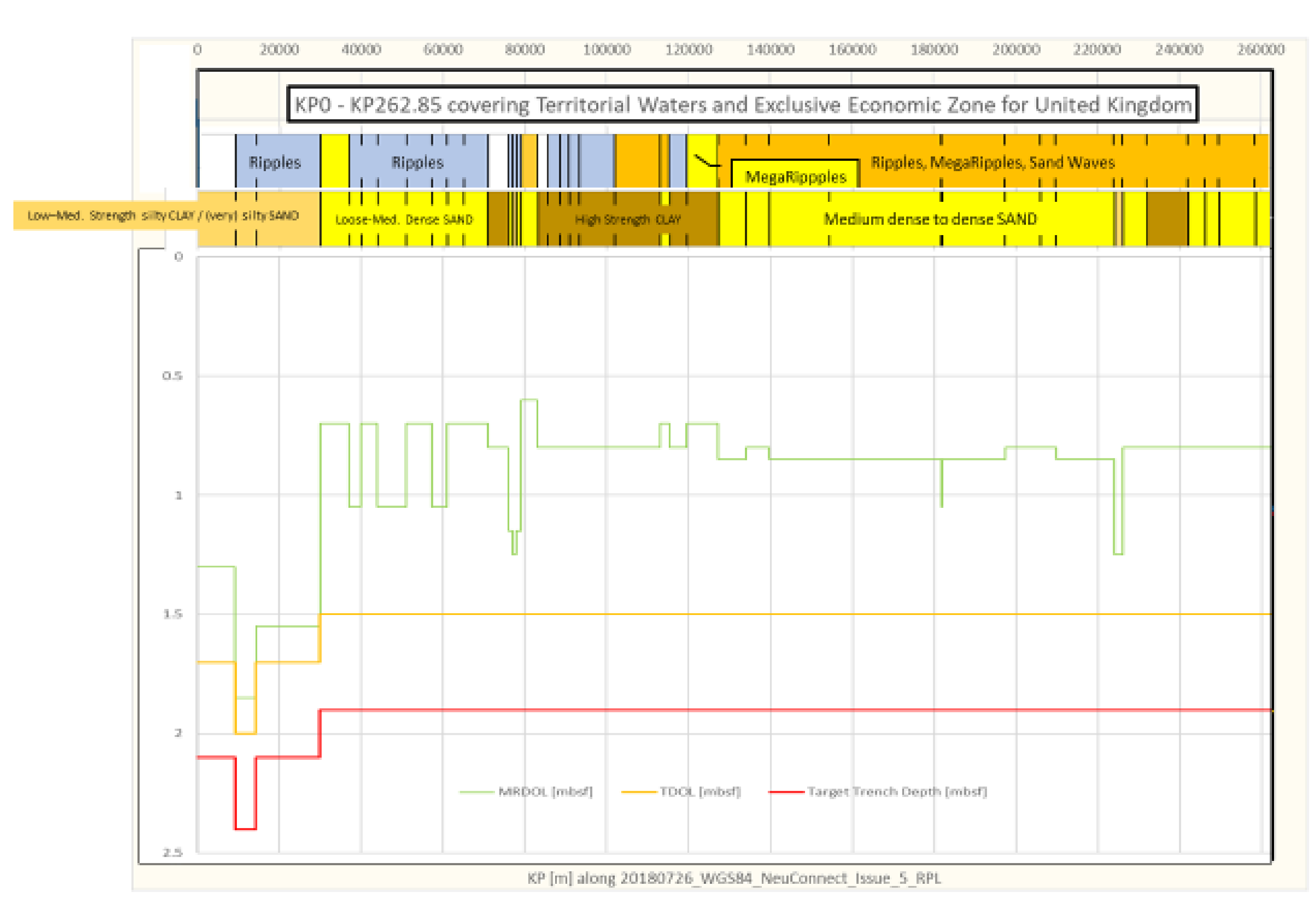


Figure B1- 3: UK SECTOR CBRA RESULTS SUMMARY - RMDOL, TDOL, TTD + Bedforms & Shallow Geology



APPENDIX B2 – CBRA Summary (Sector: The Netherlands)

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

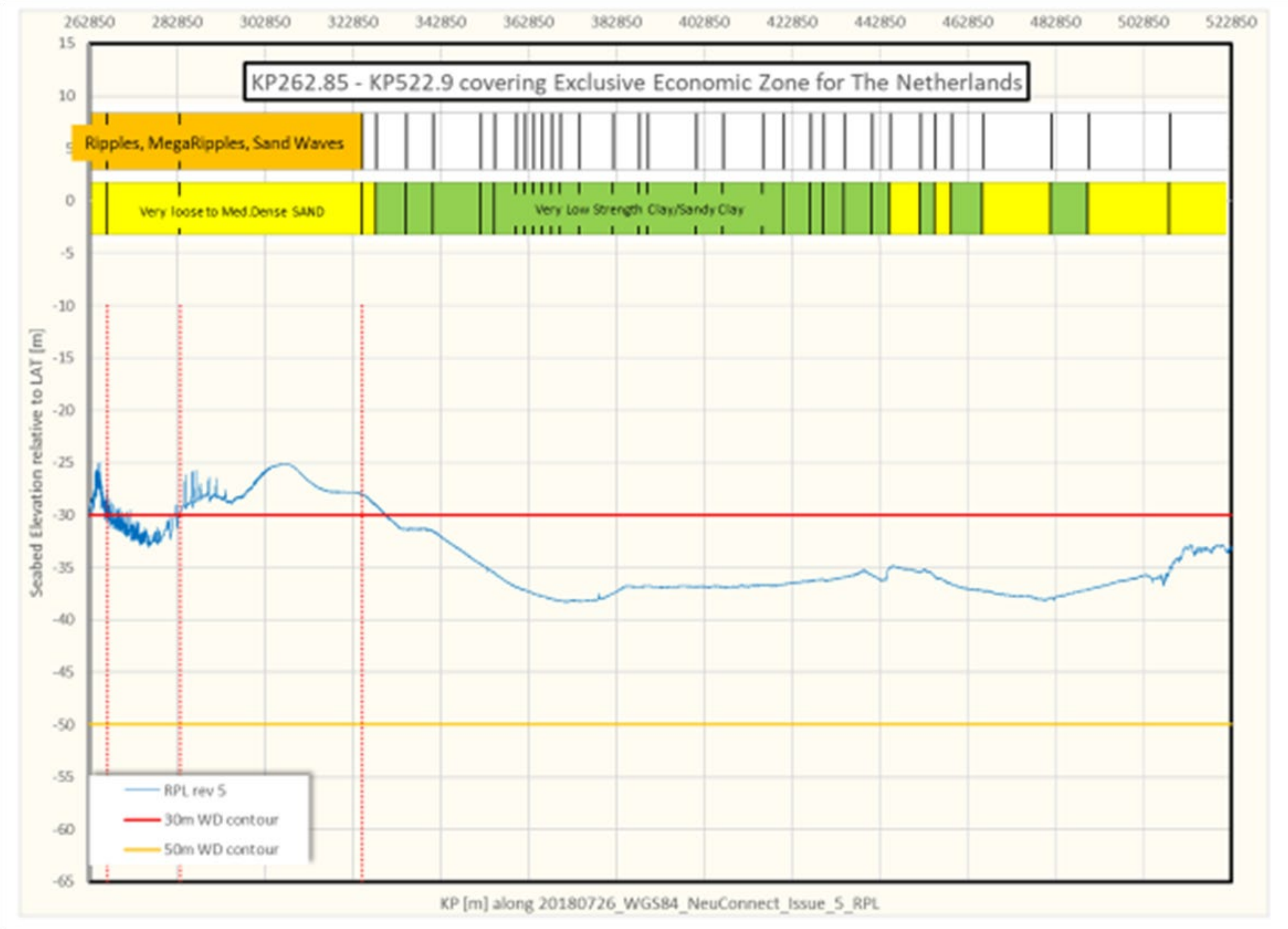


Figure B2- 2: NETHS SECTOR, CBRA RESULTS SUMMARY - Blocks, Sections + Bedforms & Shallow Geology

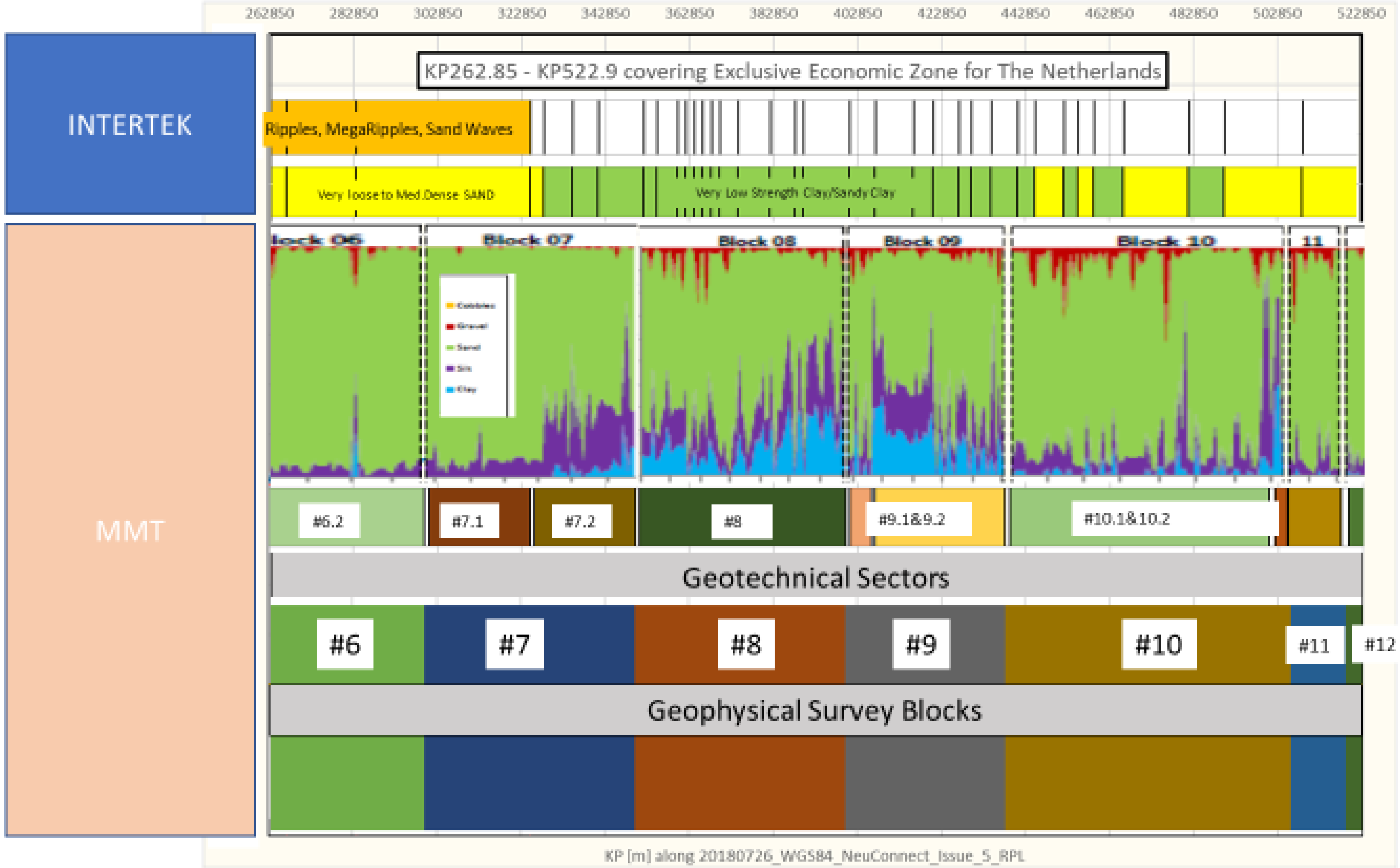
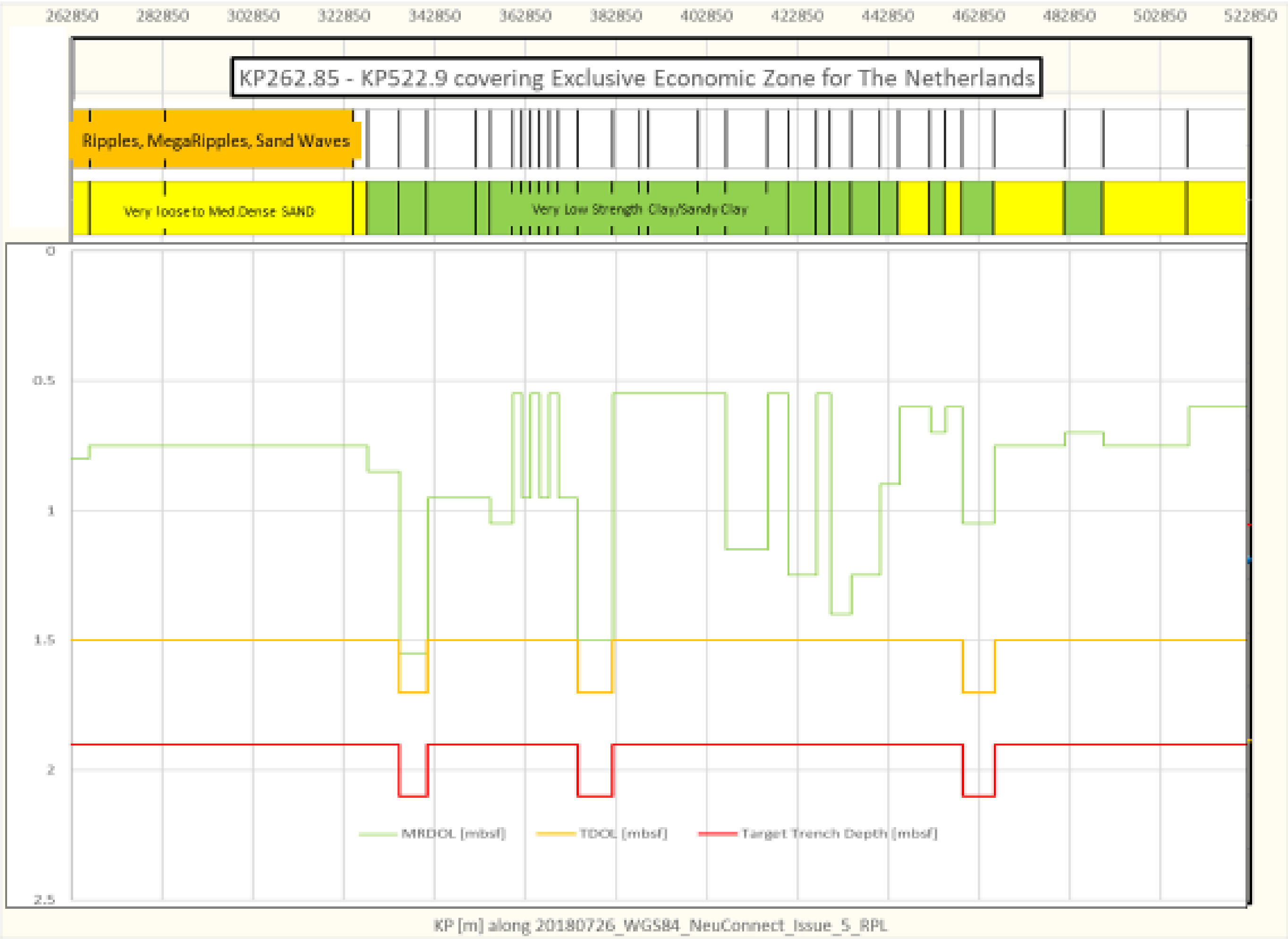


Figure B2- 3: NETHS SECTOR, CBRA RESULTS SUMMARY - RMDOL, TDOL, TTD + Bedforms & Shallow Geology

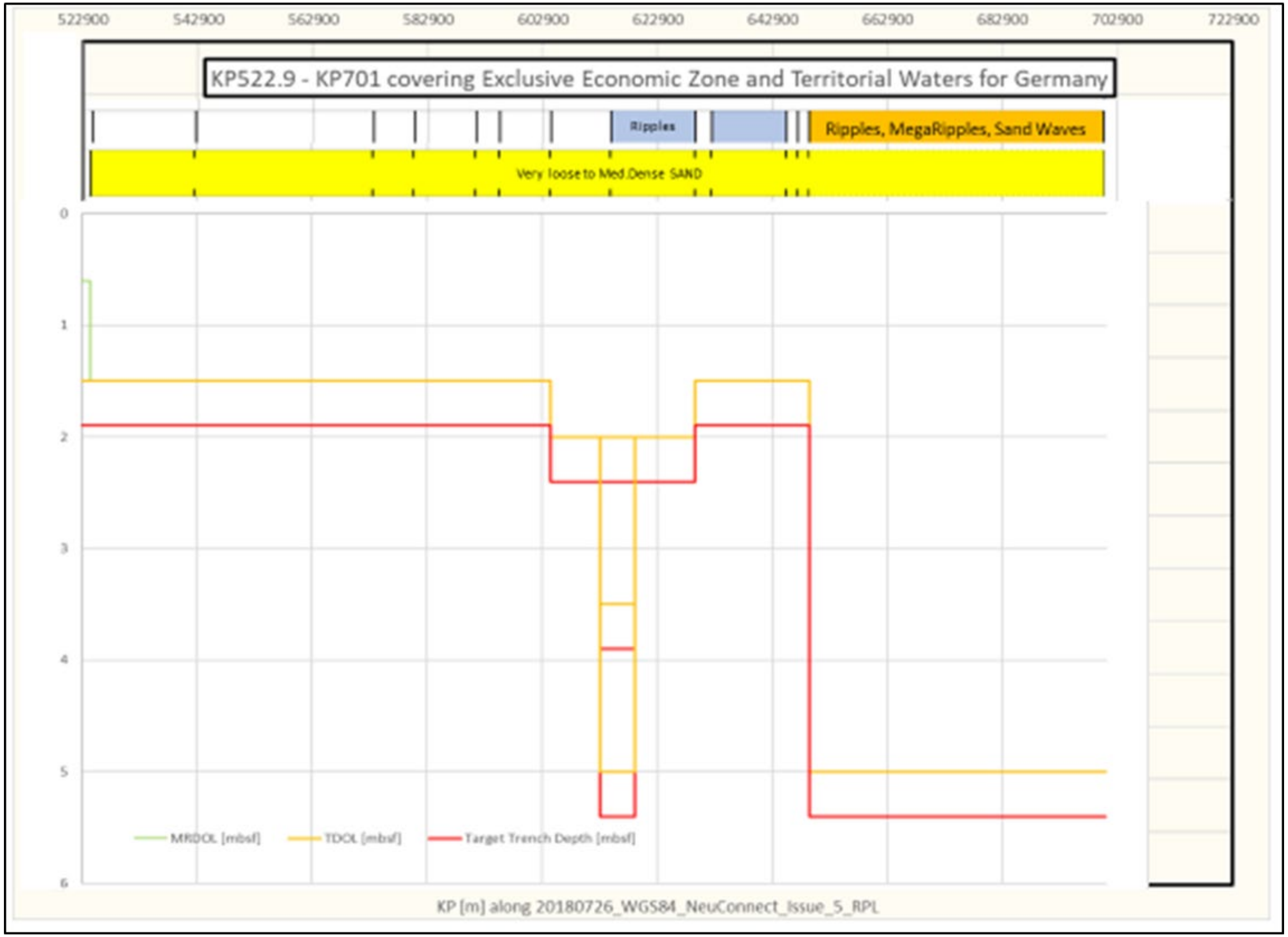


APPENDIX B3 – CBRA Summary (Sector: Germany)

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)

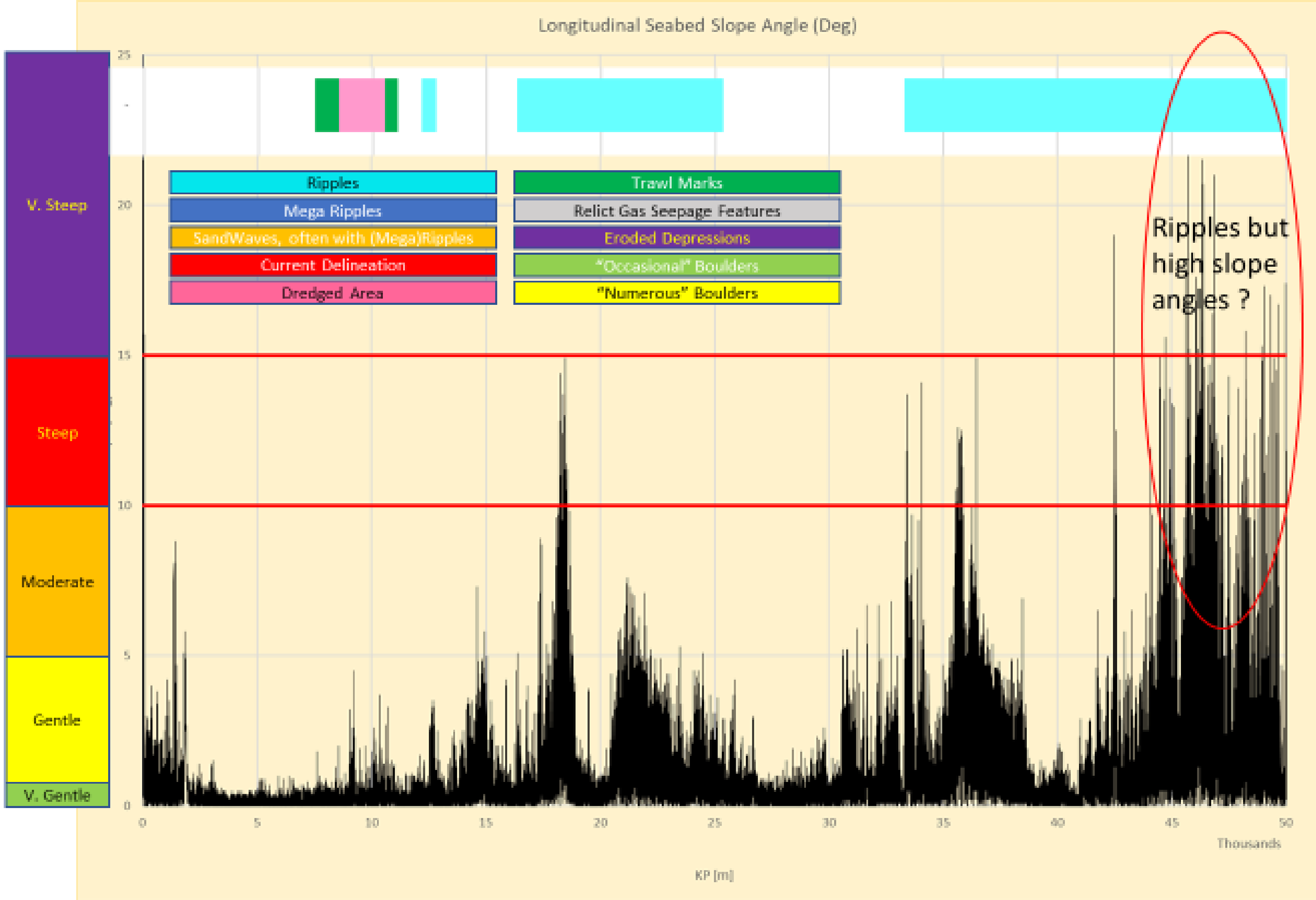


Figure C1- 2: UK SECTOR SUMMARY - Seabed Slope Profile and Bedforms (KP50 - KP100)

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

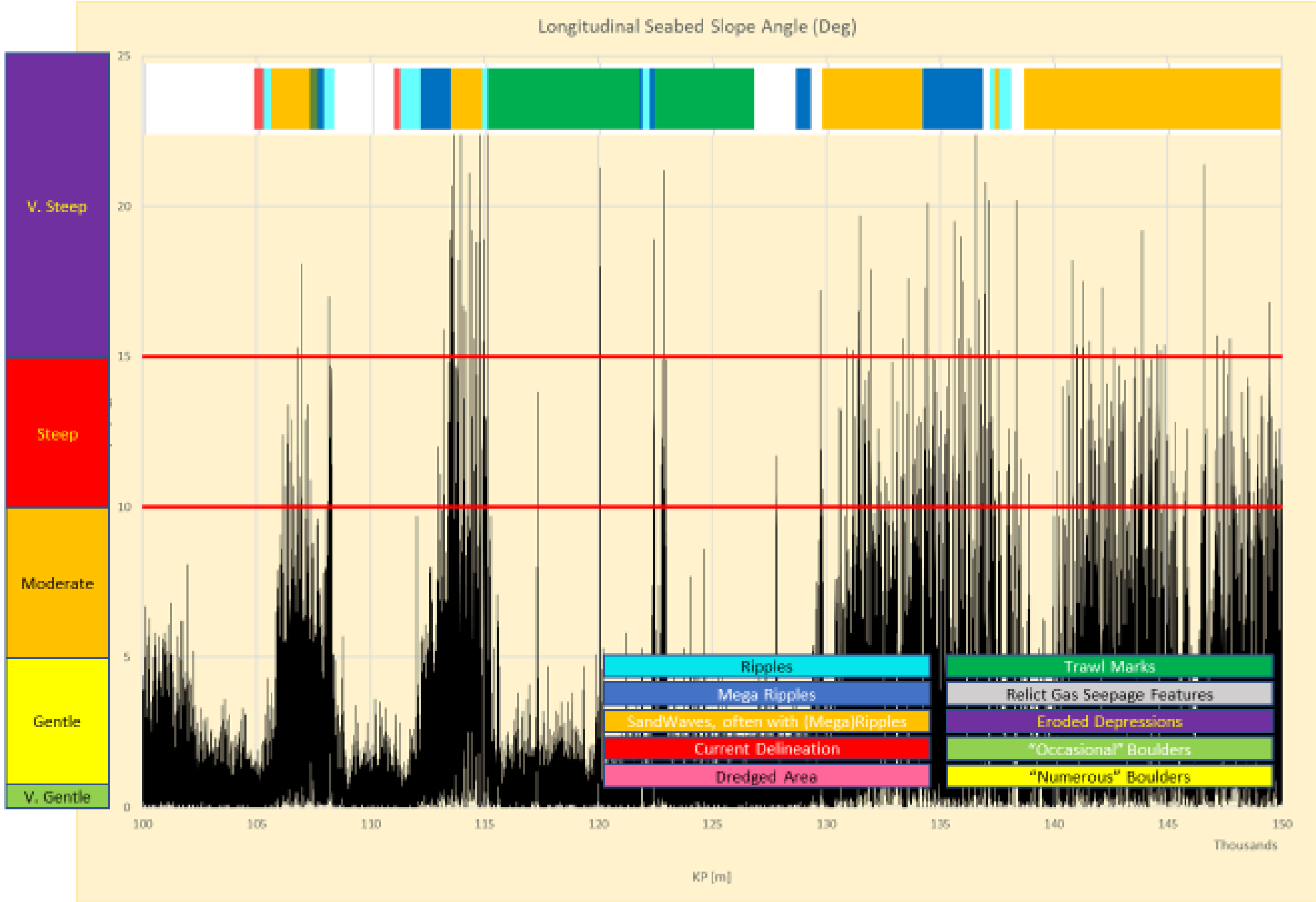


Figure C1- 4: UK SECTOR SUMMARY - Seabed Slope Profile and Bedforms (KP150 - KP200)

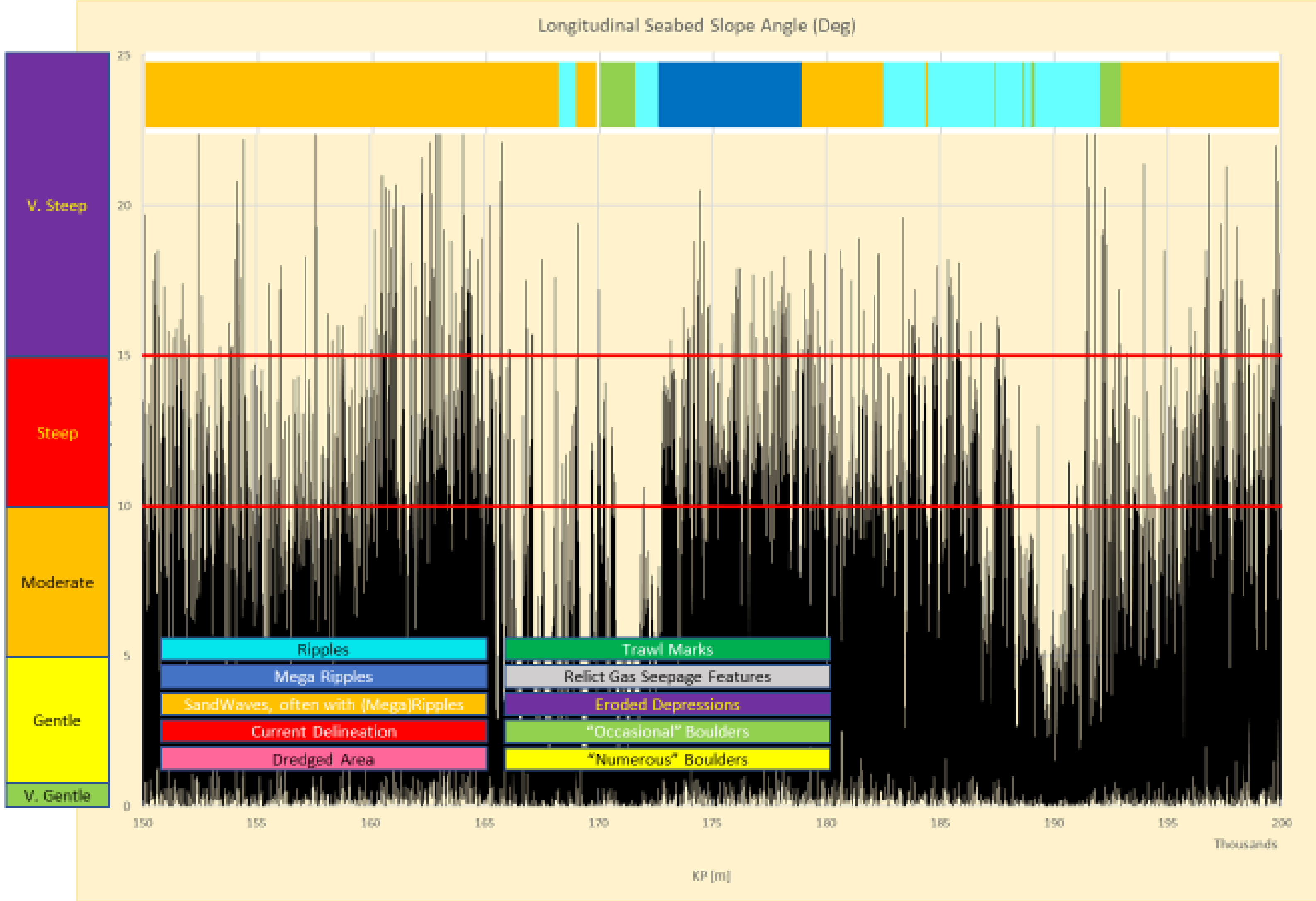


Figure C1- 5: UK SECTOR SUMMARY - Seabed Slope Profile and Bedforms (KP200 - KP250)

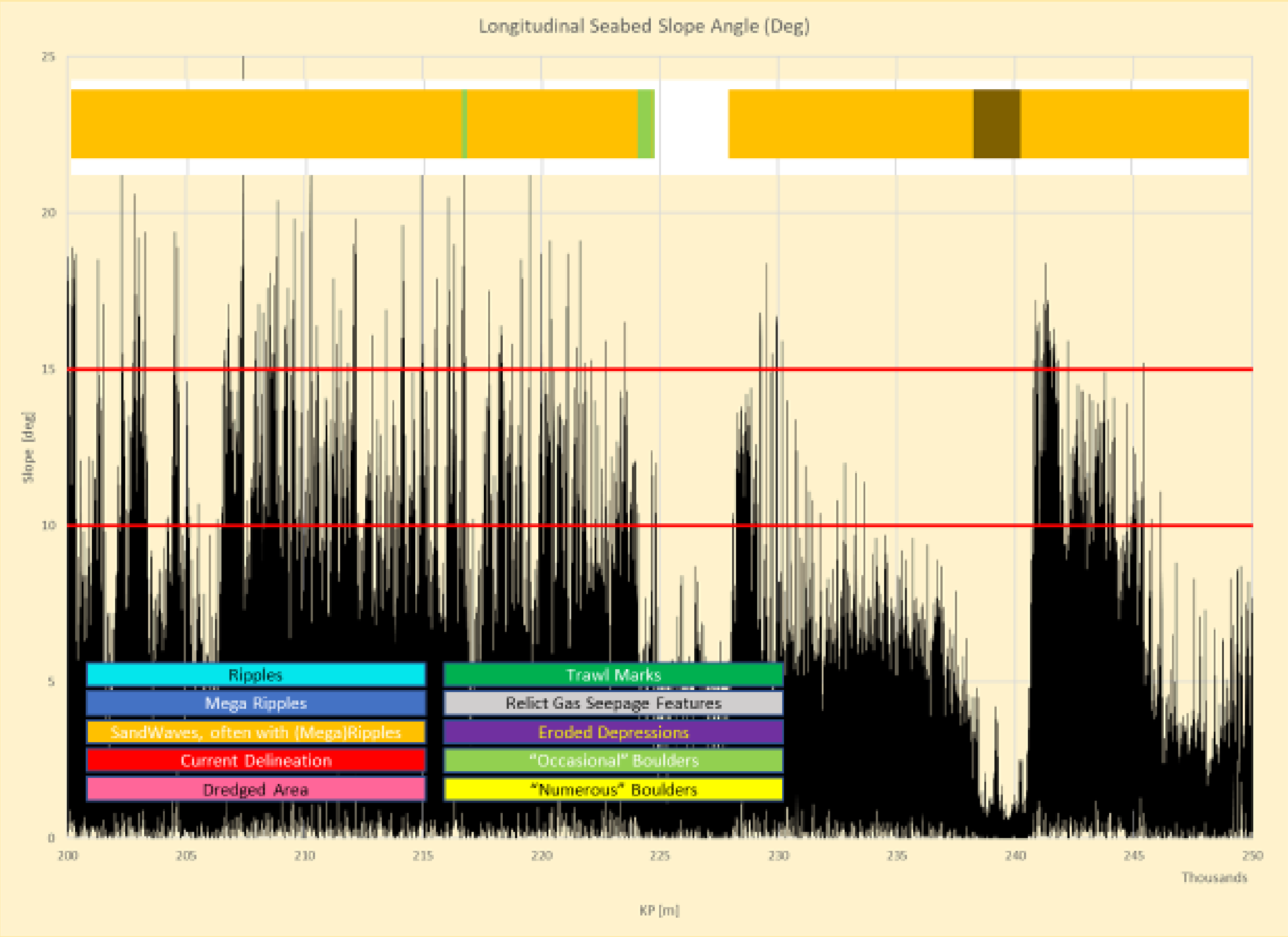


Figure C1- 6: UK SECTOR SUMMARY - Seabed Slope Profile and Bedforms (KP250 - KP262.850)

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

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

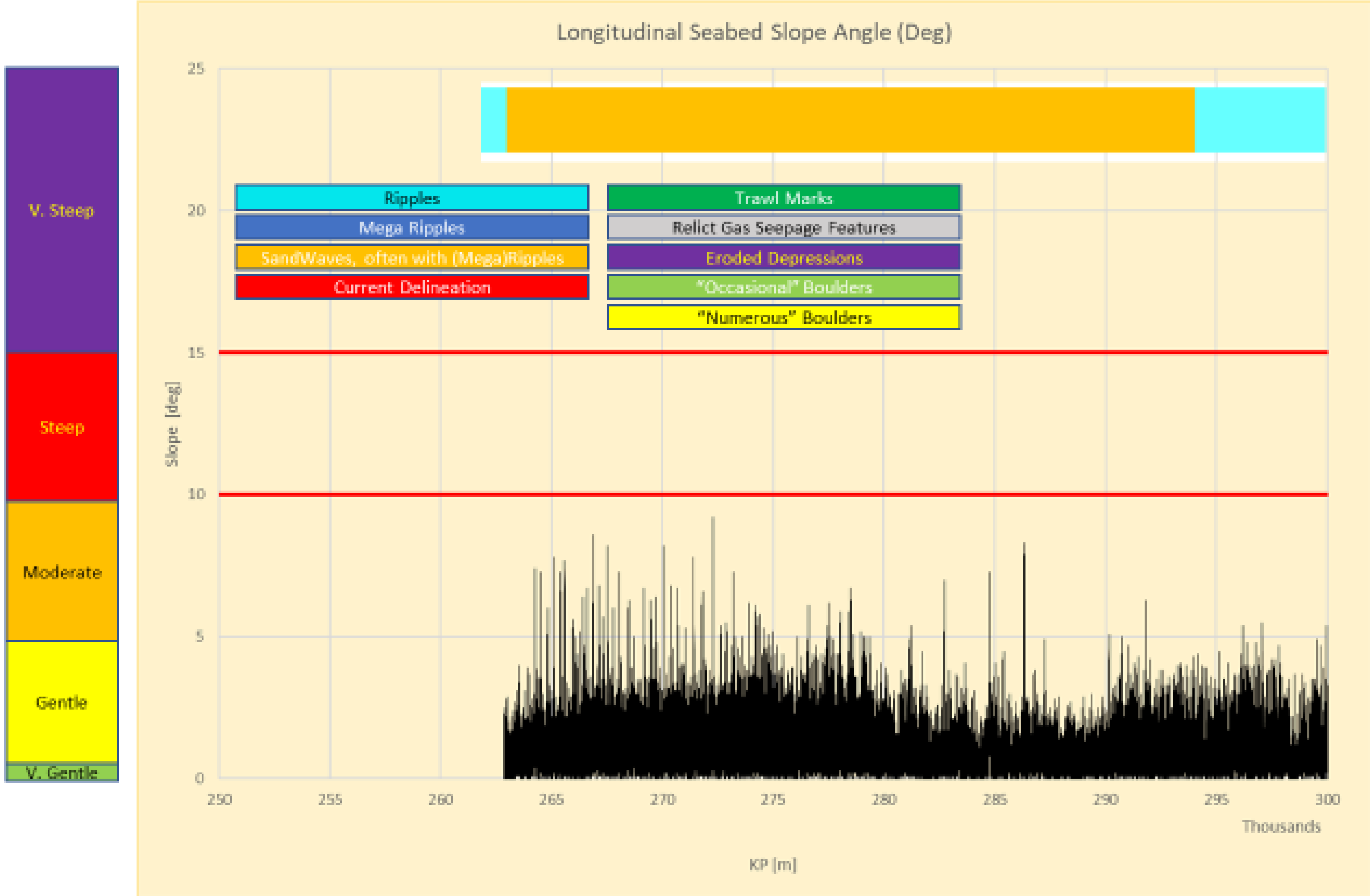


Figure C2- 2: NETHERLANDS SECTOR SUMMARY - Seabed Slope Profile and Bedforms (KP300 – KP350)

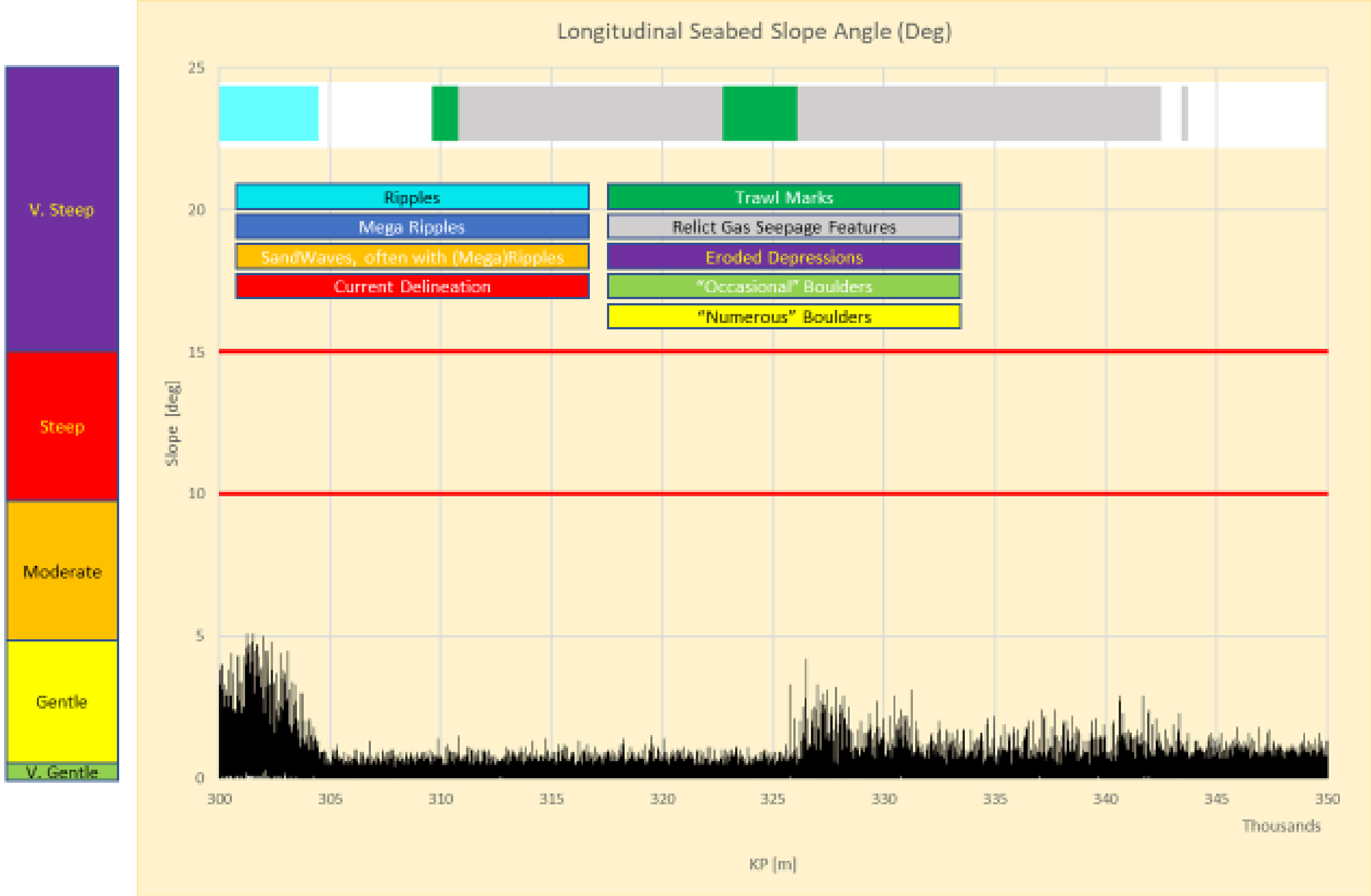


Figure C2- 3: NETHERLANDS SECTOR SUMMARY - Seabed Slope Profile and Bedforms (KP350 – KP400)

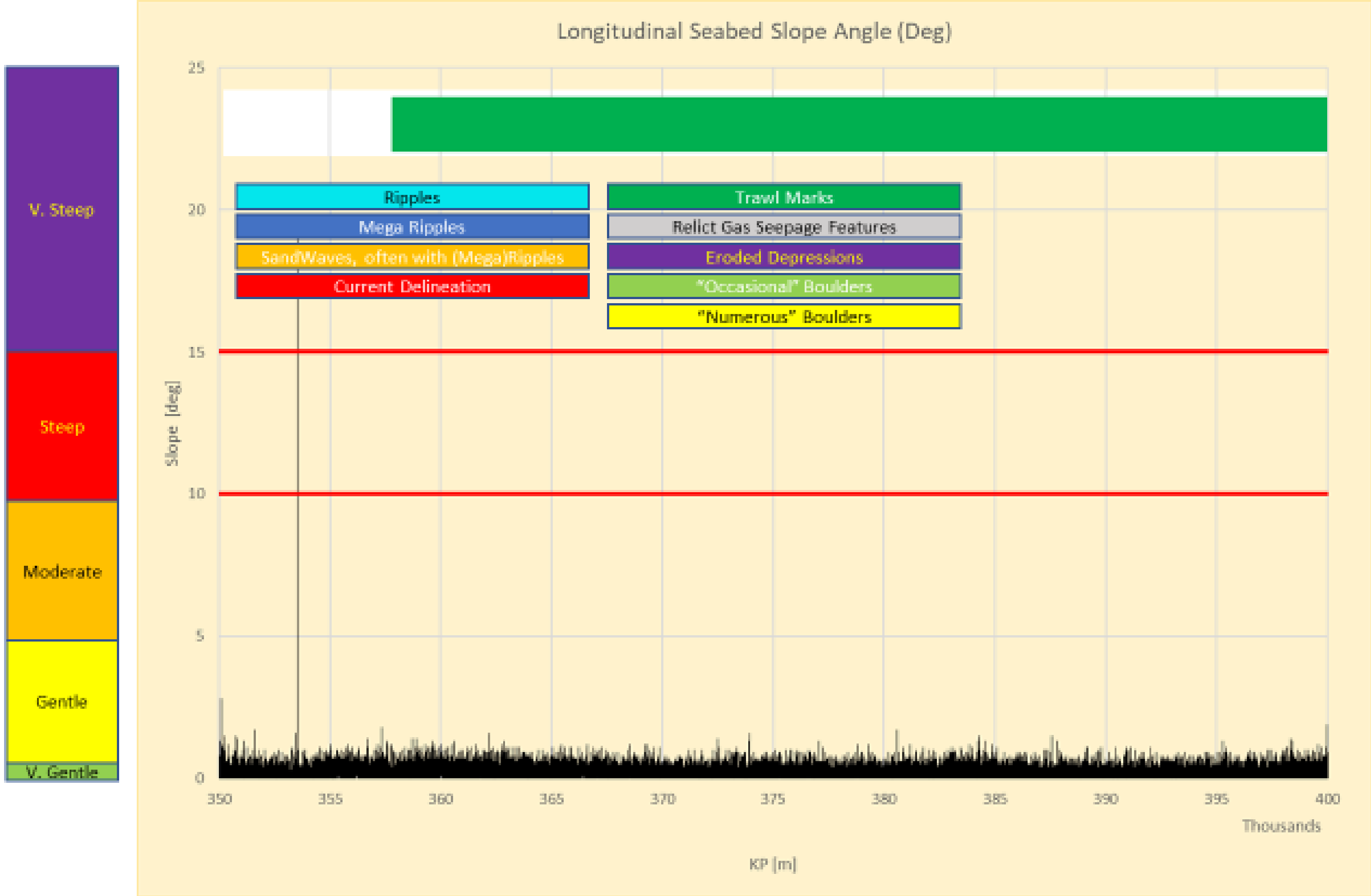


Figure C2- 4: NETHERLANDS SECTOR SUMMARY - Seabed Slope Profile and Bedforms (KP400 – KP450)

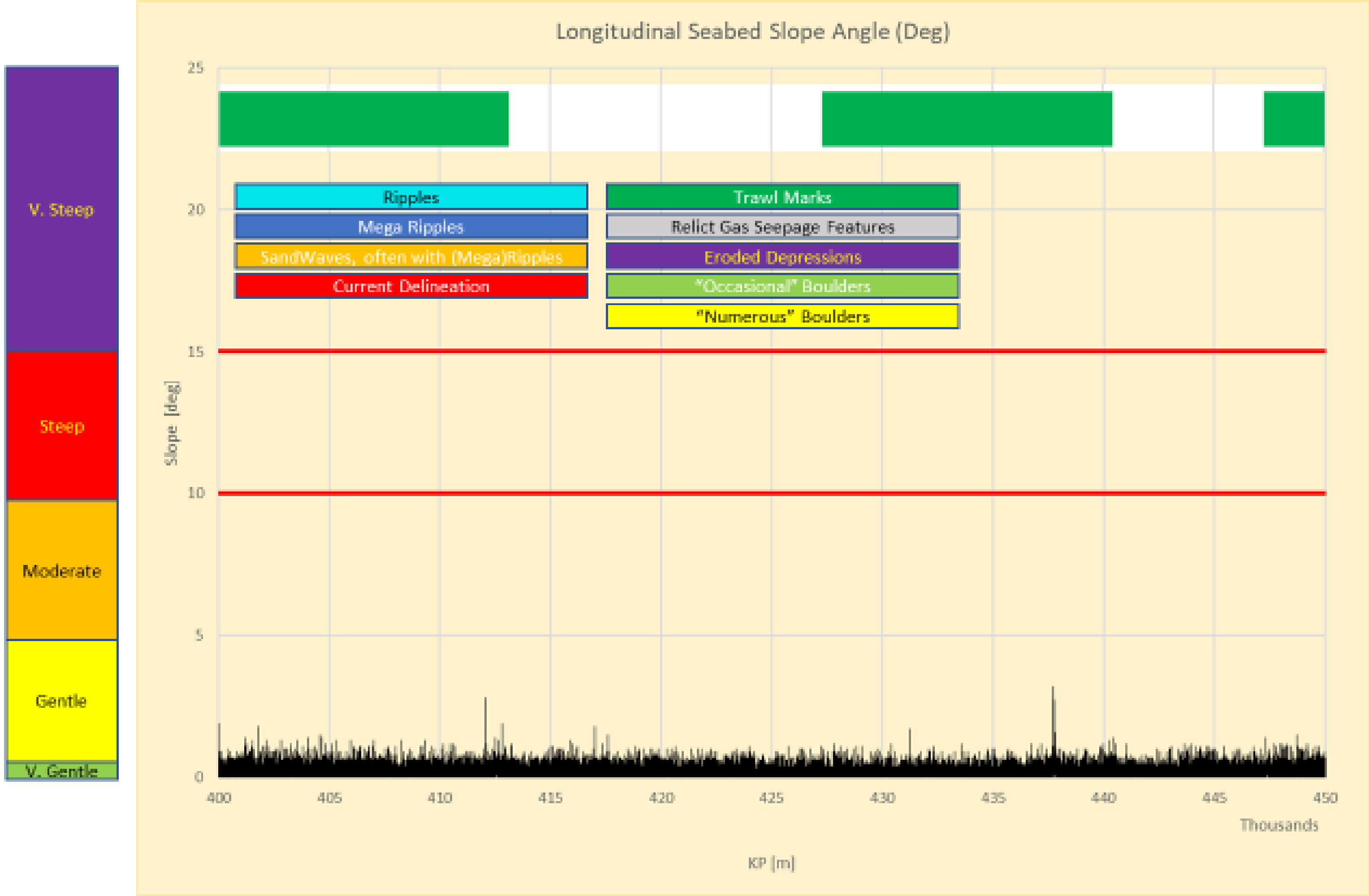


Figure C2- 5: NETHERLANDS SECTOR SUMMARY - Seabed Slope Profile and Bedforms (KP450 – KP500)

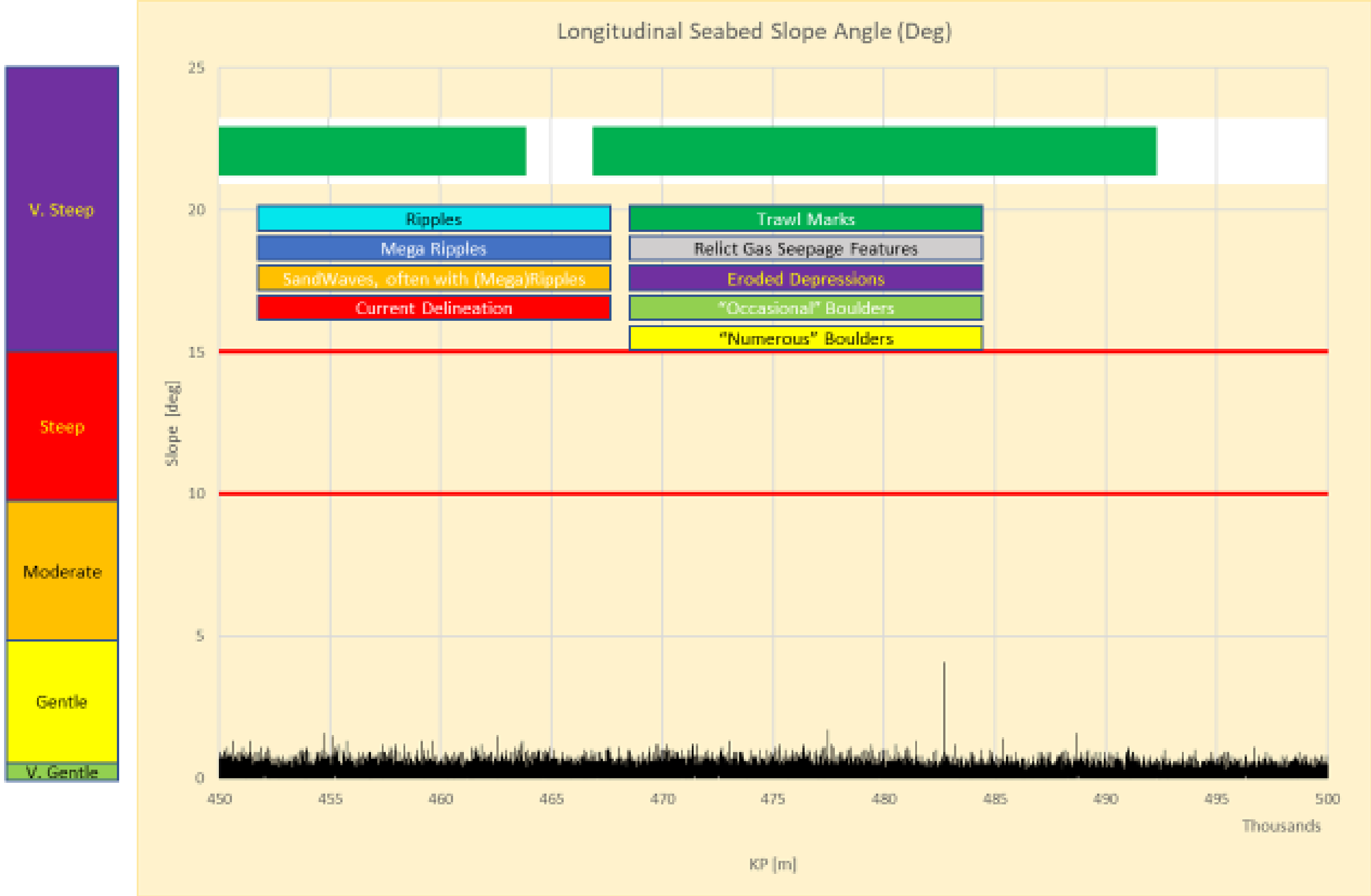
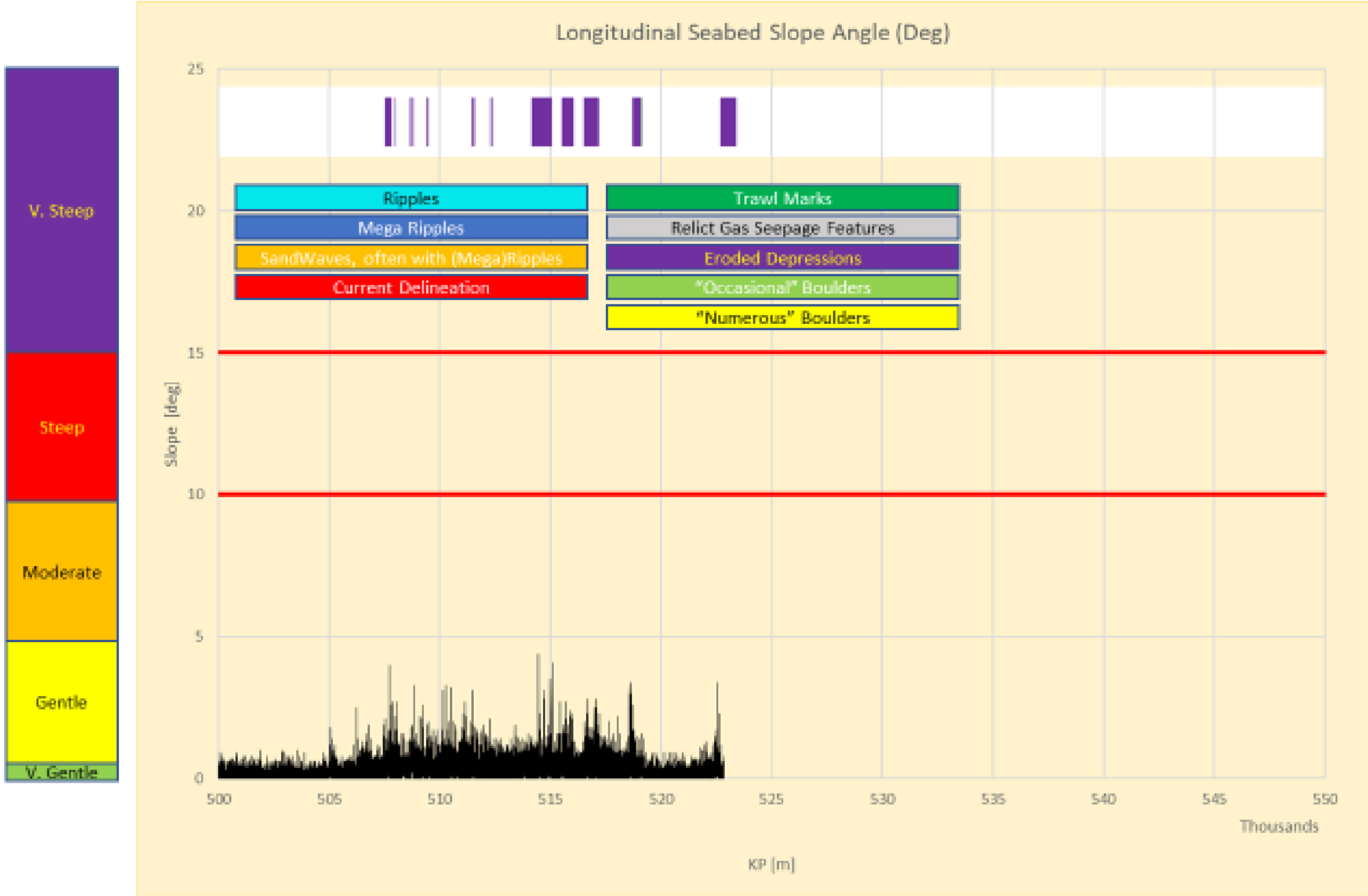


Figure C2- 6: NETHERLANDS SECTOR SUMMARY - Seabed Slope Profile and Bedforms (KP500 – KP522.9)



APPENDIX C3 – BAS Lite Results (Sector: Germany)

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

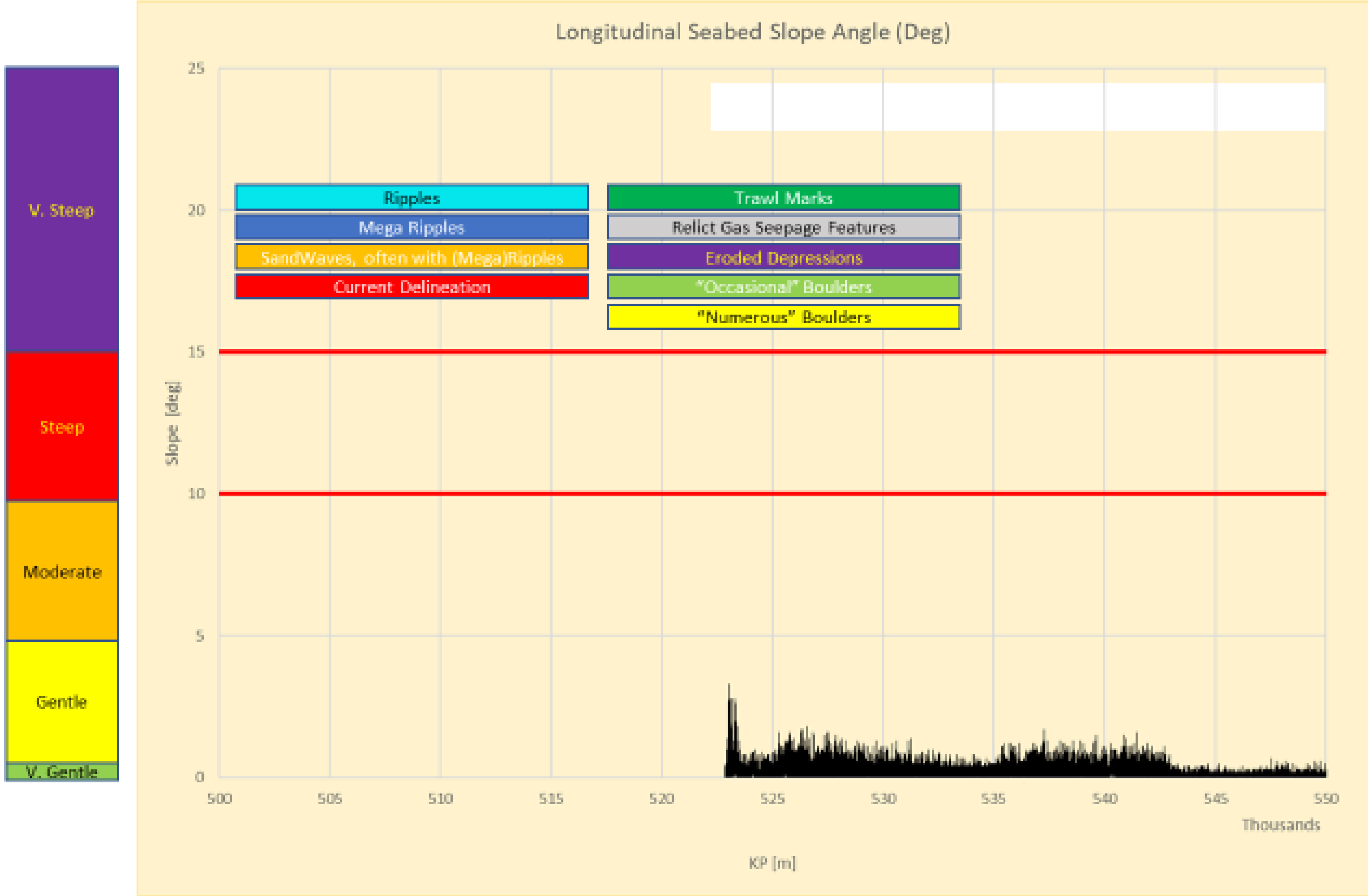


Figure C3- 2 GERMANY SECTOR SUMMARY - Seabed Slope Profile and Bedforms (KP550 – KP600)

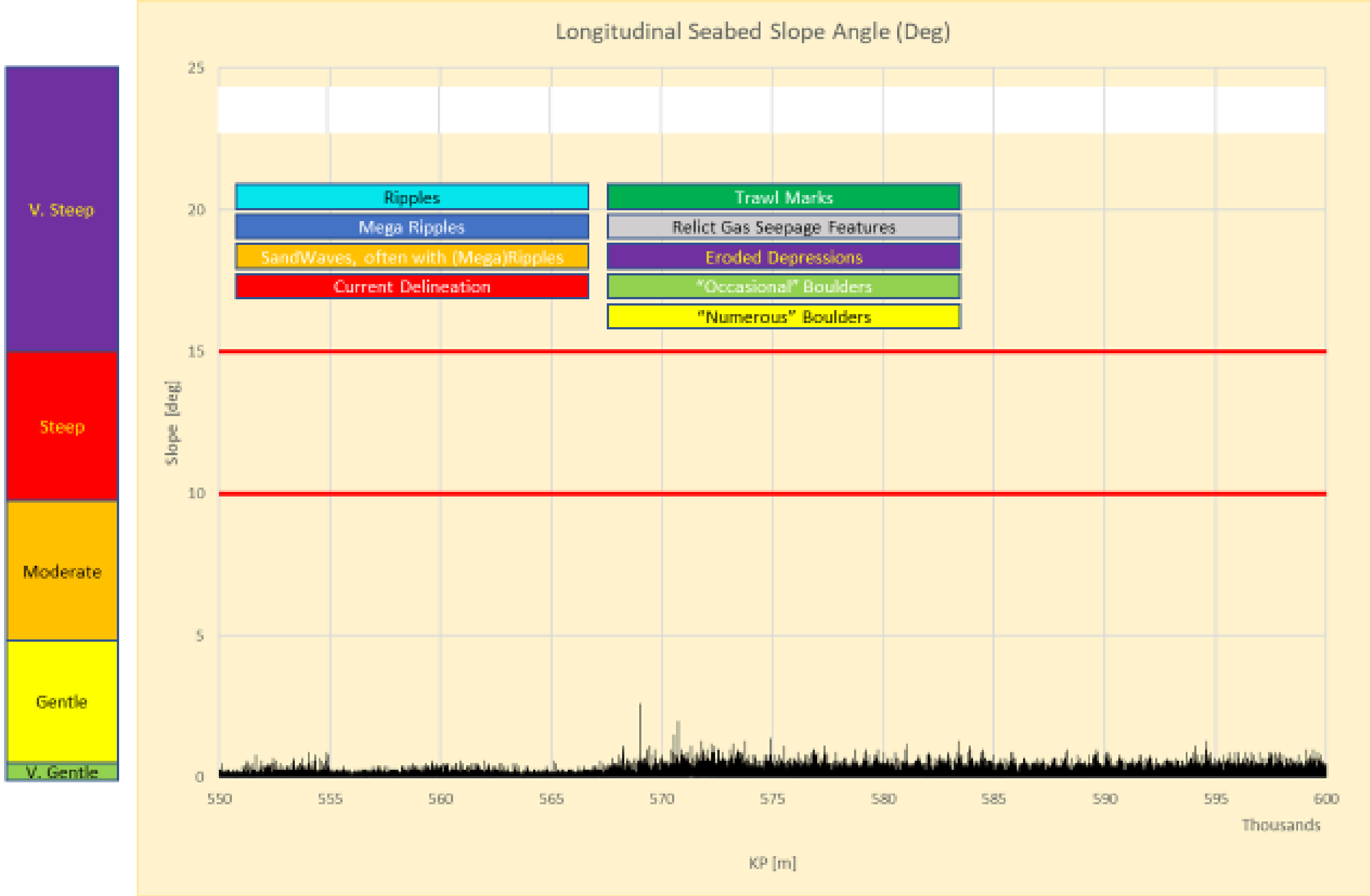


Figure C3- 3 GERMANY SECTOR SUMMARY - Seabed Slope Profile and Bedforms (KP600 – KP650)

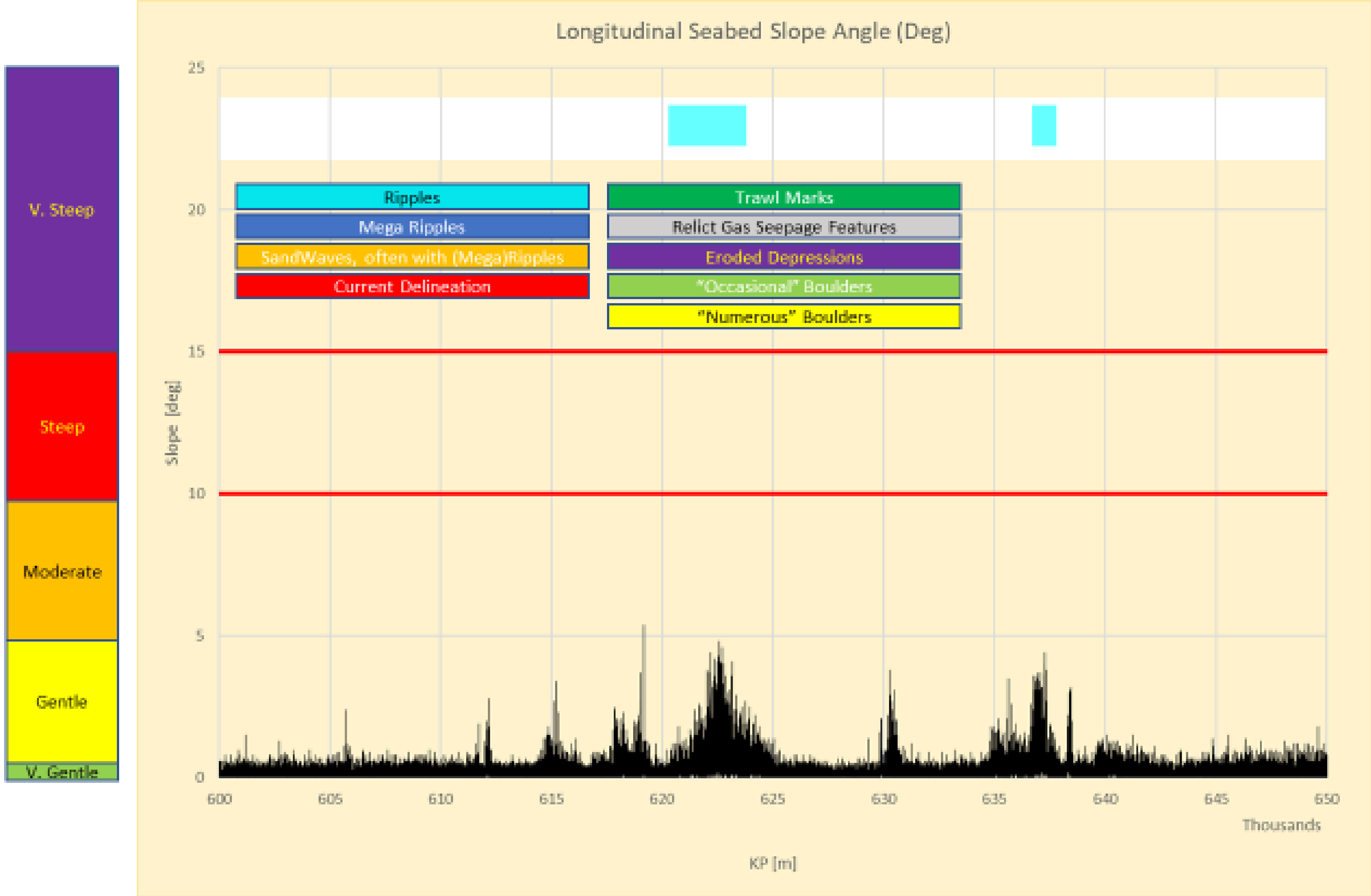


Figure C3- 4 GERMANY SECTOR SUMMARY - Seabed Slope Profile and Bedforms (KP650 – KP700)