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1 GENERAL PROJECT INFORMATION

C-Power's wind farm is located on the Thornton Bank, approximately 30 km off the coast of Zeebrugge. The construction of the project was developed in three phases.

Phase 1 (2007-2009), the pilot phase, consisted of six 5M (5 MW) wind turbine generators (WTG) on gravity base foundations (GBF).
The 30 MW installed capacity has been fully operational since end of June 2009.

Phase 2 (2011-2012) consisted of:

- the construction of 49 jacket foundations (JF);
- the installation of 30 WTGs of 6,15MW: 24 WTGs in sub area B and 6 WTGs in sub area A, mutually connected with 33/36 kV infield cables;
- the laying and connection of infield cables;
- the crossing of the 33/36kV infield cables with the Interconnector gas pipeline and the Concerto South telecom cable;
- the construction and installation of the offshore transformer station (OTS);
- disconnection works of 150/170kV cable A from D1 and connection to transformer station and the connection of a 33kV infield cable between OTS and D1;
- the installation of 2 subsoil 150kV onshore connections between the 150 kV offshore cables and the high voltage station "Sas Slijkens";
- the laying of the second 150kV offshore export cable B.

Phase 3 (2012-2013) consisted of:

- the installation of 18 WTGs (6,15MW) and the necessary connections with the offshore transformer station

The complete project comprises 54 WTGs with a total rated power of 325 MW plus the supporting infrastructure. Full operation was accomplished by end of September 2013.

The figure below shows the lay-out of the C-Power wind farm.

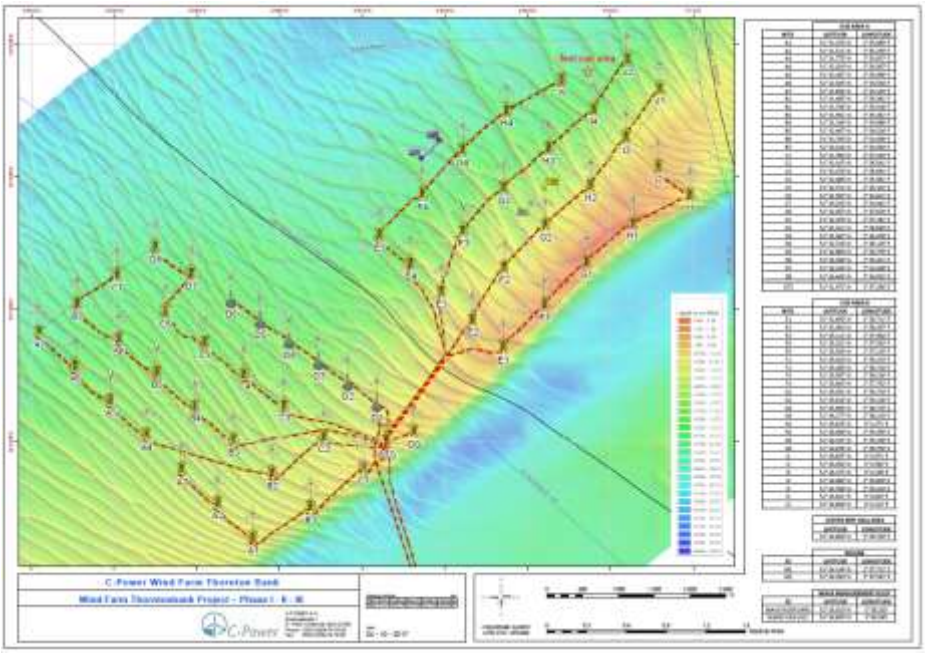

Figure 1: Lay-out of C-Power's wind farm

2 MAIN ACTIVITIES DURING 2020

In the course of 2020, C-Power decided to continue the "in house" organization of its turbine maintenance activities, meaning without reliance on a full scope maintenance contract, as was the case in the past with the Senvion agreement. The C-Power daughter company Thornton Bank Maintenance Services and the Belgian maintenance company John Cockerill (or CMI) continued to perform the main maintenance works on the wind farm (refer to the Annual report of 2019). For specific maintenance activities, requiring specialized knowledge, long-term agreements were concluded with a range of contractors, both from Belgium and abroad. C-Power took over the full responsibility for logistics, warehousing and sourcing of spare parts.

These changes had no big impact on the safety and environmental policy and management of C-Power.

2.1 MAJOR COMPONENT REPLACEMENTS

During 2020 a whole range of major component exchanges were performed on the wind farm:

- Gearbox exchanges on 9 turbines (A1, A5, D2, E1, F1, F2, E4, F4, I2)
- Generator exchange on turbine G4.

The exchanges were carried out in 3 campaigns: between 22 July and 3 August, between 1 and 12 September and between 9 and 12 December, with the Jack-Up Vessels Thor (1st and 2nd campaign) and Apollo (3rd).

2.2 GEARBOX OIL EXCHANGE

In 2020, C-Power exchanged the oil on 3 main gearboxes. In the 3 cases, we made use of containers placed on the platform or on the helideck. Nothing particular is to be reported on this activity.

3 CONSTRUCTION & OPERATION PERMIT CONDITIONS

All permit obligations are integrated and implemented in the daily management of the activities offshore by C-Power and its contractors.

The annual institutionalized Follow-up Committees ("Begeleidingscomité") took place on 21/01/2020. During this Follow-up Committee, the progress of the project is discussed as well as the compliance of the operation and maintenance activities with the permit conditions. C-Power also provides this Committee with 3-monthly reports.

Next to this regular and official reporting to the authorities, C-Power informs the federal and nautical authorities on a frequent, voluntary and transparent basis, including a regular dialogue with the relevant authorities via e-mail, ad hoc meetings, telephone exchanges etc.

An overview of the main permit conditions is given below.

Drifting or sunken objects

A detailed track record of the drifted and sunken objects is kept by C-Power. 4 incidents with objects lost at sea were reported:

- 8/09/2020: lost tool bag at sea
- 20/10/2020: Test unit fallen from nacelle in water
- 5/11/2020: Box fallen from nacelle in water
- 6/12/2020: UHF radio fallen in water

Actions have been taken after every incident such as additional tools to avoid loss of objects, dedicated workgroup and a workshop. Next to that, the next safety theme in the SCHIC safety campaign will be 'fallen objects' to raise awareness concerning this matter.

Cables

Infield and export cable surveys were performed in September 2020; the reports were made available begin 2021 and are added in annex to this Annual report. Main findings are summarized in paragraph 4 below.

Monitoring

Monitoring activities BMM
Fishing, monitoring of sea mammals with C-pods, hard substrate sampling, sampling of fauna on turbine foundations and water sampling were performed by BMM in the course of the year 2020. Next to that, there were various interventions on measurement equipment in or nearby the domain concession.

Meteorological parameters
Meteorological data (wind speed, wind direction, wave height, wave period, tide, pressure, temperature, visibility) measured in real time on C-Power's offshore transformer platform are available on "http://meteo.c-power.be".
The measurement buoy in Area B of the C-Power wind farm (see also Figure 1) installed by Vlaamse Hydrografie in August 2017 is still in operation; data of this wave buoy are visible in "Meetnet Vlaamse Banken".

Risks & Safety

Internal emergency plan
Was initially released May 2014. Updates of the ERP are updated on the C-Power management platform. Only minor organizational items were updated in 2020.

Emergency exercises:
10/09/2020: ERP on a WTG; with involvement MRCC
11/09/2020: ERP on a WTG; with involvement MRCC
16/10/2020: ERP on a WTG; with involvement MRCC
27/11/2020: ERP on OTS; with involvement MRCC

There was no involvement of the 40th squadron, due to Covid-19 regulations.
Next to the overall ERP exercises, 18 smaller drills were performed, such as Man Overboard trainings, First Aid training, evacuation exercises using the Sked and Milan. The objective of these smaller drills is to train as many technicians as possible in rescue techniques.

For 2021, 4 ERP drills are planned together with MRCC. Similar to 2020; we plan 20 smaller ERP exercises in 2021.

No Polex exercises were performed in 2020, because the relevant authorities canceled these.

Medevac
No medevac in 2020.

Spills

In 2020, we had a number of small environmental incidents:

- SF6 gas leak due to a failed infield cable connector on the GIS (Gas Insulated Switchgear) of turbine F1: on 18 March and 11 September. The cable connector and the bushing were exchanged, the GIS compartment was filled up with new SF6 gas. +-200g of SF6 leaked to the environment at each incident. Since this was not the first time this kind of incident occurred on turbine F1, the remaining original cable connectors were exchanged too.
- Dropped objects in the sea: see 'drifting or sunken objects'.

Harmful substances

Register updated when new substances present or existing substances are replaced by other.

Permit compliance procedures

An overview of permit conditions and a full copy of all permits have been integrated in all contracts with third parties operating offshore. All contractors are consequently fully informed on the mandatory permit conditions.
C-Power coordinates and supervises the permit conditions' compliance of the respective contractors.

During major component replacements, the planning of all construction related activities offshore has been communicated via a daily report sent to all relevant authorities by the Vessel Marine Coordinator. This included the contact details of C-Power's point of contact for the authorities, daily updates about offshore operations and changes in the planning.

All incident reports from contractors as well as from C-Power's staff are registered and kept on C-Power's internal server and C-Power management platform.

Wind Turbine data; Energy Production; Wind Turbine Availability: Confidential information

Data regarding energy production, availability and number of stop and maintenance hours can be found in Attachments 6.1 to 6.5. **These data are to be treated as confidential**.

4 ENVIRONMENTAL MONITORING ACTIVITIES

Bathymetric surveys

Bathymetric surveys of the all foundations, infield cables and export cables were executed in September 2020 in order to monitor the burial depth of the cables, and the evolution of the morphology of the seabed around the foundations.

Main conclusions from the Surveys are:

- Scour around the Jacket Foundations is stable. In Area A, the last MBEs shows a more or less stable scour depth; the scour seems to be fluctuating around an equilibrium depth with minor increases or decreases. For Area B there is for most jackets a more or less stable condition. For some shallower locations there is an increase of scour depth; for one turbine (F2) the scour has reached the alarm line.
- Export Cables: the MBE surveys confirm the known issues on both export cables. Both for cable A as for cable B, parts of the trajectories are covered less than 1m (over 1.4% of the trajectory for cable A and over 0.5% for cable B) however, for most of the locations there is still at least 80cm cover. The cover for cable B is at least 40cm along the trajectory. For cable B, we observe 2 locations (over 3m in total) where the cable is exposed around KP17.1, in the vicinity of a dune top and in a zone with mobile sand dunes. Due to the highly dynamic character of this zone, this critical zone should be considered very moveable, which makes it very likely that no remedial action at this spot will prevent that the same will occur in the near vicinity.

Specific reports concerning the evolution of the scouring around the foundations and the export cable burial depths have been issued. These reports can be found in Attachments 6.6 and 6.7.

A specific meeting with the Begeleidingscomité took place on 23 February to discuss the findings of the surveys.

5 HEALTH, SAFETY AND ENVIRONMENT (HSE)

2020 was still a hectic year for C-Power after the Senvion insolvency and with the set-up of a long-term "in house" solution for turbine operations and maintenance. However, health, safety and environment remained high on the agenda and everybody continued to contribute to a safer work environment.

Due to the Covid-19 regulations, offshore maintenance activities could not start on 1/4/20 as scheduled and were postponed to mid-May; for some specific works even to mid-June. From mid-March to mid-May, only urgent repairs or troubleshooting with limited teams were performed. Crew vessel occupation had to be limited to avoid spreading of potential contaminations. This has led to additional costs for crew vessels (additional charter of 1 to 2 CTVs) and to a reduction in overall work-days spent.
Over the year, we had +- 230 offshore workdays; people from 40 companies performed +- 6400 man-days on offshore work (without the MCR campaigns). This is less than in previous years, due to lower CTV occupation and later start-up of the scheduled maintenance campaigns.

C-Power's SCHIC program (Safety Culture and Health Improvement Campaign) continued in 2020. We cancelled the first of the planned safety days in March due to Covid regulations, and organised a web-based safety day in October.

C-Power, THBMS and John Cockerill will also in 2021 continue with their common SCHIC program to further stimulate the safety behaviour of all personnel and all (sub)contractors active in the windfarm. This will take the form of common toolboxes, newsletters, 2 safety days (real life or virtual) and a number of workgroups with service technicians to develop specific topics. New HSE topic will be "environment".

In 2020 there were no LTIs on the wind farm.

Remote Monitoring system

C-Power has a 24-hour SCADA (Supervisory Control and Data Acquisition) surveillance system in operation. The SCADA system enables the operational management of C-Power to have a complete overview of all turbines. The Scada data are sent to an external control room, staffed on a 24/7 basis, replacing the former Senvion monitoring centre.
On each wind turbine, 2 cameras are installed at the height of the boat landings. The camera images are sent through in real time to the operational center in Ostend and are stored for 24 hours. Also the Offshore transformer Station is equipped with 4 HD camera's covering the whole wind farm.

6 ANNEXES

6.1 AVAILABILITY PER PHASE ON MONTHLY BASE

6.2 PRODUCTION – LOW WIND – STOPS – MAINTENANCE HOURS

6.3 PRODUCTION PER MONTH PER PHASE

6.4 PRODUCTION PER YEAR PER TURBINE

6.5 WIND ROSE

6.6 ANALYSIS MULTIBEAM MEASUREMENTS

MEMO

Date	10/12/2020
To	C-Power
Author	Niels Smit
Checked	Leen Baelus
Document ref	I/NO/11609/20.265/NSM

Approved by the project manager	
Massimo Caporaso	

Subject: C-Power: Analysis multibeam measurements 2020

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3	**Analysis**	4
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1 Introduction

The concession zone of C-Power's offshore wind farm at the Thornton Bank is located in the North Sea at a distance of approximately 27km from the Belgian coast. The wind farm (Phases I, II and III) contains 54 WTGs with a combined capacity of *ca.* 325MW, and with an individual WTG capacity of 5MW (Phase I) and 6MW (Phases II & III). The wind farm is also equipped with one offshore transformer station (OTS). Two 150kV export cables bring the wind-generated electricity on land. The last turbine of the offshore wind farm was installed early July 2013.

Figure 1-1 shows the different phases for the construction of the offshore wind farm. Six gravity based foundations were erected in the pilot phase of the Thornton Bank project between 2007 and 2009. These turbines have rock dump scour protection and are not further discussed in this memo.

In the period 2011 – 2013, the offshore transformer station and 48 additional turbines were installed on jacket foundations. These quatropods are designed to allow scour to a certain level. In this memo, the evolution of the scour depth around these jacket foundations is discussed based on the available multibeam data.

This memo provides an update of the analysis of 2017 (IMDC, 2017) with the latest survey of 2020.

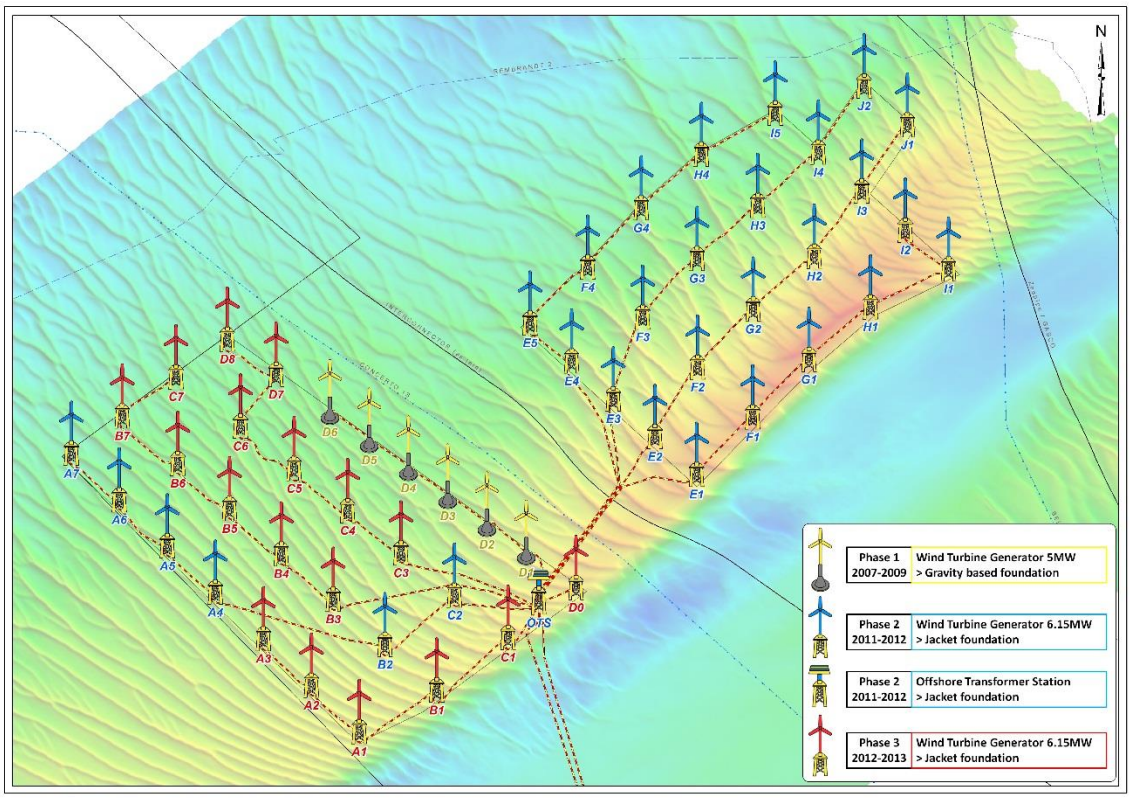


Figure 1-1: Overview of Construction Phase I – III

2 Available data

Table 2-1 lists the surveys which fully cover the area around the jacket foundations. Other surveys envisaged the infield cable trajectories and thus only cover the seabed around the jacket foundation partially.

The latest multibeam survey is carried out between June and September 2020 and covers the WTG foundations in area A and area B.

Table 2-1: List of available multibeam surveys around the jacket foundations in Area A and B

SURVEY	AREA A		AREA B	
	First measurement	Last measurement	First measurement	Last measurement
Insurvey dredging works	07/03/2011	15/04/2011	05/02/2011	20/03/2011
Outsurvey dredging works	21/03/2011	04/06/2011	22/03/2011	20/04/2011
Construction monitoring survey	14/08/2011	10/09/2011	11/06/2011	09/09/2011
Construction monitoring survey	08/11/2011	02/12/2011	28/10/2011	28/11/2011
Construction monitoring survey	25/01/2012	25/01/2012	25/01/2012	25/01/2012
Construction monitoring survey	09/03/2012	09/03/2012	09/03/2012	09/03/2012
Construction monitoring survey	27/05/2012	27/05/2012	27/05/2012	27/05/2012
Construction monitoring survey	17/07/2012	28/07/2012	15/07/2012	28/07/2012
Construction monitoring survey	01/09/2012	01/09/2012	11/09/2013	11/09/2013
As-built survey	30/09/2012	30/09/2012	02/10/2012	06/10/2012
Yearly monitoring survey	09/07/2013	17/07/2013	12/07/2013	15/07/2013
Yearly monitoring survey	11/10/2014	11/10/2014	11/10/2014	11/10/2014
Yearly monitoring survey	29/06/2015	29/06/2015	-	-
Yearly monitoring survey	28/03/2017	30/03/2017	28/03/2017	30/03/2017
Monitoring survey	05/06/2020	21/09/2020	05/06/2020	21/09/2020

In Table 2-2 an overview of the different jackets in area A and B is given. The locations of these different jackets are shown in Figure 1-1.

Table 2-2: Overview of jackets in Area A and B

Jackets Area A	Jackets Area B
A1, A2, A3, A4, A5, A6, A7 B1, B2, B3, B4, B5, B6, B7 C1, C2, C3, C4, C5, C6, C7 D0, D7, D8 OTS	E1, E2, E3, E4, E5 F1, F2, F3, F4 G1, G2, G3, G4 H1, H2, H3, H4 I1, I2, I3, I4, I5 J1, J2

3 Analysis

Per jacket, a plot of the evolution of the scour depth in time is made. All plots can be found in Annex A. As an example, the plot for jacket A1 is discussed here (see Figure 3-1).

The newest measurements date from the period of June until September 2020. As no specific metadata is available on which area was measured when, the measurements are plotted in this memo on the 1st of September 2020.

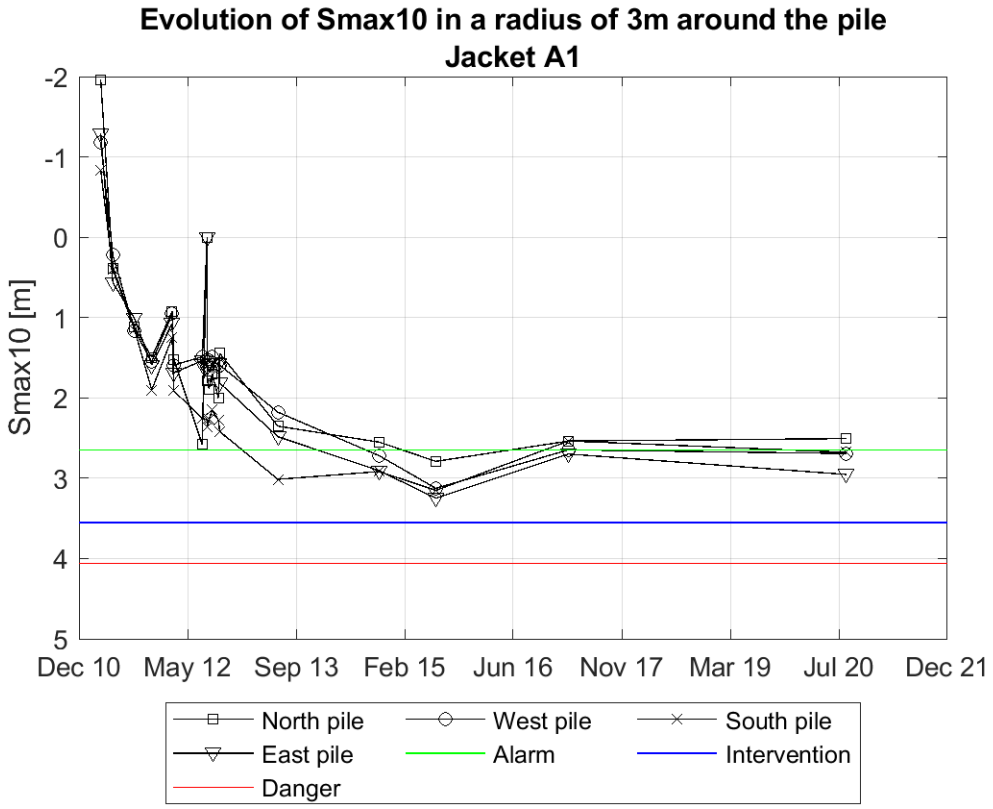


Figure 3-1: Evolution of the scour depth (S_{max10}) around the piles of Jacket foundation A1

Figure 3-1 is based on all the available multibeam surveys (listed in Table 2-1), performed before, during and after installation as well as during monitoring of the operational phase, and illustrates the scour development S_{max10} around the 4 piles of jacket foundation A1 in function of time. The parameter S_{max10} represents the average of the 10 deepest points measured in an area with a radius of 3 m around the centre of a pile and is relative to PDTDL_ab. Positive values of S_{max10} indicate levels that are lower than PDTDL_ab, negative values of S_{max10} indicate levels higher than PDTDL_ab.

Furthermore, the level of the alarm, intervention and danger line next to the piles is indicated on the figure by the green, blue and red line respectively.

As shown in Figure 3-1, scour occurred around the 4 piles of the jacket foundation. In the previous analysis with surveys up to 2017 (IMDC, 2017), it was reported that for jacket foundation A1 the situation was not yet stable up to 2015 but seemed to have stabilised by 2017. Some scour had taken place during 2014 and 2015, and some accretion occurred in 2017, reaching again the seabed level of 2014. After 2017 the scour depth stayed stable. Only a minor increase of the scour occurred again around two of the legs. The scour seems to be fluctuating around an equilibrium depth for this jacket.

4 Results

In area A the multibeam data of 2015 indicated an ongoing scour depth evolution, meaning that the equilibrium scour depth had not yet been reached for the jacket foundations. The scour depth near jackets A1, A2, A3, B1, B2, B3, C1, C2 and D0 had reached or was close to the intervention line. Moreover, the scour depth near jackets A4, A5, A6, B4 and B5 had reached or was close to the alarm line. However, the survey data from 2017 showed stabilization or even some accretion for these foundations, typically slightly above the level of the 2014 survey. The most recent survey of 2020 shows the scour depth to be more or less stable for the jackets. The scour seems to be fluctuating around an equilibrium depth with minor increases or decreases.

For area B the analysis of the data from 2014 indicated that the equilibrium scour depth had probably been reached. No survey data were available for 2015. Analysis from the 2017 survey data was in confirmation with this observation. Only at jacket H2 the scour at the west pile had almost reached the alarm line. The most recent survey of 2020 shows for most jackets a more or less stable condition. However, for the shallower locations E1, E2, F1, F2, H2, I1 and I3 there is an increase of the scour depth observed. The scour around the east pile of jacket F2 has reached below the alarm line.

Although compared to the previous surveys in general the scour depth seems to be stable or only shows a smaller variation, the scour depth remains close to or below the alarm line for many of the jackets. Therefore, regular monitoring is still strongly recommended.

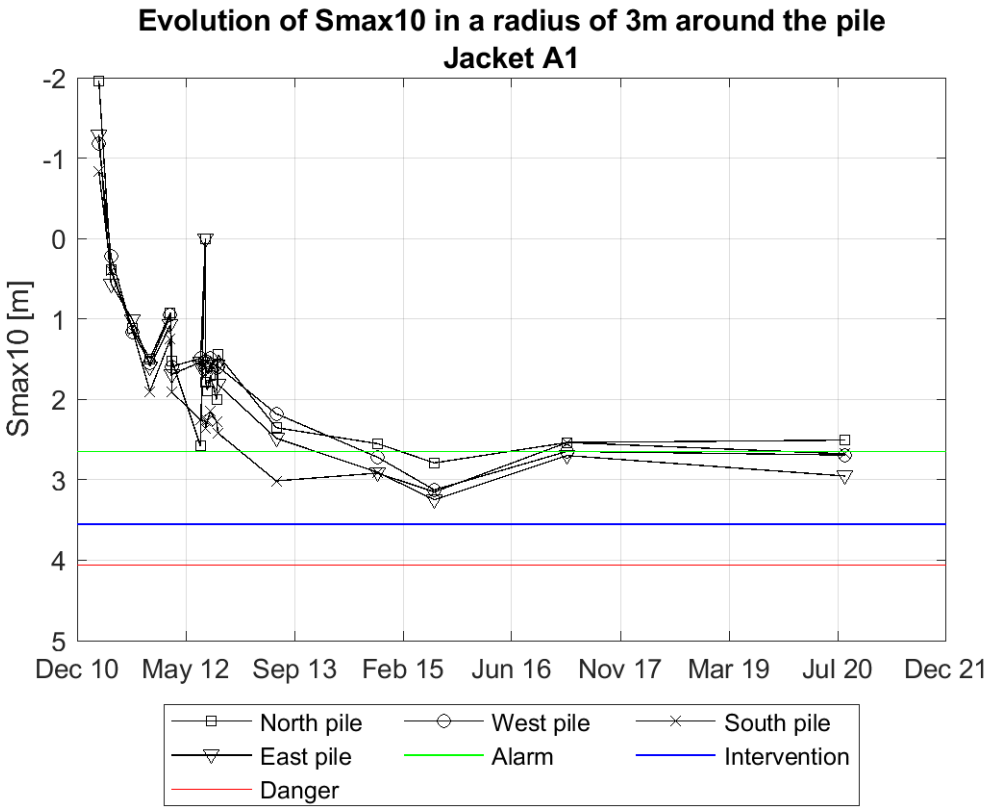
Previously it was already reported (IMDC, 2017) that the equilibrium scour depth decreases with increasing water depth. For jacket foundations installed in area B at depths larger than -19 m TAW, the reached equilibrium scour depth S_{max10} is in general not larger than 1 m. For jacket foundations with installation depths smaller than -19 m TAW, the equilibrium scour depth S_{max10} can reach up to 2 m in area B.

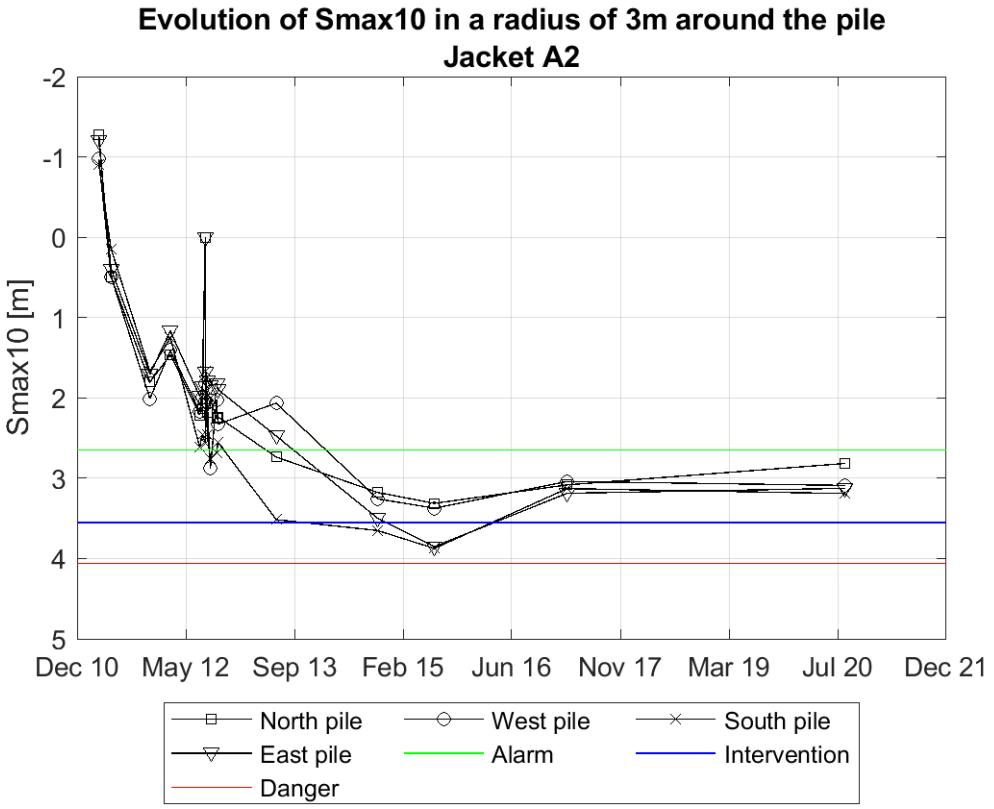
It should be noted that the results of the construction surveys of May and July 2012 are deviating. Probably the measurements of these surveys are influenced by reflections of the multibeam signal on the pile of the jacket itself. None of the other surveys show these deviations.

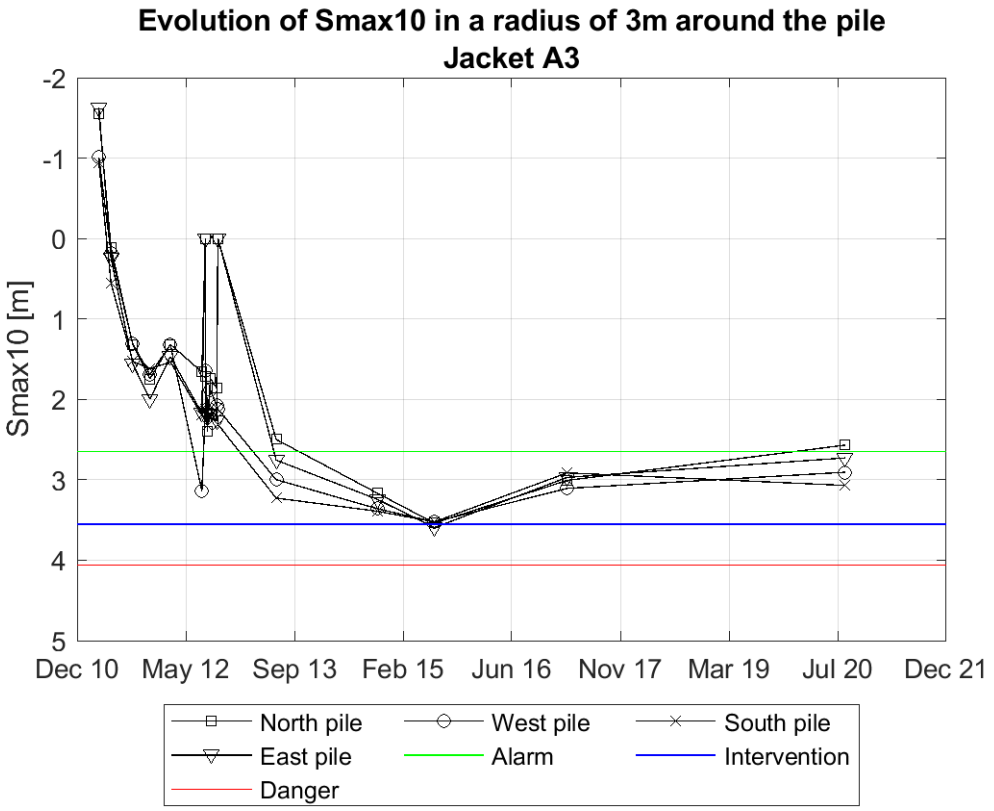
5 References

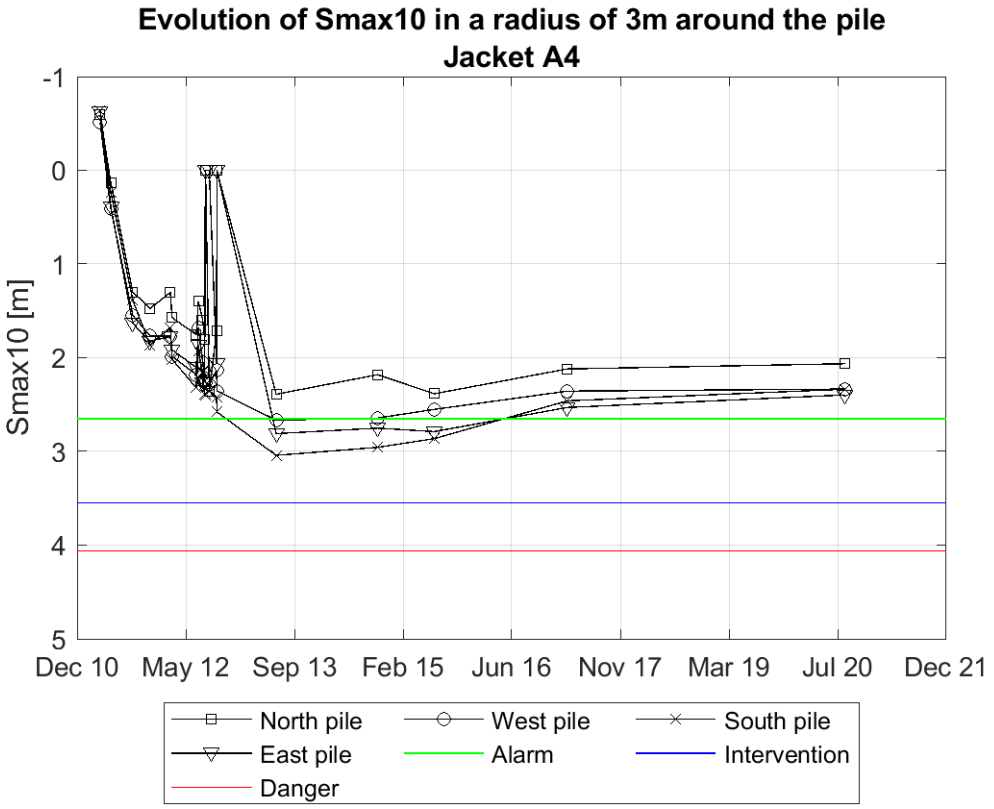
IMDC (2017). Analysis multibeam measurements. I/NO/11469/17.215/SEO/TDB.

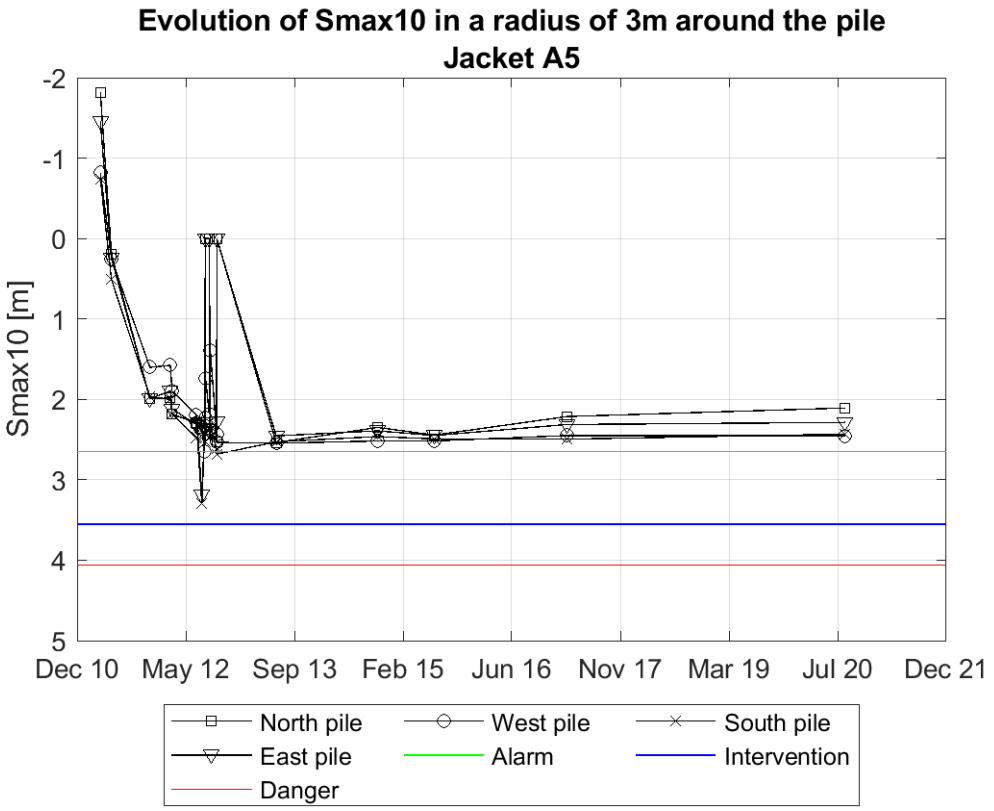
Annex A Scour evolution Jackets S_{max10}

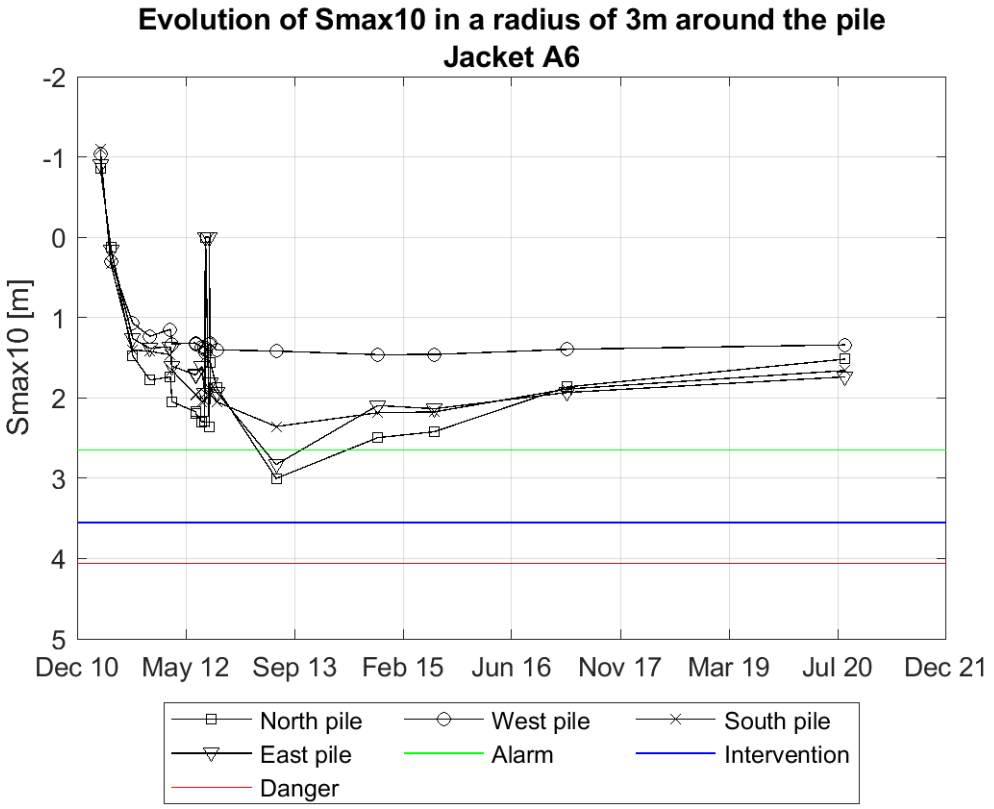


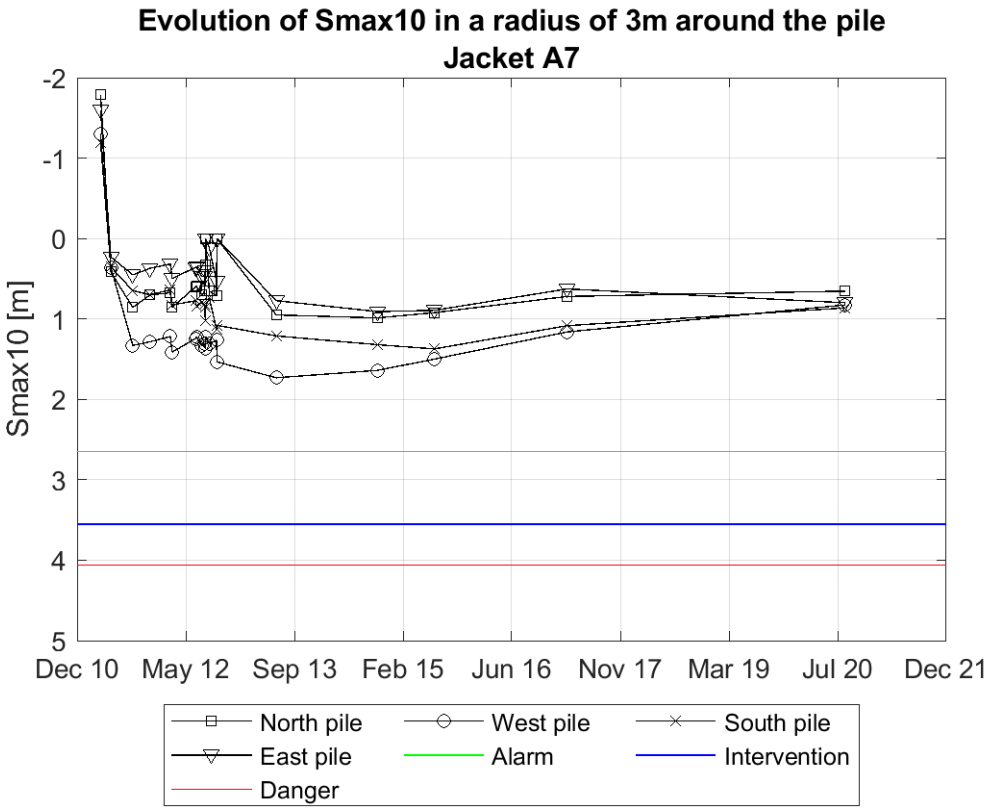


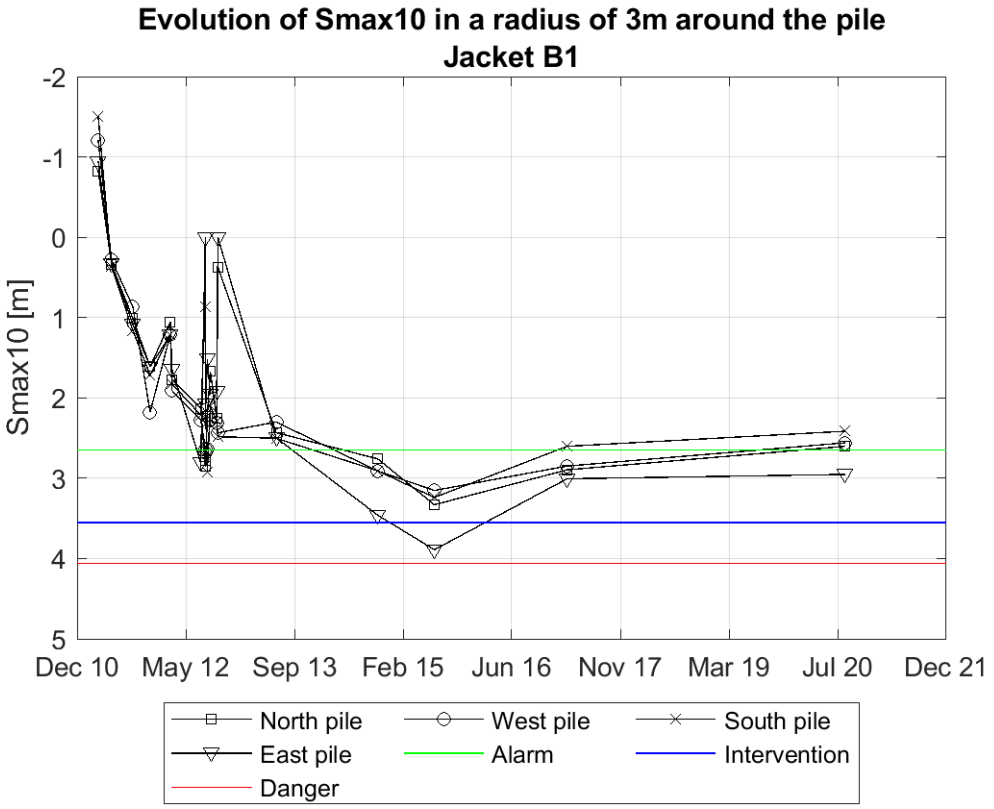


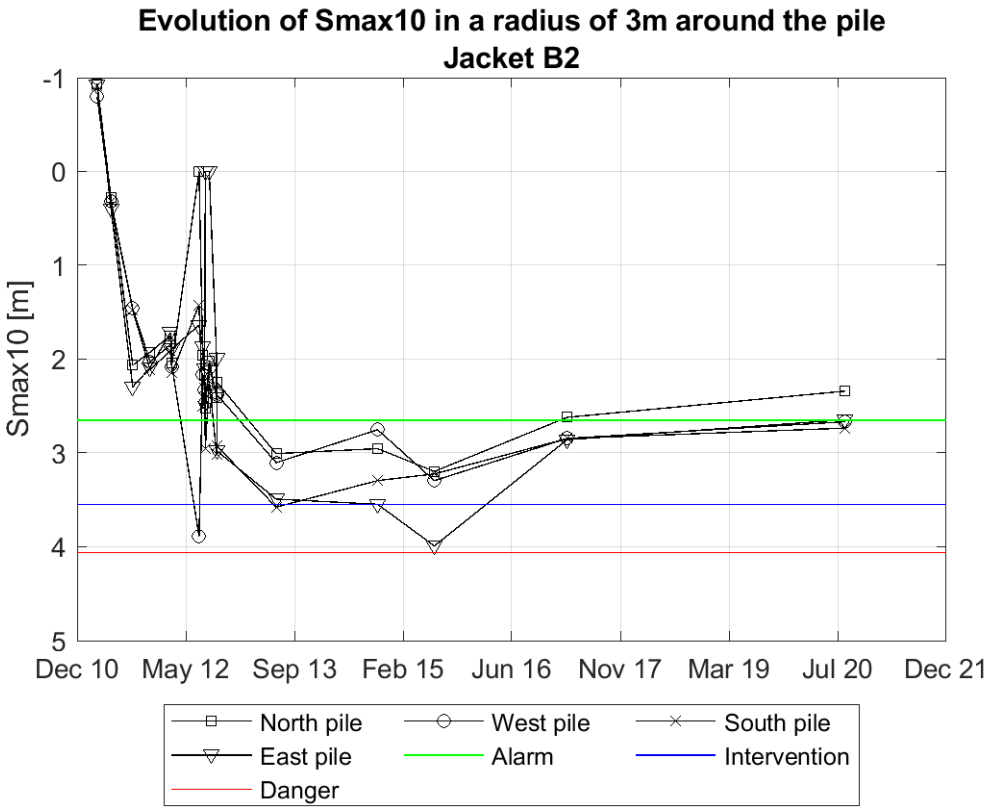


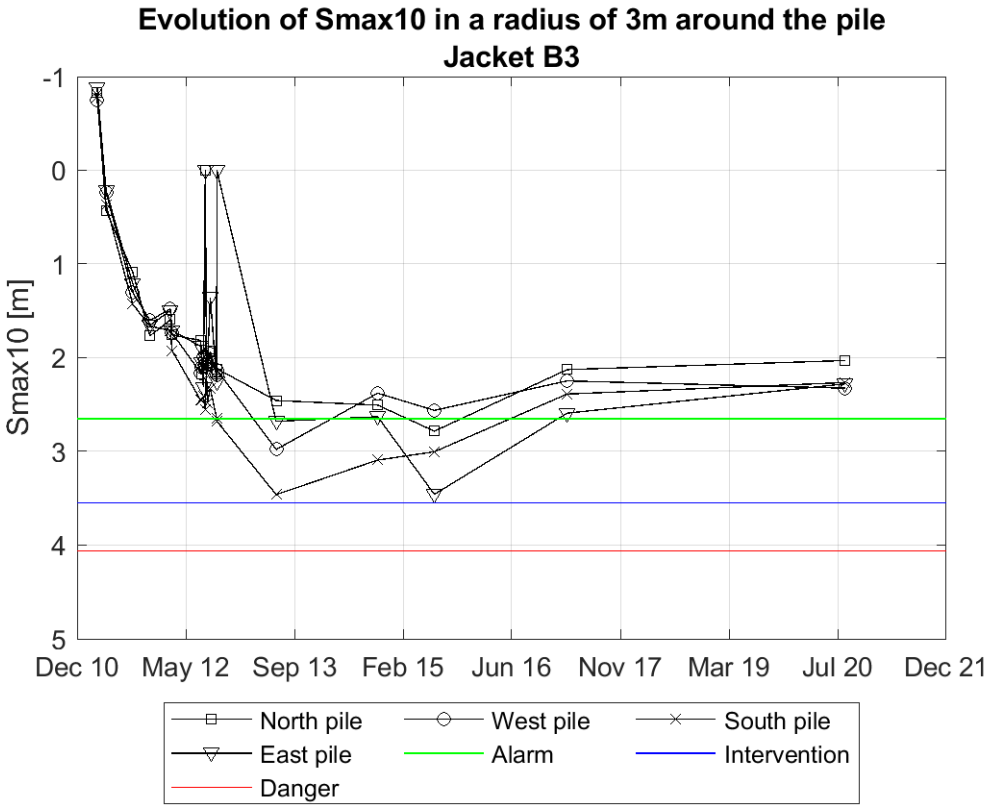


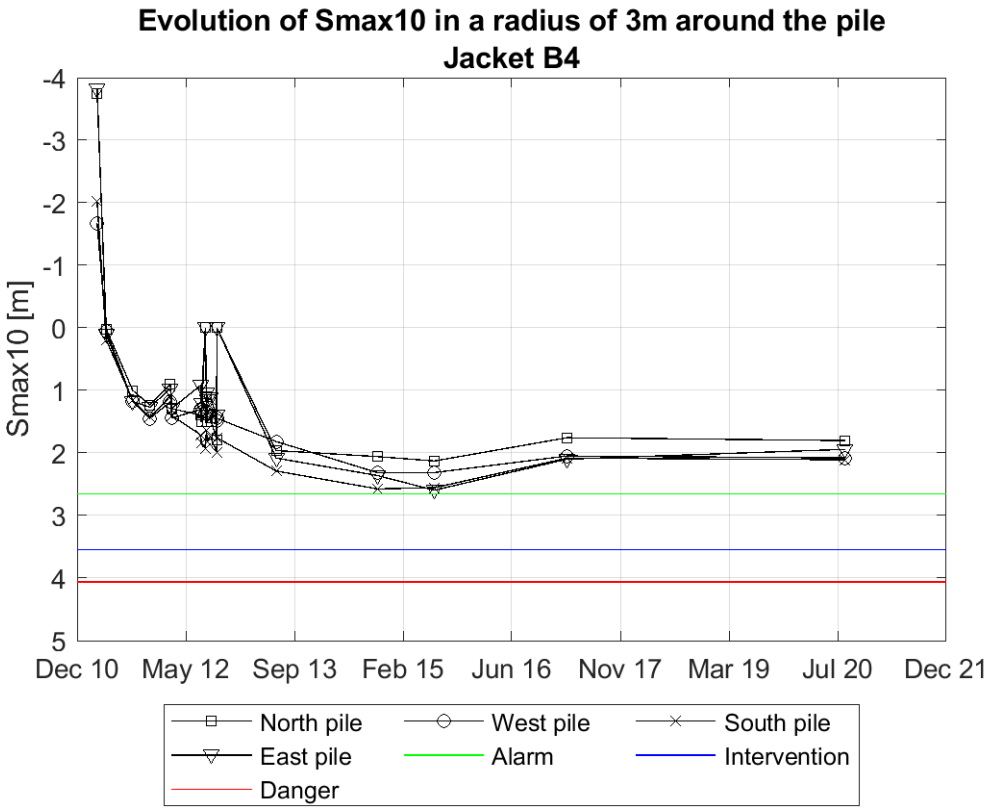


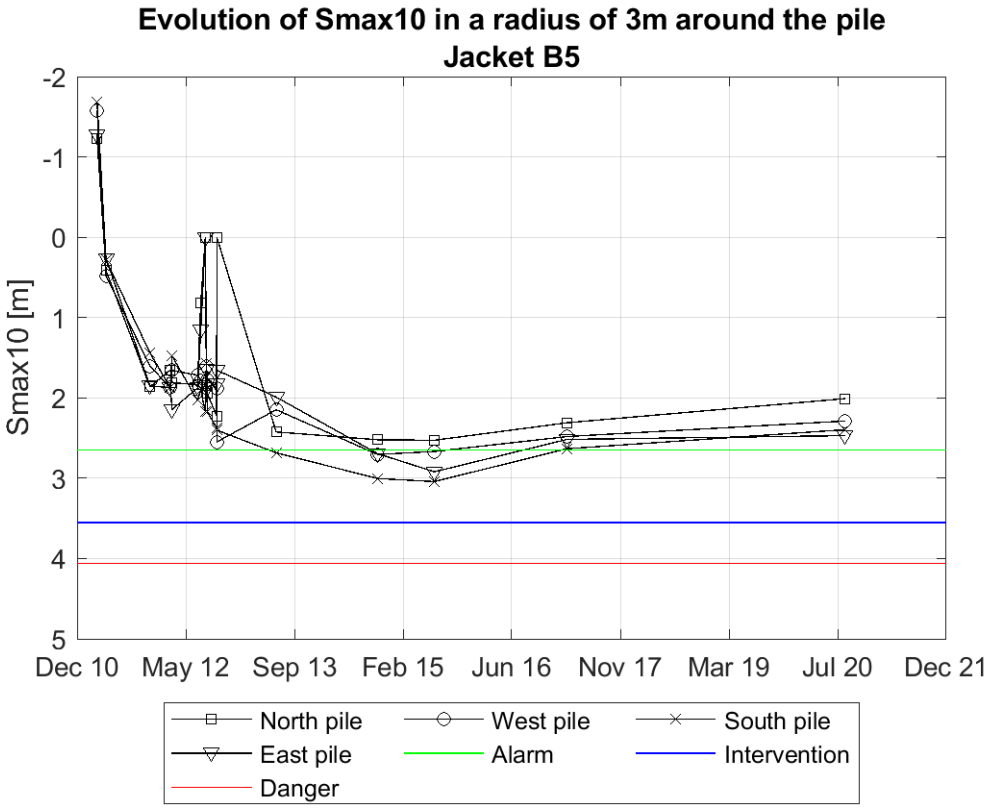


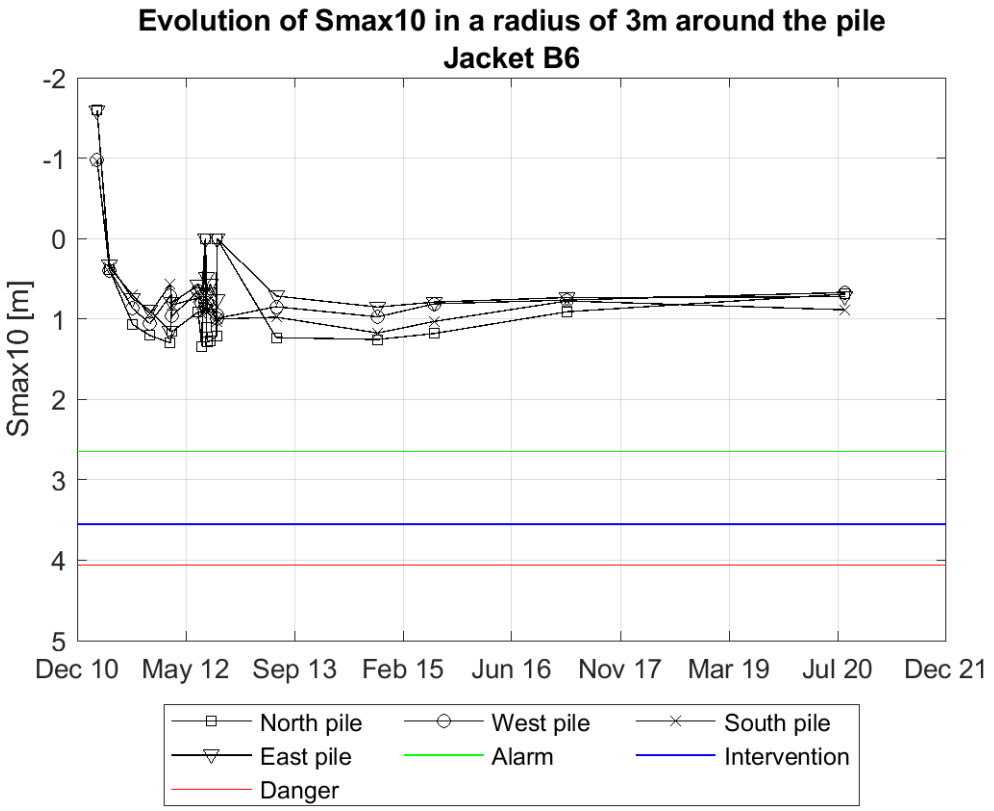


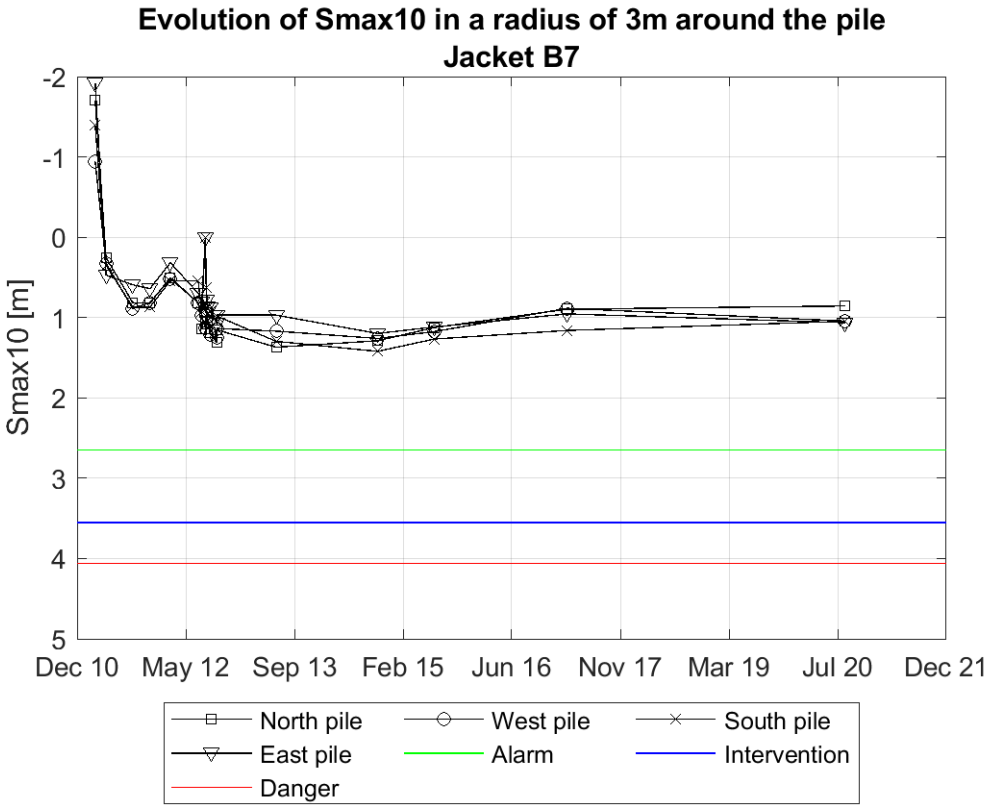


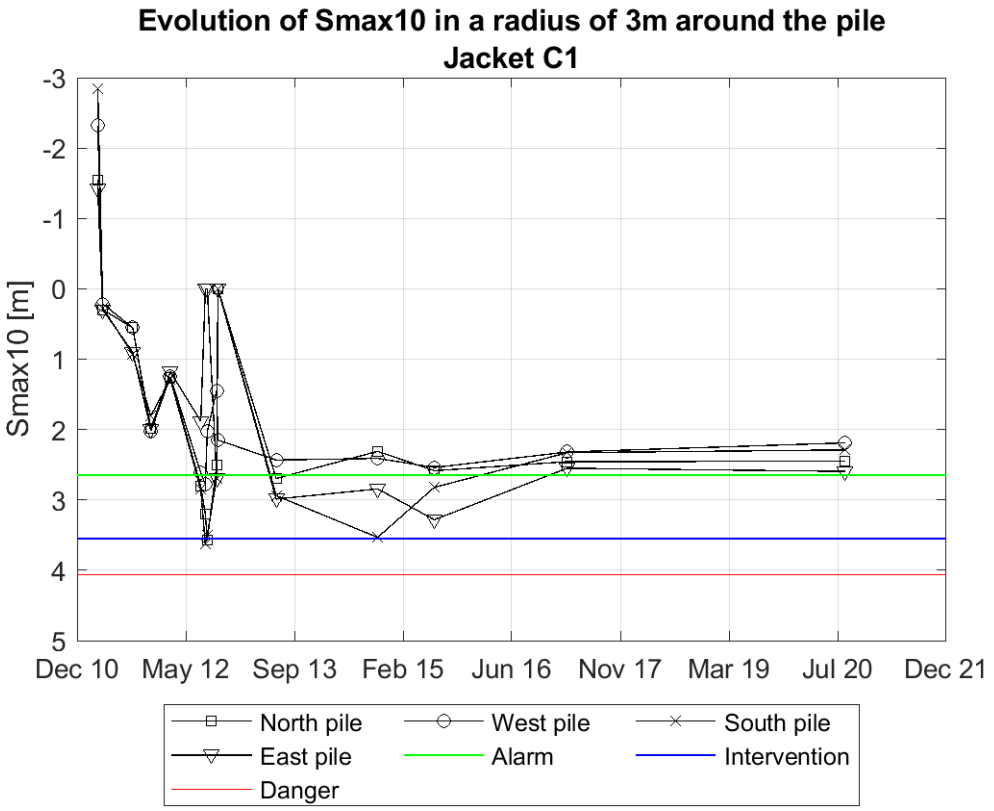


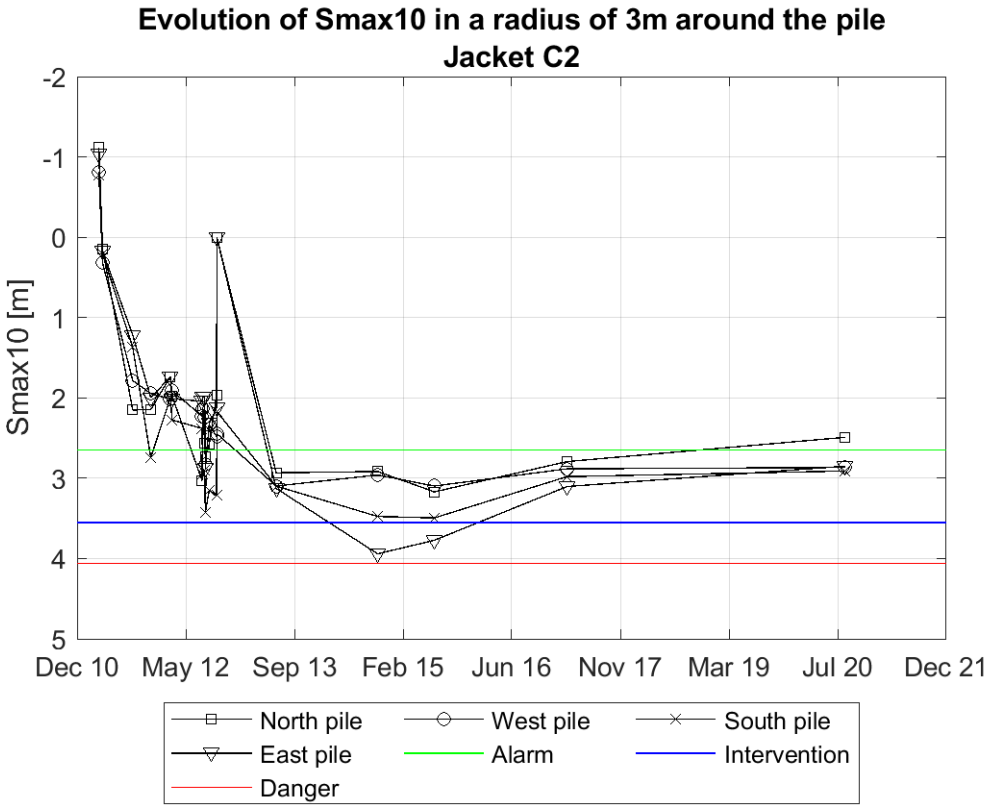


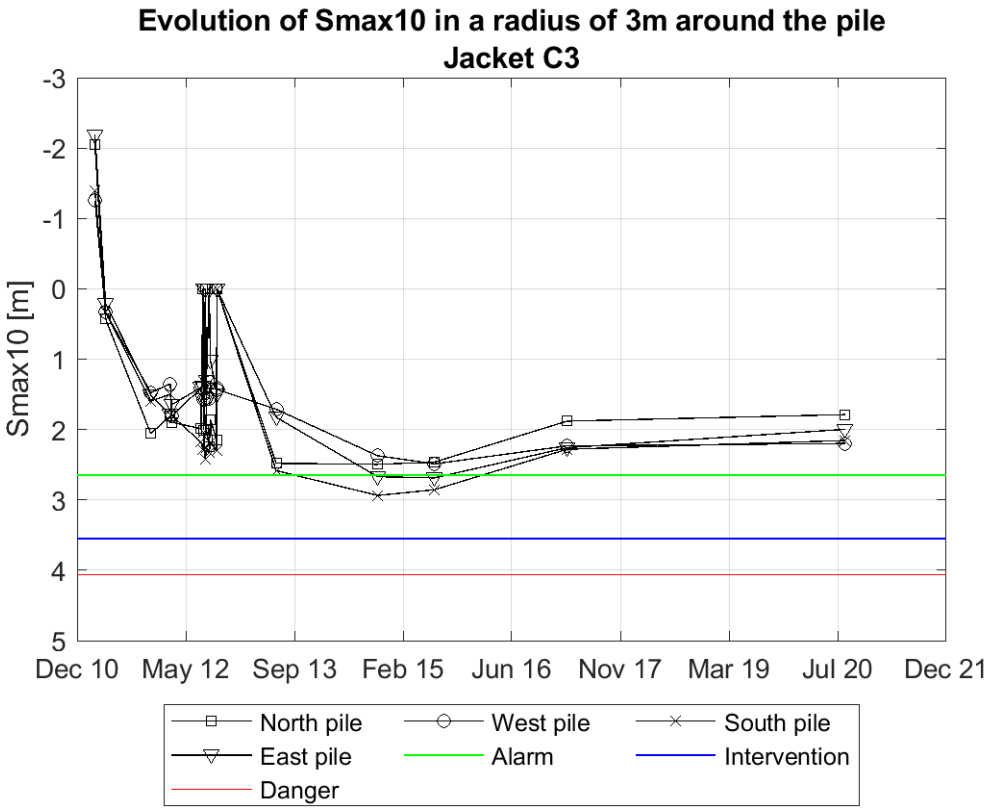


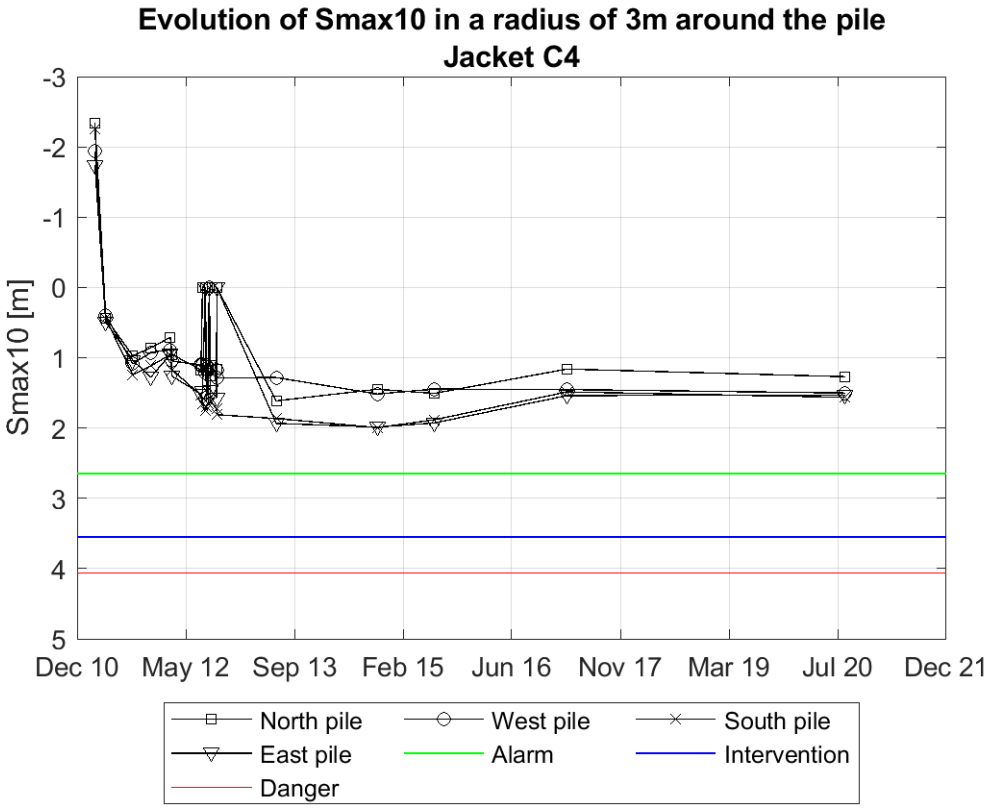


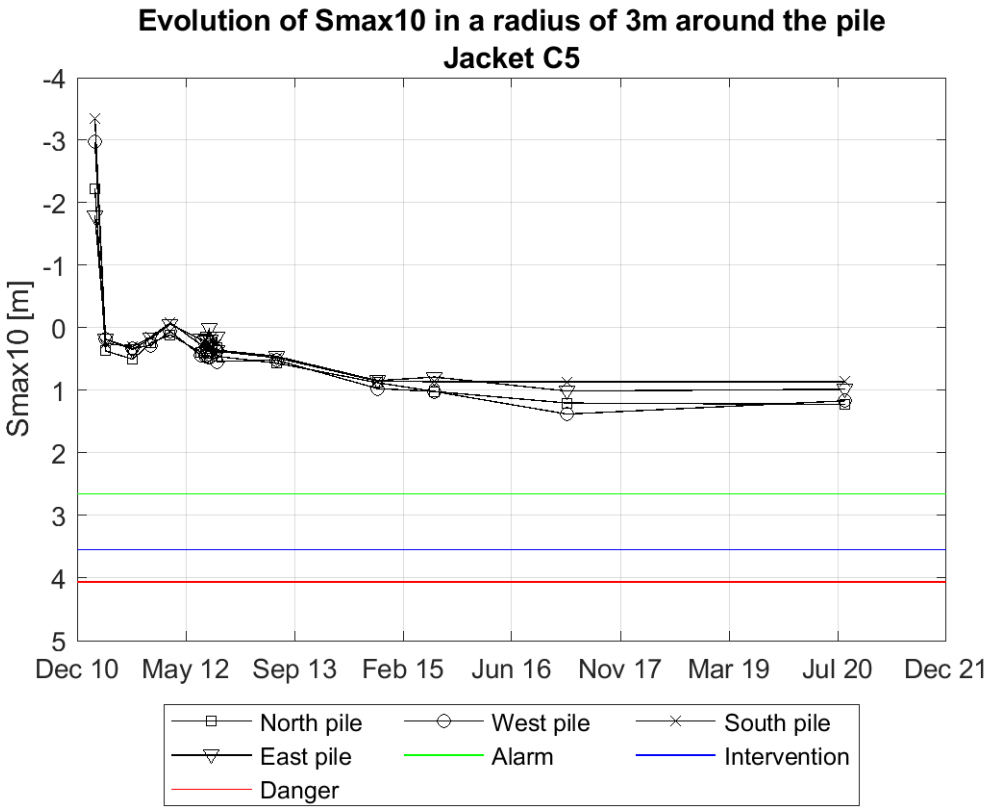


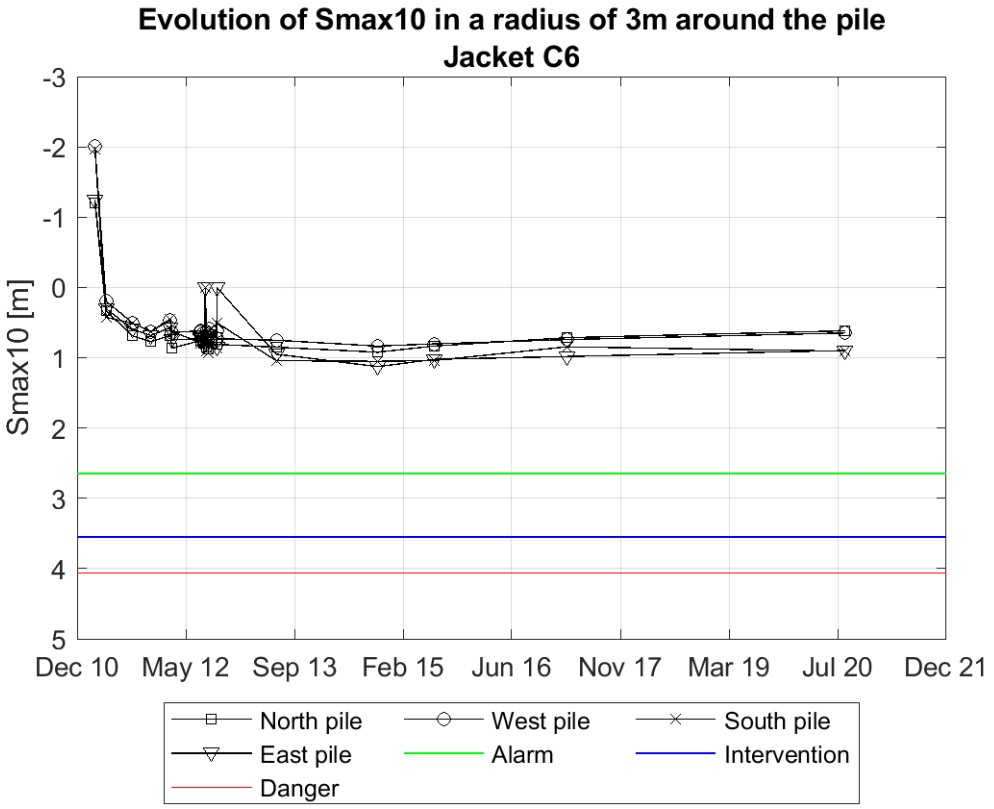


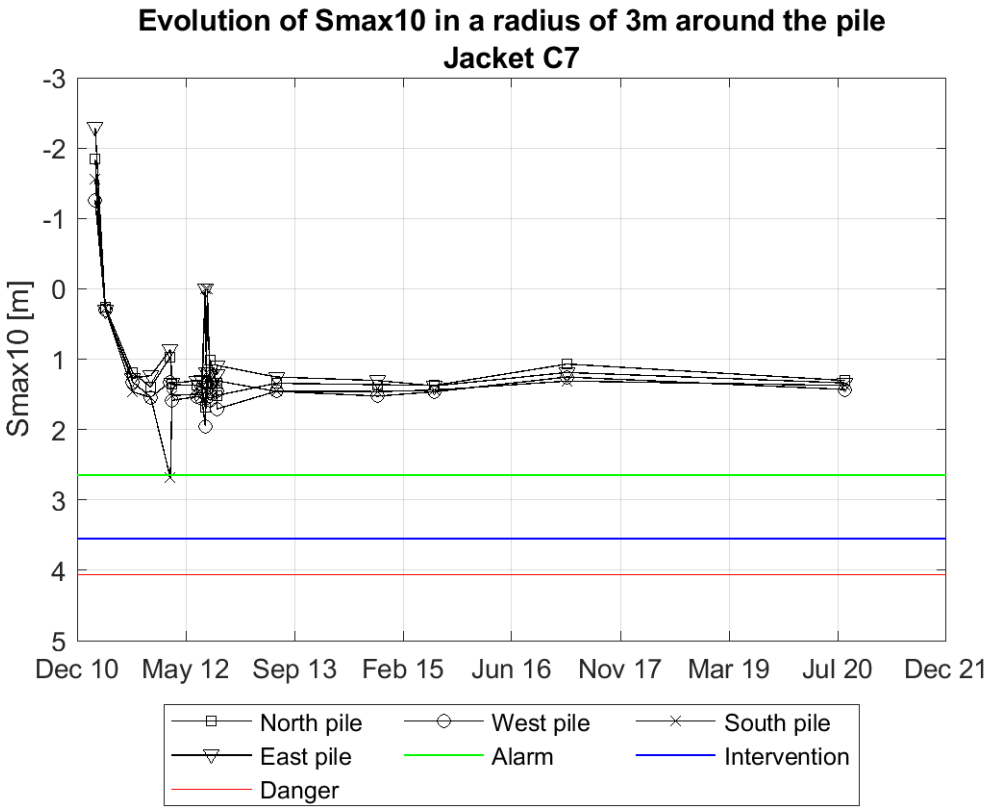


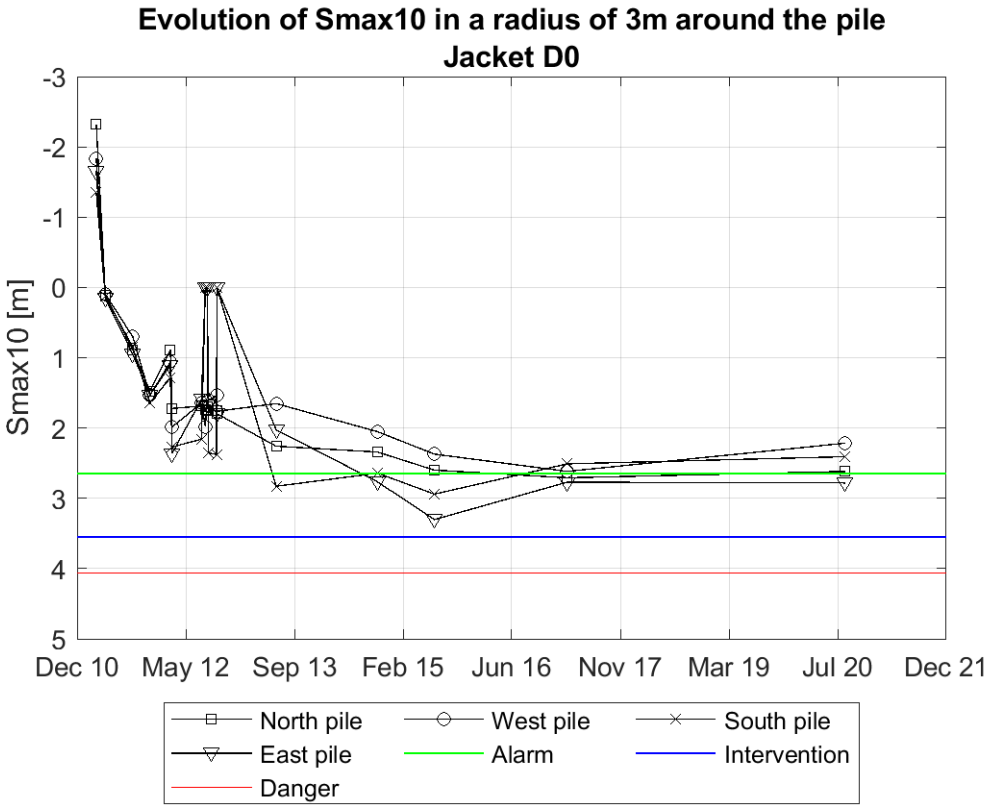


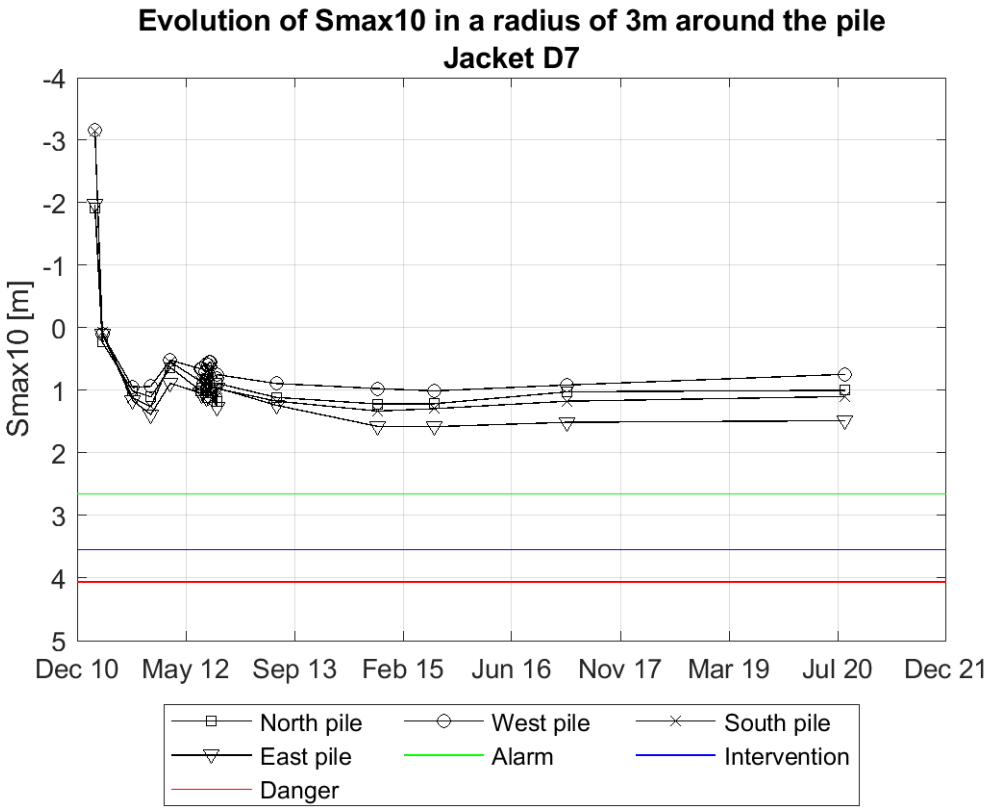


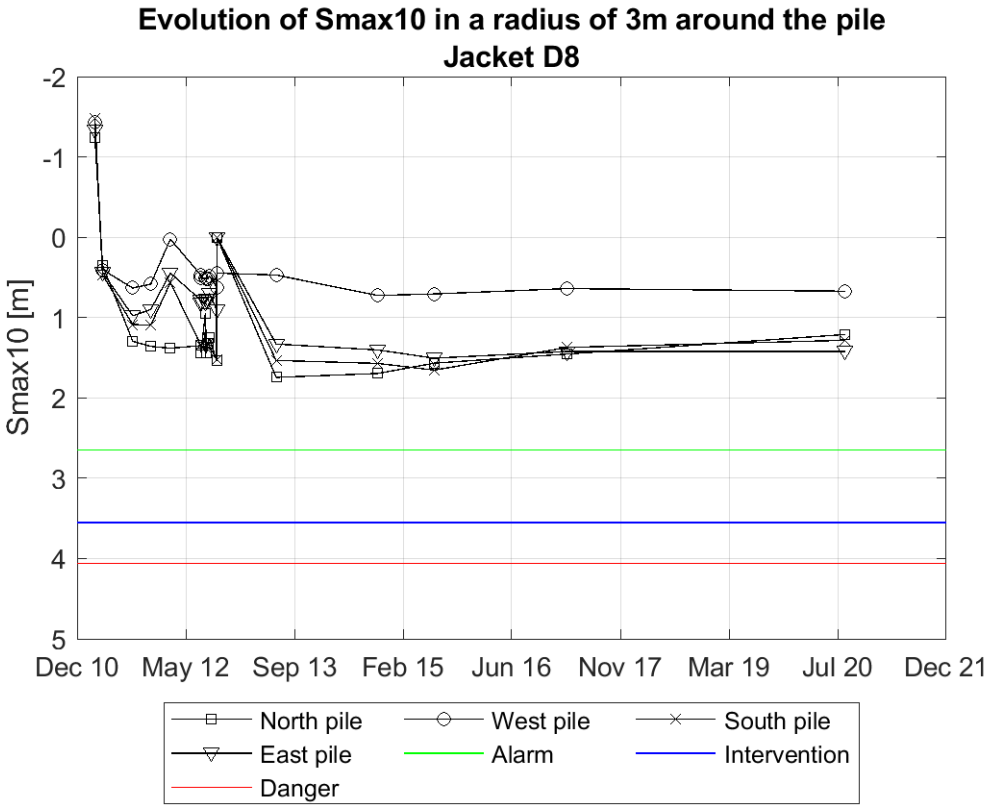


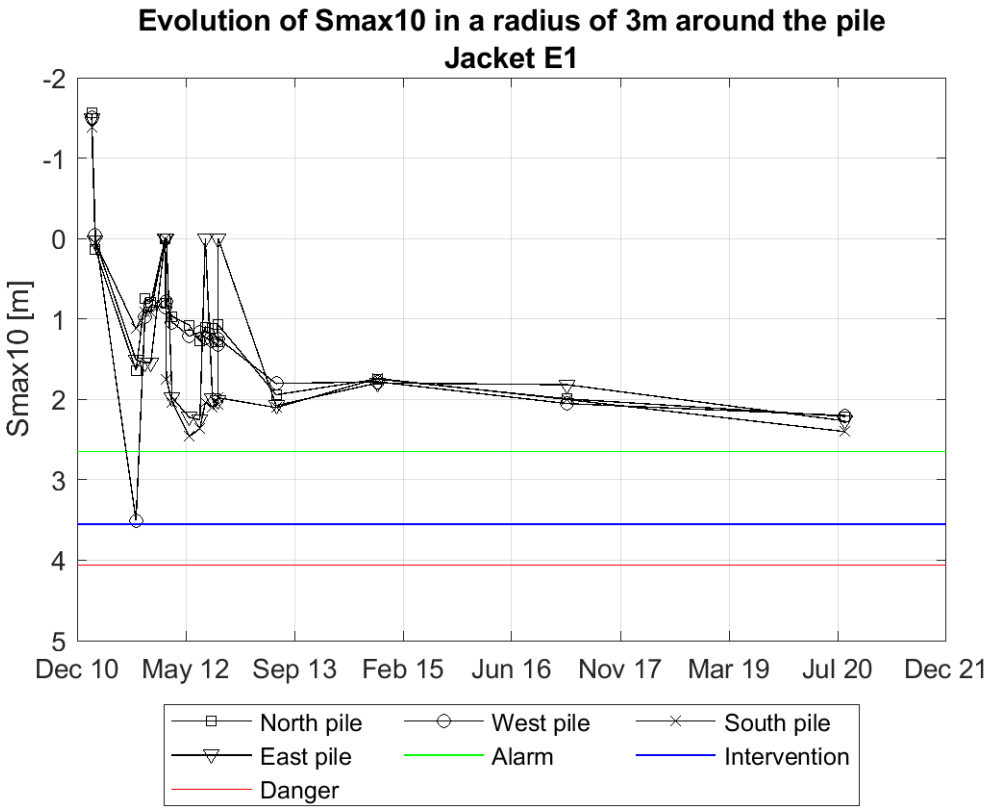


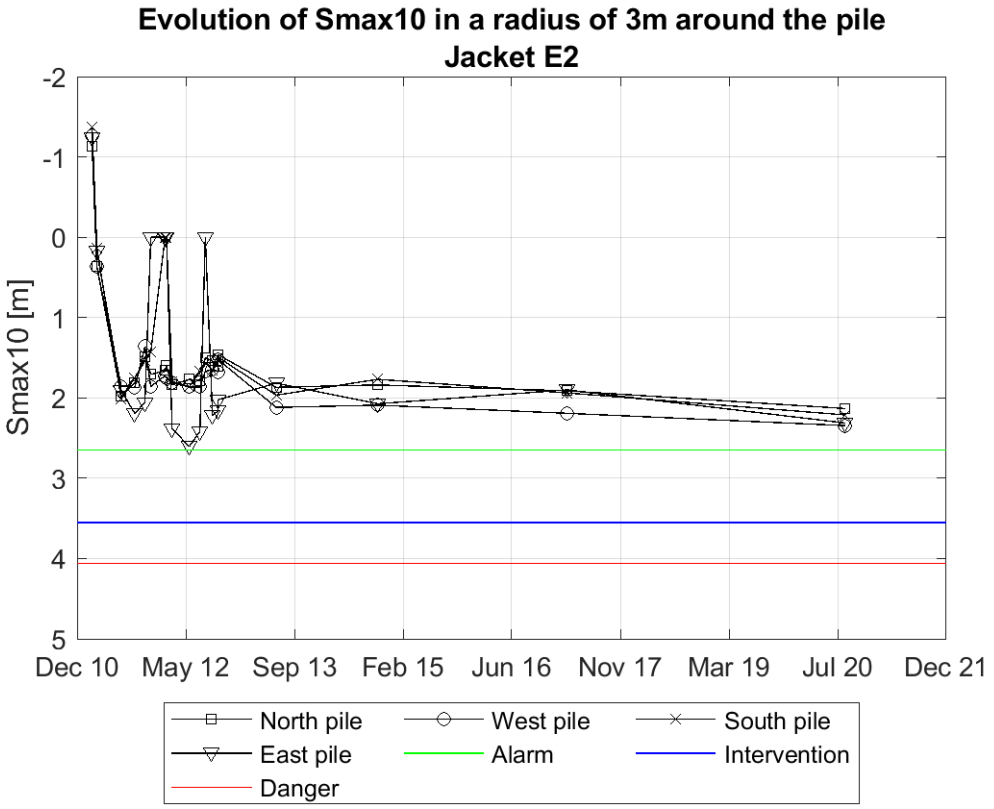


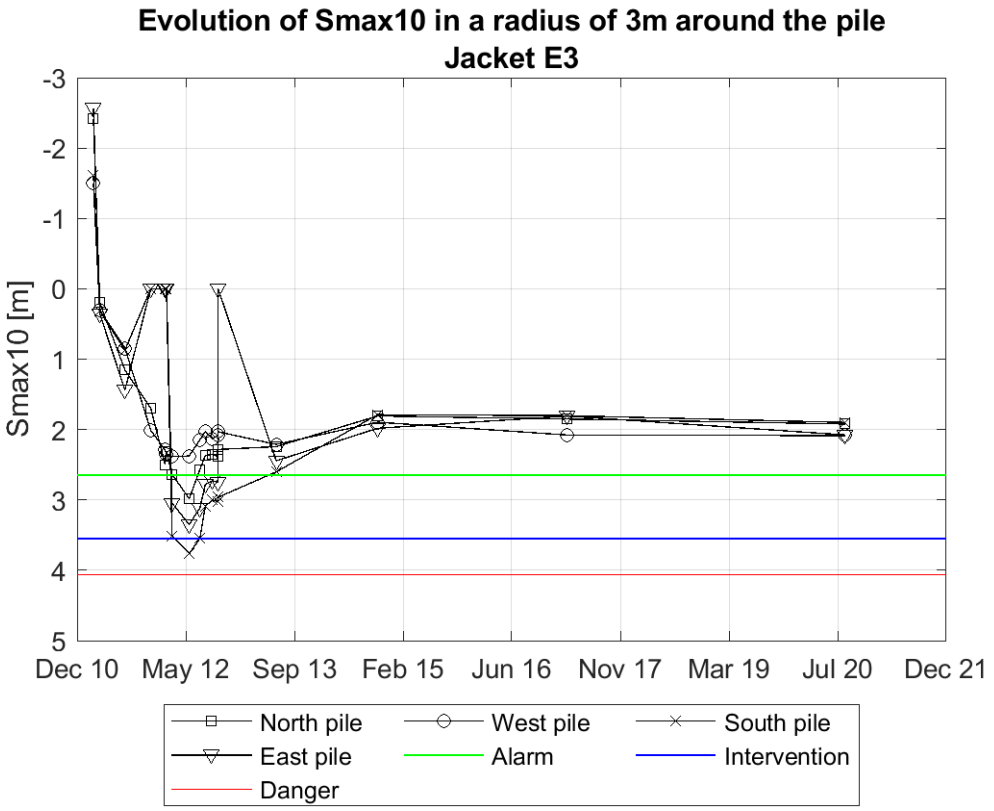


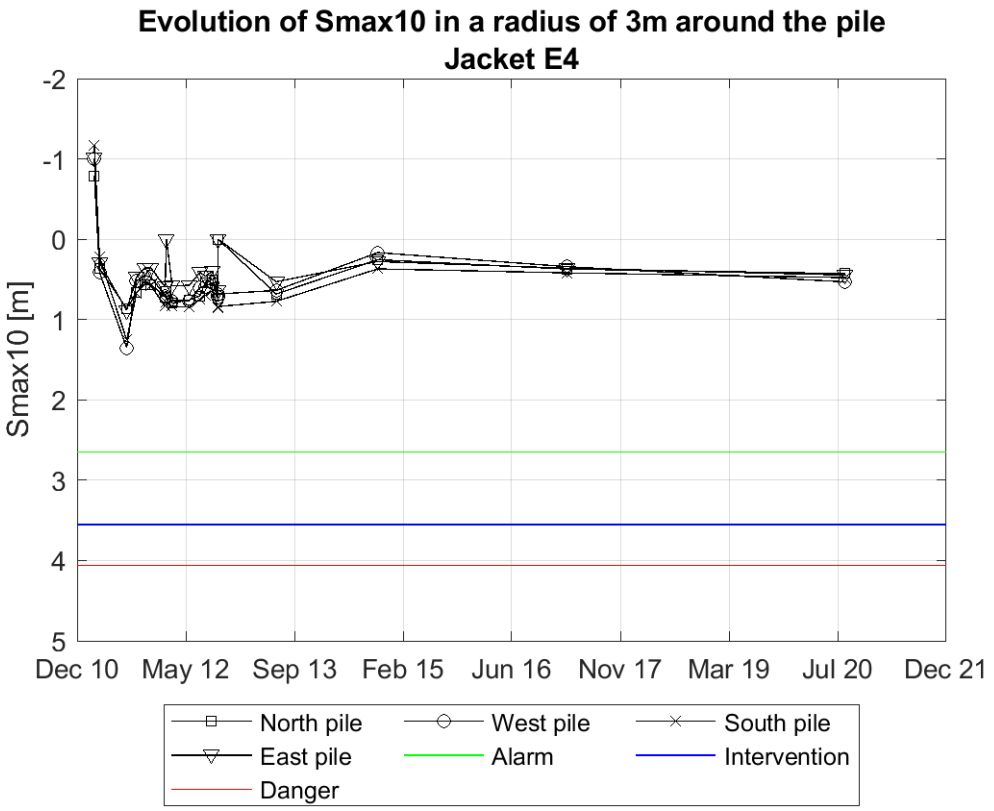


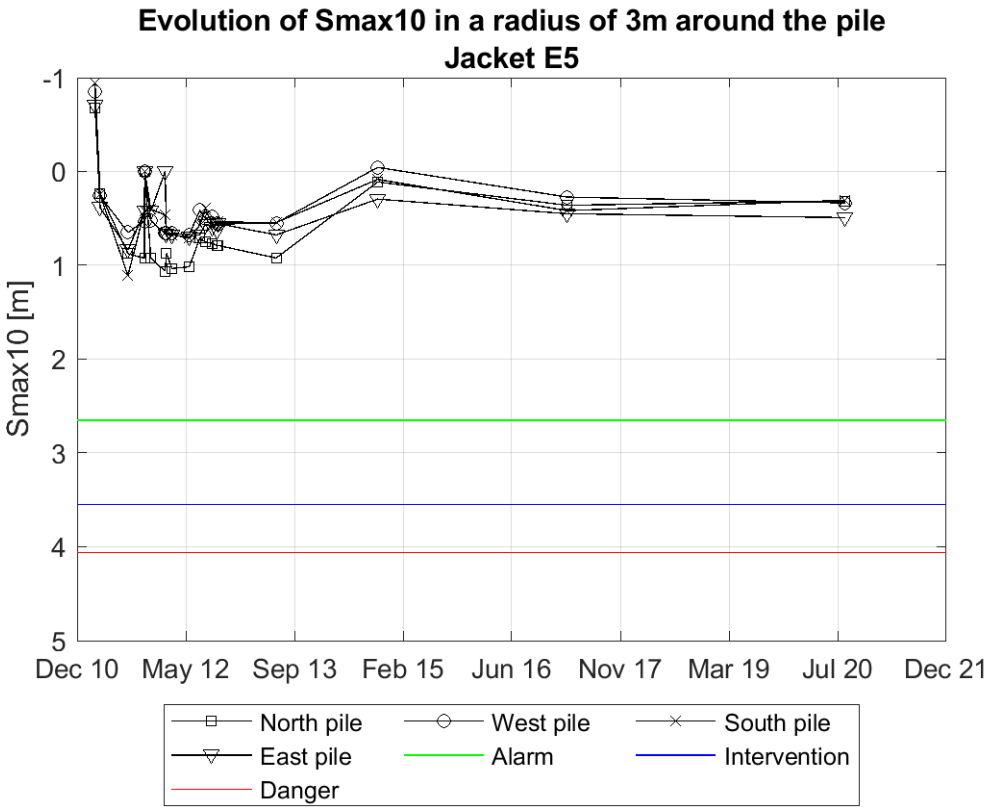


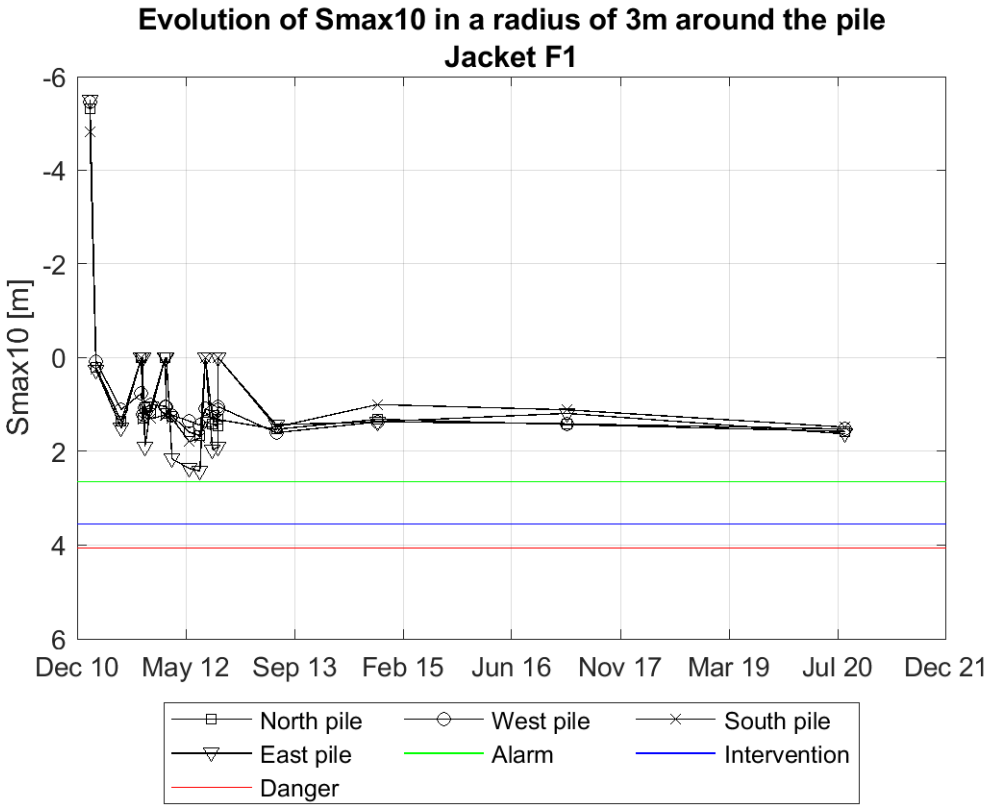


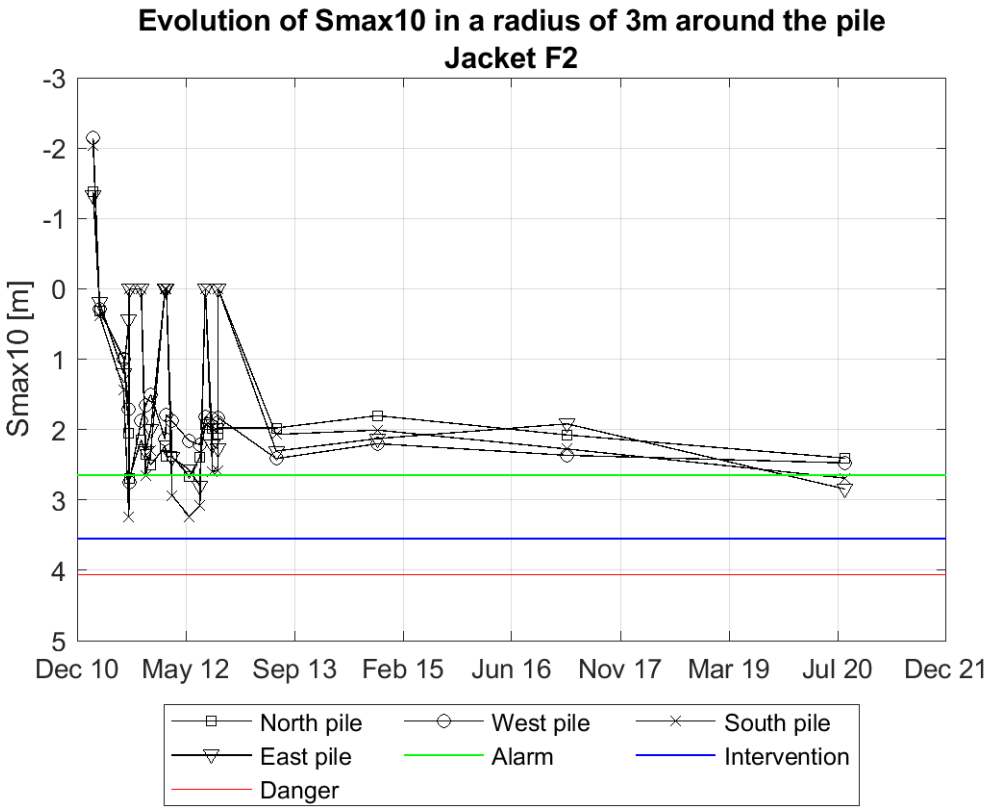


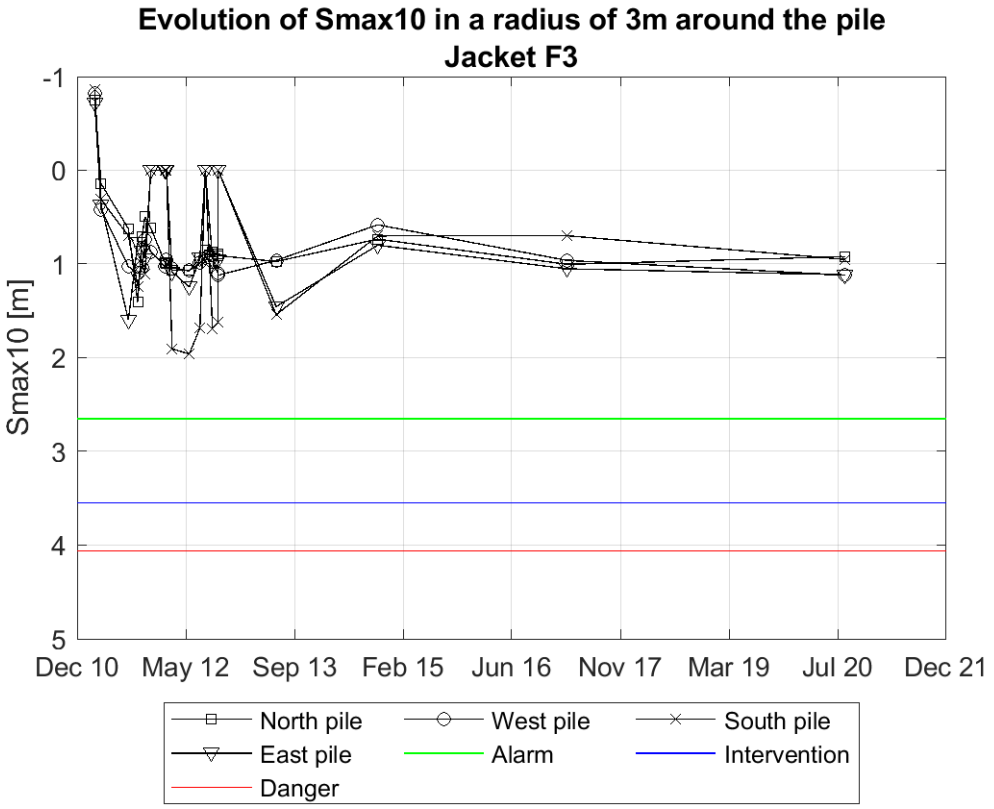


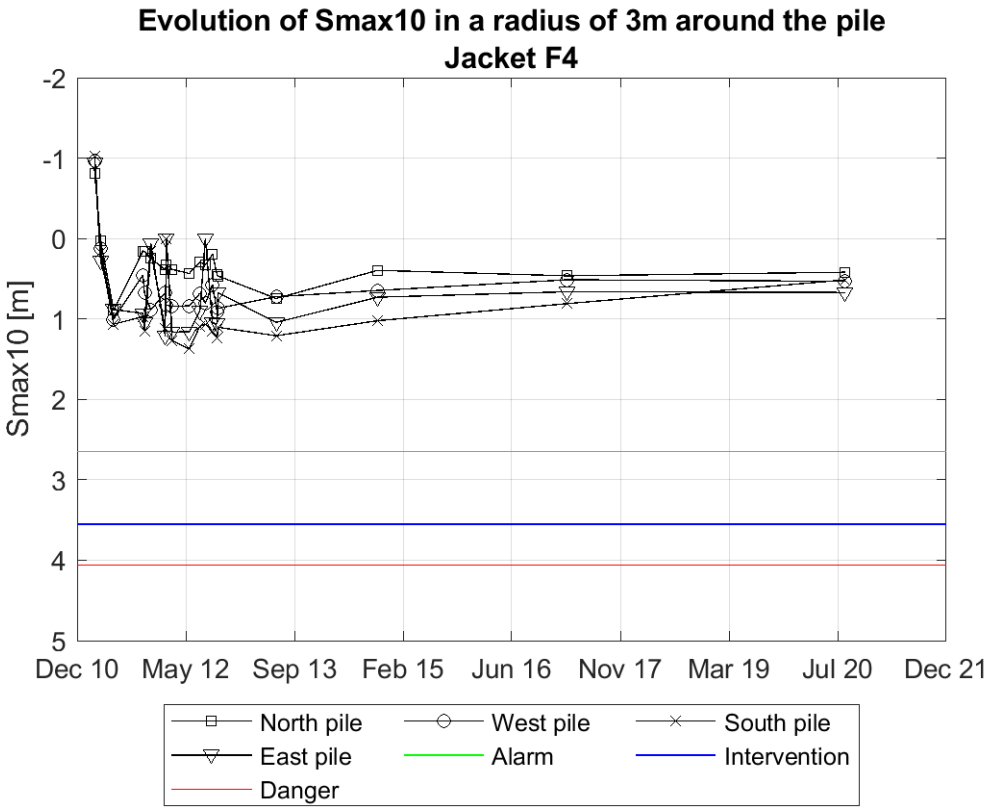


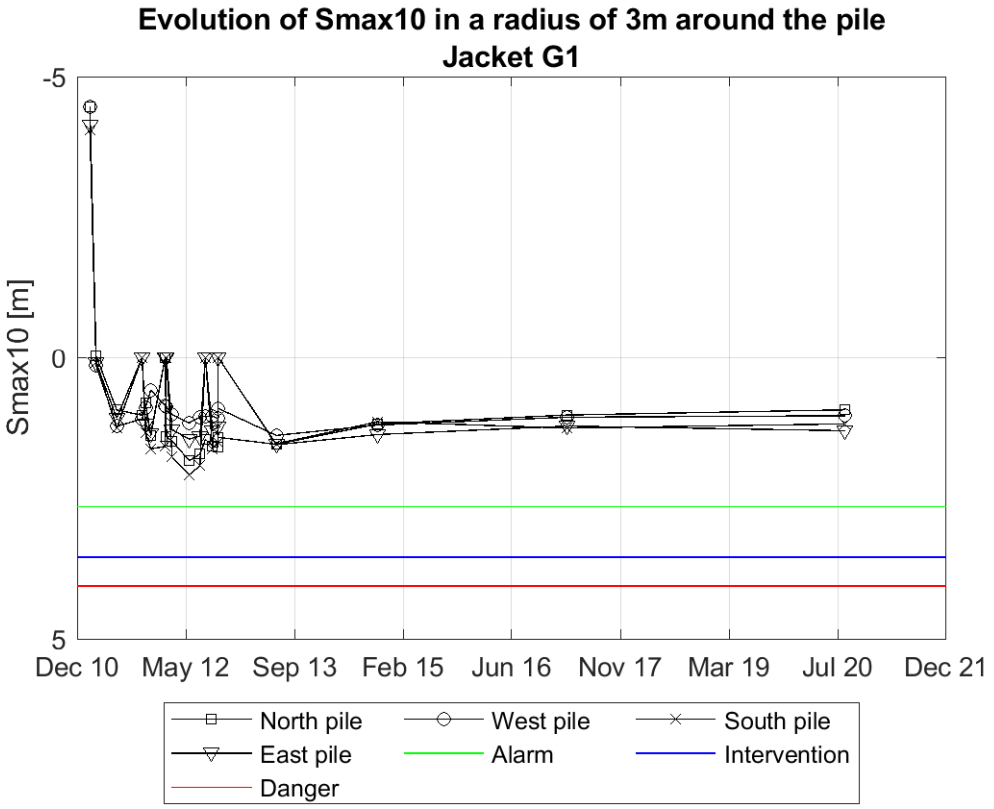


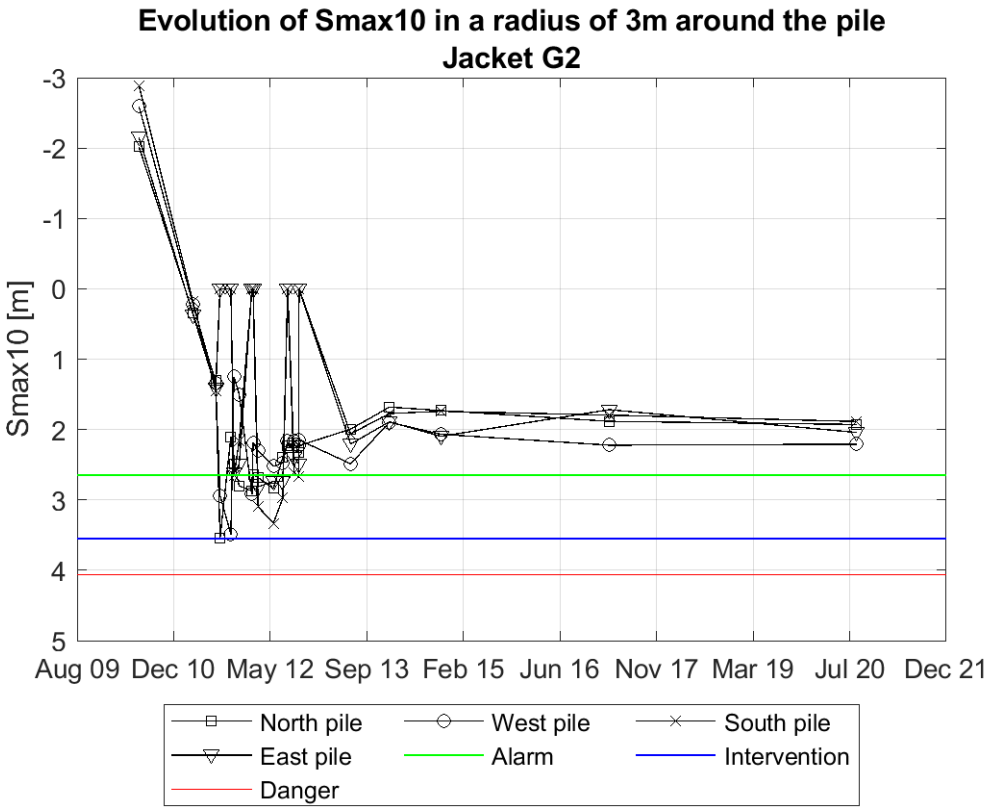


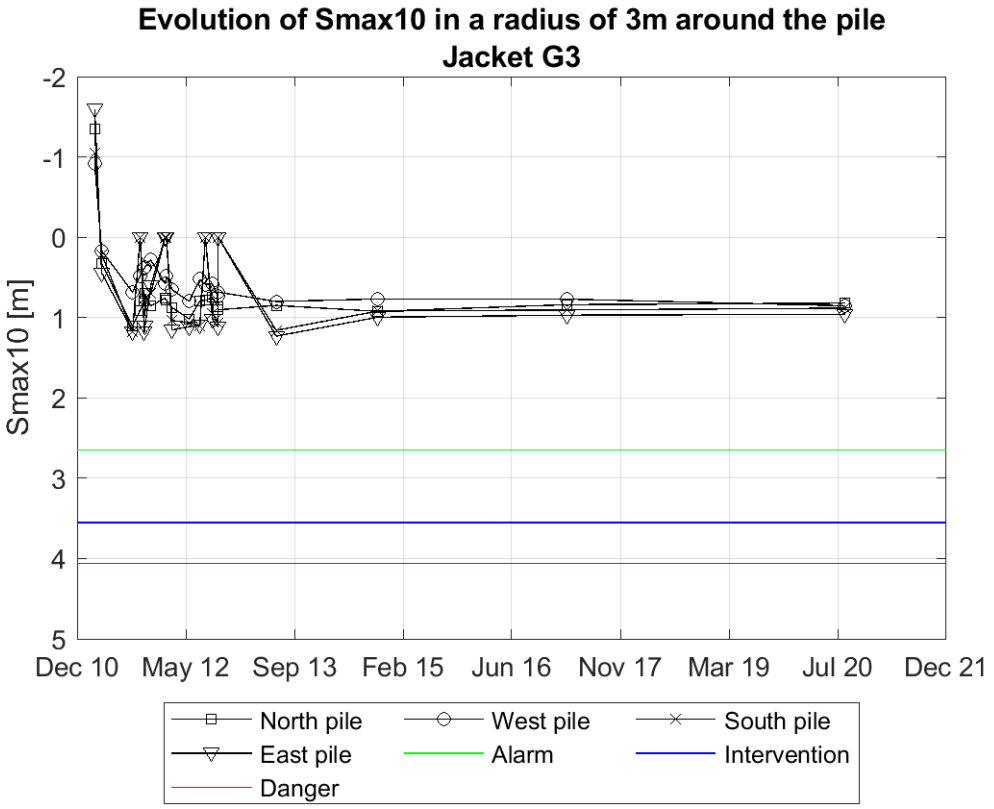


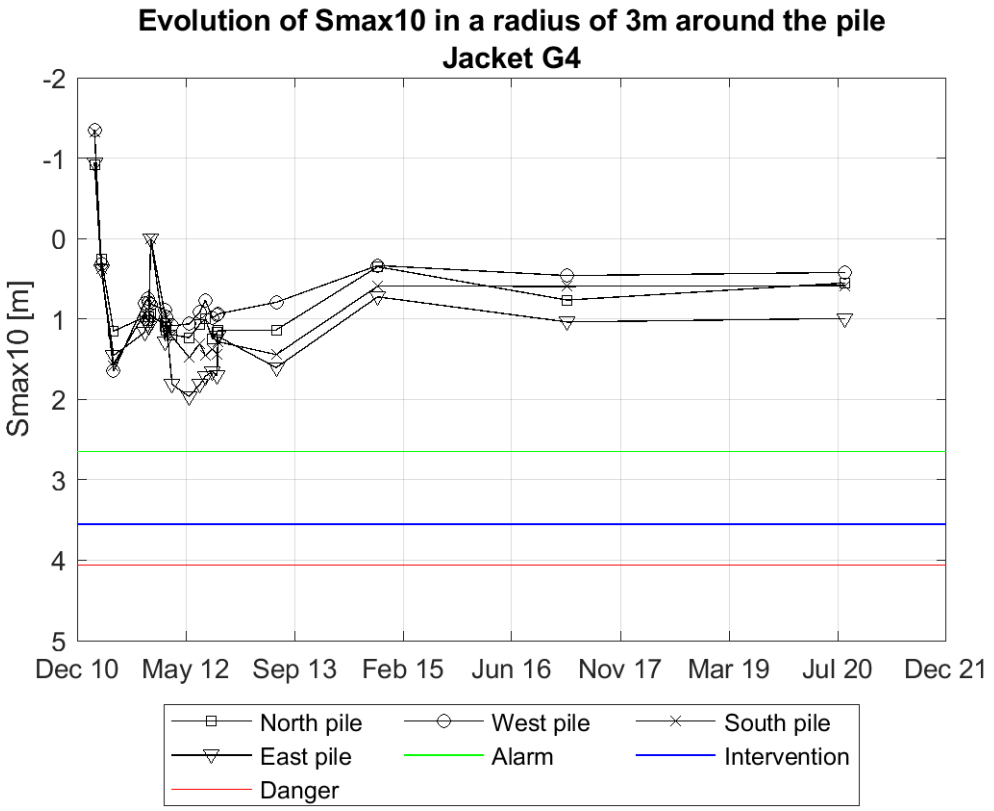


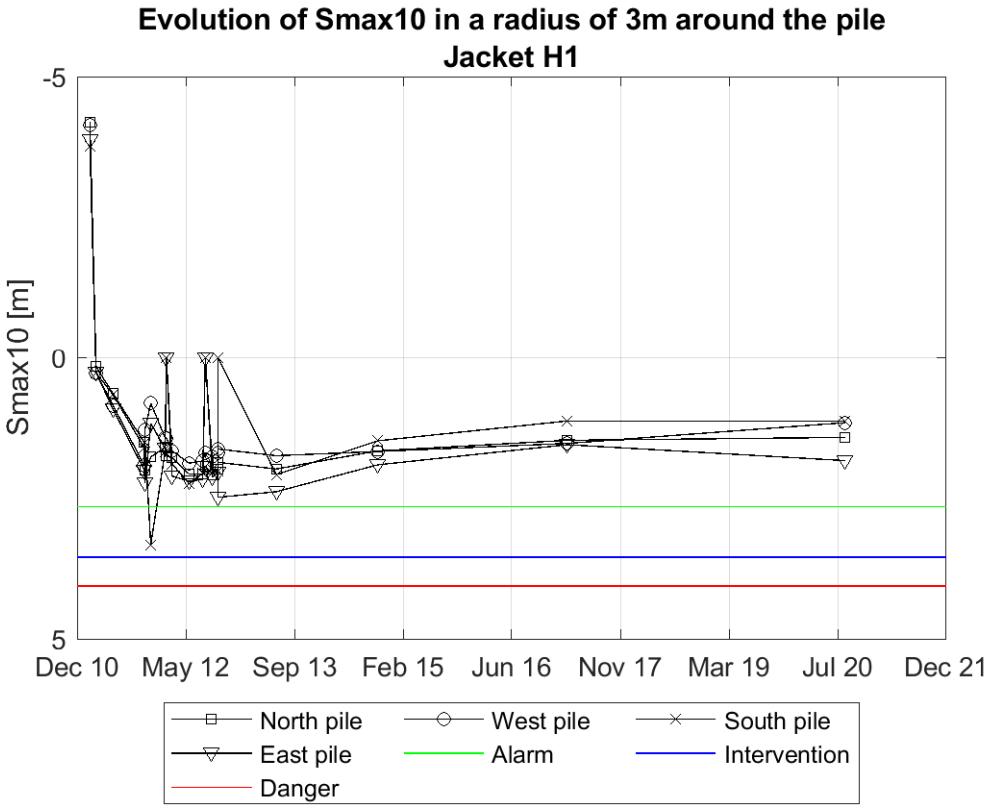


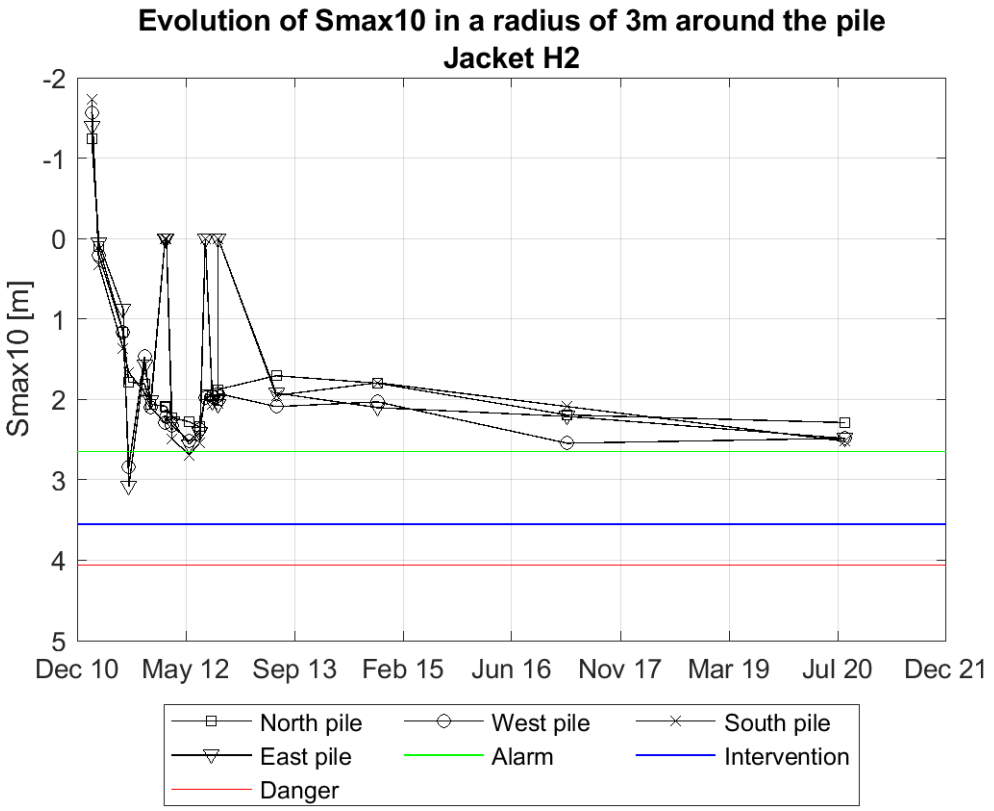


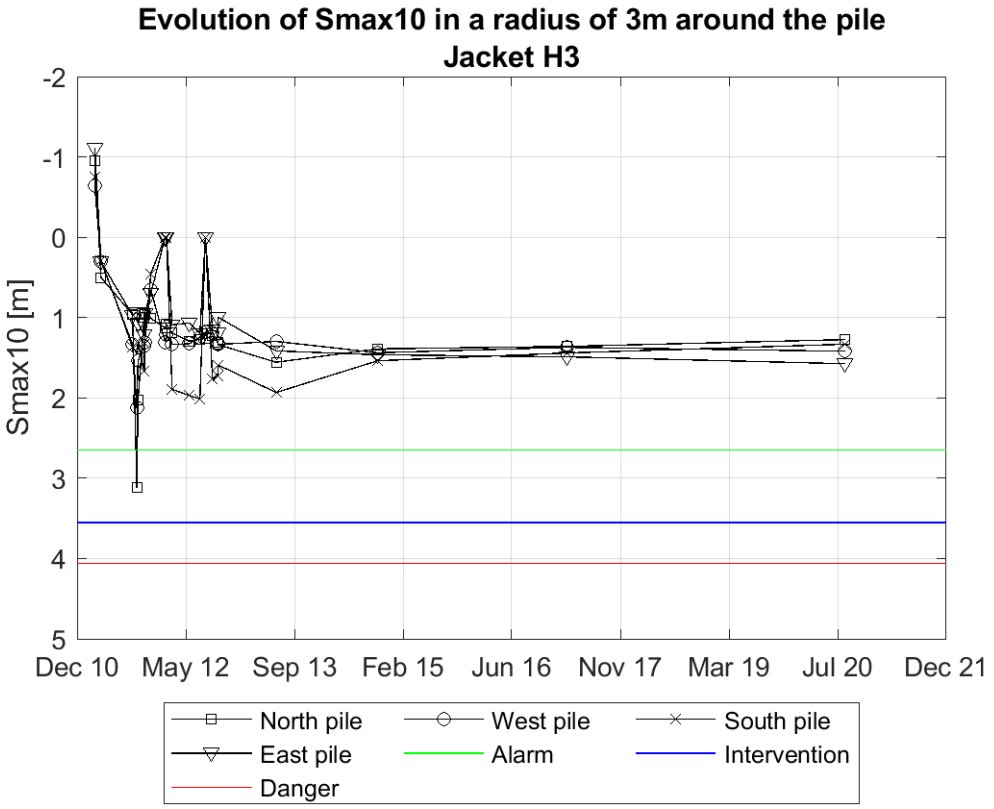


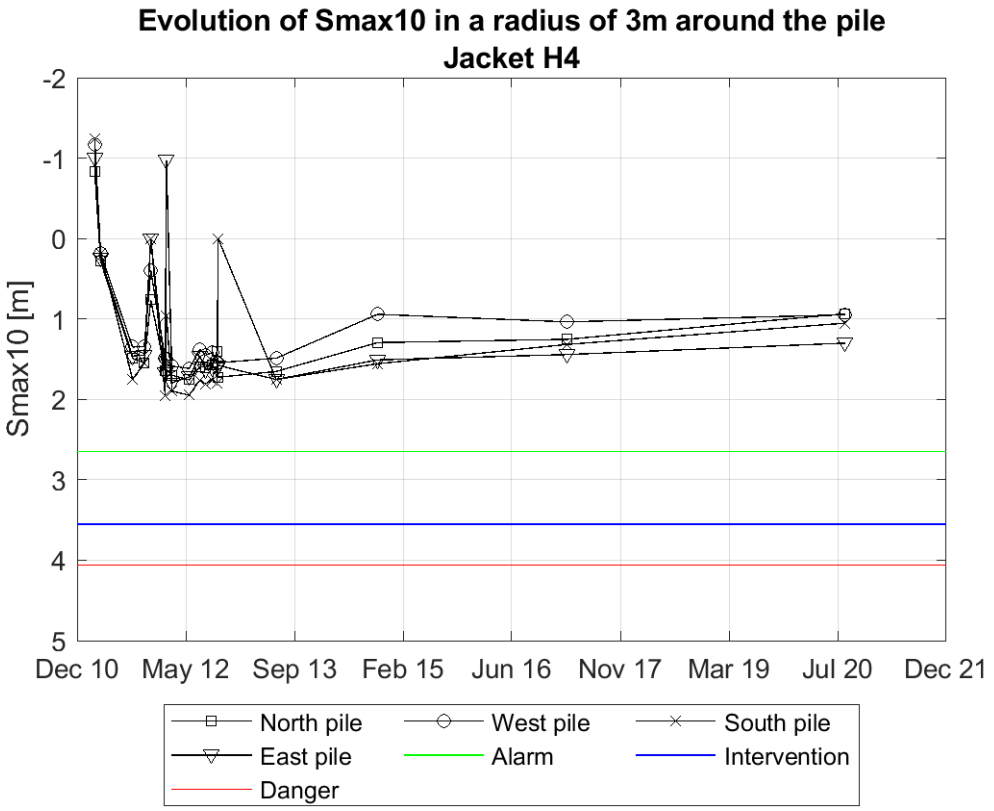


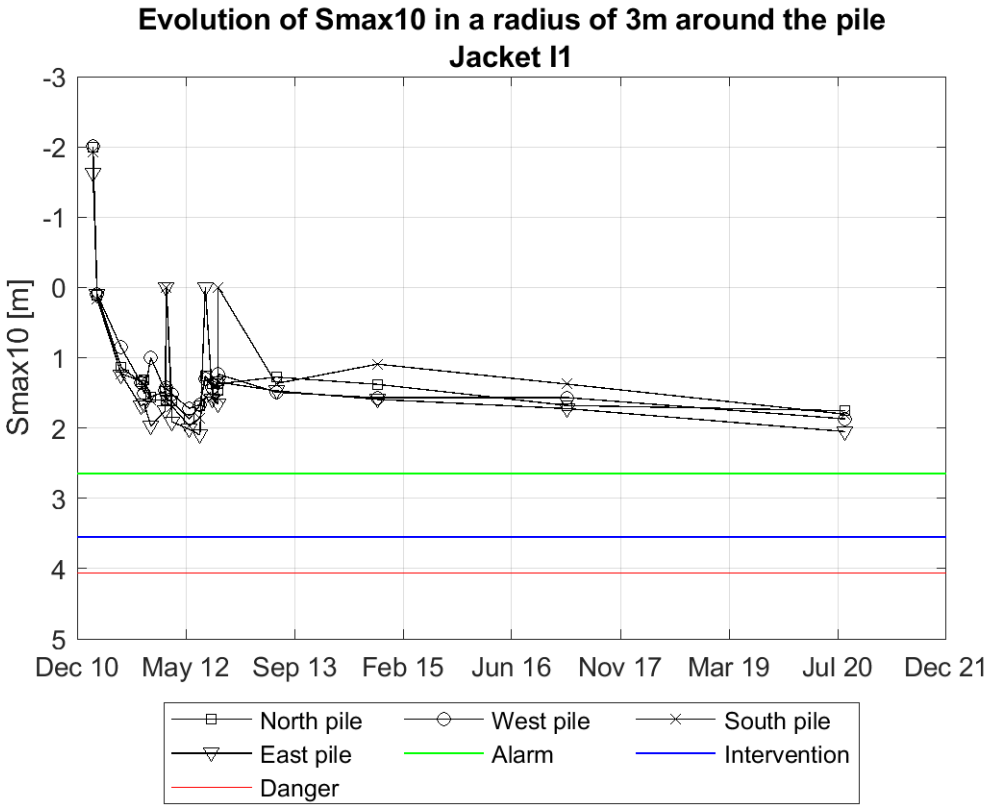


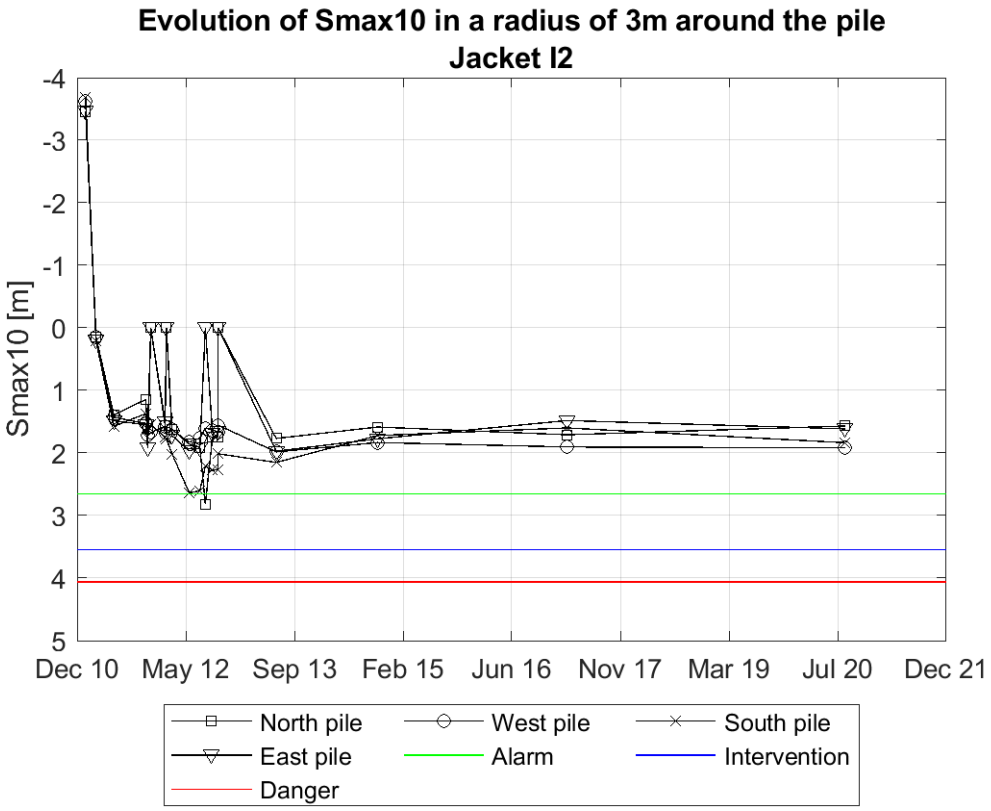


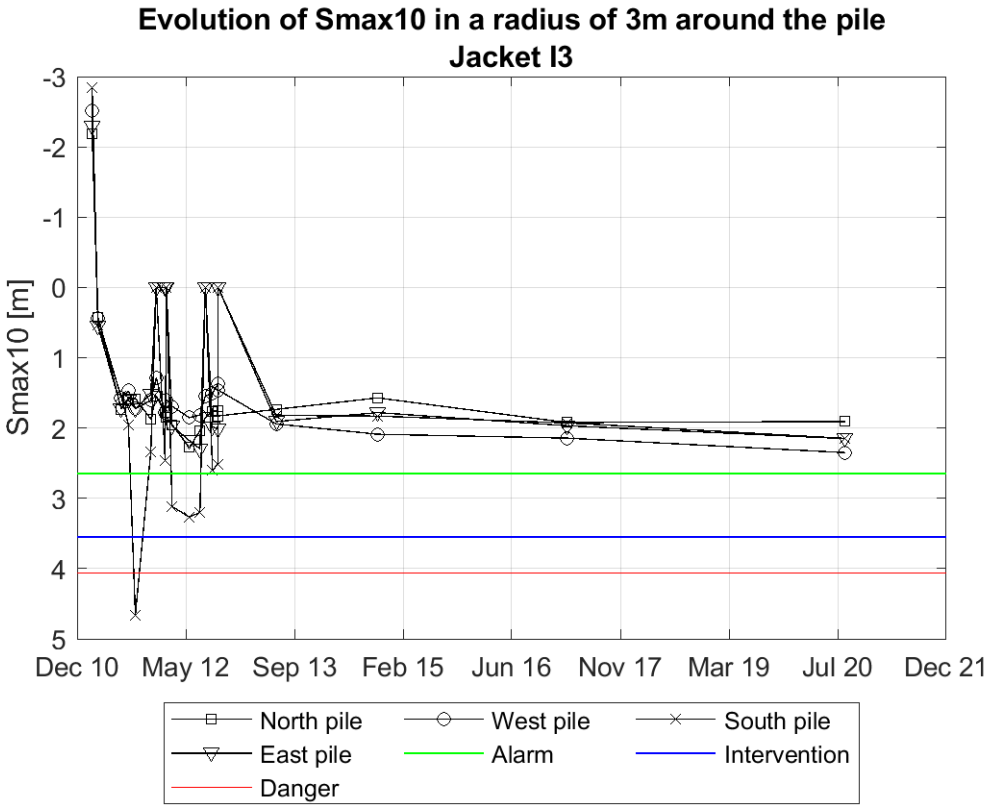


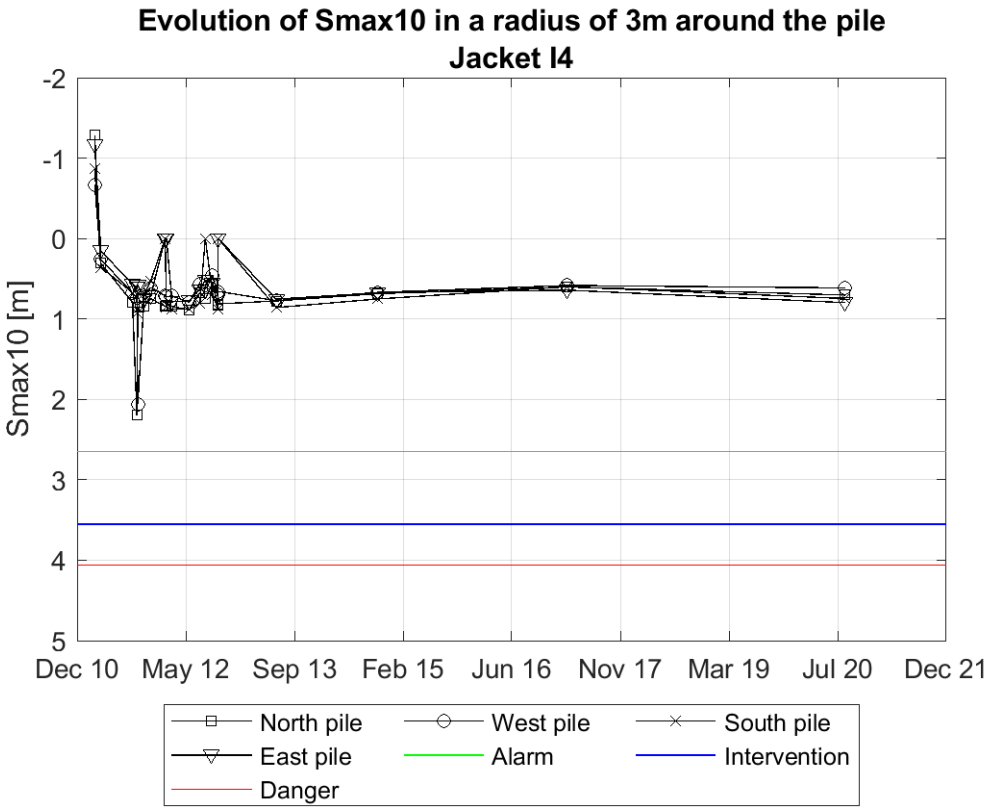


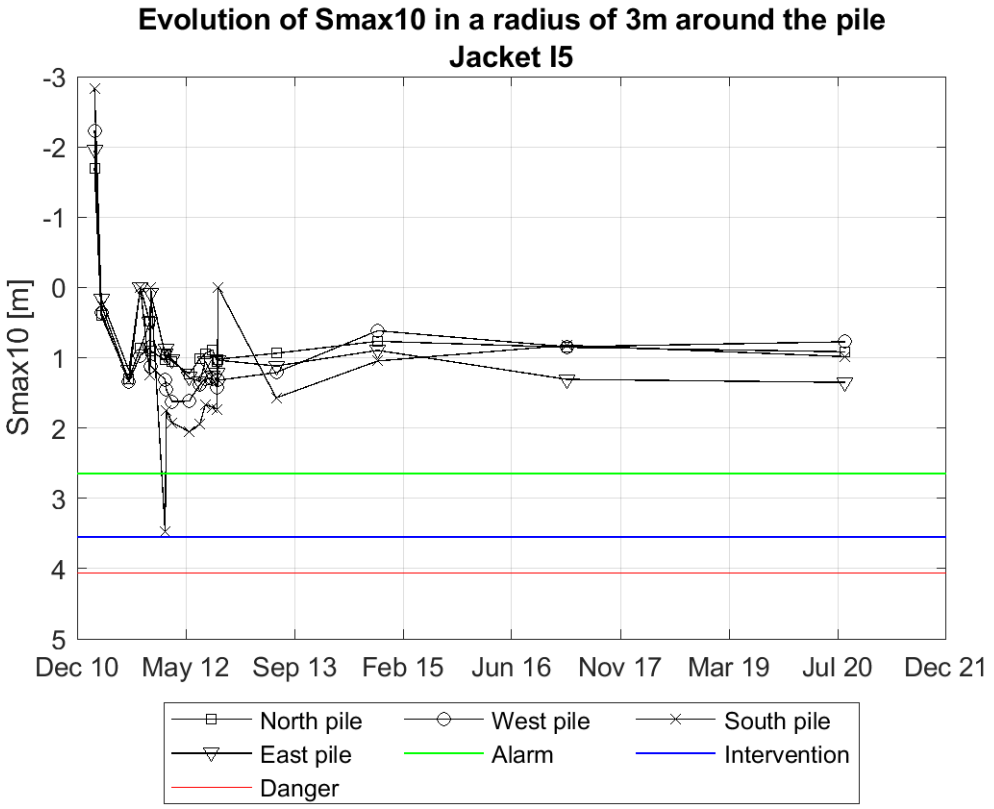


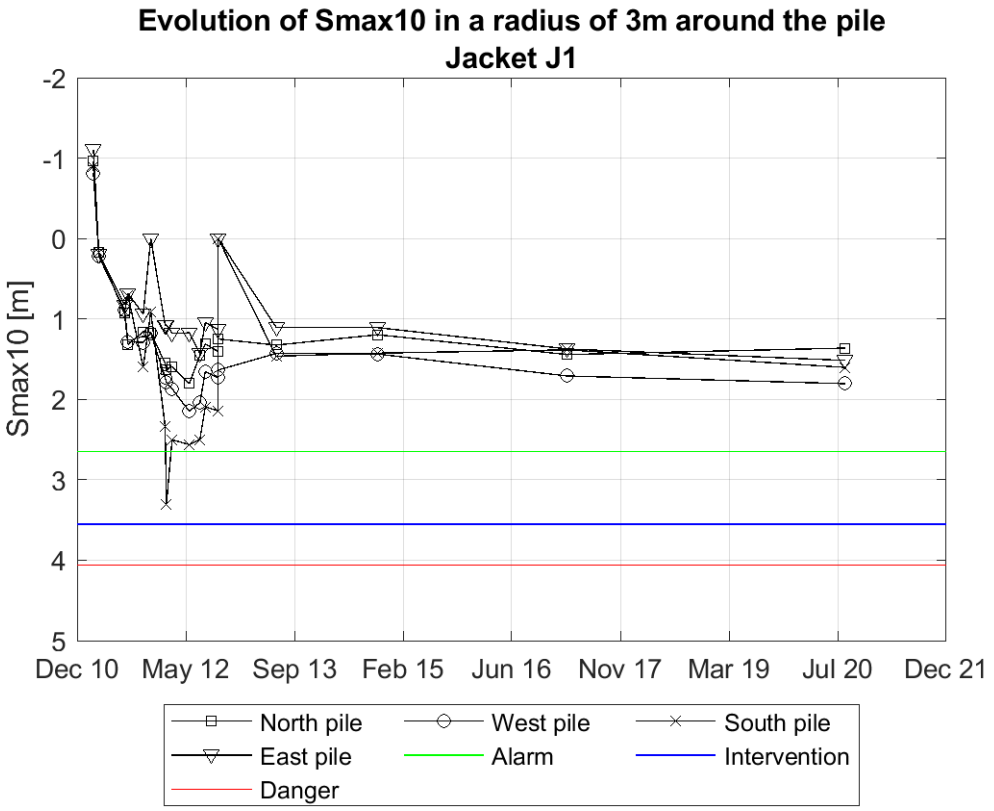


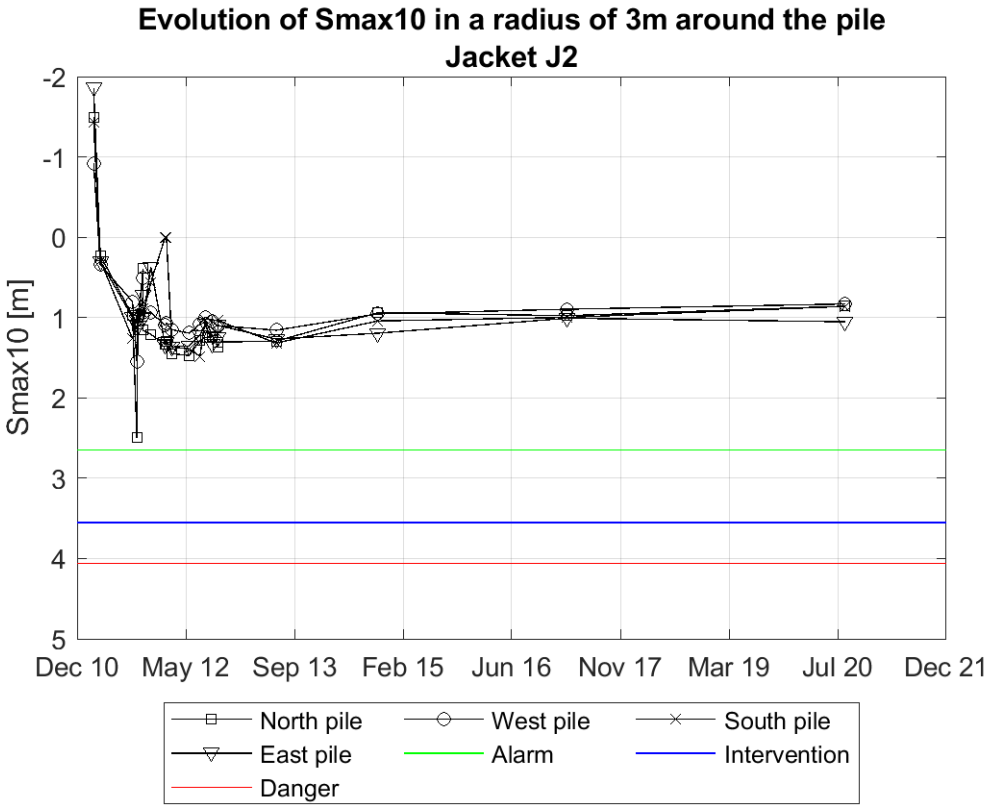












6.7 BURIAL ASSESSMENT – EXPORT CABLE A & B

C-Power - Wind Farm Thorntonbank

Burial Assessment 2020 - export cable A & B

C-Power

REPORT 17 December 20 - version 1.0

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Figure 4-35: Evolution of the Depth of Cover along the cable trajectory in zone B15 64

1 Introduction

The concession zone for C-Power's offshore wind farm at the Thornton bank is located at a distance of approximately 27 km from the coast. The wind farm (Phases 1, 2 and 3) contains 54 WTGs with a combined capacity of ca. 325 MW, and with an individual WTG capacity of 5 MW (Phase 1) and 6 MW (Phases 2 & 3) each. The wind farm is also equipped with one offshore transformer station (OTS). At the OTS the generated electrical power is transformed to 150 kV and transported to the onshore 150 kV grid system via two offshore 150 kV submarine power cables designated as export cable A (installed in 2008) and export cable B (installed in 2012).

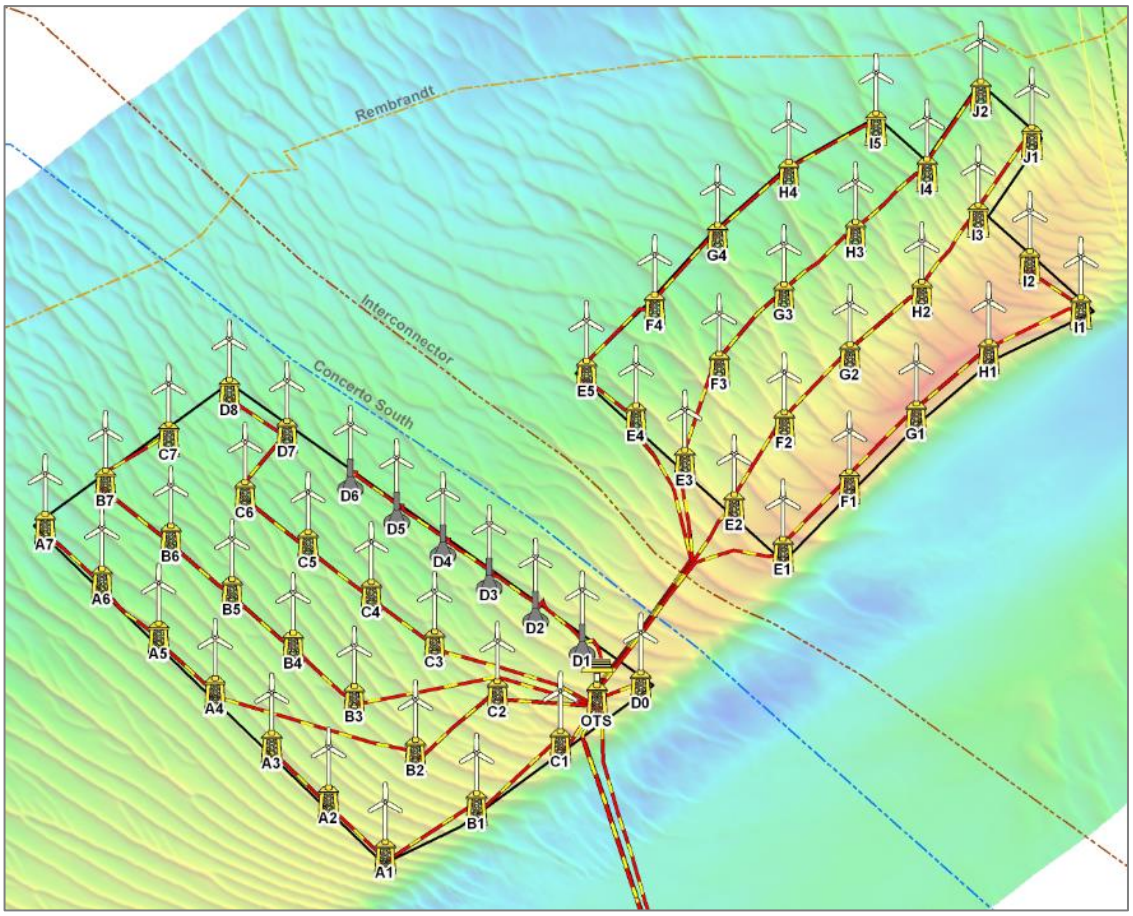

Figure 1-1: Location of C-Power's OWF project area.

1.1 The assignment

Upon completion of C-Power's wind farm, and in accordance with the permit requirements, stipulated in MD 14/04/04 Bijlage II 'Monitoring', 3.4.1, a yearly multibeam bathymetric monitoring campaign was set up to check the evolution of the seabed in the neighbourhood of the turbine locations, the offshore transformer station (OTS) and along the export cables. This yearly monitoring was required as mitigation measure to check if important changes in the seabed were observed that might jeopardize the structural stability of the foundations or the integrity of the export cables. Specific for the export cable trajectories a yearly multibeam monitoring and data analysis was performed to assess the depth of cover (DoC) of the cables along the entire trajectory.

After completion of the pilot project in 2009 (Phase 1), the monitoring campaign has been executed in the area of the six gravity based foundations and along the trajectory of export cable A. With the erection of 48 new wind turbines, the offshore transformer station (OTS) in Phase 2 & 3 and the installation of export cable B, the monitoring campaign was extended to these assets.

1.2 Scope of the report

In 2014, IMDC issued the Cable Burial Assessment Report (IMDC, 2014) for export cables A and B. In this report the latest multibeam survey data of September 2014 were analysed and reported towards the permitting authority (MUMM-BMM) as part of the monitoring obligations in the permit agreement. Based on the results of this analysis, it was decided that a new follow-up survey was only needed every 3 years.

Therefore, in 2017 a multibeam survey was executed and analysed in (IMDC, 2017). The present report provides the analysis of the results of the latest multibeam survey executed in 2020.

The analysis needs to profile the burial depth evolution in time. In the past, differences in burial depth between export cable A and export cable B were observed, since for export cable B the dunes were topped off and dredged before, while for export cable A this strategy was not applied. It is the aim of this report to assess the risk of large cable exposure due to dune movements, taking into account the trends that can be observed from multiple multibeam surveys executed over the past years. An overview of critical zones along the export cable route and expected evolutions is presented.

1.3 Reading guidance

Chapter 1 provides an introduction to the C-Power project and the aim of the study. In Chapter 2, the available data is discussed. A site description and the seabed morphology along the cable trajectory are elaborated in Chapter 3. Also the legal depth of cover (DoC), the installation strategy and the subdivision of the cable trajectory into cable zones is discussed in this chapter for both cables A and B. In Chapter 4, the available survey data is analysed. A first part of the analysis handles the actual depth of cover of both export cables A and B. In a second part, the evolution of the seabed along both cable trajectories is discussed based on recent and more historical surveys. The report is finalized with conclusions in Chapter 5.

2 Available data

2.1 As laid coordinates of the cable

The as-laid cable routes of export cable A and B are provided in the following documents:

- As-laid Cover Listing 150 KV Export A Cable October 2012 Rev 4;
- Cover list Export B Cable - combined GMSE-VSMC-THVS_rev12 August 2013 (THVS, 2013a).

2.2 Legal requirements

The information available on the building permits for the offshore 150 kV cables (2004, modified in 2005, prolonged in 2007) has been considered to determine the legal depth of cover (DoC) of the cables. The following legal documents apply:

- 040213-MB-Kabels in zee;
- 051012-MB-Kabels in zee-wijziging;
- 070223-MB-Kabels in zee-verlenging.

The following legal DoC requirements apply:

- A minimum DoC of **1 m** along the cable trajectory between KP 0.386 and KP 35.437 for cable A and between KP 0.000 and KP 35.432 for cable B;
- A minimum DoC of **4 m** along the cable trajectory at the crossing with the navigation route, **Vaargeul 1**, i.e. between KP 13.171 and KP 14.031 for Cable A and between KP 12.830 and KP 13.689 for Cable B;
- A minimum DoC of **2 m** along the cable trajectory at the crossing with the navigation route, **Aanloop Scheur**, i.e. between KP 19.090 and KP 19.954 for Cable A and between KP 18.820 and KP 19.730 for Cable B.

It is remarked that the requirements were imposed to the cable laying contractor and during the works as such targeted. Due to the selected cable laying technique and the encountered soil characteristics in the area of the crossing with the navigation route 'Aanloop Scheur' the target depth was not reached. This was already communicated during previous monitoring reports ((IMDC, 2009), (IMDC, 2010), (IMDC, 2011), (IMDC, 2012a), (IMDC, 2013)). After communication with the authorities it was agreed that the required depth of cover in this zone of the cable trajectory can be reduced to 1 m. This value is used in the performed depth of cover (DoC) evaluation.

2.3 Multibeam data

The analysis of the DoC is based on the as-laid position of the cables and a set of multibeam surveys performed between 2006 and 2017. Multibeam surveys were performed along the export cables A and B, before and after the installation of the cables.

Following data gathered along cable trajectory A are used for this analysis:

Table 2-1: Bathymetric survey data Export A

Year	Type of survey
October 2006	Pre-installation survey
March 2008	Pre-lay survey
June 2009	Post-installation survey
September 2010	Yearly monitoring survey
May 2011	Yearly monitoring survey
July 2012	Yearly monitoring survey
May 2013	Yearly monitoring survey
August/September 2014	Yearly monitoring survey
March 2017	Three-yearly monitoring survey
September 2020	Three-yearly monitoring survey

Following data gathered along cable trajectory B are used for this analysis:

Table 2-2: Bathymetric survey data Export B

Year	Type of survey
June 2010	Pre-installation survey
June 2011	Pre-installation survey
March 2012	Yearly monitoring survey
April 2012	Pre-lay survey
May 2013	Yearly monitoring survey
August/September 2014	Yearly monitoring survey
March 2017	Three-yearly monitoring survey
September 2020	Three-yearly monitoring survey

All data presented in this report are relative to TAW reference level.

3 Site description

3.1 General

This chapter focuses on the description of the local morphology in the project area and the identification of the main seabed morphologic characteristics which the two offshore export cables cross along their trajectory. This information is then used to define different zones along the cable trajectories with specific morphological and morphodynamic characteristics. It is remarked that since the cable A and cable B are installed more or less parallel to each other, the same zones can apply for both trajectories.

Figure 3-1 provides a general overview of the C-Power export cables A and B routing and the position of the major sandbanks along the cable trajectory. Sandbank characteristics as described in section 3.3 are taken from the available literature.

The cable trajectories for cable A and B are described by means of kilometre points (KP's). The KP (kilometre point) "zero" is the OTS for export B. For export cable A, the OTS corresponds to KP 0.386. This is because the export A has been rerouted in 2012 (see chapter 3.4.1) after first being connected with WTG position D1 during Phase 1 of the project. KP "zero" and KP for the landfall (exit point of the HDD at the beach) are given in Table 3-1.

Table 3-1: Cable KPs for export cables A and B

Cable	From KP (OTS)	To KP (HDD exit point)
Export A	0.386	35 437
Export B	0.005	35 432

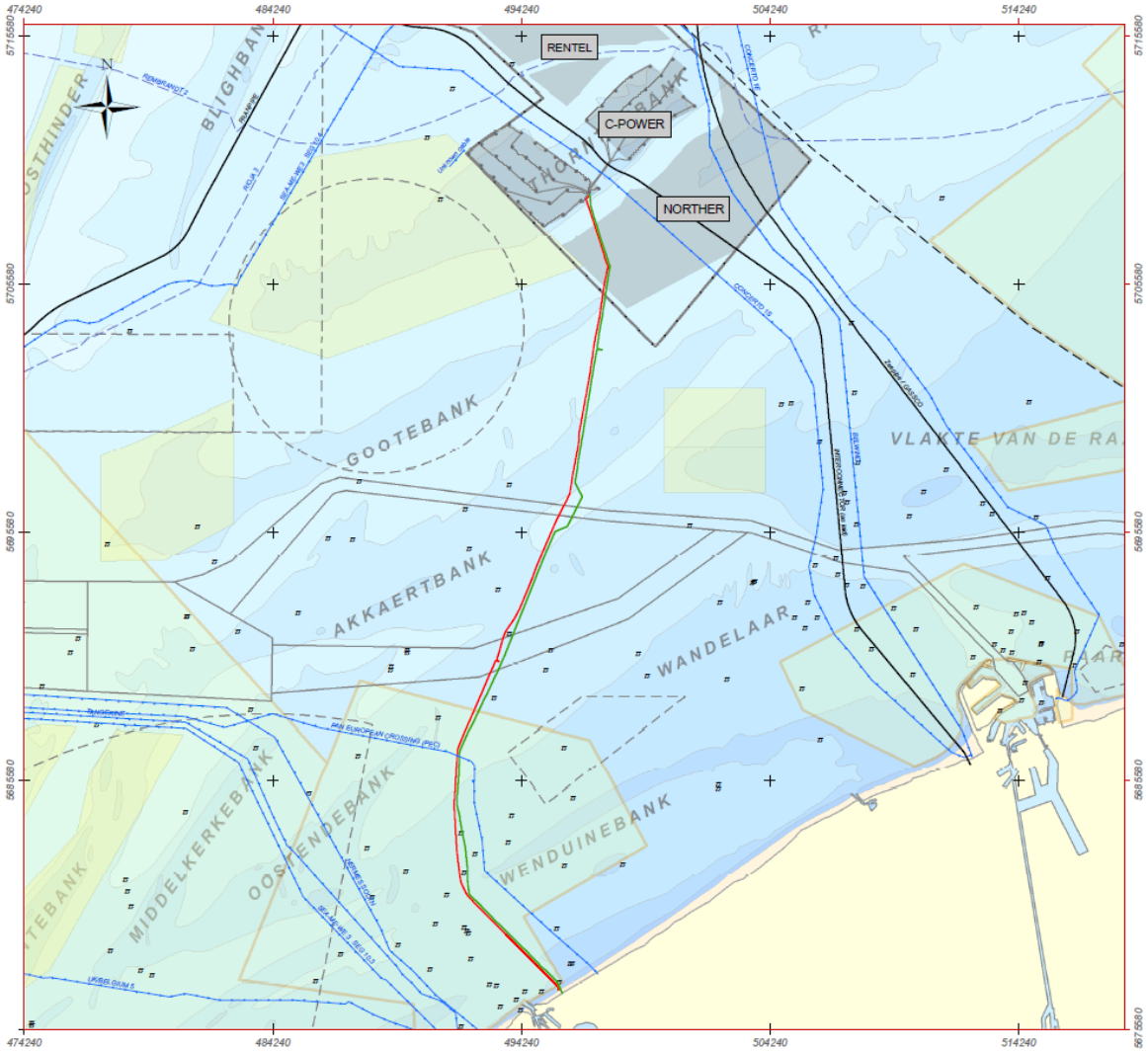

Figure 3-1: Export cable A (red) & B (green) trajectories from project area to shore.

3.2 Sandbanks and sand dunes classification

The seabed along the cable trajectories is characterised by the presence of a number of morphological features, i.e. large sandbanks, sand dunes, ripples,… In order to characterise the different zones along the cable trajectory, the morphological features first are defined.

The bottom of the North Sea along the cable trajectories might be shallow but it is not flat. Under the surface of the water lie hills of sand: the sandbanks. Off of the Belgium coast, they are so close together that they form their own landscape. They differ in height, width and length, but all lie parallel or at a small angle to the coastline. According to (Dyer and Huntley, 1999) these sandbanks are defined as 'tidal banks – open shelf linear sandbanks'. The sandbanks along the cable trajectory are the Thornton bank, the Goote bank, the Akkaert bank and a nameless large-dune field situated between the two branches of the navigation channels "Vaargeul 1" and "Aanloop Scheur".

Under the influence of tidal currents, the sediments form remarkable patterns on top of the sandbanks. Those bedforms are called small-, medium-, large dunes or ripples according to their size. Usually they are perpendicular to the direction of the net present flow. In Figure 3-2, a current rose based on measurements on the Thornton bank is given. As can be seen, the main current directions are NE and SW (~perpendicular do the direction of the dune crests on top of the sandbanks).

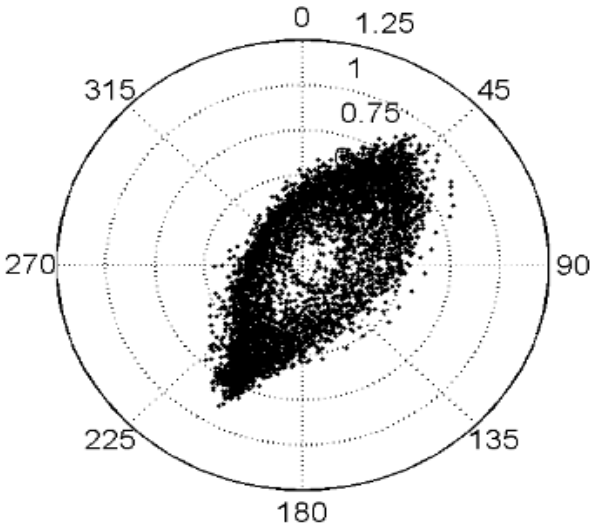

Figure 3-2: Current rose measured on the Thornton bank

Though there is no unique classification of bedforms in the literature, the generally accepted classification presented in Table 3-2 defines the different bedforms in terms of dimensions (Ashley, 1990).

Table 3-2: Characteristics of bedforms present on top of banks according to (Ashley, 1990)

	Ripples	Small dunes	Medium dunes	Large dunes	Very large dunes
Amplitude (m)	< 0.075	0,075 - 0,4	0.4 - 0.75	0.75 – 5	> 5
Wavelength (m)	< 0.6	0.6 - 5	5 - 10	10 – 100	> 100

The size of ripples of which the dimensions change at a short time scale (tidal cycle), is controlled by water depth and grain size but the causes of their presence in the southern North Sea and their dynamics are not well understood and still make the subject for further research.

In deep water, dune growth is not limited by water depth. Dunes will continue to grow in response to increases in mean flow velocity until the critical suspension threshold for a given grain size is reached.

Since critical suspension thresholds increase with increasing grain size, maximum dune size must increase with increasing grain size.

Storms have been shown to significantly affect sand dune heights in water depths of up to 20 m and more. The building up of the sand dune takes particularly place in summer when metocean conditions are gentler.

3.3 Cable route and seabed Morphology

For a detailed discussion of the morphological features along export cable A, it is referred to the basis of design (IMDC, 2006). For ease of reference the main items are repeated in this section and illustrated on the figure below. It should be noted that export B is characterized by similar morphological features as its route is parallel to export A, shifted approximate 100 m East.

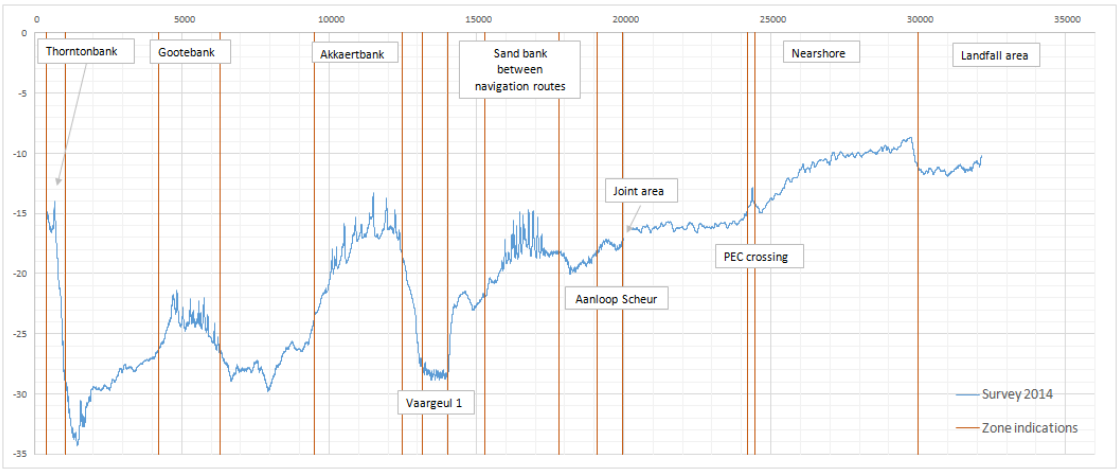

Figure 3-3: General cross section along the cable trajectory A

Both the start points of cable A and B are located at the southern border of the Thornton bank. Although depths gradually decrease towards the shore, numerous shallow and deeper areas are crossed. Three shallow areas, i.e. the sandbanks, covered with very large dunes (>5m), large dunes, medium dunes, small dunes and ripples are crossed: the Goote bank, the Akkaert bank and a nameless large-dune field situated between the two branches of the navigation channels "Vaargeul 1" and "Aanloop Scheur". These dunes are mobile over the project's lifetime, while it is expected that the sandbanks themselves remain more or less stable during the lifetime of the project, except the steeper flanks

The **Thornton bank** lies with its SW end 3 km SE of the Southern end of the Bligh Bank. It extends NE for 21.5 km and has a minimum depth of 4.6 m (National Geospatial-intelligence Agency, 2006).

According to (Stride, 1982), large sand dunes (with a height of more than 1 m) are present anywhere on the tidal shelves where there is an abundant sand supply. Those areas show near-surface tidal currents over 0.65 m/s. They appear as a separate class of bedforms, distinct from "small sand dunes" (= mega ripples, small dunes). Their distinctness may be expressed by the wavelength to height ratio, which for large sand dunes ranges generally from 10 to 100. Large sand dunes also stand out by their cross-section. Locally the sand dunes on the Thornton bank can be classified as very large dunes, i.e. larger than 5 m. The steepest slopes are mostly less than 20°, whereas small sand dunes have lee slopes most often greater than 20°.

The **Goote bank** has a relatively flat profile with several sand dunes at the surface which vary in height, from large to medium dunes. The Goote bank has an area of 38 km², is located 22 km from the coast at a water depth of 13-20 m (Van Hulle et al., 2004). It has, according to (Le Bot *et al.*, 2005), only a limited Quaternary cover, as it is located on a broad Tertiary ridge. The Goote bank is characterized by large dunes with heights up to 2 m. A migration of the dunes towards the north-east is known from the

available literature. The flanks of the bank are not subject to any significant erosion or deposition.

The **Akkaert bank** is located around 10-15 km from the Belgium coast. The bank is characterized by a series of northwest-southeast orientated ridges. At the Akkaert bank medium sized dunes with an amplitude of about 0.40 m cross the cable trajectory. On the Akkaert bank the smaller dunes and ripples mainly exist on top of the medium sized dunes. Apart from the large hydraulic sand dunes that are also found at the Thornton bank and described in (IMDC, 2006), following bed form types are encountered along the cable trajectories:

- "type 1" medium dunes: small hydraulic dunes with remarkably straight crest lines in plan view. They are typically a few decimetres high (less than 1 m) and spaced 10 to 20 m. The hydraulic conditions for development of type 1 medium dunes are not known. Type 1 medium dunes are believed to indicate intense, daily tidal sand transport;
- "type 2" medium dunes: small hydraulic dunes with slightly sinuous, bifurcating crests. They are typically a few decimetres high (lower than type 1 small dunes) and spaced 5 to 15 m. The exact hydraulic conditions needed for development of type 2 medium dunes are not known. Type 2 medium dunes are believed to indicate intense, daily tidal sand transport. The smaller crest distance might be linked to transport rates that are slightly less than in the case of type 1 medium dunes. Their different plan shape might be due to a more complex surrounding morphology, generating 3D disturbances in the overall near-bed tidal flow;
- "type 3" small dunes: small hydraulic dunes with relatively large crest separations (10 to 20 m) but small crest heights (5 to 20 cm). It is believed that type 3 small dunes are moribund bed features, i.e. they were formerly type 1 or 2 medium dunes but are not active at the moment of sounding and have gone through a phase of degeneration in the days before the survey. As such, they are found in areas with occasional (wind or wave enhanced) tidal sand transport;
- Relatively flat seabed indicates presence of:
    - Muddy sand or mud. Small and large dunes only form in loose sand;
    - Fine sand in channels or deep areas. Bottom stress is insufficient here to generate dunes;
    - Shallow areas, where wave action wipes out any existing dunes.

The main navigation channel Vaargeul I is crossed by both cables A and B. Historic data are scarce and their evolution is not unequivocal. No change in depth could be inferred. This channel is subject to maintenance dredging when the free draught is menaced. Also the navigation channel Aanloop Scheur is crossed by the cables A and B.

3.4 Installation strategies

3.4.1 Export A installation phases

Export cable A was installed in 2008. The cable was installed by ploughing into the sea bottom. Due to an incident during the installation phase, it was needed to execute an Omega joint between KP_A 20.000 and KP_A 20.300. The joint area has local KPs.

Initially the export cable A was connected offshore to the GBF D1. In May-June 2012, this cable was cut in between D1 and the Offshore Transformer Station (OTS). Directly after, the 150 kV cable was picked-up and re-routed towards the OTS. Between the surveys of July 2012 and May 2013, in autumn 2012, burial works took place for the rerouted part between KP 0.386 (OTS) and KP 0.732. In January 2013,

the zone between KP 0.890 and KP 0.950, was subject to remedial rock dump cause of decreasing depth of cover of the cable due to erosion at the southern flank of the Thornton bank.

Export cable A crosses the "Vaargeul 1" navigation channel between KP 13.171 and KP 14.031. The cable crosses the "Aanloop Scheur" navigation route between KP 19.090 and KP 19.954.

Export cable A crosses the PEC Telecom cable from KP 24.200 – KP 24.475 and a rock dump is present in this area.

3.4.2 Export B installation phases

Export cable B was installed in 2012. Before laying the cable, the dunes and areas with hard soil were pre-swept and pre-dredged (see Table 3-3). These zones were defined based on a study of the seabed mobility along cable trajectory B, performed in 2012 (IMDC, 2012b). In order to have sufficient burial depth, backfilling of the dredged areas was foreseen. In the other areas the cable was laid onto the seabed and buried by ROV jetting.

Table 3-3: Pre-sweeping and pre-dredging areas along export B

From KP	To KP	Description
0.224	6.345	Pre-sweeping, pre-dredging and backfilling
9.300	19.783	Pre-sweeping, pre-dredging and backfilling

The export cable had to be repaired end of 2012 due to an incident during the cable burial operations. An Omega joint was executed between KP_B 6.435 and KP_B 6.947. The joint area has local KPs.

In January 2013, the repair zone was covered with rocks (Design 1, see (THVS, 2013b)). The Contractor made a technical note regarding this topic with the statement that a rock cover of 60 cm provides equivalent protection to the cable as a sand burial of 1 m (THVS, 2013c).

At the same time, some zones with insufficient depth of cover were treated (Design 2 and 3) (see Table 3-4) and a rock protection was installed.

Table 3-4: Pre-sweeping, pre-dredging areas and cables sections with rock protection installed

From KP	To KP	Rock dumping design
6.320	8.620	Design 1
6.320	6.435	Design 1
0.000 (KP6.435)	0.850 (KP6.947)	Design 1 (Joint area)
6.947	7.300	Design 1
7.300	8.270	Design 2 or 3
8.270	8.620	Design 1
8.980	9.087	Design 2 or 3
9.188	9.240	Design 2 or 3
31.080	31.472	Design 2 or 3
31.675	31.830	Design 2 or 3

Export cable B crosses the "Vaargeul 1" navigation channel between KP 12.830 and 13.689. The cable crosses the "Aanloop Scheur" navigation route between KP 18.820 and 19.730.

Export cable B crosses the PEC Telecom cable from KP 24.620 till KP 24.700. Also for this crossing, a rock dump is installed.

3.5 Cable trajectory "zones"

Based on information regarding the seabed morphology and installation strategies (chapter 3.3 and 3.4), the cable routes have been divided in characteristic "zones".

These cable "zones" are identified in Table 3-5 and Annex A for export cable A and in Table 3-6 and Annex B for export cable B.

Table 3-5: Export Cable A - trajectory "zones"

Cable "zone"	Characteristic	From KP	To KP	Target DoC (m)
A1	Thornton bank	0.386	1.050	1.0
A.1.1	*Thornton bank – Natural seabed*	*0.386*	*0.890*	*1.0*
A.1.2	*Thornton bank – Rock dump*	*0.890*	*0.950*	*0.6*
A.1.3	*Thornton bank – Natural seabed*	*0.950*	*1.050*	*1.0*
A2	Swale – TB/GB	1.050	4.200	1.0
A3	Goote bank	4.200	6.300	1.0
A4	Swale – GB/AB	6.300	9.500	1.0
A5	Akkaert bank	9.500	12.500	1.0
A6	Swale – AB/VG1	12.500	13.171	1.0
A7	Navigation channel - "Vaargeul 1"	13.171	14.031	4.0
A8	Swale – VG1/SB	14.031	15.300	1.0
A9	Sand dune area between navigation routes	15.300	17.800	1.0
A10	Swale – Sand dune area / Aanloop Scheur	17.800	19.090	1.0
A11	Crossing "Aanloop Scheur"	19.090	19.954	1.0
A12	Swale – Aanloop Scheur / PEC	19.954	24.200	1.0
A12.1	*Aanloop Scheur – Joint area*	*19.954*	*20.000*	*1.0*
A12.2	*Joint area (local KP)*	*0 (KP 20.000)*	*0.521 (KP 20.300)*	*1.0*
A12.3	*Joint area until PEC crossing*	*20.300*	*24.200*	*1.0*
A13	PEC crossing – Rock dump	24.200	24.475	0.6
A14	Nearshore	24.475	30.000	1.0
A15	Landfall area	30.000	35.437	1.0

Table 3-6: Export Cable B - trajectory "zones"

Cable "zone"	Characteristic	From KP	To KP	Target DoC (m)
B1	Thornton bank	0.000	0.900	1.0
B2	Swale – TB/GB	0.900	3.500	1.0
B3	Goote bank	3.500	6.320	1.0
B4	Swale – GB/AB	6.320	8.620	1.0
B4.1	*Rock dump - Design 1*	*6.320*	*6.435*	*0.6*
B4.2	*Joint area (local KP) - Rock dump - Design 1*	*0.000 (KP6.435)*	*0.850 (KP6.947)*	*0.6*
B4.3	*Rock dump - Design 1*	*6.947*	*7.300*	*0.6*
B4.4	*Rock dump – Design 2/3*	*7.300*	*8.270*	*0.6*
B4.5	*Rock dump - Design 1*	*8.270*	*8.620*	*0.6*
B5	Akkaert bank	8.620	12.720	1.0
B5.1	*Natural seabed*	*8.620*	*8.980*	*1.0*
B5.2	*Rock dumping design 2/3*	*8.980*	*9.087*	*0.6*
B5.3	*Natural seabed*	*9.807*	*9.188*	*1.0*
B5.4	*Rock dumping design 2/3*	*9.188*	*9.240*	*0.6*
B5.5	*Natural seabed*	*9.240*	*12.720*	*1.0*
B6	Swale AB/VG1	12.720	12.830	1.0
B7	Navigation channel - "Vaargeul 1"	12.830	13.689	4.0
B8	Swale – VG1/SB	13.689	15.720	1.0
B9	Sand dune area between navigation routes	15.720	18.500	1.0
B10	Swale – Sand dune area / Aanloop Scheur	18.500	18.820	1.0
B11	Crossing "Aanloop Scheur"	18.820	19.730	1.0
B12	Swale Aanloop Scheur / PEC	19.730	24.620	1.0
B13	PEC Crossing – rock dump	24.620	24.700	0.6
B14	Nearshore	24.700	30.200	1.0
B15	Landfall	30.200	35.432	0.6
B15.1	*Landfall – Natural seabed*	*30.200*	*31.080*	*1.0*
B15.2	*Landfall - Rock dumping design 2 or 3*	*31.080*	*31.472*	*0.60*
B15.3	*Landfall – Natural seabed*	*31.472*	*31.675*	*1.0*
B15.4	*Landfall - Rock dumping design 2 or 3*	*31.675*	*31.830*	*0.6*
B15.5	*Landfall area*	*31.830*	*35.432*	*1.0*

4 Survey data analysis

4.1 Actual Depth of cover

4.1.1 Export Cable A

In this section, the actual depth of cover (DoC), based on the survey results of 2020 along the 150 kV export cable A is discussed and compared with the DoC in 2017 and 2014. The xy coordinates and the top of the as laid cable are taken from the information described in chapter 2 and 3.4.1. Based on these levels, the DoC is calculated, assuming the DoC is equal to the difference between the as laid top of the cable and the seabed level measured by means of the multibeam survey.

The export cable A was rerouted in May 2012. Previously, the 150 kV cable had a direct connection with the D1 turbine. In May-June 2012, this cable was cut in between D1 and the Offshore Transformer Station (OTS). Directly after, the 150 kV cable was picked-up and re-routed towards the OTS.

Between the surveys of July 2012 and May 2013 - in autumn 2012 - burial works took place for the rerouted part between KP 0.386 (OTS) and KP 0.800. In January 2013 the zone between KP 0.890 and KP 0.950, was subject to remedial rock dump. Also in the area of the PEC crossing from KP 24.200 till KP 24.475 a rock dump is present.

Results are presented in Annex C with one plot per km. The zone of the joint area (between KP 20.000 and KP 20.300) is shown at the end. Note that the joint area has local KPs.

Based on the multibeam measurements of March 2017 and September 2020, following observations can be made:

- Between KP 0.386 and KP 1, the cable is located on the southern border of the Thornton bank. The influence of a moving sand dune (on top of the Thornton bank) on the DoC is clearly visible. The dune present in this area has the tendency to move towards the crest of the Thornton bank when the survey of March 2017 is compared to the one of September 2020.
  This leads to a slight lowering of the seabed level from ~KP 0.70 till KP 0.80 and an increase of the seabed level from ~KP 0.58 till ~KP 0.66 and from ~KP 0.80 till ~KP 1.50. Fluctuations in the order of magnitude of ~0.5 m are observed. At some distinct locations the actual DoC is locally lower than the legal DoC.
- A remedial rock dump was placed between KP 0.890 and KP 0.950. Based on the discussed surveys it can be said that the rock dump is stable and the DoC on the cable is sufficient.
- Between KP 1.000 and 2.000, the cable is located in the swale between the Thornton bank and the Goote bank. When comparing the two surveys, erosion seems to alternate with accretion. At some locations near the boundary of the safety distance zone, the actual DoC is lower than 1.0 m.
- Between KP 2.000 and 4.000, the cable is still located in the swale between the Thornton bank and the Goote bank. Based on the last two surveys the seabed and thus the DoC remained stable. Two dune crests of 2 m height are visible at ~KP 2.50 and at ~KP 3.45.
- The area between KP 4.0 and KP 7, is located at the Goote bank and is characterised by moving sand dunes. The dune tops do not show a tendency to move in one single direction based on the two discussed surveys. Areas with seabed lowering and seabed rising alternate. It can be noted a significant increase of the cable burial depth around KP 5.34, 5.59 and KP 5.72 due to the formation of isolated dune crest of even 3 m height.
- From KP 7.000 till KP 10.000 the cable is located in the swale between the Goote bank and the Akkaert bank. The seabed level remains overall stable between March 2017 and September 2020.
- On the Akkaert bank, between KP 10.000 and KP 12.000 moving sand dunes are present. However, the difference in seabed level between March 2017 and September 2020 is in general not significant

(order of magnitude of 0.20 m). The actual DoC is due to the moving dune tops at some locations lower than 1.0 m.

- From KP 12.000 till KP 13.000 the seabed and the DoC remain relatively stable based on the surveys from March 2017 and September 2020.
- Between KP 13.171 and KP 14.031, the cable crosses the navigation channel 'Vaargeul I'. A tendency of accretion exists in the navigation channel. Between 2017 and 2020, the seabed level and thus the DoC have remained stable.
- South of crossing the navigation channel, the cable crosses a swale area from ~KP 14.000 till KP 15.000. Again this swale area can be characterised by a stable seabed based on the surveys form March 2017 and September 2020.
- Between KP 15.000 and KP 18.000, the cable crosses the large nameless dune field between the navigation channels 'Vaargeul I' and 'Aanloop Scheur'. Based on the surveys from March 2017 and September 2020, it can be observed that the dune tops have moved towards the navigation channel 'Vaargeul I', so in NW direction. Seabed changes up till ~1.0 m are measured at some local points (in general located in the vicinity of dune tops). In between dune tops the seabed varies to a smaller extent. Due to the movement of the dune tops, the DoC of the cable is sometimes less than 1.0 m.
- The cable crosses another deeper area between KP 18.000 and 19.000. As in the other swale areas, the seabed has remained stable.
- The cable crosses the 'Aanloop Scheur' channel shipping lane between KP 19.090 and KP 19.954. The seabed level remained stable between 2017 and 2020, although a sedimentation trend can be noted (~0.1 m).
- From KP 20.000 till KP 24.000, the seabed has remained stable although a sedimentation trend (between 0.1 m and 0.2 m) can be noted. A dune crest is noted in 2020 around KP 22 while in 2017 the seabed was almost flat.
- The joint area (with local KP's and located between KP 20.0 and KP 20.3) is recognized by sedimentation (~0.3 m) in a stable environment.
- From KP 24.200 till KP 24.475, the PEC telecom cable is crossed. The installed rock dump is stable.
- Shoreward, between KP 24.475 and 30.000, the seabed remained stable in between March 2017 and September 2020.
- In the near shore part of the cable, running from KP 24.475 till KP 30.000, the seabed remained stable in between March 2017 and September 2020, although several small dunes can be noted (with the height ranging between 0.1 m and 0.2 m), which make the seabed profile more irregular when compared to the one resulting from the survey carried out in March 2017.
- From KP 30.000 till KP 35.437 in the landfall area, the seabed remained stable in between March 2017 and September 2020. Alternating local zones of erosion and sedimentation (~0.2 m) are found.

Referring to the longitudinal profiles based on the survey from September 2020 in Annex C, following conclusions can be drawn related to the actual DoC:

- Table 4-1 lists the areas within the cable zones, with a minimum length of 10 m where the average DoC over the area is smaller than the 1 m target DoC . The analysis shows that 23 of such areas are identified. The length of the respective areas (> 10 m) is given, together with the average DoC over the respective areas (< 1.0 m) and the minimum DoC found per area.
- As can be observed, the majority of the areas, i.e. 17 out of 23, with a DoC lower than the required DoC are located in cable zones where mobile sand dunes are present (i.e. A1, A5 and A9). Areas located in swales, i.e. only 6 out of 23 (e.g. cable zone A2 and A11) and in the zone where the cable crosses the navigation channel 'Aanloop Scheur' are characterised by small reduction of the required DoC in those areas.
- The cable is exposed at two location, located at KP 17.077 and KP 17.206 (mobile sand dune area between the navigation routes). It should be noted that this is a very local phenomena.

In Annex D, a map with an indication of the zones from Table 4-1 can be found.

In order to filter out the areas where the average DoC is only slightly below 1.0 m, the same exercise has been repeated with a target DoC equal to 0.8 m. Table 4-2 lists the areas within cable zones, with a minimum length of 10 m, where the average DoC over the area is smaller than the target DoC minus 0.20 m. The analysis results in 13 of such areas. The length of the respective areas (> 10 m) is given, together with the DoC over the respective areas (< 0.8 m) and the minimum DoC found per area. Also the total length of the cable zone in which the area is located is given.

All identified areas are situated in cable zones with mobile sand dunes. Although some areas with an observed DoC below the target DoC are found, they represent in total only a small part of the total cable length (1.44%).

In Annex E, a map with an indication of the zones from Table 4-2 can be found.

Table 4-1: Zones along cable trajectory A with a length of minimum 10 m where the average DoC is lower than the target DoC (1.0 m)

Zone nr.	Area	From KP	To KP	Total length [m]	Average DoC [m]	Min. DoC [m]	Area Length [m]	Percentage of area length [%]
A1	Thornton Bank	0.535	0.558	24	0.72	0.55	664	3.61
		0.732	0.75	19	0.86	0.75	664	2.86
		0.756	0.776	21	0.79	0.54	664	3.16
		0.777	0.796	20	0.79	0.6	664	3.01
		1.003	1.049	47	0.67	0.48	664	7.08
A2	Swale – TB/GB	1.050	1.064	15	0.75	0.58	3150	0.48
		1.066	1.080	15	0.56	0.15	3150	0.48
		1.106	1.119	14	0.89	0.79	3150	0.44
A5	Akkaert bank	10.097	10.117	21	0.52	0.06	3000	0.70
		10.241	10.254	14	0.59	0.4	3000	0.47
		10.509	10.526	18	0.57	0.33	3000	0.60
		12.239	12.255	17	0.84	0.64	3000	0.57
A9	Sand dune area between navigation routes	15.969	15.983	15	0.93	0.81	2500	0.60
		16.282	16.292	11	0.93	0.86	2500	0.44
		16.359	16.374	16	0.66	0.55	2500	0.64
		16.672	16.688	17	0.82	0.65	2500	0.68
		16.921	16.964	44	0.55	0.06	2500	1.76
		16.988	16.999	12	0.92	0.87	2500	0.48
		17.071	17.139	69	0.40	-0.3	2500	2.76
		17.194	17.224	31	0.35	-0.46	2500	1.24
A11	Crossing "Aanloop Scheur""	19.311	19.325	15	0.94	0.89	864	1.74
		19.326	19.347	22	0.97	0.92	864	2.55
		19.586	19.597	12	0.95	0.9	864	1.39
Total				**35437**				**1.44**

Table 4-2: Zones along cable trajectory A with a length of minimum 10 m where the average DoC is lower than the target DoC – 0.20 m (0.80 m)

Zone nr.	Area	From KP	To KP	Total length [m]	Average DoC [m]	Min. DoC [m]	Area length	Percentage of area length [%]
A1	Thornton Bank	0.537	0.556	20	0.68	0.55	665	3.01
		0.764	0.773	10	0.65	0.54	665	1.50
		0.782	0.792	11	0.70	0.6	665	1.65
		1.006	1.035	30	0.59	0.48	665	4.51
A2	Swale – TB/GB	1.050	1.060	11	0.69	0.58	3151	0.35
		1.068	1.079	12	0.48	0.15	3151	0.38
A5	Akkaert bank	10.099	10.116	18	0.46	0.06	3001	0.60
		10.242	10.253	12	0.54	0.4	3001	0.40
		10.51	10.525	16	0.52	0.33	3001	0.53
A9	Sand dune area between navigation routes	16.360	16.373	14	0.62	0.55	2501	0.56
		16.922	16.964	43	0.54	0.06	2501	1.72
		17.072	17.124	53	0.26	-0.3	2501	2.12
		17.195	17.223	29	0.31	-0.46	2501	1.16
Total				**35437**				**0.79**

4.1.2 Export Cable B

In this section, the evolution of the seabed levels between 2017 and 2020 above the export cable B and the Depth of Cover (DoC) along the export cable B are discussed. Before laying cable B, the dunes and areas with hard soil were subject to pre-sweeping in order to ascertain sufficient burial depth in the mobile dune areas during the cable's life span. In other areas the cable was installed by first laying it onto the seabed and secondly ROV jetting.

The export cable was laid in April 2012, but had to be repaired end of 2012. Afterwards in January 2013, the repair zone was covered with rocks. At the same time, some zones with insufficient DoC were treated. The Contractor provided a technical note regarding this topic with the statement that a rock cover of 60 cm is equivalent to a sand burial of 1 m. (THVS, 2013b). The xy-coordinates and the top of the as laid cable are taken from the information described in chapter 2 and 3.4.2. Results are presented in Annex F with one plot per km. The zone of the joint area (between KP 6.435 and KP 6.947) is shown at the end. Note that the joint area has local KPs.

Given the soundings of March 2017 and September 2020 following observations can be made:

- From KP 0.000 till KP 1.000, the cable is located at the southern border of the Thornton bank. This area is characterized by dune tops moving in the direction of the Thornton bank. Fluctuations in the order of magnitude of ~0.5 m are observed. Due to the installation method (dredging into the dunes and backfilling) no problems with the DoC are expected in this dune area.

- From KP 1.000 till KP 3.000, the cable is located in a swale between the Thornton bank and the Goote bank. The seabed is stable in this area. When comparing the two surveys, accretion seems more prominent than accretion. At some locations the actual DoC is lower than 1.0 m
- From ~KP 3.000 till KP 6.000, the cable crosses the Goote bank. The Goote bank is characterised by mobile sand dunes. Seabed level changes in the order of magnitude of ~3 m are observed in correspondence of sand dunes crests. In this area no problems with the DoC are recorded due to the installation strategy of cable B in mobile dune areas.
- Between KP 6.000 and KP 8.000, the cable crosses a swale located between the Goote bank and the Akkaert bank. The joint area from KP 6.435 till KP 6.947 is treated with a rock dump and is relatively stable. However, local displacement of rocks is observed in this area between 2017 and 2020. Furthermore also the areas between KP 6.320 till KP 6.435, between KP 6.947 till KP 7.300, between KP 7.300 till KP 8.270 and between KP 8.270 till KP 8.620 were treated with remedial rock dump and have remained stable in between March 2017 and September 2020.
- From ~KP 8.000 till ~KP 13.000, the cable crosses the Akkaert bank. This area is characterised by mobile sand dunes. Remedial rock dump has been placed from KP 8.980 till KP 9.087 and from KP 9.188 till 9.240. The rock dump seems to be sufficient and stable. Also in the other areas, the DoC on top of the cable is sufficient due to the installation method of the cable.
- Between KP 12.830 and KP 13.689, the navigation channel 'Vaargeul I' is crossed. A slight trend of accretion exists in the navigation channel. However, no large changes in the seabed level are measured between March 2017 and September 2020.
- From KP 13.689 till KP 15.720 a swale is present. The seabed is fairly stable in this zone.
- The large dune field in between the navigation channels between KP 15.720 and KP 18.500 is characterized by seabed fluctuations. The dune tops have the tendency to move towards the navigation channel 'Vaargeul I'. Due to the installation strategy of cable B, no problems with the DoC occur.
- From KP 18.820 till KP 19.730, the navigation channel 'Aanloop Scheur' is crossed. A trend of accretion (~0.2 m) is present in the navigation channel. However, the seabed has remained relatively stable.
- After crossing the navigation channel, the cable passes another swale area between KP 19.730 and KP 24.620. The seabed level is stable in this area based on the March 2017 and September 2020. The top of dune, 2 m height, is noted around ~KP 21.95.
- The rock dump around the PEC crossing from KP 24.620 till KP 24.700 remained stable.
- From the end of the PEC crossing till KP 30.200, the seabed remained stable. An accretion trend is noted along the whole area.
- In the landfall area, the seabed remained stable in between March 2017 and September 2020. Alternating local erosion and sedimentation (~0.2 m) are found. Rock dump zones in the landfall area have remained relatively stable between 2017 and 2020.

Referring to the longitudinal profiles based on the survey from September 2020 in Annex F, following conclusions can be drawn regarding the actual DoC:

- Table 4-3 lists the areas within cable zones with a minimum length of 10 m where the average DoC over the area is smaller than the target DoC. The analysis results in 8 areas along the cable B trajectory, where the actual DoC is smaller than the target DoC. The length of the respective areas is given (> 10 m), together with the average DoC over the respective areas (< 1.0 m) and the minimum DoC found in each area. Also the total length of the cable zone in which the area is located is given.

- As can be observed, the actual DoC is bigger than the target DoC in areas with mobile sand dunes along the cable B trajectory. This is due to the installation strategy which was determined based on a preceding seabed analysis study. Some areas with an average DoC smaller than the required 1.0 m are found in the swale between Thornton bank and Goote bank, i.e. area B2, and in the landfall area. The minimum DoC found along the trajectory of cable B is 0.43 m at KP 1.635.
- In Annex G, a map with an indication of the zones from Table 4-3 can be found.

Table 4-3: Zones along cable trajectory B with a length of minimum 10 m where the average DoC is lower than the target DoC

Zone nr.	Area	From KP	To KP	Total length [m]	Average DoC [m]	Min. DoC [m]	Area length	Percentage of area length [%]
B2	Swale – TB/GB	1.613	1.649	37	0.82	0.43	2600	1.42
		2.214	2.229	16	0.96	0.91	2600	0.62
		2.239	2.253	15	0.89	0.79	2600	0.58
B15	Landfall	31.504	31.513	10	0.94	0.89	5232	0.19
		31.835	31.854	20	0.90	0.78	5232	0.38
		31.965	31.995	31	0.86	0.73	5232	0.59
		32.011	32.031	21	0.86	0.73	5232	0.40
		32.41	32.428	19	0.93	0.91	5232	0.36
Total				**35432**				**0.48**

In order to filter out the areas where the average DoC is only slightly below 1.0, the same exercise as here above has been done with a target DoC equal to 0.8 m. Table 4-4 lists the areas within cable zones with a minimum length of 10 m where the average DoC over the area is smaller than the target DoC minus 0.20 m.

This analysis results in only 2 areas where the actual DoC is smaller than the target DoC – 0.20 m, i.e. in the swale between Thornton bank and Goote bank, i.e. area B2, and in the landfall area.

In Annex H, a map with an indication of the zones from Table 4-4 can be found.

Table 4-4: Zones along cable trajectory B with a length of minimum 10 m where the average DoC is lower than the target DoC – 0.20 m (0.80 m)

Zone nr.	Area	From KP	To KP	Total length [m]	Average DoC [m]	Min. DoC [m]	Area length	Percentage of area length [%]
B2	Swale – TB/GB	1.637	1.646	10	0.65	0.43	2601	0.38
B15	Landfall	31.972	31.981	10	0.78	0.73	5233	0.19
Total				**35432**				**0.06**

It is concluded that, although some areas with an observed DoC below the target DoC are found, they represent in total only a very small part of the total cable length (0.48%).

4.2 Analysis of historical survey data

In this section, the seabed mobility over time is discussed per cable zone for both cables A and B as defined in chapter 3.5. Based on the analysis a qualitative analysis of the depth of cover (DoC) evolution is made.

4.2.1 Export cable A

For each cable zone of export cable A as defined in Table 3-5, plots of the seabed evolution can be found in Annex I. In the upper figure, the level of the top of the cable is depicted together with the seabed level of the surveys from October 2006, September 2010, August/September 2014 and March 2017. The other surveys are hidden to improve the readability of the figures.

In the lower figure, the depth of cover of the selected surveys is presented together with the legal depth of cover for the same surveys.

4.2.1.1 Cable zone A1 (KP 0.386 – KP 1.050)

Cable zone A1 (KP 0.386 to KP 1.050) is located at the southern border of the Thornton Bank. The influence of moving sand dunes on the depth of cover is clearly visible in this zone. A zoom of a moving dune top is given in Figure 4-1.

The lines represent the seabed level (in the upper figure) and the depth of cover (DoC) (in the lower figure) based on the October 2006, September 2010, August/September 2014, March 2017 and September 2020 surveys.

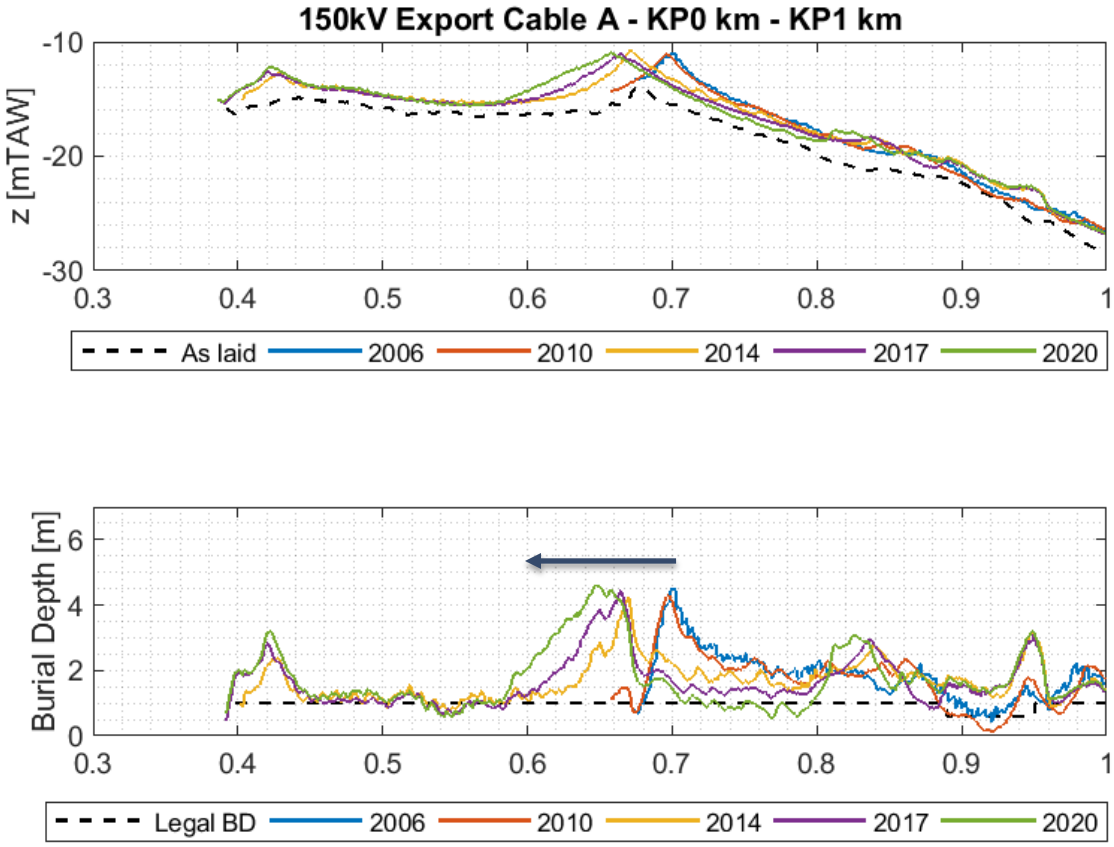

Figure 4-1: Detail of the Depth of Cover along export cable A, zone A1

In Figure 4-1, it can clearly be seen that the top of the dune is moving towards the left (= towards the Thornton bank in north-western direction). The dune top has moved about 45 m in approximately 12 years, leading to an average dune movement speed of 3.7 m/year.

The influence of the moving dune top is visible in the depth of cover of cable A. At KP 0.7 (where the top of the dune was located at the start of the measurements in 2006), depth of cover decreased from 4.5 m in October 2006 to 2.2 m in August/September 2014, to 1.7 m in March 2017 and to 1.5 m in September 2020. If this dune mobility trend would continue, a further decrease of the depth of cover (DoC) is to be expected. However, the exact location and magnitude of the decrease of the depth of cover (DoC) is difficult to predict since it is very much dependent on the dune movement speed. This speed is not constant over the years and shows an irregular pattern.

Between KP 0. 70 and KP 0.80, the depth of cover is decreasing due to erosion of the southern flank of the Thornton bank as can be seen on the plot in Annex H. At several points, the depth of cover (DoC) is less than 1.0 m.

From KP 0.39 up to KP 0.50, from KP 0.58 up to KP 0.66 and from KP 0.80 up to KP 1. 50, the depth of cover is increasing and all the area fulfils the depth of cover (DoC) requirement of 1.0 m according to the survey of 2020.

It must be noted that along the cable trajectory between KP 0.890 and KP 0.950, a rock dump was applied assuring the DoC in the future.

In Figure 4-2, the DoC based on the surveys executed between 2006 and 2017 are plotted over the cable zone to show the evolution of the critical zones in time.

- **White** areas represent zones without data;
- **Green** colouring indicates a depth of cover of at least 1.0 m;
- **Yellow** colouring a depth of at least 0.80 m;
- **Red** areas a depth of cover of 0.60 m or less, with colour transitions in between those values.

Furthermore the boundary of the concession zone is marked by a blue dotted line. The area where a remedial rock dump is present is marked by a black dotted line.

As in the figures above, it can also in this plot be observed that cable zone A1 is located in a mobile area with sand dunes moving in one direction and erosion on the southern border of the Thornton bank.

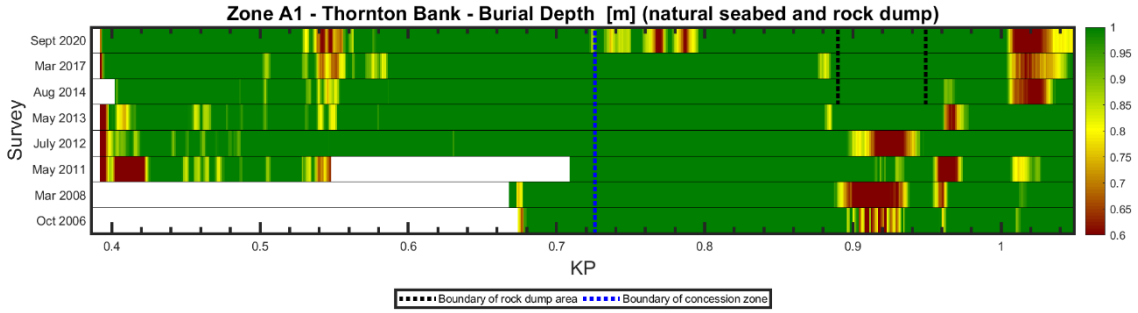

Figure 4-2: Depth of Cover evolution in time along Zone A1

Several observations can be drawn from this figure:

- The areas with low DoC near the starting KP 0.386 have improved over time;
- The DoC has decreased gradually around KP 0.540 to approximately 0.55 m in some locations;
- A significant drop of the DoC is noted in the survey of 2020 around KP 0.76;
- The rock dump installed around KP 0.900 proves to be effective and stable;
- The lowering of the seabed between KP 1.000 and 1.050 has increased. Compared to the survey of 2014, the lowering has spread out over a larger distance.

In the table below, the percentage and the length of the cable zone A1 are listed representing the depth of cover of the individual surveys:

- "**< DoC** ": areas where the seabed is located below the target depth of cover (= 1.00 m for most sections);
- "**< Doc'** ": areas where the seabed is located below the target depth of cover minus 0.20 m (= 0.80 m for most sections);
- "**< DoC"** ": areas where the seabed is located below the target depth of cover minus 0.40 m (= 0.60 m for most sections).

The average depth of cover of the individual surveys are listed as well. Since no data is available of the earlier surveys (2006 to 2011) for a part of the cable zone, no percentages of DoC are given for these surveys.

Table 4-5: Results of DoC analysis along cable zone A1
(DoC = 1.0 m, DoC' = 0.8 m, Doc'' = 0.6 m)

Cable Zone A1	**Total cable length for the zone: 664 m**						
Survey year	Percentage			Average Depth of Cover	Length		
	< DoC	< DoC'	< DoC''		< DoC	< DoC'	< DoC''
	[%]	[%]	[%]	[m]	[m]	[m]	[m]
2020	22.8	11.9	3.8	1.67	151	79	25
2017	16.7	7.5	0.5	1.59	111	49	3
2014	11.0	4.3	1.1	1.63	73	29	7
2013	13.5	3.2	0.8	1.53	90	21	5
2012	10.9	0.9	0.6	1.45	73	6	4
2011	25.8	11.5	7.0	1.36			
2010	15.0	8.7	2.3	1.69			
2008	14.7	5.5	0.0	1.74			
2006	5.3	1.1	0.0	1.80			

More than 11% of the cable length was covered by less than 1 m in 2014, which has increased to almost 23% in 2020. The percentage of cable length with a cover less than 0.80 m and 0.60 m has increased from 4.3% to 12% and from 1.1% to 3.8% respectively, as is clearly visible in Figure 4-2.

As a **conclusion** for this zone, it can be stated that the Depth of Cover is influenced by the moving dunes and changes in the DoC are to be expected in the future. Therefore, for this zone A1, close monitoring is advised in the future. Locally, the depth of cover of the cable is assured by rock dump.

4.2.1.2 Cable zone A2 (KP 1.050 – KP 4.200)

Cable zone A2 (KP 1.05 to KP 4.2) is located in the swale between the Thornton bank and the Goote bank. There is a dune top present in this zone, which is moving towards the Thornton bank. A detail of this moving dune top is provided in Figure 4-3.

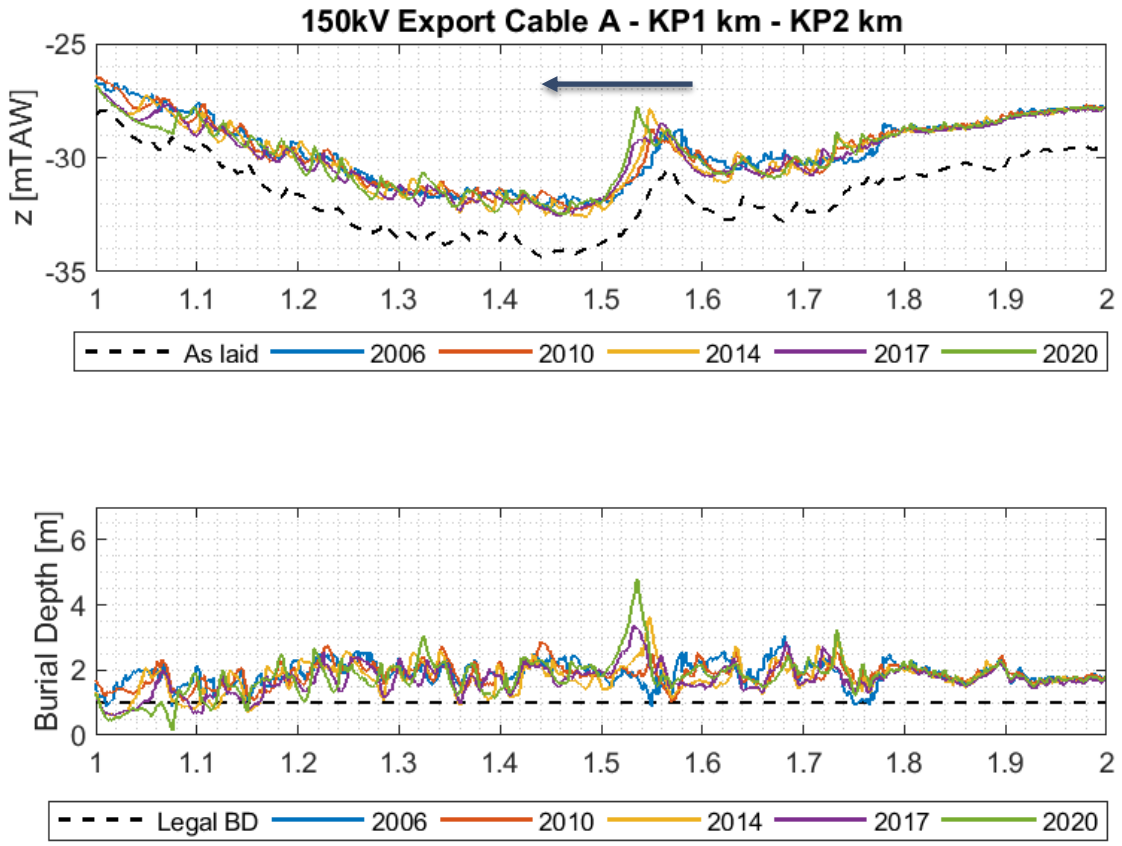

Figure 4-3: Detail of the Depth of Cover along export cable A, zone A2

The dune has moved around 30 m in 11 years, resulting in an average dune movement speed of 2.7 m/year. Due to the presence of the dune, the depth of cover of the cable will not be stable in the future. However, the exact location and magnitude of the decrease of the depth of cover is difficult to predict since this is very much dependent on the dune movement speed which is not constant in time.

Figure 4-4 illustrates the evolution of the depth of cover between 2006 and 2020 illustrating the evolution of the critical zones in time. The red dotted line depicts the safety zone around the C-Power concession zone. The graph only shows some small areas between KP 1.050 and 1.200 with a depth of cover less than 1.0 m.

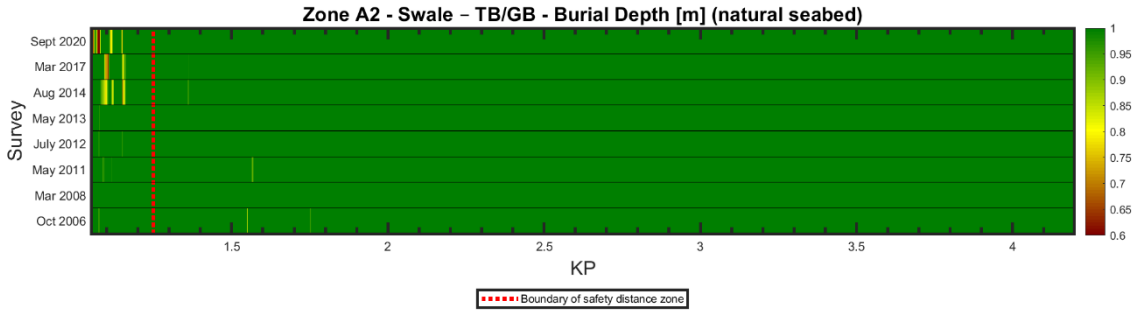

Figure 4-4: Evolution of the Depth of Cover along the cable trajectory in zone A2

Similarly to cable section A1, in Table 4-6 the percentage and the length of the cable zone A2 with DoC < 1.0 m (DoC), DoC < 0.8 m (DoC') and DoC < 0.6 m (DoC'') as well as the average DoC of the individual surveys are listed.

Table 4-6: Results of DoC analysis along cable zone A2
(DoC = 1.0 m, DoC' = 0.8 m, Doc'' = 0.6 m)

Cable Zone A2	Total cable length for the zone: 3150 m						
Survey year	Percentage			Average Depth of Cover	Length		
	< DoC	< DoC'	< DoC''		< DoC	< DoC'	< DoC''
	[%]	[%]	[%]	[m]	[m]	[m]	[m]
2020	1.5	0.8	0.3	1.92	46	26	9
2017	1.0	0.4	0.0	1.83	30	13	0
2014	1.6	0.2	0.0	1.87	51	6	0
2013	0.1	0.0	0.0	1.83	4	0	0
2012	0.1	0.0	0.0	1.87	2	0	0
2011	0.6	0.0	0.0	1.93	19	0	0
2010	0.0	0.0	0.0	1.92	0	0	0
2008	0.0	0.0	0.0	1.95	0	0	0
2006	0.3	0.0	0.0	1.95	9	0	0

About 1.5% of the cable length is covered by less than 1.0 m in the recent survey. For the first time since 2006 the survey of 2020 shows a limited area, less than 10m, where the cable zone is covered by less than 0.6 m. During all previous surveys no area with less than 0.6 m was detected. When looking at the average depth of cover over the years, no trend can be foreseen.

As a **conclusion** for this zone it can be stated that the zone is situated in an area with few mobile dunes. Furthermore, a trend of slight erosion is noticed. However, this erosion seems to have stabilized over the last few years. Monitoring is advised in cable zone A2.

4.2.1.3 Cable zone A3 (KP 4.200 – KP 6.300)

Cable zone A3 (KP 4.2 to KP 6.3) is located on the Goote bank and is characterized by moving sand dunes. Contrary to the dunes described in cable zone A1 and A2, these dunes are not moving in one single direction but an oscillating trend can be observed. A detail of a dune zone within zone A3 is given in Figure 4-5.

It can be noted a significant increase of the cable burial depth around KP 5.34, 5.59 and KP 5.72 due to the formation of dune crest of even 3 m height.

At some points in cable zone A3, very local areas with a depth of cover of the cable less than 1.0 m are noticed over the years. Also in the future, local areas with insufficient depth of cover are to be expected. It has to be noted that due to the oscillatory behaviour of the dunes, these areas characterised by an actual DoC < target DoC occur not only locally, but they are also limited in time.

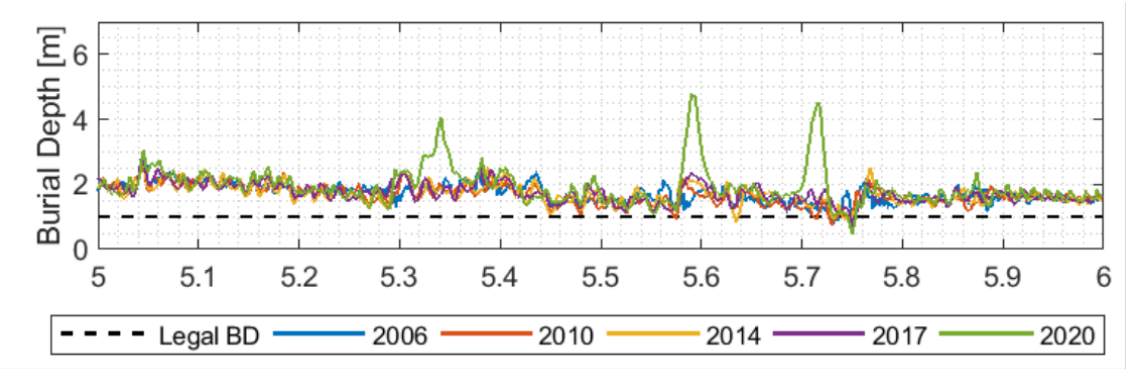

Figure 4-5: Detail of the Depth of Cover along cable A - zone A3)

Figure 4-6 illustrates the evolution of the depth of cover based on the surveys executed between 2006 and 2020 and the evolution of the critical zones in time. The mobile seabed with oscillating sand dunes can also be noticed in this graph, especially between KP 4.600 and KP 4.800 as well as between KP 5.500 and KP 5.800.

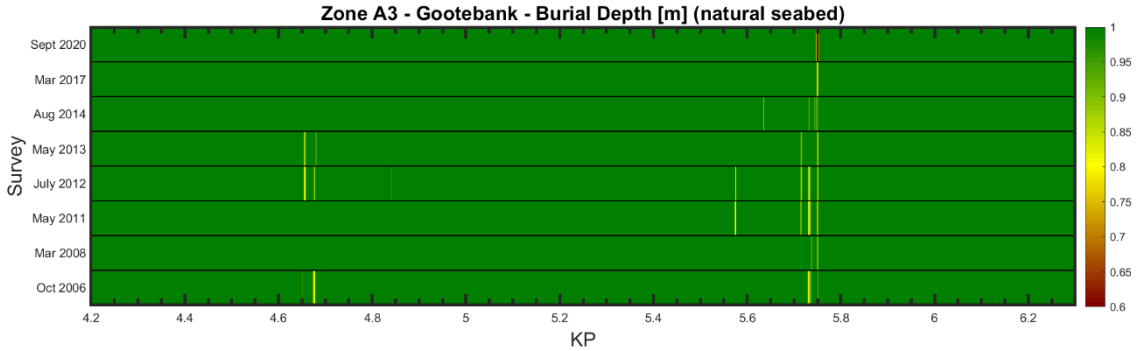

Figure 4-6: Evolution of the Depth of Cover along the cable trajectory along zone A3

Less than 2% of the cable length was covered by less than 1.0 m in all surveys, this length has decreased again to 0.4% in 2020. Only a small area of 2 m length, has been detected with less than 0.6 m of cover above the cable.

Table 4-7: Results of DoC analysis along cable zone A3
(DoC = 1.0 m, DoC' = 0.8 m, Doc'' = 0.6 m)

Cable Zone A3	Total cable length for the zone: 2100 m						
Survey year	Percentage			Average Depth of Cover	Length		
	< DoC	< DoC'	< DoC''		< DoC	< DoC'	< DoC''
	[%]	[%]	[%]	[m]	[m]	[m]	[m]
2020	0.4	0.2	0.1	1.86	8	5	2
2017	0.2	0.1	0.0	1.72	4	1	0
2014	0.8	0.0	0.0	1.70	17	0	0
2013	0.9	0.1	0.0	1.66	18	1	0
2012	1.6	0.2	0.0	1.67	33	4	0
2011	0.8	0.1	0.0	1.74	16	1	0
2010	0.9	0.1	0.0	1.68	19	1	0
2008	0.4	0.0	0.0	1.61	9	0	0
2006	0.8	0.1	0.0	1.72	17	1	0

As a **conclusion** for this zone it can be stated that the DoC is influenced by the oscillating dunes and changes in the DoC are to be expected in the future. Due to the influence of dune movement, monitoring is advised.

4.2.1.4 Cable zone A4 (KP 6.300 – KP 9.500)

Cable zone A4 (KP 6.3 to KP 9.5) is located in the swale between the Goote bank and the Akkaert bank. As can be seen on the plot in Annex I, the seabed level and thus the DoC remained relatively stable over time. Only slight seabed level variations of +/-20 cm are observed.

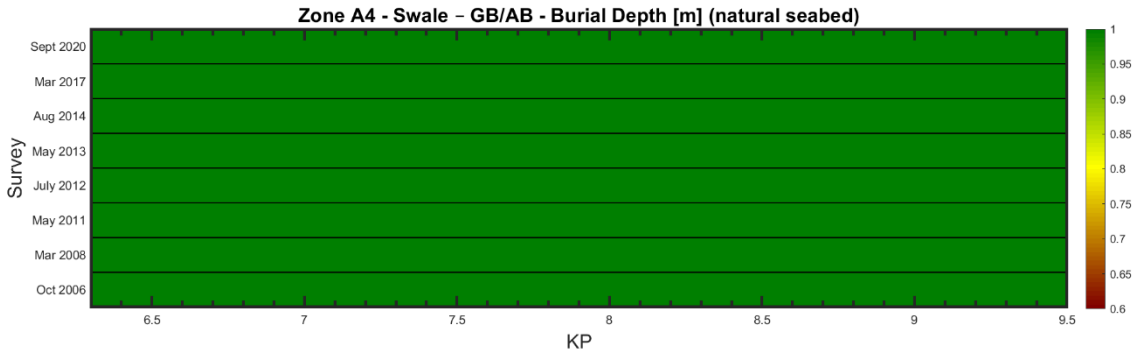

Figure 4-7: Evolution of the Depth of Cover along the cable trajectory along zone A4

During all individual surveys the cable has been covered by more than 1.0 m. Minor seabed level variations can be noticed looking at the average depth of cover. Overall, a stable and sufficient depth of cover has been present during all surveys since 2006.

Table 4-8: Results of DoC analysis along cable zone A4
(DoC = 1.0 m, DoC' = 0.8 m, Doc'' = 0.6 m)

Cable Zone A4	Total cable length for the zone: 3200 m						
Survey year	Percentage			Average Depth of Cover	Length		
	< DoC	< DoC'	< DoC''		< DoC	< DoC'	< DoC''
	[%]	[%]	[%]	[m]	[m]	[m]	[m]
2020	0	0	0	2.00	0	0	0
2017	0	0	0	1.90	0	0	0
2014	0	0	0	1.91	0	0	0
2013	0	0	0	1.88	0	0	0
2012	0	0	0	1.89	0	0	0
2011	0	0	0	1.97	0	0	0
2010	0	0	0	1.93	0	0	0
2008	0	0	0	1.82	0	0	0
2006	0	0	0	1.98	0	0	0

As a **conclusion** for this zone it can be stated that the cable DoC is not influenced by the presence of any dunes and only small changes (+/- 20 cm) in the DoC are to be expected in the future. The DoC in this cable zone is constant and relatively stable.

4.2.1.5 Cable zone A5 (KP 9.500 – KP 12.500)

Cable zone A5 (KP 9.5 to KP 12.5) is located on the Akkaert bank and is characterized by moving sand dunes. As in cable zone A3, the measurements reveal an oscillating movement of the dune tops, instead of a advance in one constant direction.

The areas where the DoC requirement is not achieved are located between KP 10.0 and 10.6, thus confirming the trend that was detected from the previous survey.

Due to this oscillatory dune behaviour and the limited depth of cover of the cable in this zone, it is possible that the cable DoC becomes less than 1.0 m in local areas in the future. However, the exact location and magnitude of the possible depth of cover decrease is difficult to predict since this is very much dependent on the dune movement speed, which is not constant over the years.

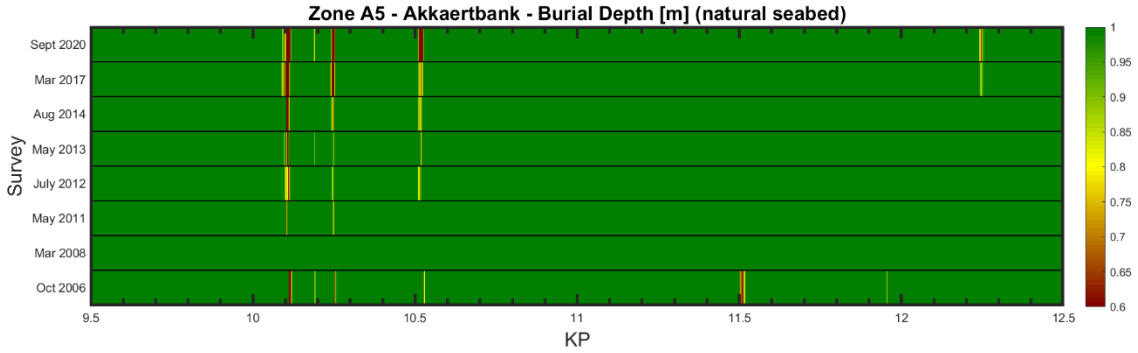

Figure 4-8: Evolution of the Depth of Cover along the cable trajectory along zone A5

The seabed level variations are most pronounced from KP 10.0 till KP 10.6, making this area most vulnerable. In total, 1.0% of the cable zone has been covered by less than 0.6 m during the latest survey. These locations occur in the vicinity of dune tops.

Table 4-9: Results of DoC analysis along cable zone A5
(DoC = 1.0 m, DoC' = 0.8 m, Doc'' = 0.6 m)

Cable Zone A5	Total cable length for the zone: 3000 m						
Survey year	Percentage			Average Depth of Cover	Length		
	< DoC	< DoC'	< DoC''		< DoC	< DoC'	< DoC''
	[%]	[%]	[%]	[m]	[m]	[m]	[m]
2020	2.6	1.7	1.0	1.86	77	51	30
2017	2.4	1.2	0.6	1.77	71	37	18
2014	1.3	0.5	0.2	1.80	40	16	7
2013	1.0	0.3	0.2	1.80	29	8	5
2012	1.3	0.3	0.0	1.76	38	8	0
2011	0.4	0.2	0.0	1.77	12	5	0
2010	0.2	0.0	0.0	1.80	6	1	0
2008	0.0	0.0	0.0	1.70	0	0	0
2006	1.8	0.9	0.3	1.81	53	26	10

As a **conclusion** for this zone it can be stated that the zone is situated in an area with mobile dunes. Generally, a change in the DoC can be expected in the future. Monitoring of this cable zone is advised.

4.2.1.6 Cable zone A6 (KP 12.500 – KP 13.171)

Cable zone A6 (KP 12.5 to KP 13.171) is located in the swale between the Akkaert bank and the navigation channel 'Vaargeul I'. No sandbanks are present in this zone. The seabed level is relatively stable between KP 12.5 and KP 12.6. From KP 12.6 till KP 12.85, a trend of accretion can be observed and on average, ~30 cm accretion is measured.

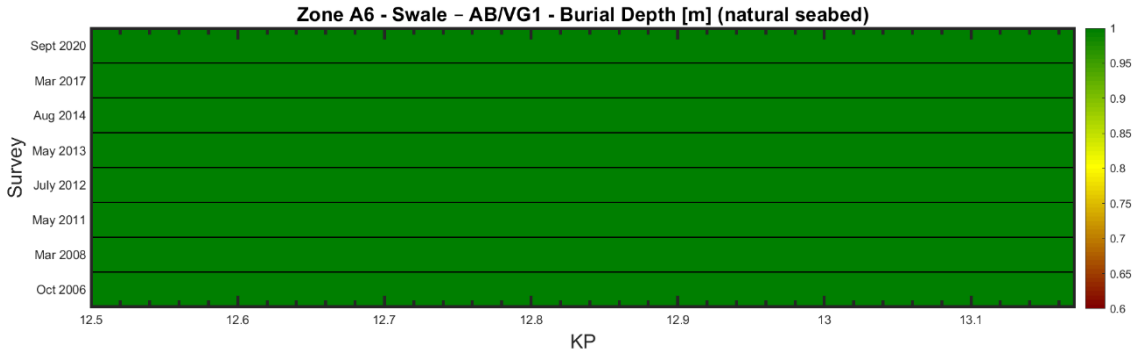

Figure 4-9: Evolution of the Depth of Cover along the cable trajectory along zone A6

The entire length of this cable zone has been covered by more than 1.0 m over the years. Minor seabed level variations can be noticed looking at the average DoC. Overall, a relatively constant and sufficient average depth of cover has been present during the surveys since 2006.

Table 4-10: Results of DoC analysis along cable zone A6
(DoC = 1.0 m, DoC' = 0.8 m, Doc'' = 0.6 m)

Cable Zone A6	Total cable length for the zone: 671 m						
Survey year	Percentage			Average Depth of Cover	Length		
	< DoC	< DoC'	< DoC''		< DoC	< DoC'	< DoC''
	[%]	[%]	[%]	[m]	[m]	[m]	[m]
2020	0.0	0.0	0.0	3.18	0	0	0
2017	0.0	0.0	0.0	3.01	0	0	0
2014	0.0	0.0	0.0	2.85	0	0	0
2013	0.0	0.0	0.0	2.82	0	0	0
2012	0.0	0.0	0.0	2.77	0	0	0
2011	0.0	0.0	0.0	2.71	0	0	0
2010	0.0	0.0	0.0	2.77	0	0	0
2008	0.0	0.0	0.0	3.15	0	0	0
2006	0.0	0.0	0.0	3.17	0	0	0

As a **conclusion** for this zone it can be stated that the DoC is not influenced by the presence of any dunes and only small changes in the DoC are to be expected in the future. This cable zone is stable.

4.2.1.7 Cable zone A7 (KP 13.171– KP 14.031)

In zone A7 (KP 13.171 to KP 14.031), the export cable A crosses the navigation channel 'Vaargeul I'. An accretion trend exists in the navigation channel. This trend can be observed in the plot in Annex I, comparing the 2020 survey with the surveys from September 2010, July 2012, August/September 2014 and March 2017. The drop in seabed level between March 2008 and September 2010 is caused by maintenance dredging works.

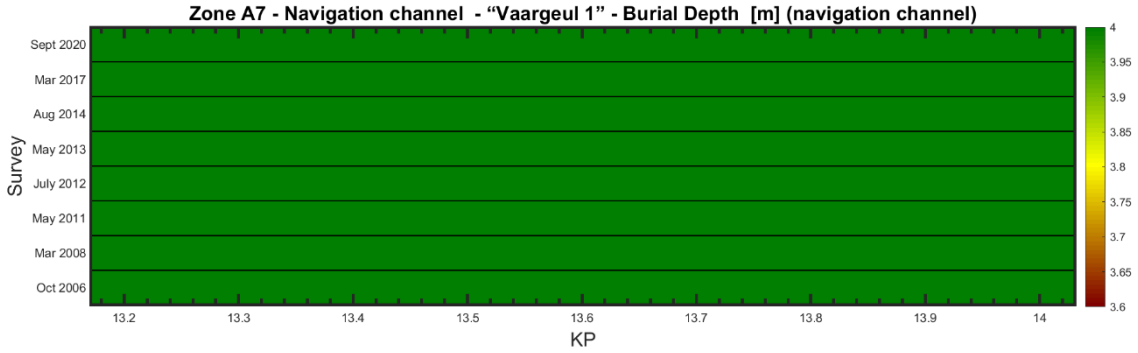

Figure 4-10: Evolution of the Depth of Cover along the cable trajectory along zone A7

No area of the cable has been buried less than 4.0 m since 2006. Based on the average DoC, a trend of accretion can be observed since the survey in 2010. Overall, cable zone A7 shows a relatively constant and sufficient average depth of cover.

Table 4-11: Results of DoC analysis along cable zone A7
(DoC = 4.0 m, DoC' = 3.8 m, Doc" = 3.6 m)

Cable Zone A7	Total cable length for the zone: 860 m						
Survey year	Percentage			Average Depth of Cover	Length		
	< DoC	< DoC'	< DoC"		< DoC	< DoC'	< DoC"
	[%]	[%]	[%]	[m]	[m]	[m]	[m]
2020	0.0	0.0	0.0	6.03	0	0	0
2017	0.0	0.0	0.0	6.00	0	0	0
2014	0.0	0.0	0.0	5.71	0	0	0
2013	0.0	0.0	0.0	5.67	0	0	0
2012	0.0	0.0	0.0	5.57	0	0	0
2011	0.0	0.0	0.0	5.49	0	0	0
2010	0.0	0.0	0.0	5.49	0	0	0
2008	0.0	0.0	0.0	6.13	0	0	0
2006	0.0	0.0	0.0	6.10	0	0	0

As a **conclusion** for this zone it can be stated that the DoC is not influenced by the presence of any dunes and only small changes in the DoC are to be expected in the future. This cable area is stable.

4.2.1.8 Cable zone A8 (KP 14.031 – KP 15.3)

Cable zone A8 comprises the cable trajectory between KP 14.031 and KP 15.3. No sand dunes are present in the swale in this zone. The seabed level has been relatively stable over the years as can be seen on the plot in Annex I (erosion is not significant, i.e. 10 to 15 cm between 2006 and 2014).

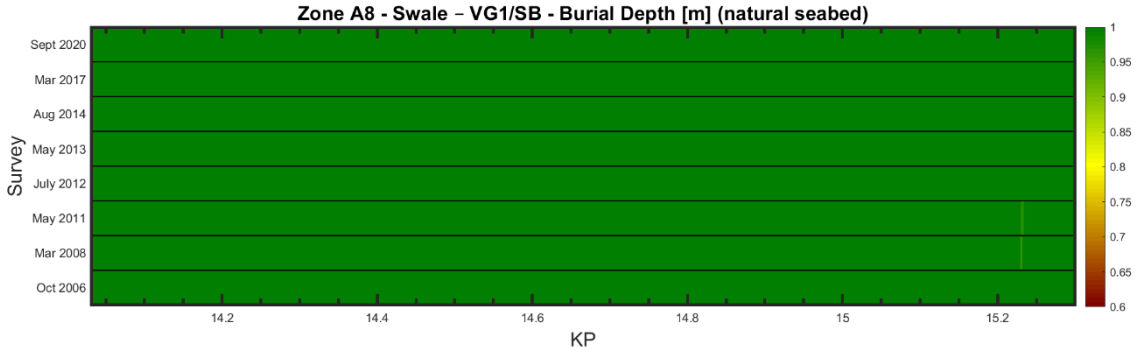

Figure 4-11: Evolution of the Depth of Cover along the cable trajectory along zone A8

Although the surveys between 2008 and 2011 show small areas with a DoC of less than 1 m, no area of the cable was buried less than 1.0 m since 2012.

Overall, a stable seabed is present with a minor erosion trend. Since the average DoC is larger than 1.5 m, the risk for an insufficient depth of cover in the future is assumed to be low.

Table 4-12: Percentage and length of depth over cover of zone A8
(DoC = 1.0 m, DoC' = 0.8 m, Doc'' = 0.6 m)

Cable Zone A8	Total cable length for the zone: 1269 m						
Survey year	Percentage			Average Depth of Cover	Length		
	< DoC	< DoC'	< DoC''		< DoC	< DoC'	< DoC''
	[%]	[%]	[%]	[m]	[m]	[m]	[m]
2020	0.0	0.0	0.0	1.80	0	0	0
2017	0.0	0.0	0.0	1.76	0	0	0
2014	0.0	0.0	0.0	1.71	0	0	0
2013	0.0	0.0	0.0	1.71	0	0	0
2012	0.0	0.0	0.0	1.68	0	0	0
2011	0.5	0.0	0.0	1.66	6	0	0
2010	0.3	0.0	0.0	1.68	4	0	0
2008	0.4	0.0	0.0	1.77	5	0	0
2006	0.0	0.0	0.0	1.83	0	0	0

As a **conclusion** for this zone it can be stated that the DoC is not influenced by the presence of any dunes and only limited changes in the DoC are to be expected in the future. This cable zone is also assumed to be stable.

4.2.1.9 Cable zone A9 (KP 15.300 – KP 17.800)

Cable zone A9 runs from KP 15.3 till KP 17.8 and is located between the navigation channel 'Vaargeul I' and the navigation channel 'Aanloop Scheur'. The area is characterized by mobile sand dunes. As in cable zone A3, observations show that the dune tops are oscillating instead of moving in one single direction. Due to this oscillatory dune behaviour and the limited DoC in this zone, the depth of cover of the cable is currently smaller than 1 m in local areas in the vicinity of dune tops. The exact location and magnitude of the decrease of the DoC in the future is however difficult to predict due to the oscillating nature of the dunes.

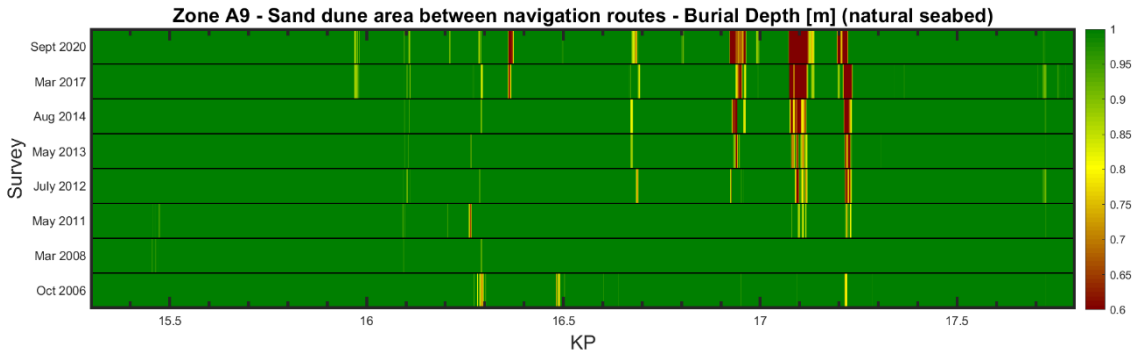

Figure 4-12: Evolution of the Depth of Cover along the cable trajectory along zone A9

Almost 10% of the length of the cable zone is covered by less than 1 m of natural seabed and 3.4% by even less than 0.6 m.

Table 4-13: Percentage and length of depth over cover of zone A9
(DoC = 1.0 m, DoC' = 0.8 m, Doc'' = 0.6 m)

Cable Zone A9	Total cable length for the zone: 2500 m						
Survey year	Percentage			Average Depth of Cover	Length		
	< DoC	< DoC'	< DoC''		< DoC	< DoC'	< DoC''
	[%]	[%]	[%]	[m]	[m]	[m]	[m]
2020	9.9	5.8	3.4	1.59	247	144	85
2017	8.7	3.6	2.4	1.51	217	91	60
2014	4.8	2.8	1.0	1.55	119	69	25
2013	3.9	1.6	0.4	1.57	97	40	9
2012	3.6	1.4	0.3	1.52	89	34	7
2011	2.6	0.3	0.0	1.52	66	8	0
2010	1.4	0.0	0.0	1.54	34	1	0
2008	0.9	0.0	0.0	1.59	23	0	0
2006	1.9	0.5	0.0	1.61	48	13	1

As a **conclusion** for this zone it can be stated that the zone is situated in an area with mobile dunes, areas with DoC smaller than 0.6 m are already observed and in general, a change in the DoC can be expected in the future. Close monitoring of this cable zone in the future is advised.

4.2.1.10 Cable zone A10 (KP 17.800 – KP 19.090)

Cable zone A10 runs from KP 17.8 till 19.09. As this cable zone is located in a swale, no dunes are present. The seabed shows a minor eroding trend.

On average, about 10 to 20 cm erosion is measured between 2006 and 2017, while between 2017 and 2020 sedimentation is noted along the area. At some points in this cable zone, the DoC is below 1.0 m. Only between KP 17.8 and KP 18.0 a few locations with a cable DoC below 1 m can be observed.

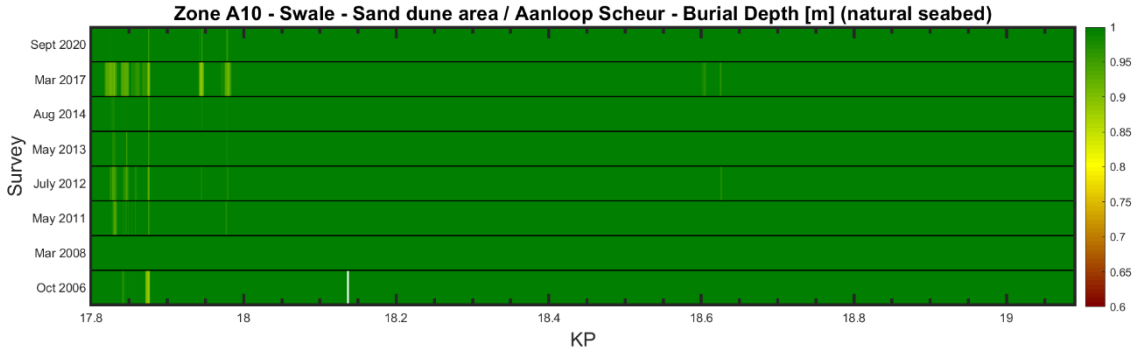

Figure 4-13: Evolution of the Depth of Cover along the cable trajectory along zone A10

In total 1.2% of the cable section shows a depth of cover of less than 1.0 m, which is as it was in 2014 and in 2013. The DoC value never drops below 0.8 m.

Table 4-14: Percentage and length of depth over cover of zone A10
(DoC = 1.0 m, DoC' = 0.8 m, Doc'' = 0.6 m)

Cable Zone A10	Total cable length for the zone: 1290 m						
Survey year	Percentage			Average Depth of Cover	Length		
	< DoC	< DoC'	< DoC''		< DoC	< DoC'	< DoC''
	[%]	[%]	[%]	[m]	[m]	[m]	[m]
2020	1.2	0.0	0.0	1.41	15	0	0
2017	7.3	0.0	0.0	1.29	94	0	0
2014	1.2	0.0	0.0	1.36	15	0	0
2013	1.2	0.0	0.0	1.35	16	0	0
2012	3.5	0.0	0.0	1.30	45	0	0
2011	1.8	0.0	0.0	1.37	23	0	0
2010	1.2	0.0	0.0	1.38	15	0	0
2008	0.1	0.0	0.0	1.38	1	0	0
2006	0.9	0.0	0.0	1.44	12	0	0

As a **conclusion** for this zone it can be stated that the cable DoC is partly influenced by the presence of any dunes. The average DoC is still far above 1.0 m and the DoC is not below 0.8 m. This area is considered to be stable.

4.2.1.11 Cable zone A11 (KP 19.090 – KP 19.954)

Cable zone A11 runs from KP 19.09 till KP 19.954 and includes the crossing with the navigation channel 'Aanloop Scheur'. A trend of sedimentation exists across the navigation channel. It should be noted that the legal depth of cover of the cable is 2.0 m for the crossing with the navigation channel 'Aanloop Scheur'. However, during installation a DoC of 1.0 m was accepted since it was not possible to plough deeper into the sea bottom.

Variations in percentage of cover below 1.0 m are observed over the different years. In general, the DoC has improved with respect to conditions detected in 2017. The DoC rarely drops below 0.8 m, as is also the case for 2020.

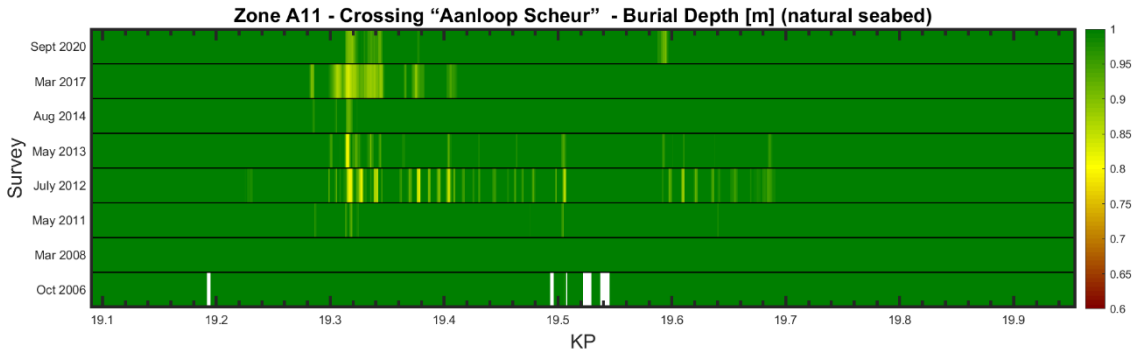

Figure 4-14: Evolution of the Depth of Cover along the cable trajectory along zone A11

Overall, the risk for an insufficient DoC in the future is considered to be low.

Table 4-15: Percentage and length of depth over cover of zone A11
(DoC = 1.0 m, DoC' = 0.8 m, Doc'' = 0.6 m)

Cable Zone A11	Total cable length for the zone: 864 m						
Survey year	Percentage			Average Depth of Cover	Length		
	< DoC	< DoC'	< DoC''		< DoC	< DoC'	< DoC''
	[%]	[%]	[%]	[m]	[m]	[m]	[m]
2020	5.8	0.0	0.0	1.40	50	0	0
2017	10.0	0.0	0.0	1.25	86	0	0
2014	2.0	0.0	0.0	1.30	17	0	0
2013	6.8	0.0	0.0	1.24	59	0	0
2012	17.6	0.1	0.0	1.18	152	1	0
2011	1.6	0.0	0.0	1.27	14	0	0
2010	0.0	0.0	0.0	1.28	0	0	0
2008	0.0	0.0	0.0	1.40	0	0	0
2006	0.1	0.0	0.0	1.42	1	0	0

As a **conclusion** for this zone it can be stated that although minor seabed level variations are noticed, the cable depth of cover is expected to be relatively stable.

4.2.1.12 Cable zone A12 (KP 19.954 – KP 24.200)

Cable zone A12 runs from KP 19.954 till 24.00. As a swale is crossed, no sand dunes are present in the area. Overall the seabed level remained relatively stable over the years as can be seen in the plots in Annex I.

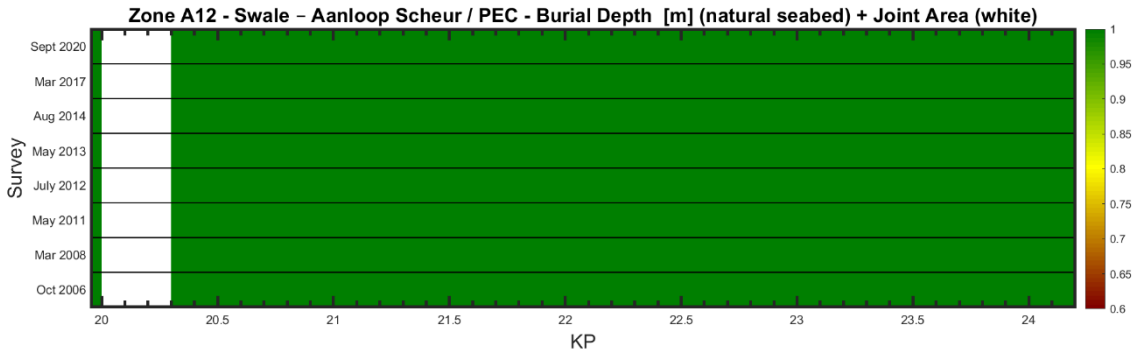

Figure 4-15: Evolution of the Depth of Cover along the cable trajectory along zone A12

No area in this zone shows a DoC of less than 1 m for any of the surveys.

Table 4-16: Percentage and length of depth over cover of zone A12
(DoC = 1.0 m, DoC' = 0.8 m, Doc'' = 0.6 m)

Cable Zone A12	Total cable length for the zone: 4246 m						
Survey year	Percentage			Average Depth of Cover	Length		
	< DoC	< DoC'	< DoC''		< DoC	< DoC'	< DoC''
	[%]	[%]	[%]	[m]	[m]	[m]	[m]
2020	0.0	0.0	0.0	1.97	0	0	0
2017	0.0	0.0	0.0	1.87	0	0	0
2014	0.0	0.0	0.0	1.96	0	0	0
2013	0.0	0.0	0.0	1.92	0	0	0
2012	0.0	0.0	0.0	1.85	0	0	0
2011	0.0	0.0	0.0	1.93	0	0	0
2010	0.0	0.0	0.0	1.97	0	0	0
2008	0.0	0.0	0.0	1.96	0	0	0
2006	0.0	0.0	0.0	1.93	0	0	0

As a **conclusion** for this zone it can be stated that the cable depth of cover is not influenced by the presence of any dunes and that only small changes in the DoC are to be expected in the future. This cable zone is stable.

4.2.1.13 Cable zone A12.2 (joint area KP 0.000 – KP 0.521)

The joint area A12.2 has local KP values from KP 0.000 to KP 0.521 and is located between KP 20 and KP 20.3. No sand dunes are present in the joint area. The seabed level is stable due to the presence of a rock dump.

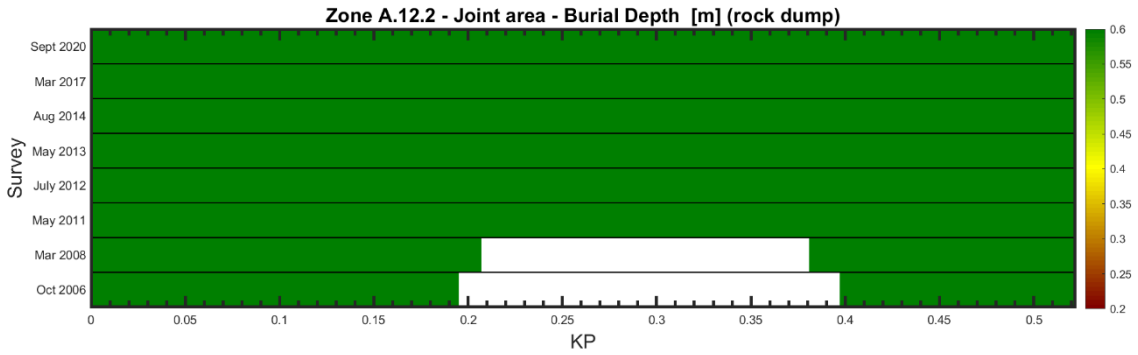

Figure 4-16: Evolution of the Depth of Cover along the cable trajectory along zone A12.2

Over the entire length of the cable zone, the cable has been buried more than 0.6 m deep and the DoC remained stable over the years.

Table 4-17: Percentage and length of depth over cover of zone A12.2
(DoC = 0.6 m, DoC' = 0.4 m, Doc'' = 0.2 m)

Cable Zone A12.2	Total cable length for the zone: 521 m						
Survey year	Percentage			Average Depth of Cover	Length		
	< DoC	< DoC'	< DoC''		< DoC	< DoC'	< DoC''
	[%]	[%]	[%]	[m]	[m]	[m]	[m]
2020	0.0	0.0	0.0	1.95	0	0	0
2017	0.0	0.0	0.0	1.81	0	0	0
2014	0.0	0.0	0.0	1.85	0	0	0
2013	0.0	0.0	0.0	1.79	0	0	0
2012	0.0	0.0	0.0	1.77	0	0	0
2011	0.0	0.0	0.0	1.80	0	0	0
2010	0.0	0.0	0.0	1.80	0	0	0

As a **conclusion** for this zone it can be stated that the depth of cover of the cable is stable.

4.2.1.14 Cable zone A13 (KP 24.200 – KP 24.475)

Cable zone A13 is defined between KP 24.2 and KP 24.475. In this cable zone the PEC telecom cable is crossed and a rock dump is installed.

In the results of the surveys in 2006 and 2008, the cable DoC between KP 24.35 and KP 24.39 has been less than 0.2 m. Since the remedial rock dump in 2010, the cable zone has been covered by more than 0.6 m over its entire length.

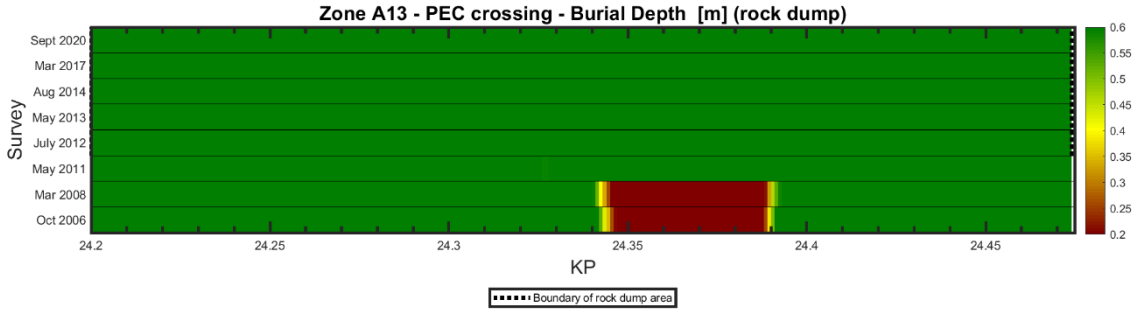

Figure 4-17: Evolution of the Depth of Cover along the cable trajectory along zone A13

Table 4-18 shows the insufficient coverage until the remedial action took place. Since 2010, no areas with less than 1.0 m DoC have been observed and the cable zone is relatively stable.

Table 4-18: Percentage and length of depth over cover of zone A13
(DoC = 0.6 m, DoC' = 0.4 m, Doc'' = 0.2 m)

Cable Zone A13	Total cable length for the zone: 275 m						
Survey year	Percentage			Average Depth of Cover	Length		
	< DoC	< DoC'	< DoC''		< DoC	< DoC'	< DoC''
	[%]	[%]	[%]	[m]	[m]	[m]	[m]
2020	0.0	0.0	0.0	1.77	0	0	0
2017	0.0	0.0	0.0	1.66	0	0	0
2014	0.0	0.0	0.0	1.77	0	0	0
2013	0.0	0.0	0.0	1.73	0	0	0
2012	0.0	0.0	0.0	1.68	0	0	0
2011	0.0	0.0	0.0	1.12	2	0	0
2010	0.0	0.0	0.0	1.11	0	0	0
2008	19.3	17.1	15.6	0.76	53	47	43
2006	18.2	16.7	14.9	0.84	50	46	41

As a **conclusion** for this zone it can be stated that the rock dump in this area is stable.

4.2.1.15 Cable zone A14 (KP 24.475 – KP 30.000)

The cable zone A14 represents the near shore part of the cable and runs from KP 24.5 till KP 30. Overall, the seabed level is relatively stable.

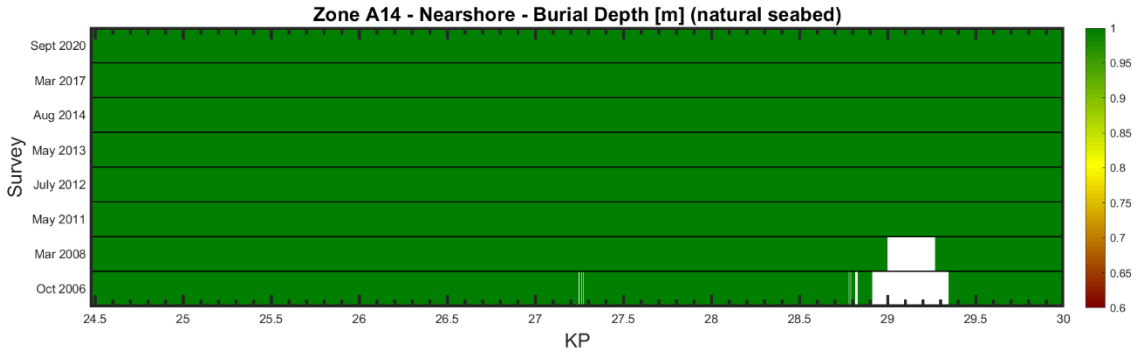

Figure 4-18: Evolution of the Depth of Cover along the cable trajectory along zone A14

Over the entire cable zone length, the cable is covered by more than 1.0 m.

Table 4-19: Percentage and length of depth over cover of zone A14
(DoC = 1.0 m, DoC' = 0.8 m, Doc'' = 0.6 m)

Cable Zone A14	Total cable length for the zone: 5525 m						
Survey year	Percentage			Average Depth of Cover	Length		
	< DoC	< DoC'	< DoC''		< DoC	< DoC'	< DoC''
	[%]	[%]	[%]	[m]	[m]	[m]	[m]
2020	0.0	0.0	0.0	1.88	0	0	0
2017	0.0	0.0	0.0	1.81	0	0	0
2014	0.0	0.0	0.0	1.91	0	0	0
2013	0.0	0.0	0.0	1.85	0	0	0
2012	0.1	0.0	0.0	1.80	4	0	0
2011	0.0	0.0	0.0	1.90	0	0	0
2010	0.0	0.0	0.0	1.89	0	0	0

As a **conclusion** for this zone it can be stated that the DoC is not influenced by the presence of any dunes. This cable zone is stable.

4.2.1.16 Cable zone A15 (KP 30.000 – KP 35.437)

The landfall area is defined as cable zone A15 between KP 30 and KP 35.437. A trend of erosion exists up till 2012. Between 2012 and 2017, further erosion ~5 cm was measured. This trend seems to be arrested in 2020.

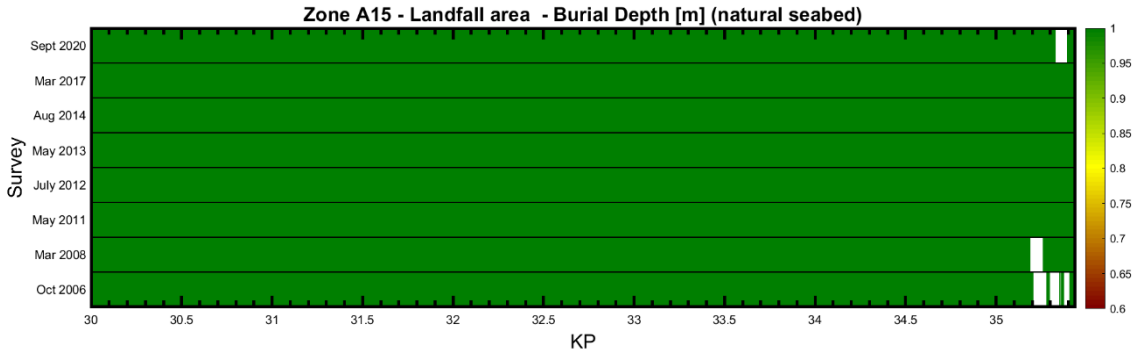

Figure 4-19: Evolution of the Depth of Cover along the cable trajectory along zone A15

An increase of the average DoC can be observed. The DoC is still around 2.0 m.

Table 4-20: Percentage and length of depth over cover of zone A15
(DoC = 1.0 m, DoC' = 0.8 m, Doc'' = 0.6 m)

Cable Zone A15	Total cable length for the zone: 5437 m						
Survey year	Percentage			Average Depth of Cover	Length		
	< DoC	< DoC'	< DoC''		< DoC	< DoC'	< DoC''
	[%]	[%]	[%]	[m]	[m]	[m]	[m]
2020	0.0	0.0	0.0	1.95	0	0	0
2017	0.0	0.0	0.0	1.93	0	0	0
2014	0.0	0.0	0.0	1.99	0	0	0
2013	0.0	0.0	0.0	1.99	0	0	0
2012	0.0	0.0	0.0	1.99	0	0	0
2011	0.0	0.0	0.0	2.17	1	1	1
2010	0.0	0.0	0.0	2.19	0	0	0
2008	0.0	0.0	0.0	2.11	0	0	0
2006	0.0	0.0	0.0	2.33	0	0	0

As a **conclusion** for this zone it can be stated that the DoC is not influenced by the presence of any dunes, but influenced by erosion in the nearshore area. The depth of cover is however still more than required.

4.2.2 Export cable B

In Annex J, a plot of the evolution of the seabed and depth of cover can be found per kilometre section for export cable B. In the upper figures, the level of the top of the cable (black dashed line) is depicted together with the seabed level of the following surveys: May 2013 (blue line), August/September 2014 (red line) March 2017 (orange line) and September 2020 (purple line).

In the lower figure, the depth of cover of the cable of each survey is presented together with the legal depth of cover (thick dashed black line). The blue, red, orange and purple lines represent the cable depth of cover based on the May 2013, August/September 2014 and March 2017 surveys respectively.

Export cable B is characterized by similar morphological features as cable A as its route is parallel to A, shifted approximately 100 m to the East. Therefore, the description of the different cable zones along the cable B trajectory is less detailed than for cable A.

4.2.2.1 Cable zone B1 (KP 0.000 – KP 0.900)

Cable zone B1 runs from KP 0.000 till 0.900 and is located on the southern border of the Thornton Bank. In the plot in Annex J, the seabed and cable level as well as the depth of cover are depicted. Some fluctuation due to dune movement can be seen. As for cable A, the dune tops on the southern border of the Thornton bank have the tendency to move towards the Thornton bank.

The blue dotted line on the figure depicts the boundary of the C-Power concession zone. The red dotted line represents the safety distance around the concession area.

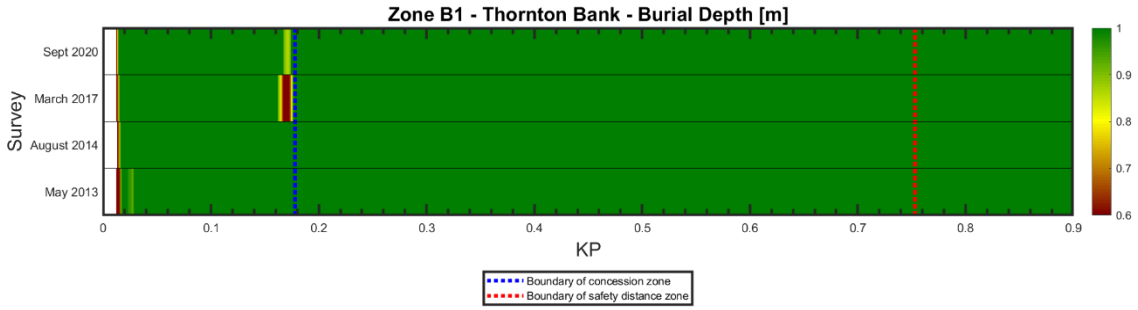

Figure 4-20: Evolution of the Depth of Cover along the cable trajectory in zone B1

A local decrease of DoC below 1.0 m is observed near the boundary of the concession zone. Annex J shows that this local lowering of the seabed was already visible in 2014, although the DoC was still above 1.0 m during this survey. In total only 0.1% of the cable is buried less than 0.6 m in section A1. The average DoC is well above 2 m.

Table 4-21: Percentage and length of depth over cover of zone B1
(DoC = 1.0 m, DoC' = 0.8 m, Doc'' = 0.6 m)

Cable Zone B1	Total cable length for the zone: 900 m						
Survey year	Percentage			Average Depth of Cover	Length		
	< DoC	< DoC'	< DoC''		< DoC	< DoC'	< DoC''
	[%]	[%]	[%]	[m]	[m]	[m]	[m]
2020	1.0	0.2	0.1	2.79	9	2	1
2017	2.1	1.4	0.7	2.71	19	12	6
2014	0.3	0.2	0.1	2.71	3	2	1
2013	1.4	0.5	0.3	2.64	12	4	3

As a **conclusion** for this zone it can be stated that the cable DoC is influenced by the moving dune tops on the southern border of the Thornton bank. Due to the cable installation strategy however, the possible risk of lowered DoC has been mitigated significantly. One area with a DoC less than 0.6 m was observed during the 2017 survey. In this area, the DoC has improved in the 2020 survey. Annex J shows that the area between KP 0.0 and KP 0.3 is vulnerable to possible future dune movement. From KP 0.3 onwards, no other areas with a depth of cover smaller than the target depth of cover are to be expected in the nearer future for area A1.

4.2.2.2 Cable zone B2 (KP 0.900 – KP 3.500)

Cable zone B2 runs from KP 0.900 till KP 3.500 and is located in the swale between the Thornton bank and the Goote bank. This cable zone is characterized by mobile sand dunes. The location of these dune tops has been fairly stable over the three surveys as can be seen on the plot of this cable zone in Annex J. However, a general trend of erosion is visible on the figure.

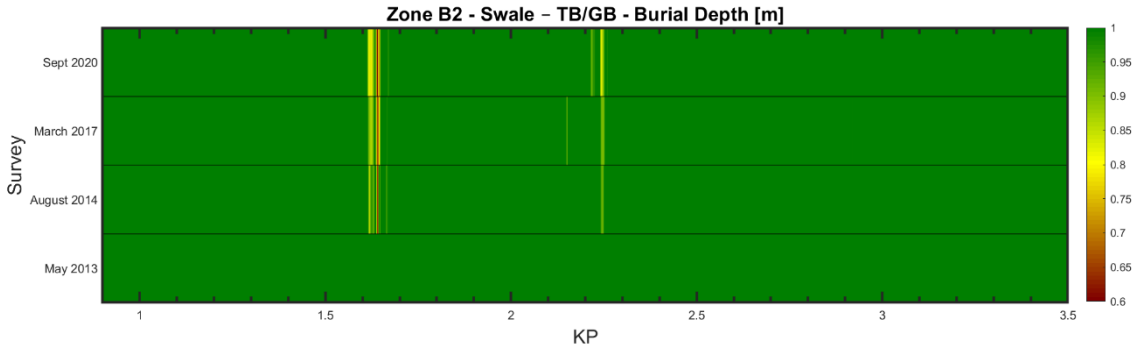

Figure 4-21: Evolution of the Depth of Cover along the cable trajectory in zone B2

The latest survey reveals a small percentage of cable length being covered by less than 0.8 m. The increase in average depth of cover decrease in average depth of cover is indicative that the gradual decrease of seabed level, resulting from the previous surveys, seems to be stopped.

Table 4-22: Percentage and length of depth over cover of zone B2
(DoC = 1.0 m, DoC' = 0.8 m, Doc'' = 0.6 m)

Cable Zone B2	Total cable length for the zone: 260 m						
Survey year	Percentage			Average Depth of Cover	Length		
	< DoC	< DoC'	< DoC''		< DoC	< DoC'	< DoC''
	[%]	[%]	[%]	[m]	[m]	[m]	[m]
2020	2.9	0.4	0.1	1.89	74	11	3
2017	2.1	0.3	0.0	1.82	55	8	0
2014	1.7	0.2	0.1	1.86	44	4	2
2013	0.0	0.0	0.0	1.97	0	0	0

As a **conclusion** for this zone it can be stated that the depth of cover is influenced by the variations of seabed level in the swale and the presence of dune tops. Due to the variability of the seabed in this area and the rather limited depth of cover, it is possible that the depth of cover becomes smaller in the future. It is however very difficult to predict when and where this will happen. Therefore, monitoring is advised.

4.2.2.3 Cable zone B3 (KP 3.500– KP 6.320)

Cable zone B3 is defined between KP 3.5 and KP 6.32 and is located on the Goote bank. Large dune tops are visible. From the analysis of the surveys of cable A, it is known that these dune tops oscillate. However, based on the three surveys available for cable B, the seabed seems fairly stable.

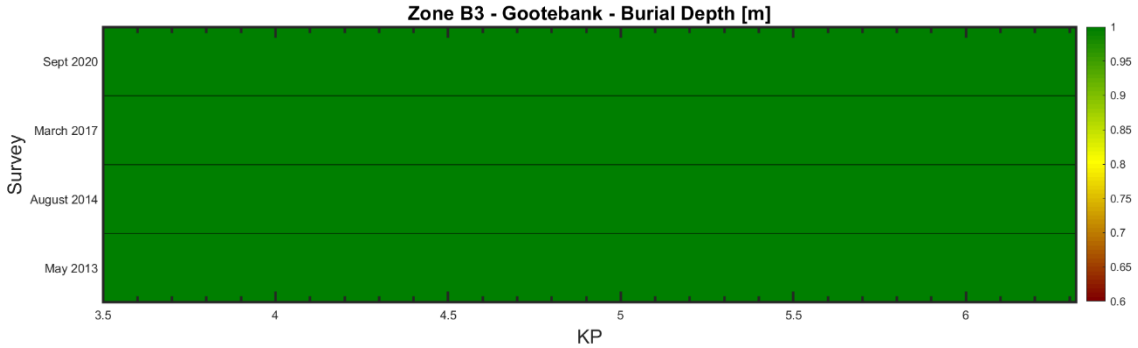

Figure 4-22: Evolution of the Depth of Cover along the cable trajectory in zone B3

The entire length of the cable is buried deeper than 1 m and no areas with insufficient depth of cover can be detected. The average depth of cover during all surveys was larger than 2 m.

Table 4-23: Percentage and length of depth over cover of zone B3
(DoC = 1.0 m, DoC' = 0.8 m, Doc'' = 0.6 m)

Cable Zone B3	Total cable length for the zone: 282 m						
Survey year	Percentage			Average Depth of Cover	Length		
	< DoC	< DoC'	< DoC''		< DoC	< DoC'	< DoC''
	[%]	[%]	[%]	[m]	[m]	[m]	[m]
2020	0.0	0.0	0.0	2.43	0	0	0
2017	0.0	0.0	0.0	2.25	0	0	0
2014	0.0	0.0	0.0	2.14	0	0	0
2013	0.0	0.0	0.0	2.11	0	0	0

As a **conclusion** for this zone it can be stated that the cable depth of cover is influenced by the variations of seabed level on the Goote bank and the presence of sand dunes. However, due to the installation strategy of cable B the cable depth of cover is sufficient and no areas with insufficient depth of cover are expected in the nearer future.

4.2.2.4 Cable zone B4 (KP 6.320 – KP 8.620)

Cable zone B4 runs between KP 6.320 and KP 8.620 and is located in the swale between Goote bank and Akkaert bank. In this cable zone, rock protection was placed in January 2013. The white area indicates the zone of the joint, see chapter 4.2.2.5, the rock protection is present along the entire zone, between the two vertical dashed lines.

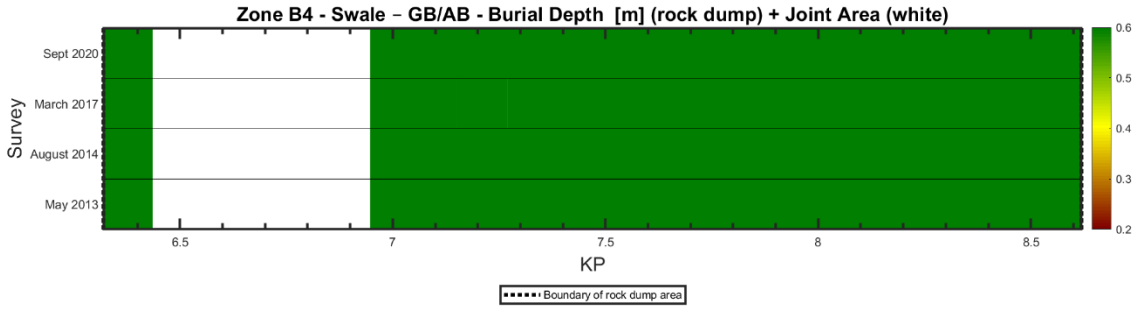

Figure 4-23: Evolution of the depth of cover along the cable trajectory in zone B4

The entire length of the cable is buried deeper than 1 m and no areas with insufficient depth of cover can be detected. The average depth of cover during all surveys was larger than 1.5 m.

Therefore it is concluded that the rock protection is stable and has sufficient thickness.

Table 4-24: Percentage and length of depth over cover of zone B4
(DoC = 0.6 m, DoC' = 0.4 m, Doc'' = 0.2 m)

Cable Zone B4	Total cable length for the zone: 3200 m						
Survey year	Percentage			Average Depth of Cover	Length		
	< DoC	< DoC'	< DoC''		< DoC	< DoC'	< DoC''
	[%]	[%]	[%]	[m]	[m]	[m]	[m]
2020	0.0	0.0	0.0	1.60	0	0	0
2017	0.2	0.0	0.0	1.51	4	0	0
2014	0.0	0.0	0.0	1.55	0	0	0
2013	0.0	0.0	0.0	1.57	0	0	0

As a **conclusion** for this zone it can be stated that the seabed is stable due to the sufficiently thick rock dump. No areas with insufficient depth of cover are thus expected in the future in this cable zone.

4.2.2.5 Cable zone B4.2 (joint area KP 0.000 – KP 0.850)

The export cable B had to be repaired by the end of 2012 due to an incident during the cable burial operation. An omega joint was installed between KP 6.435 and KP 6.947. The joint area has local KPs. A rock dump with filter and armour layer is present.

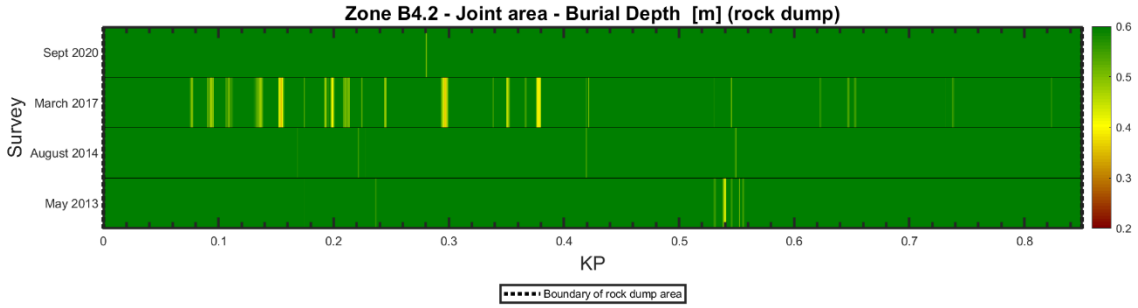

Figure 4-24: Evolution of the Depth of Cover along the cable trajectory in zone B4.2

Compared to 2017 and to the previous surveys in general, an improvement in term of DoC can be noted. Only 0.2% of the area is below the required Depth of Cover of 1 m. The average DoC is around 1.1 m for the available surveys and thus well above the required 0.6 m.

Table 4-25: Percentage and length of depth over cover of zone B4.2
(DoC = 0.6 m, DoC' = 0.4 m, Doc'' = 0.2 m)

Cable Zone B4.2	Total cable length for the zone: 850 m						
Survey year	Percentage			Average Depth of Cover	Length		
	< DoC	< DoC'	< DoC''		< DoC	< DoC'	< DoC''
	[%]	[%]	[%]	[m]	[m]	[m]	[m]
2020	0.2	0.1	0.1	1.11	2	1	1
2017	9.9	0.6	0.0	0.84	84	5	1
2014	0.7	0.0	0.0	0.95	6.	0	0
2013	1.8	0.0	0.0	0.99	15	0	0

As a **conclusion** for this zone it can be stated that the seabed is relatively stable due to the rock dump. No areas with insufficient depth of cover are thus expected in the future in this cable zone.

4.2.2.6 Cable zone B5 (KP 8.620 – KP 12.720)

Cable zone B5 runs from KP 8.620 till KP 12.720 and is located on the Akkaert bank. Between KP 8.980 and KP 9.087 as well as between KP 9.187 and KP 9.240, armour rock has been placed in January 2013. The rock dump is stable and sufficient in these areas.

Between KP 9.500 and 12.716, the cable zone is characterized by mobile sand dunes. The dunes are variable in size (see plot in Annex J) and the dune tops are slightly oscillating. Consequently, the depth of cover of the cable is variable in time. However, the cables where originally placed with sufficient depth of cover (around 2 m) and no areas with insufficient depth of cover are recorded so far.

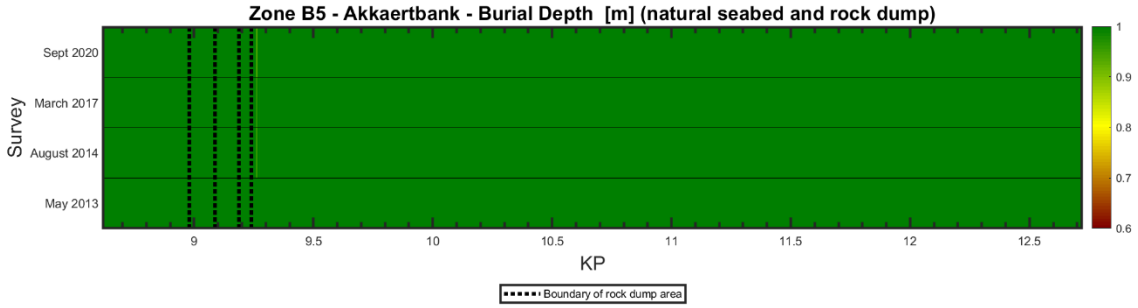

Figure 4-25: Evolution of the Depth of Cover along the cable trajectory in zone B5

The values show a short part of the cable being buried by less than 1 m adjacent to the rock dump. On average, the cable is buried by more than 2 m.

Table 4-26: Percentage and length of depth over cover of zone B5
(DoC = 1.0 m, DoC' = 0.8 m, Doc'' = 0.6 m)

Cable Zone B5	Total cable length for the zone: 4100 m						
Survey year	Percentage			Average Depth of Cover	Length		
	< DoC	< DoC'	< DoC''		< DoC	< DoC'	< DoC''
	[%]	[%]	[%]	[m]	[m]	[m]	[m]
2020	0.1	0.0	0.0	2.43	4	0	0
2017	0.2	0.0	0.0	2.30	6	0	0
2014	0.2	0.0	0.0	2.22	6	0	0
2013	0.0	0.0	0.0	2.18	0	0	0

As a **conclusion** for this zone it can be stated that the seabed is variable, but that the risk for insufficient depth of cover in the future in the dune area of the Akkaert bank is considered to be fairly limited due to the installation strategy of the cable.

4.2.2.7 Cable zone B6 (KP 12.720 – KP 12.830)

Cable zone B6 runs from KP 12.720 till KP 12.830 and is located in a swale between the Akkaert bank and the navigation channel 'Vaargeul I'. The seabed is fluctuating with a magnitude of decimetres. However, the cable is buried with a sufficient depth of above 2 m.

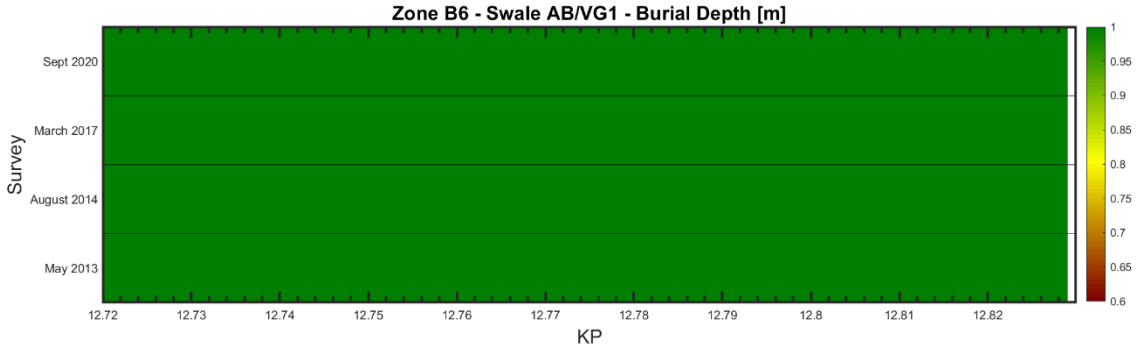

Figure 4-26: Evolution of the Depth of Cover along the cable trajectory in zone B6

No areas with insufficient DoC are detected and the average DoC is above 3 m.

Table 4-27: Percentage and length of depth over cover of zone B6
(DoC = 1.0 m, DoC' = 0.8 m, Doc'' = 0.6 m)

Cable Zone B6	Total cable length for the zone: 1100 m						
Survey year	Percentage			Average Depth of Cover	Length		
	< DoC	< DoC'	< DoC''		< DoC	< DoC'	< DoC''
	[%]	[%]	[%]	[m]	[m]	[m]	[m]
2020	0.0	0.0	0.0	3.24	0	0	0
2017	0.0	0.0	0.0	3.39	0	0	0
2014	0.0	0.0	0.0	3.04	0	0	0
2013	0.0	0.0	0.0	3.08	0	0	0

As a **conclusion** for this zone it can be stated that the DoC is relatively stable and that no areas with insufficient depth of cover are expected in the future.

4.2.2.8 Cable zone B7 (KP 12.830 – KP 13.689)

Cable zone B7 is defined between KP 12.830 and KP 13.689 and crosses the navigation channel 'Vaargeul I'. This navigation channel is in general prone to sedimentation and maintained by regular dredging. No areas with insufficient depth of cover are recorded so far and the seabed is found to be relatively stable.

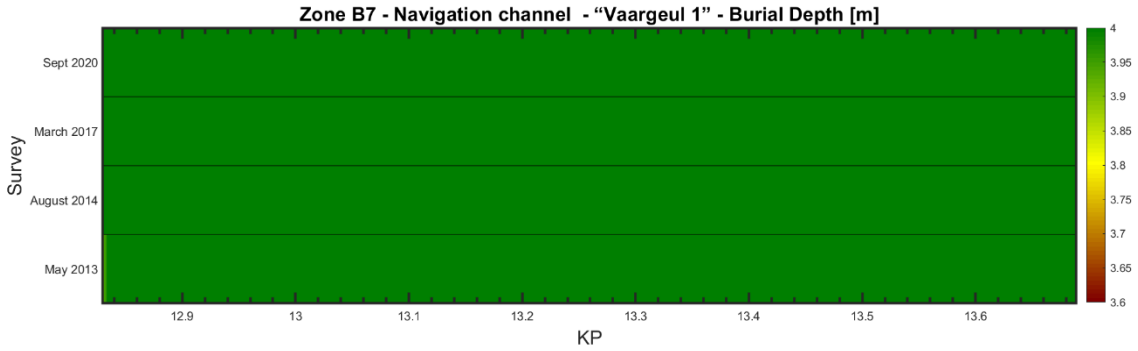

Figure 4-27: Evolution of the Depth of Cover along the cable trajectory in zone B7

The results of the first survey show a very small area with burial of less than 4 m. Due to the trend of accretion, the DoC increased and the average cable depth of cover is larger than 4.5 m.

Table 4-28: Percentage and length of depth over cover of zone B7
(DoC = 4.0 m, DoC' = 3.8 m, Doc" = 3.6 m)

Cable Zone B7	Total cable length for the zone: 859 m						
Survey year	Percentage			Average Depth of Cover	Length		
	< DoC	< DoC'	< DoC"		< DoC	< DoC'	< DoC"
	[%]	[%]	[%]	[m]	[m]	[m]	[m]
2020	0.0	0.0	0.0	4.81	0	0	0
2017	0.0	0.0	0.0	4.92	0	0	0
2014	0.0	0.0	0.0	4.56	0	0	0
2013	0.5	0.0	0.0	4.63	4	0	0

As a **conclusion** for this zone it can be stated that the depth of cover is relatively stable and will stay so in the future.

4.2.2.9 Cable zone B8 (KP 13.689 – KP 15.720)

Cable zone B8 is defined between KP 13.689 and KP 15.700 and is located in a swale. As can be seen in the plot in Annex J, a slight erosion trend is visible. The cable was originally trenched quite deep (DoC around 2.5 m) and no areas with a depth of cover less than the target DoC have been noticed so far.

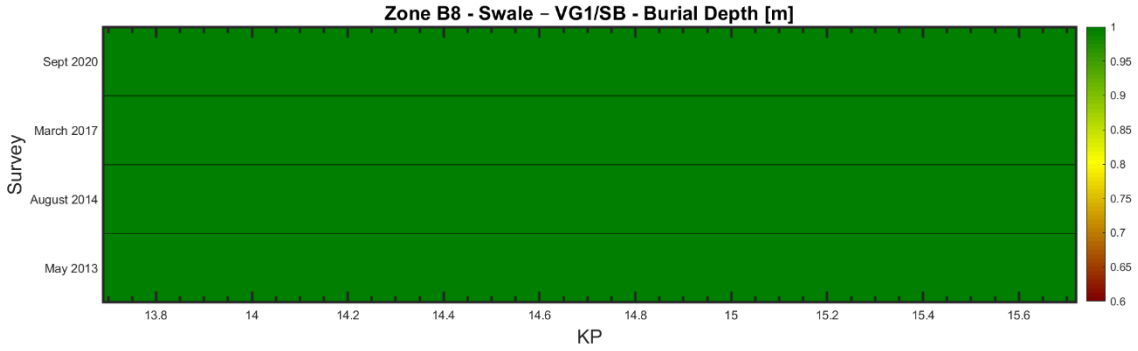

Figure 4-28: Evolution of the Depth of Cover along the cable trajectory in zone B8

No problems are found and the average DoC is larger than 2 m.

Table 4-29: Percentage and length of depth over cover of zone B8
(DoC = 1.0 m, DoC' = 0.8 m, Doc'' = 0.6 m)

Cable Zone B8	Total cable length for the zone: 2031 m						
Survey year	Percentage			Average Depth of Cover	Length		
	< DoC	< DoC'	< DoC''		< DoC	< DoC'	< DoC''
	[%]	[%]	[%]	[m]	[m]	[m]	[m]
2020	0.0	0.0	0.0	2.45	0	0	0
2017	0.0	0.0	0.0	2.32	0	0	0
2014	0.0	0.0	0.0	2.34	0	0	0
2013	0.0	0.0	0.0	2.45	0	0	0

As a **conclusion** for this zone it can be stated that although the seabed level is prone to some erosion, no areas with insufficient DoC are expected in the future due to the large original burial depth.

4.2.2.10 Cable zone B9 (KP 15.720 – KP 18.500)

Cable zone B9 runs from KP 15.720 till KP 18.500 and covers the large dune field in between the navigation channels 'Vaargeul I' and 'Aanloop Scheur'. The seabed level in this cable zone is very variable due to the mobile sand dunes as visible in Annex J.

The dune tops are not moving in one single direction, but are oscillating leading to a variable DoC in this cable zone. However, the cable was initially installed quite deep (> 2 m cable burial) and consequently no areas with insufficient DoC have been noticed so far.

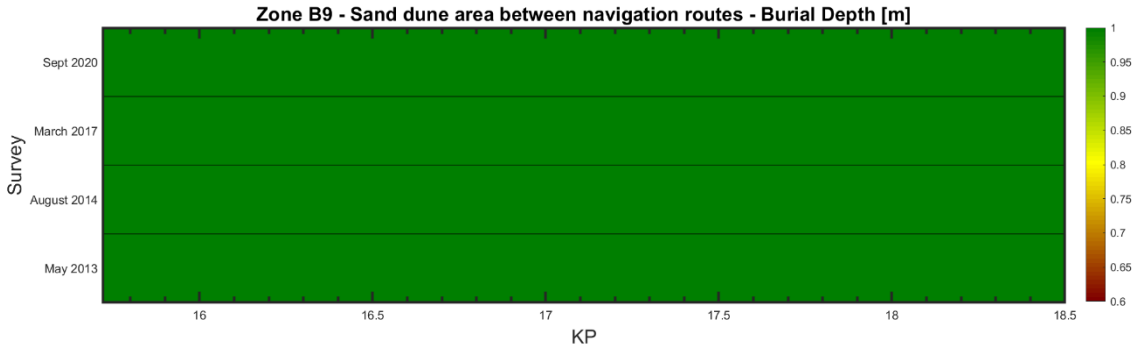

Figure 4-29: Evolution of the Depth of Cover along the cable trajectory in zone B9

The entire length of the cable is buried by more than 1 m and the average DoC is larger than 2 m.

Table 4-30: Percentage and length of depth over cover of zone B9
(DoC = 1.0 m, DoC' = 0.8 m, Doc'' = 0.6 m)

Cable Zone B9	Total cable length for the zone: 2780 m						
Survey year	Percentage			Average Depth of Cover	Length		
	< DoC	< DoC'	< DoC''		< DoC	< DoC'	< DoC''
	[%]	[%]	[%]	[m]	[m]	[m]	[m]
2020	0.0	0.0	0.0	2.38	0	0	0
2017	0.0	0.0	0.0	2.25	0	0	0
2014	0.0	0.0	0.0	2.23	0	0	0
2013	0.0	0.0	0.0	2.27	0	0	0

As a **conclusion** for this zone it can be stated that although the seabed level is quite variable, no areas with insufficient depth of cover are expected in the future due to the installation strategy of cable B.

4.2.2.11 Cable zone B10 (KP 18.500 – KP 18.820)

Cable zone B10 is located in a swale between KP 18.500 and KP 18.820. Some significant changes in the seabed level are visible. As the cable has been installed with a burial depth of at least 2 m, no areas with insufficient depth of cover have been noticed so far though.

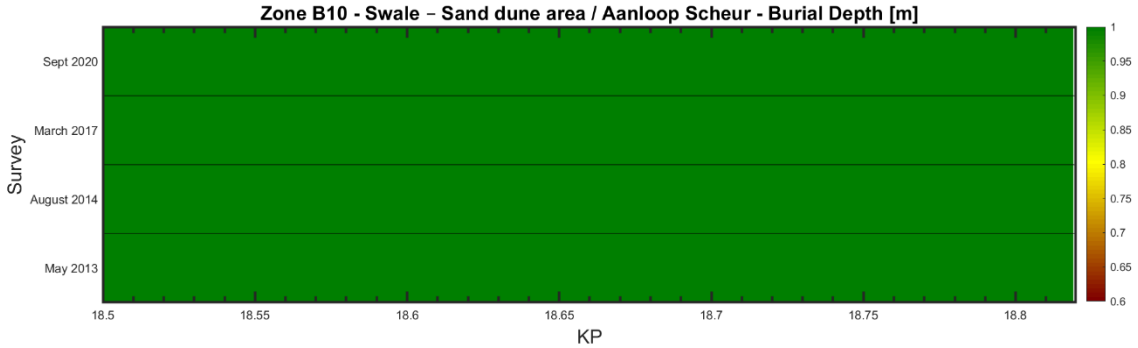

Figure 4-30: Evolution of the Depth of Cover along the cable trajectory in zone B10

Over the entire length of the cable, the DoC is > 1 m. The figures show no areas with possible insufficient depth of cover and the average depth of cover is well above 2 m.

Table 4-31: Percentage and length of depth over cover of zone B10
(DoC = 1.0 m, DoC' = 0.8 m, Doc'' = 0.6 m)

Cable Zone B10	Total cable length for the zone: 320 m						
Survey year	Percentage			Average Depth of Cover	Length		
	< DoC	< DoC'	< DoC''		< DoC	< DoC'	< DoC''
	[%]	[%]	[%]	[m]	[m]	[m]	[m]
2020	0.0	0.0	0.0	2.49	0	0	0
2017	0.0	0.0	0.0	2.40	0	0	0
2014	0.0	0.0	0.0	2.40	0	0	0
2013	0.0	0.0	0.0	2.49	0	0	0

As a **conclusion** for this zone it can be stated that although the seabed level is fluctuating, no areas with insufficient depth of cover are expected in the future due to the large original burial depth.

4.2.2.12 Cable zone B11 (KP 18.820 – KP 19.730)

Cable zone B11 runs from KP 18.820 till 19.730 and crosses the 'Aanloop scheur' navigation channel. There exists a tendency of accretion in the navigation channel, which is clearly visible in the plot in Annex J.

The legal depth of cover of the cable for the crossing with the navigation channel 'Aanloop Scheur' is equal to 2 m. However, 1.0 m was accepted.

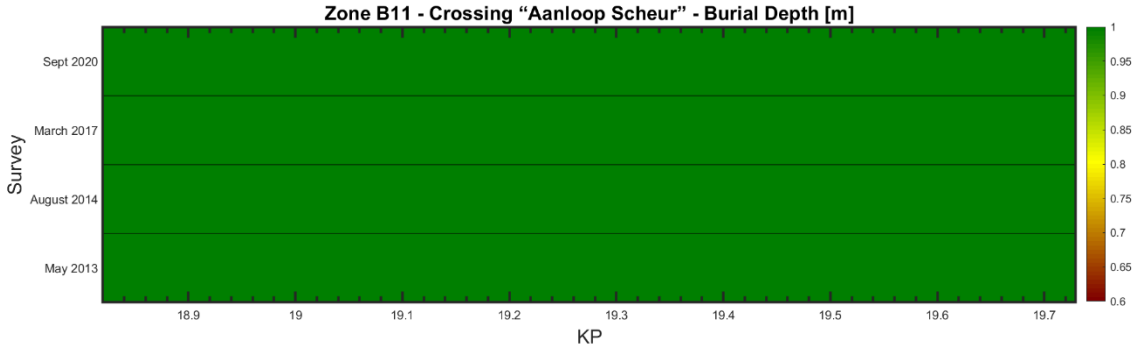

Figure 4-31: Evolution of the Depth of Cover along the cable trajectory in zone B11

The entire cable has been buried deeper than 1 m over its entire length and the average DoC exceeds 2 m.

Table 4-32: Percentage and length of depth over cover of zone B11
(DoC = 1.0 m, DoC' = 0.8 m, Doc'' = 0.6 m)

Cable Zone B11	Total cable length for the zone: 910 m						
Survey year	Percentage			Average Depth of Cover	Length		
	< DoC	< DoC'	< DoC''		< DoC	< DoC'	< DoC''
	[%]	[%]	[%]	[m]	[m]	[m]	[m]
2017	0.0	0.0	0.0	2.47	0	0	0
2017	0.0	0.0	0.0	2.38	0	0	0
2014	0.0	0.0	0.0	2.23	0	0	0
2013	0.0	0.0	0.0	2.16	0	0	0

As a **conclusion** for this zone it can be stated that no areas with insufficient depth of cover are expected in the future.

4.2.2.13 Cable zone B12 (KP 19.730 – KP 24.620)

Cable zone B12 runs from KP 19.73 till KP 24.62 and represents a swale between the crossing with the navigation channel and the PEC. The seabed level is fairly stable in this zone with minor fluctuations in the order of magnitude of centimetres (see plot in Annex J).

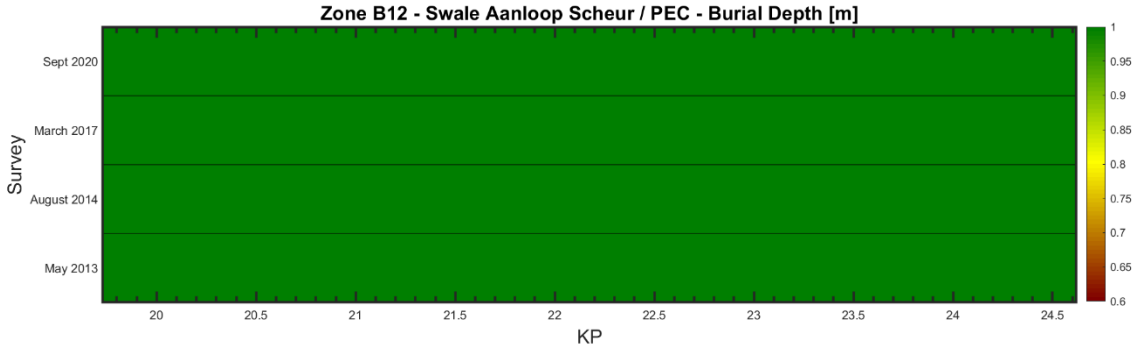

Figure 4-32: Evolution of the Depth of Cover along the cable trajectory in zone B12

The cable is over its entire length buried by at least 1 m and no areas with insufficient depth of cover are visible. The average DoC exceeds 1.5 m.

Table 4-33: Percentage and length of depth over cover of zone B12
(DoC = 1.0 m, DoC' = 0.8 m, Doc'' = 0.6 m)

Cable Zone B12	Total cable length for the zone: 4790 m						
Survey year	Percentage			Average Depth of Cover	Length		
	< DoC	< DoC'	< DoC''		< DoC	< DoC'	< DoC''
	[%]	[%]	[%]	[m]	[m]	[m]	[m]
2020	0.0	0.0	0.0	1.84	0	0	0
2017	0.0	0.0	0.0	1.76	0	0	0
2014	0.0	0.0	0.0	1.73	0	0	0
2013	0.0	0.0	0.0	1.80	0	0	0

As a **conclusion** for this zone it can be stated that although the seabed level is prone to some minor fluctuation, no areas with insufficient depth of cover are expected in the future due to the sufficiently large original burial depth.

4.2.2.14 Cable zone B13 (KP 24.620 – KP 24.700)

Cable zone B13 is defined as the crossing with the PEC telecom cable between KP 24.620 and KP 24.700. The area is covered by rock dump leading to a relatively stable seabed level as can be seen in Annex J.

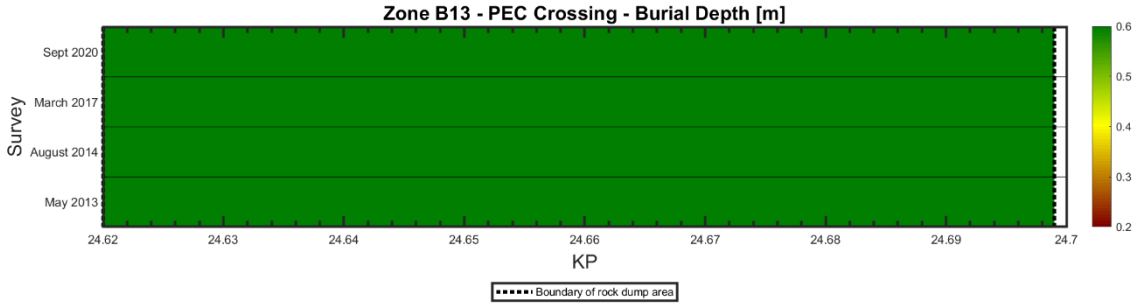

Figure 4-33: Evolution of the Depth of Cover along the cable trajectory in zone B13

The values indicate the absence of areas with insufficient depth of cover in this zone and with an average DoC of above 1 m, the entire cable is sufficiently buried in this zone.

Table 4-34: Percentage and length of depth over cover of zone B13
(DoC = 0.6 m, DoC' = 0.4 m, Doc'' = 0.2 m)

Cable Zone B13	Total cable length for the zone: 80 m						
Survey year	Percentage			Average Depth of Cover	Length		
	< DoC	< DoC'	< DoC''		< DoC	< DoC'	< DoC''
	[%]	[%]	[%]	[m]	[m]	[m]	[m]
2020	0.0	0.0	0.0	1.36	0	0	0
2017	0.0	0.0	0.0	1.31	0	0	0
2014	0.0	0.0	0.0	1.28	0	0	0
2013	0.0	0.0	0.0	1.36	0	0	0

As a **conclusion** for this zone it can be stated that no areas with insufficient DoC are expected in the future due to the presence of rock dump.

4.2.2.15 Cable zone B14 (KP 24.700 – KP 30.200)

Cable zone B14 represents the nearshore area between KP 24.700 and KP 30.200. The seabed level is relatively stable and only minor fluctuations in the order of magnitude of centimetres are measured.

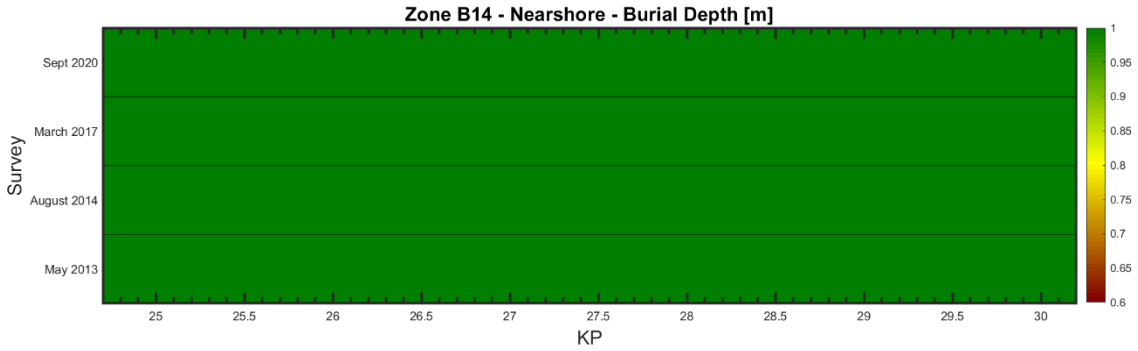

Figure 4-34: Evolution of the Depth of Cover along the cable trajectory in zone B14

Also these values do not indicate any areas with insufficient depth of cover in this zone. The average DoC exceeds 1.5 m.

Table 4-35: Percentage and length of depth over cover of zone B14
(DoC = 1.0 m, DoC' = 0.8 m, Doc'' = 0.6 m)

Cable Zone B14	Total cable length for the zone: 5500 m						
Survey year	Percentage			Average Depth of Cover	Length		
	< DoC	< DoC'	< DoC''		< DoC	< DoC'	< DoC''
	[%]	[%]	[%]	[m]	[m]	[m]	[m]
2020	0.0	0.0	0.0	1.69	0	0	0
2017	0.0	0.0	0.0	1.61	0	0	0
2014	0.0	0.0	0.0	1.66	0	0	0
2013	0.0	0.0	0.0	1.70	0	0	0

As a **conclusion** for this zone it can be stated that although the seabed level is prone to minor fluctuation, no areas with insufficient depth of cover are expected in the future.

4.2.2.16 Cable zone B15 (KP 30.200– KP 35.432)

Cable zone B15 represents the landfall area between KP 30.200 and KP 35.432. The seabed level is fluctuating leading to variations of the depth of cover of the cable (see plot in Annex J). From KP 31.080 till 31.472 and from KP 31.675 till KP 31.830, a remedial rock dump has been placed. In some areas, the DoC is below 1 m.

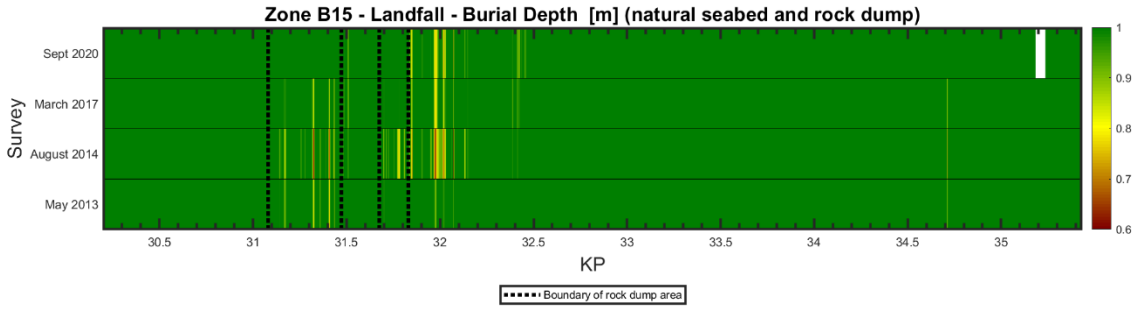

Figure 4-35: Evolution of the Depth of Cover along the cable trajectory in zone B15

It is visible that in several areas the DoC is below 1 m, i.e. less than 3% of the cable length. No areas with a DoC below 0.6 m are observed and the average DoC is above 1.5 m.

It is concluded that other areas with a depth of cover smaller than the target value can be expected in the future.

Table 4-36: Percentage and length of depth over cover of zone B15
(DoC = 1.0 m, DoC' = 0.8 m, Doc'' = 0.6 m)

Cable Zone B15	Total cable length for the zone: 5230 m						
Survey year	Percentage			Average Depth of Cover	Length		
	< DoC	< DoC'	< DoC''		< DoC	< DoC'	< DoC''
	[%]	[%]	[%]	[m]	[m]	[m]	[m]
2020	2.8	0.4	0.0	1.61	145	20	0
2017	2.1	0.2	0.0	1.55	110	10	0
2014	3	0.7	0.0	1.57	156	38	2
2013	0.5	0.0	0.0	1.69	27	0	0

As a **conclusion** for this zone it can be stated that due to fluctuations of the seabed level the DoC is insufficient at some locations and that additional areas not fulfilling the burial requirement can be expected in the future. Close monitoring of this cable zone is advised.

4.3 Summary of Depth of coverage analysis

The actual depth of cover of the export cable A is investigated based on the survey from September 2020. The actual depth of cover is at some locations smaller than the target depth of cover, however the areas where the actual DoC is significantly smaller than the target DoC are very limited in comparison with the entire cable trajectory length. The cable is exposed at two location, at KP 17.077 and KP 17.206 (mobile sand dune area between the navigation routes). It should be noted that this is a very local phenomena, so no immediate actions are required.

Furthermore, due to the mobile dunes, this phenomenon is also variable in place and time. In general, most areas where the depth of cover is smaller than the target value are located in mobile dune areas, for which the dune mobility trend cannot be predicted in order to derive potential mitigation measures.

Less zones with a depth of cover smaller than the target depth of cover are encountered along the export cable B trajectory. This is due to the installation strategy of cable B. The depth of cover along the cable trajectory B is always larger than 0.43 m.

The below tables describe for cable A and B and per cable zone the morphological main characteristics of the zone, the observed trend and identification of future possible behaviour of the seabed in the zone and the conclusions regarding actions.

Table 4-37: Conclusions for Cable A

Cable zone	Start KP	End KP	Characteristics	Observed trends and identification of possible future changes	Conclusion
A1	0.386	1.050	Thornton bank	When and where changes in DoC will occur in this cable zone is difficult to predict since this is depending on the (not-constant) dune movement speed.	Monitoring is advised
A1.1	0.386	0.890	*Thornton bank – Natural seabed*	Area with sand dunes moving towards the Thornton bank.	Monitoring is advised
A1.2	0.890	0.950	*Thornton bank – Rock dump*	Rock dump is sufficient and stable.	Relatively stable
A1.3	0.950	1.050	*Thornton bank – Natural seabed*	Area with sand dunes moving towards the Thornton bank.	Monitoring is advised
A2	1.05	4.2	Swale – TB/GB	When and is difficult to predict since this is depending on the (not-constant) dune movement speed. Area is also prone to gradual erosion.	Monitoring is advised
A3	4.2	6.3	Goote bank	Due to the oscillatory behaviour of the dunes, it is very difficult to predict when and where changes in the DoC can be expected.	Monitoring is advised
A4	6.3	9.5	Swale – GB/AB	Area located between the Goote bank and the Akkaert bank. Minor seabed level variations (both erosion and accretion) but overall the seabed remains stable.	Relatively stable
A5	9.5	12.5	Akkaert bank	Due to the oscillatory behaviour of the dunes, it is very difficult to predict when and where changes in the DoC can be expected.	Monitoring is advised
A6	12.5	13.2	Swale – AB/VG1	Area between the Akkaert bank and the Vaargeul I navigation channel. Minor seabed level variations.	Relatively stable
A7	13.2	14	Navigation channel - "Vaargeul 1"	A trend of accretion exists in the navigation channel. Maintenance dredging occurs in the navigation channel.	Relatively stable
A8	14	15.3	Swale – VG1/SB	An alternating trend of erosion and accretion is observed. No sand dunes present, stable seabed.	Relatively stable

A9	15.3	17.8	Sand dune field between navigation routes	Due to the oscillatory behaviour of the dunes, it is very difficult to predict when and where changes in the DoC can be expected.	Monitoring is advised
A10	17.8	19.1	Swale - SB/SC	Only minor seabed level variations are noticed.	Relatively stable
A11	19.1	20	Crossing "Aanloop Scheur"	Crossing of the cables with the navigation channel 'Aanloop Scheur'. Minor seabed level variations are noticed.	Relatively stable
A12	20	24.2	Swale – SC/PEC	Relative stable seabed, only minor variations.	Relatively stable
A12.1	20	20	*SC – Joint area*	Relative stable seabed, only minor variations.	Relatively stable
A12.2 (joint area)	0	0.52	*Joint area (local KP)*	Rock dump is sufficient and stable.	Relatively stable
A12.3	(KP 20.000)	(KP 20.300)	*Joint area until PEC crossing*	Relative stable seabed, only minor variations.	Relatively stable
A12.3	20.3	24.2	*Joint area until PEC crossing*	Relative stable seabed, only minor variations.	Relatively stable
A13	24.2	24.5	PEC crossing – Rock dump	Due to the large depth of cover in the area, very low risk for insufficient depth of cover in the future. Stable due to rock dump.	Relatively stable
A14	24.5	30	Nearshore	Near shore part of the cable. Relatively stable area.	Relatively stable

Table 4-38: Conclusions for Cable B

Cable zone	Start KP	End KP	Characteristics	Comments	Conclusion
B1	0	0.9	Thornton bank	Dunes moving towards the Thornton bank are present in the area. The DoC is sufficient.	Relatively stable
B2	0.9	3.5	Swale – TB/GB	Dunes moving towards the Thornton bank are present in the area. Area also prone to gradual erosion.	Monitoring is advised
B3	3.5	6.32	Goote bank	Oscillating dunes are present. Due to installation strategy, the DoC is sufficient.	Relatively stable
B4	6.32	8.62	Swale – GB/AB	The rock dump is stable and has sufficient thickness.	Relatively stable
B4.1	6.32	6.435	*Rock dump - Design 1*	Stable and sufficient rock protection.	Relatively stable
B4.2	0	0.85	*Joint area (local KP) - Rock dump - Design 1*	Overall the protection is stable.	Relatively stable
B4.3	(KP6.435)	(KP6.947)	*Rock dump - Design 1*	Stable and sufficient rock protection.	Relatively stable
B4.3	6.947	7.3	*Rock dump - Design 1*	Stable and sufficient rock protection.	Relatively stable
B4.4	7.3	8.27	*Rock dump – Design 2/3*	Stable and sufficient rock protection.	Relatively stable
B4.5	8.27	8.62	*Rock dump - Design 1*	Stable and sufficient rock protection.	Relatively stable
B5	8.62	12.72	Akkaert bank	Area with oscillating sand dunes.	Relatively stable
B5.1	8.62	8.98	*Natural seabed*	Area with oscillating sand dunes. Due to installation strategy no problems are expected.	Relatively stable
B5.2	8.98	9.087	*Rock dumping design 2/3*	Stable and sufficient rock protection.	Relatively stable
B5.3	9.087	9.188	*Natural seabed*	Area with oscillating sand dunes. Due to installation strategy no problems are expected.	Relatively stable
B5.4	9.188	9.24	*Rock dumping design 2/3*	Stable and sufficient rock protection.	Relatively stable
B5.5	9.24	12.72	*Natural seabed*	Area with oscillating sand dunes. Due to installation strategy no problems are expected.	Relatively stable
B6	12.72	12.83	Swale AB/VG1	Besides from some minor fluctuations of the seabed level the area is fairly stable.	Relatively stable

B7	12.83	13.689	Navigation channel - "Vaargeul 1"	Area prone to accretion and to regular maintenance dredging.	Relatively stable
B8	13.689	15.72	Swale – VG1/SB	Besides from some minor fluctuations of the seabed level the area is fairly stable.	Relatively stable
B9	15.72	18.5	Sand dune field between navigation routes	Mobile sand dunes in the area. Due to installation strategy, no problems are expected in the future.	Relatively stable
B10	18.5	18.82	Swale – SB/SC	Besides from some minor fluctuations of the seabed level the area is fairly stable.	Relatively stable
B11	18.82	19.73	Crossing "Aanloop Scheur"	Area prone to accretion.	Relatively stable
B12	19.73	24.62	Swale SC/PEC	Besides from some minor fluctuations of the seabed level the area is fairly stable.	Relatively stable
B13	24.62	24.7	PEC Crossing – rock dump	Stable and sufficient DoC due to rock dump.	Relatively stable
B14	24.7	30.2	Nearshore	Stable area, only minor seabed level variations are measured.	Relatively stable
B15	30.2	35.432	Landfall	Area prone to gradual erosion.	Monitoring is advised
B15.1	30.2	31.08	*Landfall – Natural seabed*	Area prone to accretion.	Relatively stable
B15.2	31.08	31.472	*Landfall - Rock dumping design 2 or 3*	Stable and sufficient DoC due to rock dump.	Relatively stable
B15.3	31.472	31.675	*Landfall – Natural seabed*	Area prone to gradual erosion.	Monitoring is advised
B15.4	31.675	31.83	*Landfall - Rock dumping design 2 or 3*	Stable and sufficient DoC due to rock dump.	Relatively stable

5 Conclusions

This report focuses on the analysis of the Depth of Coverage (DoC) along the export cable trajectories A and B of the C-Power OWF and aims to:

- Analyse the status of the DoC along the export cable A and B trajectories based on a multibeam survey of September 2020;
- Analyse the historical evolution of the DoC along export cable trajectories A and B from the year of installation until 2020, with the aim of defining trends and formulate suggestions for future mitigation activities and adapted monitoring program.

For the latter, the cable trajectory is subdivided into cable zones reflecting the encountered seabed morphological and morphodynamic characteristics. For each of these zones, trends are defined as a basis to outline future actions.

In general, it can be concluded that the cable trajectory is characterised by mobile and relatively stable zones, both applicable for cable A and cable B, since both cables are installed parallel to each other with an average distance of about 100 m.

The analysis of the actual (2020) status of the depth of cover (DoC) along cable A show that the cable is exposed at two location, located at KP 17.077 and KP 17.206 (mobile sand dune area between the navigation routes). This phenomenon is only very local (over a distance of ± 3 m), in the vicinity of a dune top and in a zone with mobile sand dunes. Due to the highly dynamic character of this zone, this critical zone should be considered very moveable, which makes it very likely that no remedial action at this spot will prevent that the same will occur in the near vicinity.

Along cable B no exposed sections have been identified.

Only at a few locations along both cable routes, the actual DoC appears to be smaller than the target DoC of 1.0 m. However, for most of these locations, the difference is less than 0.20 m which corresponds actually to the measurements accuracy. Moreover, these stretches represent only a small percentage of the total cable length (1.44% of the total cable length along cable trajectory A and 0.48% of the total cable length along cable trajectory B), which allows to conclude that there is no immediate need for actions.

For cable A, most of the zones where the DoC is actually smaller than the targeted 1.0 m are found in the mobile dune zones (Thornton bank, Akkaert bank, nameless dune field in between the navigation channels). Besides this, also the swale area between the Thornton bank and the Goote bank, as well as the crossing with 'Aanloop Scheur' show local decreases of the seabed, resulting in areas with actual DoC below target DoC.

For cable B, the zones where the DoC is actually smaller than the targeted 1.0 m, are mainly located in the landfall area and in the swale between the Thornton bank and the Goote bank. Furthermore, compared to 2017, two areas, previously identified as requiring close monitoring, are now identified as relatively stable: on the Thornton bank near the boundary of the concession zone and in the joint area. Overall, less areas which require further monitoring occur across the trajectory of cable B with respect to cable A. This is related to the different installation strategy of cable B in the sand dune areas. Over its entire length, cable B is covered by at least 0.4 m.

Based on this analysis, zones requiring closely monitoring are determined, both for the cable trajectories A as B. Closer monitoring is advised for cable A than for cable B. In the zones where a more stable DoC is assessed, one survey every 3 year is considered sufficient.

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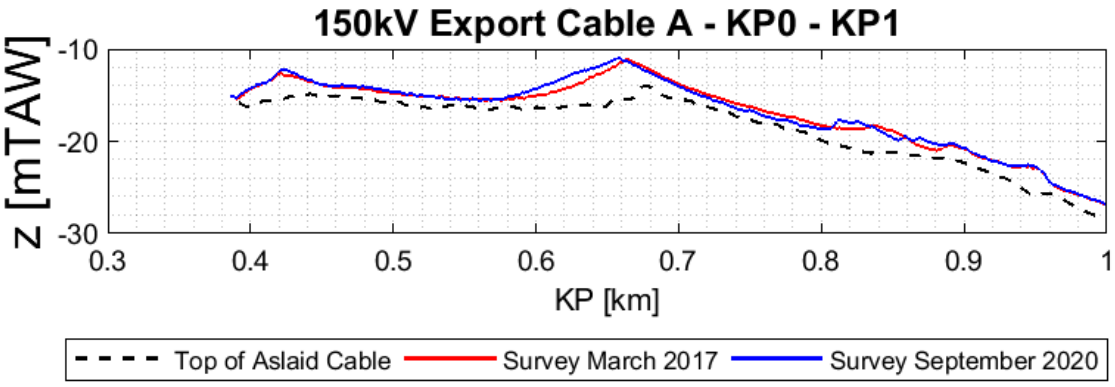
Annex A Export cable A “zones”

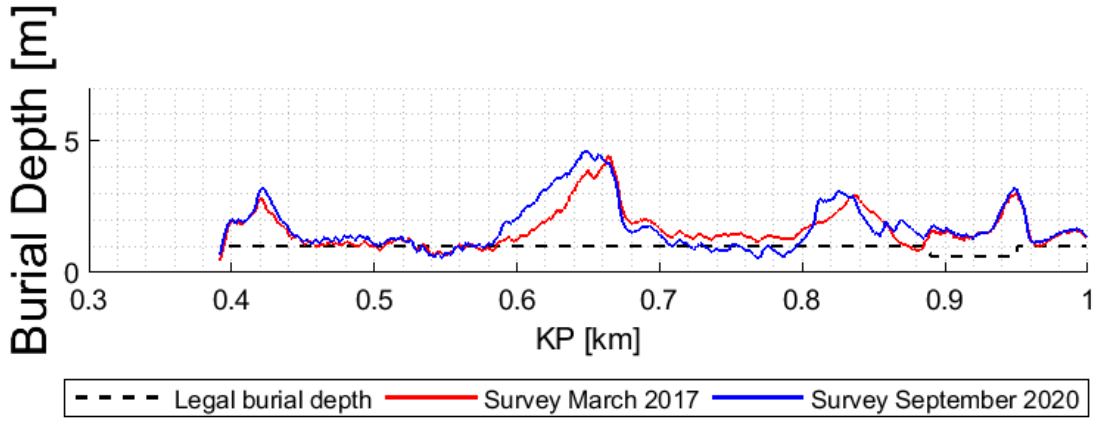
Cable "zone"	Characteristic	From KP	To KP	Target DoC (m)
A1	Thornton bank	0.386	1.050	1.0
A.1.1	*Thornton bank – Natural seabed*	*0.386*	*0.890*	*1.0*
A.1.2	*Thornton bank – Rock dump*	*0.890*	*0.950*	*0.6*
A.1.3	*Thornton bank – Natural seabed*	*0.950*	*1.050*	*1.0*
A2	Swale – TB/GB	1.050	4.200	1.0
A3	Goote bank	4.200	6.300	1.0
A4	Swale – GB/AB	6.300	9.500	1.0
A5	Akkaert bank	9.500	12.500	1.0
A6	Swale – AB/VG1	12.500	13.171	1.0
A7	Navigation channel - "Vaargeul 1"	13.171	14.031	4.0
A8	Swale – VG1 / Sand dune area	14.031	15.300	1.0
A9	Sand dune area between navigation routes	15.300	17.800	1.0
A10	Swale – Sand dune area / Aanloop Scheur	17.800	19.090	1.0
A11	Crossing "Aanloop Scheur"	19.090	19.954	1.0
A12	Swale – Aanloop Scheur / PEC	19.954	24.200	1.0
A12.1	*Aanloop Scheur – Joint area*	*19.954*	*20.000*	*1.0*
A12.2	*Joint area (local KP)*	*0 (KP 20.000)*	*0.521 (KP 20.300)*	*1.0*
A12.3	*Joint area until PEC crossing*	*20.300*	*24.200*	*1.0*
A13	PEC crossing – Rock dump	24.200	24.475	0.6
A14	Nearshore	24.475	30.000	1.0
A15	Landfall area	30.000	35.437	1.0

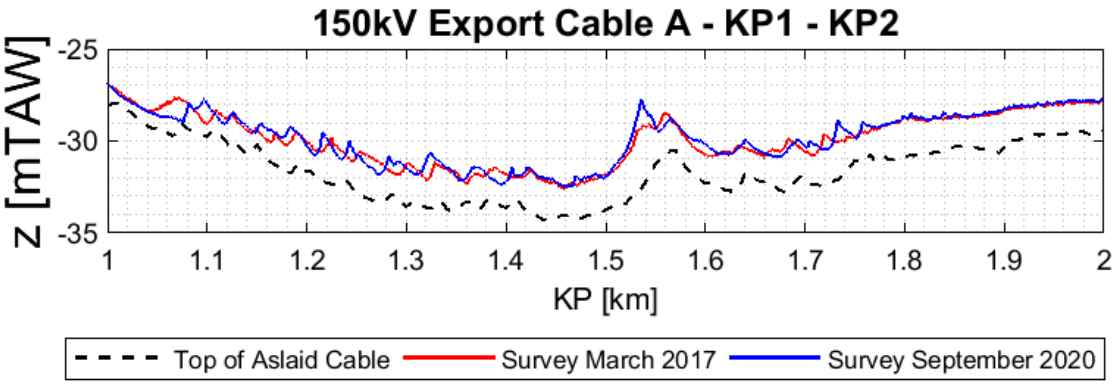
Annex B Export cable B “zones”

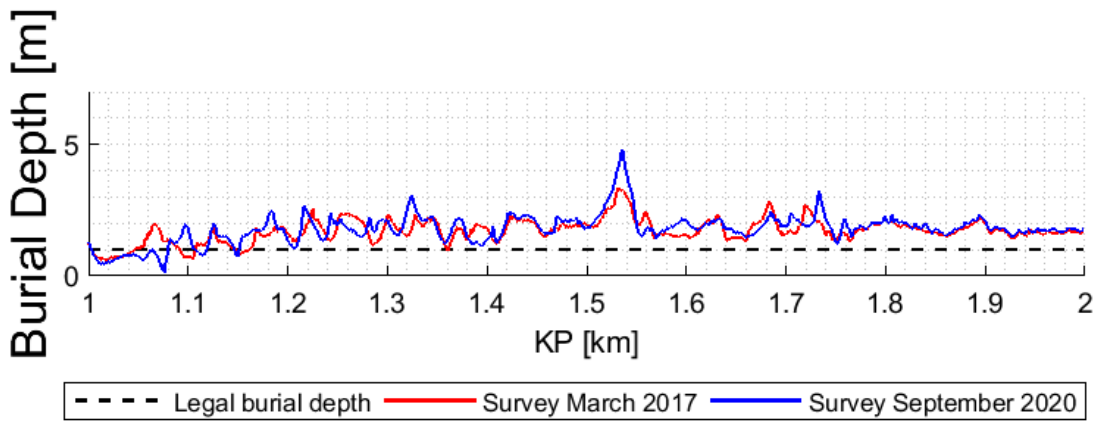
Cable "zone"	Characteristic	From KP	To KP	Target DoC (m)
B1	Thornton bank	0.000	0.900	1.0
B2	Swale – TB/GB	0.900	3.500	1.0
B3	Goote bank	3.500	6.320	1.0
B4	Swale – GB/AB	6.320	8.620	1.0
B4.1	*Rock dump - Design 1*	*6.320*	*6.435*	*0.6*
B4.2	*Joint area (local KP) - Rock dump - Design 1*	*0.000 (KP6.435)*	*0.850 (KP6.947)*	*0.6*
B4.3	*Rock dump - Design 1*	*6.947*	*7.300*	*0.6*
B4.4	*Rock dump – Design 2/3*	*7.300*	*8.270*	*0.6*
B4.5	*Rock dump - Design 1*	*8.270*	*8.620*	*0.6*
B5	Akkaert bank	8.620	12.720	1.0
B5.1	*Natural seabed*	*8.620*	*8.980*	*1.0*
B5.2	*Rock dumping design 2/3*	*8.980*	*9.087*	*0.6*
B5.3	*Natural seabed*	*9.807*	*9.188*	*1.0*
B5.4	*Rock dumping design 2/3*	*9.188*	*9.240*	*0.6*
B5.5	*Natural seabed*	*9.240*	*12.720*	*1.0*
B6	Swale AB/VG1	12.720	12.830	1.0
B7	Navigation channel - "Vaargeul 1"	12.830	13.689	4.0
B8	Swale – VG1 / Sand dune area	13.689	15.720	1.0
B9	Sand dune area between navigation routes	15.720	18.500	1.0
B10	Swale – Sand dune area / Aanloop Scheur	18.500	18.820	1.0
B11	Crossing "Aanloop Scheur"	18.820	19.730	1.0
B12	Swale Aanloop Scheur / PEC	19.730	24.620	1.0
B13	PEC Crossing – rock dump	24.620	24.700	0.6
B14	Nearshore	24.700	30.200	1.0
B15	Landfall	30.200	35.432	0.6
B15.1	*Landfall – Natural seabed*	*30.200*	*31.080*	*1.0*
B15.2	*Landfall - Rock dumping design 2 or 3*	*31.080*	*31.472*	*0.60*
B15.3	*Landfall – Natural seabed*	*31.472*	*31.675*	*1.0*
B15.4	*Landfall - Rock dumping design 2 or 3*	*31.675*	*31.830*	*0.6*
B15.5	*Landfall area*	*31.830*	*35.432*	*1.0*

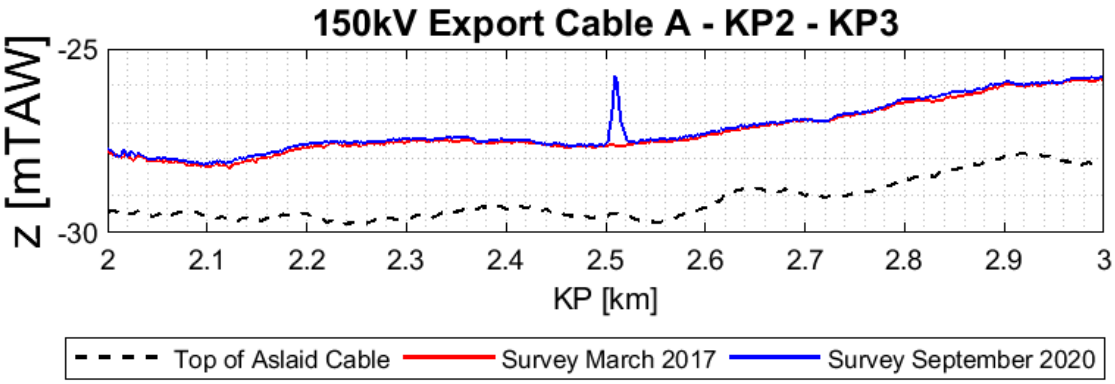
Annex C Actual Depth of Cover export cable A

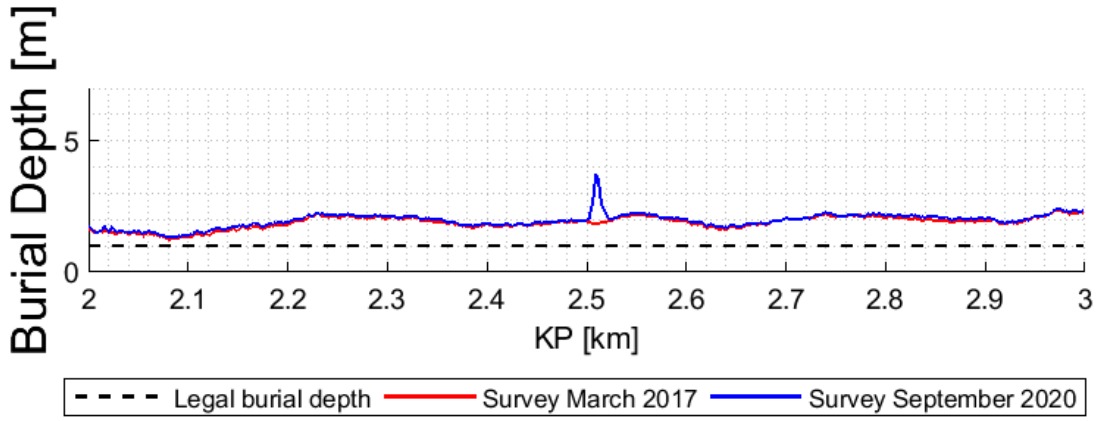


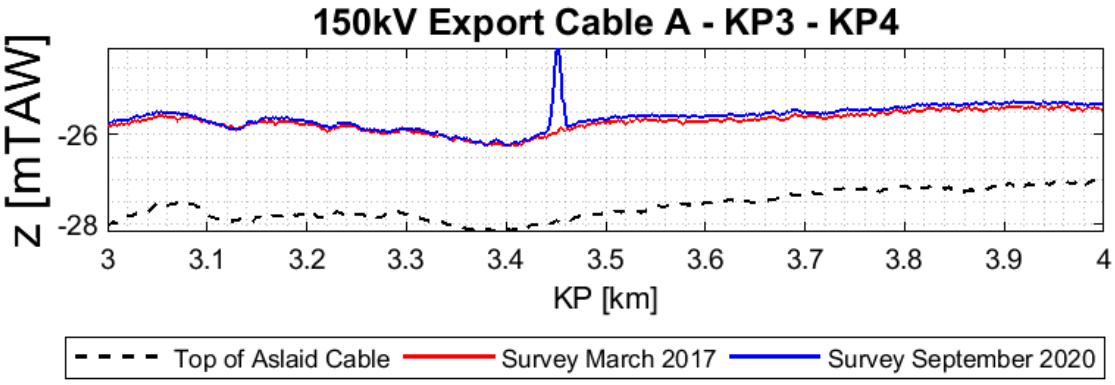


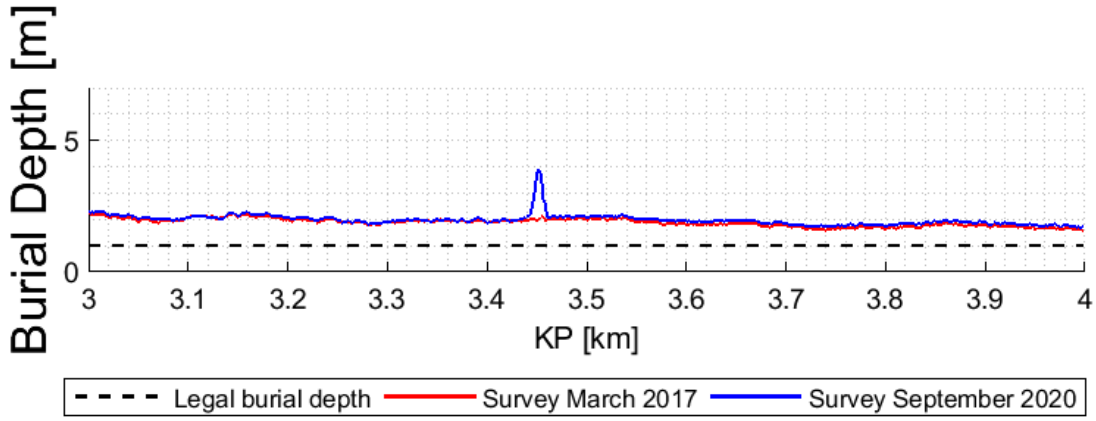


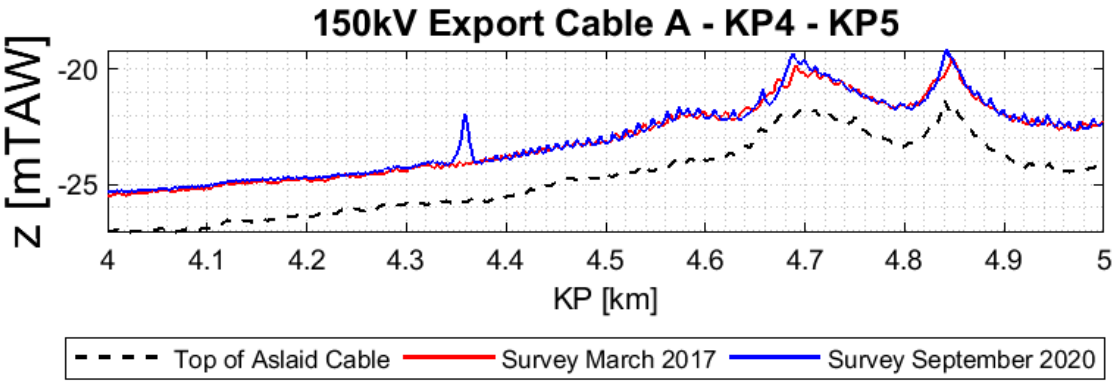


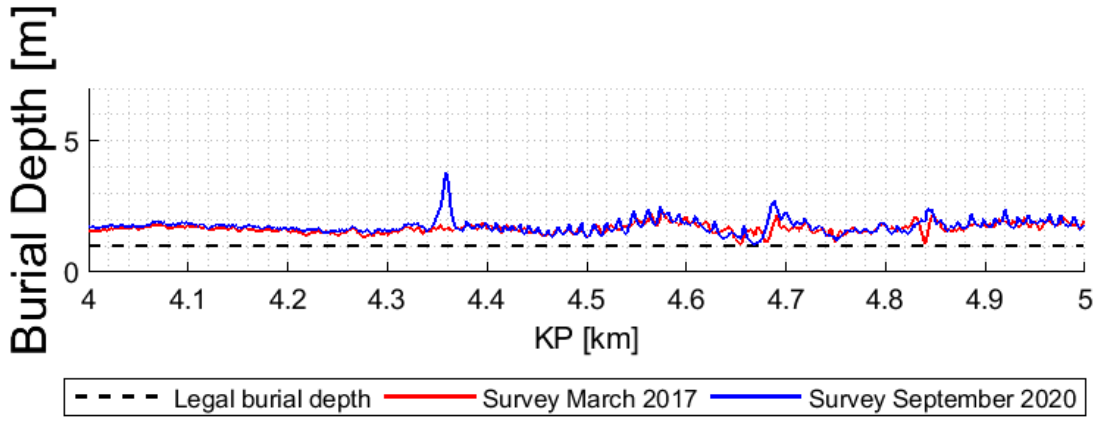


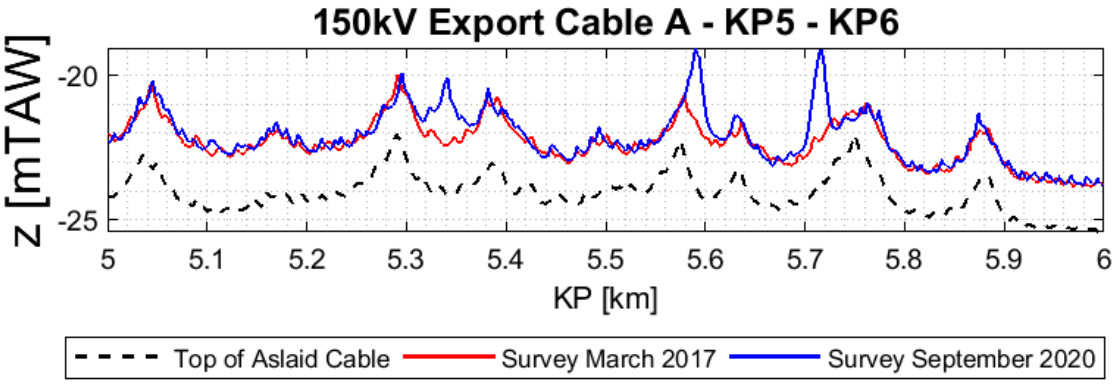


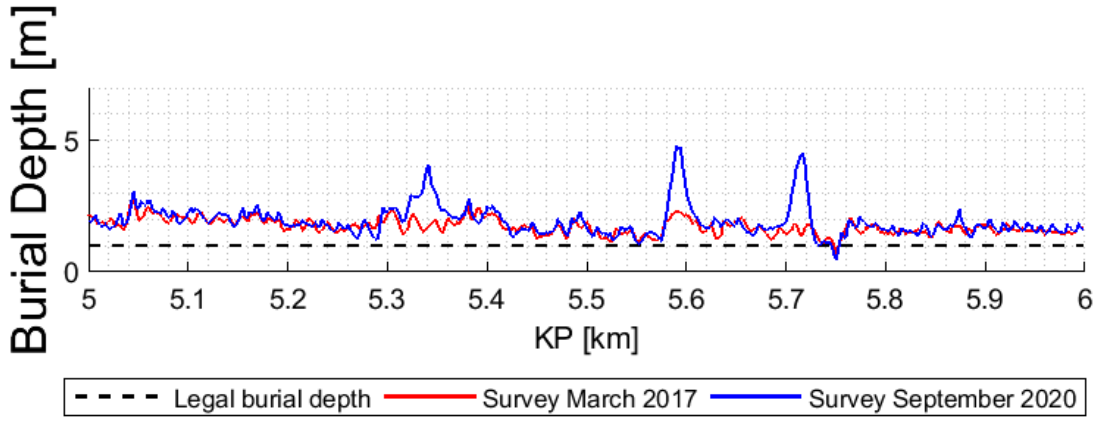


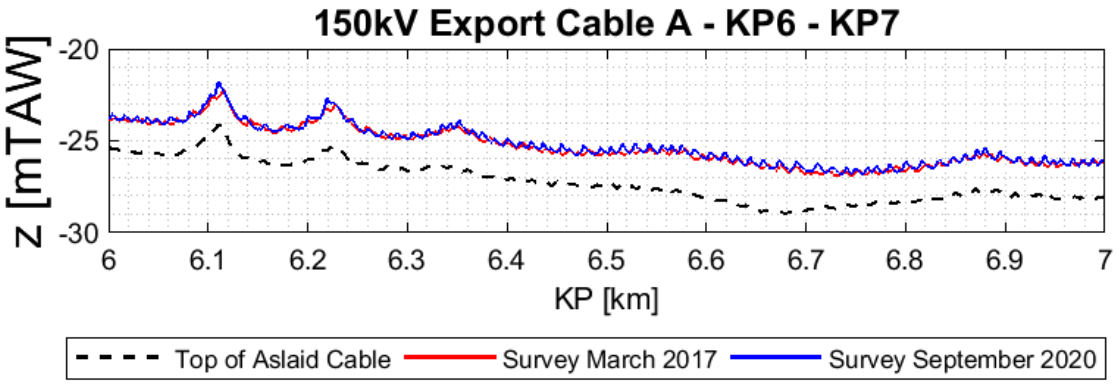


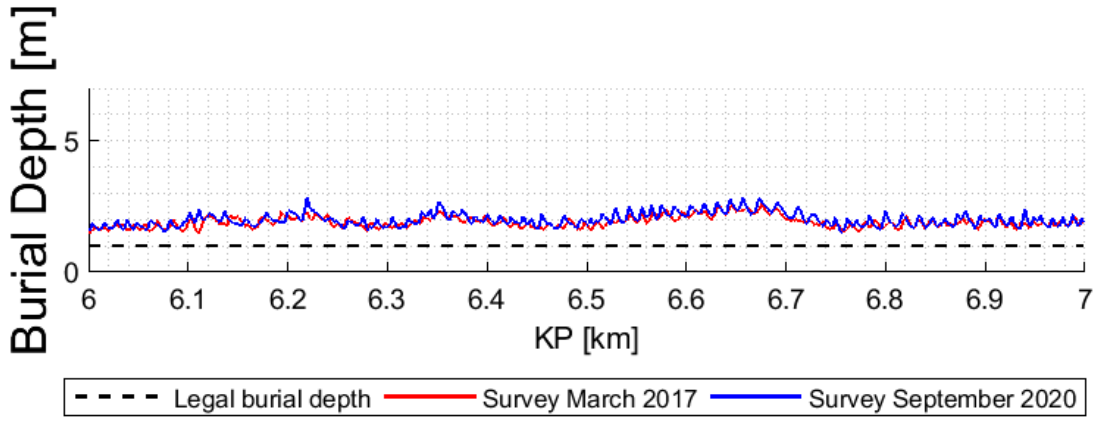


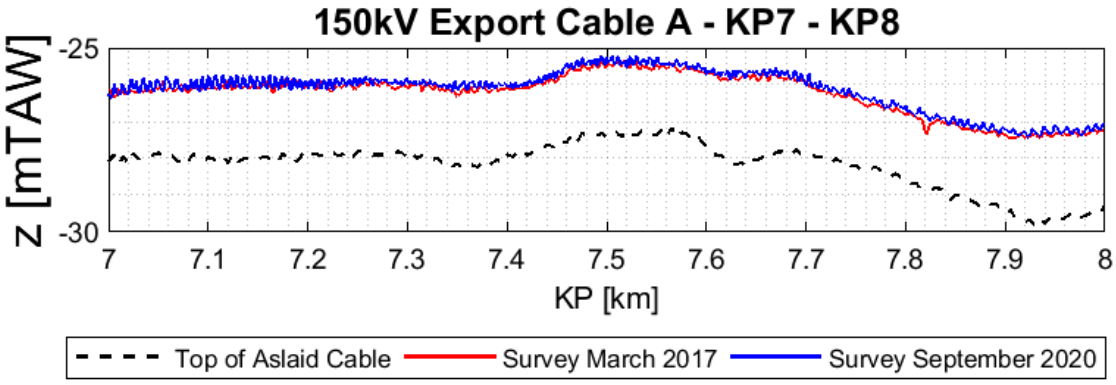


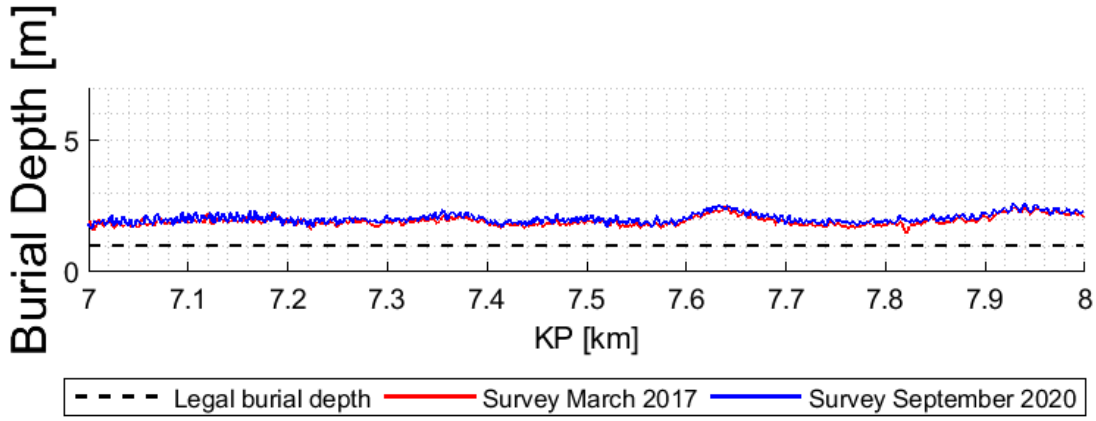


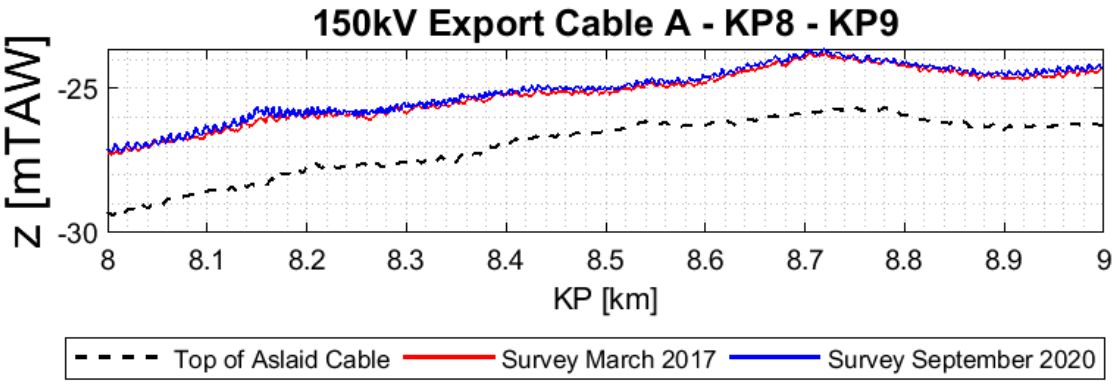


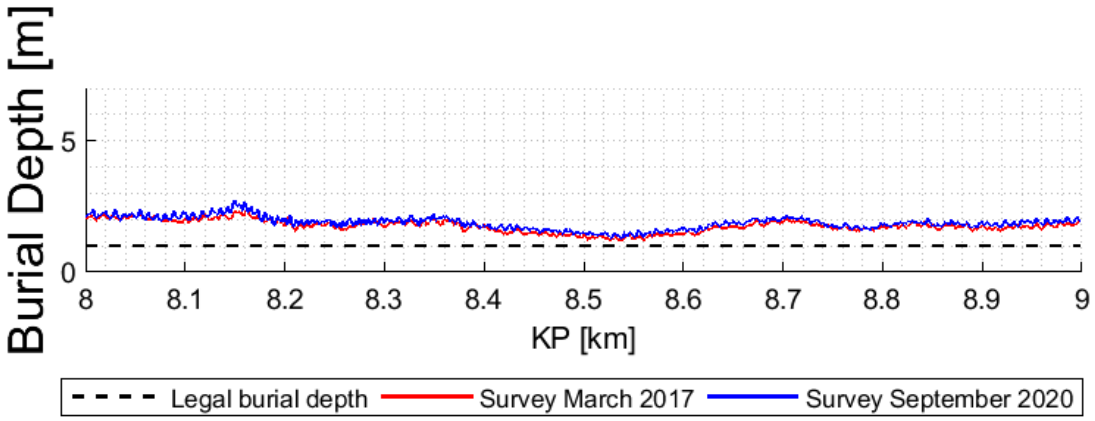


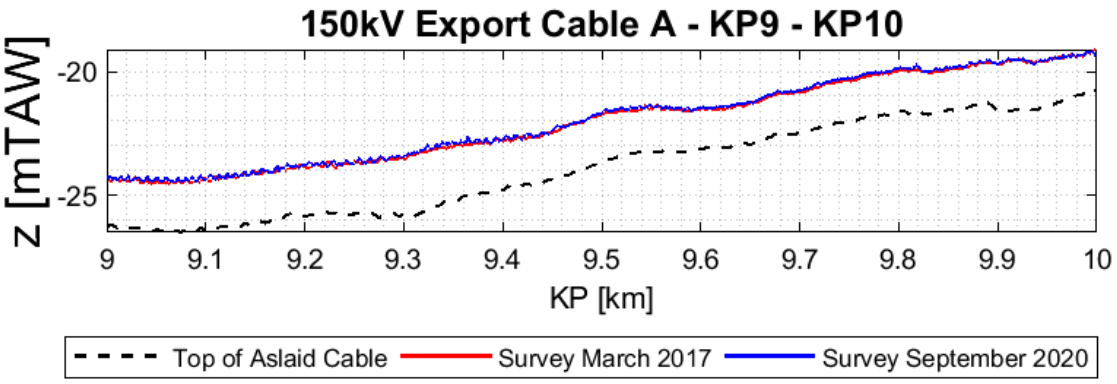


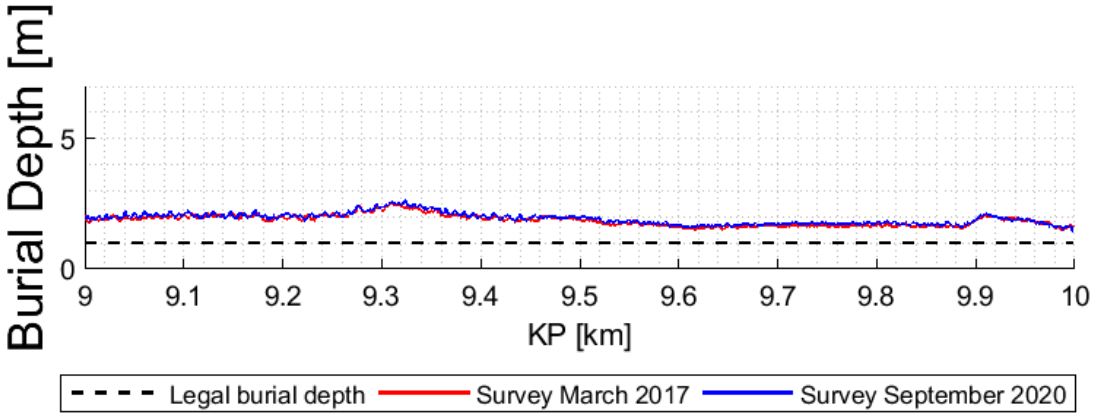


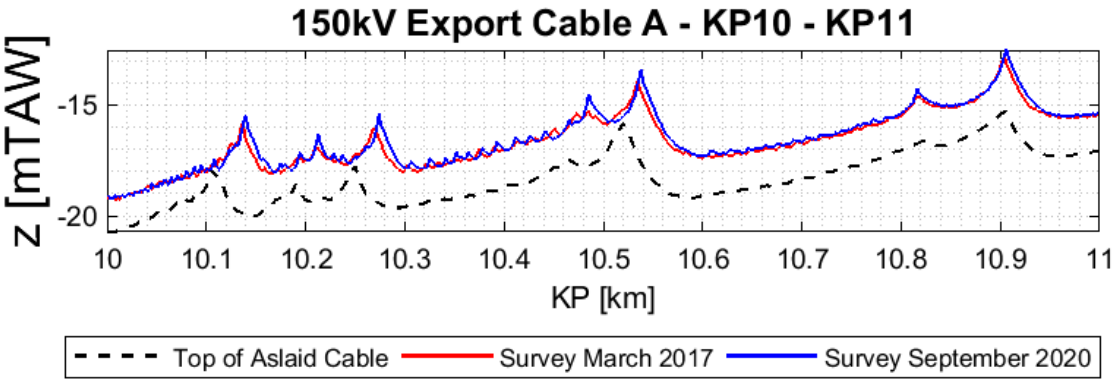


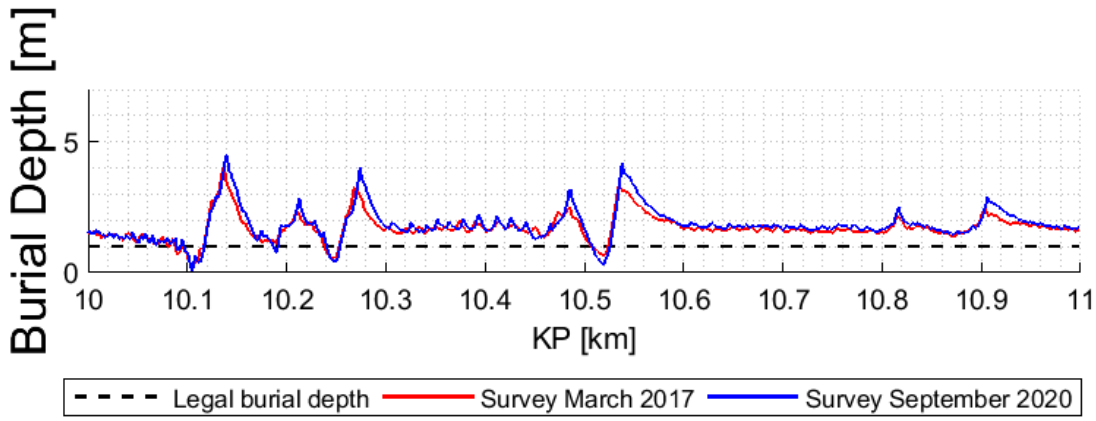


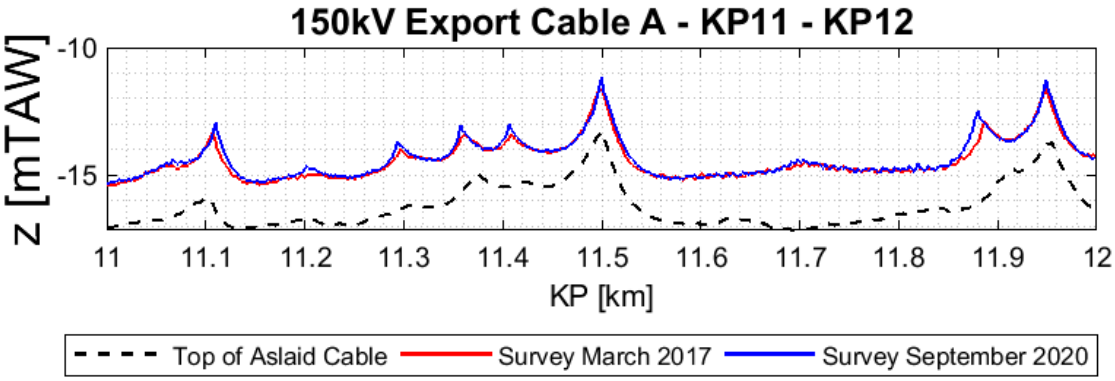


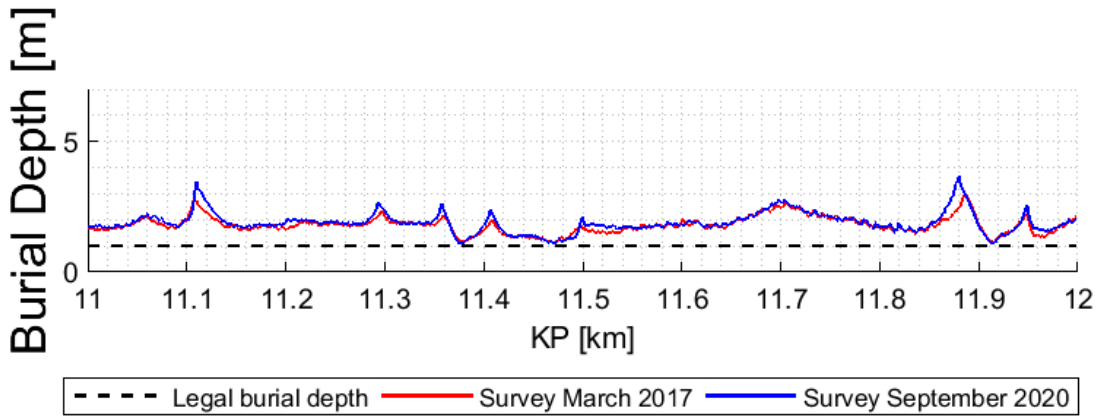


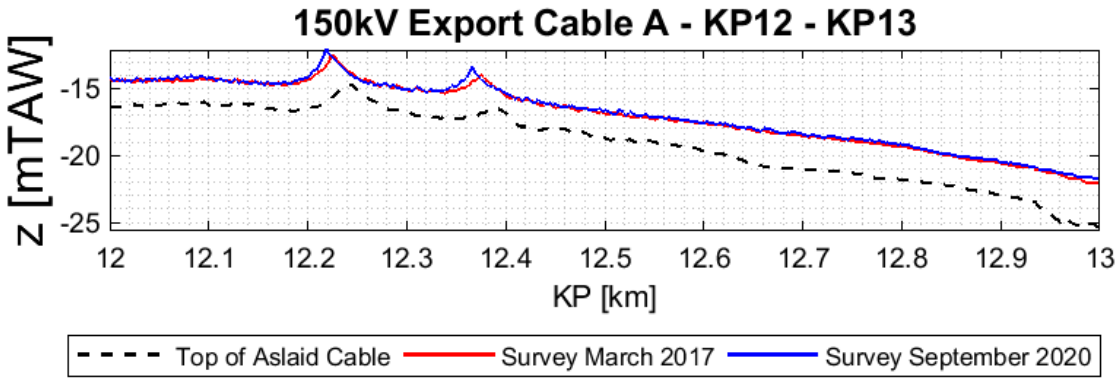


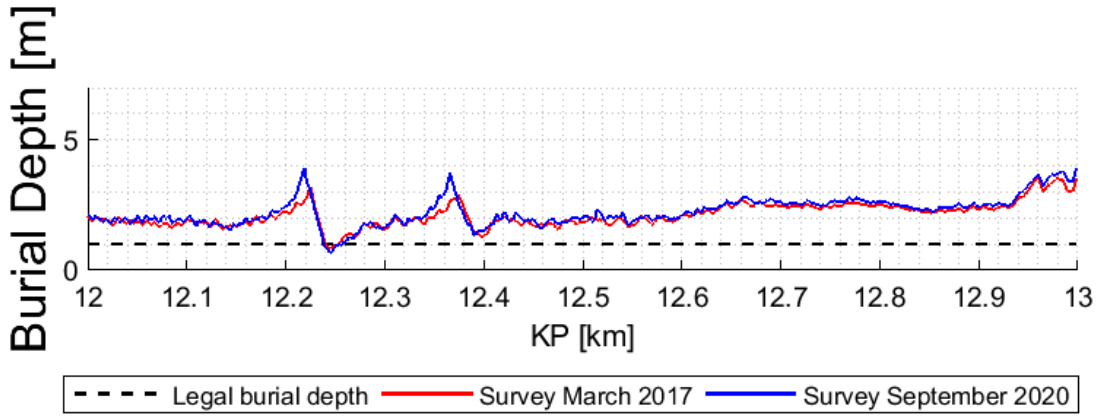


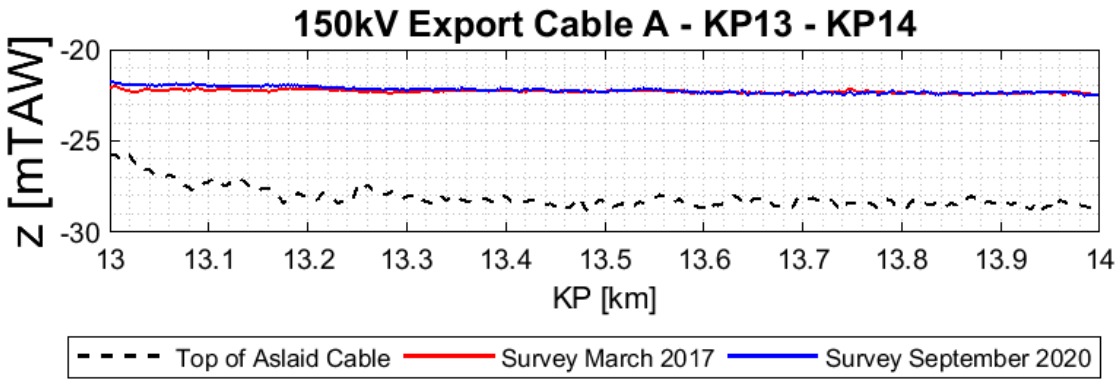


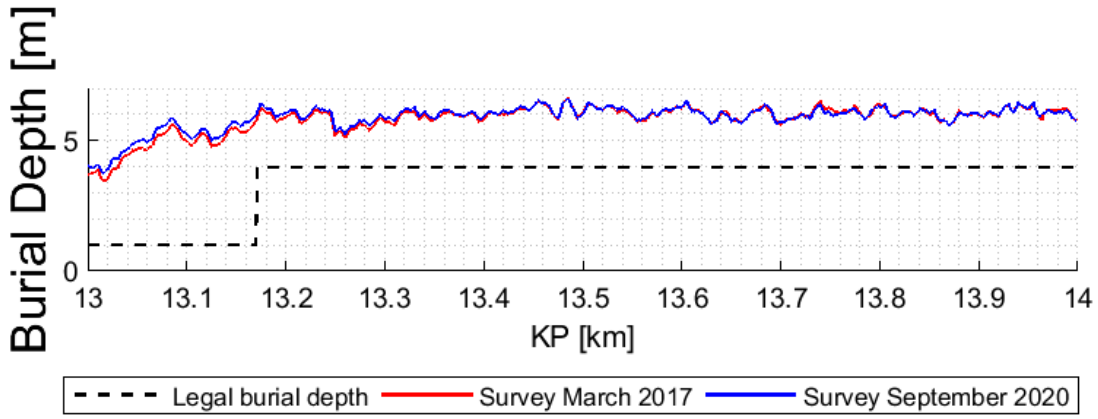


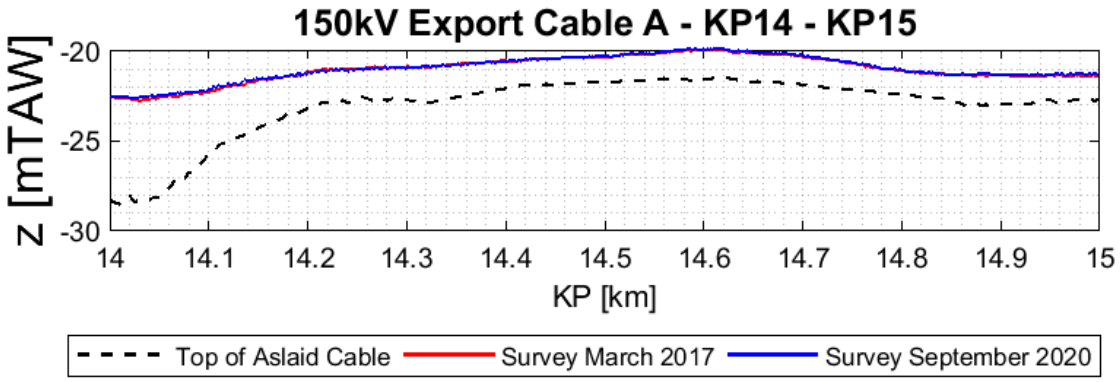


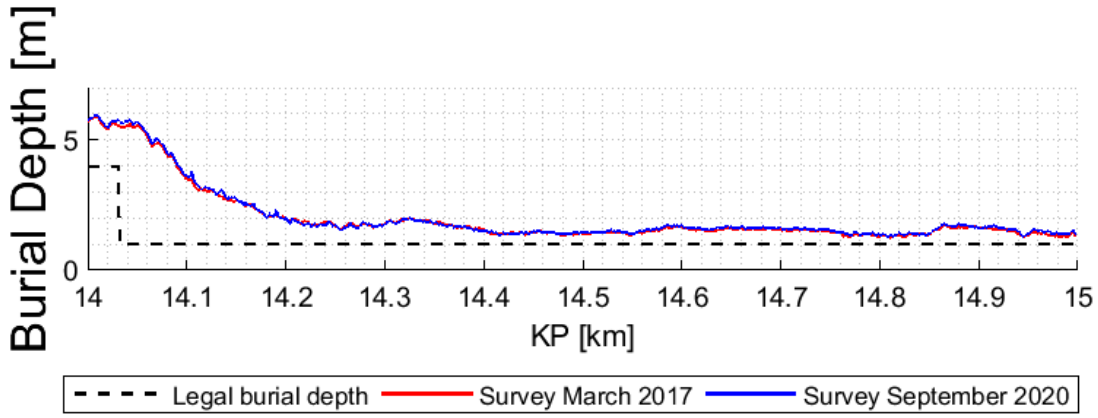


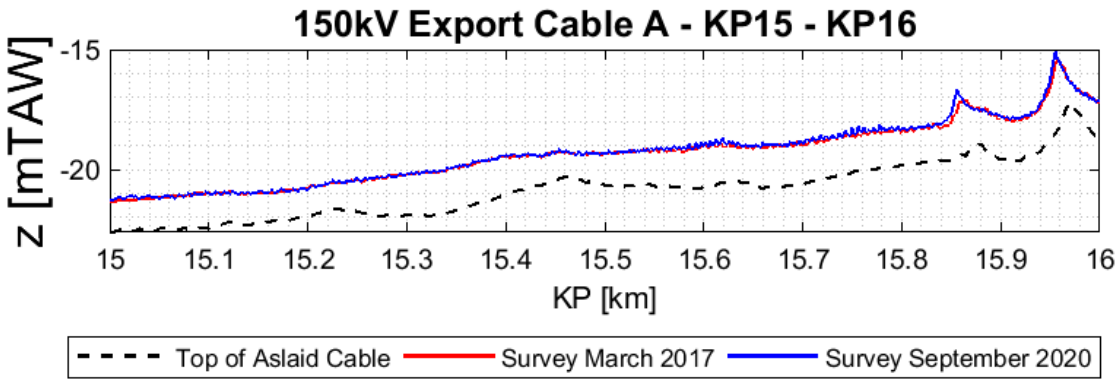


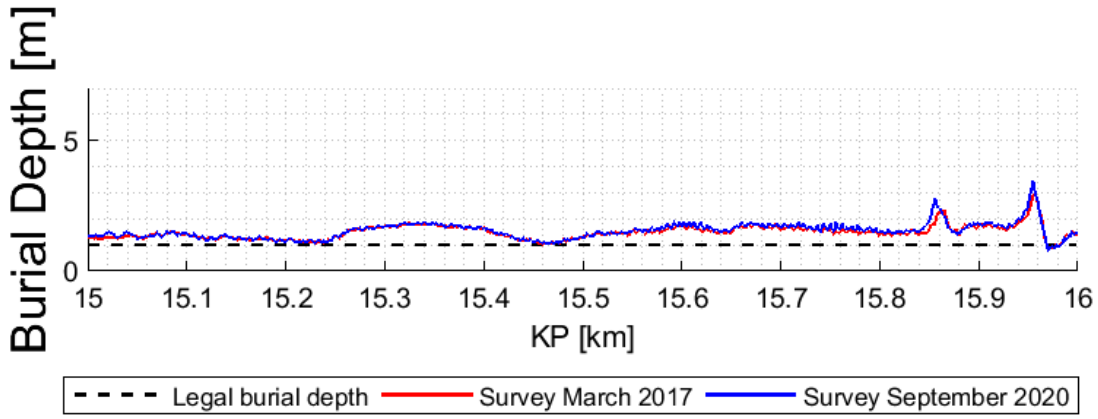


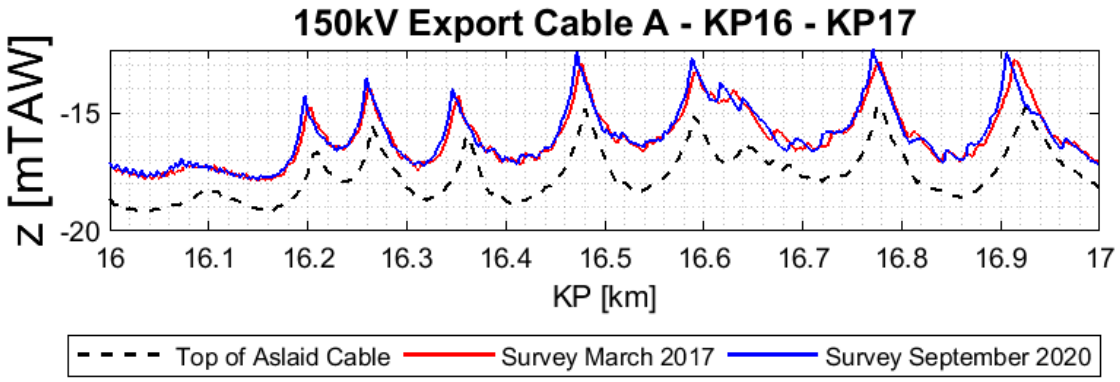


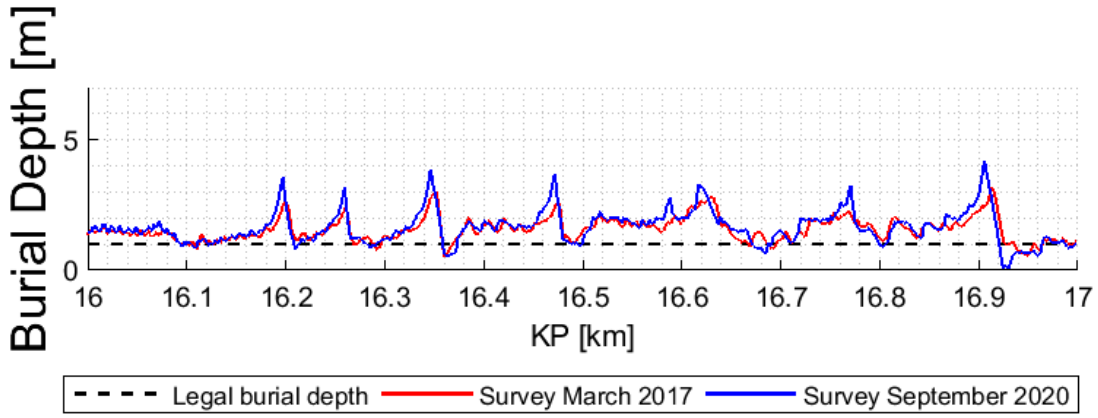


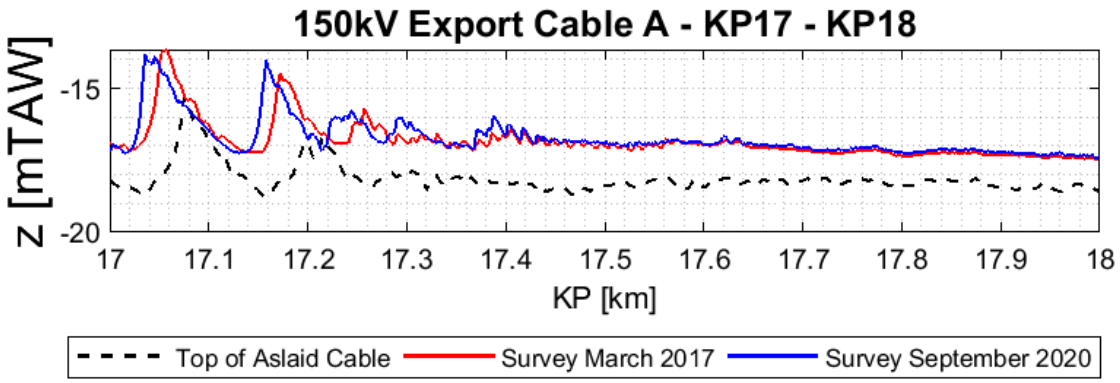


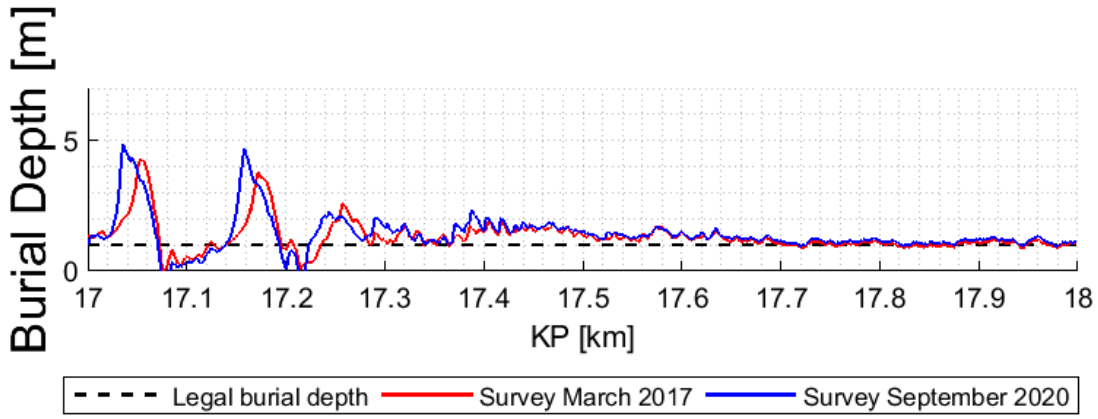


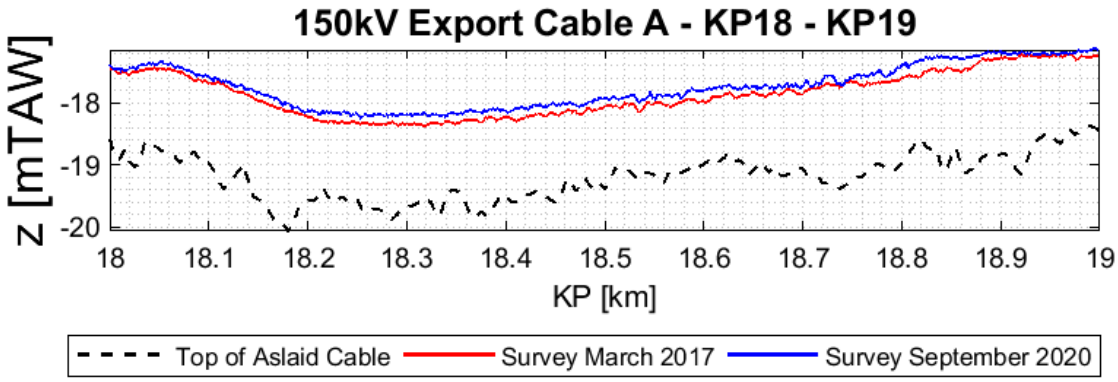


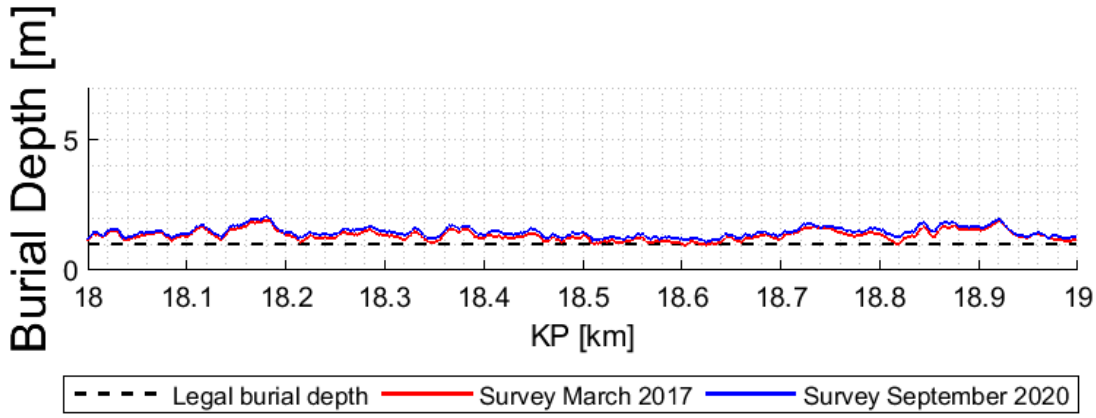


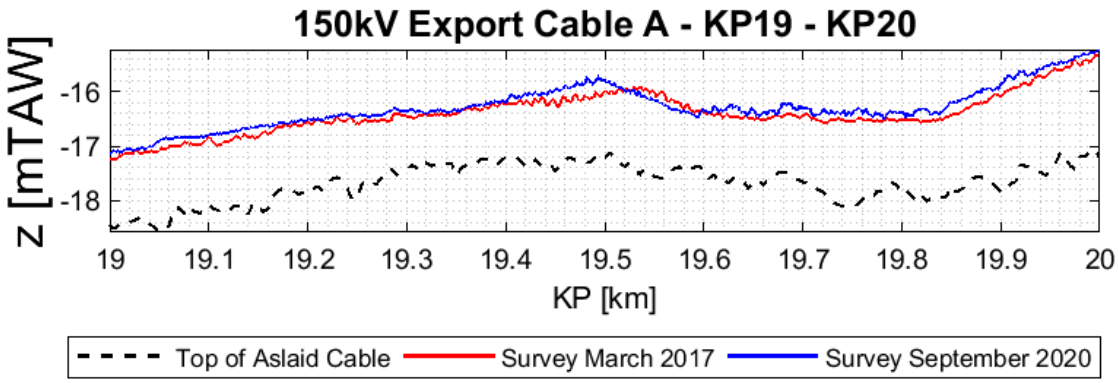


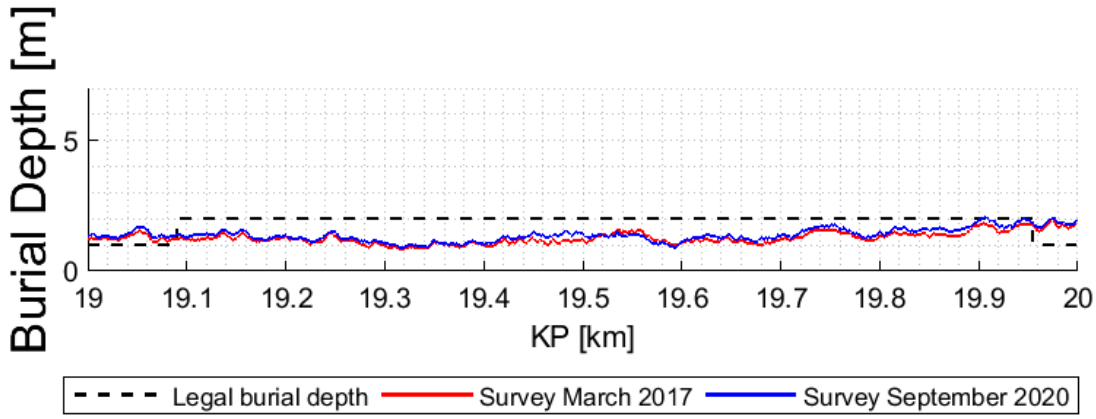


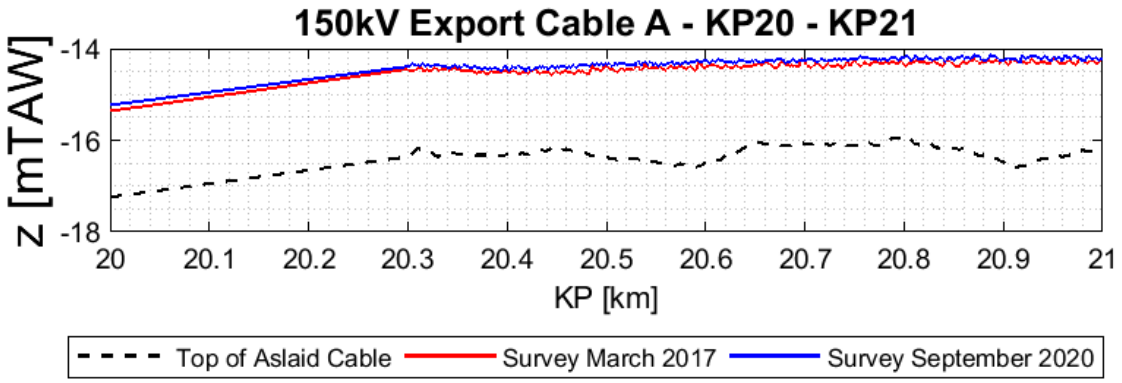


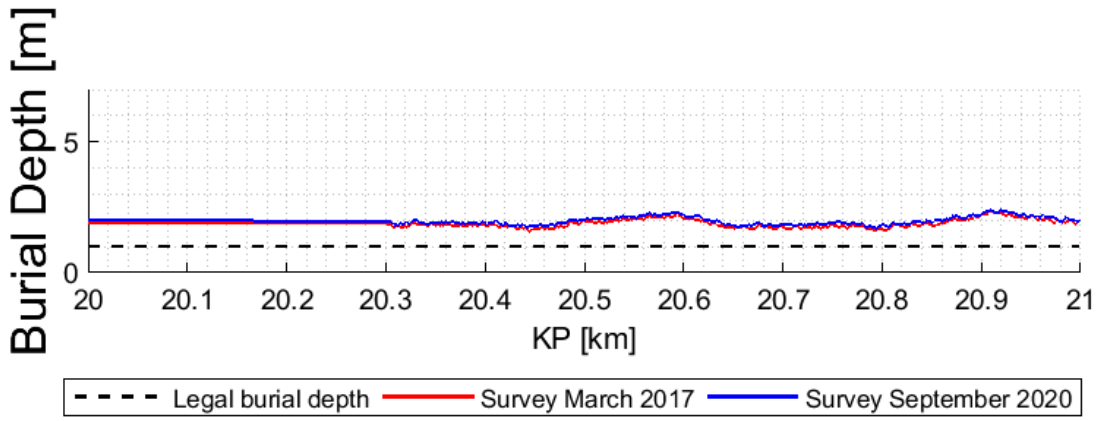


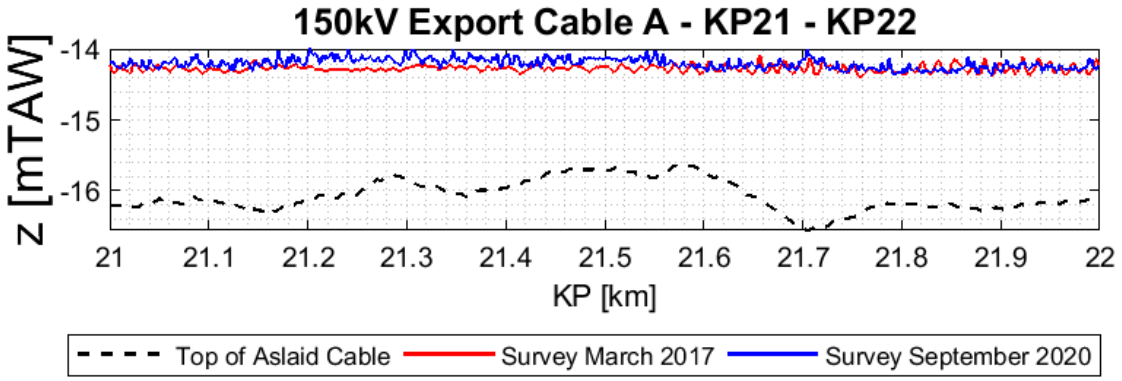


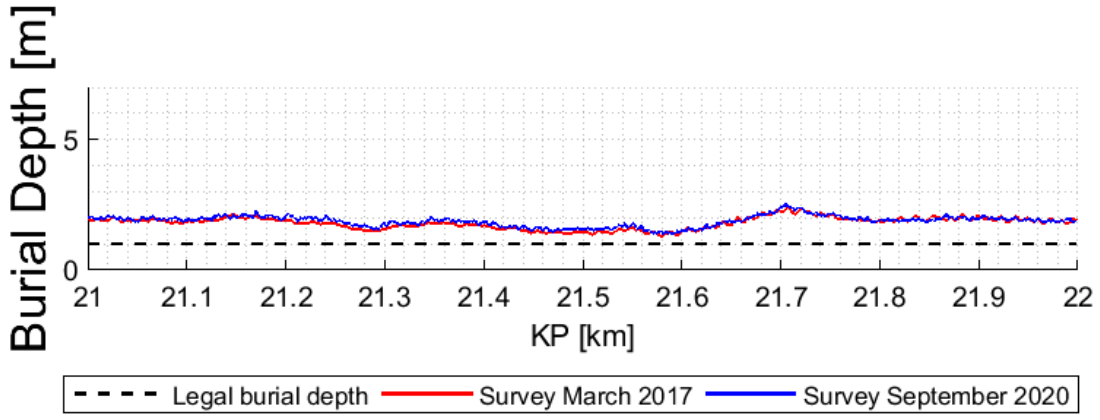


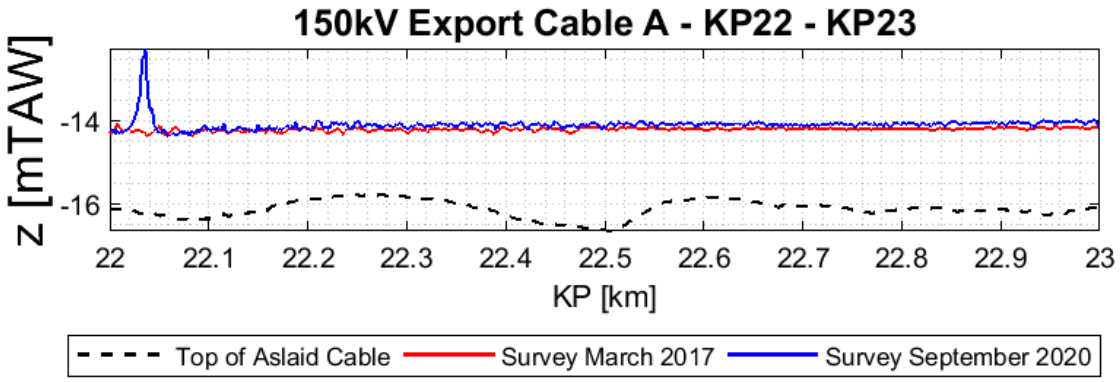


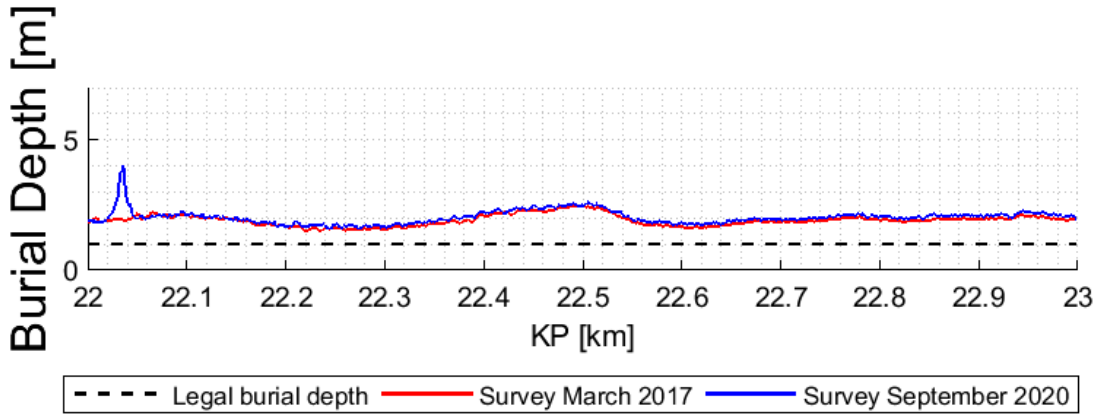


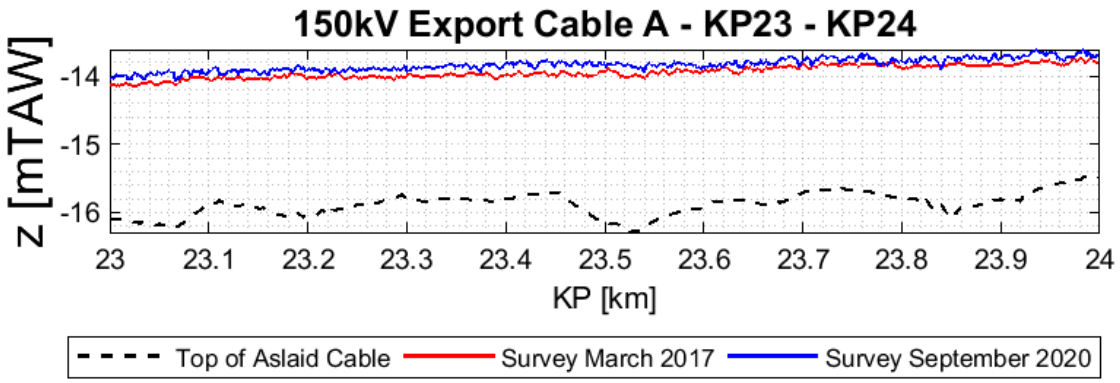


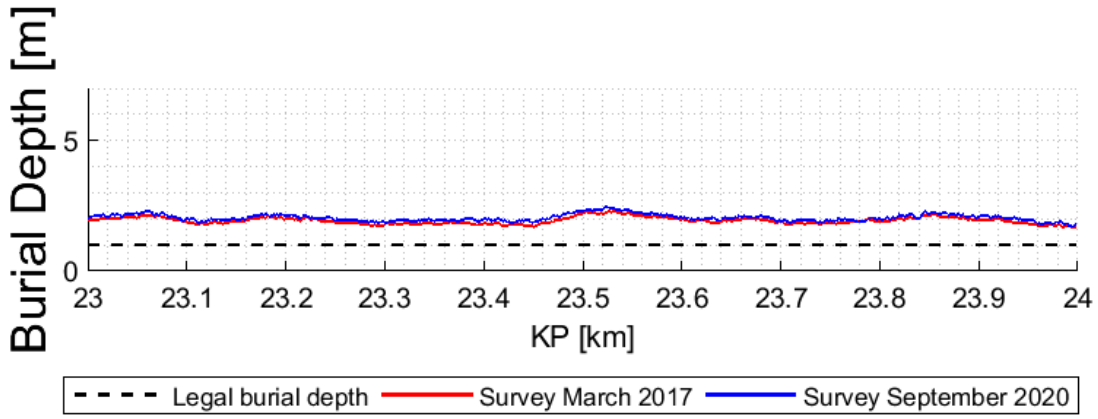


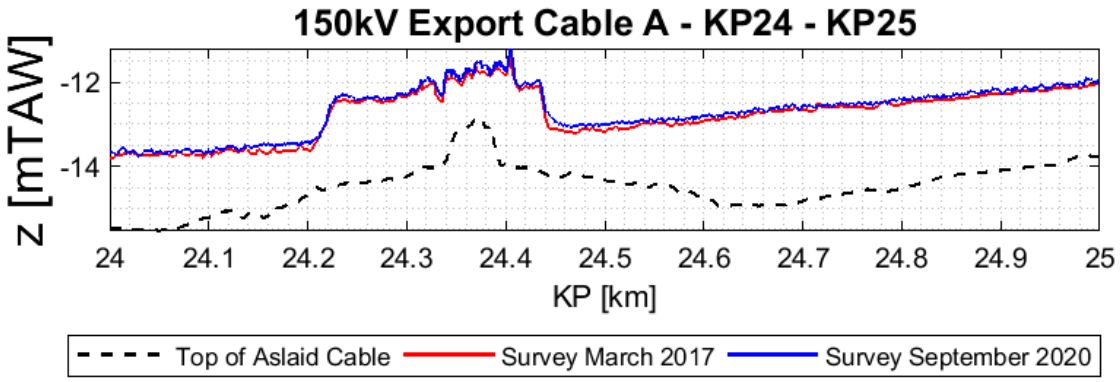


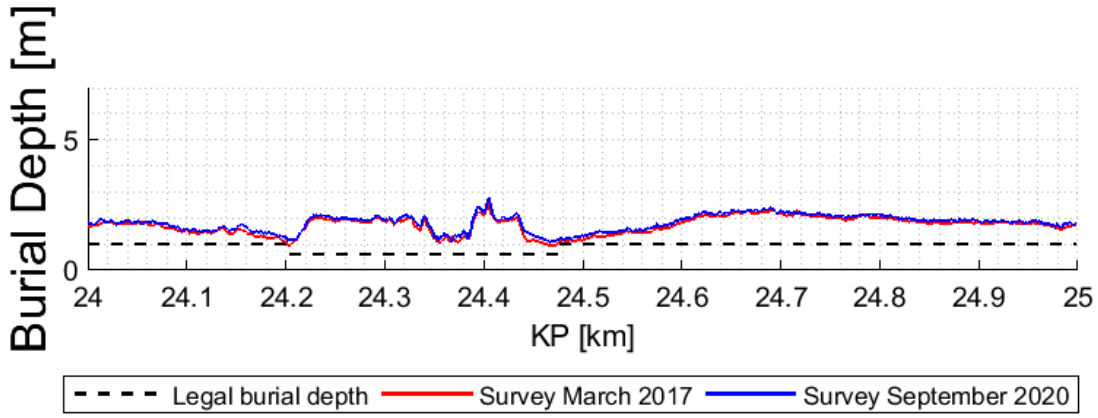


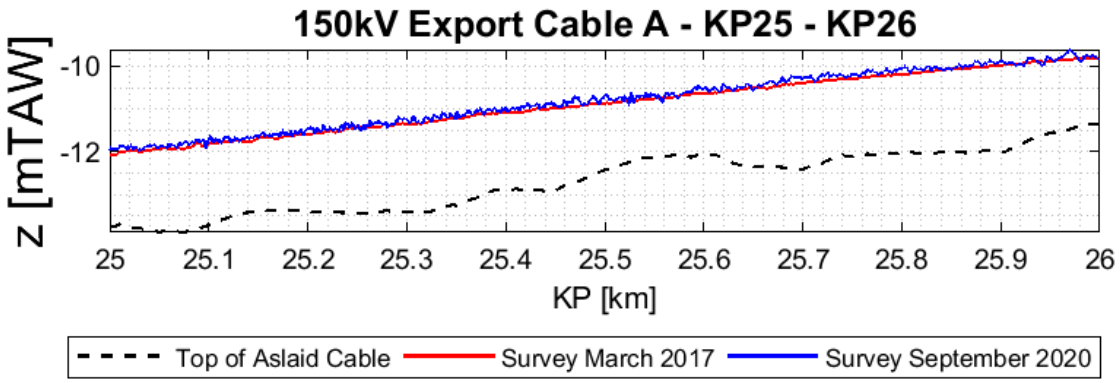


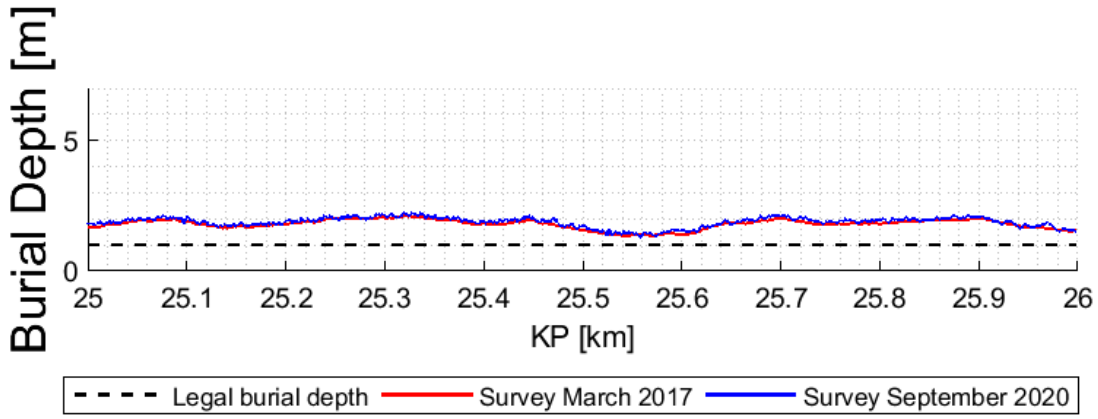


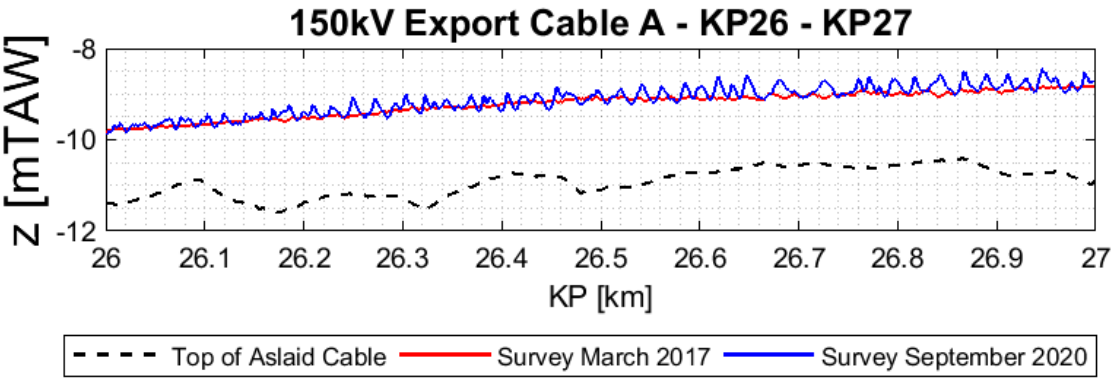


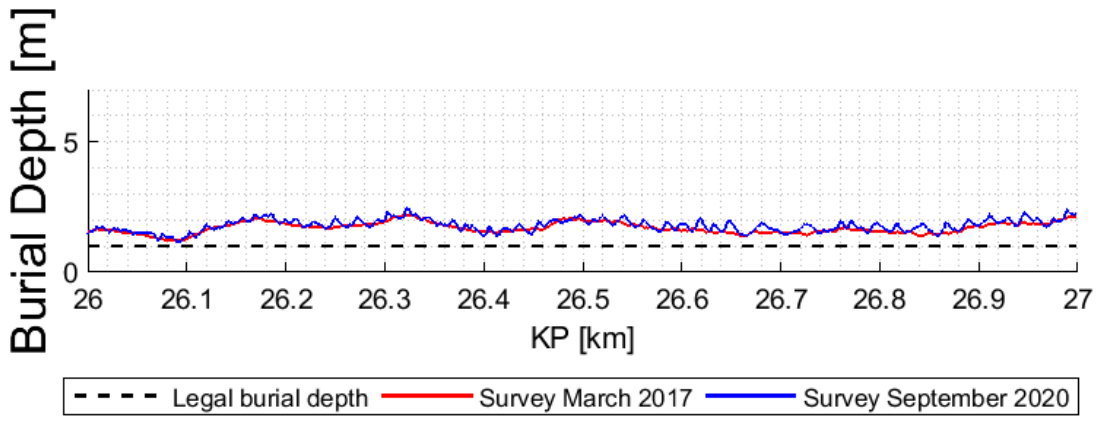


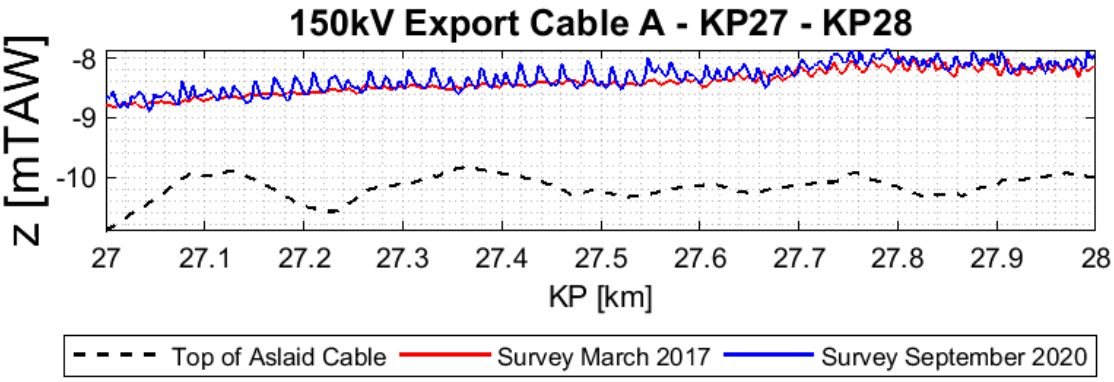


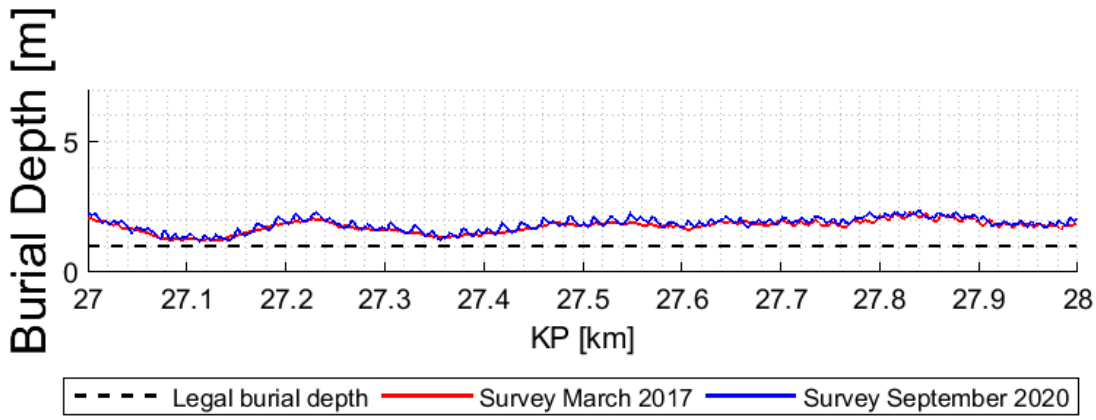


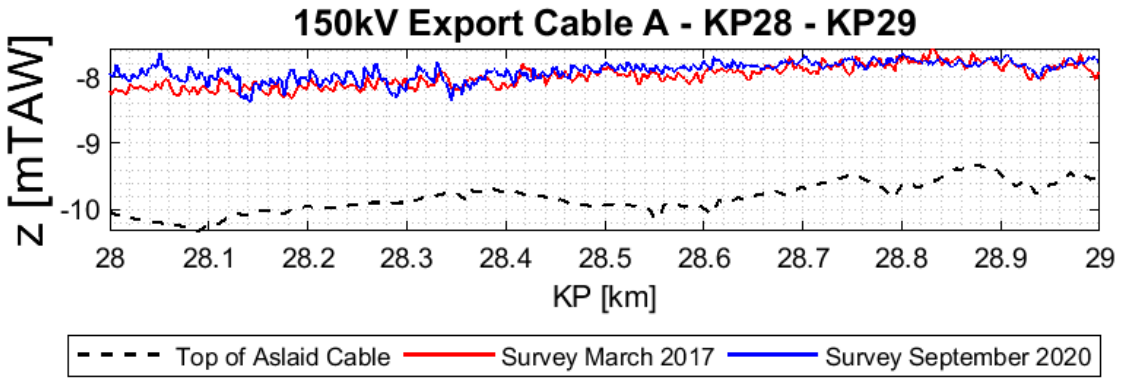


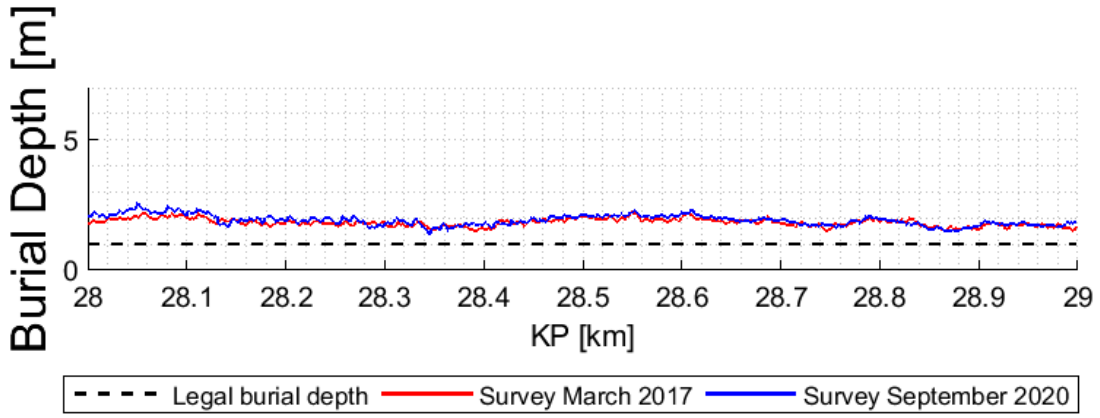


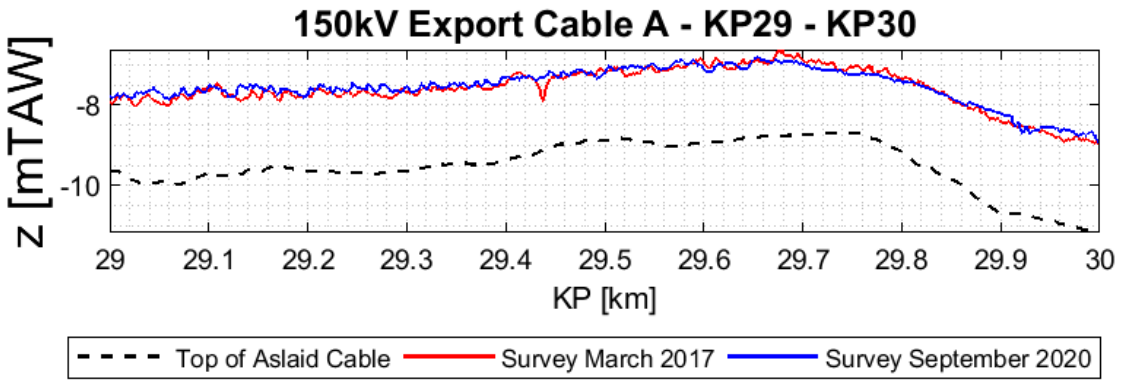


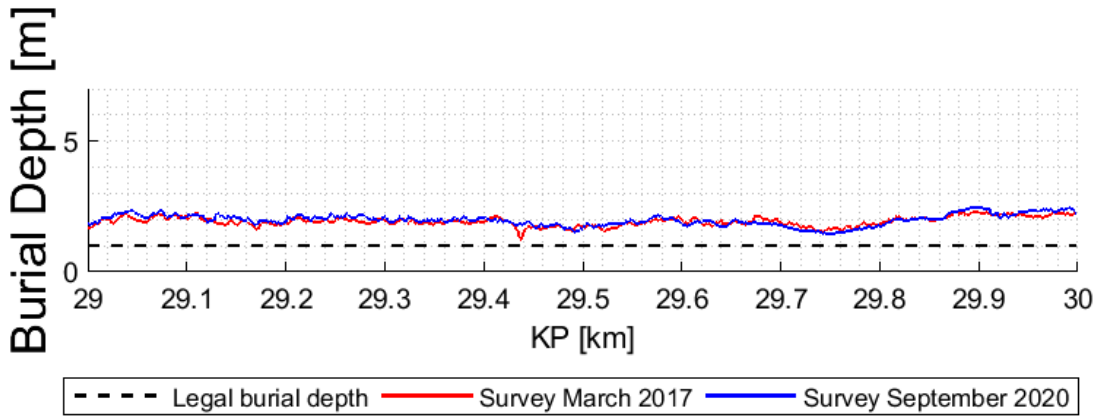


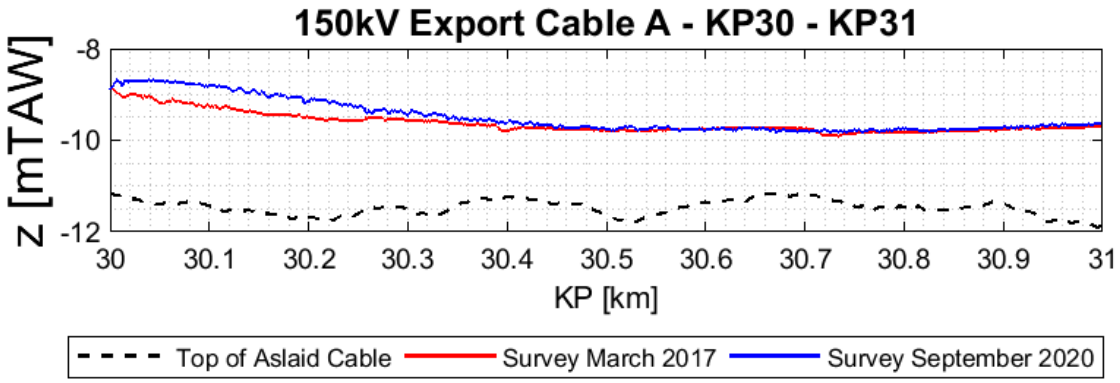


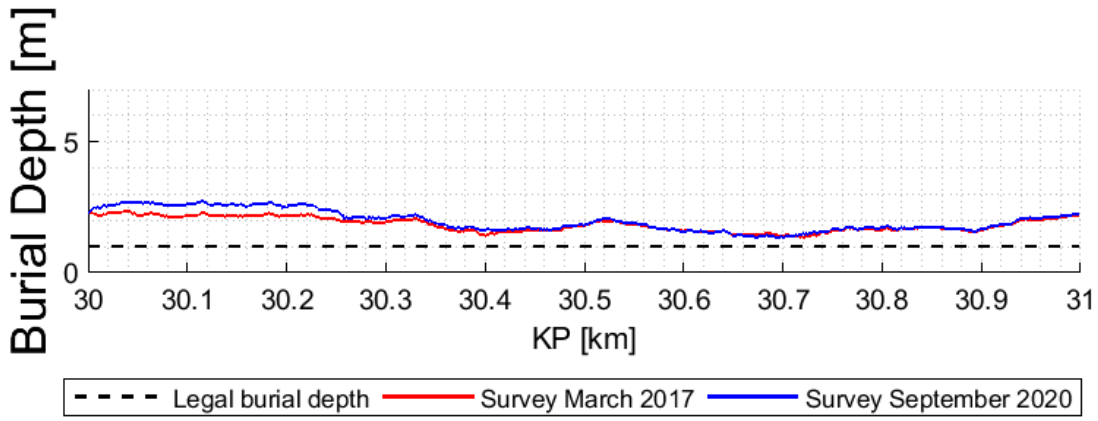


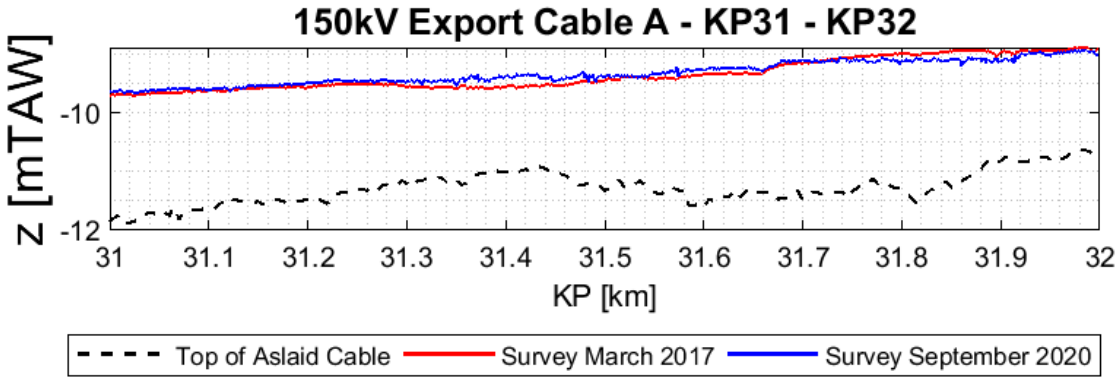


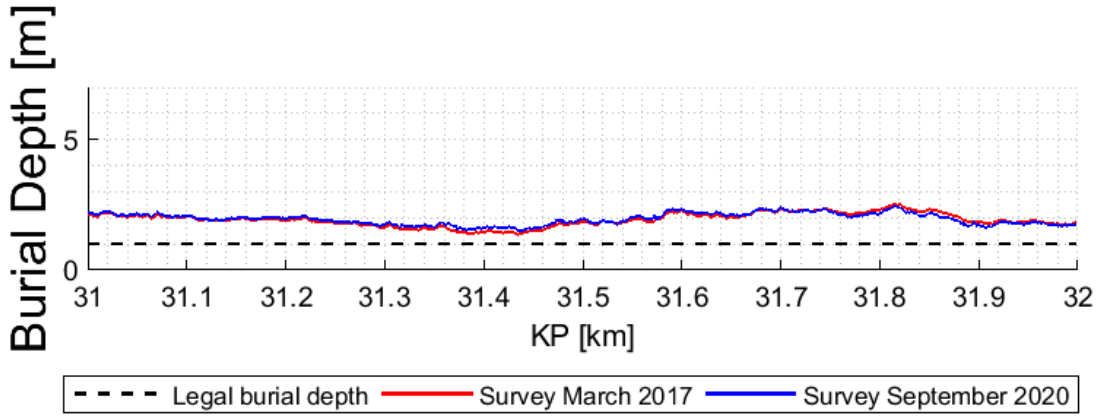


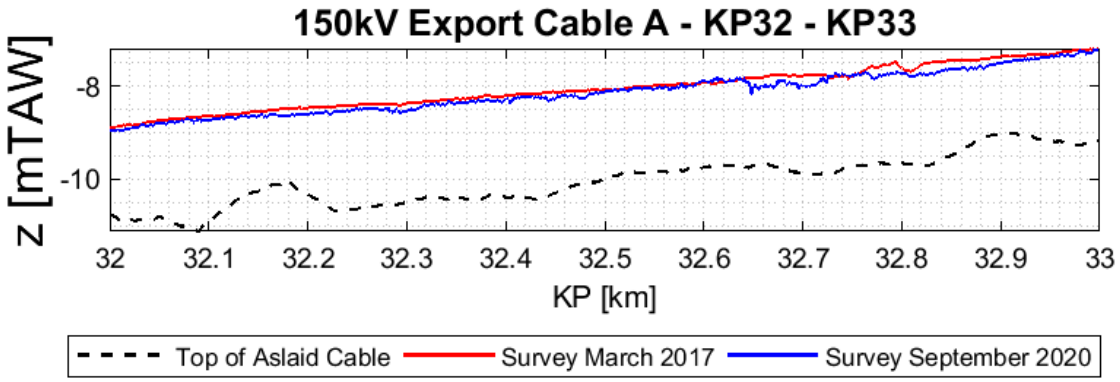


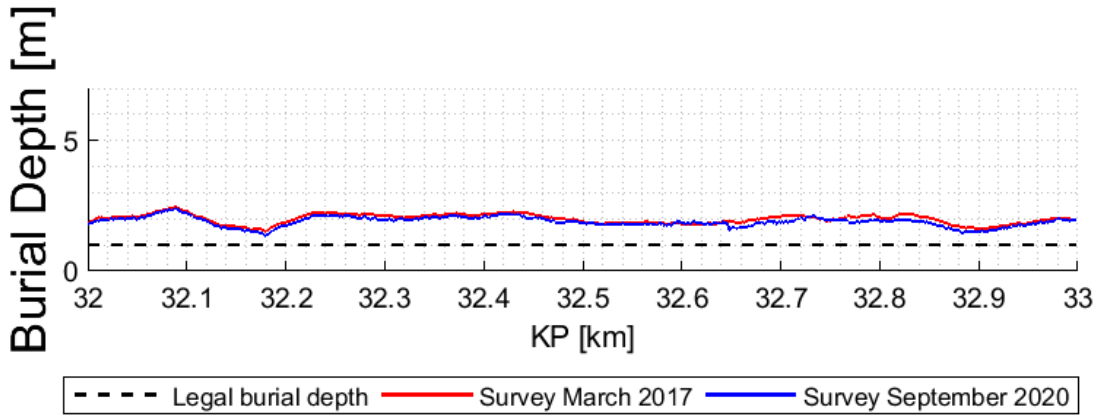


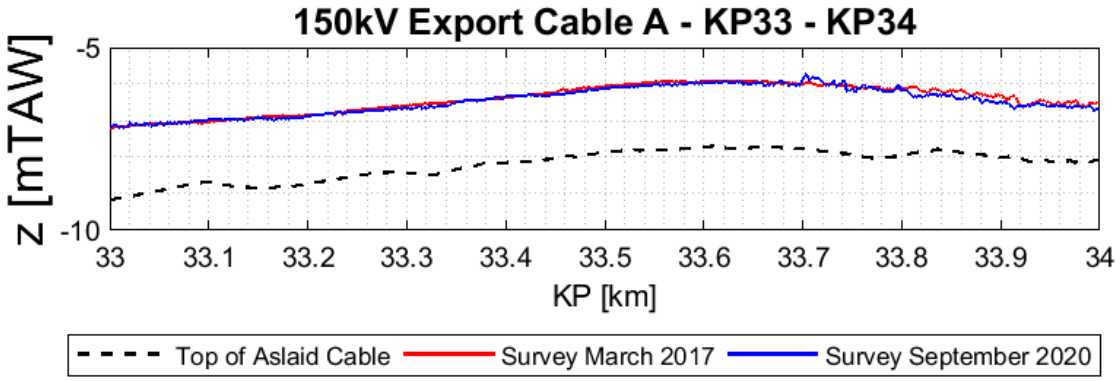


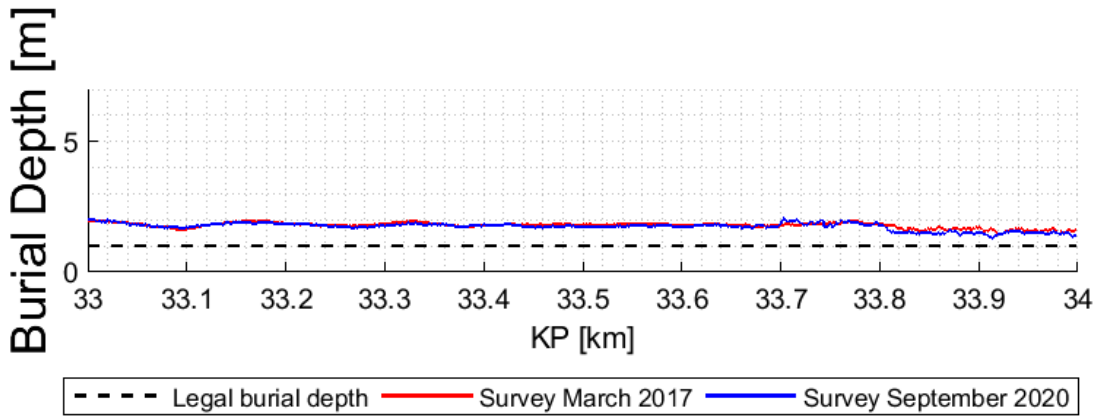


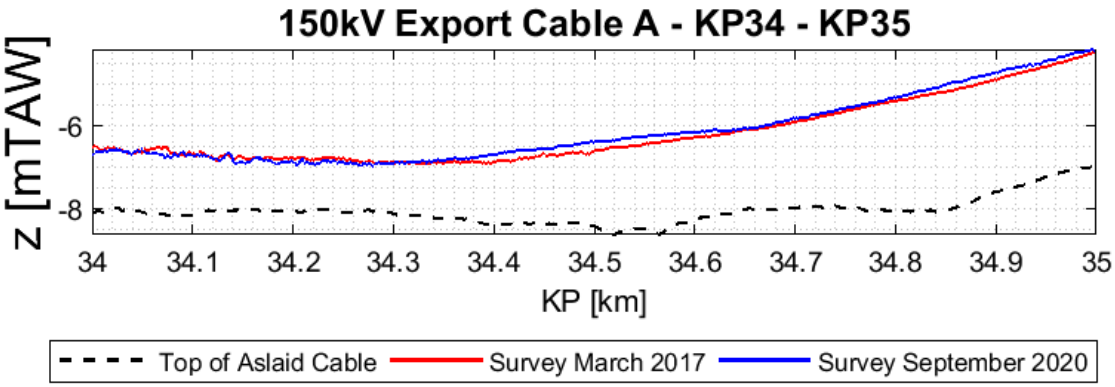


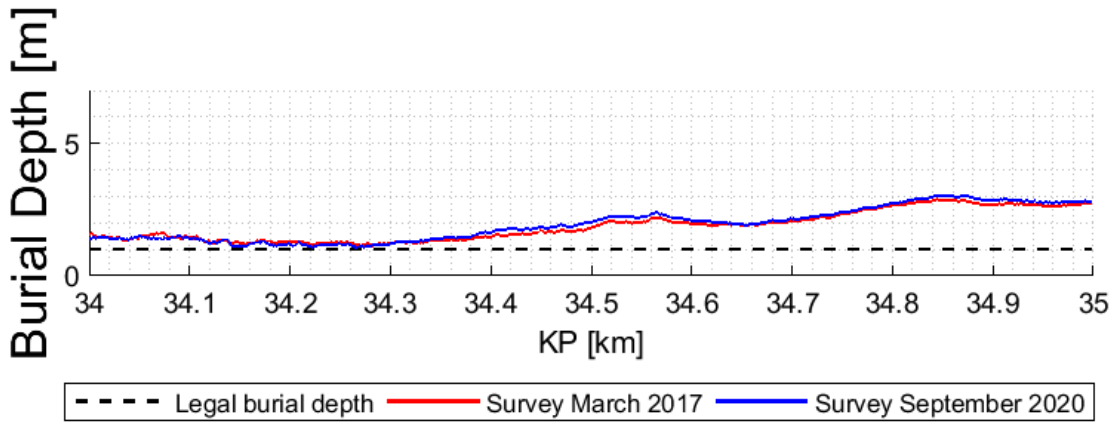


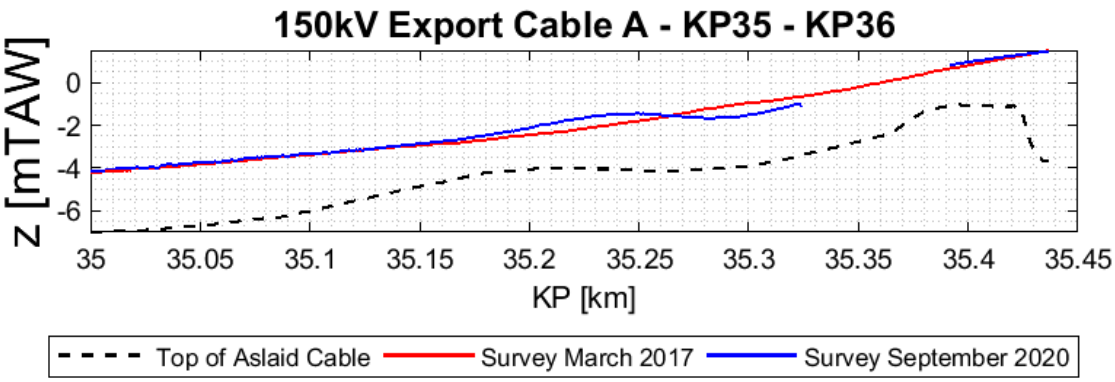


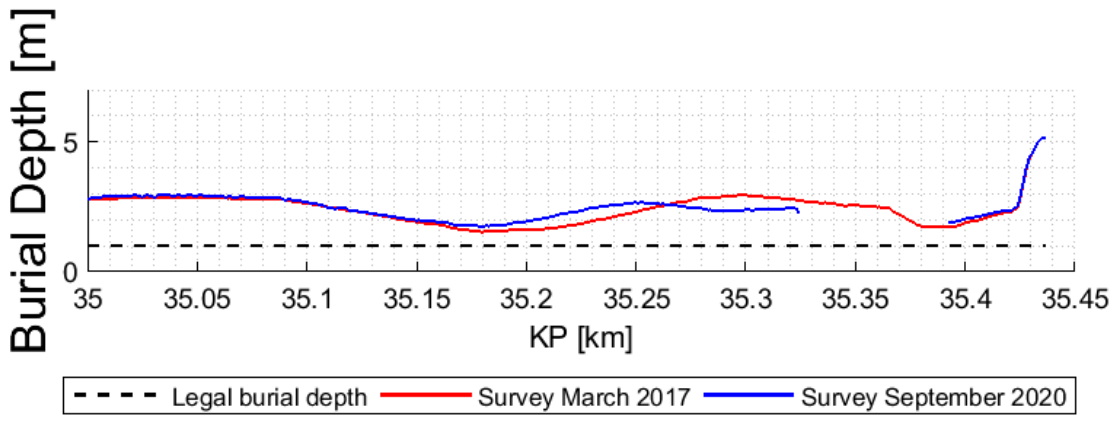


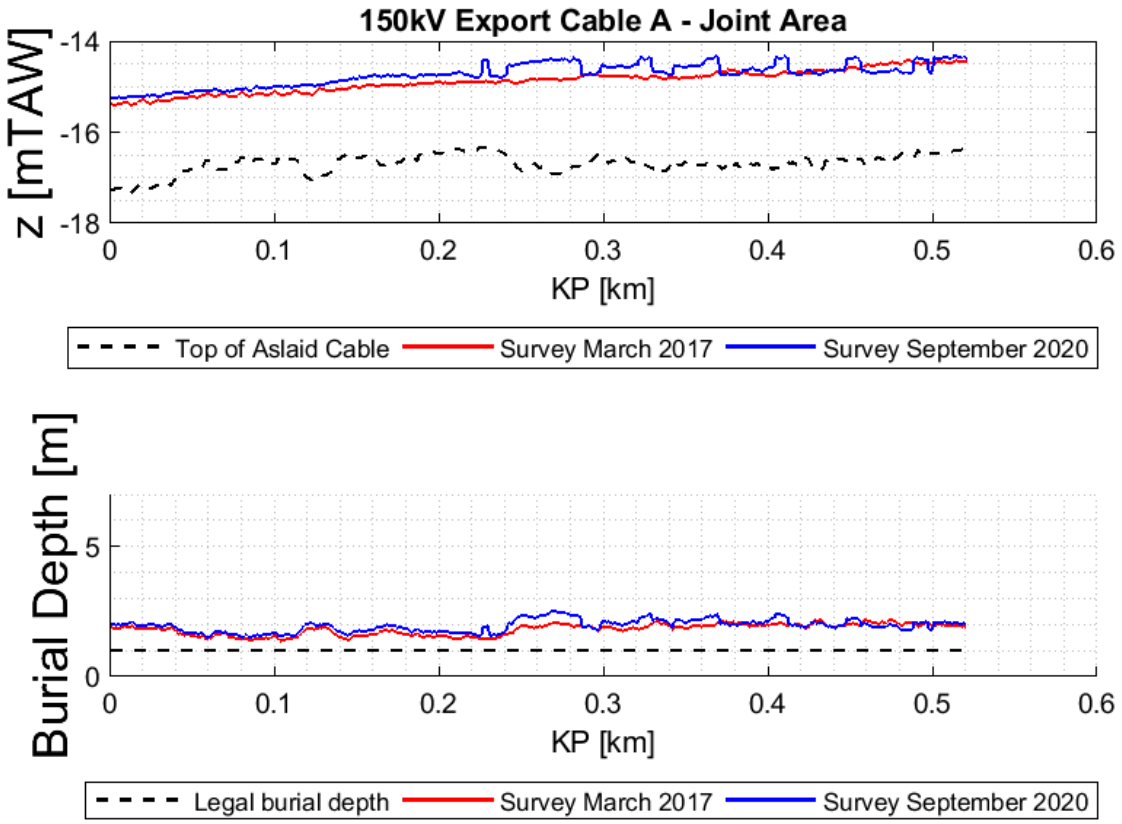










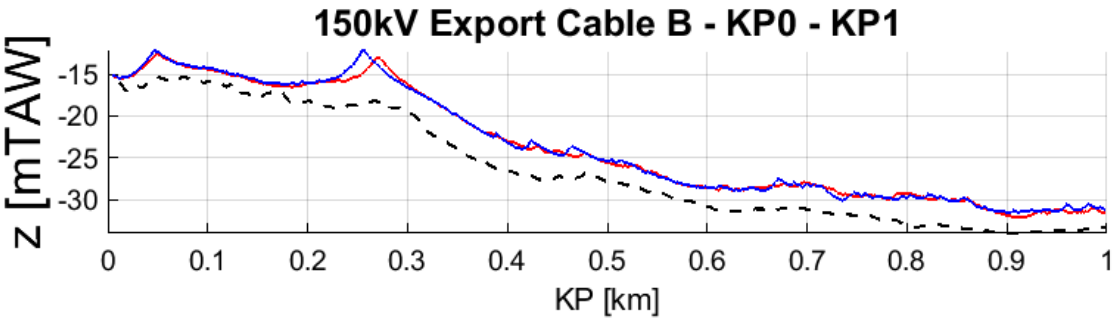


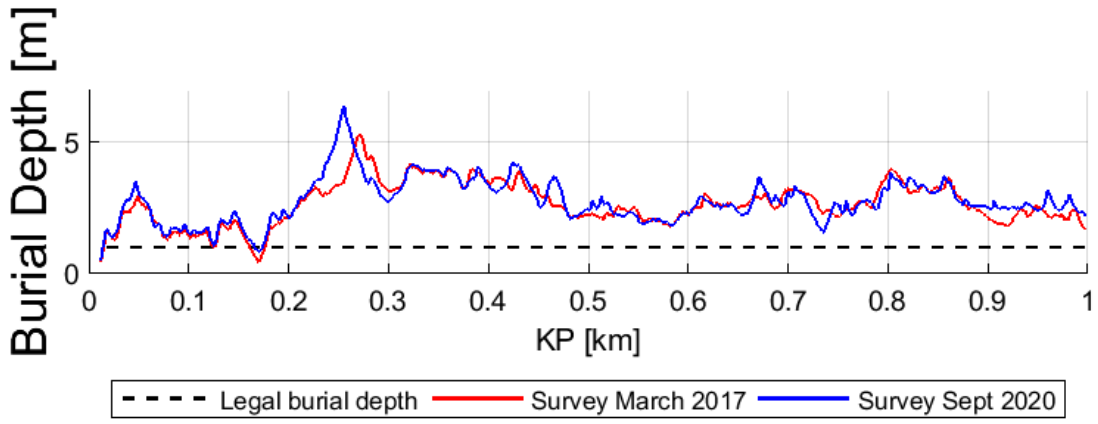
Annex D

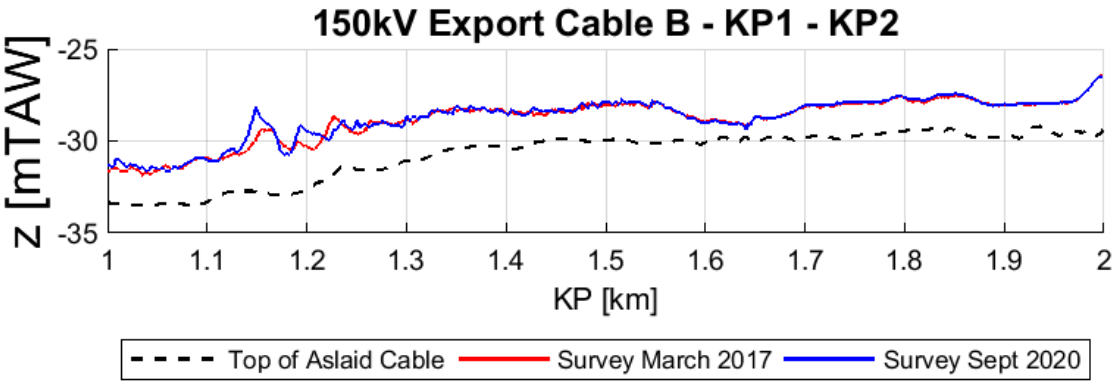
Cable A – zones > 10 m with Actual DoC < Target DoC

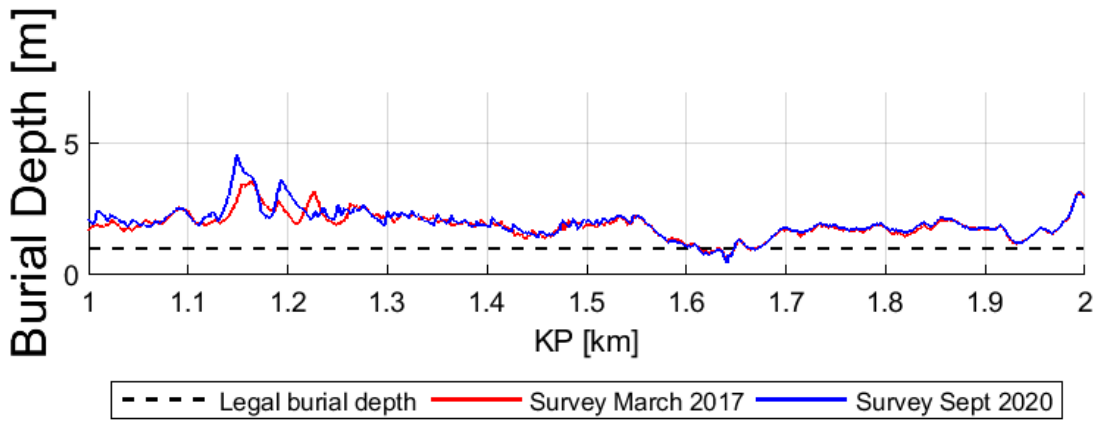
Annex E Cable A – areas > 10 m with Actual DoC < Target DoC – 0.20 m

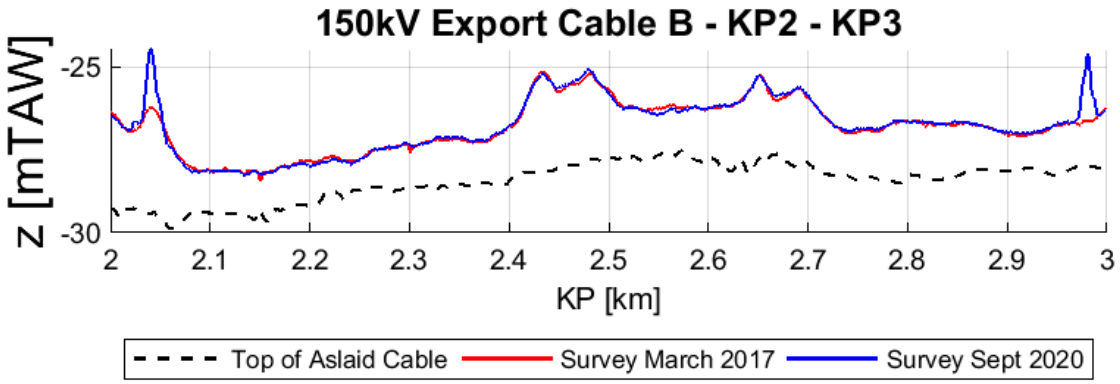
Annex F Actual Depth of Cover export cable B

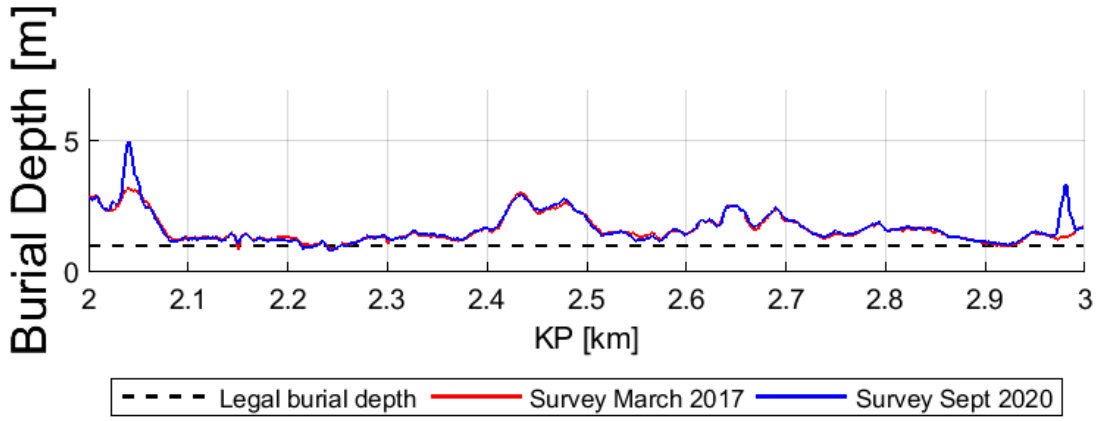


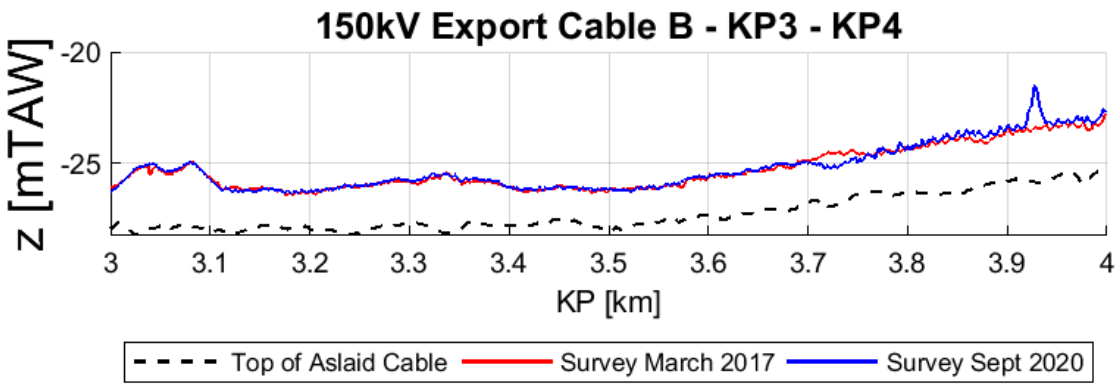


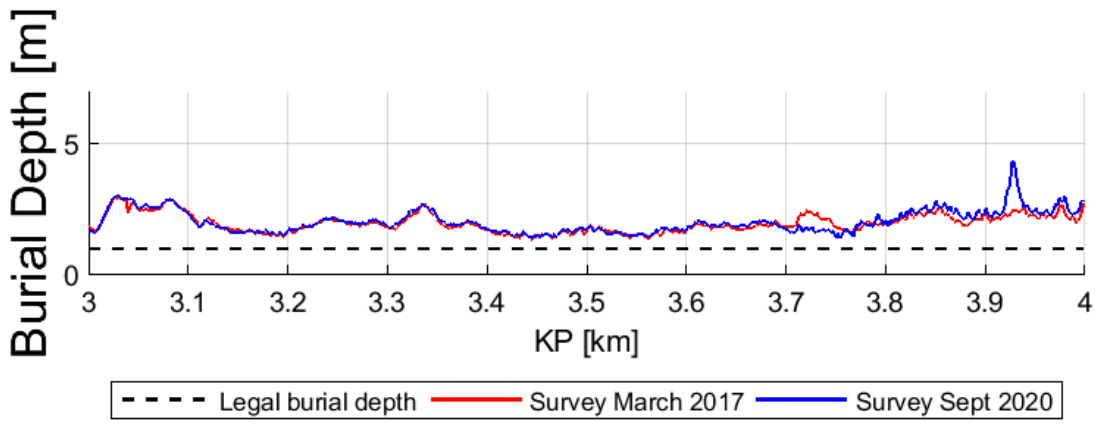


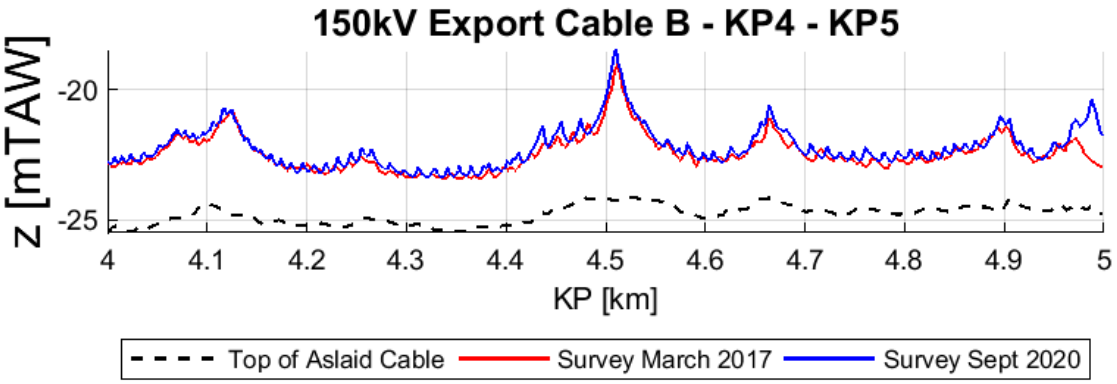


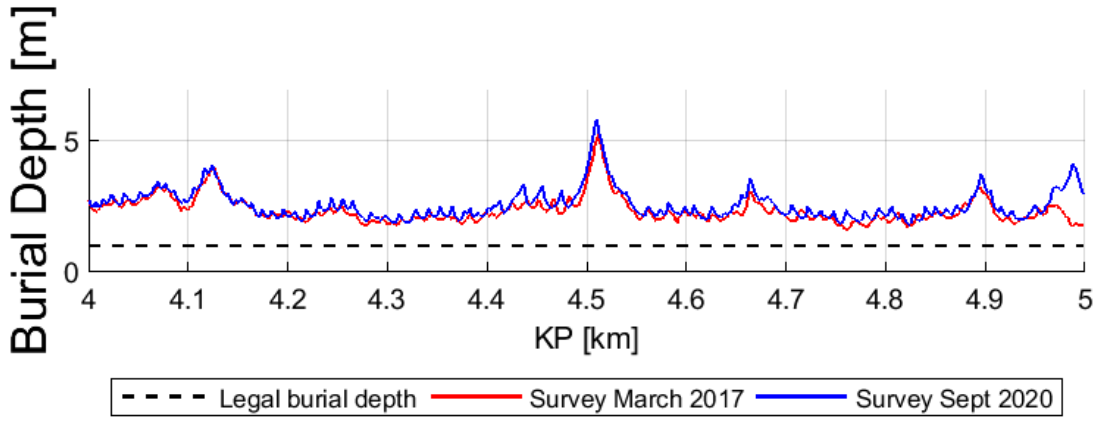


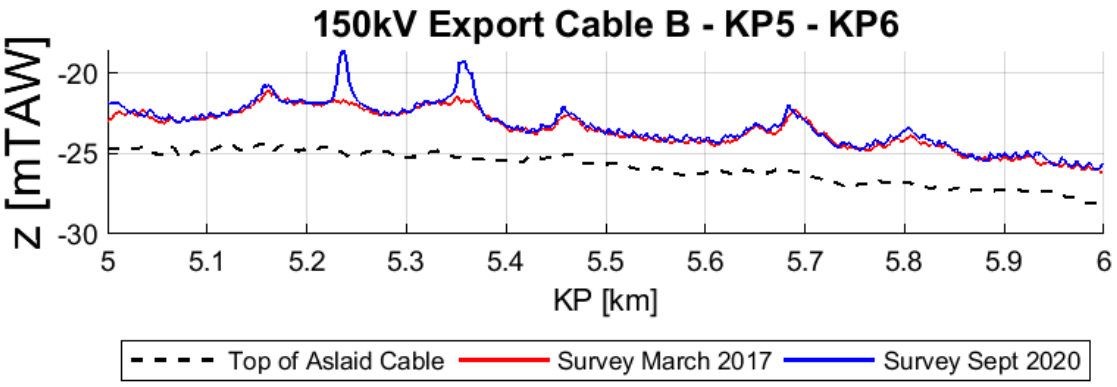


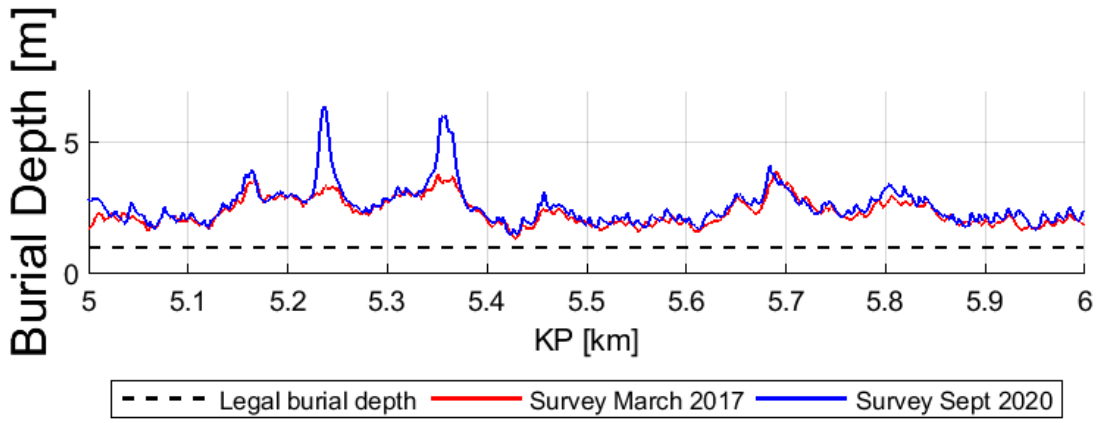


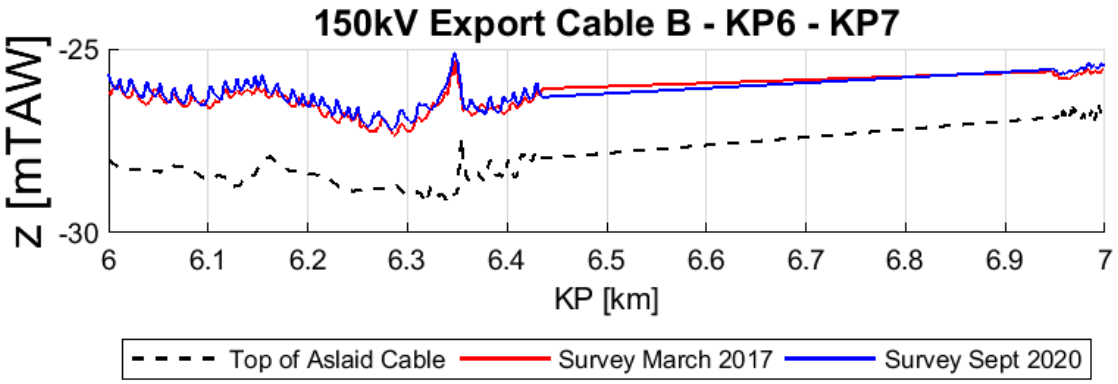


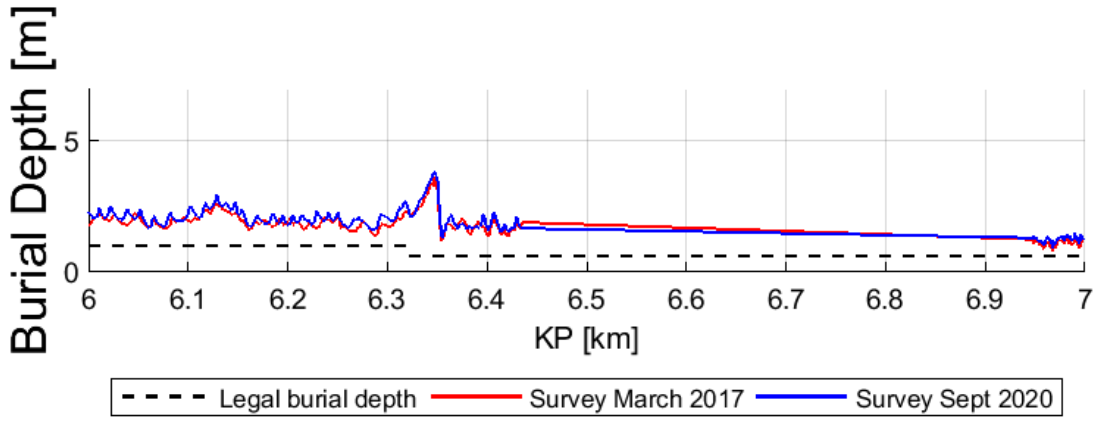


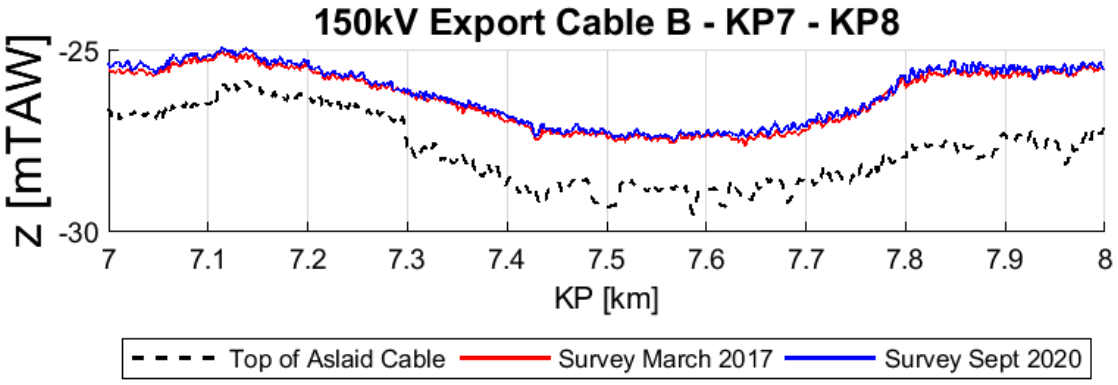


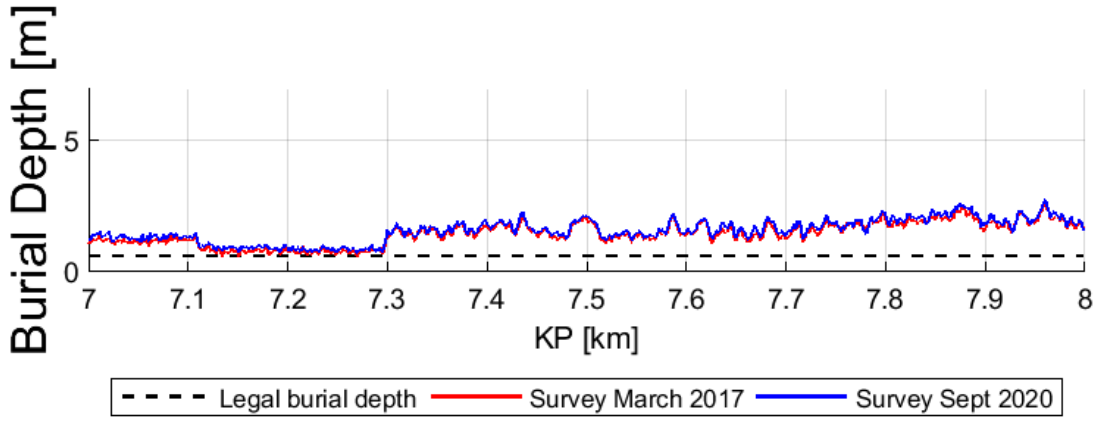


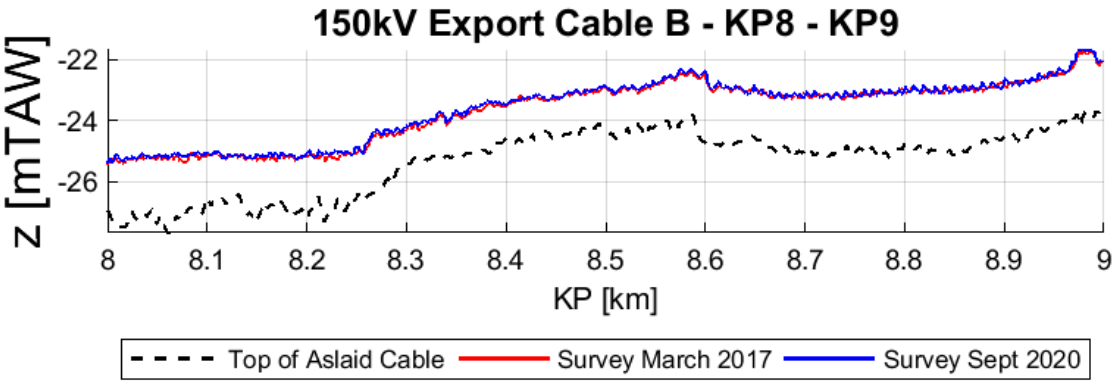


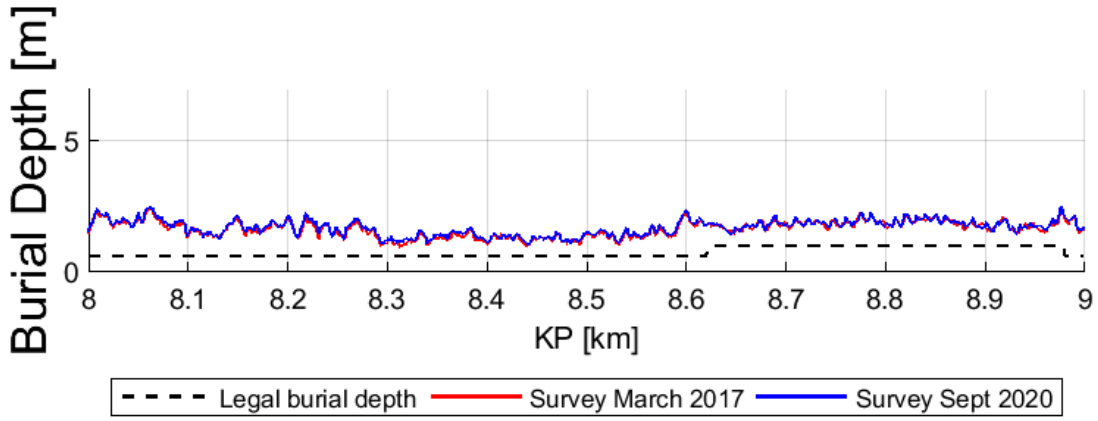


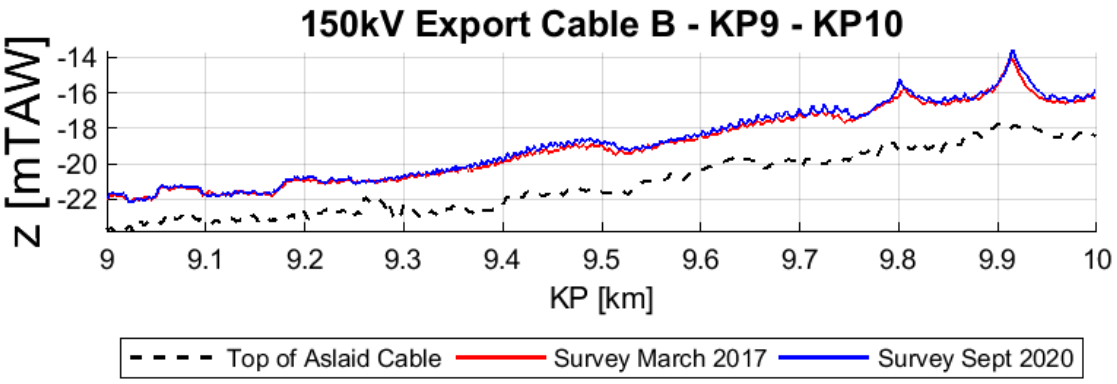


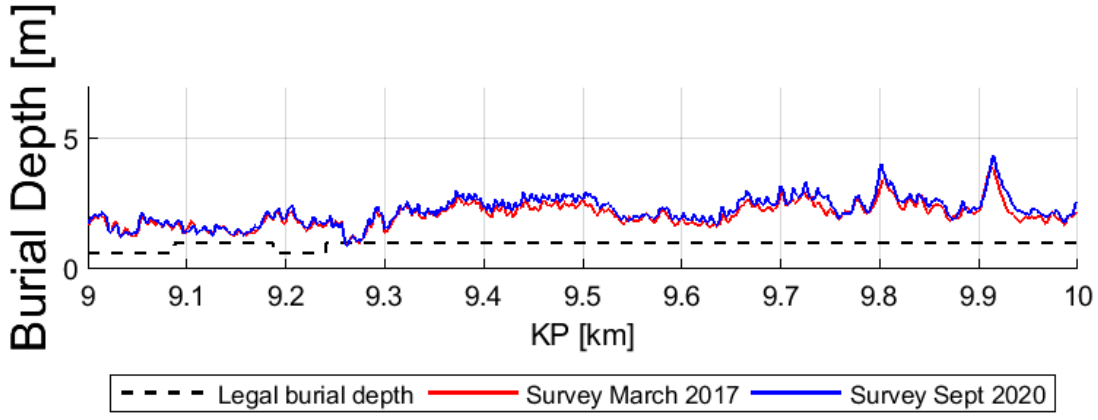


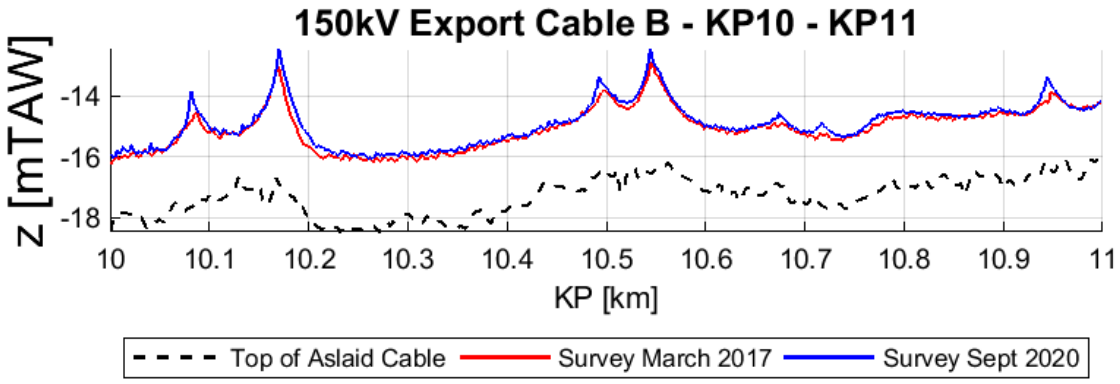


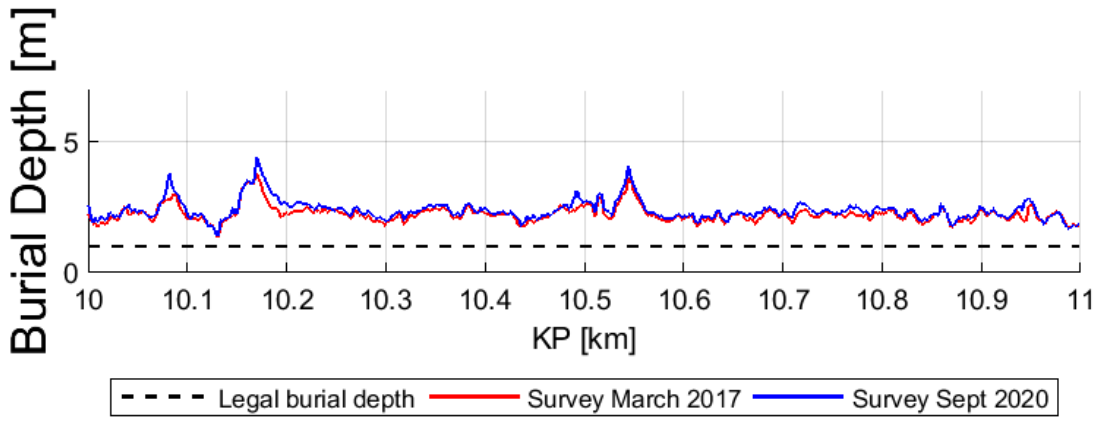


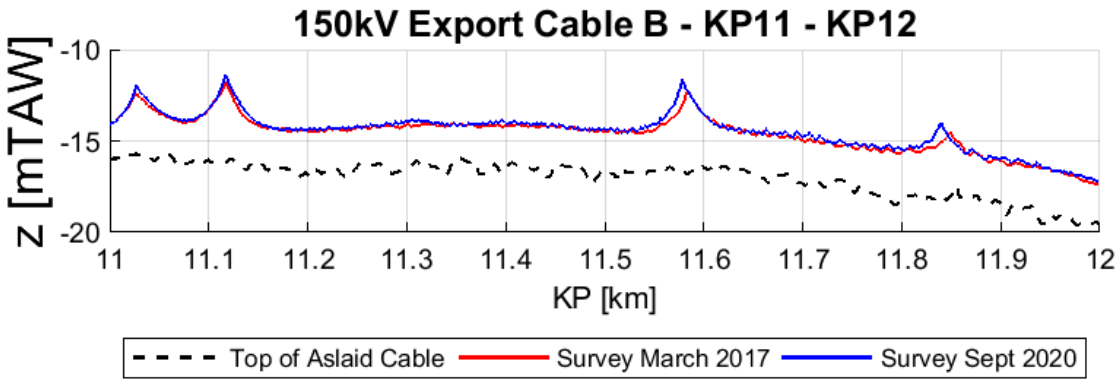


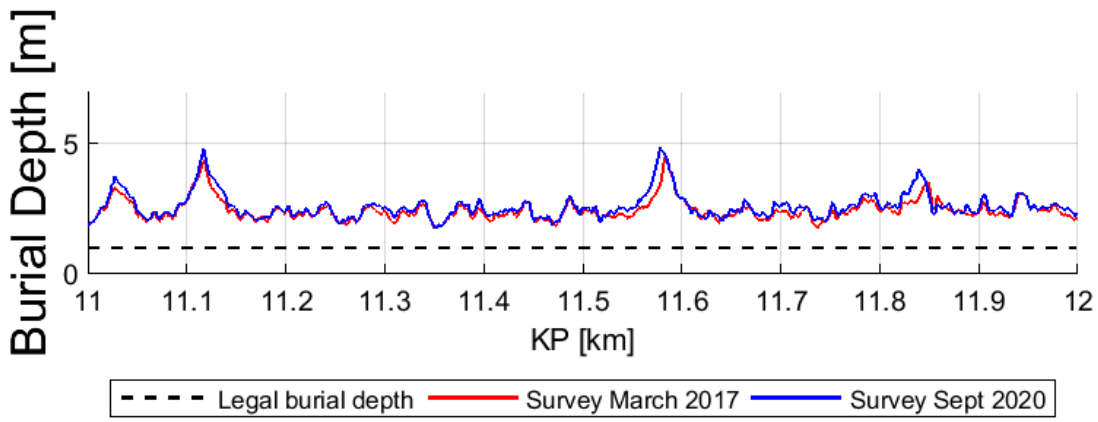


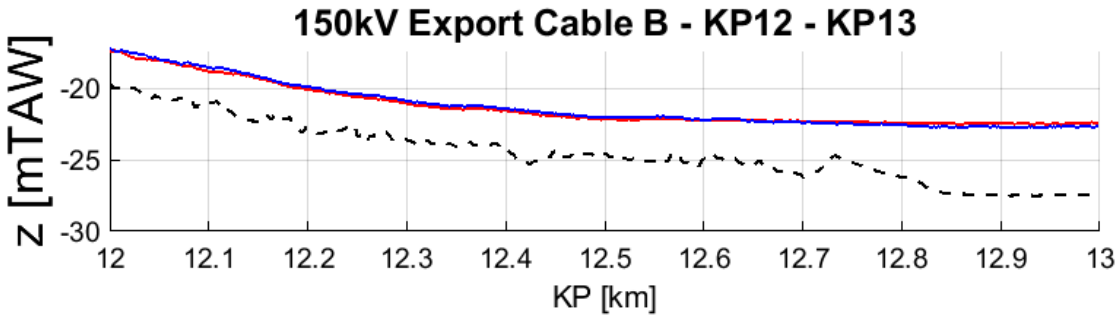


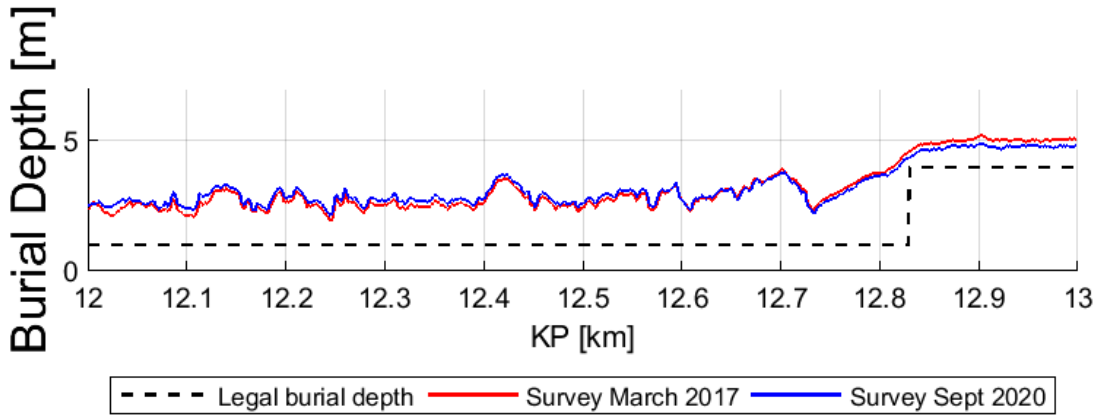


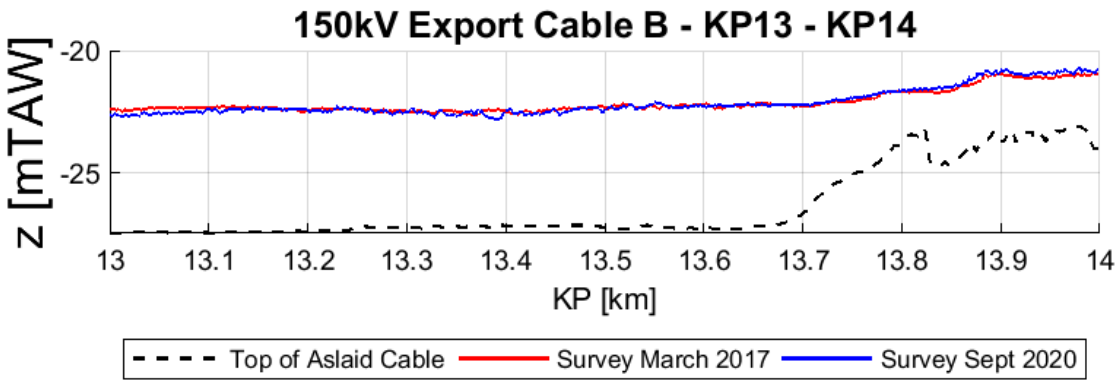


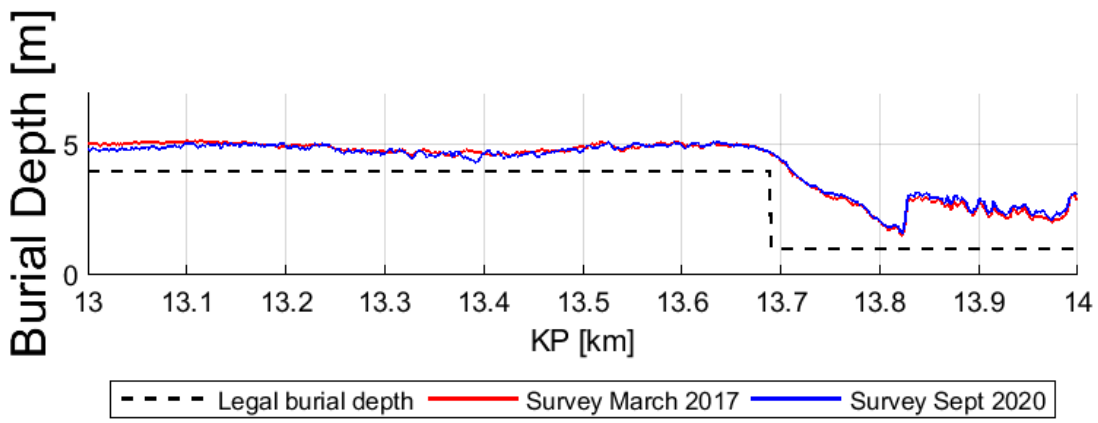


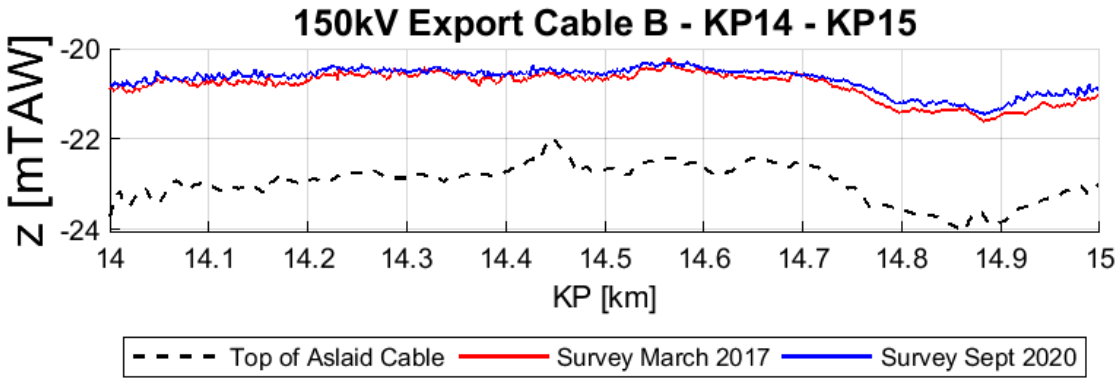


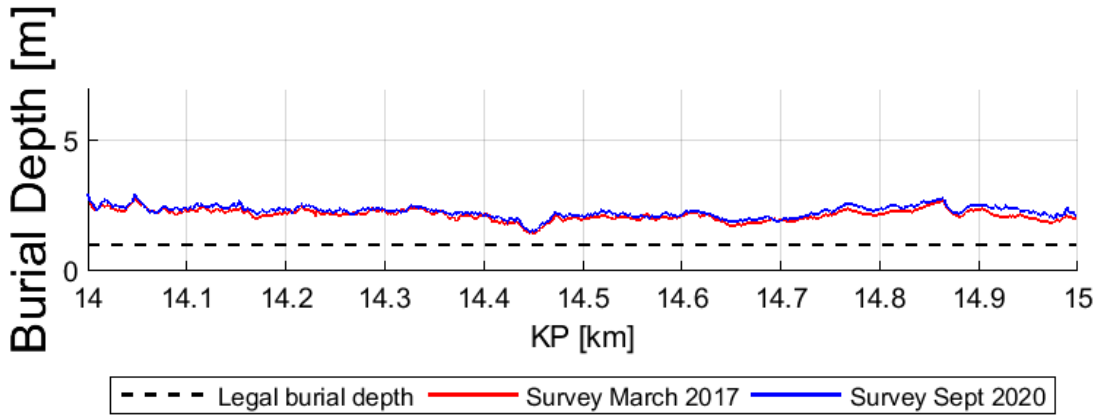


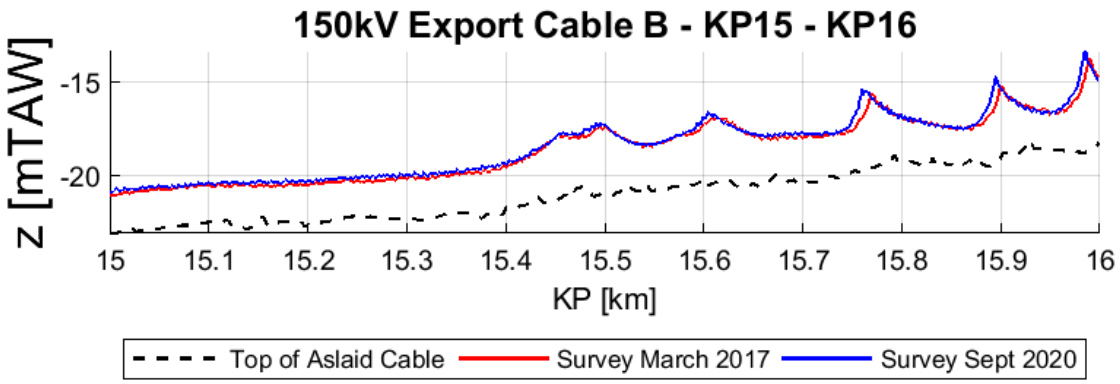


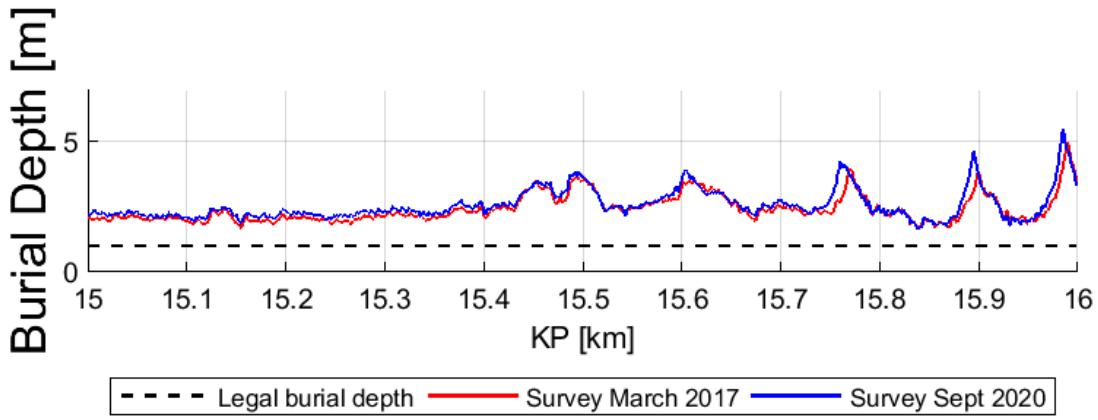


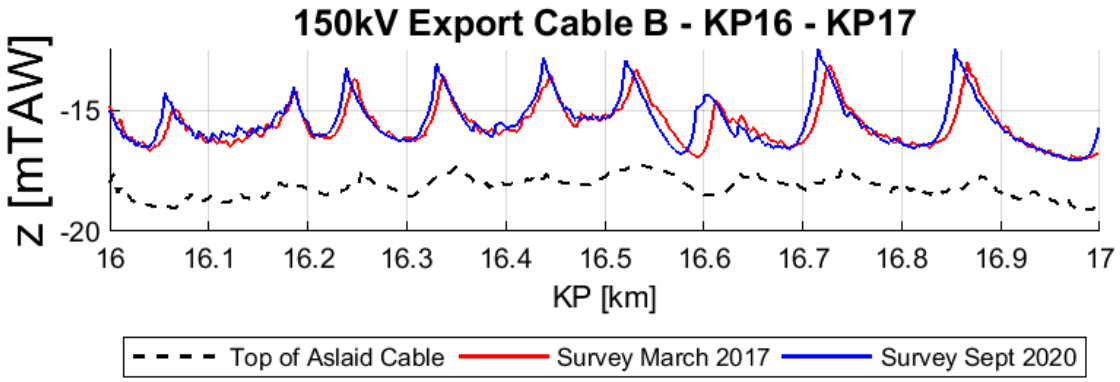


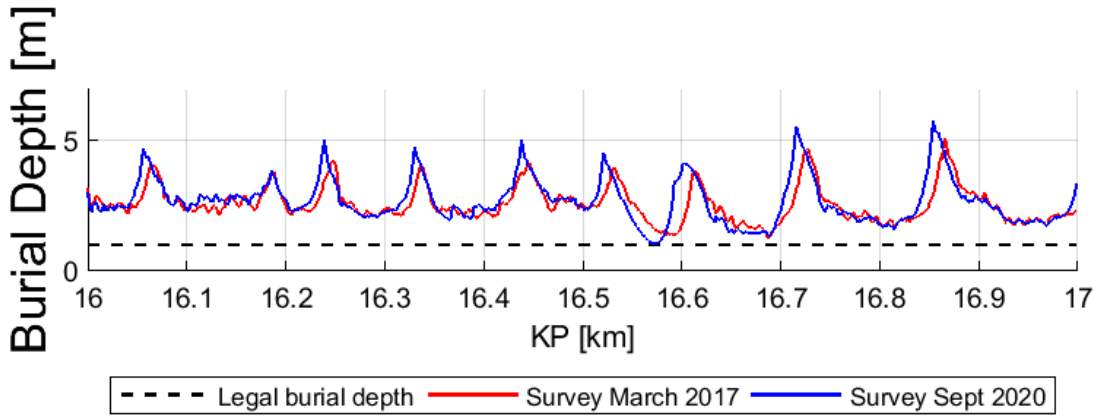


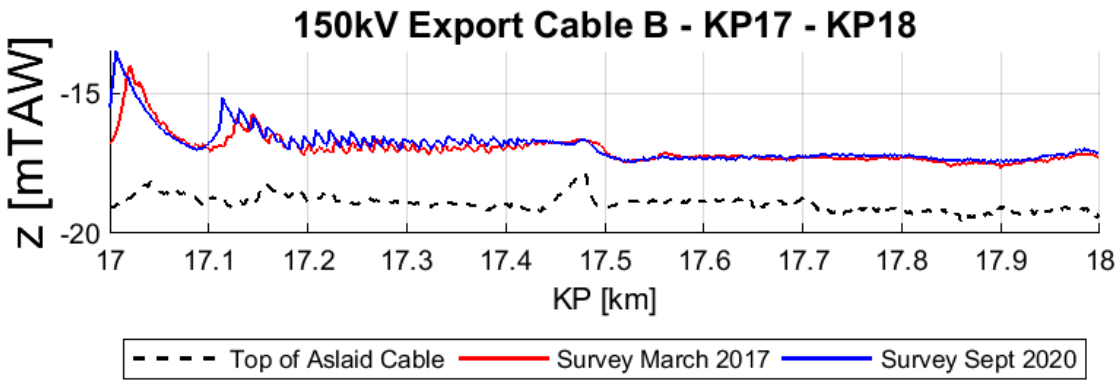


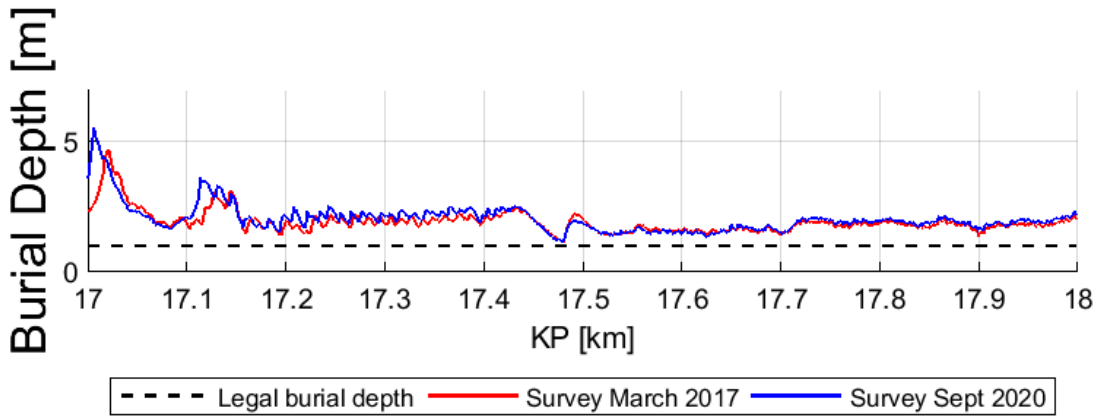


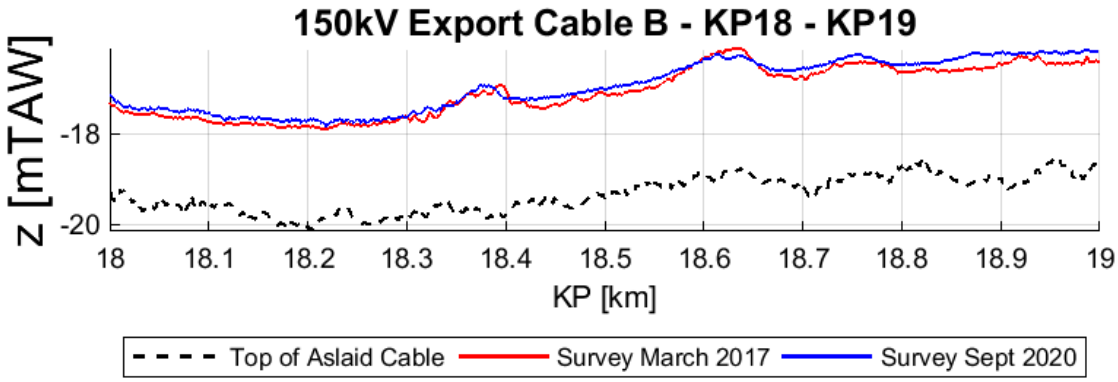


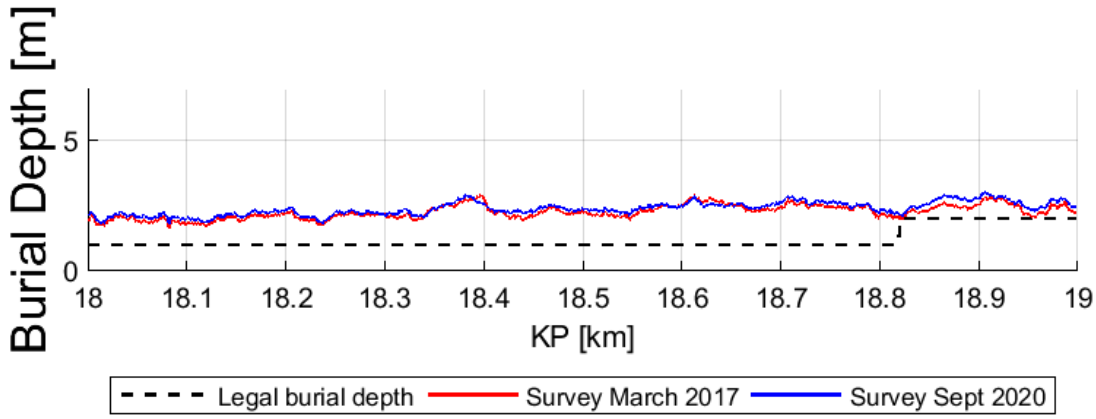


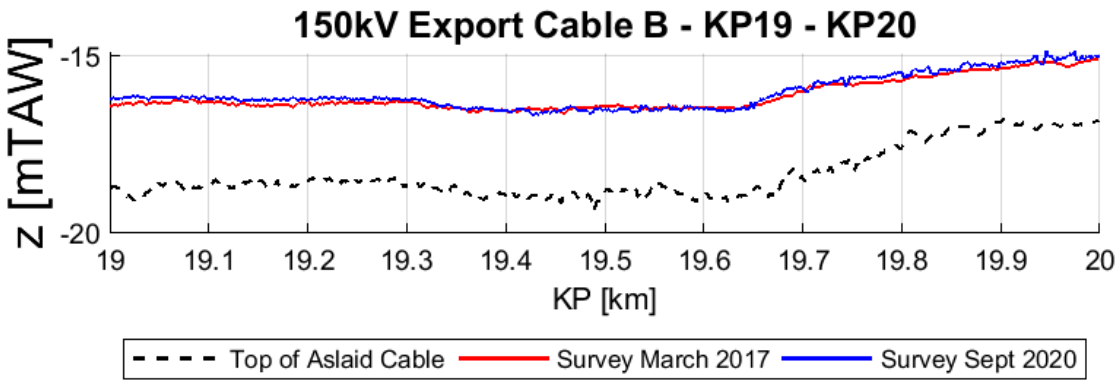


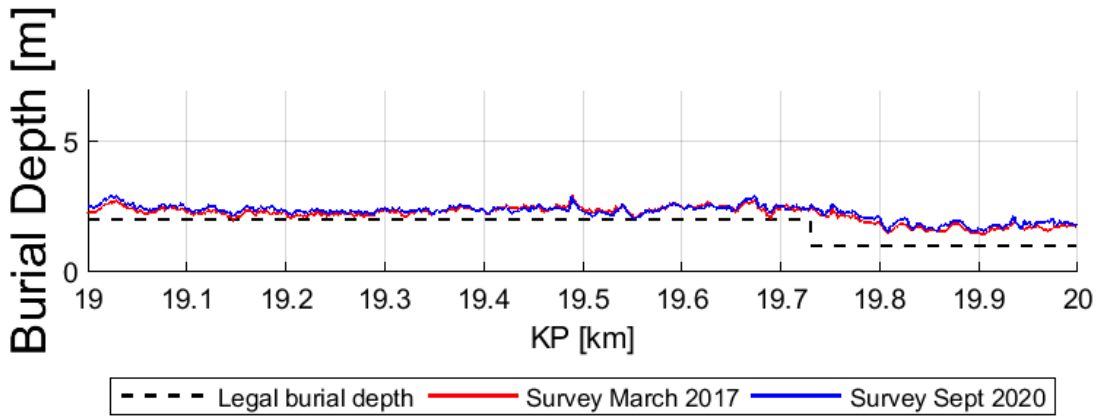


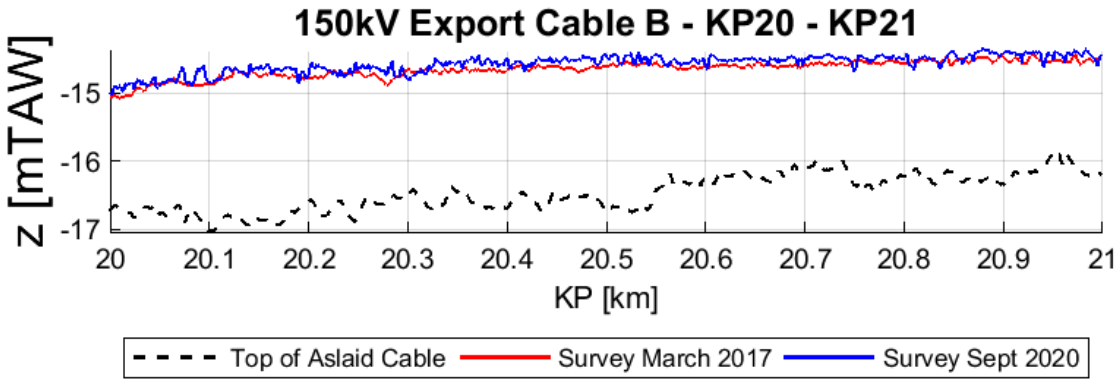


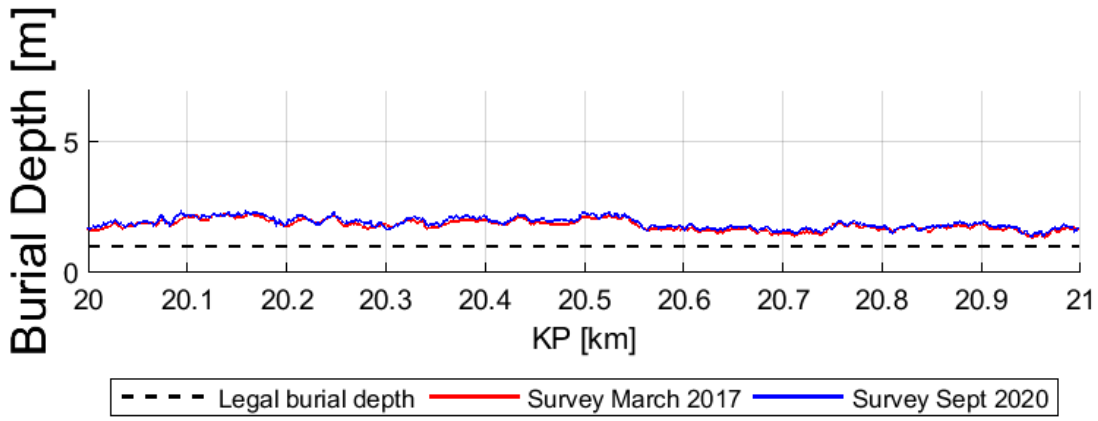


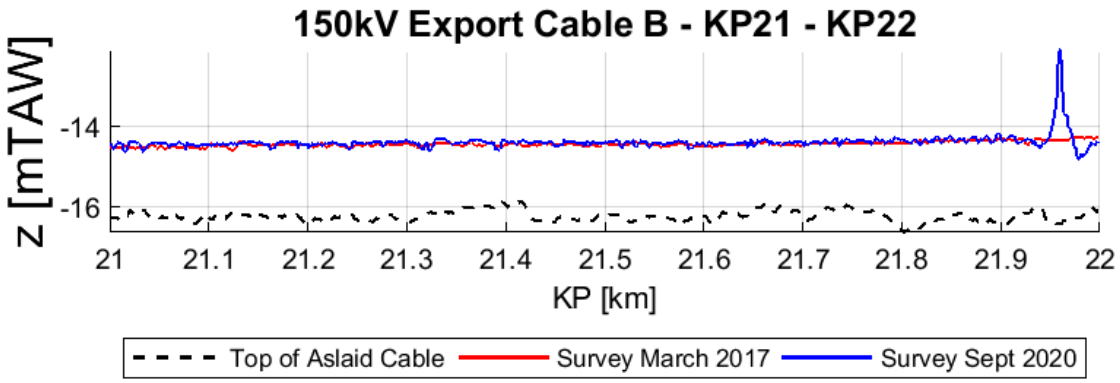


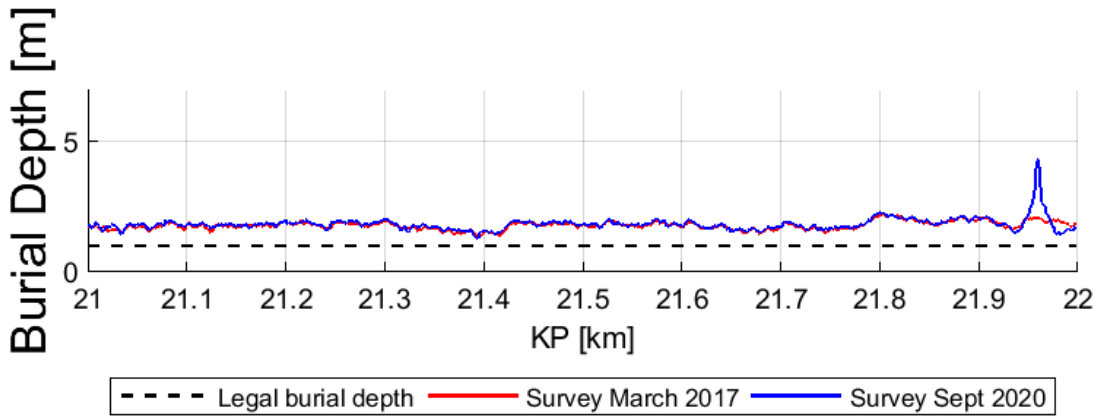


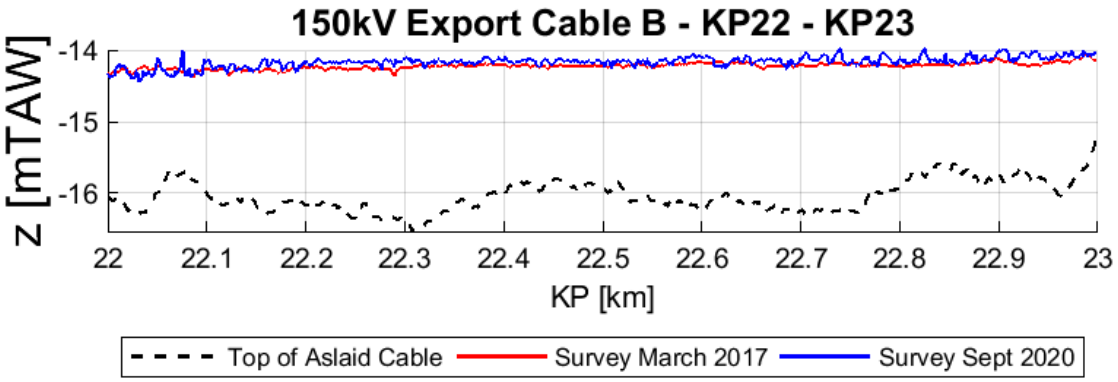


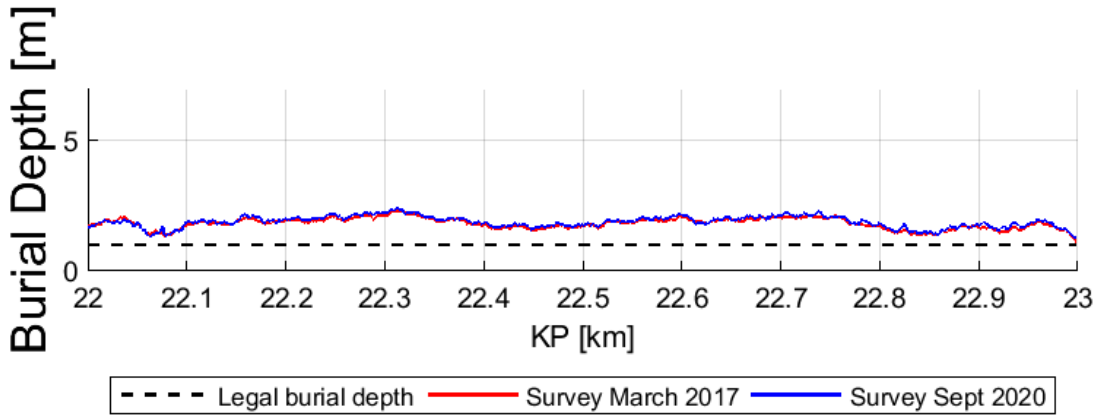


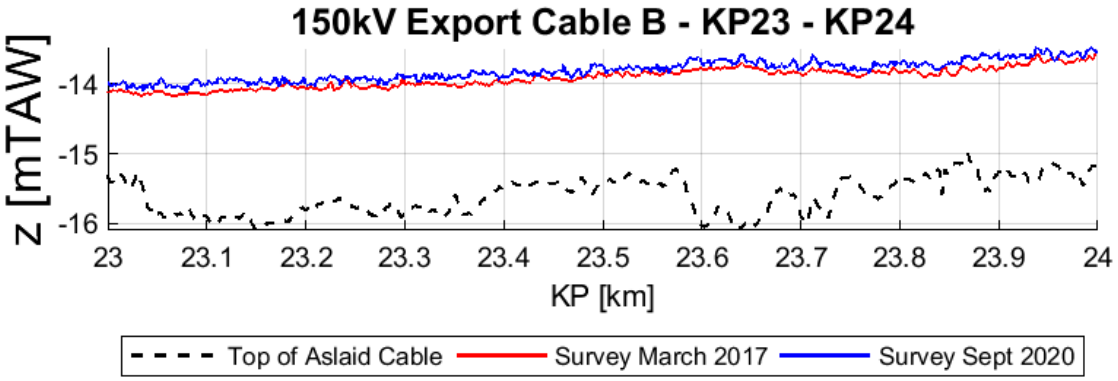


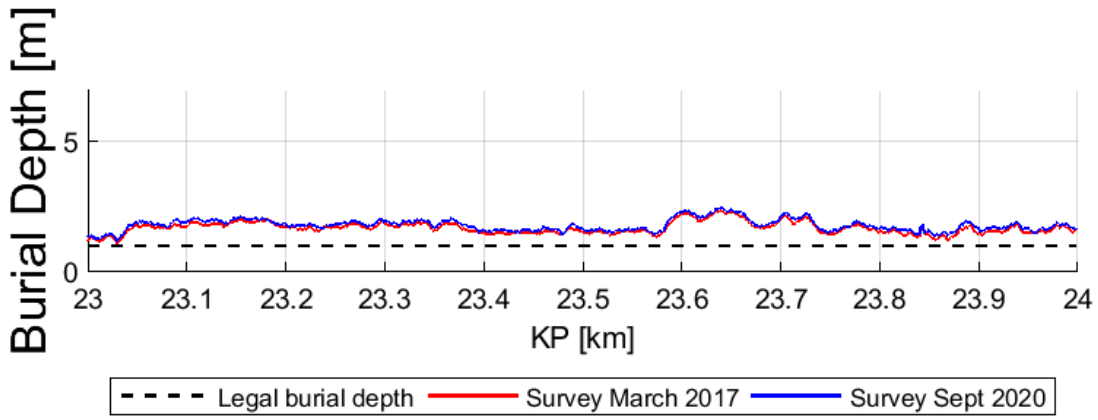


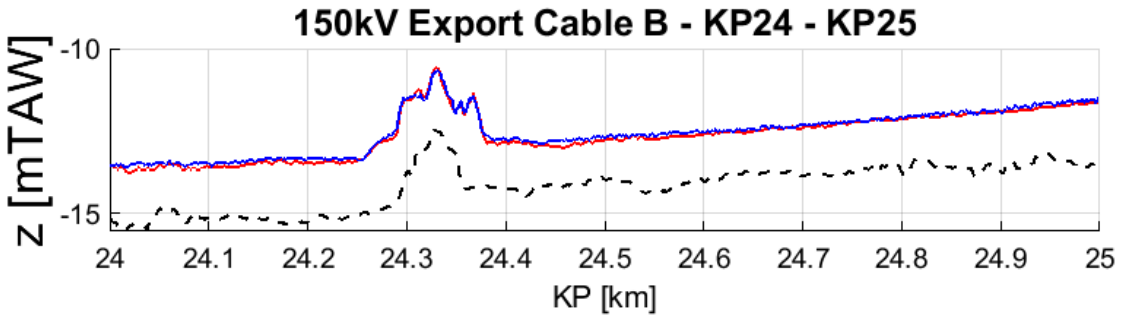


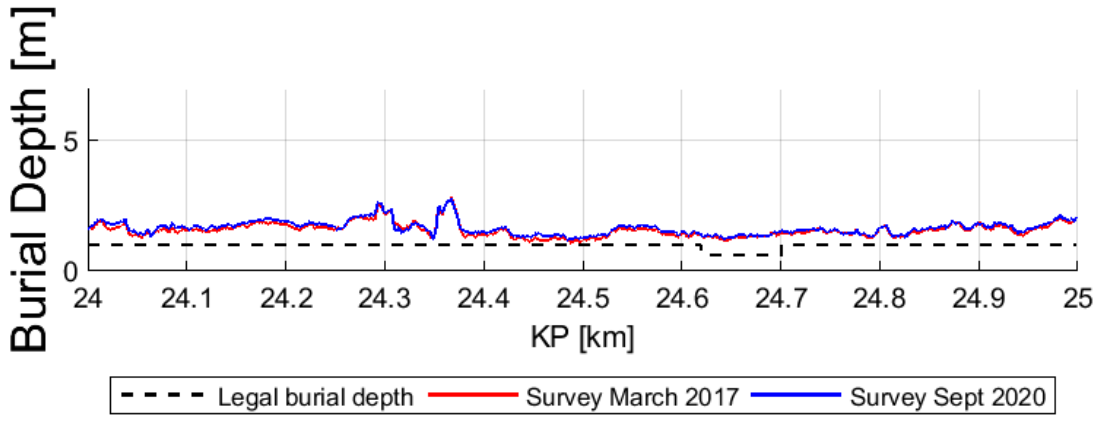


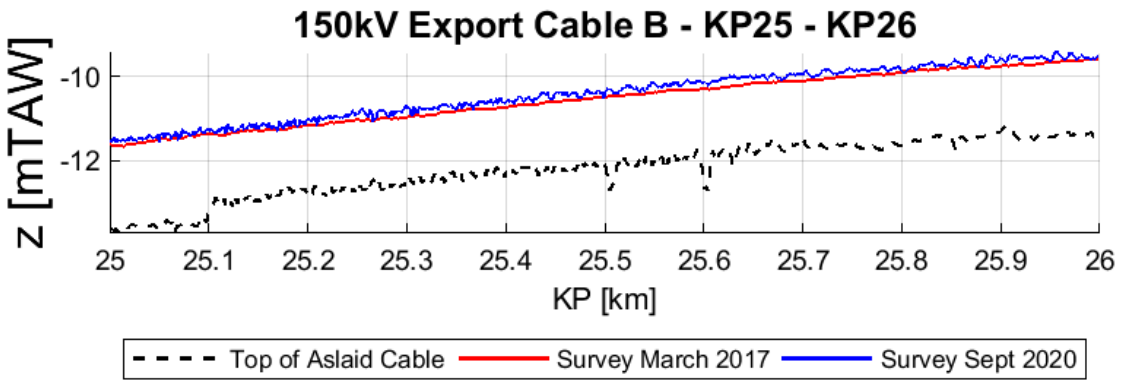


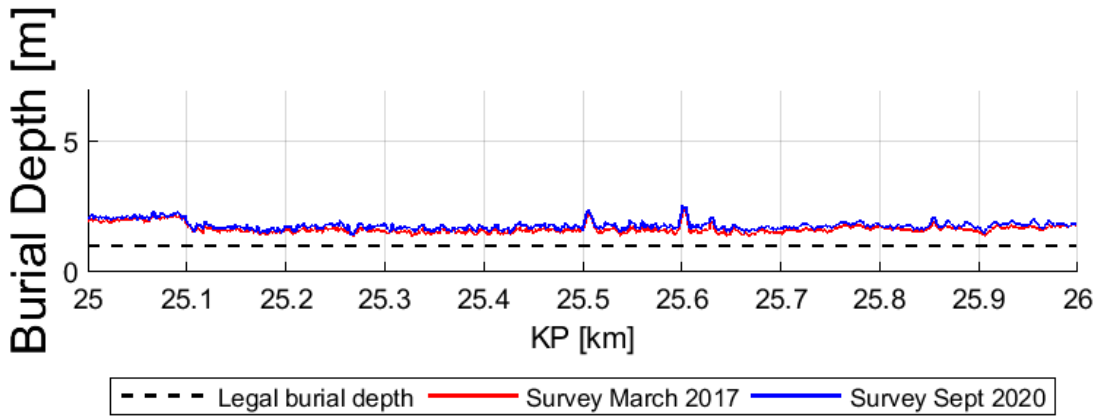


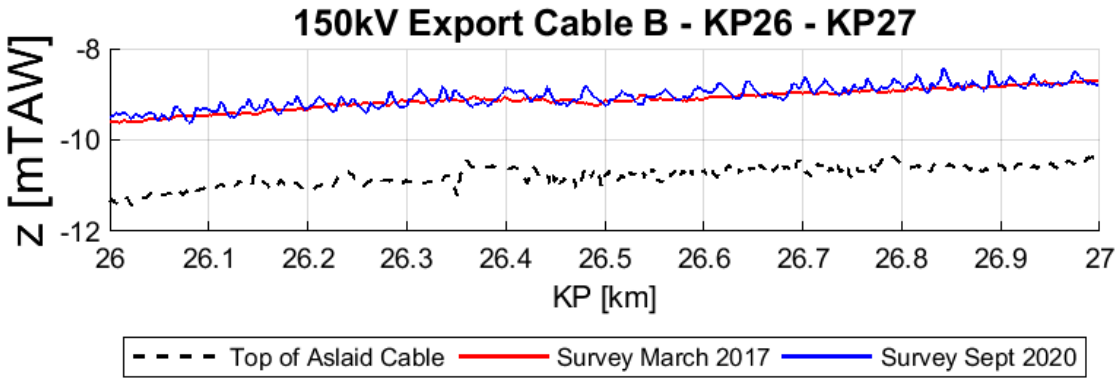


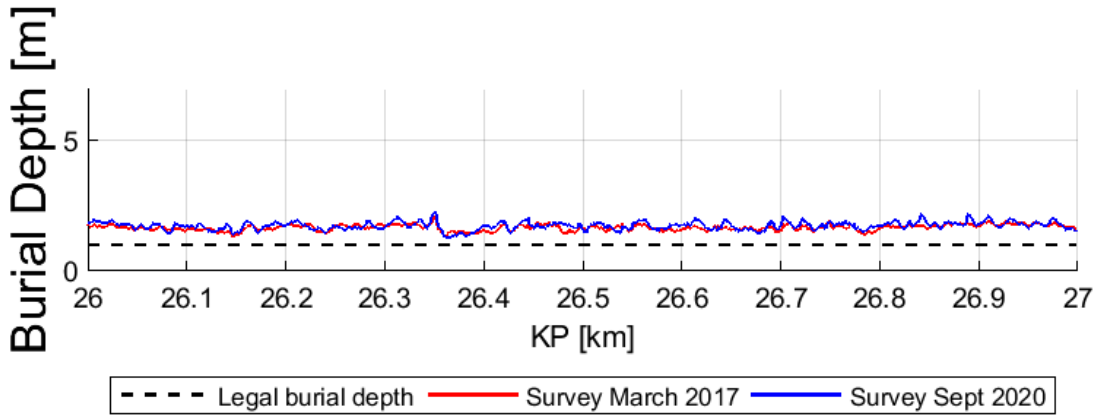


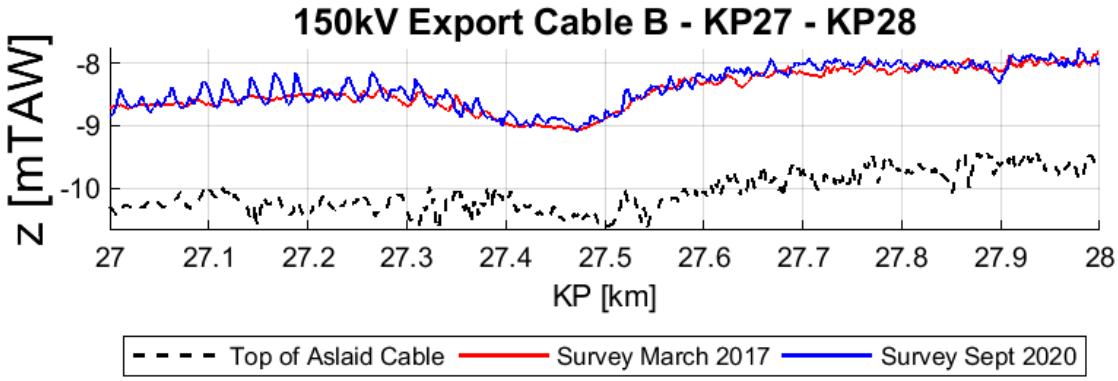


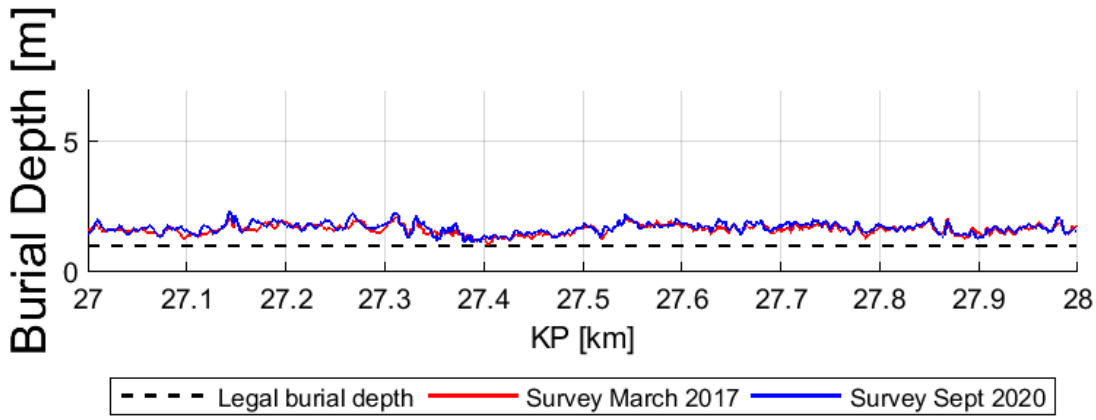


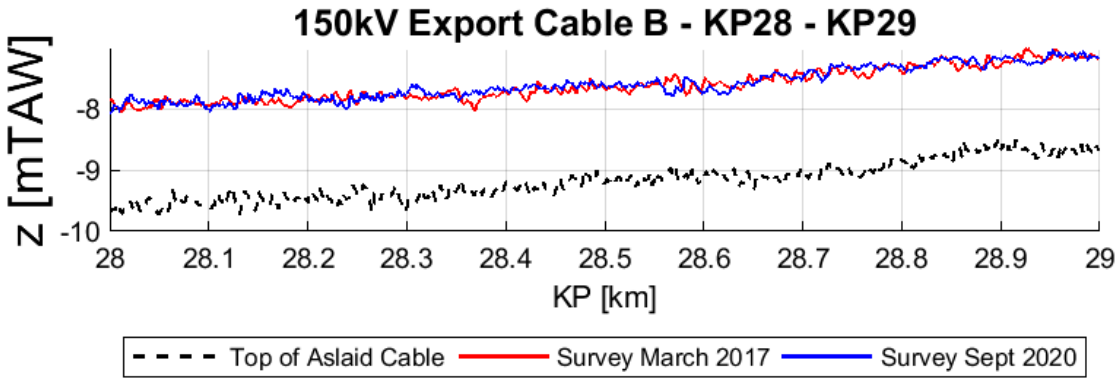


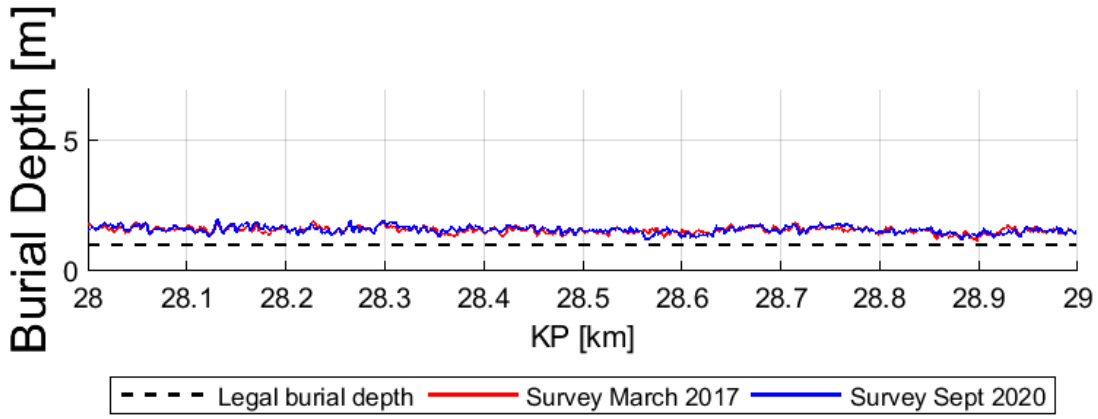


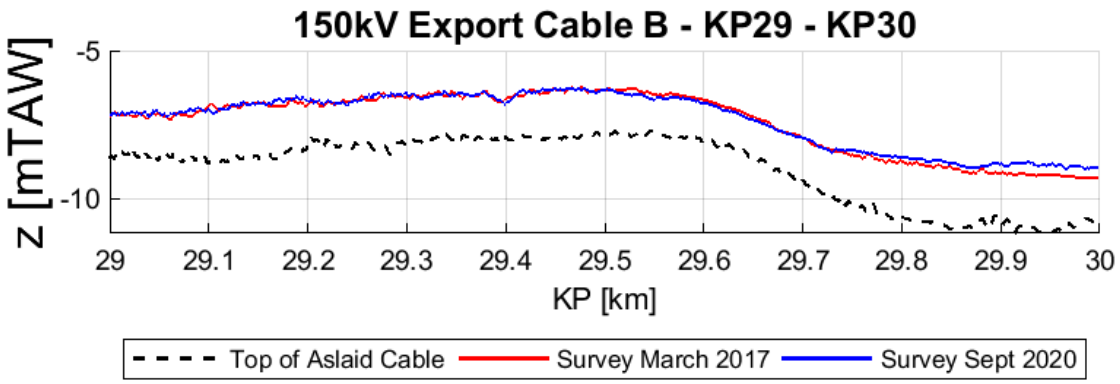


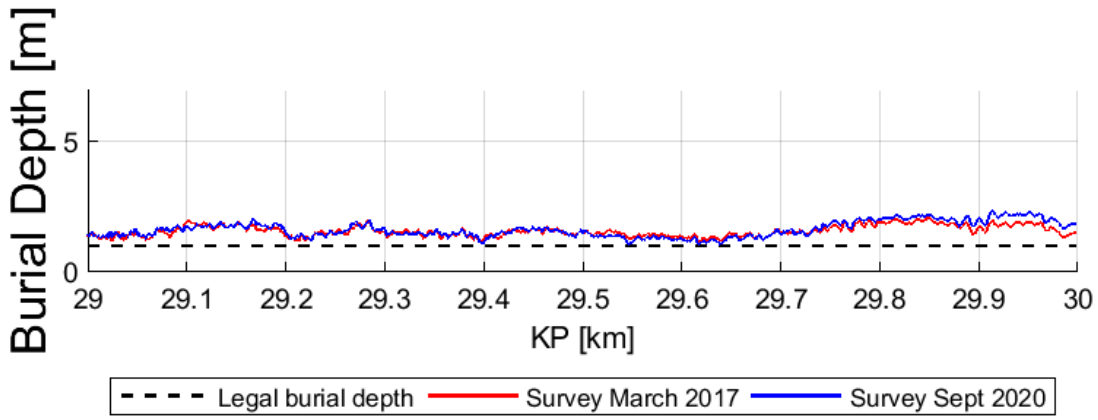


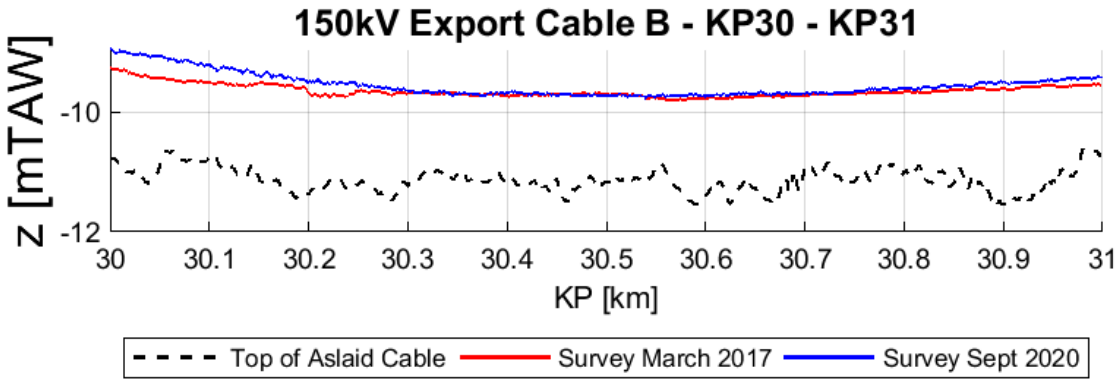


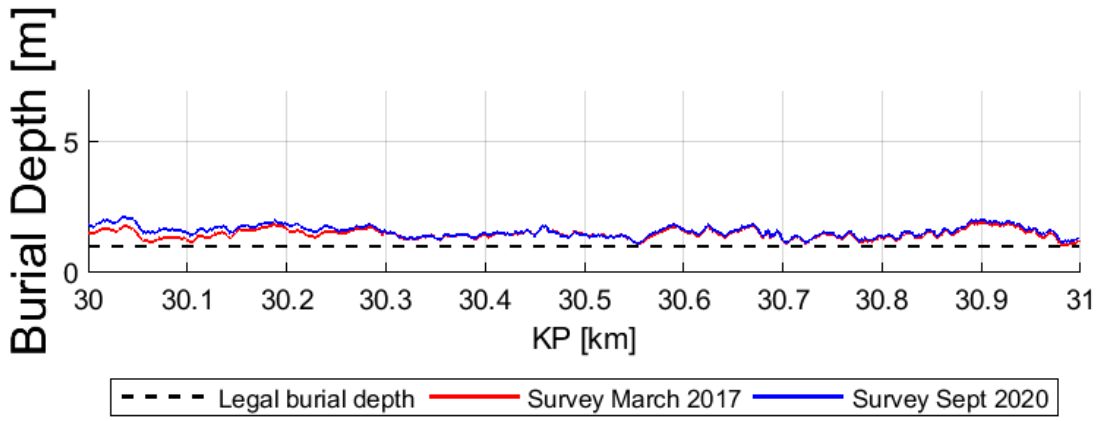


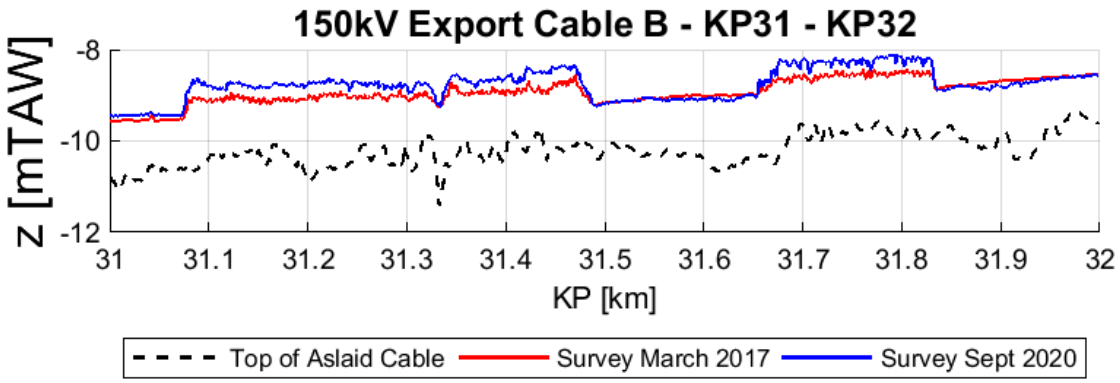


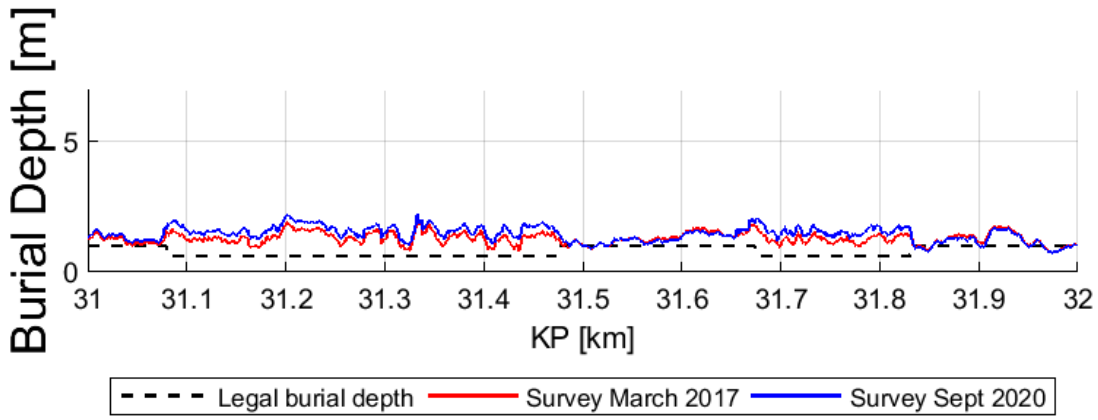


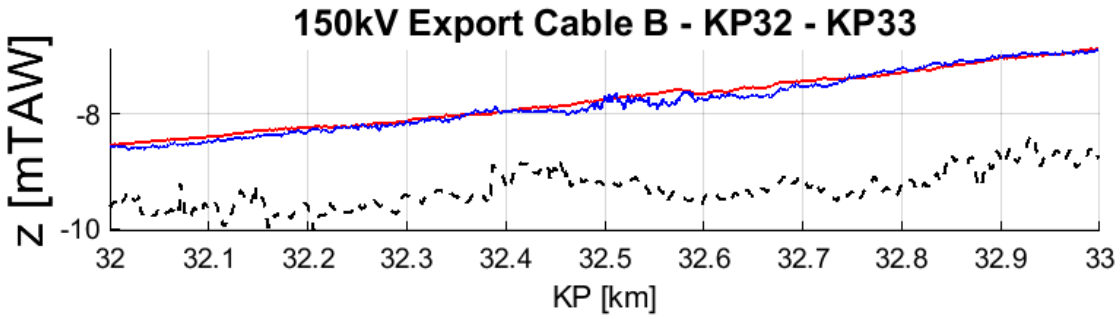


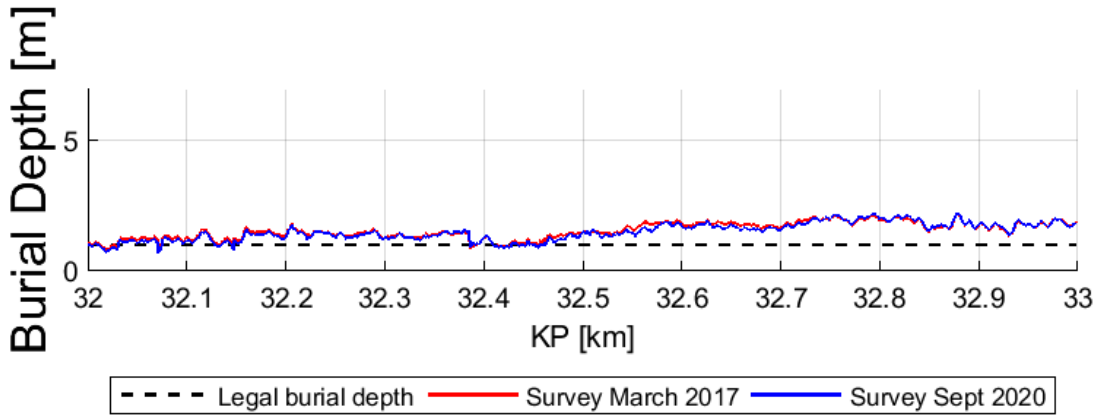


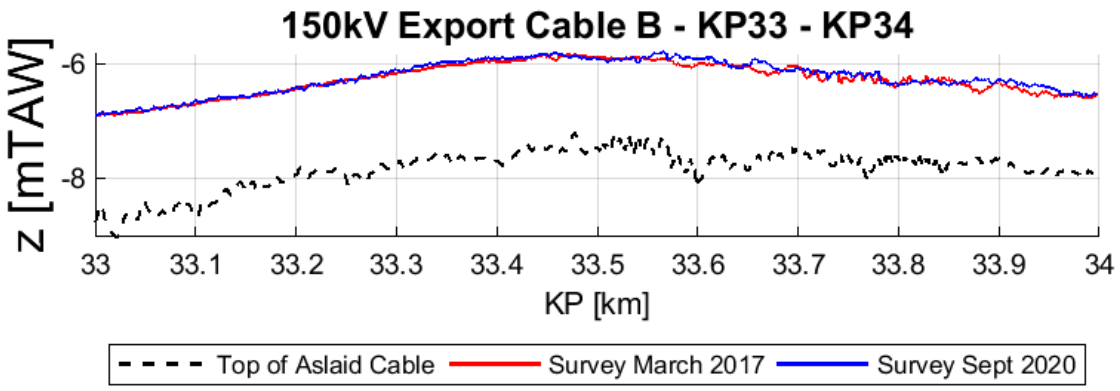


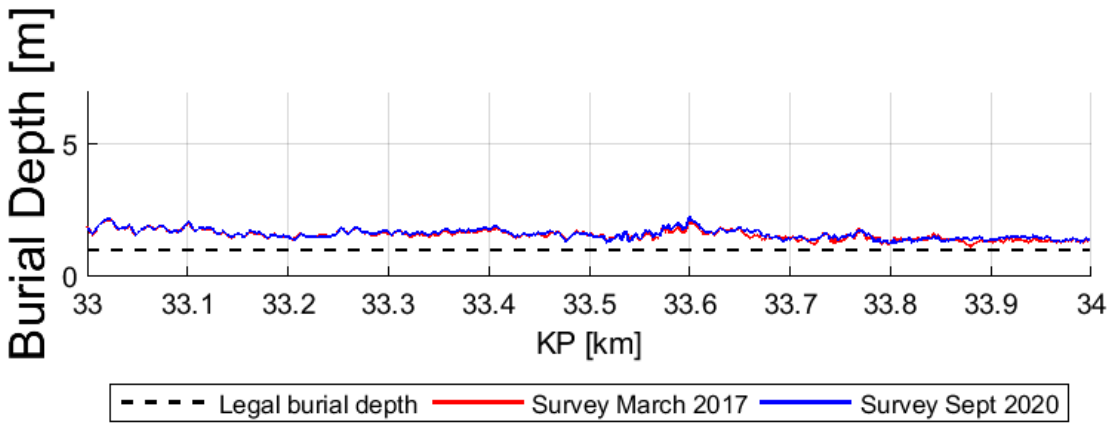


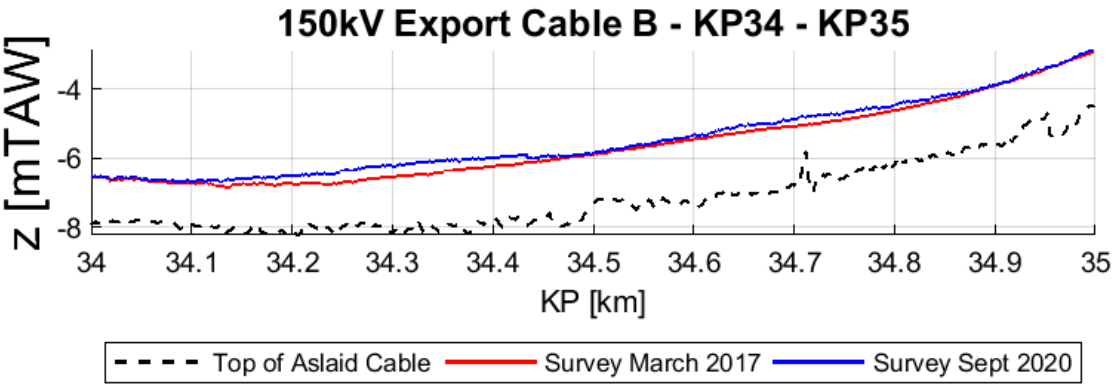


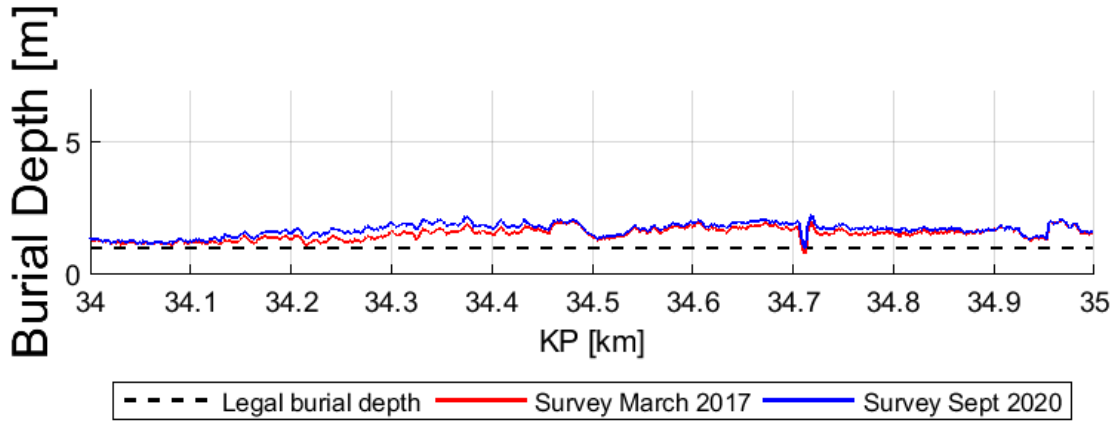


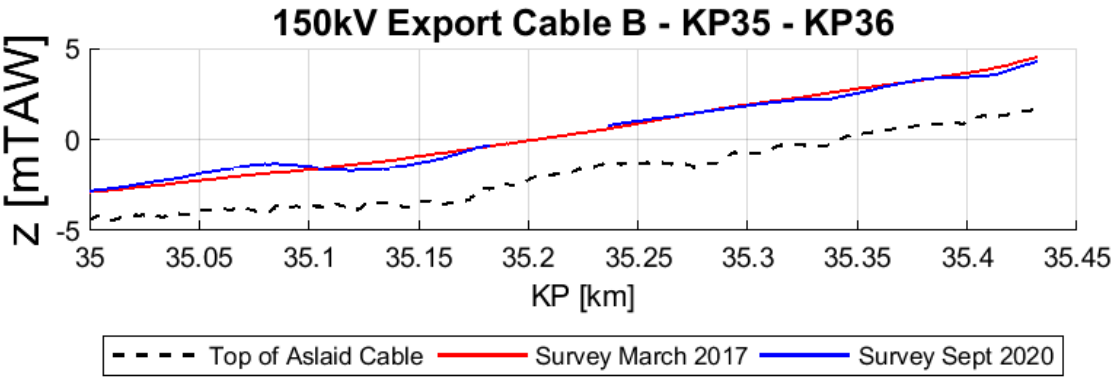


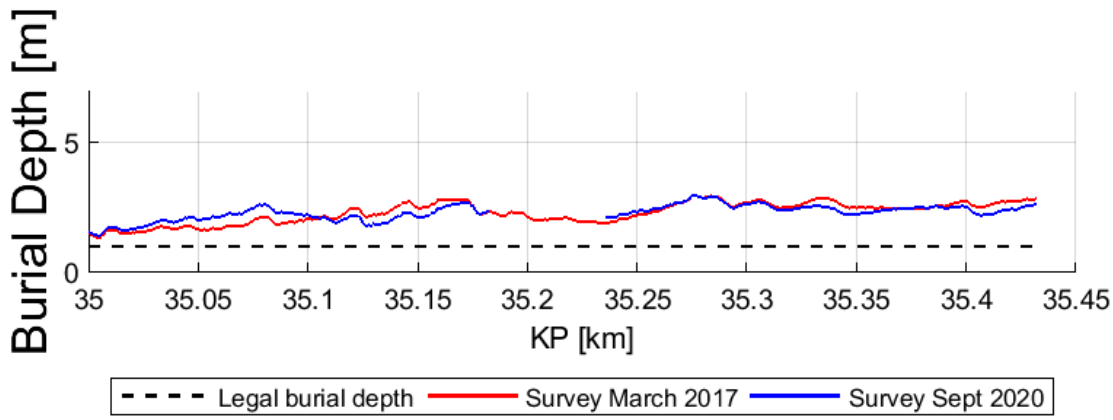


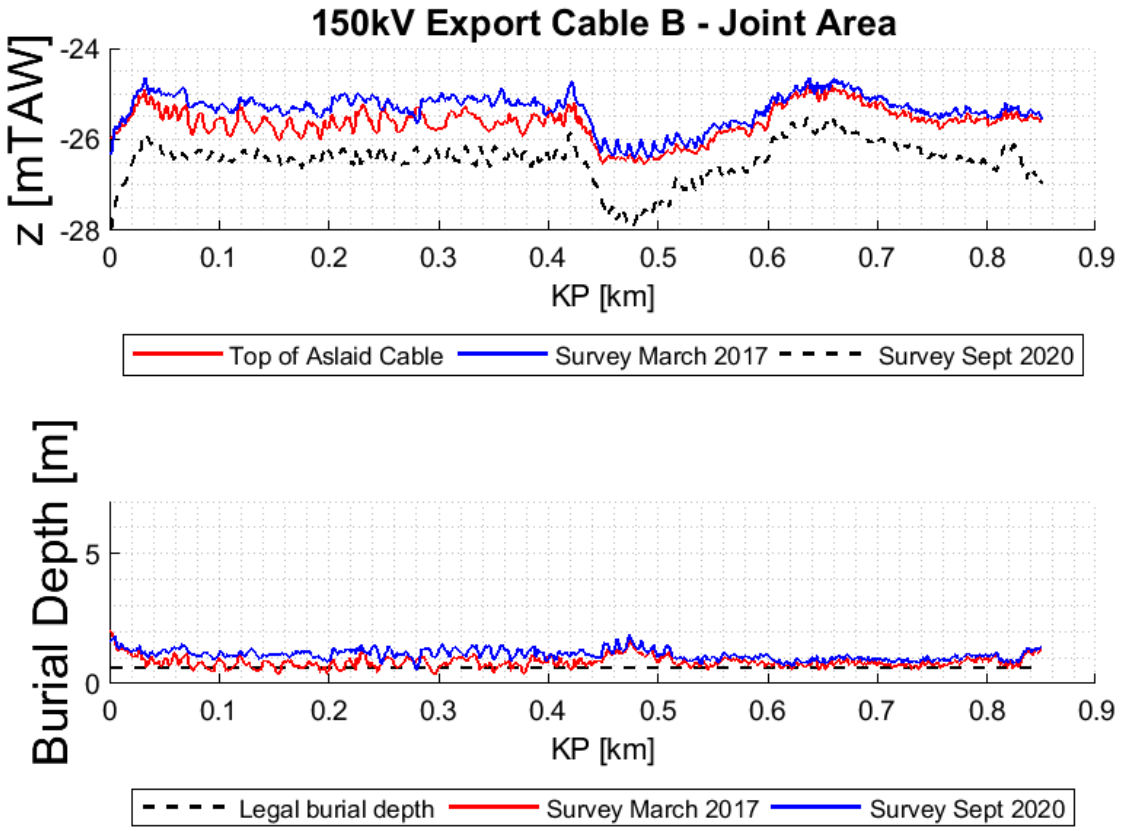










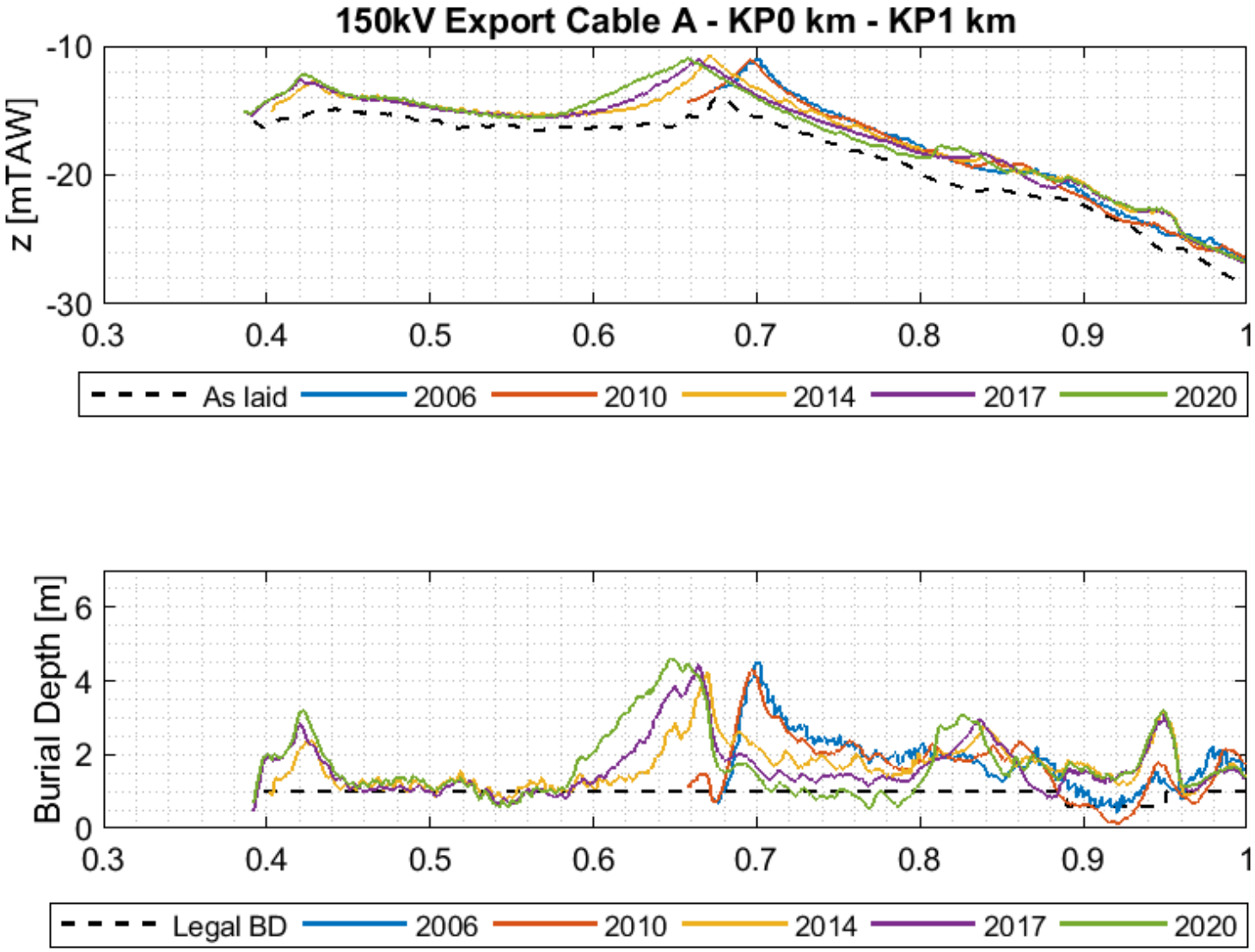


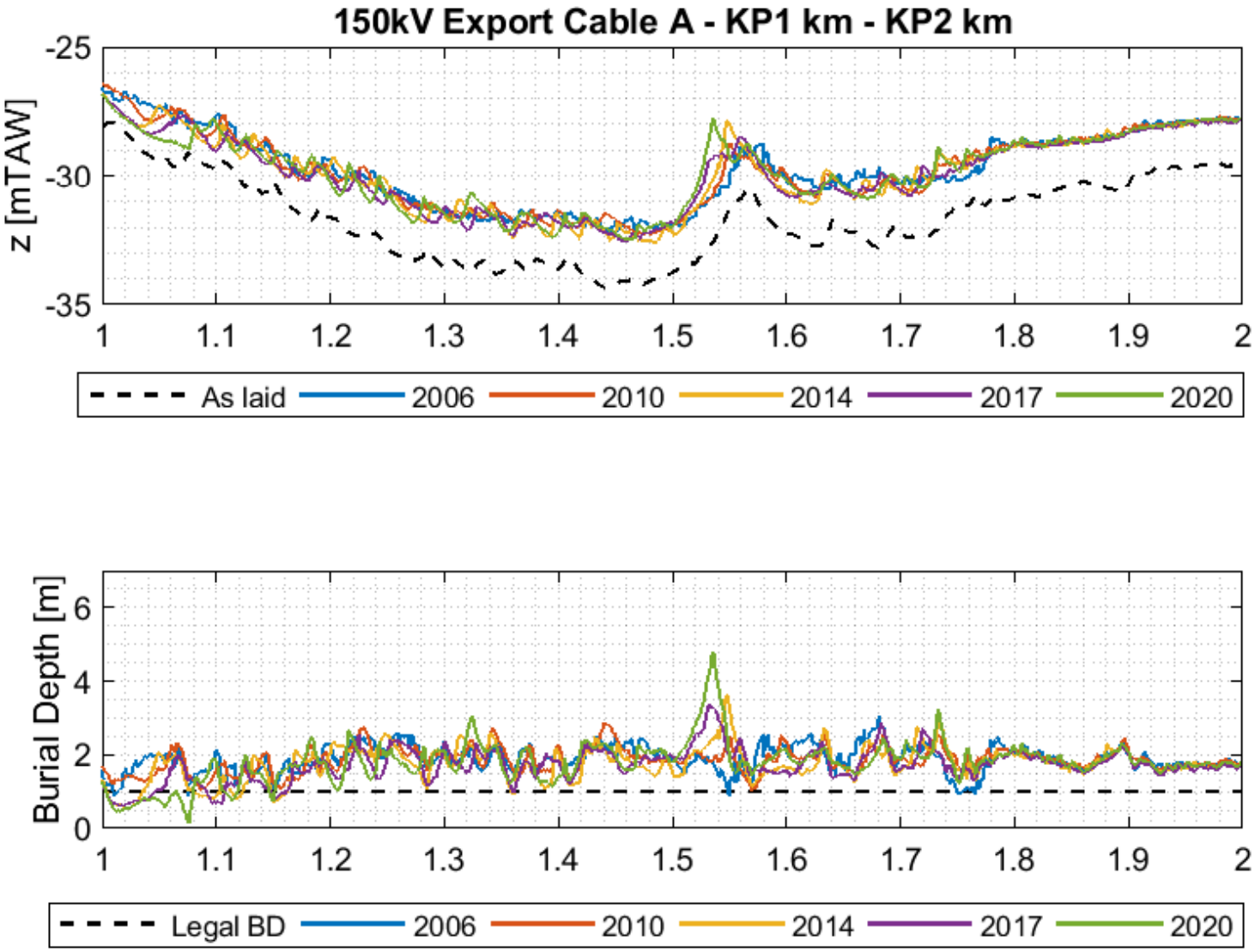
Annex G

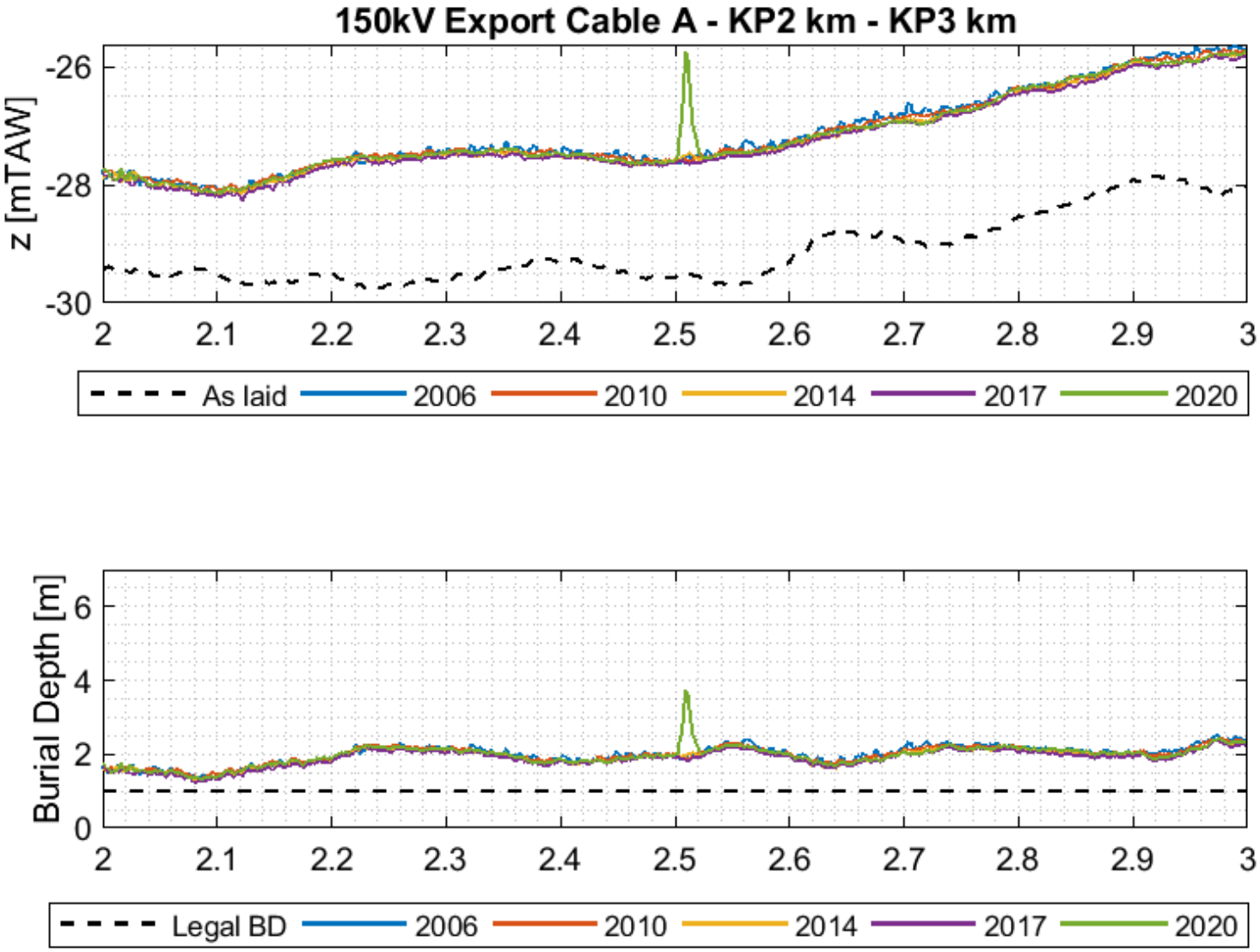
Cable B – Areas > 10 m with Actual DoC < Target DoC

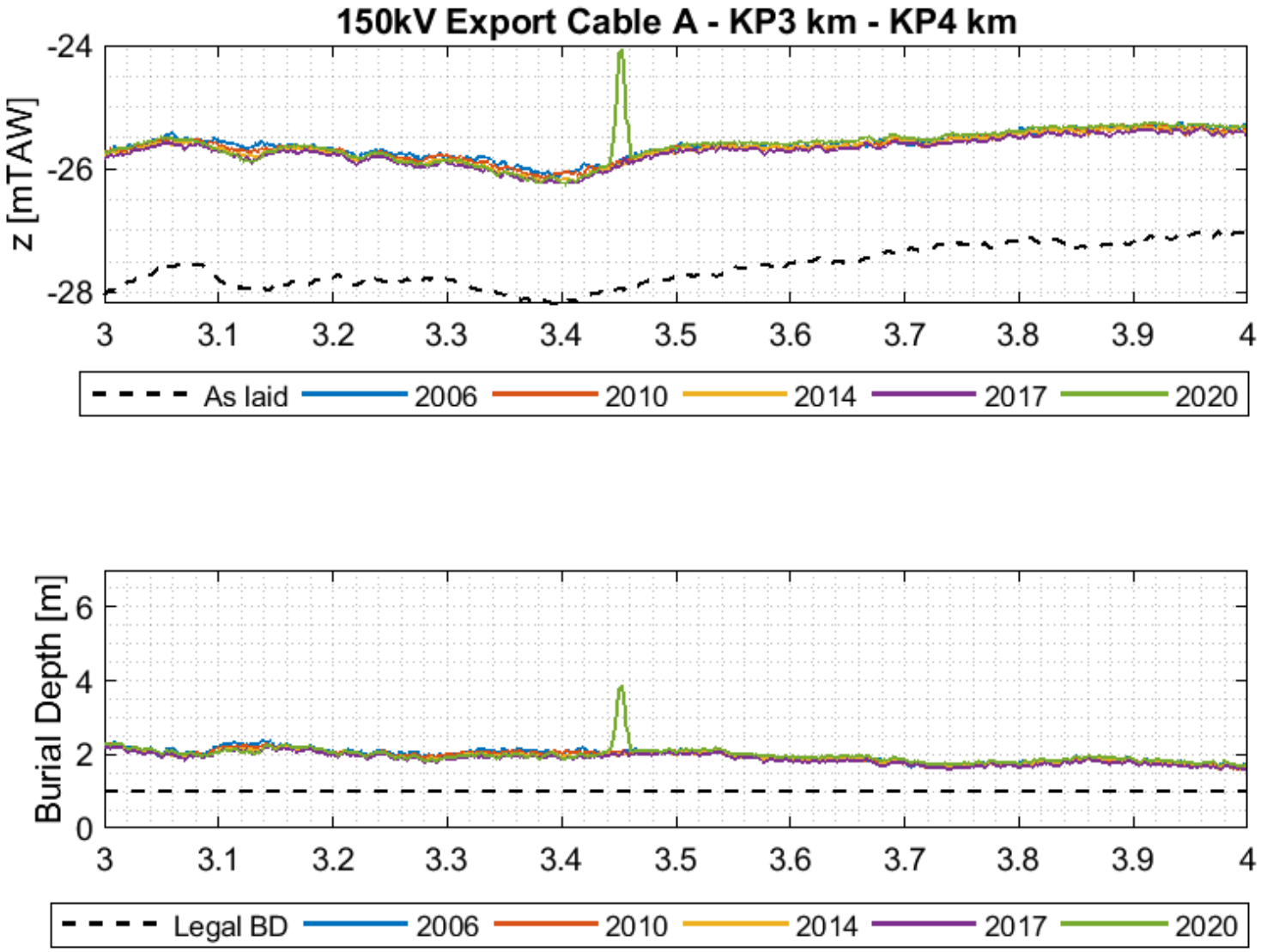
Annex H Cable B – Areas > 10 with Actual DoC < Target DoC – 0.20 m

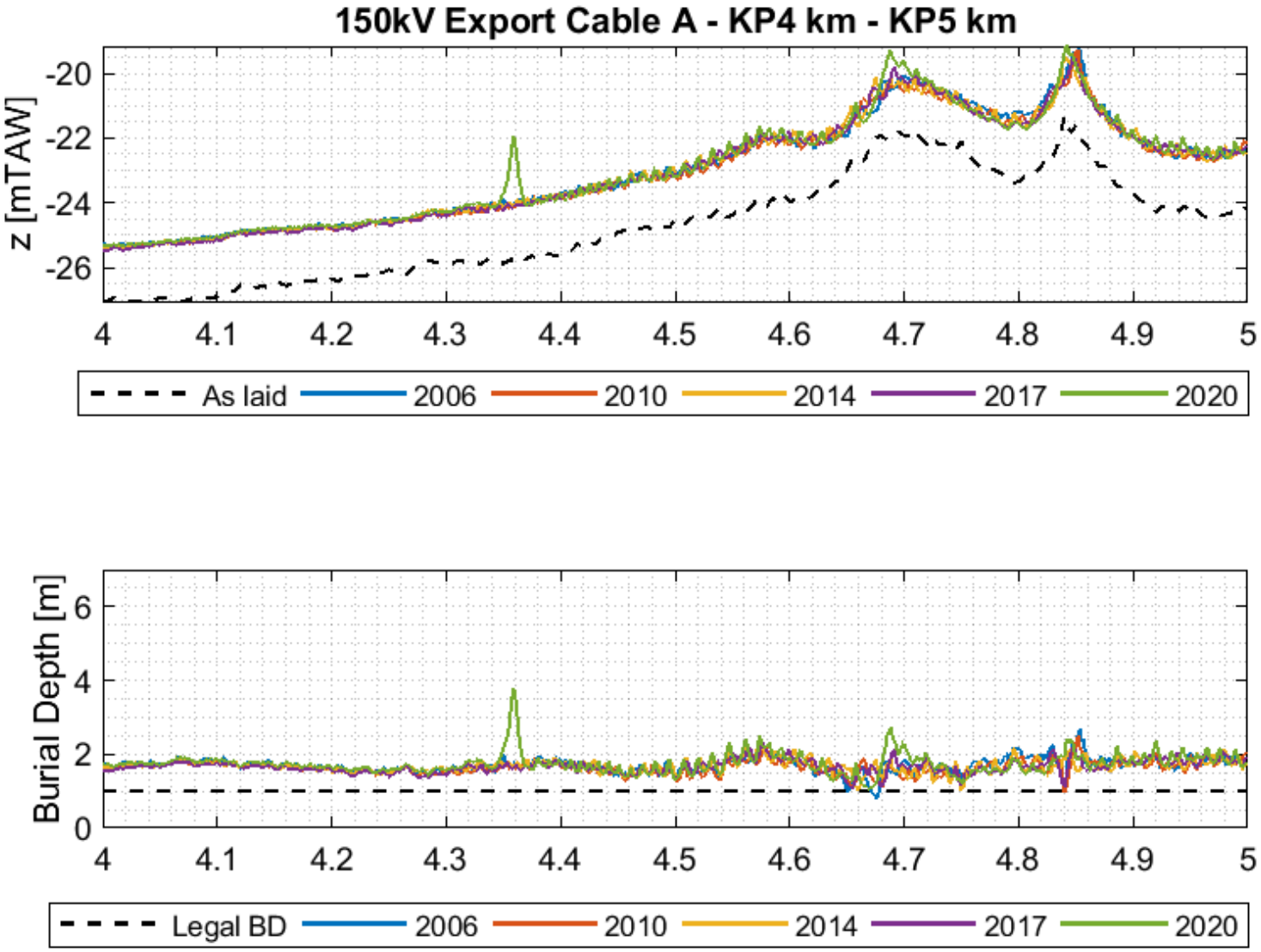
Annex I Evolution of seabed and Depth of Cover Export Cable A

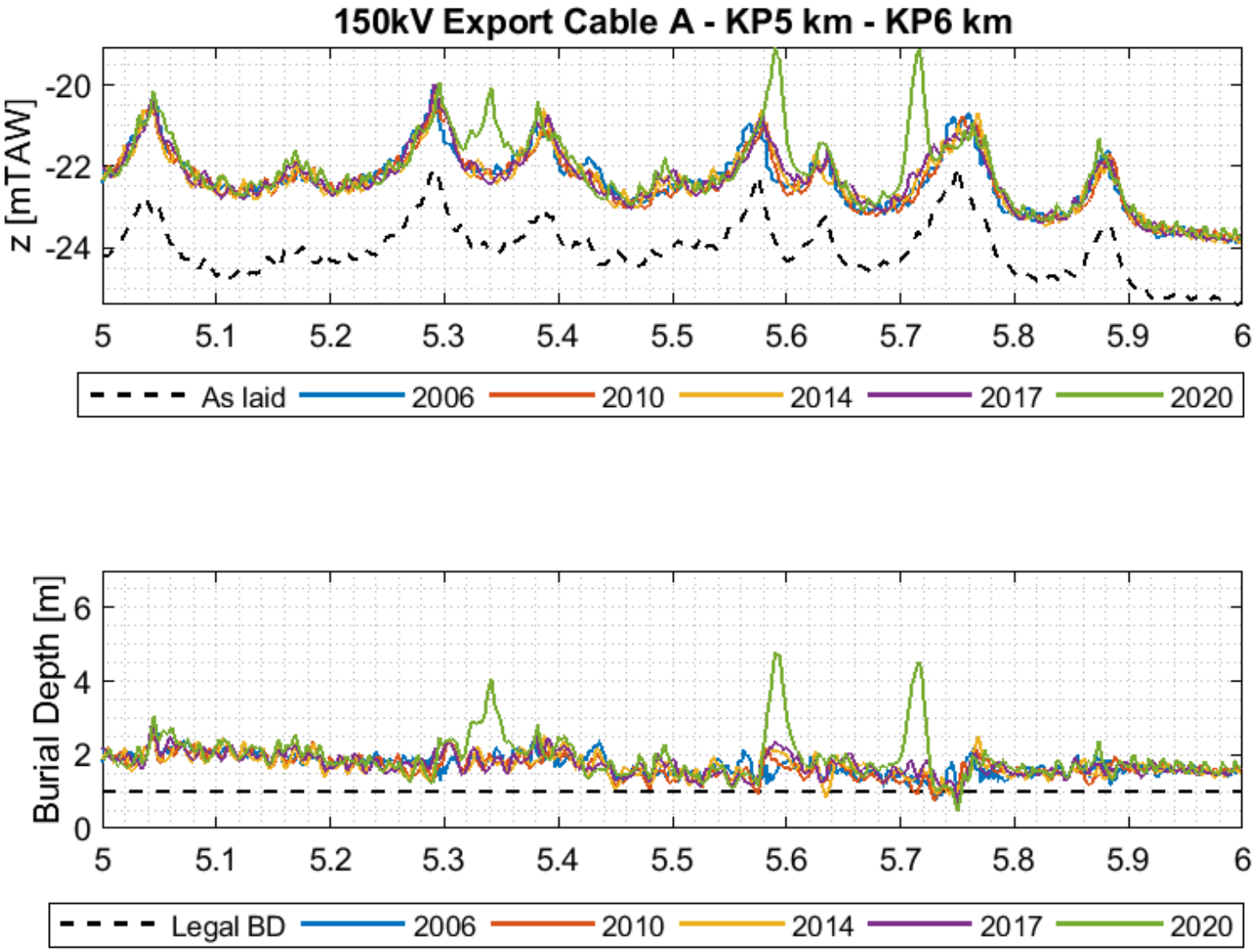


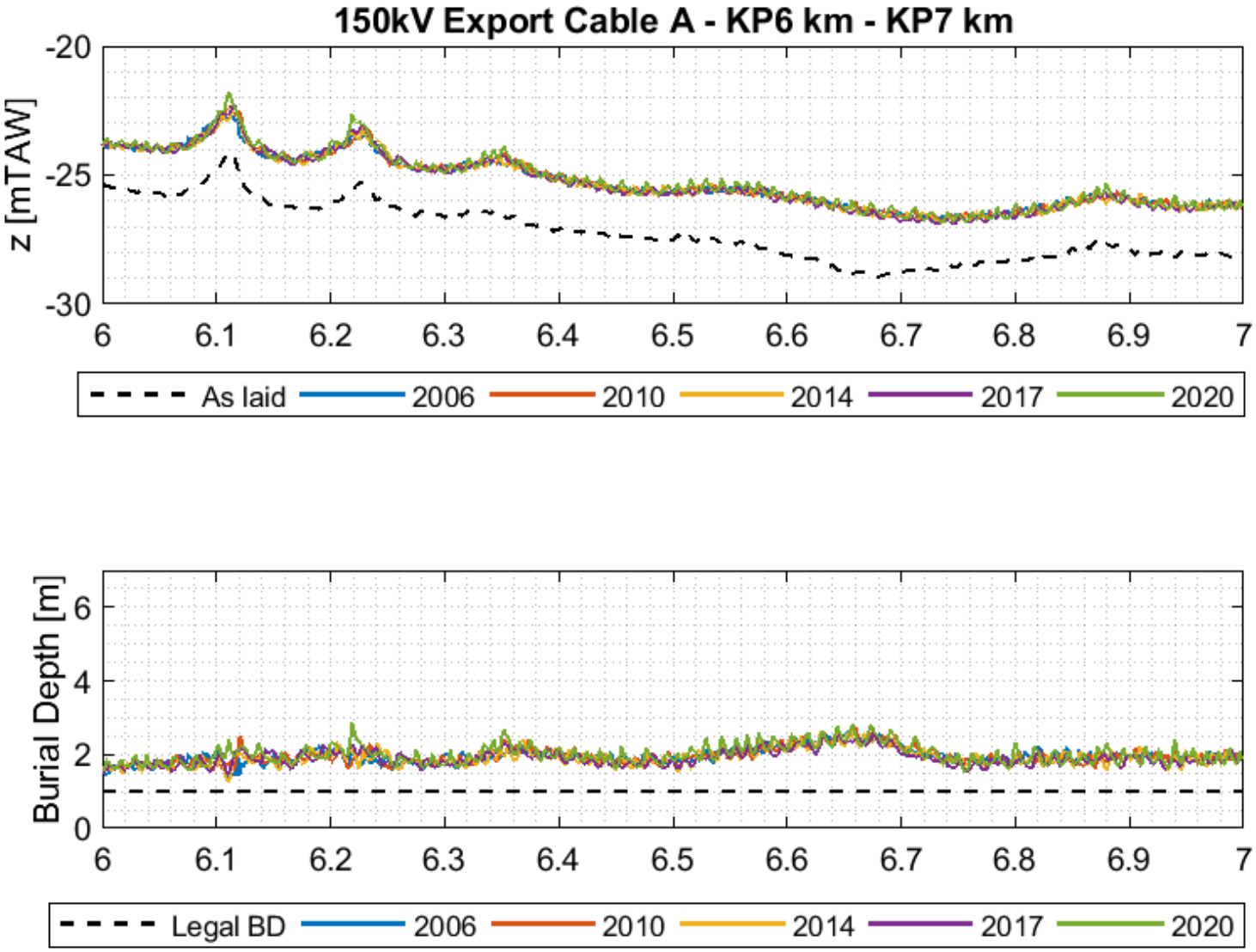


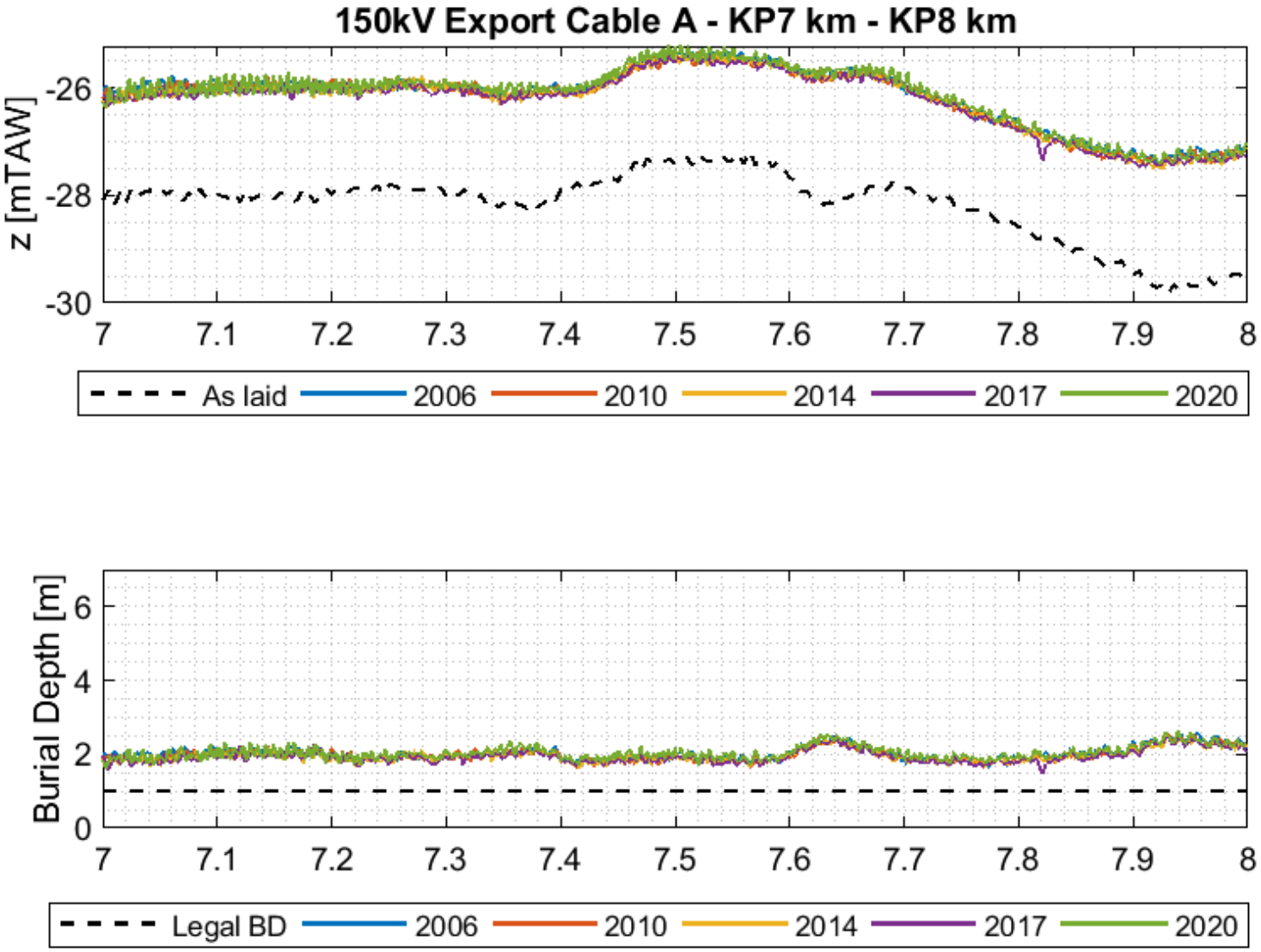


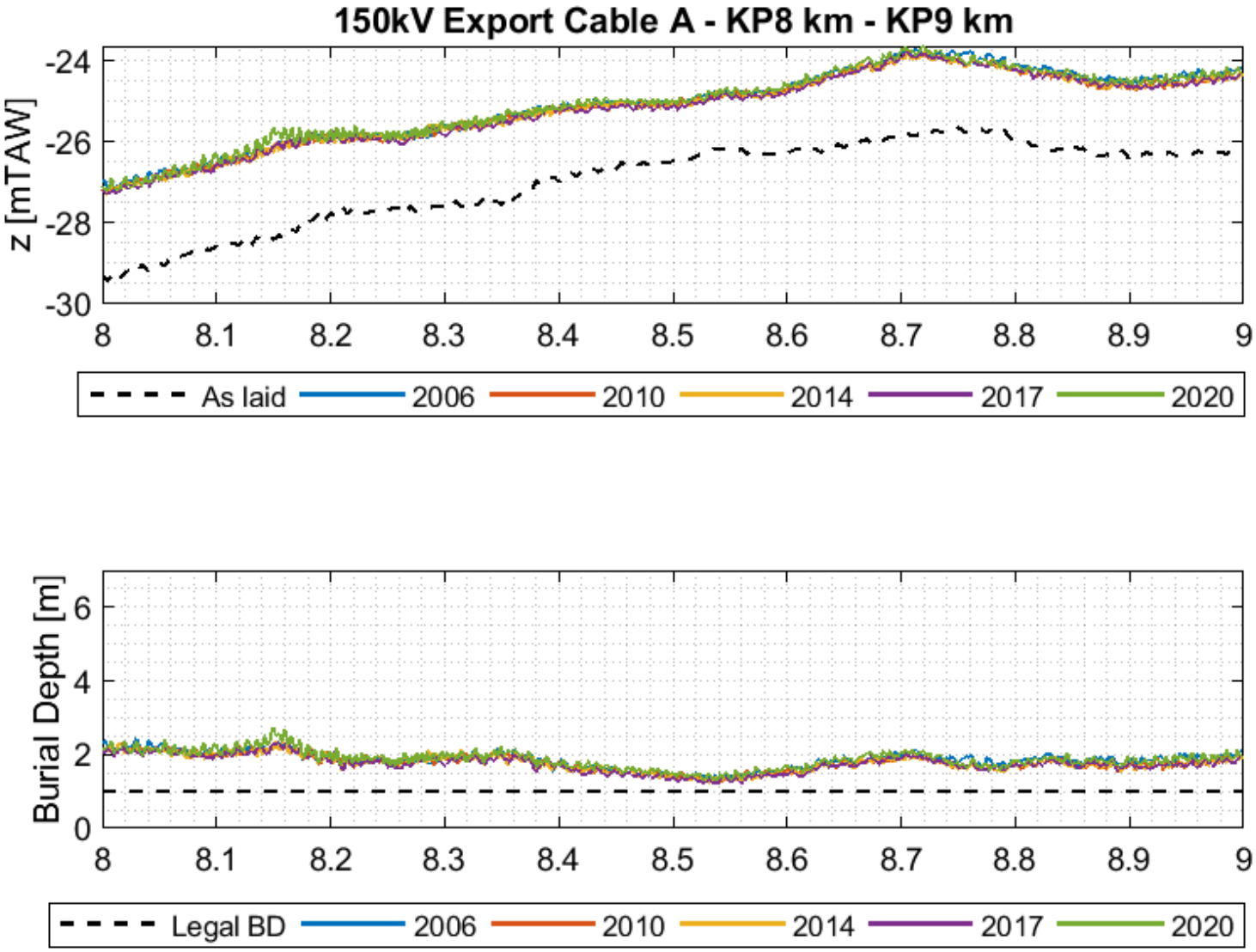


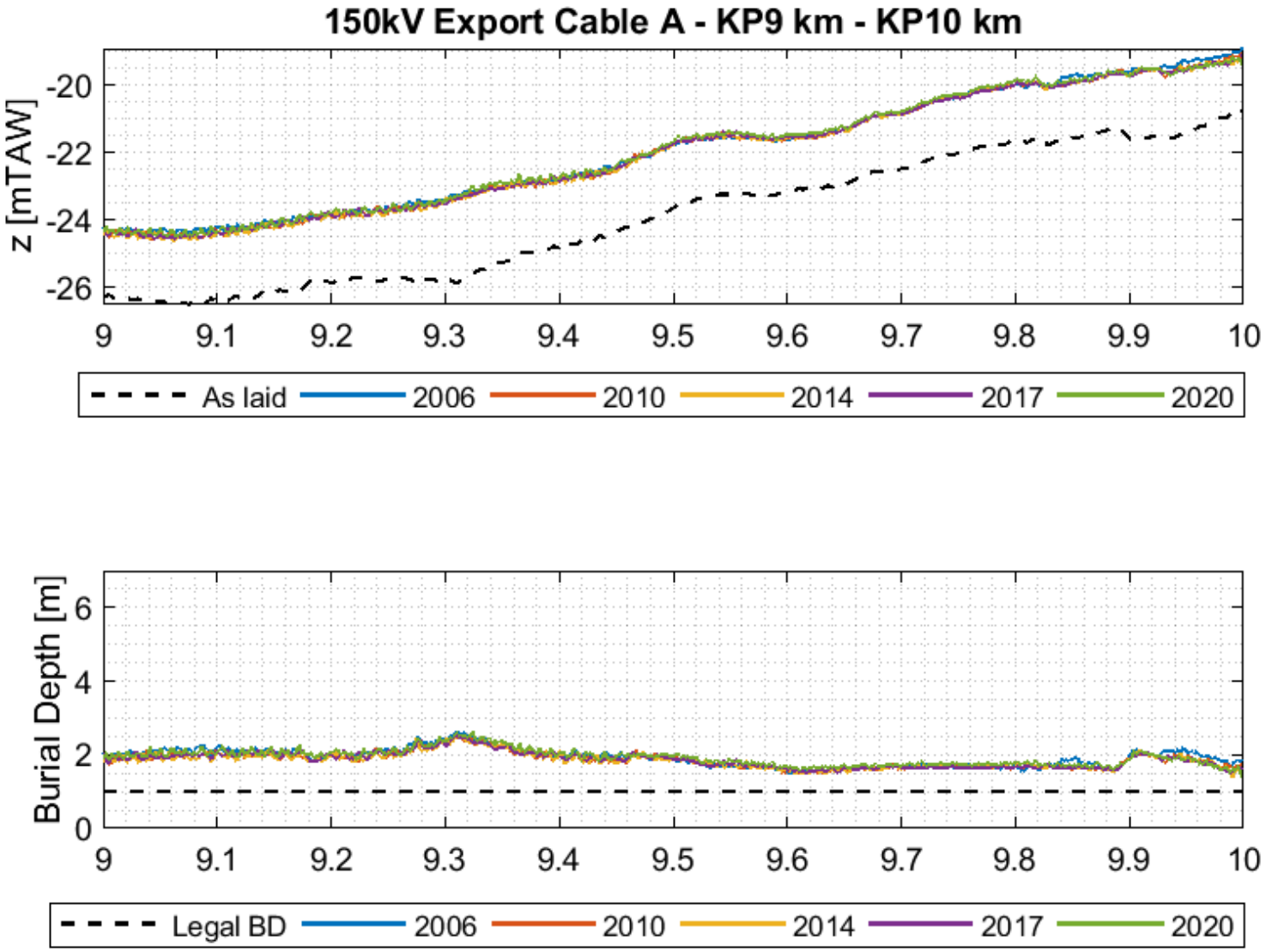


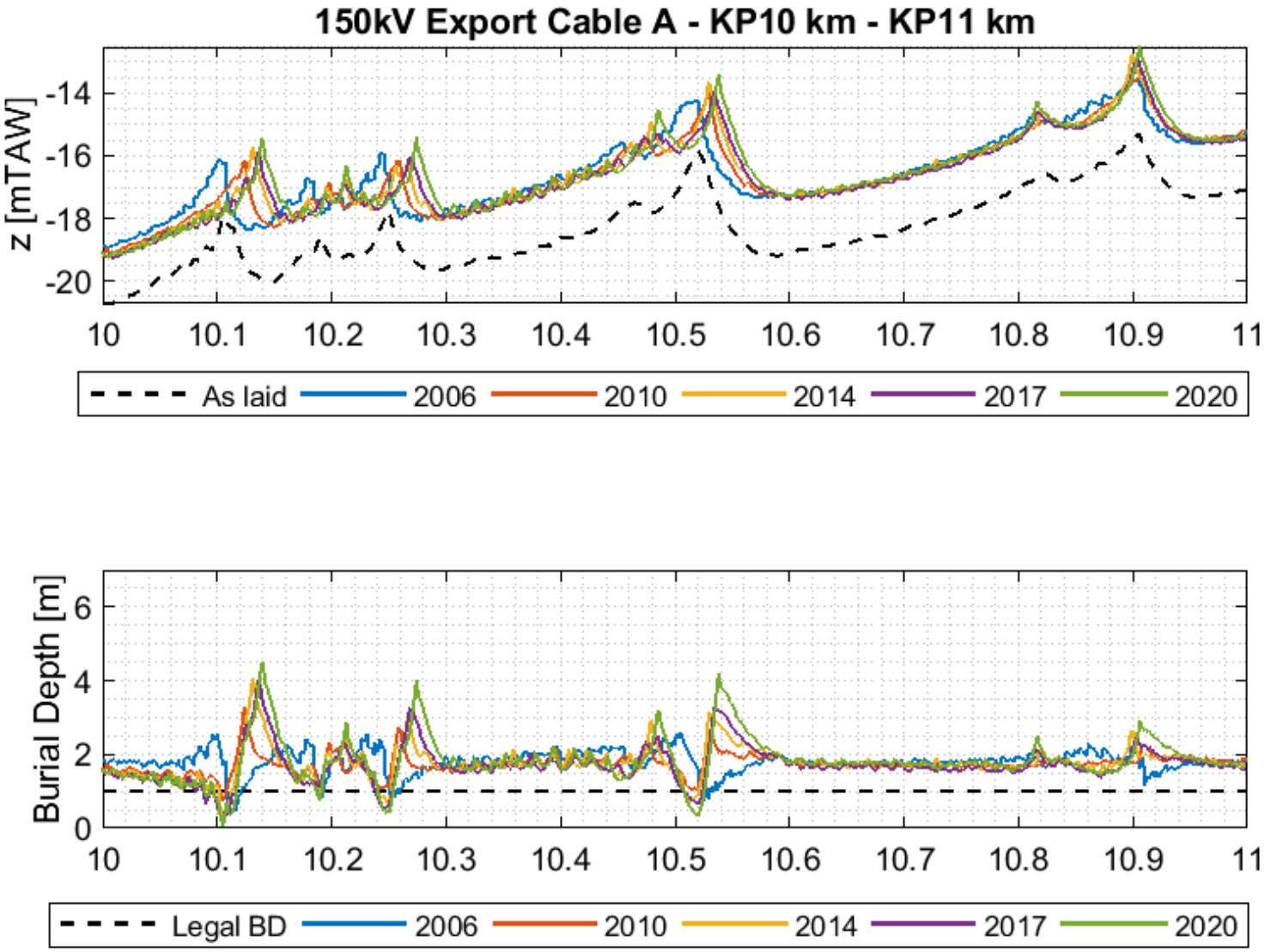


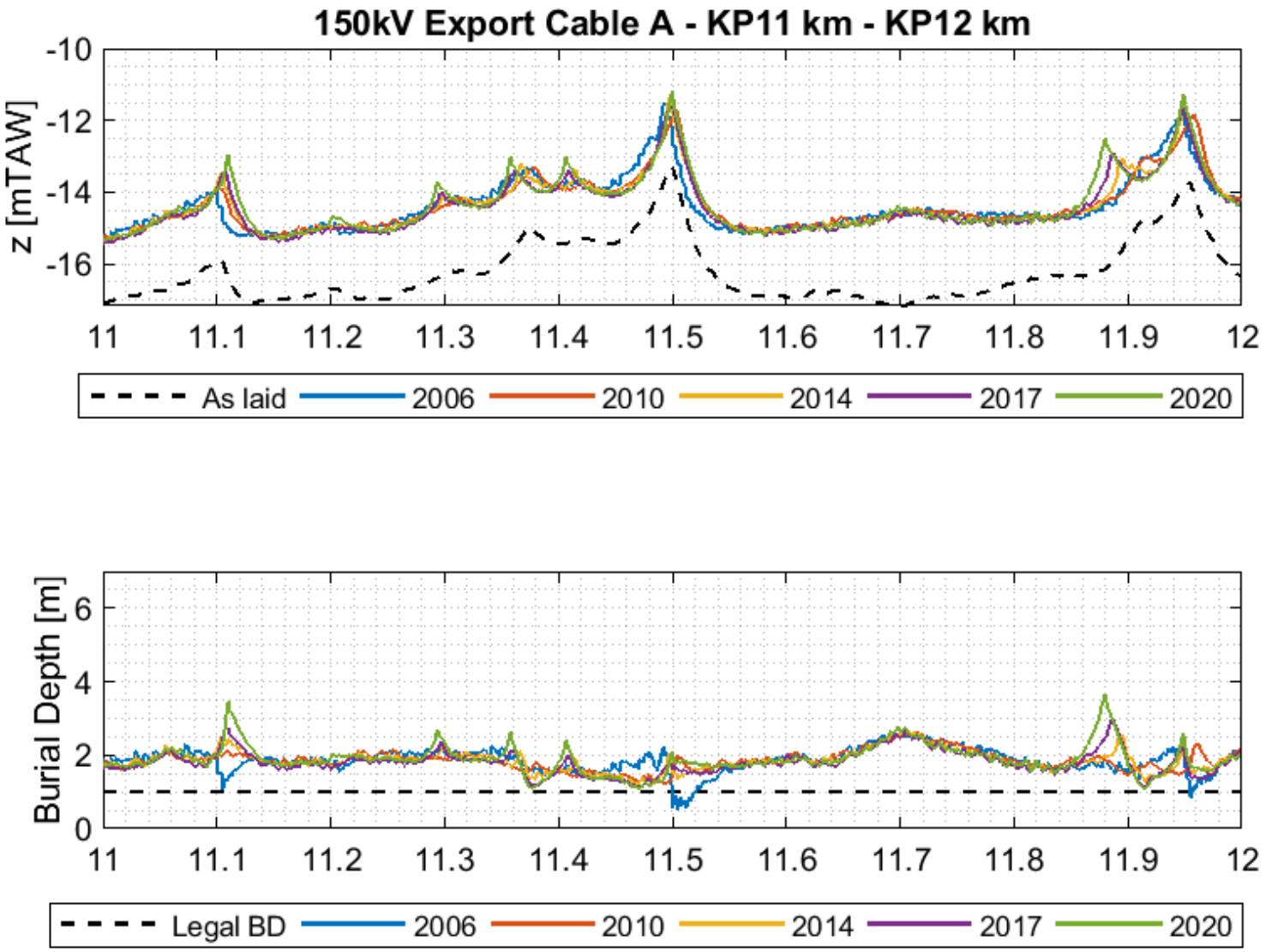


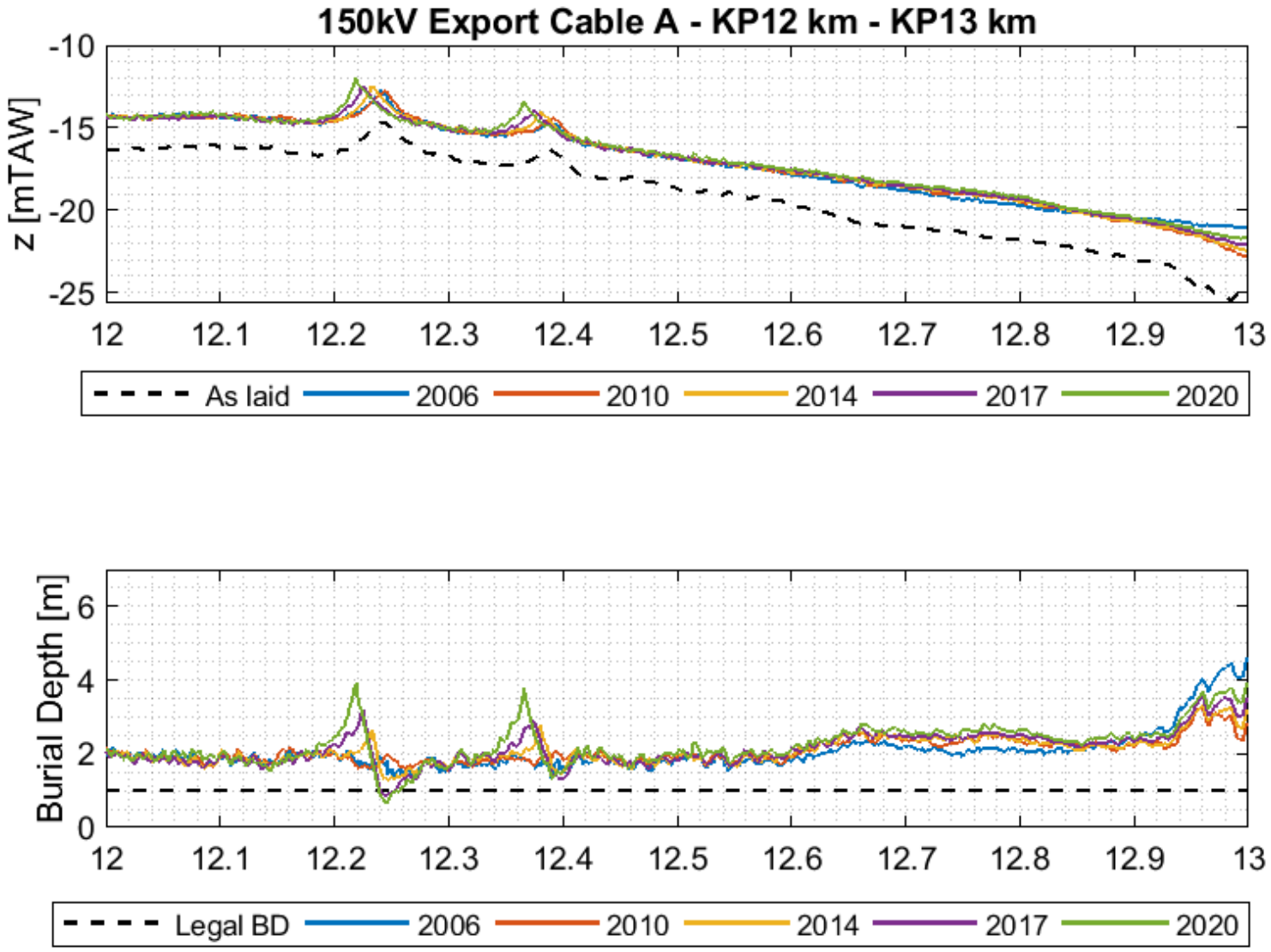


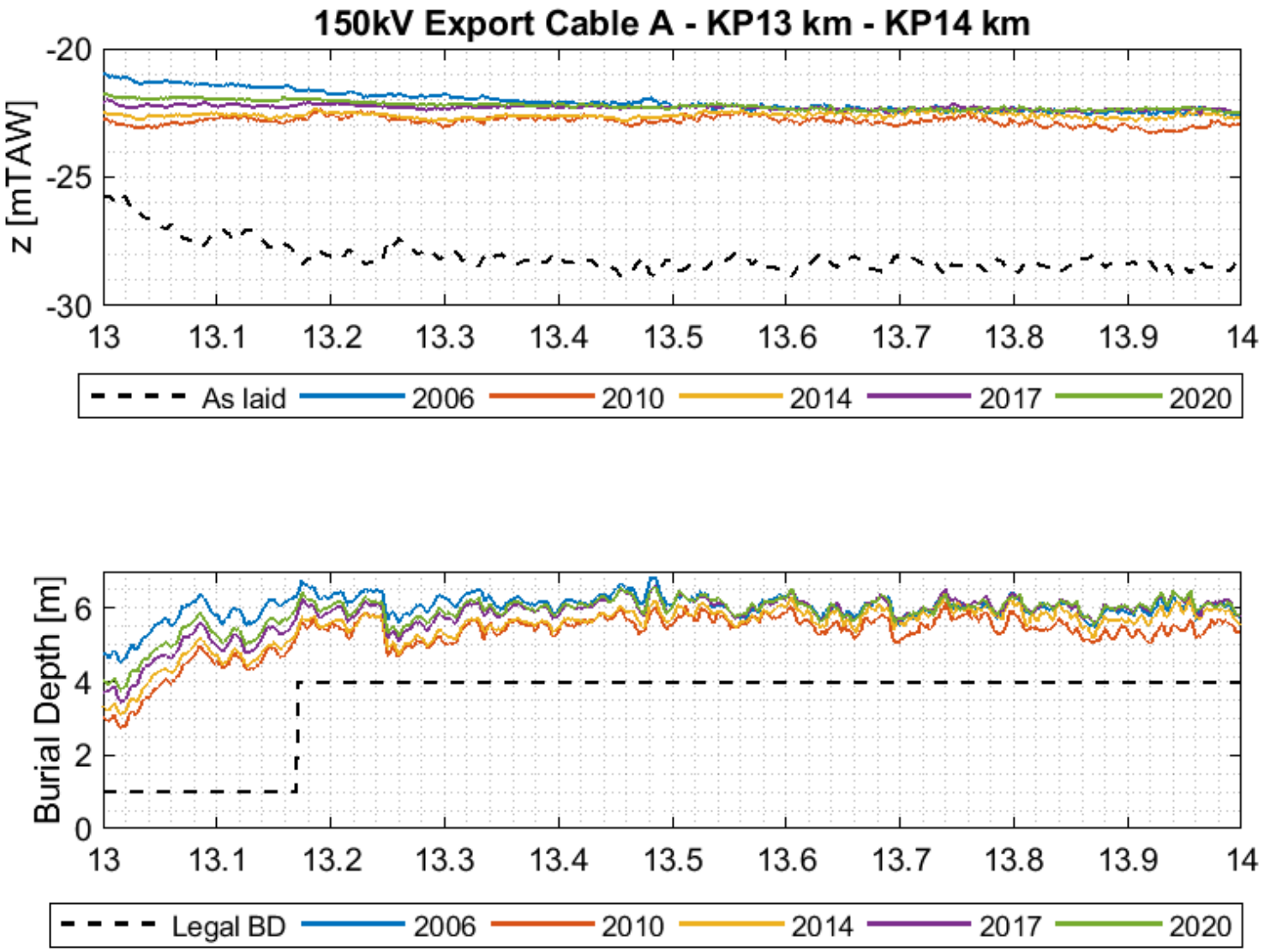


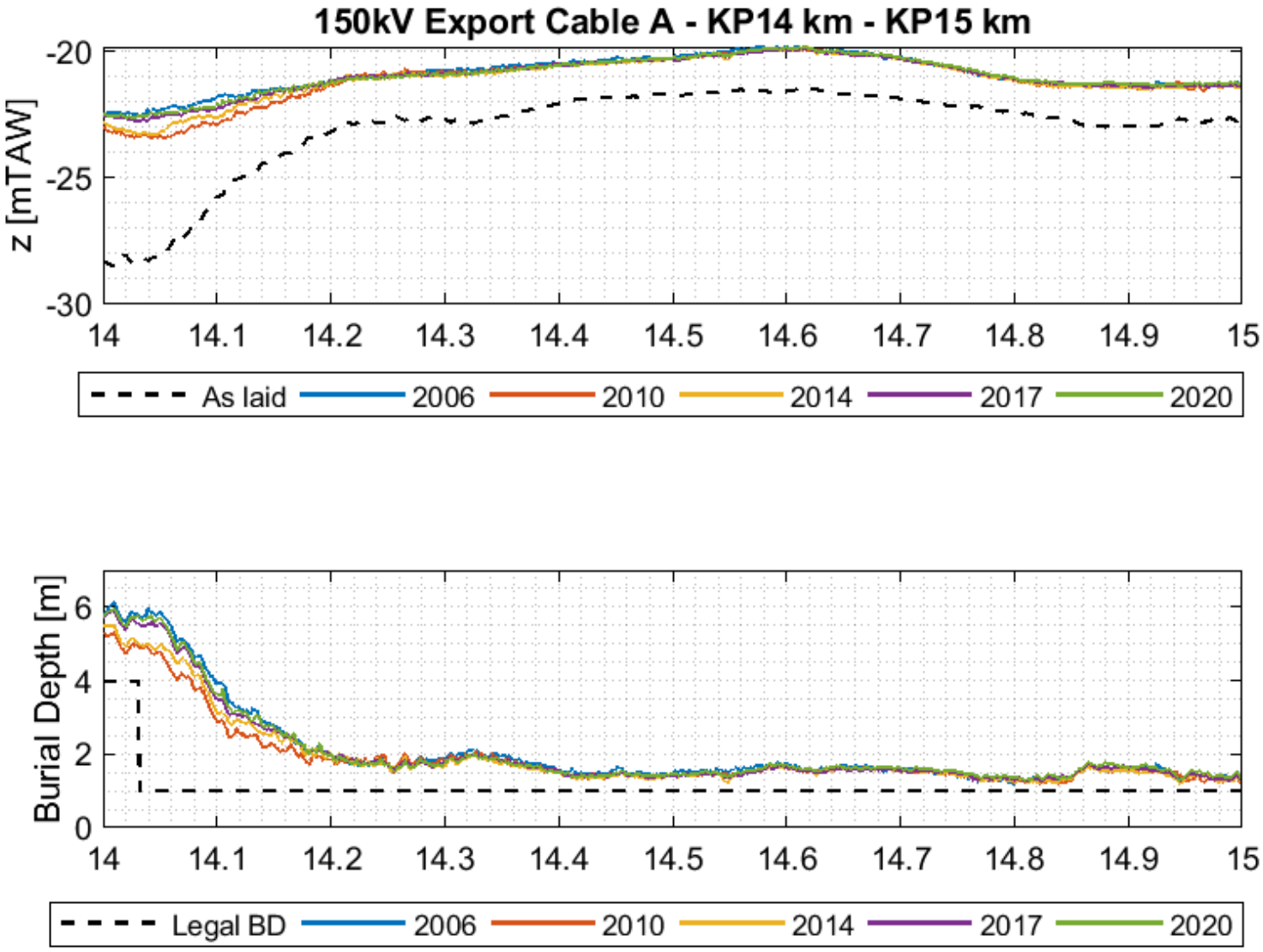


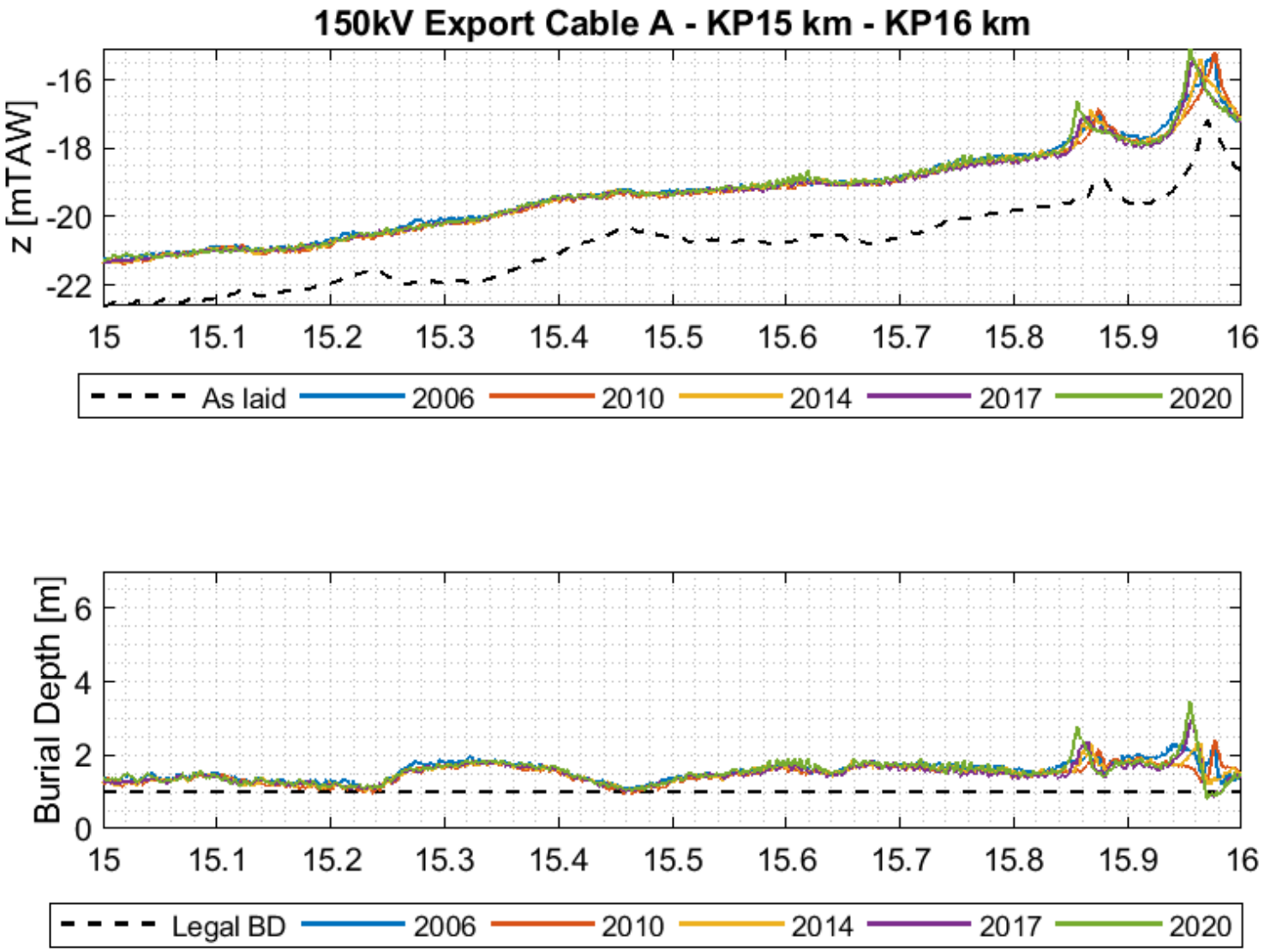


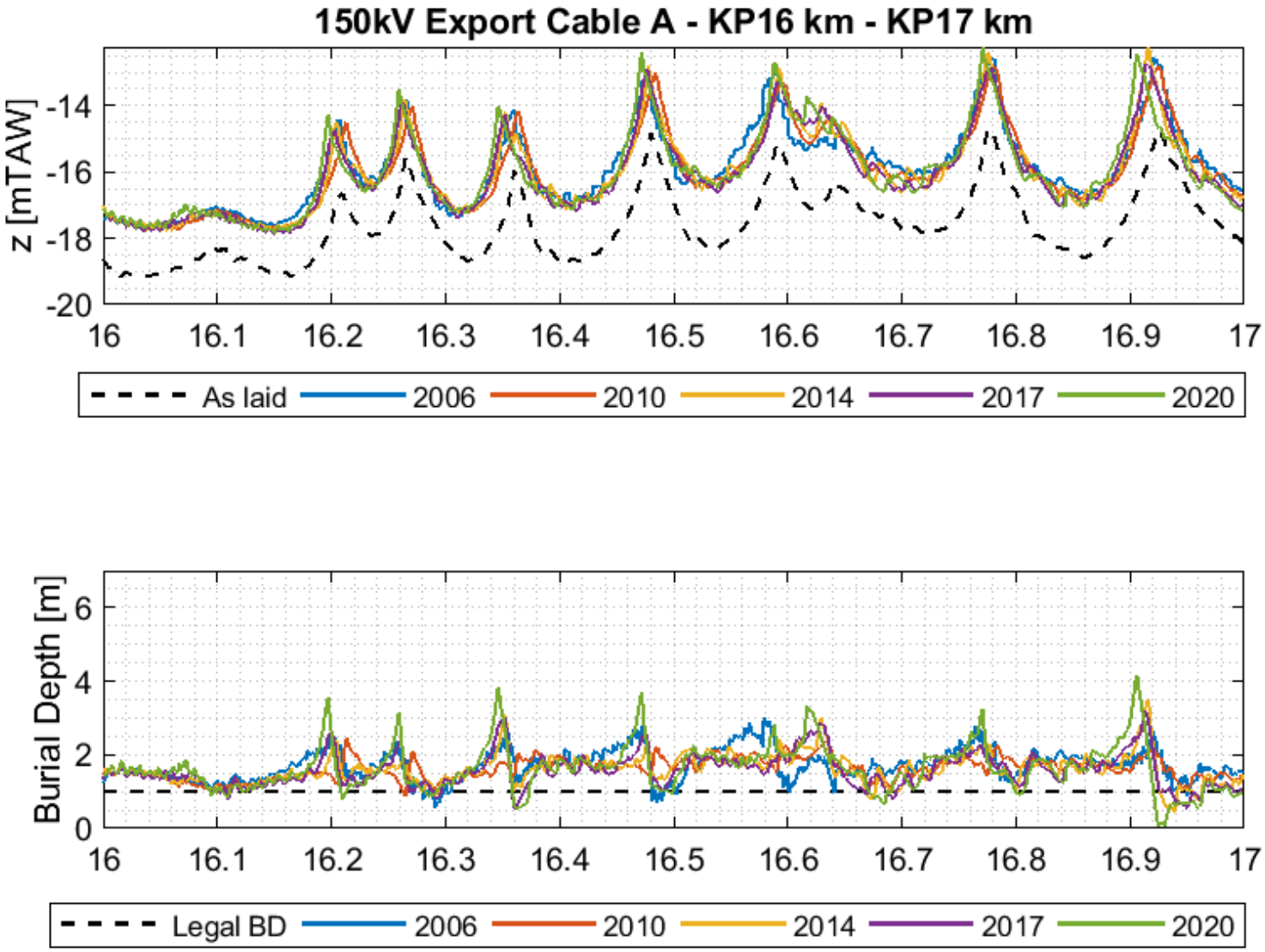


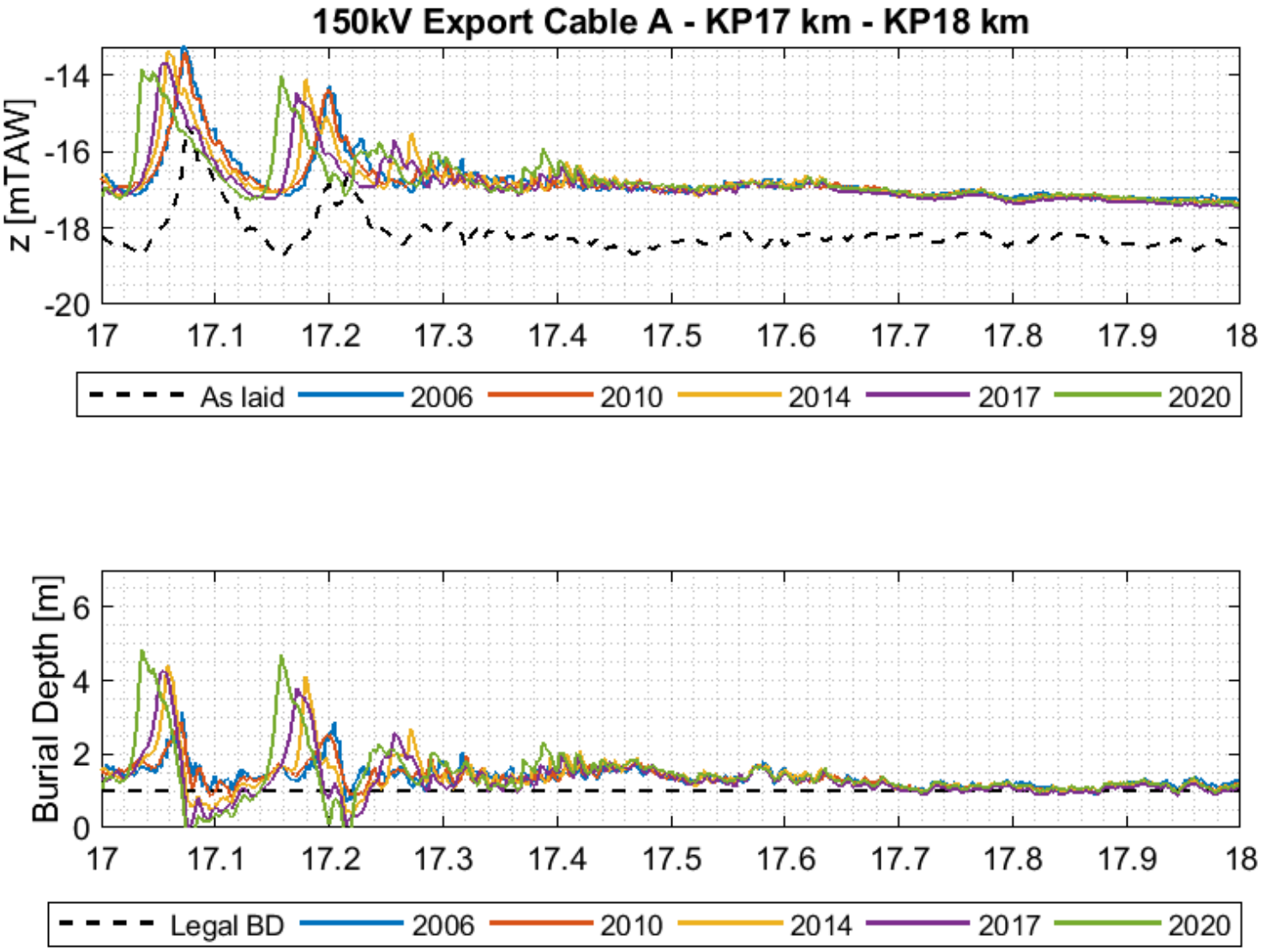


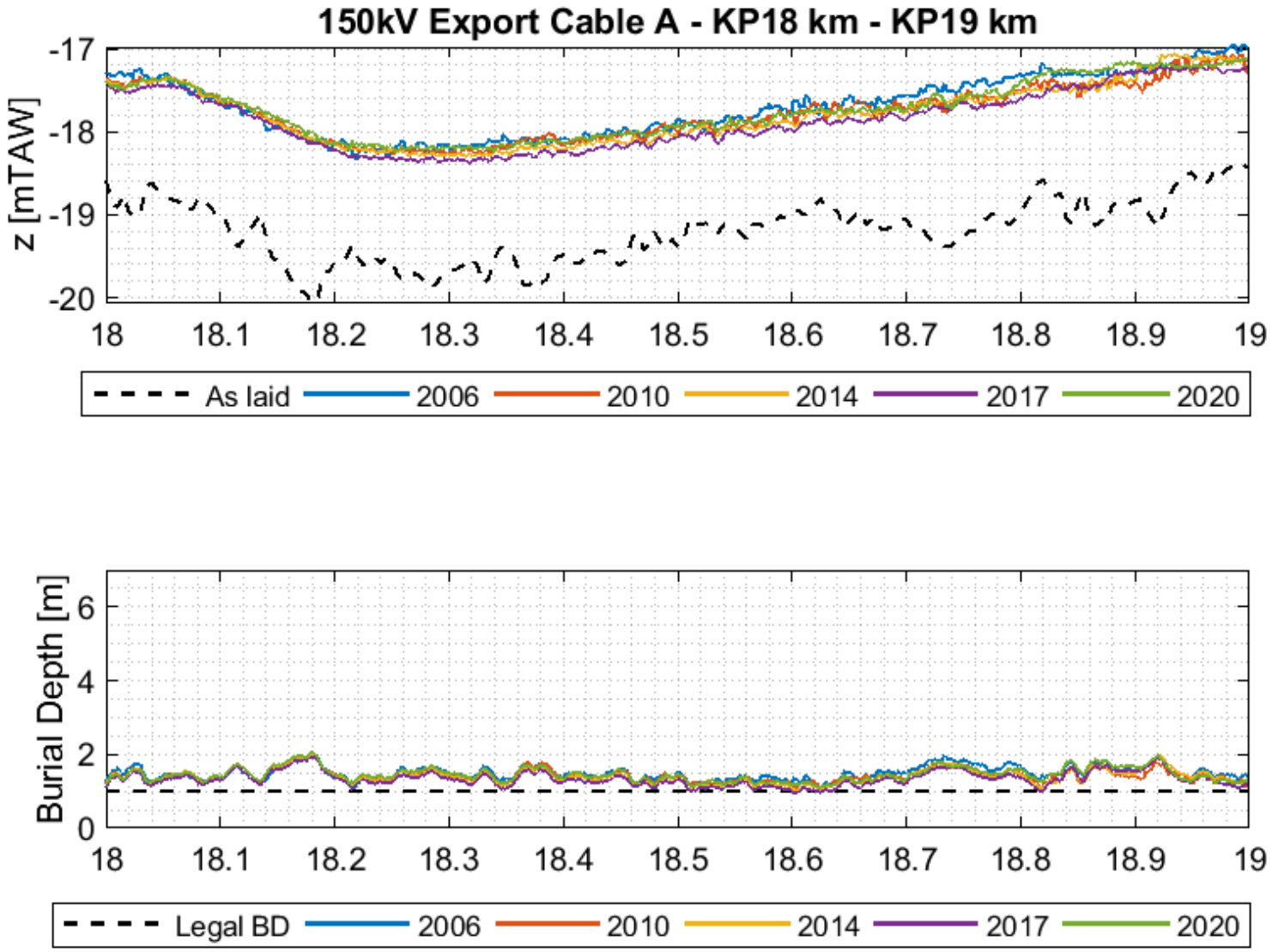


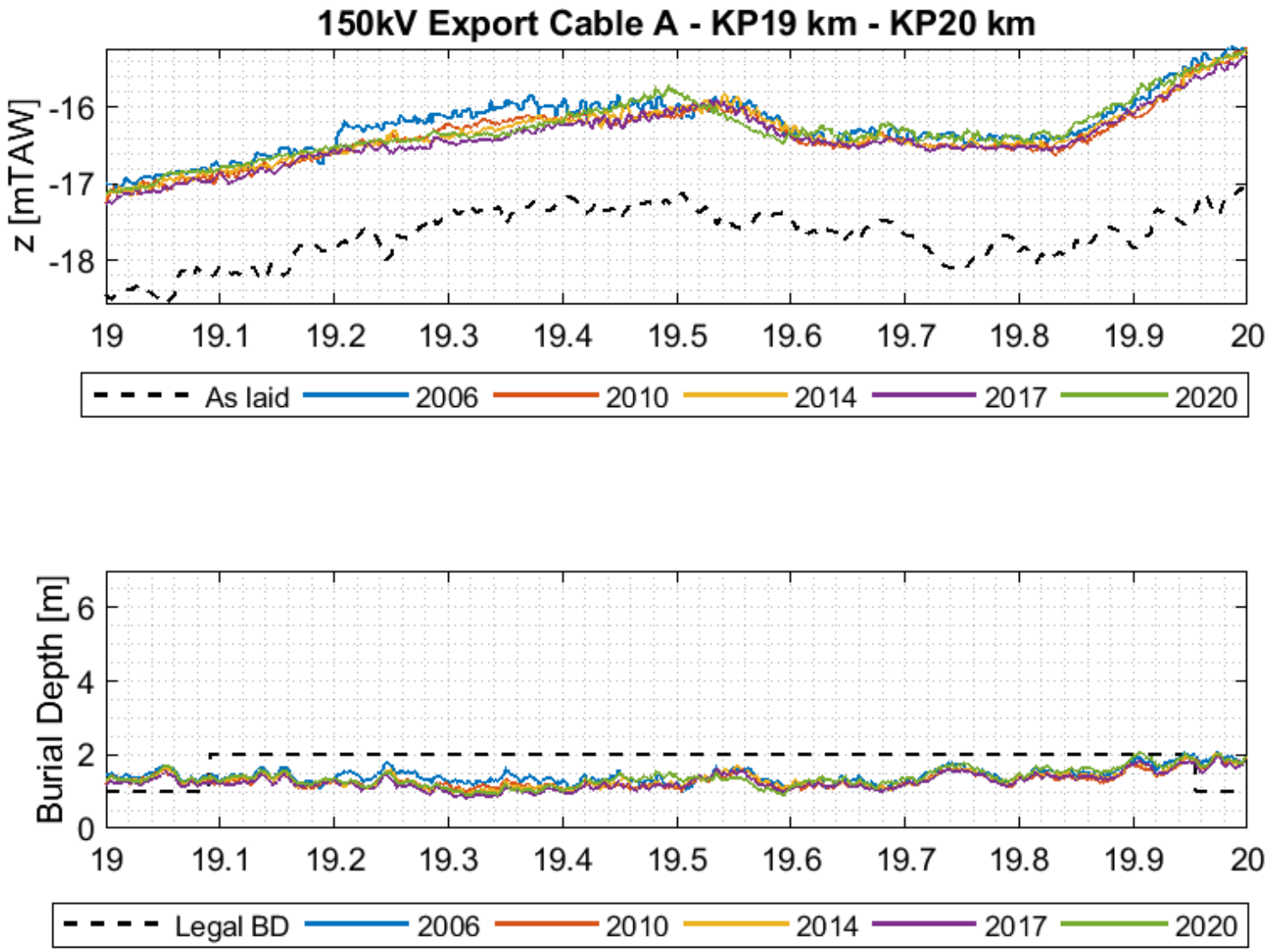


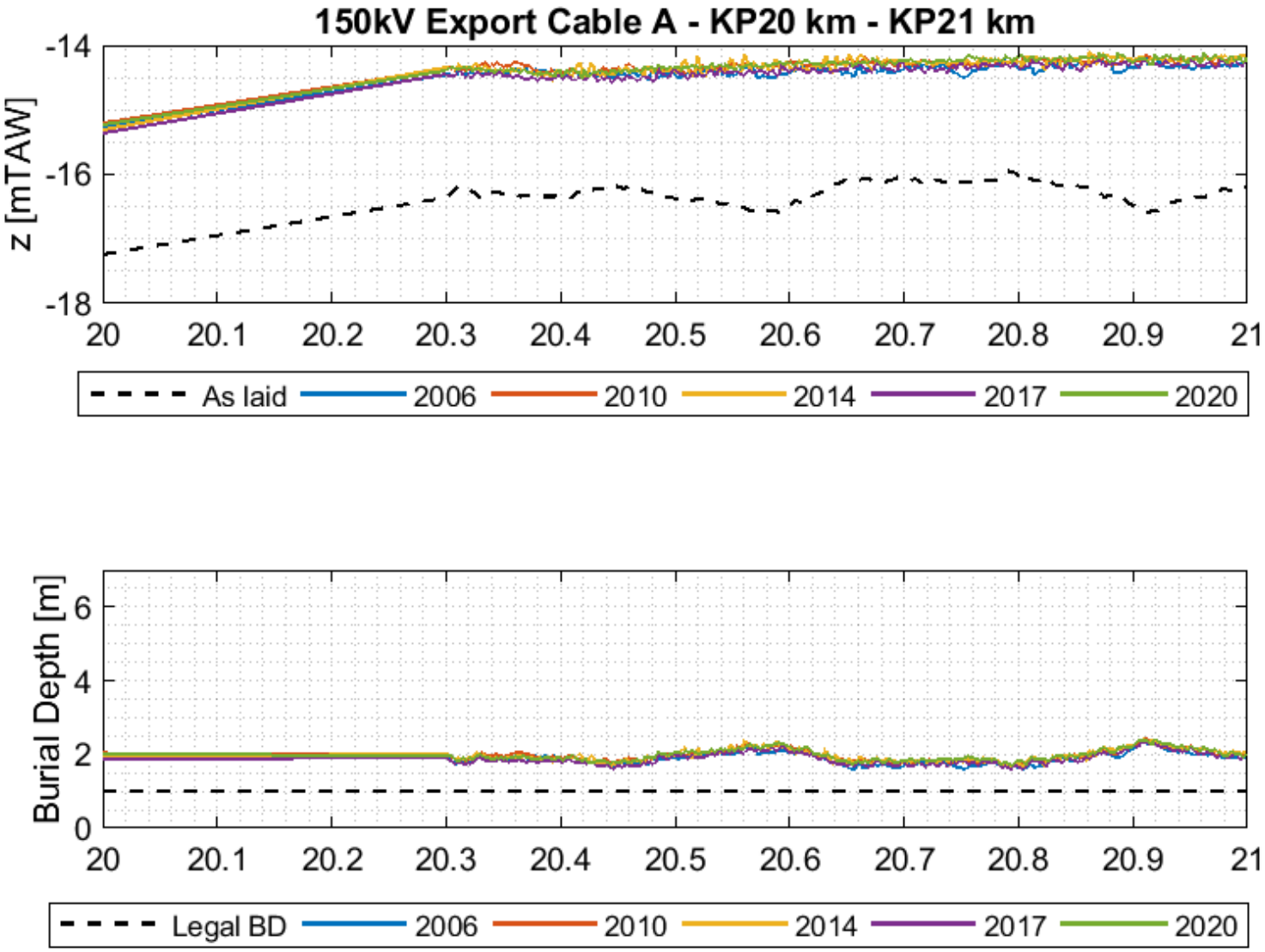


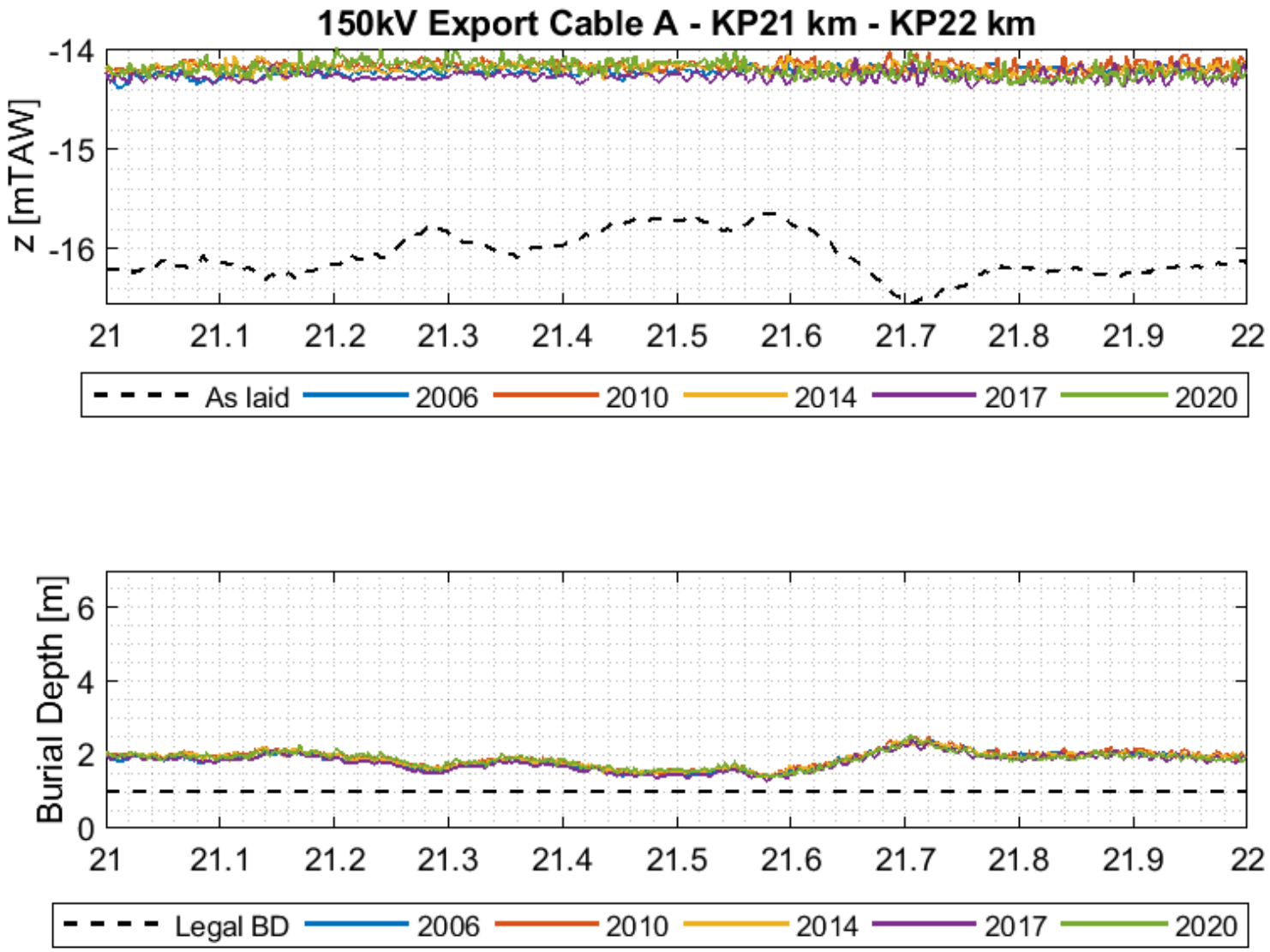


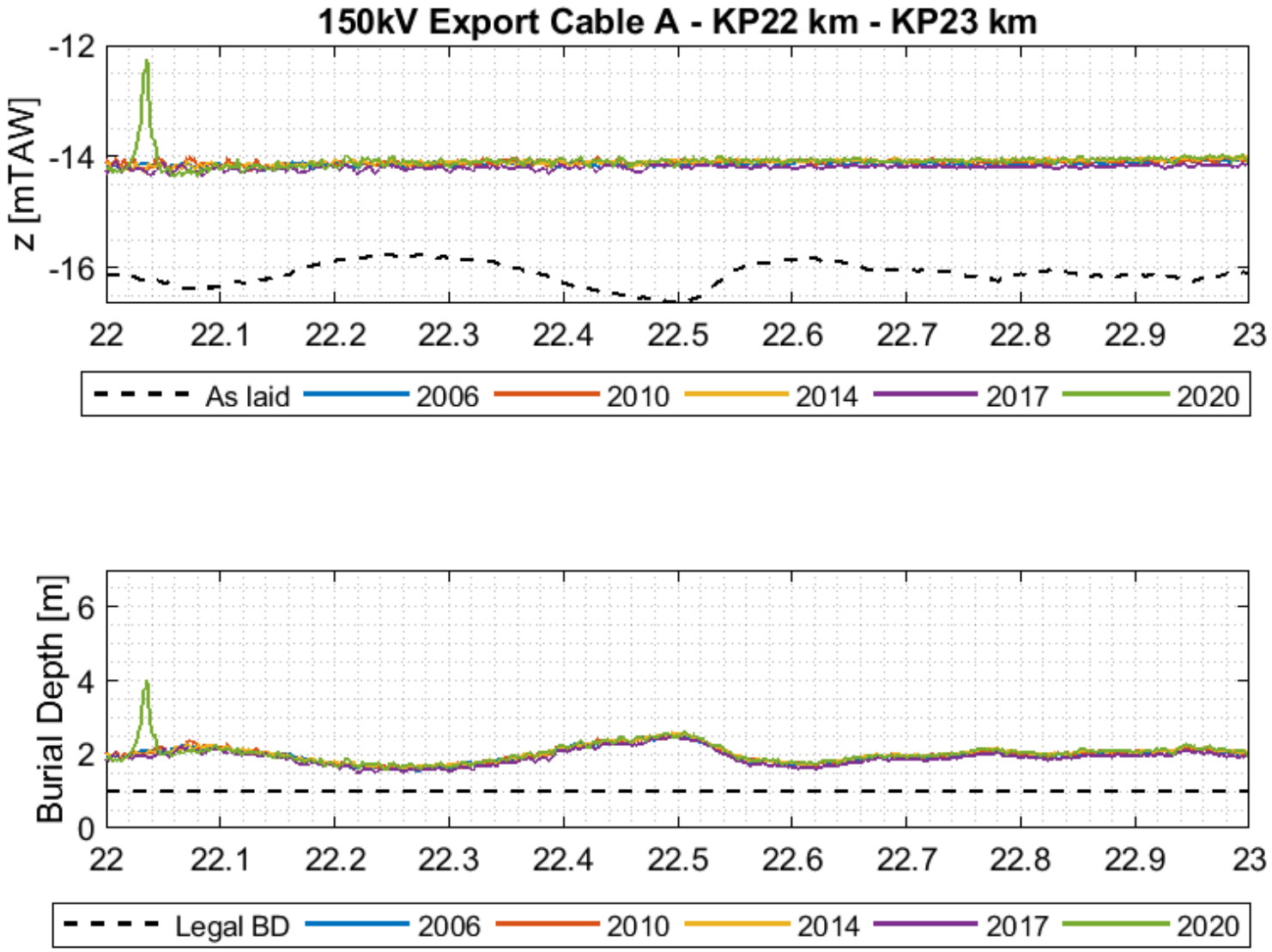


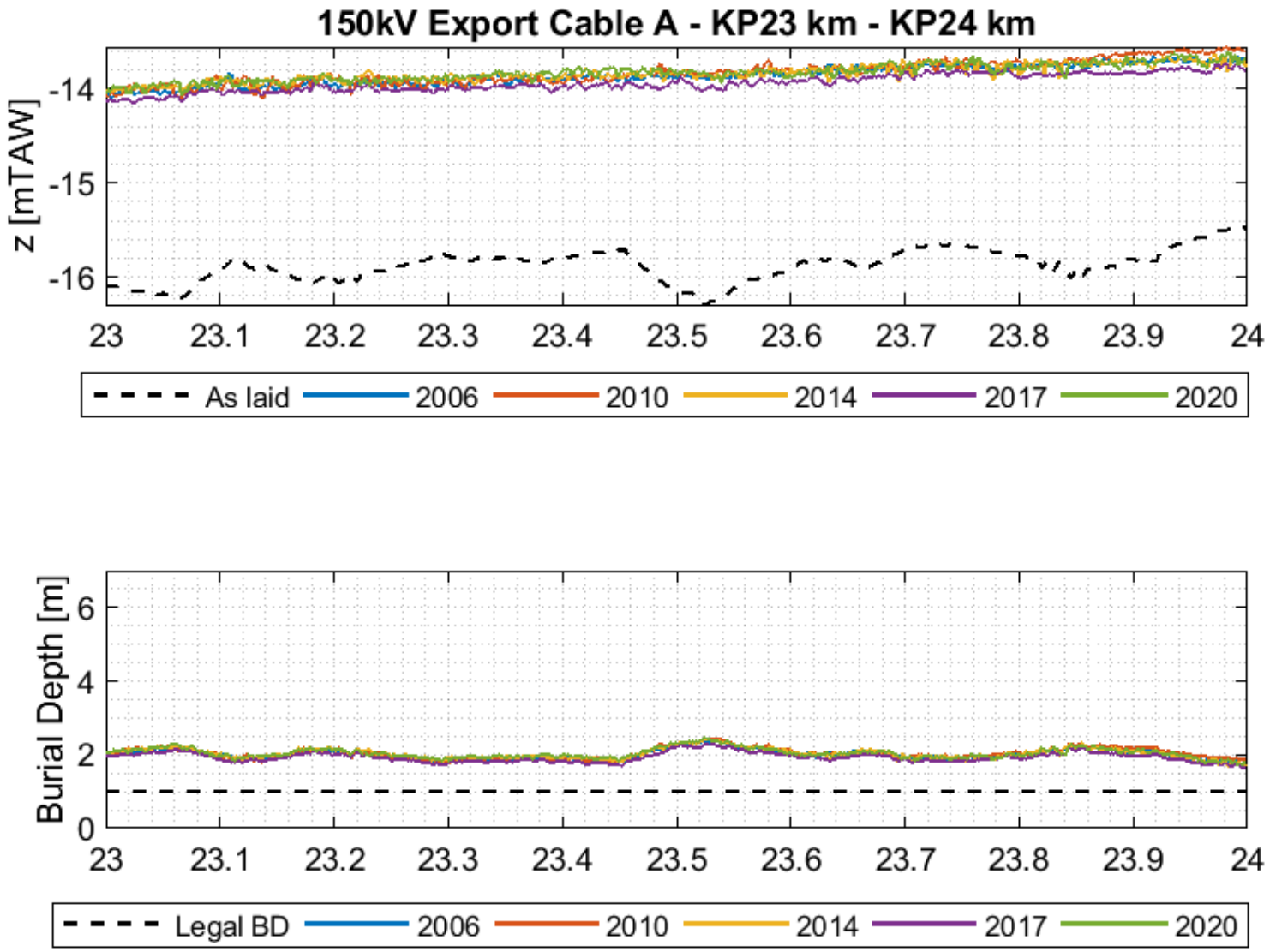


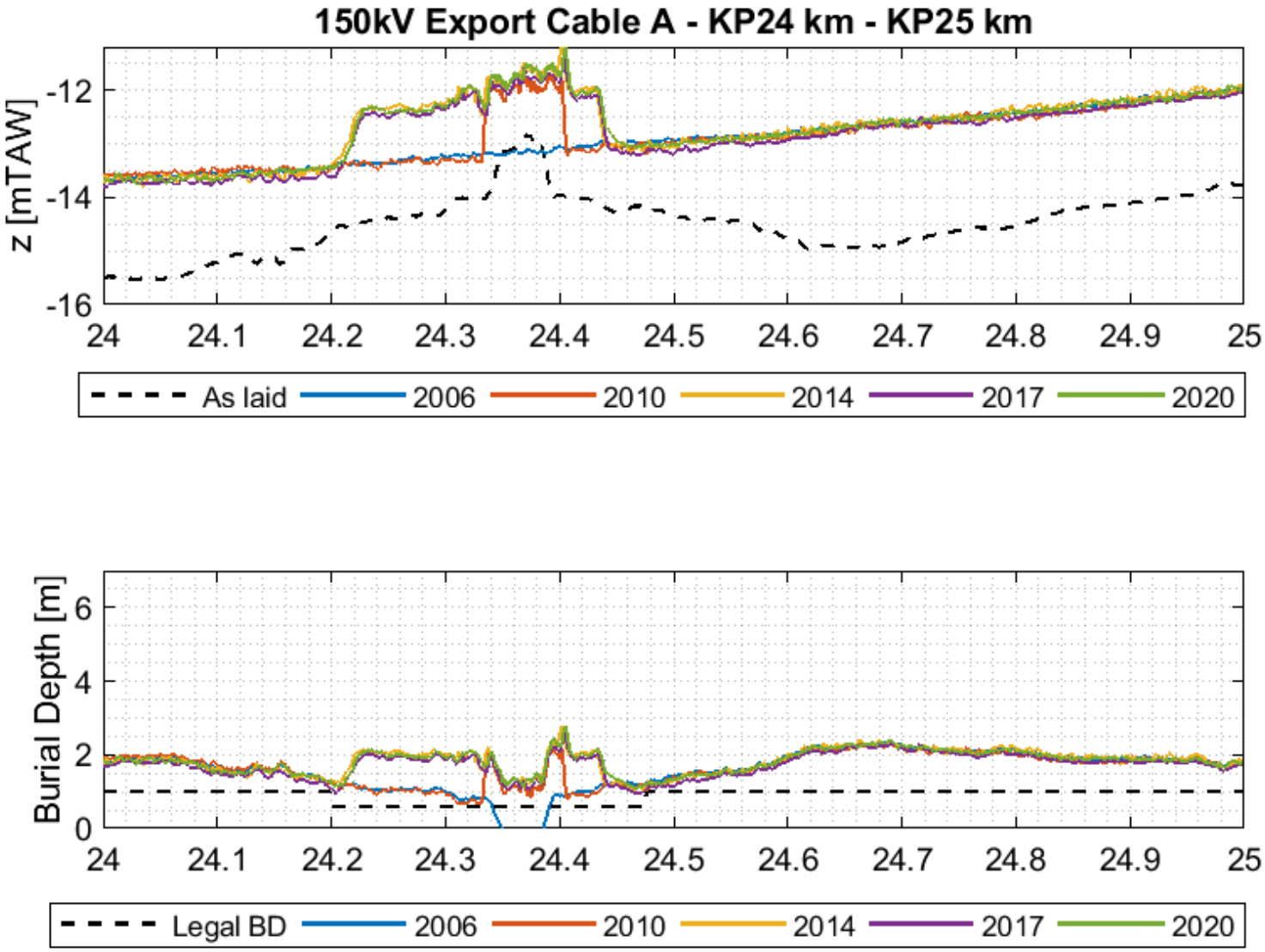


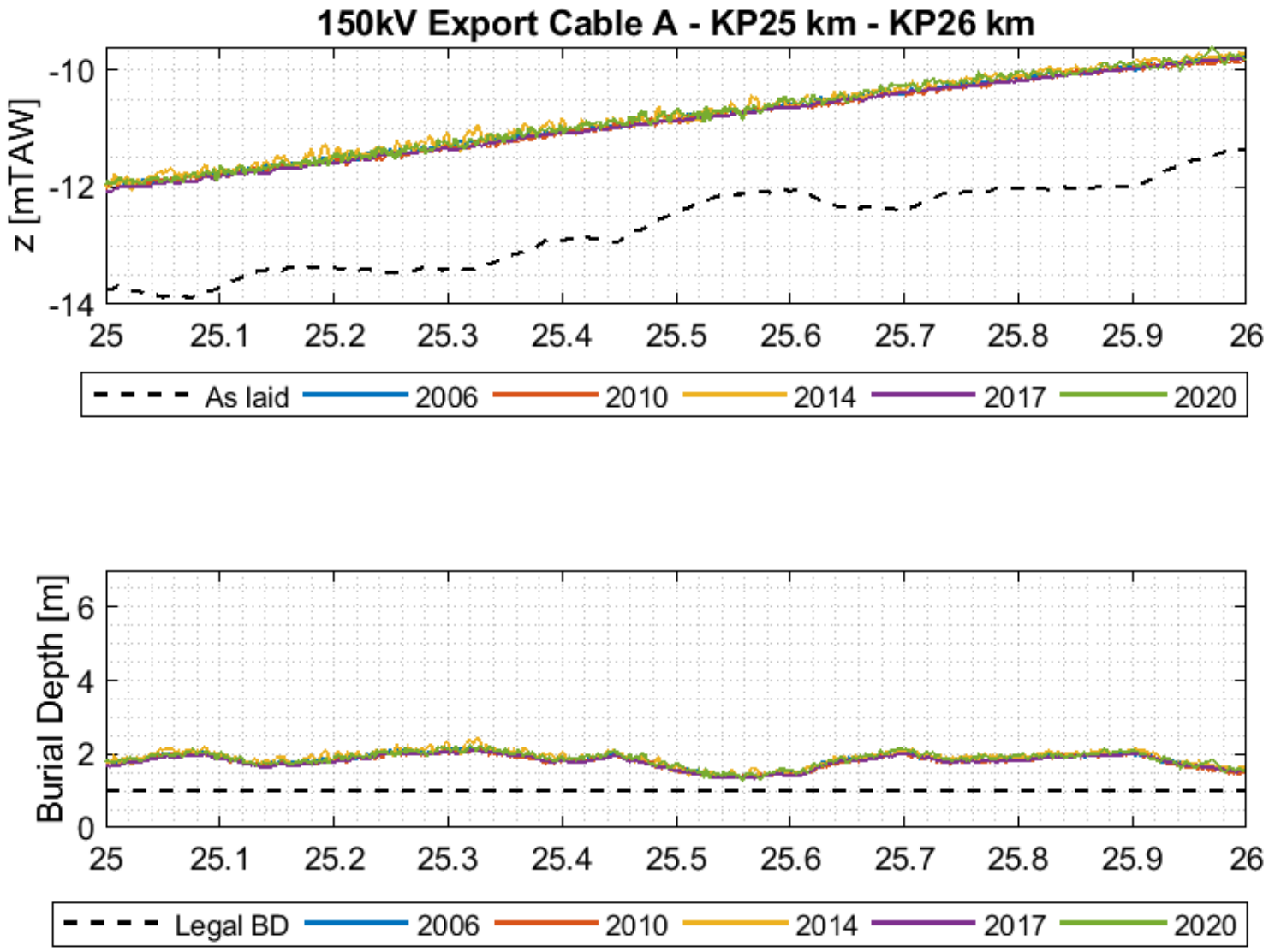


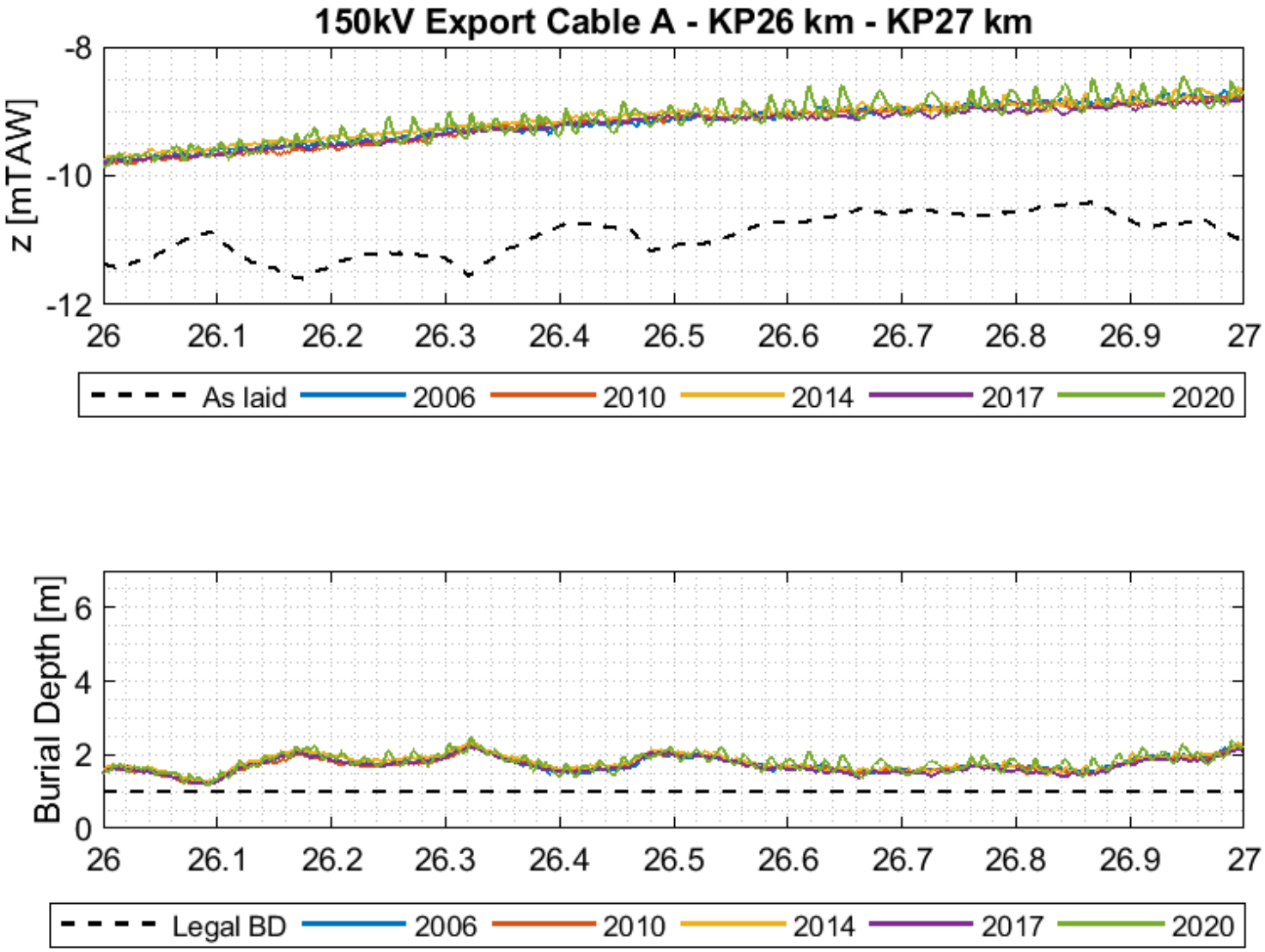


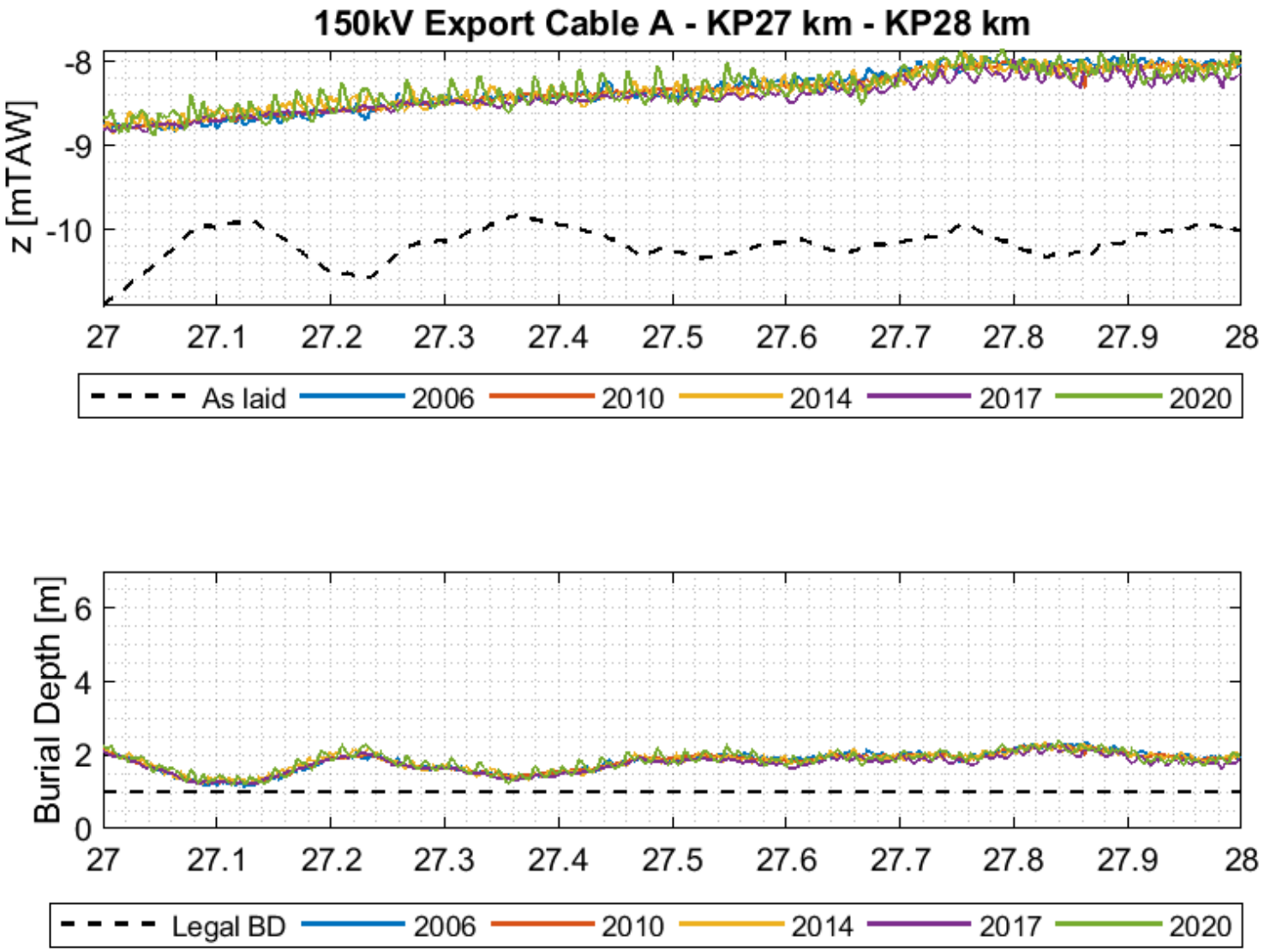


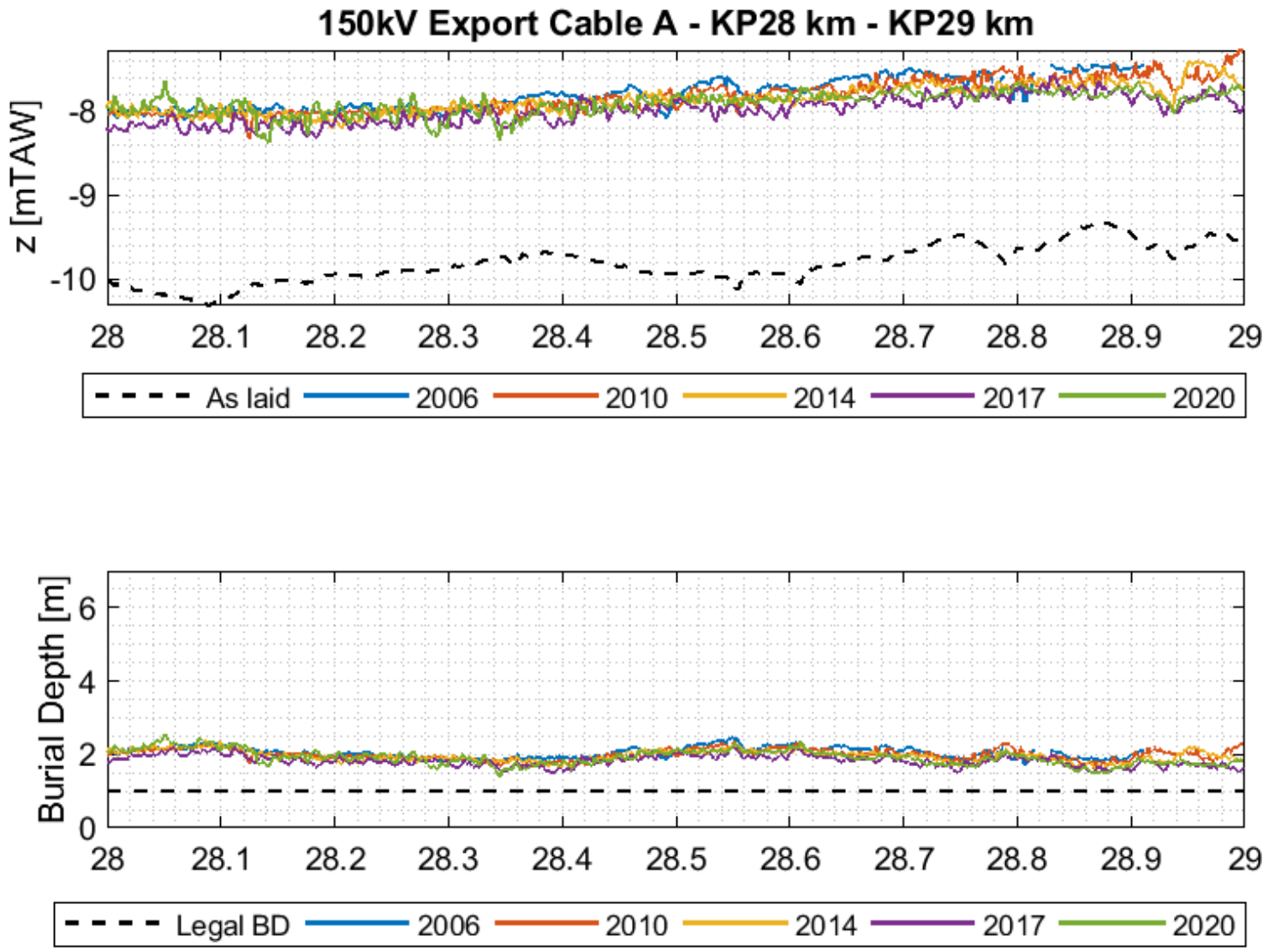


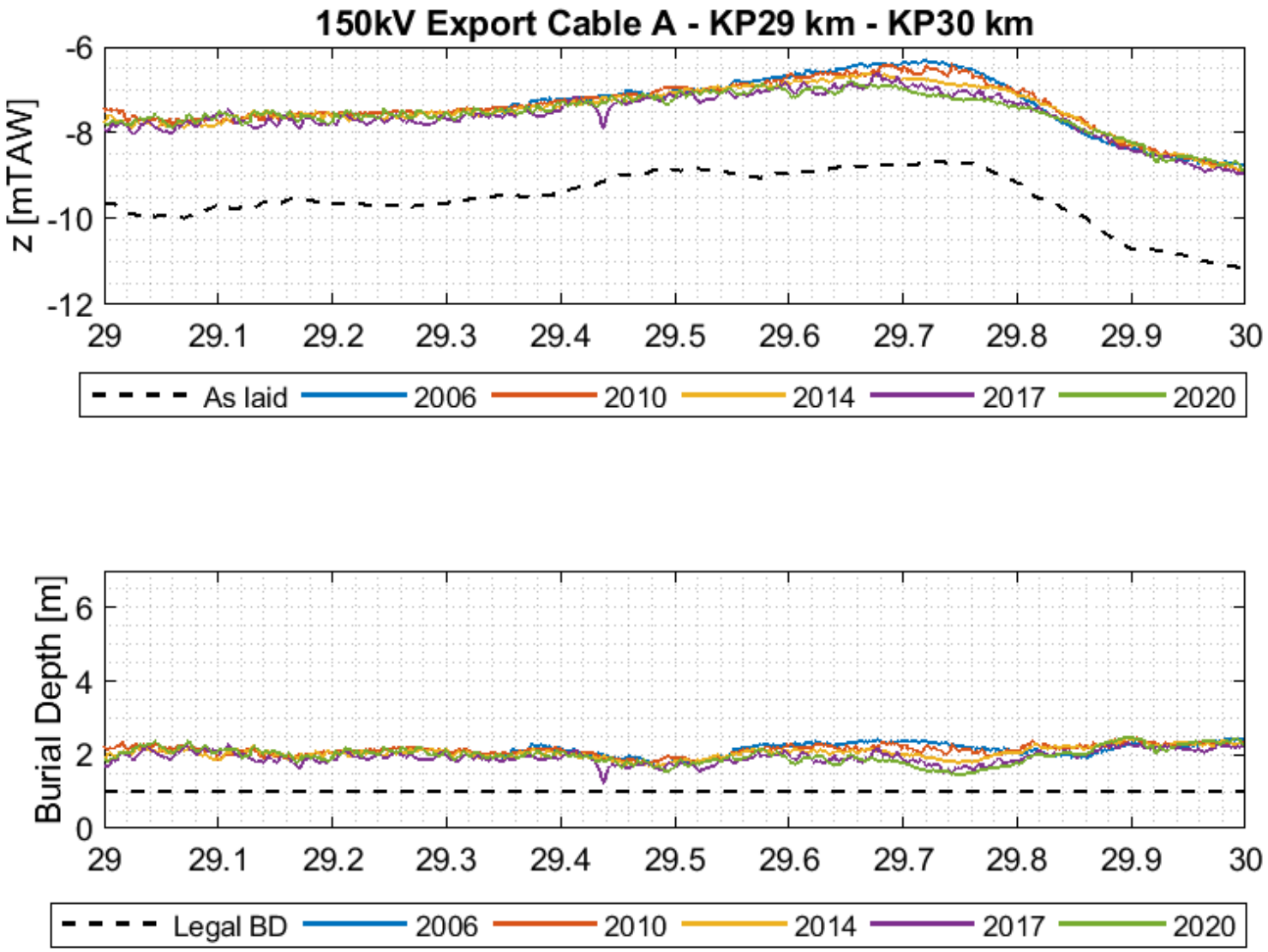


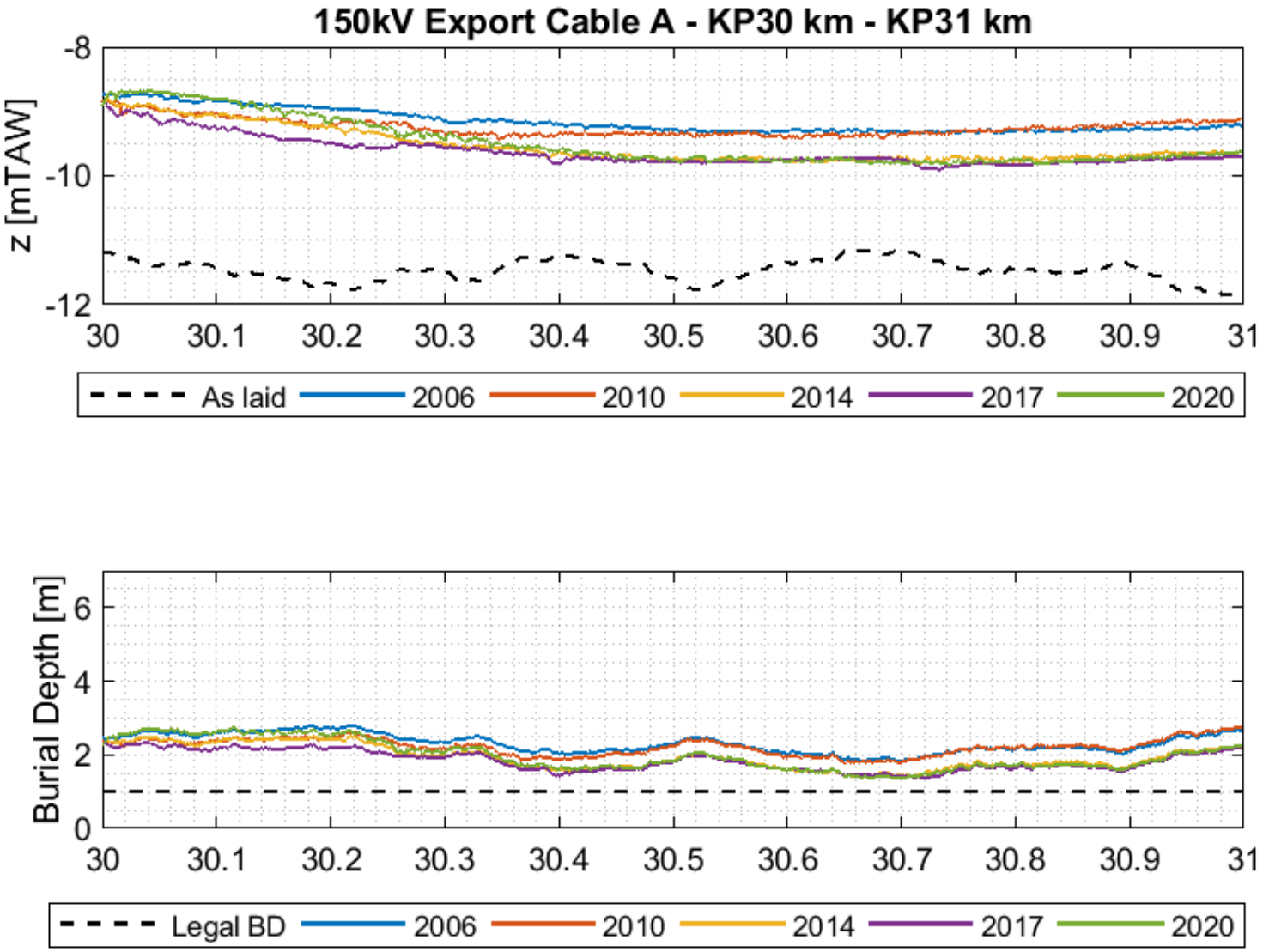


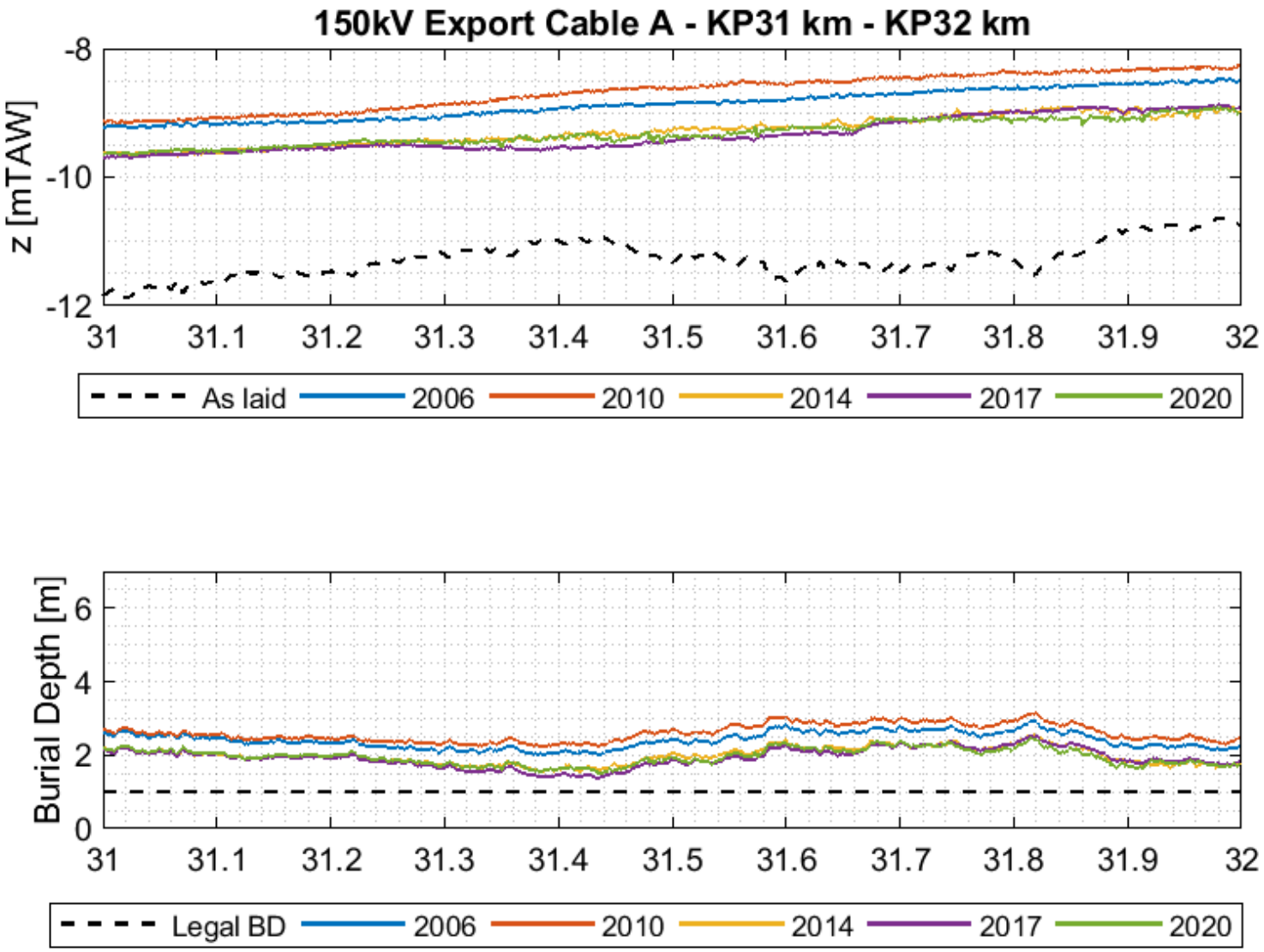


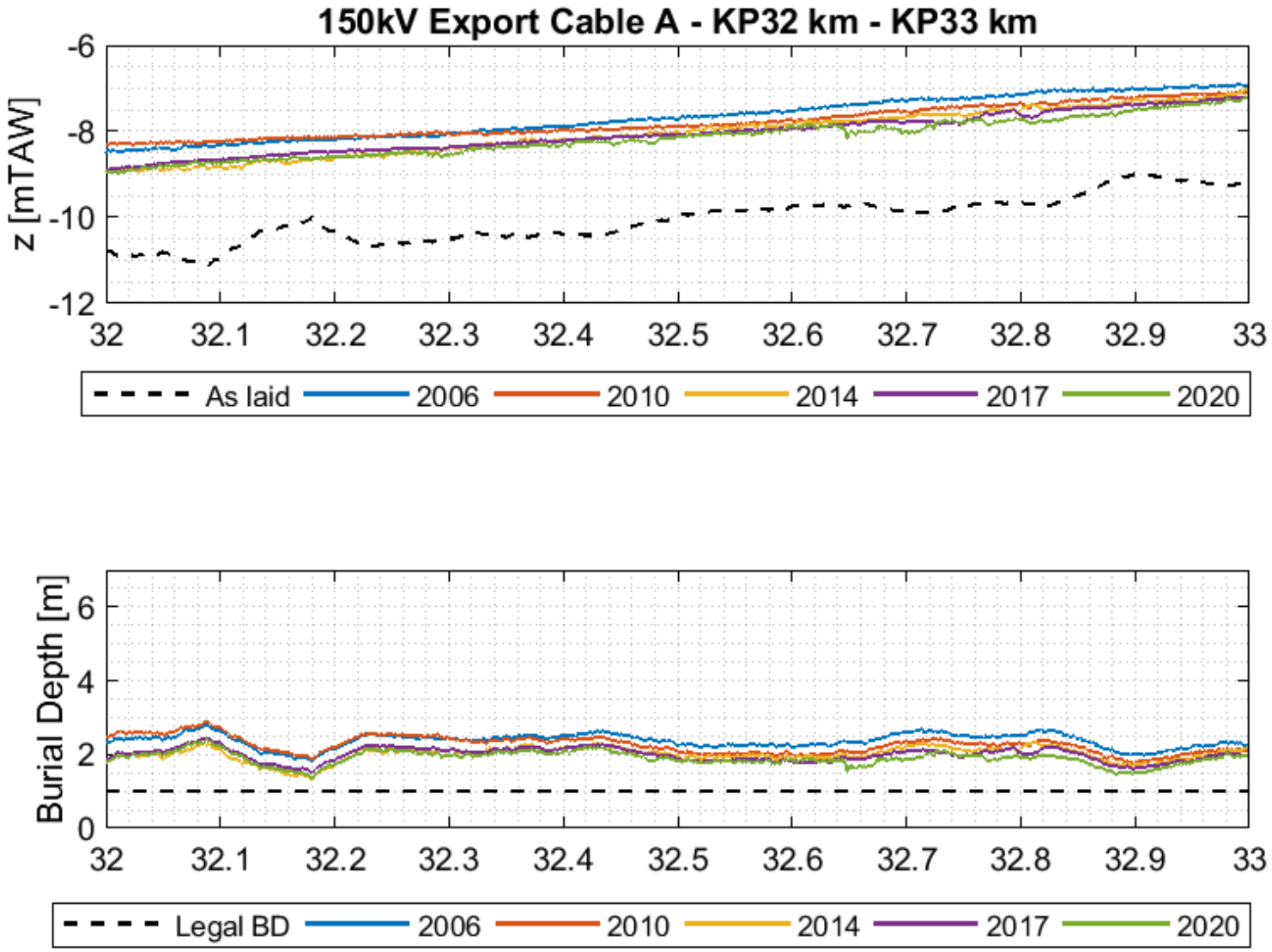


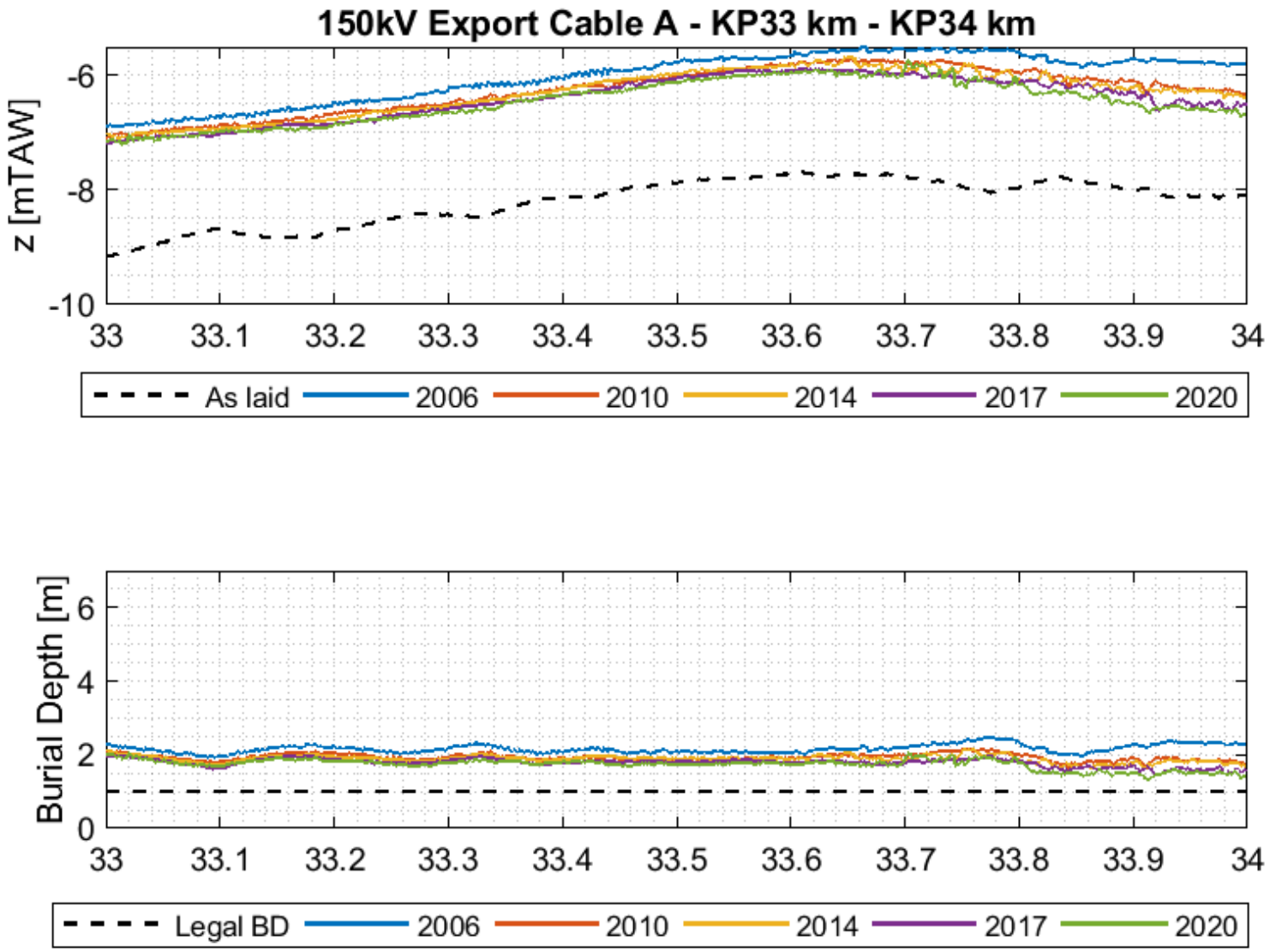


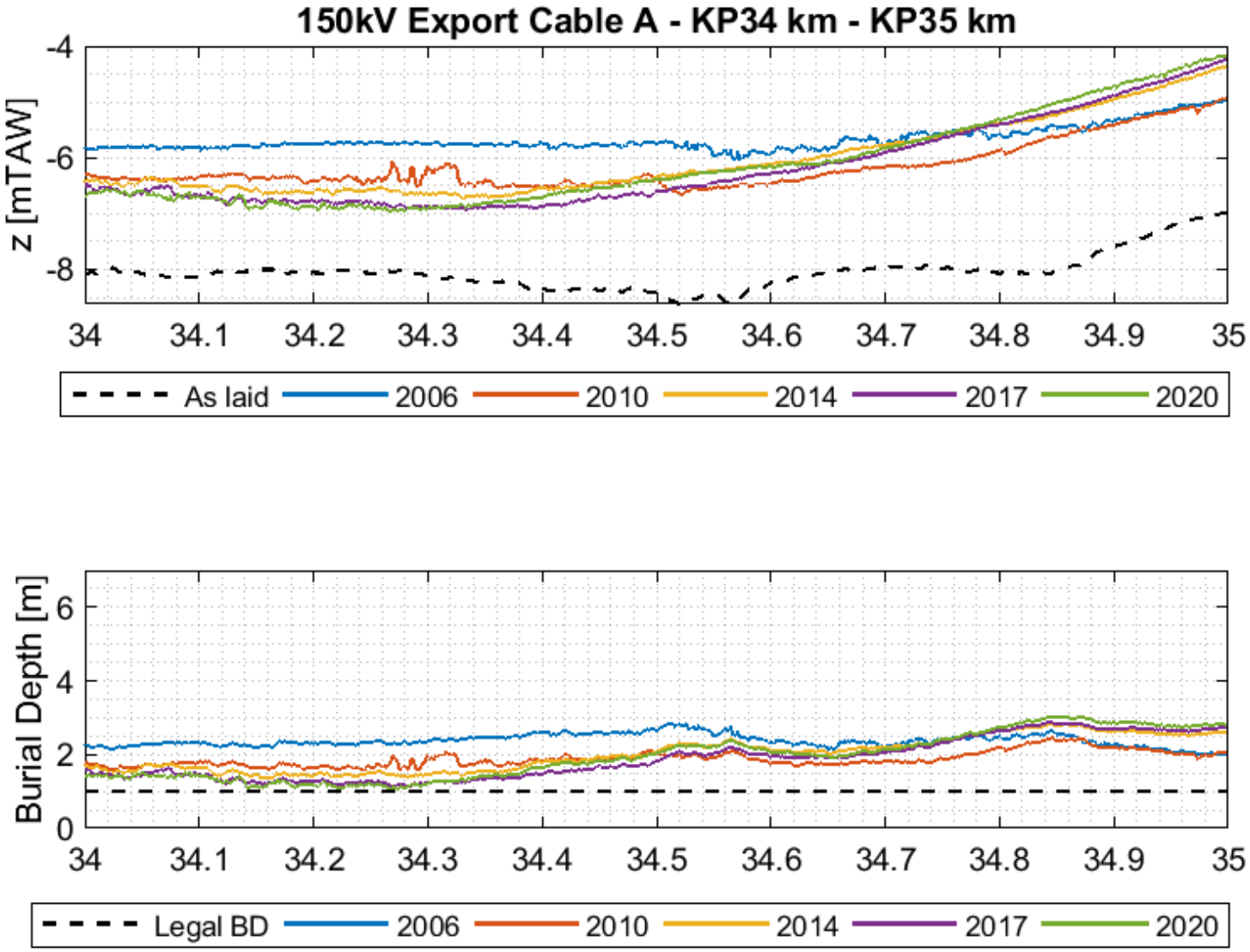


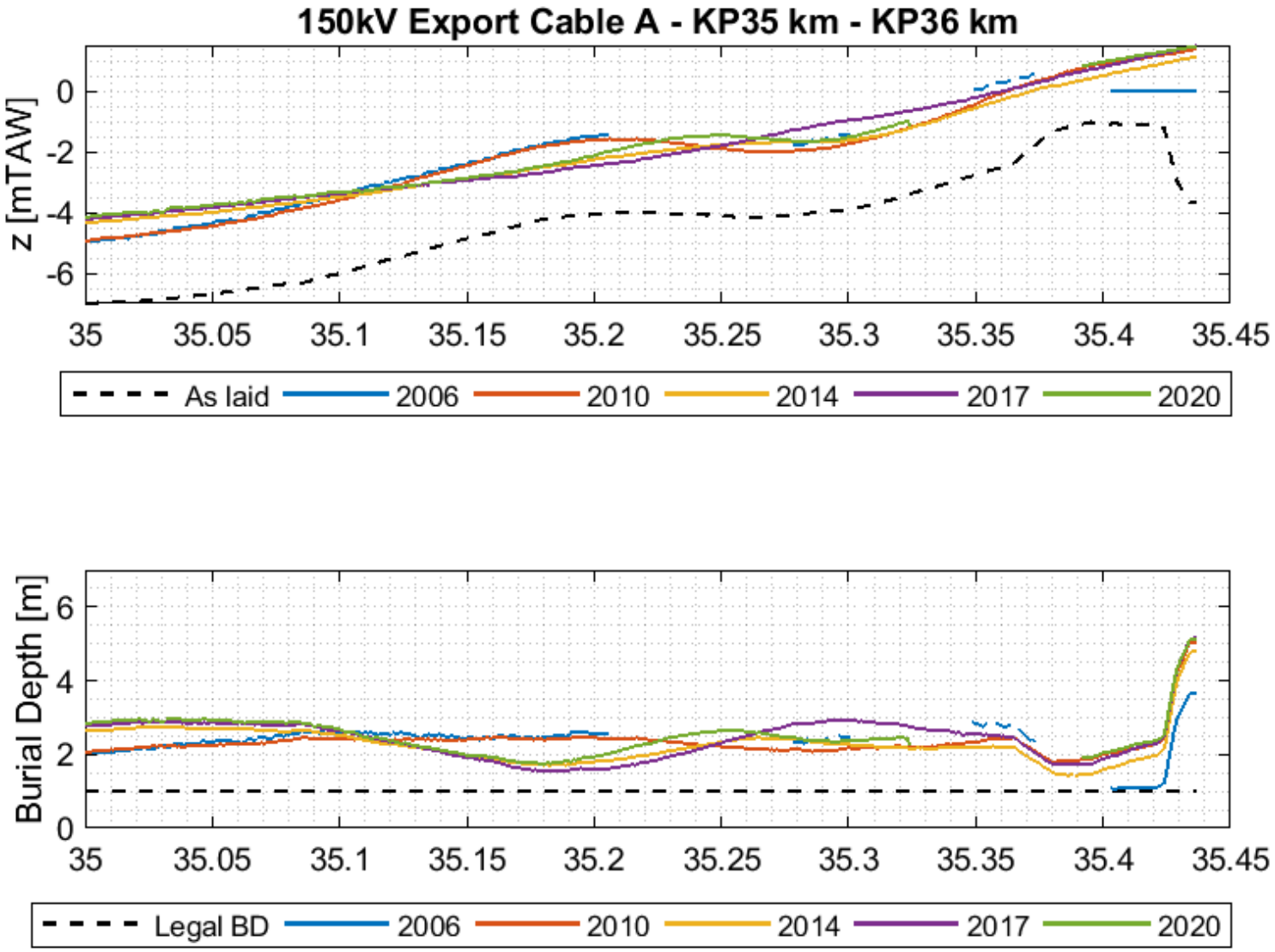


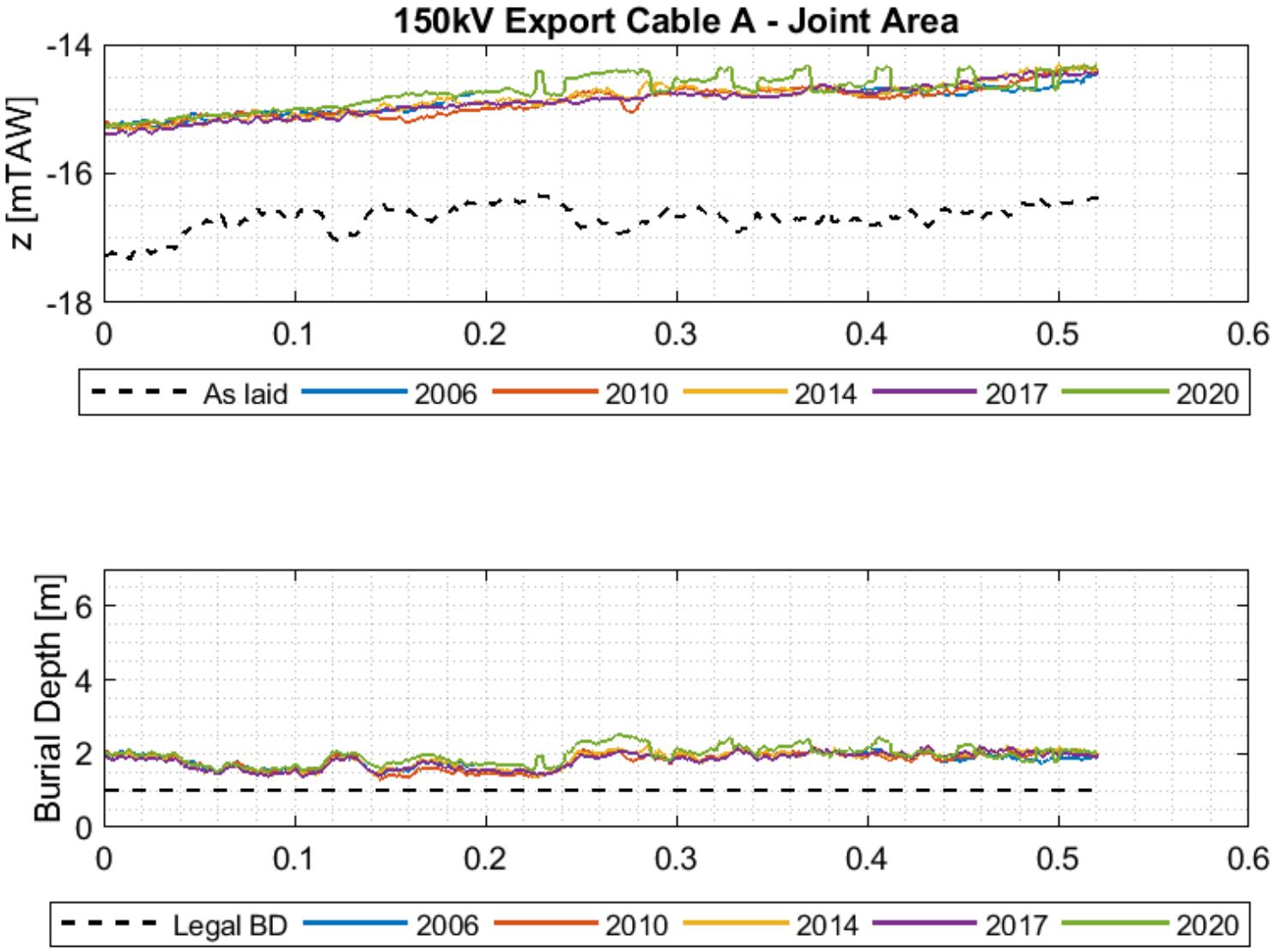












Annex J Evolution seabed and Depth of Cover Export Cable B