Chapter 11: Water Quality (Marine Environment)

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11.1 Introduction

This chapter provides an assessment of marine water quality and potential water quality effects associated with the installation and operation of the NorthConnect HVDC cable infrastructure. Mitigation measures to minimise effects are identified and potential cumulative impacts are discussed.

It is noted that the operation and decommissioning phases were scoped out of the assessment in agreement with Marine Scotland, as detailed in Chapter 3: Methodology.

11.1.1 Marine Planning Framework

In the National Marine Plan (Scottish Government, 2015a), the Scottish government released general policies in favour of the sustainable development and use of marine resources, these include:

- **GEN 10 Invasive Non-Native Species**: Opportunities to reduce the introduction of invasive non-native species to a minimum or proactively improve the practice of existing activity should be taken when decisions are being made (Scottish Government, 2015a); and
- **Gen 12 Water Quality and Resource:** Developments and activities should not result in a deterioration of the quality of waters to which the Water Framework Directive, Marine Strategy Framework Directive or other related Directives apply (Scottish Government, 2015a).

The National Marine Plan also provides a series of good environmental status descriptors, which reflect the ecosystem services approach in the adoption of strategic objectives (Scottish Government, 2015a). The descriptors identify vital parts of the ecosystem structure and functions, and set targets to maintain their status. These include:

- **GES 2:** Non-indigenous species introduced by human activity are at levels that do not adversely alter the ecosystem;
- **GES 5:** Human-induced eutrophication is minimised, especially adverse effects thereof, such as losses in biodiversity, ecosystem degradation, harmful algal blooms and oxygen deficiency in bottom waters; and
- **GES 8:** Concentrations of contaminants are at a levels not giving rise to pollution effects (Scottish Government, 2015a).

11.1.2 Legislative Framework

11.1.2.1 Water Framework Directive

The Water Framework Directive's (2000/60/EC) (WFD) primary purpose is to create a framework to protect groundwater, coastal waters, transitional and inland surface waters (European Parliament *et al.*, 2000). The framework details multiple aims which include:

- Prevention and protection of aquatic environments and enhancement of their ecosystem status in regard to the water needs of wetland and terrestrial ecosystems which rely upon aquatic environments;
- Enhancement of aquatic environments through the introduction of measures to reduce discharges, emissions and losses of hazardous substances; and
- Continues progressive reduction of groundwater pollution and further prevention of its pollution.

Under the Water Framework directive, member states are to achieve "*good ecological status*" of their coastal, transitional and inland waters. Protection and restoration of member states ground waters to maintain the dependent surface water and terrestrial ecosystems are also required. In Scotland, the Water Environment and Water Services (Scotland) Act 2003 transposed the Directive into Scottish Law (Scottish Parliament, 2003).

The directive also requires that classified waterbodies are given legal protection. In Scotland this was incorporated into law under the Environmental Liability (Scotland) Regulations 2009, making it an offence to adversely affect a classified waterbody so that its status or potential under the WFD are deteriorated (Scottish Parliament, 2009).

11.1.2.2 Bathing Water Directive (2006/7/EC)

The Bathing Water Directive 76/160/EC came into force in 1975 and is a further piece of European legislation that should be considered. The main objective of the directive is to protect public health and that of the aquatic environment including coastal and inland areas, which include rivers and lakes, from pollution. It placed a mandatory duty upon member states to conduct regular monitoring of designated bathing sites which must comply with specific standards set out within the directive. In 2006 the directive was revised (2006/7/EC), introducing higher standards but simplifying classifications of designated bathing sites by only considering two measurements (19 laboratory tests previously), intestinal enterococci and *Escherichia coli* (Mansilha *et al.*, 2009). New compliance categories which included excellent, good, sufficient and poor were also introduced while placing a duty upon the member state to ensure all bathing waters meet the criteria to be categorised as sufficient, in addition to taking action to increase numbers of designated sites to categories of excellent and good. In Scotland the revised directive was transposed into law through the Bathing Waters (Sampling & Analysis) (Natrual Scotland) Direction 2008 and the Bathing Waters (Natrual Scotland) Regulations 2008 (The Scottish Goverment, 2010).

11.1.2.3 The Water Environment (Shellfish Water Protected Areas: Environmental Objectives etc.) (Scotland) Regulations 2013

The Water Environment (Shellfish Water Protected Areas: Designation) (Scotland) Order 2013 (Scottish Parliament, 2013a) identifies waters as 'shellfish water protected areas'. In 2016, 84 waters were identified under the order (Marine Scotland, 2016). Under the Shellfish Regulations, specific environmental objectives are placed upon the identified designated sites (Scottish Parliament, 2013b) with regular monitoring of the water quality conducted by SEPA (Marine Scotland, 2016).

11.2 Guidance

The following sources of information were utilised:

- GPP 5: Works and maintenance in or near water (NIEA SEPA *et al.*, 2017);
- River Basin Management Plan 2015 (Natrual Scotland, 2015);
- Horizontal Directional Drilling (HDD) Feasibility Report (Riggal, 2017);
- Protocol for the Derivation of Canadian Sediment Quality Guidelines for the Protection of Aquatic Life (CCME, 2001);
- Guidance on Marine Non-Native Species (GreenBlue, 2013);
- Marine Biosecurity Planning: Guidance for Producing Site and Operation-Based Plans for Preventing the Introduction of Non-native Species (Natural Resources Wales *et al.*, 2015);
- The Alien Invasive Species and the Oil and Gas Industry Guidance (IPIECA *et al.*, 2010);
- Marine Biosecurity Planning – Identification of Best Practice (Cook *et al.*, 2014); and

- Guidelines for the Assessment of Indirect and Cumulative Impacts as well as Impact Interactions (European Commission, 1999).

11.3 Assessment Methodology

11.3.1 Baseline Data Collection

Baseline conditions were established by undertaking a marine survey of the proposed consenting corridor within Scottish Territorial Waters (STW) (mean high-water mark to 12NM) and the UK exclusive economic zone (UKEEZ) (12-200NM). The survey continued into the Norwegian EEZ, however, these results are not discussed in this environmental impact assessment report (EIAR). Surveying involved sediment sampling (5 in STW and 12 in UKEEZ), however, water quality sampling was not undertaken within the consenting corridor. Additionally, a literature review of reports, research articles and other subsea cable projects was undertaken to establish the baseline conditions, which will be used to inform the assessment of the potential effects on marine water quality.

The North Sea has been extensively researched by projects such as the Land-Ocean Interaction Study (LOIS) to gain data on a large scale. Covering river catchments, estuaries, coastal seas and their long-term evolution, air-sea interaction, and self-edge interaction with the open ocean. However, the number of abiotic, biotic, and anthropogenic influences upon the North Sea water quality results in data gaps and uncertainties (Cardenas *et al.*, 2016; Thurstan *et al.*, 2015). Where uncertainties in baseline conditions exist, these are acknowledged in the EIAR with an indication of the magnitude of the uncertainty.

11.3.2 Impact Assessment Methodology

Potential impacts upon the water quality resulting from the installation, operation and decommissioning of the NorthConnect subsea cable have been assessed utilising the methodology outlined below.

11.3.2.1 Magnitude of Impact

The magnitude of impact takes into account change to the baseline conditions resulting from a given effect. It considers the level of change of the baseline conditions, value of the hydrological feature and duration of the effect upon the receptor prior to recovery. Definitions for a range of hydrological elements are set out in Table 11.1.

Table 11.1 Definitions of magnitude of impact.

Magnitude of Impacted of Impact	Examples of Impact/Effect Magnitude
High	Material reduction in water quality. Characteristics may include: • Significant diffuse pollution. • Ecological impact e.g. fish deaths. • Medium to long-term impacts.
Medium	Reduction in water quality. Characteristics may include: • Minor diffuse pollution. • Measurable changes in water quality. • Minor harm to the ecosystem. • Reversible with no long-term impacts.
Low	Small changes to the water quality. Characteristics may include: • Localised pollution incident with reversible effects. • Potential visible signs of pollution. • No medium-term impacts. • No impacts on the ecosystem.

11.3.2.2 Likelihood of Impact Occurring

The likelihood of an impact occurring is also assessed. A qualitative approach is taken to predict the likelihood of an impact based on the probability of an impact occurring and professional judgement rather than data frequency. In this chapter, the likelihood categories are displayed in Table 11.2 with their definition. The likelihood of any effect occurring is described in the impact characterisation text.

Table 11.2 Likelihood Categories and their Definitions.

Likelihood	Definition
Certain/near-Certain	> 1 in 1 year
Probable	< 1 in 1 year but > 1 in 10 years
Unlikely	< 1 in 10 years but > 1 in 100 years
Extremely Unlikely	< 1 in 100 years

11.3.2.3 Significance of Effect

The significant of effect is derived by considering the magnitude of impact and probability of the impact occurring. Determination of whether the identified effect was categorised as significant or non-significant utilised the matrix set out in Table 11.3.

Table 11.3 Significance of Effects Matrix.

Magnitude of Impact	Probability			
	Certain	**Probable**	**Unlikely**	**Extremely Unlikely**
High	Major	Moderate	Moderate	Minor
Medium	Moderate	Moderate	Minor	Negligible
Low	Minor	Minor	Negligible	Negligible

Key

(orange)	**Significant Effect**
(light blue)	**Non-Significant Effect**

11.3.3 Identification and Assessment of Mitigation

Mitigation measures have been identified in line with best practice to prevent, minimise and mitigate impacts.

11.3.4 Assessment of Residual Effects

Where mitigation has been identified, the magnitude and likelihood of the impact will be reassessed as per Table 11.1 and11.2 and the overall significance of effect reassessed in line with Table 11.3 to understand the resultant residual effect.

11.4 Baseline Information

11.4.1 Sediment Loading

Occurrence of sediment loading within the water column of aquatic bodies is a natural phenomenon due to the natural abundance of particle matter within water bodies, like sands and minerals, with the levels of remobilised sediment fluctuating. Multiple combining factors result in naturally occurring increases of sediment loading, such as storms, which increase in frequency in winter months in the North Sea, resulting in remobilised sediment from the seabed entering the water column (Gohin *et al.*, 2015; Schulz *et al.*, 2015). The fluctuations of sediment loading levels are important to the marine ecosystem, as remobilised sediments influence primary production, heat transfer, sedimentation rates, and act as a natural cleansing cycle of the water column by attaching to some contaminates and dragging these down to the seabed, where they are buried overtime (UKMMAS, 2010b). High levels of remobilised sediments can alter light penetration in the marine water column, impacting ecological process like photosynthesis and, over prolonged periods, can alter energy fluxes throughout the marine food web (Remy *et al.*, 2017).

Data on North Sea sediment loading levels are relatively low and fragmented to localised studies, mostly within the Dutch and German North Sea. The Southern North Sea Sediment Transport Study (Phase 2) covered the eastern coastline of England between Flamborough Head and North Foreland, and ran from 2000 to 2002. It was concluded that the southern North Sea possesses stronger tidal currents and shallower waters which result in greater resuspension of sediment, hence, the northern North Sea generally has a lower rate of sediment loading (Wallingford *et al.*, 2002). The study also identified that concentrations of suspended particles or suspended particular matter (SPM) in the southern North Sea in offshore areas lies around 4 mg/l, with estuaries generally having much higher concentrations, over 300 mg/l (UKMMAS, 2010b). However, research by Capuzzo *et al* (2015) identified that an increase in sediment loading levels in the southern and central North Sea since the 20th century has occurred, with multiple combining factors contributing to the increase (Cappuzzo *et al.*, 2015). Values for the northern North Sea were not identified in this literature review. The type of sediment disturbed also influences the degree of increase in sediment loading, its geographical spread and the period of suspension within the water column. Lighter sediment types like silt are more readily remobilised if disturbed and stay suspended over longer periods, allowing greater geographical dispersal. Heavier sediment types like sand require greater kinetic energy to be resuspended and, due to their greater mass, quickly fall back to the seabed, hence, geographic spread is more limited (Jones *et al.*, 2016). The results from the benthic survey Particle Size Distribution (PSD) analysis from the mean high-water mark to the UK EEZ limit will be discussed here, with additional description of sediment types provided in Chapter 7: Seabed Quality. The locations of the PSD samples within the consenting corridor are shown in Figure 11.1 below.

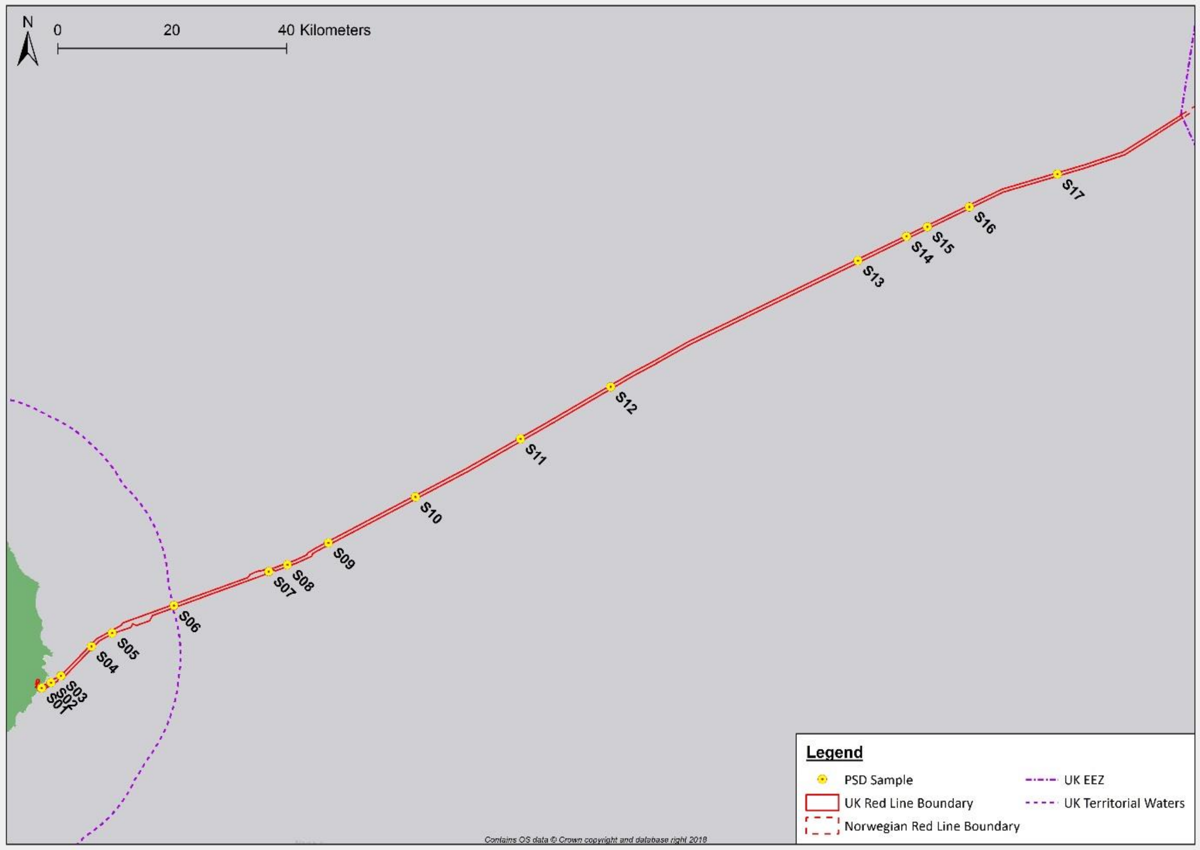

Figure 11.1. Locations of PSD samples within UK Consenting Corridor.

The particle size distribution (PSD) analysis of five samples taken within STW (S1 – S5) (Figure 11.2) along the consenting corridor showed that the PSD was dominated by sand and moderate fractions of gravel and small volumes of silt and cobbles/boulder (MMT, 2018).

Between the Scottish 12NM limit and the limit of the UK EEZ, sites S6 to S10 also contained high proportions of sands and gravels. Towards the east of the UK consenting corridor, the proportion of silts and clays increase, as sands and gravels decrease. Sites S11-S17 contain high proportions of silt, with clays also becoming more prominent, and silt is the dominant particle size in sites S12 to S17 (MMT, 2018).

The PSD samples are only representative of a very small area of the consenting corridor, however, the results of the geophysical and geotechnical surveys were used to classify sediment types throughout the whole consenting corridor, with further detail available in Chapter 7: Seabed Quality. The results from the PSD analysis agree with the interpretation of the geophysical and geotechnical data, which found that sands and gravels were dominant in the western end of the UK consenting corridor, with increasing silt and clay fractions towards the east.

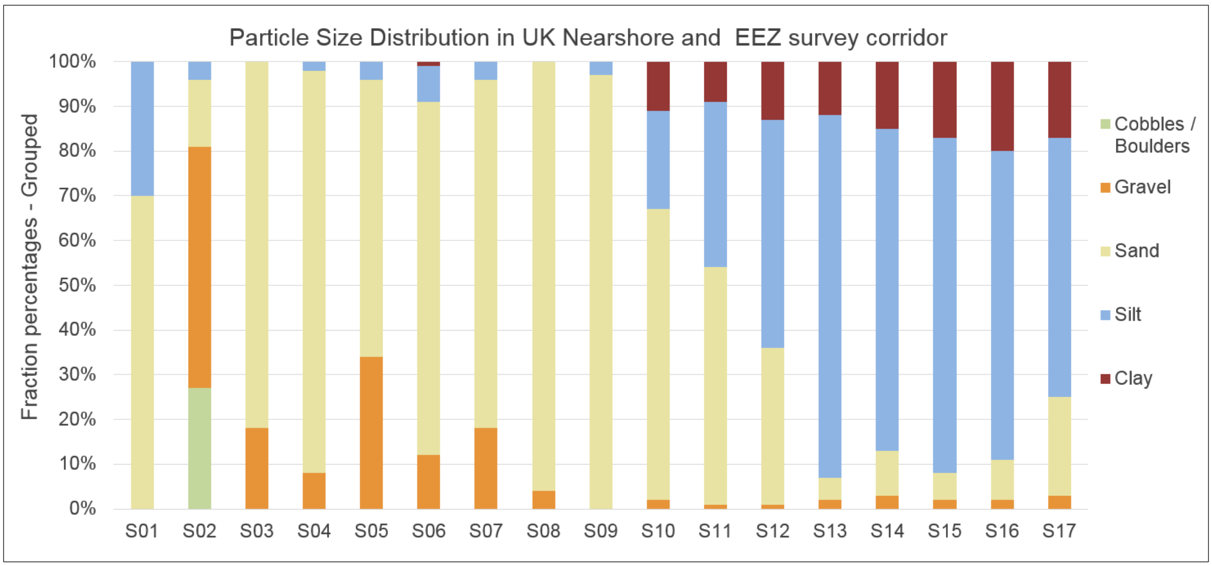

Figure 11.2 Particle Size Distribution from the UK Coast to the UK EEZ limit (MMT, 2018).

11.4.2 Sediment Contaminants

11.4.2.1 Organic

Organic contaminants are carbon-based chemicals such as oils, pesticides, and solvents. In the North Sea, organic contaminants enter through three main sources: terrestrial run off; atmospheric deposition; and offshore oil and gas exploitation facilities. Extensive levels of organic contaminants within the marine water column poses a direct risk to marine species like acute and chronic damage to organic tissue upon exposure. Indirect effects also occur throughout the food web due to bioaccumulation, potentially impacting upon marine ecological processes (Henry *et al.*, 2017). A recent study by Robinson *et al* (2017) identified that concentrations of pollutants across all sampled sites in the North Sea are elevated above normal background levels, with an increasing gradient of contamination conditions across the northern and southern North Sea, coinciding with OSPAR Commissions' findings (OSPAR Commission, 2010).

Chemical analysis of the grab samples examined 18 Polycyclic aromatic hydrocarbons (PAHs) compounds across the survey corridor with results within STW and UKEEZ. Chapter 7: Seabed Quality provides a detailed discussion of the PAH results, with a summary of the findings provided in this chapter.

In order to evaluate the potential environmental effects of the PAH concentrations identified within the consenting corridor, the assessment criteria developed by the United States Environmental Protection Agency (USEPA) and Canadian Council of Ministers of the Environment (CCME), were used as guidelines. Assessment of total petroleum hydrocarbons (TPH) levels used the Dutch National Institute for Public Health and the Environment (RIVM) criteria for aquatic sediments, as no USEPA or CCME contamination threshold values for TPH exist (MMT, 2018).

The USEPA criteria utilised for PAHs, referred to as effect range low (ERL), is defined as a concentration below which adverse effects on organisms are rarely observed. Identified concentrations of PAHs in the samples were also compared against CCME probable effect level (PEL), which is defined as the concentration above which adverse environmental effects frequently occur. Criteria for TPH is the Dutch target value, a level below which there is sustainable sediment quality.

Concentrations of PAHs in the UK consenting corridor are detailed in Chapter 7: Seabed Quality, Table 7.7. Concentrations of PAHs of all extracted sediment samples within the STW and UKEEZ were low, regularly falling below detection levels. No samples exceeded the PAHs ERL criteria and, as such, levels of PAHs are below concentrations where adverse effects on marine organisms are even rarely observed (MMT, 2018).

This concurs with PAH levels identified during the literature review, which indicate that PAH levels in the North Sea are below the environmental effects range (Remy, Hillebrand, & Flöder) and thus unlikely to harm marine species, as assessed by OSPAR Commission. However, mean PAH concentrations within sediment remain elevated above normal background concentrations (OSPAR Commission, 2010; UKMMAS, 2010a).

Total Petroleum Hydrocarbons (TPH) concentrations were also assessed as detailed in Chapter 7: Seabed Quality. The analysis identified that no sample exceeded the Dutch Target Value, hence, levels of TPHs of sediments at the sample sites within the consenting corridor are sustainable and are unlikely to result in adverse environmental effects. Samples S12 and S14 to S17 contained markedly higher TPH concentrations and, at these sample locations, elevated levels of PAHs and metal concentrations were also found (MMT, 2018).

11.4.2.2 Inorganic

Anthropogenic discharges rich in inorganic contaminants to rivers that flowed into the North Sea, and direct discharges to the marine environment, increased within a few decades almost exponentially during the industrial revolution (Ansari *et al.*, 2004). As a result, coastal industrialized areas regularly contain elevated levels of heavy metals within aquatic sediments. Natural and agricultural processes also contribute to inorganic compounds entering the marine environment (Alsenoy *et al.*, 1993). Inorganic contamination can also be found in the open North Sea from offshore industrial processes including gas and oil extraction (Ansari, Marr, & Tariq, 2004).

While discharges in of inorganic contaminants have been decreasing through advances in technology and enforcement of legislative frameworks, the lack of carbon within inorganic compounds prevents breakdown overtime and the contaminants simply become trapped in deeper levels of sediment until they are physically disturbed. When such sediments are disturbed, the inorganic contaminants trapped within them can be re-released, potentially resulting in adverse environmental effects. The ability of some inorganic substances (such as mercury) to bioaccumulate, also allows migration through the food-chain, with potential to affect ecological processes.

Chemical analysis results of grab samples from the survey corridor were compared against the Threshold Effect Level (TEL) and PEL criteria developed by the CCME. TEL is defined as a concentration above which adverse effects may occasionally occur. Concentrations of metals from samples throughout the consenting corridor were generally low, as detailed in Chapter 7: Seabed Quality. In the STW, three sample locations contained arsenic and/or nickel exceeding TEL levels (S03-S05). Between the 12NM limit and the limit of the UKEEZ, seven sample locations (S06, S08, and S13-17) contained concentrations of Arsenic, copper, nickel, or zinc which exceeded the TEL criteria. Exceedances of the nickel TEL criteria were the most prevalent. No sample contained metal contamination exceeding the PEL criteria, hence, heavy metal contamination in some areas of the consenting corridor are at concentrations where adverse environmental effects may occur, but are considered unlikely.

The results from the grab samples coincide with results from the Charting Progress 2 Feeder Report (2010) and OSPAR Environmental Assessment (2017) which highlighted inorganic contamination in the North Sea is above natural background, but considered generally of low risk.

Therefore, heavy metal contamination of sediments within the consenting corridor is expected to be generally low, with little or no potential to result in water quality deterioration if re-suspended.

11.4.3 SEPA Coastal Water Monitoring

The HVDC landfall at Long Haven lies within the SEPA water quality monitoring zone of Buchan Ness to Cruden Bay. SEPA categorised the water quality as having an overall high status and chemical pass in 2016 (SEPA, 2017).

To the North of the Buchan Ness to Cruden Bay area, lies the monitoring zone Ugie Estuary to Buchan Ness. The coastal area was categorised as having overall good ecological potential with a chemical pass in 2016 (SEPA, 2017). The Cruden Bay area is situated to the South of the Buchan Ness to Cruden Bay zone, where SEPA categorised the area to have an overall high status and chemical pass in 2016 (SEPA, 2017).

11.4.4 Bathing Waters

Three designated bathing water sites are located in the vicinity of the UK landfall end of the consenting corridor, Peterhead (Lido) (UK7616042) being the closest (approximately 5km from the consenting corridor). Peterhead (Lido) was designated in 1999 and assessed as having good overall bathing water quality (SEPA, 2016). Southwards of the proposed landfall site lie Cruden Bay and Collieston. Cruden Bay, approximately 6km from the landfall site, was designated in 1999 and assessed in 2016 as having poor bathing water quality (SEPA, 2016). Collieston beach, approximately 14km from the proposed landfall site, was designated in 2014 and surveyed in 2017, resulting in a designation of excellent (SEPA, 2016). Balmadie and Aberdeen also possess designated bathing waters, however, these are not considered in this Chapter due their considerable distance from the HVDC cable landfall area, approximately 26km and 36km respectively (SEPA, 2016).

Peterhead (Lido) is located within the breakwaters of Peterhead harbour and so is effectively isolated from any potential reduction in water quality resulting from the NorthConnect marine HVDC cable installation. All other bathing water sites are too far from the consenting corridor for water quality effects at these receptors to be expected and, as such, bathing waters will not be considered further in this assessment.

11.4.5 Shellfish Waters

The closest designated shellfish waters to the UK consenting corridor are located approximately 140km to the north west within the Cromarty Firth (Marine Scotland, 2018). As such, the installation of the marine HVDC cables does not have any potential to affect water quality within any designated shellfish waters, hence, these sites will not be considered further.

11.5 Impact Assessment

11.5.1 Horizontal Directional Drilling (HDD) Fluid Discharges to the Marine Environment

As detailed in Chapter 2: Project Description, horizontal directional drilling (HDD) is required to link the onshore and marine HVDC cable routes. HDD operations require the use of drilling fluids in order to lubricate the drill head. Prior to breaking through the seabed, the HDD holes will be pumped out as so far as is possible, to remove all excess drilling fluid, and further information on this is provided in the Construction Method Statement (CMS). However, some drilling fluid that cannot be removed will remain in the holes and will escape to the marine environment when the HDD breaks out through the seabed. It is estimated that a total of 3,000m^3 of drilling fluid will be lost to sea during the drilling of the 3 HDD holes. The fluids will contain approximately 18m^3 of drilling solids, which is most likely to be bentonite drilling compound and pulverised granite drill cuttings. However, the HDD holes are drilled individually, therefore only 1,000m^3 of fluid and 6m^3 of solids are released at any one time. Assessment of potential ecological effects are discussed in Chapter 14: Benthic Ecology, Chapter 15: Fish and Shellfish and Chapter 16: Marine Mammals and Chapter 17: Ornithology.

Bentonite consists of a mixture of water and naturally occurring non-toxic clay. Additives like natural occurring xanthum gum and gypsum on occasions may be added to bentonite to improve the efficiency of the fluid (Sigma-Aldrich, 2012). Alternatives available to bentonite include Ecodrill and PureBore. Ecodrill is a silicate-based fluid that may be utilised for the last section of the drilling prior to pushing through to the seabed. Ecodrill could pose some environmental implications for the marine environment if large volumes were released in an undiluted or un-neutralised state. The high pH of the fluid may affect the localised water quality by increasing the pH of the water (Silicates, 2012). However, utilisation of Ecodrill in an undiluted form is not proposed. Any potential use of Ecodrill will see appropriate reduction of its pH using caustic Soda as a pH modifier (MI Swaco, 2015). PureBore, is similar to Ecodrill in that it is a silicate-based fluid. It differs from bentonite and Ecodrill by having a lower pH, ranging from 6.5 to 8.5. If PureBore is used, soda ash (sodium carbonate Na_2CO_3) will be used as a pH modifier to neutralise the drilling fluid prior to use (Clear Solutions, 2018).

The release of bentonite, PureBore or Ecodrill into the North Sea during the drilling process will see a **certain** localised increase in water column sediment loading. The drilling fluids are non-toxic and will be dispersed rapidly due to localised wave action and tidal currents (Kim *et al.*, 2018), thereby reducing the duration of the effect. Therefore, the potential effect is considered to be short term and reversible. As such the magnitude of effect is assessed as **low**, and the resulting impact is **minor: non-significant** effect.

11.5.2 Increased Sediment Loading from Offshore Cable Installation

As detailed in Chapter 2: Project Description and the CMS, cable installation will utilise a range of techniques, potentially including jet trenching, ploughing and mechanical trenching. Rock placement will also be required in areas where burial is not possible or does not provide sufficient protection. The trenching, ploughing and, where required, rock placement, will see a **near certain** resuspension of sediment into the water column, increasing localised sediment loading in the water column. Geographic spread and duration of suspension of the remobilised sediments from cable installation activities depend on the sediment's particle size (Wenger *et al.*, 2017).

The STW sediment samples (S01-S05) are dominated by sand with fractions of gravel and minor volumes of silt, except for S01, which consisted of 30% silt, as identified by the marine survey. However, the samples are only representative of very limited areas of the consenting corridor. But the results concur with the identified seabed types discussed in 7: Seabed Quality. The larger sized and heavier sand and gravel particles will quickly resettle once disturbed, decreasing the size of any resulting sediment plume.

Considering the sediment from the UK shore to the limits of the STW are dominated by sand and gravel which quickly resettles, any remobilisation of sediment will be short term and reversible. Therefore, the magnitude is assessed as **low**, giving rise to a **minor: non-significant** effect.

As detailed in Section 11.4.1 Figure 11.4.1, particle size distribution analysis of sediment samples identified much larger fractions of silt in the consenting corridor near the limits of the UK EEZ. Although high fractions of sand were also identified (S05 to S10), with small fractions of clay and gravel found throughout the UK EEZ samples, clay concentrations being significantly larger in the UK EEZ samples. Disturbance to the areas containing higher fractions of silt may result in increased sediment loading of the water column over extended periods, compared to those containing substrates with large particle size. The silts smaller particle mass will also mean greater geographic spread once disturbed and a prolonged resuspension state (Jones *et al.*, 2016). However, a study of resuspension of sediment during subsea cable installation through ploughing identified 90% of suspended sediment re-deposited within 20m of the source, with a further 5% re-deposited between 20m and 500m from the source (BERR, 2008). Thus, geographic spread of re-suspended sediment is not expected to extend outwith the consenting corridor.

While disturbance of finer sediments like silt will see increased sediment loading of the water column lasting for longer periods than when larger sediment types are remobilised, the effects will still be localised and temporary. Therefore, the magnitude is assessed as **low**, giving rise to a **minor: non-significant** effect. Impacts on marine flora and fauna exposed to the remobilised sediments are discussed in Chapter 14: Benthic Ecology, Chapter 15: Fish and Shellfish, Chapter 16: Marine Mammals and Chapter 17: Ornithology.

11.5.3 Remobilisation of Sediment Bound Contaminants

The remobilisation of sediments can result in sediment bound contaminants entering the water column which, in turn, can degrade water quality and become bioavailable to increased assemblages of marine species (Roberts, 2012).

As detailed in Section 11.4.2, with further information provided in Chapter 7: Seabed Quality, the chemical analysis of grab samples conducted during the survey operations found that generally contamination levels were very low. PEL levels were not exceeded at any site for organic or inorganic contaminants, and TPH levels were below the Dutch Target Value at all sites. All PAHs were also below the ERL criteria at all sites. Some heavy metals, notably arsenic and nickel, were present at levels exceeding the TEL criteria at 10 of the 17 sample locations, however, PEL levels were not exceeded. As such, it can be said that the sediments within the UK consenting corridor are relatively uncontaminated, with levels of contaminants below the levels where environmental effects can be expected. It is however noted, that the chemical analysis results are only representative of the areas sampled and the distances between the sample locations mean that unidentified areas of more significant contamination may be present within the consenting corridor, though this is not considered likely according to the literature review detailed in Section 11.4.2.

The low levels of observed sediment contamination mean that the disturbance of sediments during the installation of the marine HVDC cables are **unlikely** to result in the mobilisation of sediment bound contaminants levels with a potential to result in a significant deterioration of water quality within the consenting corridor. Also, as detailed in Section 11.5.2, the duration and extent of sediment plumes resulting from the installation activities will be limited, and likely to be confined within the consenting corridor. Therefore, any reduction in water quality which does result from the mobilisation of sediment bound contaminants will be short term and localised and, hence, the magnitude of effect is assessed as **low.** The resulting impact is therefore assessed as **minor: non-significant** effect. Impacts on marine flora and fauna exposed to the remobilised sediments are discussed in Chapter 14: Benthic Ecology, Chapter 15: Fish and Shellfish, Chapter 16: Marine Mammals and Chapter 17: Ornithology.

11.5.4 Release of Hazardous Substances

11.5.4.1 Loss of Chemicals and Fuels from Installation Vessels

Loss of chemicals and fuels from vessels required for HVDC cables installation has the potential to degrade water quality. The magnitude of any reduction in water quality is dependent on the type of pollutant and volumes entering the aquatic body (Chang *et al.*, 2014; Nelson *et al.*, 2018).

Installation vessels are expected to carry potential pollutants, with hydrocarbon-based fuels, lubricants and hydraulic fluids being the biggest potential pollution sources. The assessment assumes that all vessels and equipment are well maintained and operated by suitably trained personnel. In addition, all installation and support vessels are required to comply with the International Convention for the Prevention of Pollution from Ships (MARPOL) regulations. The regulations cover the prevention of chemical spills and hydrocarbons during both routine operations and incidents. The operating vessels will also have shipboard oil pollution emergency plans (SOPEP), which will minimise the potential impacts of any loss of containment that may occur.

Table 11.4 provides an assessment of the pollution risks likely to be present on the installation spread. It utilises the source, pathway, receptor model, with the marine environment being the receptor. Effects on other receptors are considered within Chapter 7: Seabed Quality, and the marine ecology Chapters: 14-17.

Table 11.4. Loss of Containment Impact Assessment

Source	Scenario	Pathway	Probability	Impact Magnitude	Impact Significance
Deck Equipment – Hydraulic Fluids	Loss of hydraulic fluid, due to pipe burst (5l to 100l)	Spillage to deck - potential to reach water.	**Probable** Despite being well maintained, hydraulic pipes may rupture unexpectedly.	**Low**	**Minor: Non-Significant**
ROVs – Hydraulic Fluids	Loss of containment from ROV due to mechanical failure of the ROV (5l to 100l).	Spillage directly to water.	**Probable** Despite being well maintained, ROVs are known to suffer mechanical failures which can result in losses of hydraulic fluid.	**Low**	**Minor: Non-Significant**
Support and Guard Vessels	Accidental damage to fuel tank loss of contents (<100m^3), through collision or impact with submerged object.	Spillage directly to water.	**Unlikely** Masters of the vessels will be appropriately trained. Operating in open water. Further detail provided in Chapter 19: Navigation and Shipping.	**Medium**	**Minor: Non-Significant**
Installation Vessels	Accidental damage to fuel tank loss of contents (<500m^3), through collision or impact with submerged object.	Spillage directly to water.	**Extremely Unlikely** Masters of the vessels will be appropriately trained. Guard vessels and safety zones maintained, Further detail provided in Chapter 19: Navigation and Shipping. Vessels are DP2 so have full backup power systems in the event of loss of propulsion.	**High**	**Minor: Non-Significant**

11.5.4.2 Discharge of Wastewaters and Sewage from Installation Vessels

Under normal operating conditions, installation and support ships are **certain** to discharge wastewaters and potentially sewage, which may contain chemical and biological contaminants that can influence the marine environment. However, all vessels employed to facilitate the installation of NorthConnect marine HVDC cables will be MARPOL compliant and, as such, all discharges will be appropriately treated to reduce potential contaminants to acceptable levels, and conducted in an appropriate manner to minimise water quality impacts. When considered in the context of existing shipping levels and associated discharges in the North Sea, the magnitude of the impact is **low.** Therefore, the effect is assessed as **minor: non-significant**.

11.5.4.3 Accidental Damage to Subsea Oil and Gas Infrastructure

The North Sea in the vicinity of the consenting corridor is widely exploited by the oil and gas sector and, as such, numerous existing submarine pipelines are present in the area. As discussed in Chapter 2: Project Description, the consenting corridor crosses pipelines between the UK landfall and the limit of the UK EEZ. Cable installation (laying and burial), together with the placement of rock to protect the existing asset and the proposed NorthConnect cables, have the potential to damage submarine pipelines within the consenting corridor. Damage to an oil pipeline has the potential to result in a significant release of oil into the marine environment, which could lead to a major reduction of marine water quality over an extended area. The magnitude of the effect which could result from damaging an existing submarine pipeline is therefore **high.**

However, NorthConnect will follow the International Cable Protection Committee (ICPC) recommendations for existing infrastructure crossings. Individual crossing agreements will be made with the respective asset owners prior to cable installation commencing, so that the crossing design, installation techniques and associated safety exclusion zones for different installation tools, can be agreed. Emergency response procedures will also be agreed to ensure that, in the event of damage to a pipeline occurring, all parties can work quickly to minimise the magnitude of the spill.

Detailed crossing engineering will be performed by the cable installation contractor, in close cooperation with NorthConnect and the asset owners. The engineering will allow mitigation to be designed and implemented for each crossing, further reducing the likelihood of a submarine pipeline being damaged. As such, it is **extremely unlikely** that the installation activities will result in damage to a submarine pipeline which would lead to a significant reduction in water quality. The resulting effect is therefore assessed as **minor: non-significant**.

11.5.5 Invasive Non-Native Species (INNS)

The introduction of INNS has the potential to result in severe ecological impacts which, in turn, can result in major economic costs due to the difficulty in trying to eradicate a species once it has been introduced. The vector with the greatest risk of introducing INNS associated with the installation of the marine HVDC cables is the vessels that will make up the installation spread. Vessels travelling from already contaminated ports and harbours, or different ecoregions, can transport INNS via their ballast water and, to a more limited extent, through biofouling (marine growth) on hulls (Yang et al., 2018). Further detail on the vessel movements expected during the installation of the marine HVDC cables is provided in Chapter 19: Navigation and Shipping. There is also the potential that other equipment, such as trenching tools, ROVs, and ploughs, could introduce INNSs via soils and sediment trapped in the equipment from previous deployments.

As detailed in Chapter 14: Benthic Ecology, no INNS were identified within the consenting corridor during the benthic survey operations. There are also ecologically sensitive habitats in the vicinity of the consenting corridor which could be affected through the introduction of INNS. The duration of such an impact would be long-term to permanent, due to the difficulties in eradicating an INNS once it is established. As such, the magnitude of impact resulting from the introduction of an INNS is assessed as **high.** Ecological impacts of INNS introduction are specifically considered in Chapter 14: Benthic Ecology.

With regard to the potential for introduction of INNS via vessel ballast water, the International Maritime Organization (IMO) ratified the International Convention for the Control and Management of Ships' Ballast Water and Sediments Management (Ballast Water Management (BWM) Convention) in September 2017. This requires all commercial vessels to adopt an approved ballast water management plan, involving either the exchange of ballast water outwith coastal waters, or the treatment of ballast water to denature potential INNSs. NorthConnect will require that all vessels employed to facilitate the installation of the marine HVDC cables are fully IMO compliant, including the BWM Convention. As such, the ballast water vector for INNS is effectively removed. The probability of INNS being introduced is therefore assessed as **very unlikely**, resulting in a **minor: non-significant** effect.

Implementation of the BWM Convention does not mitigate the risk of an INNS being introduced via biofouling on a vessel. However, this vector is considered to carry a lower risk of INNS introduction than ballast water. Furthermore, the North Sea in the region of the consenting corridor is frequently visited by vessels from around the UK, Europe, and wider world, as detailed in Chapter 19. As such, the installation vessel movements are unlikely to constitute a change from baseline conditions with respect to the potential for introducing INNS. Therefore, the probability of INNS introduction occurring through biofouling of vessels is assessed as **unlikely**, and the resulting effect is **minor: non-significant**.

The probability of INNS being introduced via sediments and soils trapped on equipment mobilised to facilitate the marine cable installation is considered to be **unlikely**. This is due to the fact that the soils and sediment which could act as a vector are likely to dry during transit to site, greatly reducing the probability of an INNS surviving the transit to the consenting corridor. The resultant effect is therefore assessed as **minor: non-significant**.

11.6 Mitigation measures

The assessment identified no potential significant effects from the proposed development on marine water quality, therefore, no further mitigation is required.

11.7 Residual effects

No potential significant effects from the proposed development on marine water quality were identified, therefore, no reassessment of the residual effects taking into account mitigation measures is required.

11.8 Cumulative Effects

The potential impacts on marine water quality associated with the seabed preparation and installation of the NorthConnect marine HVDC cables are extremely localised in nature. This will also be true of the water quality impacts resulting from the other marine developments detailed in Chapter 6: Cumulative Effects. With the exception of the Norwegian section of the NorthConnect project, the closest marine development to the UK consenting corridor is the Peterhead Port Authority Harbour Masterplan, which is 3km to the north of the consenting corridor at its closest point. All other projects are located 20km or more from the consenting corridor. As such, there is no potential for any interaction between the NorthConnect marine water quality impacts and those resulting from the other marine developments. The cumulative effects are therefore assessed as **no-change**.

With regard the Norwegian section of the NorthConnect project, the Norwegian operations may be conducted concurrently, and adjacent to the UK installation works. The installation techniques that will be used in Norwegian waters will be analogous to those described here and in the supporting chapters. As such, the water quality impacts associated with the seabed preparation and cable installation works in the Norwegian EEZ will be the same as those expected in the UK EEZ and, hence, the resulting cumulative effects are assessed as **non-significant**.

11.9 Summary of Effects

This chapter has assessed the potential environmental impacts on marine water quality resulting from the seabed preparations and installation of the proposed NorthConnect marine HVDC cables. No impacts were assessed as being significant under the terms of the EIA Regulations. A summary of the assessment is provided in Table 11.5 below.

Table 5 Summary of Impacts on Marine Water Quality and Mitigation.

Aspect	Phase	Predicted Impact	Probability	Impact Magnitude	Significance (Absence of Secondary Mitigation)	Mitigation Summary	Residual Probability	Significance of Residual Effect
HDD Drilling	Installation	Drilling fluid Discharges to Marine Environment Increased sediment loading of the water column.	Certain	Low	Minor: Non-Significant	Pumping out of excess drilling fluid from drilled ducts reducing the total lost volumes.	Certain	Minor: Non-Significant
Offshore Cable Installation and Protection	Installation	Increased water column sediment loading	Near-certain	Low	Minor: Non-Significant	No specific mitigation required/	Near-certain	Minor: Non-Significant
		Remobilisation of sediment bound contaminates.	Near-certain	Low	Minor: Non-Significant	No specific mitigation required/	Near-certain	Minor: Non-Significant
Release of Hazardous Substances from Installation Vessels	Installation	Loss of hydraulic fluid (5L to 100L) from deck equipment.	Probable	Low	Minor: Non-Significant	• Equipment to be well maintained. • MARPOL compliance. • SOPEPs.	Probable	Minor: Non-Significant
		Loss of hydraulic fluid (5L to 100L) from ROVs .	Probable	Low	Minor: Non-Significant	• Equipment to be well maintained • SOPEPs.	Probable	Minor: Non-Significant
		Damage to fuel tank and loss of contents (<100m^3) of support and guard vessels.	Unlikely	Medium	Minor: Non-Significant	International Regulations for the Prevention of Collision at Sea.	Unlikely	Minor: Non-Significant
		Accidental damage to fuel tank and loss of contents (<500m^3).	Extremely Unlikely	High	Minor: Non-Significant	• International Regulations for the Prevention of Collision at Sea. • Guard Vessels. • Vessels DP2.	Extremely Unlikely	Minor: Non-Significant

Aspect	Phase	Predicted Impact	Probability	Impact Magnitude	Significance (Absence of Secondary Mitigation)	Mitigation Summary	Residual Probability	Significance of Residual Effect
Release of Hazardous Substances from Installation Vessels	Installation	Planned discharges of waste water and sewage from installation spread vessels.	Certain	Low	Minor: Non-Significant	Following of MARPOL convention.	Certain	Minor: Non-Significant
Exisitng Pipeline Crossings	Installation	Accidental damage to subsea oil and gas infrastructure resulting in widespread pollution.	Extremely Unlikely	High	Minor: Non-Significant	• Following of International Cable Protection Committee recommendations. • Crossing Agreements. • Mitigation identified through detailed crossing engineering and cooperation between stakeholders. • Procedures in place to deal with damage to infrastructure.	Extremely Unlikely	Minor: Non-Significant
Use of Vessels from Outwith the North Sea Ecoregion.	Installation	Introduction of invasive non-native species through ballast water.	Extremely Unlikely	High	Minor: Non-Significant	Compliance with International Convention for the Control and Management of Ships' Ballast Water and Sediments Convention.	Extremely Unlikely	Minor: Non-Significant

Aspect	Phase	Predicted Impact	Probability	Impact Magnitude	Significance (Absence of Secondary Mitigation)	Mitigation Summary	Residual Probability	Significance of Residual Effect
Use of Vessels from Outwith the North Sea Ecoregion.	Installation	Introduction of invasive non-native species through biofouling of vessels.	Unlikely	High	Minor: Non-Significant	No specific mitigation required.	Unlikely	Minor: Non-Significant
		Introduction of invasive non-native species through contamination of tools and equipment with organic material from previous sites.	Unlikely	High	Minor: Non-Significant	Equipment will be cleaned and inspected prior to mobilisation.	Unlikely	Minor: Non-Significant

11.10 References

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