GREEN VOLT

Chapter 8
Marine Sediment and Water Quality

Offshore EIA Report: Volume 1

Revision history

Revision	Date	Description	Prepared	Checked	Approved
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Appendices (Volume 2)

Acronyms

Acronym	Description
AL1	Action Level 1
AL2	Action Level 2
BAC	Background Assessment Concentration
BEIS	Department for Business, Energy and Industrial Strategy
BGS	British Geological Survey
CAR	Controlled Activities Regulations
CCME	Canadian Council of Ministers of the Environment
CCS	Carbon Capture Storage
Cefas	Centre for Environment, Fisheries and Aquaculture Science
CIA	Cumulative Impact Assessment
CPI	Carbon Preference index
EEZ	Exclusive economic zone
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
EPA	US Environmental Protection Agency
EQS	Environmental Quality Standard
ERL	Effects Range Low
FPSO	Floating Production Storage and Offloading
GETM	General Estuarine Transport Model
HDD	Horizontal Directional Drilling
HVDC	High Voltage Direct Current
ISQG	Interim Marine Sediment Quality Guidelines
LOD	Limit of Detection
LTOBM	Low Toxicity Oil-Based Mud
MARPOL Convention	International Convention for Prevention of Marine Pollution by Ships
MAU	Marine Analytical Unit (a unit of Marine Scotland)
MHWS	Mean High Water Springs
MS-LOT	Marine Scotland Licensing Operations Team
MSS	Marine Scotland Science
NMP	National Marine Plan
NMPI	National Marine Plan Interactive
NPD	The sum of naphthalene, phenanthrene, dibenzothiophene and their C1-, C2- and C3 alkyl homologues
NPF	National Planning Framework
O&G	Oil & Gas

O&M	Operation and Maintenance
OPRED	Offshore Petroleum Regulator for Environment and Decommissioning
OSP	Offshore Substation Platform
OSPAR	Convention for the Protection of the Marine Environment of the North-East Atlantic
PAH	Polyaromatic Hydrocarbons
PEL	Probable Effect Level
PSA	Particle Size Analysis
RIVM	Dutch National Institute for Public Health and the Environment
SEPA	Scottish Environment Protection Agency
SFF	Scottish Fisherman's Federation
SPM	Suspended Particulate Matter
SPP	Scottish Planning Policy
STW	Scottish Territorial Waters
TEL	Threshold Effect Level
THC	Total Hydrocarbons
TPH	Total Petroleum Hydrocarbons
UCM	Unresolved complex mixture
UK	United Kingdom
UKOOA	United Kingdom Offshore Operators Association
WFD	Water Framework Directive
WTG	Wind Turbine Generator

Glossary

Term	Description
Applicant	Green Volt Offshore Windfarm Ltd.
Buzzard	Buzzard Platform Complex.
Buzzard Export Cable Corridor	The area in which the export cables will be laid, from the perimeter of the Windfarm Site to Buzzard Platform Complex.
Green Volt Offshore Windfarm	Offshore windfarm including associated onshore and offshore infrastructure development (Combined On and Offshore Green Volt Projects).
Horizontal Directional Drilling	Mechanism for installation of export cable at landfall.
Inter-array cables	Cables which link the wind turbines to each other and the offshore substation platform.
Landfall Export Cable Corridor	The area in which the export cables will be laid, from the perimeter of the Windfarm Site to landfall.
Mean High Water Springs	At its highest and 'Neaps' or 'Neap tides' when the tidal range is at its lowest. The height of Mean High Water Springs (MHWS) is the average throughout the year, of two successive high waters, during a 24-hour period in each month when the range of the tide is at its greatest (Spring tides).
Moorings	Mechanism by which wind turbine generators are fixed to the seabed.
NorthConnect Parallel Export Cable Corridor Option	Landfall Export Cable Corridor between NorthConnect Parallel Landfall and point of separation from St Fergus South Export Cable Corridor Option.
NorthConnect Parallel Landfall	Southern landfall option where the offshore export cables come ashore.
Offshore Development Area	Encompasses i) Windfarm Site, including offshore substation platform ii) Offshore Export Cable Corridor to Landfall, iii) Export Cable Corridor to Buzzard Platform Complex.
Offshore export cables	The cables which would bring electricity from the offshore substation platform to the Landfall or to the Buzzard Platform Complex.
Offshore Export Cable Corridor	The proposed offshore area in which the export cables will be laid, from offshore substation to landfall or to the Buzzard Platform Complex.
Offshore infrastructure	All of the offshore infrastructure, including wind turbine generators, offshore substation platform and all inter-array and export cables.
Offshore substation platform	A fixed structure located within the Windfarm Site, containing electrical equipment to aggregate the power from the wind turbine generators and convert it into a more suitable form for export to shore.
Onshore Export Cable Corridor	The proposed onshore area in which the export cables will be laid, from landfall to the onshore substation.
Project	Green Volt Offshore Windfarm project as a whole, including associated onshore and offshore infrastructure development.

Safety zones	An area around a structure or vessel which must be avoided.
St Fergus South Export Cable Corridor Option	Landfall Export Cable Corridor between St Fergus South Landfall and point of separation from NorthConnect Parallel Export Cable Corridor Option.
St Fergus South Landfall	Northern landfall option where the offshore export cables come ashore.
Windfarm Site	The area within which the wind turbine generators, offshore substation platform and inter-array cables will be present.

CHAPTER 8: MARINE SEDIMENT AND WATER QUALITY

8.1 Introduction

1. This chapter of the **Offshore Environmental Impact Assessment (EIA) Report** assesses impacts on marine sediment and water quality associated with the Project (in this instance the Project refers to the offshore elements of the Green Volt Offshore Windfarm only, up to Mean High Water Springs (MHWS)). It covers the Windfarm Site (area within which the wind turbine generators (WTG), offshore substation platform (OSP) and inter-array cables will be present), the Landfall Export Cable Corridor (two options for landfall, NorthConnect Parallel Landfall and St. Fergus South Landfall) and the Buzzard Export Cable Corridor.

2. This chapter provides a description of the baseline for marine sediment and water quality, followed by an assessment of the magnitude and significance of the effects upon the baseline conditions resulting from the construction, operation and decommissioning of the Project. It also covers those effects resulting from cumulative interactions within the project and with other existing or planned projects.

3. This assessment has been informed by the interpretation of existing datasets and reports relating to earlier projects and survey data specifically collected for the Project. This includes sediment contaminant data collected along the Landfall Export Cable Corridor in April 2022 (Apem, 2022) and in the Windfarm Site in September 2021 (Gardline 2022). It has also been informed by the evidence presented in **Chapter 7: Marine Geology, Oceanography and Physical Processes**. The potential effects have been assessed conservatively using realistic worst case scenarios for the Project (**Section 8.7.2**).

8.2 Legislation, Guidance and Policy

4. National legislation used to inform the assessment of potential impacts on marine sediment and water quality for this project is described in **Table 8.1**.

Table 8.1 Summary of national legislation relevant to the Project

Legislation	Relevance
Water Environment and Water Services (Scotland) Act 2003 (WEWS Act)	Arose from the Water Framework Directive (WFD) 2000/60/EC and commits Scotland to achieve good qualitative and quantitative status of all water bodies by 2015 with the final deadline for meeting objectives being 2027. River basins comprise all transitional waters (estuaries) and coastal waters extending to 3 nautical miles (nm) seaward from the territorial baseline. Any proposed development within 3 nm must have regard to the requirements to ensure that all transitional and coastal water bodies achieve 'Good Ecological Status' and that there is no deterioration in status.
Water Environment (Controlled Activities) (Scotland) Regulations 2011 (as amended)	The Controlled Activities Regulations 2011 (CAR) (and its amendments in 2013 and 2017) apply regulatory controls over activities which may affect Scotland's water environment. The regulations cover rivers, lochs, transitional waters (estuaries), coastal waters, groundwater and groundwater dependent wetlands.
The Marine Strategy Regulations 2010	The Marine Strategy Framework Directive 2008 (Directive 2008/56/EC) was transposed in 2010 through the Marine Strategy Regulations 2010. This establishes a framework for community action in the field of marine environmental policy and aims to achieve 'Good Environmental Status' in United Kingdom (UK) marine waters by 2020.
Water Environment (Shellfish Water Protected Areas: Environmental Objectives etc.) (Scotland) Regulations 2013	The Shellfish Waters Directive was repealed in 2013 and was replaced by these regulations in 2013. The objectives are to prevent the deterioration of water quality within a shellfish water protected area and protect and improve each protected area to achieve good water quality by 2015.

Legislation	Relevance
Bathing Waters (Scotland) Amendment Regulations 2012	Previously designated under the Bathing Water Directive (76/160/EEC), these waters are now covered by the revised Bathing Water Directive (2006/7/EC) which are transposed into Scottish law through the Bathing Waters (Scotland) Amendment Regulations 2012. Scottish Environment Protection Agency's (SEPA) aim was for all of Scotland's bathing waters to achieve a classification of at least sufficient by 2020 and with no real deteriorations in class. Any bathing water which has five successive poor classifications will have permanent advice against bathing displayed.
International Convention for Prevention of Marine Pollution by Ships (MARPOL)	MARPOL is the main international convention covering prevention of pollution of the marine environment by ships from operational or accidental causes. It is a combination of two treaties adopted in 1973 and 1978 respectively and updated by amendments through the years. The Convention covers all the technical aspects of pollution from ships, except the disposal of waste into the sea by dumping, and applies to ships of all types, although it does not apply to pollution arising out of the exploration and exploitation of sea-bed mineral resources.

5. The assessment also considers the core objectives and relevant marine planning policies of both Scotland's National Marine Plan (NMP) (Scottish Government 2015) and the principles of Scotland's National Planning Framework 3 (NPF3) (Scottish Government, 2014a) and draft NPF4, which is supported by the Scottish Planning Policy (SPP) (Scottish Government, 2014b). These are discussed further in **Chapter 3: Policy and Legislative Context**.

6. In the NMP, the Scottish government released general policies in favour of the sustainable development and use of marine resources, including '*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, 2015).

7. The NMP also provides a series of good environmental status descriptors, which reflect the ecosystem services approach in the adoption of strategic objectives. The descriptors identify vital parts of the ecosystem structure and functions, and set targets to maintain their status. This includes '*GES 8: Concentrations of contaminants are at levels not giving rise to pollution effects'* (Scottish Government, 2015a).

8.2.1 Guidance

8. There is no specific guidance available for the impact assessment of marine sediment and water quality. Two approaches to assessing sediment quality have been used.

9. For offshore sediments within the Windfarm Site, a comparison of sediment concentrations has been made to mean values collated by the United Kingdom Offshore Operators Association (UKOOA) (2001) and the Centre for Environment, Fisheries and Aquaculture Science (Cefas) (2001) to provide context to sediment contamination in areas potentially impacted by oil and gas industry activities.

10. Where the data available supports it, sediment quality guidelines used by The Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR) (OSPAR Commission 2014), Marine Scotland (Marine Scotland, 2017) and those developed by the Canadian Council of Ministers of the Environment (CCME, 2002) have been used.

11. With respect to OSPAR, assessments are undertaken using Background Assessment Concentration (BAC) and the US Environmental Protection Agency's (EPA) Effects Range-Low (ERL). The ERL value is defined as the lower tenth percentile of the data set of concentrations in sediments which were associated with biological effects. Adverse effects on organisms are rarely observed when concentrations fall below the ERL value. BACs are statistical tools defined in relation to the background concentrations which enable statistical testing of whether observed concentrations can be considered to be near background concentrations. Relevant BACs and ERLs are provided in **Table 8.2**.

12. In the UK, licensing authorities for dredge material disposal to sea, regulate the activity using guidelines, part of which require characterisation of the sediments for disposal to enable the consideration of potential adverse environmental effects. To undertake this assessment, regulating authorities apply action levels (sediment quality criteria) for contaminants on a primary list. These action levels are then used as part of a 'weight of evidence' approach to decision making on the disposal of dredged material. There are two levels – Action Level 1 (AL1) and Action Level 2 (AL2). Contaminant levels below AL1 are generally assumed to be of no concern and are unlikely to influence the licensing decision. Contaminant levels between Level 1 and 2 generally trigger further investigation of the material, and contaminants in dredged material above AL2 are generally considered unsuitable for sea disposal (Marine Scotland, 2017).

13. Although the majority of the material assessed against these standards arises from a specific activity i.e. dredging and disposal activities, they are also considered a good way of undertaking an initial risk assessment with respect to determining risks to marine waters from other marine activities as part of the EIA and associated WFD compliance assessments. If, overall, levels do not generally exceed AL1 then contamination levels are considered to be low risk in terms of the potential for impacts on water quality. This approach is recommended by the Environment Agency in their WFD compliance assessment guidance 'Clearing the Waters for All' for example (Environment Agency, 2017). Relevant ALs are presented in **Table 8.2.**

14. The Canadian Sediment Quality guidelines have also been applied because they provide values for a wider range of contaminants. These guidelines derive Interim marine Sediment Quality Guidelines (ISQGs) or Threshold Effect Levels (TEL) and Probable Effect Levels (PEL) (CCME, 2002) (see **Table 8.2**). It should be noted these levels were designed specifically for the protection of pristine environments and therefore are considered a very precautionary approach to sediment assessments. The lower level is referred to as the TEL and represents the concentration below which adverse biological effects are expected to occur only rarely. The higher level, the PEL, defines a concentration above which adverse effects may be expected in a wider range of organisms.

15. Where total petroleum hydrocarbons (TPH) levels have been reported, the Dutch National Institute for Public Health and the Environment (RIVM) criteria for aquatic sediments threshold value of 50 mg/kg has been applied (MMT, 2018). This target value is considered to be a level below which there is sustainable sediment quality.

Table 8.2 Selected Canadian Sediment Quality guidelines (CCME. 2002) and OSPAR BAC and ERL

Contaminant	Units	CSQG TEL	CSQG PEL	OSPAR BAC	OSPAR ERL	AL1 (Scotland)[1]	AL2 (Scotland)
Arsenic	mg/kg	7.24	41.6	25	8.2[2]	20	70
Cadmium		0.7	4.2	0.31	1.2	0.4	4
Chromium		52.3	160	81	81	50	370
Copper		18.7	108	27	34	30	300
Mercury		0.13	0.7	0.07	0.15	0.25	1.5
Nickel				36	21[1]	30	150
Lead		30.2	112	38	47	50	400
Zinc		124	247	122	150	130	600
Acenaphthene	µg/kg	6.71	88.9	-	-	100	-

[1] *See https://www.gov.scot/binaries/content/documents/govscot/publications/advice-and-guidance/2020/02/marine-licensing-applications-and-guidance/documents/guidance/pre-disposal-sampling-guidance/pre-disposal-sampling-guidance/govscot%3Adocument/Pre-disposal%2Bsampling%2Bguidance.pdf*

[2] *The ERLs for arsenic and nickel are below the OSPAR Background Concentrations of 15 and 30 mg/kg respectively; arsenic and nickel concentrations are only assessed against the BAC*

Contaminant	Units	CSQG TEL	CSQG PEL	OSPAR BAC	OSPAR ERL	AL1 (Scotland)[1]	AL2 (Scotland)
Acenaphthylene		5.87	128	-	-	100	-
Anthracene		46.9	245	5	85	100	-
Benz(a)anthracene		74.8	693	16	261	100	-
Benzo(a)pyrene		88.8	763	30	430	100	-
Chrysene		108	846	20	-	100	-
Dibenzo(a,h)anthracene		6.22	135	-	-	10	-
Fluoranthene		113	1494	39	600	100	-
Fluorene		21.2	144	-	-	100	-
Naphthalene		34.6	391	8	160	100	
Phenanthrene		86.7	544	32	240	100	-
Pyrene		153	1398	24	665	100	-
Benzo(ghi)perylene		-	-	80	-	100	-
Indeno[1,2,3-cd]pyrene		-	-	103	-	100	-

8.3 Consultation

16. Consultation is a key feature of the EIA process, and continues throughout the lifecycle of the Green Volt Offshore Windfarm, from the initial stages through to consent and post-consent.

17. To date, consultation with regards to marine sediment and water quality has been undertaken via the **Offshore Scoping Report** (Royal HaskoningDHV, 2021) (**Appendix 1.2**), which was submitted to Marine Scotland Licensing Operations Team (MS-LOT) in November 2021. A 30-day consultation process on the **Offshore Scoping Report** was coordinated by MS-LOT, commencing on 3rd December 2021.

18. The Scottish Ministers' **Scoping Opinion** (MS-LOT, 2022) (**Appendix 1.1**) on the **Offshore Scoping Report** and associated wider consultation responses that are relevant to marine sediment and water quality are presented in **Table 8.3**.

Table 8.3 Summary of consultation responses relevant to marine sediment and water quality topic

Consultee	Date / Document	Comment	Response / where addressed in the EIA Report
Marine Scotland Licensing Operations Team (MS-LOT)	April 2022, Marine Scotland - Licensing Operations Team: Scoping Opinion for Green Volt Offshore Windfarm	**[Ref: 5.6.1] Sediment Quality**: The Scottish Ministers are content with the data sources identified by the Developer in Table 5.13 of the Scoping Report. In Table 5.18 of the Scoping Report the Developer summarises the potential impacts to sediment quality identified during the different phases of the Proposed Development.	Noted

Consultee	Date / Document	Comment	Response / where addressed in the EIA Report
MS-LOT	April 2022, Marine Scotland - Licensing Operations Team: Scoping Opinion for Green Volt Offshore Windfarm	**[Ref: 5.6.2] Sediment Quality**: The Scottish Ministers direct the Developer to Appendix A of the representation from NatureScot and advise that the points raised on drill arisings must be fully addressed by the Developer. The Scottish Ministers also direct the Developer to the representation from the Scottish Fisherman's Federation (SFF), which highlights the uncertainty surrounding oil-based cuttings and the substances they may contain, and advise that this point must also be fully addressed by the Developer.	There are no cutting piles contaminated with oil based muds at Ettrick and Blackbird (Genesis, 2016). Water-based muds will have been used and discharged with drill arisings under the appropriate permit from Department for Business, Energy and Industrial Strategy - Offshore Petroleum Regulator for Environment and Decommissioning (BEIS-OPRED) following a chemical risk assessment to confirm that there would be no significant environmental effects either at the time or in the future. The array pattern and position applied will deliberately avoid placing turbines and substructures directly above pipelines and umbilicals remaining in-situ, and abandoned well-centres at the seabed. The final offsets applied will be determined by collaboration with the oil and gas operator via a structured risk assessment approach. Any crossings will be finalised with the input and agreement with the oil & gas (O&G) operator.
MS-LOT	April 2022, Marine Scotland - Licensing Operations Team: Scoping Opinion for Green Volt Offshore Windfarm	**[Ref: 5.6.3] Sediment Quality:** The Scottish Ministers highlight the MSS advice which states that it agrees with the Developer's proposal to scope in pollution of the sediment through disturbance of the existing contaminated sediments to the EIA Report in the construction and decommissioning phases of the Proposed Development. However, due to the new nature of the catenary mooring line technology and the potential number of mooring lines included in the Proposed Development, MSS advise that disturbance of existing contaminated sediments should also be scoped in to the EIA Report during the operation and maintenance phase of the Proposed Development. The Scottish Ministers agree and advise that this must be fully addressed by the Developer.	Although the use of catenary mooring systems has only been applied to floating offshore wind on limited occasions to date, the technology has been widely used in the oil and gas industry on both semi-submersible drilling rigs and for floating production storage and offloading (FPSOs) structures. At Ettrick and Blackbird there was an FPSO moored at one location for several years and tens of semi-submersible drilling rig moorings across the site for drilling and well intervention works as well as decommissioning activities. The catenary mooring technology, therefore, is not considered to be new. During the operation and maintenance (O&M) phase of the Project, any vessels visiting the site will use dynamic positioning - anchors will only be used in an emergency situation. Mooring lines on the seabed will be largely stationary except under extreme conditions. Furthermore, moorings and lines will not be placed within the safety zones of the decommissioned wells (or their associated arisings piles) so there will not be the risk of remobilising potentially contaminated sediments from these known locations during operation.
MS-LOT	April 2022 Offshore Scoping Opinion	**[Ref: 5.5.1] Water Quality:** The Scottish Ministers are content with the baseline information regarding water quality obtained and used by the Developer in the Scoping Report.	Noted
MS-LOT	April 2022, Marine Scotland - Licensing	**[Ref: 5.5.2] Water Quality:** The Scottish Ministers draw attention to the MSS advice regarding pollution of	Potential deterioration in water quality due to re-suspension of sediment on contaminants offshore and along the

Consultee	Date / Document	Comment	Response / where addressed in the EIA Report
	Operations Team: Scoping Opinion for Green Volt Offshore Windfarm	water, specifically the point raised regarding catenary mooring lines potentially disturbing sediment along the seabed. As the technology is novel and there is potential for a large number of mooring lines, the Scottish Ministers agree with MSS' request that pollution of water through disturbance of existing contaminated sediments during the construction, operation and maintenance and decommissioning phases of the Proposed Development should be scoped in to the EIA Report.	Offshore Export Cable Corridors and increase in suspended sediment concentrations are assessed in **Section 8.7**.
MS-LOT	April 2022, Marine Scotland - Licensing Operations Team: Scoping Opinion for Green Volt Offshore Windfarm	**[Ref: 5.5.3] Water Quality:** The Scottish Ministers agree with the other potential impacts proposed to be scoped out of the EIA Report, and provide no further comments.	Noted
Marine Scotland Science (MSS)	4th February 2022 Representation to MS-LOT during consultation on Offshore Scoping Opinion	With respect to section 5.2.3, MSS do not agree that increases in suspended sediments and seabed scour should be scoped out of the EIA. The installation of cables within the Windfarm Site and along the export cable routes will entrain sediments and the ultimate fate of these sediments should be scoped into the EIA	These impacts are addressed in **Section 8.7**
MSS	4th February 2022 Representation to MS-LOT during consultation on Offshore Scoping Opinion	Regarding scour around the systems, MSS note that the Ettrick and Blackbird oil and gas decommissioning survey data suggest this is likely to be minimal. There is the potential for a large number of mooring lines and anchors (up to 6 per turbine, totalling up to 180), and this cumulative effect is unknown. MSS therefore advice that suspended sediment be scoped into the EIA for construction and decommissioning and seabed scour be scoped into the EIA for construction, operation, and decommissioning. It may well be the case that there is sufficient evidence from the Ettrick and Blackbird survey data to dismiss these concerns during the EIA process, but this evidence should be presented.	These impacts are addressed in **Section 8.7**
MSS	4th February 2022 Representation to MS-LOT during consultation on Offshore Scoping Opinion	There is no mention of the baseline water column conditions in section 5.3, metocean conditions, including whether the region is stratified or fully mixed. The region is likely to undergo seasonal stratification (van Leeuwen *et al*., 2015). The baseline water column conditions should be described in the EIA. Whether the wind farm is likely to change the extent and timing of seasonal stratification should be scoped into the EIA. The wind farm could change water column mixing by the presence of the structures and/or by altering the near sea surface wind speeds.	The baseline is outlined in **Section 8.6.1** and the associated impacts identified are considered in **Section 8.7.4**

Consultee	Date / Document	Comment	Response / where addressed in the EIA Report
MSS	4th February 2022 Representation to MS-LOT during consultation on Offshore Scoping Opinion	With respect to section 5.4.3, MSS agree that pollution of the water through disturbance of the existing contaminated sediments during construction and decommissioning, should be scoped into the EIA.	Noted. These impacts are addressed in **Section 8.7**.
MSS	4th February 2022 Representation to MS-LOT during consultation on Offshore Scoping Opinion	MSS do not agree that pollution of the water through disturbance of the existing contaminated sediments during operation should be scoped out of the EIA. This is because the catenary mooring lines will lie along the seabed potentially disturbing sediments. This disturbance is likely to be extremely minimal, but MSS advise that it is scoped into the EIA given that this is a new technology and there is the potential for a large number of mooring lines and the possibility of high concentrations of contaminants (from the oil and has operations) within the seabed. MSS also welcome the use of safety exclusion zones around plugged and abandoned well heads in order to minimise disturbance of contaminated sediments	These impacts are addressed within **Section 8.7**
MSS	Stakeholder engagement meeting 10th February 2022	Queried if there were much in the way of drill cuttings at this site	There are no cutting piles contaminated with oil based muds at Ettrick and Blackbird (Genesis, 2016). Water-based muds will have been used and discharged with drill arisings under the appropriate permit from BEIS-OPRED following a chemical risk assessment to confirm that there would be no significant environmental effects either at the time or in the future. Additionally, infrastructure will be sited to avoid the wells.
North Sea Transition Authority (NTSA)	Stakeholder engagement meeting 8th June 2022	NSTA has no remit on renewables, but very supportive of the effort to re-use former O&G fields • Secretary of State is liable for exploration and appraisal wells, therefore mooring line proximity to exploration and appraisal wells is not a matter for the NSTA • The O&G Operator is liable for developed wells • It was suggested to engage the O&G field operator would be good practice to ensure the following is applied: o A crossing is categorised as a pipeline modification and a Pipeline Works Authorisation (PWA) will need to be submitted to the NSTA by the O&G operator (an associated environmental approval may be required from BEIS-OPRED) o Any addition of rock or concrete mattresses for protection will need a “deposit” consent (again from the NSTA and an associated environmental approval may be required from BEIS-OPRED) o The monitoring obligation remains with the O&G operator	The array pattern and position applied will deliberately avoid placing turbines and substructures directly above pipelines and umbilicals remaining in-situ, and abandoned well-centres at the seabed. The final offsets applied will be determined by collaboration with the oil and gas operator via a structured risk assessment approach. Any crossings will be finalised with the input and agreement with the O&G operator

Consultee	Date / Document	Comment	Response / where addressed in the EIA Report
		o The approved O&G decommissioning programme will need to be revised with ORPED	
Offshore Petroleum Regulator for Environment and Decommissioning (OPRED)	Stakeholder engagement meeting 8th June 2022	OPRED scope with respect to pipeline/umbilical crossings is focused on decommissioned lines, not live lines. JNCC and SFF will need to be consulted for each crossing and this will also require an update to the O&G decommissioning program. • Mooring lines crossing pipelines is not a new concept in O&G operations, however, normally this involves the same operator crossing their own pipeline/umbilical. • Since the exclusion zone applied around a wind turbine is small (50 m), the pipelines will still be considered as a potential hazard for other marine users. This means the pipelines still must be accessible for survey to verify they continue to not present a hazard to other users of the sea.	The array pattern and position applied will deliberately avoid placing turbines and substructures directly above pipelines and umbilicals remaining in-situ, and abandoned well-centres at the seabed. The final offsets applied will be determined by collaboration with the oil and gas operator via a structured risk assessment approach. Any crossings will be finalised with the input and agreement with the O&G operator
CNOOC (Ettrick and Blackbird Operator)	Stakeholder engagement meetings April 2022	The conclusion was a risk assessment would be used to determine the proximity of each feature since there was no existing clear guidance in place.	The array pattern and position applied will deliberately avoid placing turbines and substructures directly above pipelines and umbilicals remaining in-situ, and abandoned well-centres at the seabed. The final offsets applied will be determined by collaboration with the oil and gas operator via a structured risk assessment approach. Any crossings will be finalised with the input and agreement with the O&G operator
CMS Legal Counsel	Meeting 6th & 7th April 2022	CMS Legal Counsel mentioned the law is unclear with regards to the interaction between renewables and O&G infrastructure on the seabed.	The array pattern and position applied will deliberately avoid placing turbines and substructures directly above pipelines and umbilicals remaining in-situ, and abandoned well-centres at the seabed. The final offsets applied will be determined by collaboration with the oil and gas operator via a structured risk assessment approach. Any crossings will be finalised with the input and agreement with the O&G operator

8.4 Assessment Methodology

8.4.1 Impact Assessment Methodology

19. In **Chapter 6: EIA Methodology**, an overarching method is presented for enabling assessments of the potential impacts arising from the Project on the receptors under consideration. Such assessments incorporate a combination of the sensitivity of the receptor, its value (if applicable) and the magnitude of the change to determine a significance of effect. This method has been followed for the assessment of marine sediment and water quality with topic specific definitions for sensitivity and magnitude provided below.

8.4.1.1 Sensitivity

20. The sensitivity of a receptor (in this case marine water quality/sediment) is dependent upon its:

- Tolerance to an impact (i.e. the extent to which the receptor is adversely affected by a particular impact);
- Adaptability (i.e. the ability of the receptor to avoid adverse effects that would otherwise arise from a particular impact); and
- Recoverability (i.e. a measure of a receptor's ability to return to a state at, or close to, that which existed before the effect caused a change).

21. The sensitivity is assessed using expert judgement and described with a standard semantic scale. Definitions for each term are provided in **Table 8.4**. Expert judgements regarding receptor sensitivity is closely guided by the conceptual understanding of baseline conditions.

Table 8.4 Definitions of Sensitivity levels for marine sediment and water quality

Sensitivity	Definition
High	The water quality of the receptor supports or contributes towards the designation of an internationally or nationally important feature and/or has a very low capacity to accommodate any change to current water quality status, compared to baseline conditions. With respect to sediment quality all inorganic/organic contaminants below sediment quality values.
Medium	The water quality of the receptor supports high biodiversity and/or has low capacity to accommodate change to water quality status. All inorganic/organic contaminants below sediment quality values.
Low	The water quality of the receptor has a high capacity to accommodate change to water quality status due, for example, to large relative size of the receiving water and capacity for dilution and flushing. Background concentrations of certain parameters already exist. Inorganic/organic contamination between lower and upper sediment quality guideline values.
Negligible	Specific water quality conditions of the receptor are likely to be able to tolerate proposed change with very little or no impact upon the baseline conditions detectable. With respect to sediments, significant contamination present, upper sediment quality guidelines regularly exceeded.

22. Water quality is considered to be of low sensitivity because the project is not located within a confined area and therefore has a high capacity to accommodate change and ability to dilute/flush any contamination. Sediment quality is also considered to be of low sensitivity given that some parameters exceed the lower sediment quality guideline values (see **Section 8.6.2**).

8.4.1.2 Magnitude

23. Prediction of the magnitude of potential impacts has been based on the consequences that the proposed project might have on marine water and sediment quality.

24. These descriptions of magnitude are specific to the assessment of impacts and are considered in addition to the generic descriptors of impact magnitude that will be presented in the EIA. Potential effectss have been considered in terms of permanent or temporary, and adverse or beneficial impacts. The magnitude of an impact is dependent upon its:

- Scale (i.e. size, extent or intensity);
- Duration;
- Frequency of occurrence; and
- Reversibility (i.e. the capability of the environment to return to a condition equivalent to the baseline after the impact ceases).

25. The magnitude of impact is assessed using expert judgement and described with a standard semantic scale. Definitions for each term of provided in **Table 8.5**.

Table 8.5 Definitions of Magnitude levels for marine water and sediment quality

Magnitude	Definition
High	Fundamental, permanent / irreversible changes, over the whole receptor, and / or fundamental alteration to key characteristics or features of the particular receptors character or distinctiveness. Water quality status degraded to the extent that a permanent or long term change occurs. Inability to meet (for example) Environmental Quality Standard (EQS) or sediment quality guidelines is likely.
Medium	Considerable, permanent / irreversible changes, over the majority of the receptor, and / or discernible alteration to key characteristics or features of the particular receptors character or distinctiveness. Water/sediment quality likely to take considerable time to recover to baseline conditions.
Low	Discernible, temporary (throughout project duration) change, over a minority of the receptor, and / or limited but discernible alteration to key characteristics or features of the particular receptors character or distinctiveness. Activity not likely to alter local status to the extent that water quality characteristics change considerably or EQSs/sediment quality guidelines are compromised.
Negligible	Discernible, temporary (for part of the project duration) change, or barely discernible change for any length of time, over a small area of the receptor, and/or slight alteration to key characteristics or features of the particular receptors character or distinctiveness. Any change to quality would be quickly reversed once activity ceases.

8.4.1.3 Impact Significance

26. Following the identification of receptor value and sensitivity and magnitude of the impact, it is possible to determine the significance of the effect. A matrix is presented in **Table 8.6** as a framework to show how a judgement of the significance of an effect has been reached.

Table 8.6 Effect Significance Matrix

		Negative Magnitude				Beneficial Magnitude			
		High	Medium	Low	Negligible	Negligible	Low	Medium	High
Sensitivity	High	Major	Major	Moderate	Minor	Minor	Moderate	Major	Major
	Medium	Major	Moderate	Minor	Minor	Minor	Minor	Moderate	Major
	Low	Moderate	Minor	Minor	Negligible	Negligible	Minor	Minor	Moderate
	Negligible	Minor	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Minor

27. Through use of this matrix, an assessment of the significance of an effect can be made in accordance with the definitions in **Table 8.7**. Impacts may be deemed as being either positive (beneficial) or negative (adverse).

Table 8.7: Significance Definitions

Effect Significance	Definition
Major	Very large or large change in receptor condition, both adverse or beneficial, which are likely to be important considerations at a regional or district level because they contribute to achieving national, regional or local objectives, or, could result in exceedance of statutory objectives and / or breaches of legislation.
Moderate	Intermediate change in receptor condition, which are likely to be important considerations at a local level.

Effect Significance	Definition
Minor	Small change in receptor condition, which may be raised as local issues but are unlikely to be important in the decision making process.
Negligible	No discernible change in receptor condition.
No Impact	No impact, therefore no change in receptor condition.

28. Note that for the purposes of the EIA, major and moderate effects are deemed to be significant. In addition, whilst minor effects are not significant in their own right, it is important to distinguish these from other non-significant effects as they may contribute to significant effects cumulatively or through interactions.

29. Following initial assessment, if the impact does not require additional mitigation (or none is possible) the residual effect will remain the same. However, if additional mitigation is proposed there will be an assessment of the post-mitigation residual effect.

30. With respect to best working practices, the Project will formulate an environmental policy specific to the Project which will set out environmental targets for all phases. The Applicant's company environmental management systems will be translated for use in the Project and referenced within the Construction Environmental Management Plan (CEMP). The policy will be included in tender documents as a requirement on contractors who must demonstrate a track record and proven ability to meet the environmental standards. The policy will also include a requirement to develop a (CEMP) to cover each phase to ensure that all legislative and regulatory requirements are met and risks to the environment are reduced as far as reasonably practicable. These plans will include details of discharges, environmental monitoring, auditing and reporting systems to be employed. Where there is the potential for pollution or an accidental spill or leak, the plans will focus on control measures that would be employed to reduce the risk of pollution such as accidental releases to the environment.

31. Given the above control measures, the risks associated with accidental release of pollutants have been scoped out (see the **Offshore Scoping Report** in **Appendix 1.2** of the **Offshore EIA Report)** and are not considered further in this chapter.

8.4.2 Cumulative Impact Assessment

32. Cumulative impacts are assessed through consideration of the extent of influence of changes to marine sediment and water quality arising from the project alone and those arising from the project cumulatively or in combination with other offshore wind farm developments but also considering any other nearby seabed activities. The approach is based on that presented in **Chapter 6: EIA Methodology**.

8.4.3 Transboundary Impact Assessment

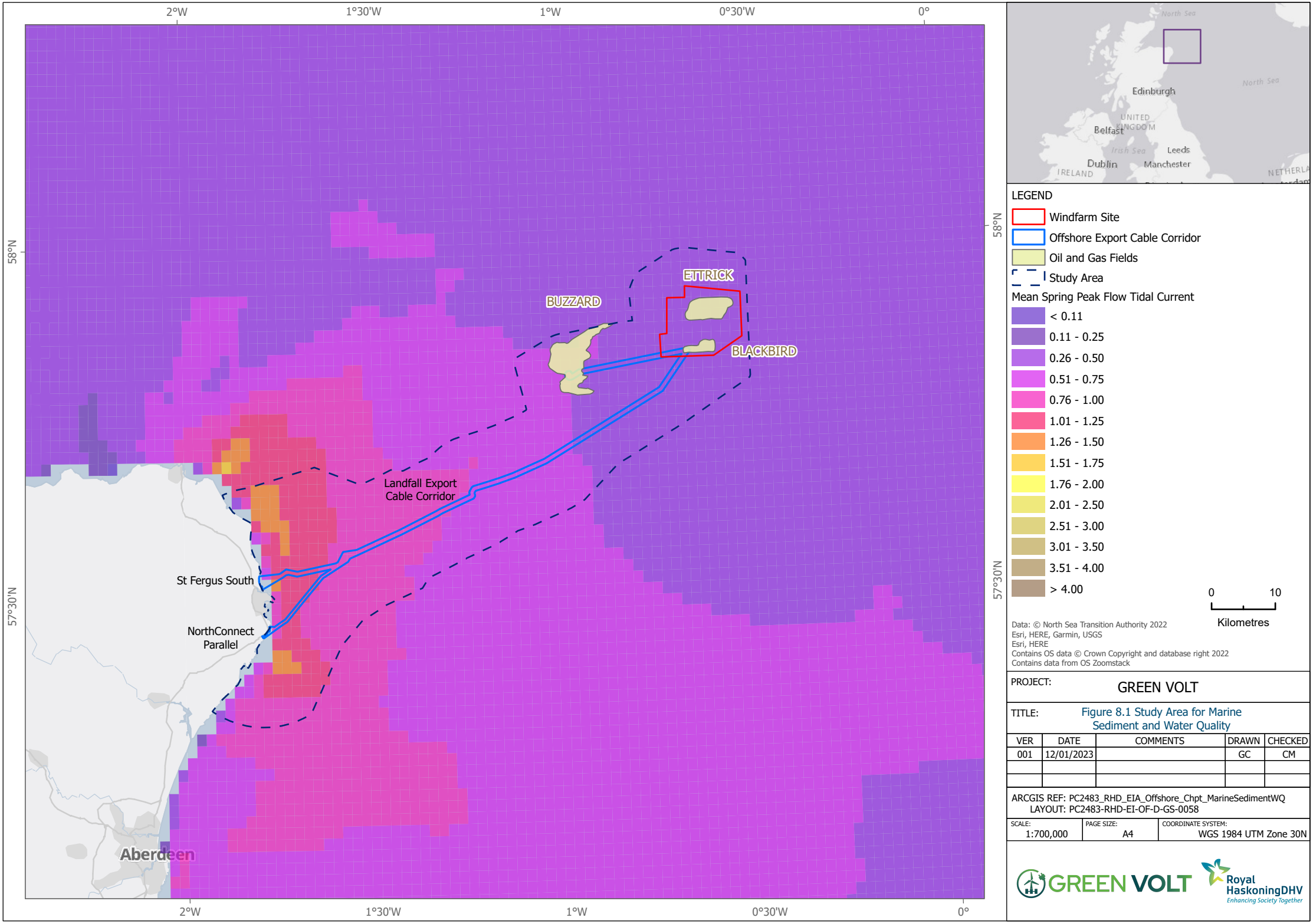
33. The localised nature of the potential impacts on marine water and sediment quality mean that significant transboundary effects are unlikely. In accordance with the **Offshore Scoping Report** (**Appendix 1.2**) transboundary impacts have been scoped out of this chapter (see **Chapter 20** and **Table 8.19**).

8.5 Scope

8.5.1 Study Area

34. Consideration of the potential effects of the Project on marine sediment and water quality are carried out over the following spatial scales as shown in **Figure 8.1**:

- The Windfarm Site: including the WTGs, floating substructures, moorings, inter-array cables and OSP;
- Buzzard Export Cable Corridor; and
- The Landfall Export Cable Corridor which connects the array site to the landfalls (two possible options; St Fergus South landfall and NorthConnect Parallel Landfall) in the vicinity of Peterhead.



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PROJECT: GREEN VOLT

TITLE: Figure 8.1 Study Area for Marine Sediment and Water Quality

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8.5.2 Existing Data Sources

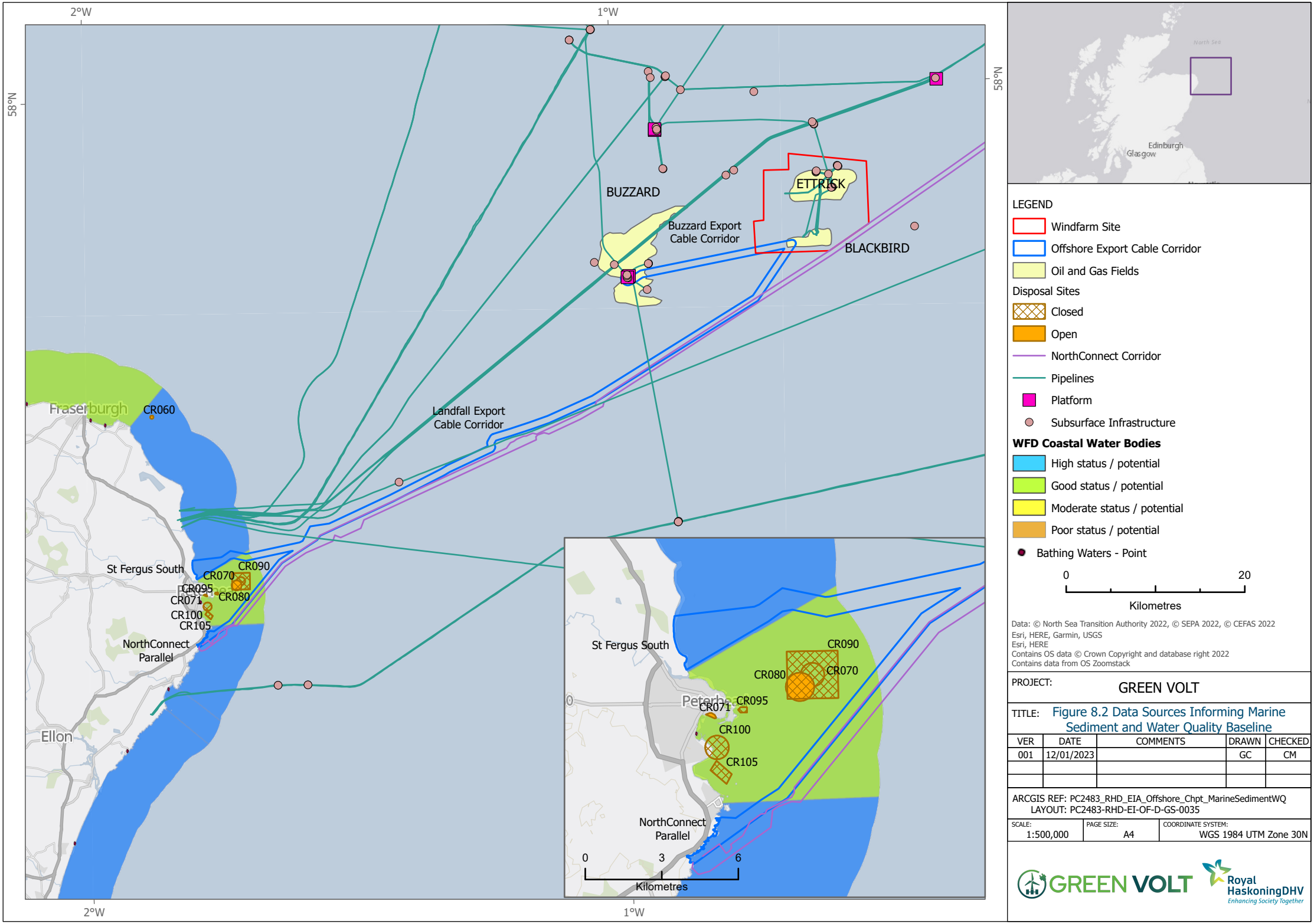
35. The Windfarm Site is located at the former Ettrick and Blackbird oil fields as shown in **Figure 8.2** which have collected data spanning approximately 20 years.

36. The proposed NorthConnect High Voltage Direct Current (HVDC) Link would provide an electrical link between Scotland and Norway, allowing the two nations to exchange power and increase the use of renewable energy. The NorthConnect HVDC Link would make landfall at Longhaven Bay just south of Peterhead as shown in **Figure 8.2**. Data collected for this project is therefore relevant to this assessment.

37. The two landfall options for the Project (the NorthConnect Parallel Landfall and the St Fergus South Landfall) lie within the following waterbodies as shown in **Figure 8.2**: Cairnbulg Point to the Ugie Estaury (to the north), and Buchan Ness to Cruden Bay (to the south). The closest bathing water beaches are Cruden Bay and Peterhead (Lido) (**Figure 8.2**). A long sea outfall (Scottish Water) is located to the south of Peterhead harbour and the water discharge location for the Peterhead power station (**Figure 8.2**).

38. Three dredge disposal sites (sediment from dredging projects), approximately 3 km from shore are located within the vicinity of the two options for landfall (the NorthConnect Parallel Landfall and the St Fergus South Landfall) (**Figure 8.2**), the open disposal sites ‘North Buchan Ness’ and ‘Peterhead’ and the closed ‘Middle Buchan Ness’. It should be noted, however, that these disposal sites have been avoided by the routeing for both the NorthConnect Parallel Landfall and the St Fergus South Landfall options (see **Section 8.7.1**).

39. **Table 8.8** summarises the existing data available used in this assessment.



LEGEND

- Windfarm Site
- Offshore Export Cable Corridor
- Oil and Gas Fields

Disposal Sites

- Closed
- Open
- NorthConnect Corridor
- Pipelines
- Platform
- Subsurface Infrastructure

WFD Coastal Water Bodies

- High status / potential
- Good status / potential
- Moderate status / potential
- Poor status / potential
- Bathing Waters - Point

0 20

Kilometres

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TITLE: Figure 8.2 Data Sources Informing Marine Sediment and Water Quality Baseline

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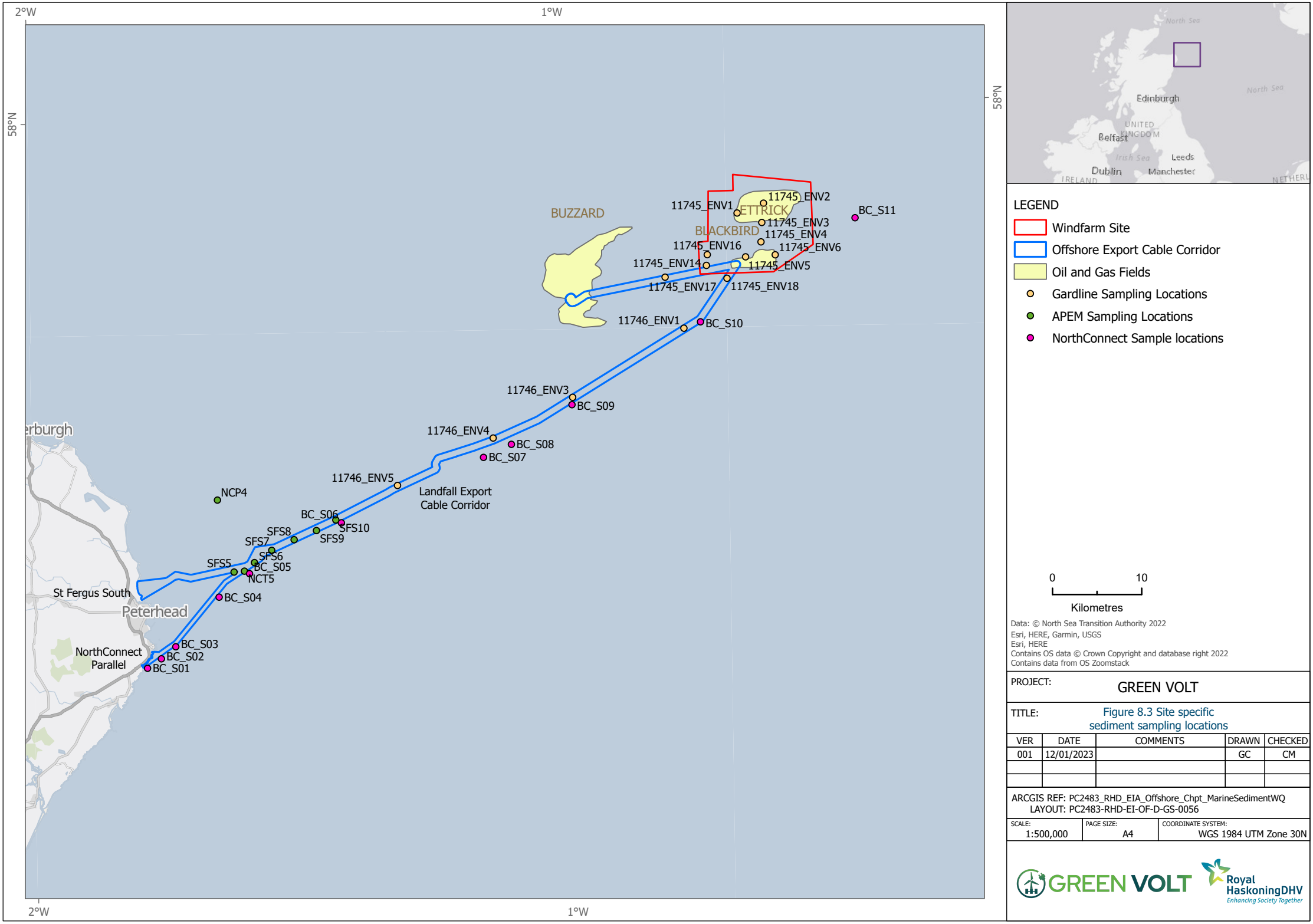
Table 8.8: Data Sources

Data	Year	Coverage	Confidence	Notes
Bathing waters and Scottish Water discharge locations collected by the SEPA	2021	Landfall and export cable corridor area	High	Found at https://www.sepa.org.uk/data-visualisation/water-classification-hub/
Water quality (clean and safe data) National Marine Plan Interactive (NMPI) data. Marine Scotland NMPI database	Various	UK	High	The Clean and Safe seas section of Marine Scotland Information covers the various components that are measured to ensure that the seas are clean and safe: including the inputs of natural substances and man-made contaminants. The information is derived mainly from the monitoring programmes of Marine Scotland and SEPA Found at Clean and Safe | Marine Scotland Information.
Existing sediment quality data from Ettrick and Blackbird oil field surveys (2006-2021).	Various	Particle Size Analysis (PSA) and contaminants analysis in Windfarm Site	High	Site-specific information available
NorthConnect – sediment data provided in the NorthConnect HVDC Cable Infrastructure UK EIA Report (2018)	2016/2017	Sediment quality only for cable corridor (adjacent to southern option)	High	Cable route located directly adjacent to proposed Southern cable route
Information presented in Technical report produced for Strategic Environmental Assessment – SEA2 Contaminant Status of the North Sea (Cefas 2001)	Various	North Sea	High	Considers the major potential sources of chemical contamination of the North Sea from oil and gas exploration and production activities in northern, central and southern production field areas of the North Sea and provides mean concentrations for selected contaminants in estuaries, coastal environment, offshore and in sediments within oil and gas installations
UKOOA An Analysis of UK Offshore Oil and Gas Environmental Gas Surveys (UKOOA., 2001)	1975-95	North Sea	High	Study which transferred historical environmental survey data around oil and gas platforms from paper reports into a database. Provides mean values for estuaries, offshore and within oil and gas installations also referenced in Cefas 2001.

8.5.3 Site-Specific Surveys

40. During August and September 2021, Gardline Limited conducted a debris clearance survey and an environmental baseline survey within the footprint of the Ettrick and Blackbird oil fields. These surveys covered the Windfarm Site, part of the Landfall Export Cable Corridor and the associated Buzzard Export Cable Corridor as shown in **Figure 8.3**. A total of 14 samples were collected for Particle Size Analysis (PSA) and chemical contaminant analysis.

41. Sediment samples were also collected by APEM as part of a site-specific survey considering the second of the two export cable routes - St Fergus South Export Cable Corridor option, in 2022 as shown in **Figure 8.3**.



LEGEND

- Windfarm Site
- Offshore Export Cable Corridor
- Oil and Gas Fields
- Gardline Sampling Locations
- APEM Sampling Locations
- NorthConnect Sample locations

0 10

Kilometres

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TITLE: Figure 8.3 Site specific sediment sampling locations

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8.5.4 Assumptions and Limitations

42. None to note.

8.6 Existing Environment

8.6.1 Water Quality

8.6.1.1 Physical Parameters

Currents and water column mixing

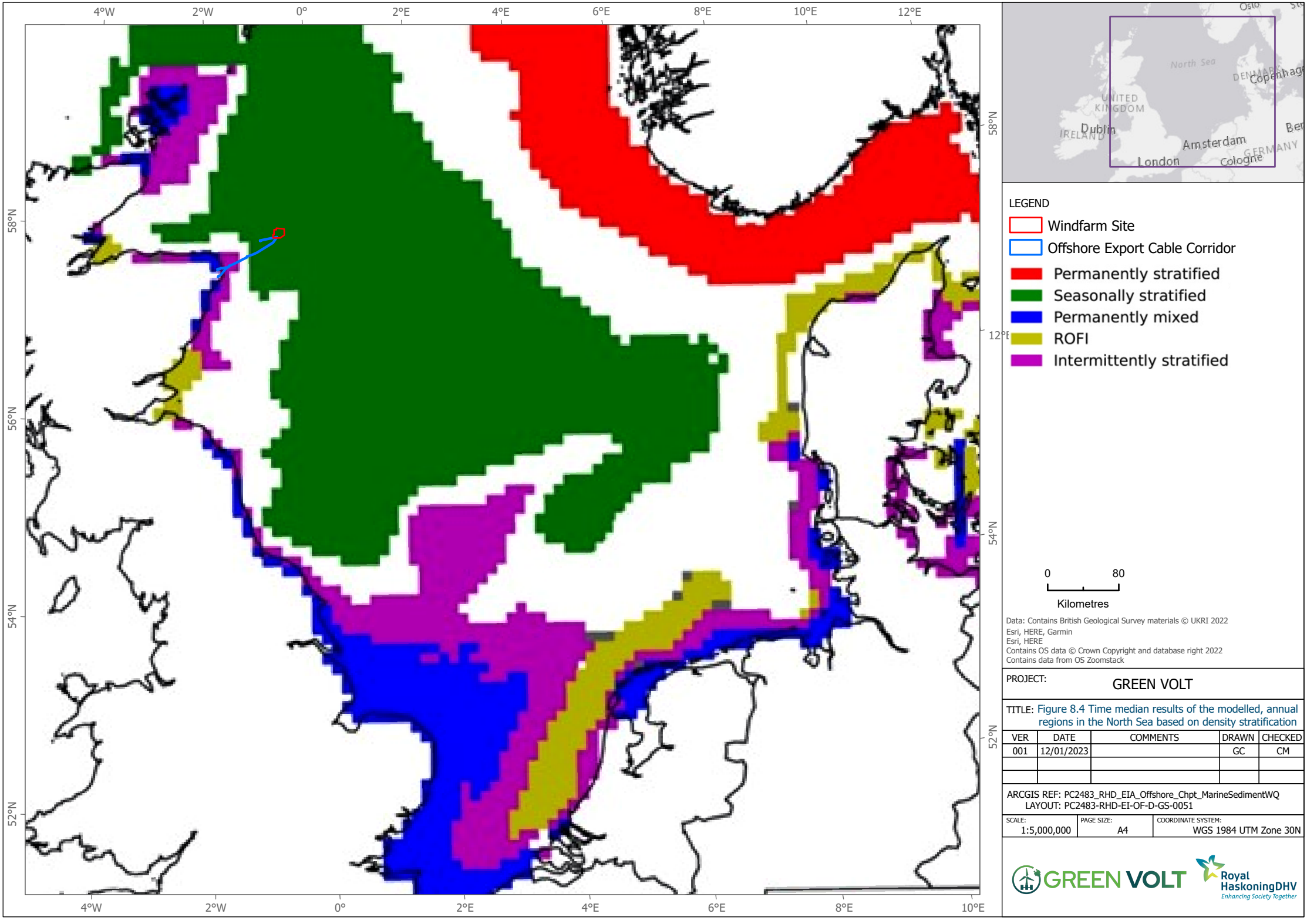
43. Current speeds and extreme tidal current surges for the Windfarm Site are comparably low when compared to other floating offshore wind farms located closer to the coast. This was confirmed by reviewing the multibeam survey data and identifying features on the seabed from previous oil and gas exploration and operation activities within the Ettrick and Blackbird oil field areas (pipelines and previous mooring patterns evident on the seabed). The oil and gas subsea infrastructure and older oil and gas wells dating back to the 1980s can still be clearly seen, with their associated sediment mounds around them on the 2021 multibeam surveys (Gardline, 2021) (**Appendix 8.1**). This demonstrates that the tidal currents at this location are not sufficiently strong enough to mobilise these recently deposited sediments.

44. With respect to water column mixing, the only data available is the output from a 51-year simulation period using an applied ecosystem General Estuarine Transport Model (GETM) (specifically the coupled hydro-bio-geo-chemical model, van Leeuwen *et al*., (2015)). This study delineated the North Sea into five distinct regimes, based on multi-decadal stratification characteristics as follows:

    1. Permanently stratified;
    2. Seasonally stratified;
    3. Intermittently stratified;
    4. Permanently mixed; and
    5. Region of freshwater influence.

45. Whilst each region shows some interannual variation in geographic coverage (meaning that 29% of North Sea waters fail to classify as any one particular defined stratification regime), they are overall remarkably stable features within the North Sea.

46. The time median results of the modelled annual regions in the North Sea, based on density stratification, are reproduced in **Figure 8.4**. This shows that the Windfarm Site is within a region of the North Sea classified as being seasonally stratified. This region extends widely across the northern and central North Sea (representing, on average over the 51-year period, 27% of North Sea waters) and is stated to thermally stratify in spring when air temperatures increase and stay stratified until autumn processes remix the water column. Winter is characterised by continuous mixed conditions. These results are not unexpected given the water depths at the Windfarm Site are typically in the order of 100 m – 115 m and there would be an expected measurable temperature difference between the water surface and the near-bed layers of the water column during spring and especially summer months, and possibly extending into early autumn.


4°W
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4°E
6°E
8°E
10°E
12°E
58°N
56°N
54°N
52°N
North Sea
DENMARK
Copenhagen
UNITED KINGDOM
Dublin
IRELAND
Amsterdam
London
Cologne
GERMANY
LEGEND
Windfarm Site
Offshore Export Cable Corridor
Permanently stratified
Seasonally stratified
Permanently mixed
ROFI
Intermittently stratified
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TITLE: Figure 8.4 Time median results of the modelled, annual regions in the North Sea based on density stratification
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Suspended solid concentrations

47. The Southern North Sea Transport Study identified that the northern North Sea, with weaker tidal currents and deeper water, has lower suspended particulate matter (SPM) concentrations than the southern North Sea (United Kingdom Marine Monitoring and Assessment Strategy, 2010). This difference between the southern and northern North Sea areas is supported by information on SPM values presented in Cefas (2001) and reproduced in **Figure 8.5**. Baseline SPM values in the study area are therefore expected to be relatively low i.e. within 0.2 to 1 mg/l.

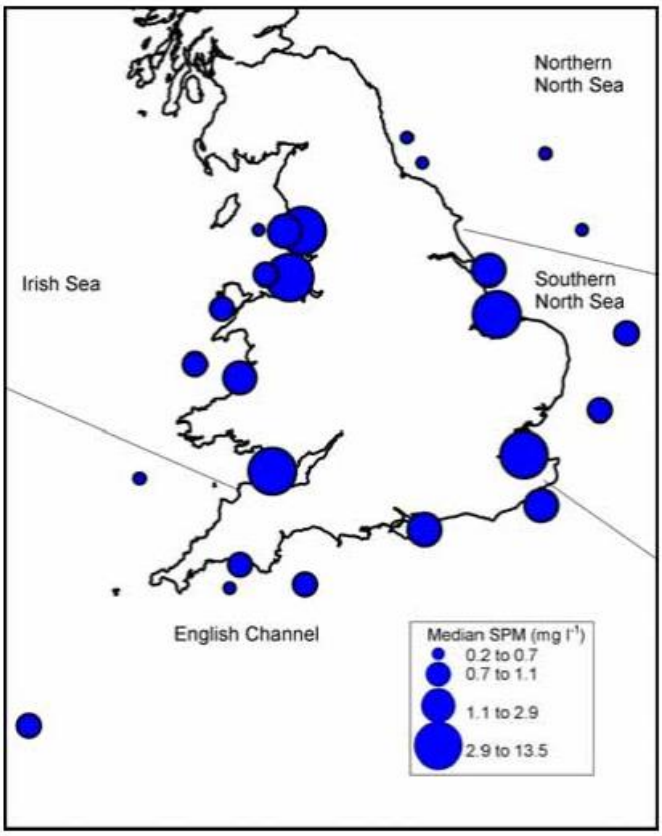


Figure 8.5 Map illustrating difference in median suspended particulate matter concentrations (mg/l) between the southern and northern North Sea areas (taken from Cefas 2001)

8.6.1.2 Other Water Quality Parameters

48. Given the oil and gas history of the Windfarm Site, the main contaminants (if present) are likely to come from produced water and drill cuttings. Drill cuttings consist of the fragments of rock that are removed as each oil or gas well is drilled, mixed with drilling muds (or drilling fluids) which are used to lubricate the drill bit, carry rock fragments back to the surface and maintain pressure in the well as it is drilled. Produced water from the platforms can contain biocides, corrosion inhibitors, gas treatment and scale inhibitors. Any chemicals used and discharged by the oil and gas industry have to be permitted by the regulator after completion of a chemical risk assessment and an environmental assessment to demonstrate that there will be no significant environmental impacts.

49. The Ettrick and Blackbird Decommissioning Programmes (Nexen, 2017) states there are no drill cuttings piles in either field and no oil based mud discharge was reported at either site. Nexen (2017) also reports that there are no piles that exceed the OSPAR criteria, and they will be left in place to degrade naturally. From this it is determined that water-based muds will have been used and discharged with drill arisings under the appropriate permit from Department for Business, Energy and

Industrial Strategy - Offshore Petroleum Regulator for Environment and Decommissioning (BEIS-OPRED) following a chemical risk assessment to confirm that there would be no significant environmental effects either at the time or in the future. The OSPAR Recommendation 2006/5 on the Management Regime for Offshore Cuttings Piles says that if water-based drilling fluids were used then no further investigation is necessary and the criteria/thresholds do not need to be applied, which would be the case for the Ettrick and Blackbird fields. Due to the nature of water-based mud drill arisings and their discharge being mostly within the water column rather than at the seabed it is more likely for the drill arisings to become widely dispersed as a thin veneer rather than forming piles, particularly when drilling is undertaken from a mobile offshore drilling unit rather than a fixed platform drilling package.

50. The array pattern and position applied will deliberately avoid placing turbines and substructures directly above pipelines and umbilicals remaining in-situ, and abandoned well-centres at the seabed. The final offsets applied will be determined by collaboration with the oil and gas operator via a structured risk assessment approach. Any crossings will be finalised with the input and agreement with the oil & gas (O&G) operator.

51. In the North Sea, water samples with the highest levels of chemical contamination are generally found at inshore estuary and coastal sites subject to high industrial usage (Cefas, 2001). High concentrations of total hydrocarbons (THC) tend to occur in the immediate vicinity of oil and gas installations offshore, although concentrations in the water column generally fall to background levels within a very short distance from the point of discharge (Cefas, 2001). OSPAR (2017) identified that concentrations of pollutants across all sampled sites in the North Sea are elevated above normal background levels.

52. As stated in **Section 8.5.1**, the two landfall options lie within the following waterbodies: Cairnbulg Point to the Ugie Estuary (to the north), and Buchan Ness to Cruden Bay (to the south). Both waterbodies have been classified as having ‘high’ status under the WFD (SEPA Water Classification Hub 2022) thus indicating that parameters pass their respective water quality EQS’ for chemical parameters and are at high status for dissolved oxygen and dissolved inorganic nitrogen.

53. The closest bathing waters are Cruden Bay and Peterhead (Lido). Cruden Bay bathing water is a long sandy bay, about 2.5 km long, backed by sand dunes. This bathing water is subject to short term pollution when heavy rainfall washes bacteria into the sea. Pollution risks include faecal contamination via agricultural run-off, combined sewer overflows and gulls congregating at the mouth of the Water of Cruden.

54. Peterhead (Lido) bathing water is in Peterhead harbour and forms the shoreline of a boating marina situated within the outer harbour. The sandy beach is approximately 300 m long with pollution sources linked to wet weather resulting from surface water urban drainage and combined sewer overflows. It is also located in a Nitrate Vulnerable Zone indicating a risk associated with elevated nitrate concentrations.

55. Water quality monitoring at these sites measures concentrations of microbiological parameters and Cruden is classified as having ‘Good’ water quality and Peterhead (Lido) as ‘Excellent’ water quality. A long sea outfall (Scottish Water) is located to the south of Peterhead harbour and the water discharge location for the Peterhead power station. No known outfalls are sited within St Fergus South Landfall option (north of Peterhead).

8.6.2 Sediment Quality

8.6.2.1 Physical characteristics

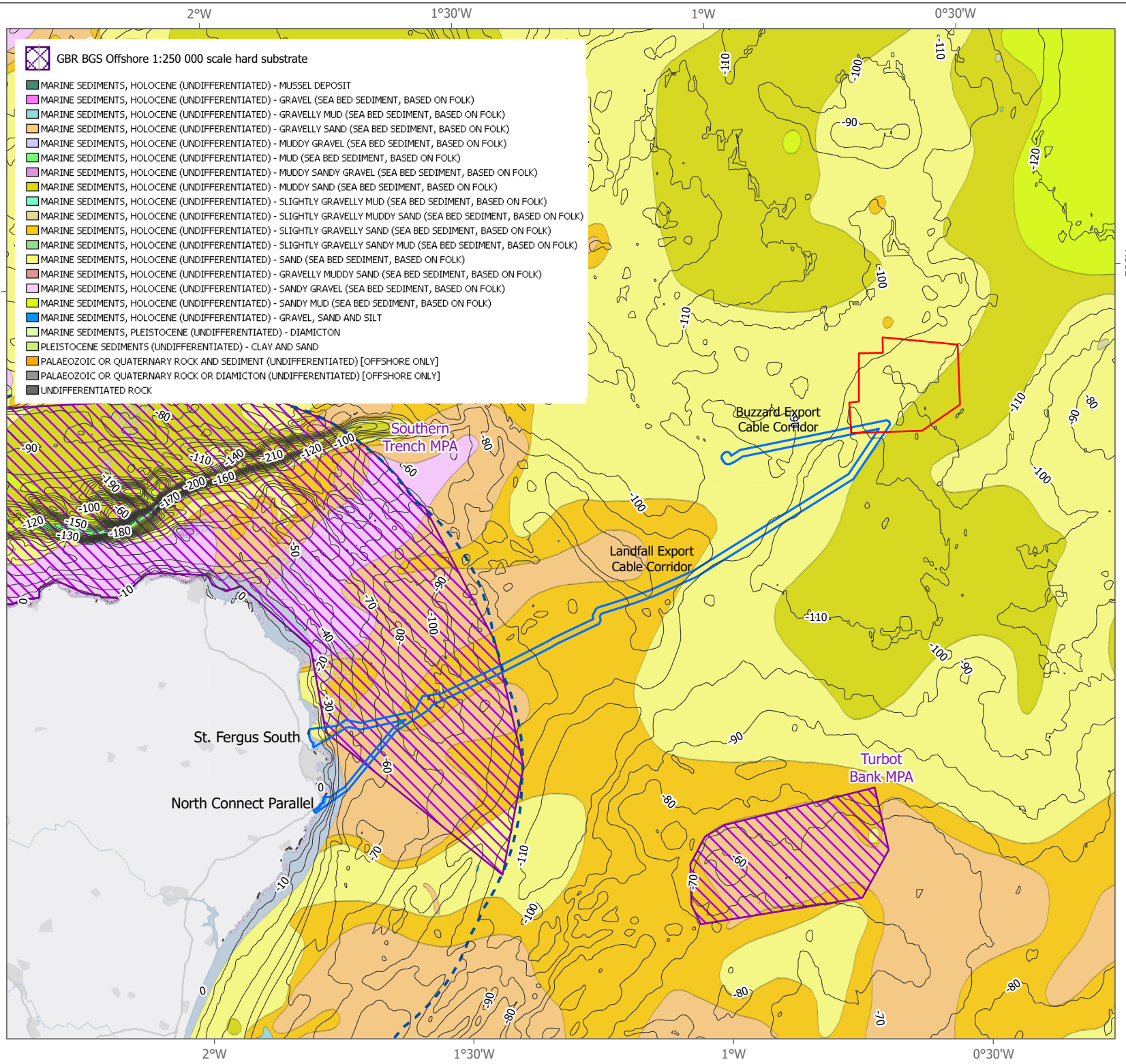
56. Sediment grain size is important to inform assessment of the risk of contamination because finer grained materials (silts and clays) function as a sink for contaminants and therefore have a greater potential to retain contaminants than larger grained materials (Cefas, 2001). For example, particles

of various types and sizes, notably the silt/clay fraction, can absorb petroleum hydrocarbons from sea water and, through this pathway, hydrocarbons become incorporated into the sediment system. Organic matter within the sediment matrix is also likely to absorb hydrocarbons and heavy metals, providing a means of transport and incorporation into sediments. Sediment grain size also assists in predicting the extent of any sediment plume should the material be disturbed.

57. The online British Geological Survey (BGS) GeoIndex Offshore data for seabed sediments, shown in in **Figure 8.6** indicates that the seabed in the Windfarm Site is sand and muddy sand and that the Buzzard Export Cable Corridor is predominantly sand. The export cable corridor predominantly consists of gravelly sand and slightly gravelly sand with gravel close to the shore.

58. The seabed geology along the NorthConnect Export Cable Corridor (immediately adjacent to the NorthConnect Parallel landfall option) consists of bedrock outcropping at the coastal cliffs, followed by fine gravelly sand and silty fine sand to 1.5 km from shore. Between 1.5 km and 4.0 km from shore, the seabed is coarser, dominated by sand and gravel, with gentle gradients and steep bedrock outcrops. Some large ripples, megaripples, individual boulders and boulder fields were also identified as being present (NorthConnect, 2018).

59. The PSA data for the St Fergus South Landfall option shows that all samples consisted of predominantly sand, with varying proportions of gravel and low proportions of silt/clay. As presented in **Figure 8.6**, stations NCP5, SFS7, SFS9 and SFS10 had the highest proportions of sand (74 - 91%), with moderate proportions of gravel. Stations NCP4, SFS5, SFS6 and SFS8 had relatively high proportions of gravel (31 - 47%) (APEM, 2022).



LEGEND

- Windfarm Site
- Offshore Export Cable Corridor
- Marine Protected Area (MPA)
- 12nm Limit
- Bathymetry Contours

0 20

Kilometres

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TITLE: Figure 8.6 Seabed Sediments in the vicinity of the Development and Export Cable Corridor

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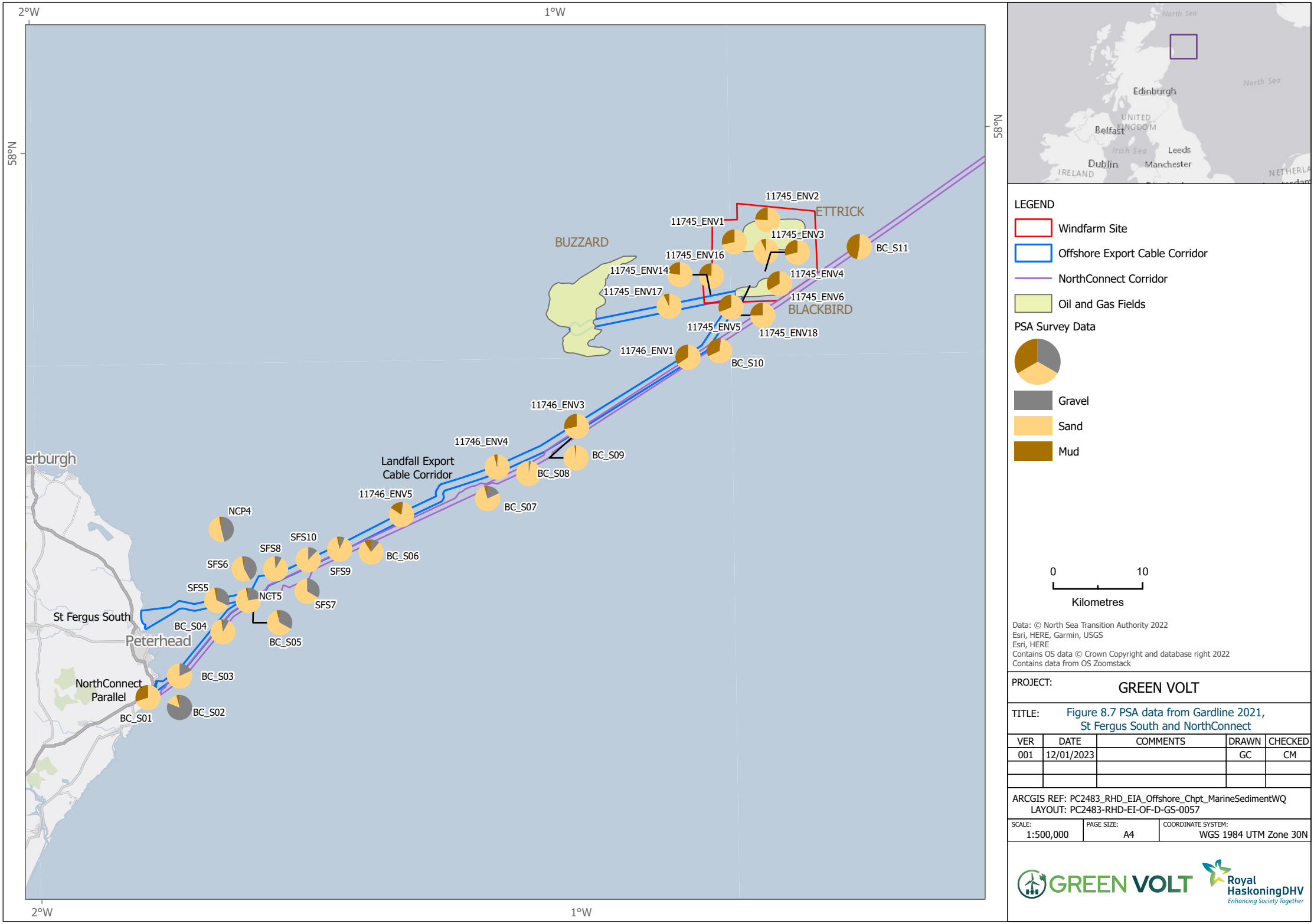

PROJECT: GREEN VOLT

TITLE: Figure 8.7 PSA data from Gardline 2021, St Fergus South and NorthConnect

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60. From within the Windfarm Site, sediment data is available from a number of surveys, the outputs of which are summarised in **Table 8.9**. The sediment data in the area of the Ettrick subsea infrastructure is sand and muddy sand and the sediment in the area of the Blackbird development is predominantly fine silty sand to very fine sands. This was supported by the findings of the Green Volt Environmental Surveys undertaken in 2021 (Gardline 2022) which found that seabed sediments were predominantly fine silty sand with occasional shell fragments.

Table 8.9 Summary of sediment data available within the Windfarm Site

Survey and year	Areas covered	Seabed sediment results
Fugro 2006 RIG SITE SURVEY UKCS 20/2a & 20/3a ETTRICK DRILL SITES. Volume II: Environmental Baseline Survey	Ettrick	Sediment distribution across the site is homogeneous, comprising poorly sorted, very fine sand and moderately sorted fine sand located in a shallower area to the north of the Survey Area. The proportion of sand at the majority of sample locations, ranged from 78.3% to 87.1% and the proportion of fines ranged from 12.8% to 21.7%.
Ettrick Debris Clearance and Green Volt Environmental Surveys – 2021 (Gardline, 2022)	Ettrick, Windfarm Site, Landfall Export Cable Corridor and Buzzard Export Cable Corridor	Results of the PSA presented muddy sand to sand sediment type. Sand (≥63µm and <2 mm) was the dominant fraction across all stations accounting for between 66% and 95% of the sediment. Gravel (≥2 mm) was absent at three stations and accounted for less than 1% of the sediment composition at all remaining stations, with the exception of one station where gravel accounted for 2% of the sediment.
Sediment sampling Blackbird – sampling by Gardline in 2007	Blackbird Development location	Seabed sediments dominated by fine silty sand to very fine sands. The Blackbird to Ettrick route survey confirmed that the sediment was generally uniform throughout the survey corridor and between stations, consisting of silty fine sand.
Sediment sampling in 2009/2010 (Gardline, 2010).	Blackbird Development location	Recorded poorly sorted to very poorly sorted muddy very fine sand at most locations at the Blackbird Development site with 27% to 35% fines and less than 1% gravel. A shallower region sampled was found to have very poorly sorted muddy very fine to medium sand with a slightly lower proportion of fine material at 23%. The slightly coarser nature of the sediment is consistent with the higher levels of exposure likely at a shallower location.
Repeat sediment sampling of Blackbird Development Location in 2007 and 2009	Blackbird Development location	Revealed changes in sediment composition to increased fines – considered likely to be due to the presence of fine drilling muds associated with drilling the PB1 well.

61. Overall, seabed sediments in the Windfarm Site are predominantly sand or muddy sand. The coastline consists of areas of hard substrate located in the nearshore environment with sediment particle sizes gradually decreasing from gravelly sand to fine sand along the Offshore Export Cable Corridors. This is considered to reflect increased tidal current velocities closer to the Aberdeenshire coastline.

8.6.2.2 Contaminants

Offshore

62. Given that the Windfarm Site is located within the Blackbird and Ettrick Oil and Gas fields, specific contaminants and groups of contaminants have been analysed to identify the potential impact the activities in the area have had on the seabed sediments (see **Table 8.10**). To evaluate concentrations, data is compared to background levels and trends throughout the North Sea where they have been sampled, as indicated in Cefas 2001 and UKOOA 2001. **Table 8.13** summarises the results of the sediment data available with the main findings against the parameters listed in **Table 8.10** and background concentrations in **Table 8.11** and **Table 8.12**.

Table 8.10 Specific offshore oil and gas sediment contaminant indicators and reason for use as an indicator

Indicator	Explanation
Total Hydrocarbon (THC)	Provides an indication of the total oil in the sediment but does not give an indication of the source
Unresolved Complex Mixture (UCM)	Represents a large variety of branched alicyclic hydrocarbons, which remain after substantial weathering and biodegradation of petrogenic inputs has taken place. Abundant UCM is indicative of either degraded or weathered oil residues, and therefore its occurrence in environmental samples is an indicator of oil pollution.
Total alkane concentrations	Alkanes are the simplest aliphatic compounds. They are less susceptible to weathering than their straight chain equivalents and are therefore of use when investigating the degree of weathering of a sample. They can also provide valuable information to aid in the determination of hydrocarbon sources
Total Polyaromatic Hydrocarbon (PAH) concentrations	Distribution of the measured PAHs and their alkyl derivatives can suggest origin
Carbon preference index (CPI)	Assesses the relative contribution from petrogenic and biogenic sources in hydrocarbon samples and is determined by calculating the ratio of the sum of odd- to the sum of even-carbon alkanes.
Pristane and phytane	Isoprenoidal alkanes which are common constituents of crude oils. However, phytane is generally absent or only present at low levels in uncontaminated natural systems. A presence of both isoprenoids at certain levels is therefore taken as an indication of petroleum contamination.
Barium	Indicates presence of barite rich drilling mud.
Metals	Apart from barium being an indicator of discharges of drilling fluids, most metals are introduced to the sediment as impurities in the barite used in the drilling fluids, and therefore occur at relatively low concentrations. Higher concentrations may, however, occur in drill cuttings due to the mineral composition of the formation drilled. The most relevant elements are cadmium, chromium, lead, copper, mercury and zinc.
NPDs (sum of naphthalene, phenanthrene, dibenzothiophene)	Sum of naphthalene, phenanthrene/anthracene, dibenzothiophene and their C1, C2, C3 alkyl-homologues -indicative of petroleum derived aromatic hydrocarbons

Table 8.11 Concentrations of contaminants typically found in surface sediments from the North Sea (taken from Cefas 2001)

Location	THC	PAH (list of 16 compounds)	PCB	Nickel	Copper	Zinc	Cadmium	Mercury
Coast	-	0.2-2.8	6.8-19.1	-	-	-	-	-
Offshore	17-120	-	2	-	-	-	-	-
Oil and Gas installations	10-450	0.2-2.7	<1	9.5	3.96	20.87	0.43	0.16

Table 8.12 Concentrations of contaminants typically found in surface sediments from the North Sea (taken from UKOOA 2001)

n-alkanes	CPI	PAH	THC	NPD
Mean values for the Central North Sea 0.4 mg/kg and 95%ile of 1.18 mg/kg	Mean value for Central North Sea 2.0 with 95%ile of 2.8	Mean values for the Central North Sea 0.287 mg/kg	Mean values for the Central North Sea 9.5 mg/kg with a 95%ile of 40.1 mg/kg	Mean values for the Central North Sea 0.105 mg/kg

Table 8.13 Summary of main sources of contaminant information in relation to sediment chemistry for previous projects

Survey and year	Areas covered	Contaminant observations
Fugro 2006 NEXEN PETROLEUM U.K. LIMITED RIG SITE SURVEY UKCS 20/2a & 20/3a ETTRICK DRILL SITES. Report No.: 68 - 8713.2 Volume II: Environmental baseline Survey (2006)	Ettrick drill sites	THC ranges are lower than mean levels recorded for the Central North Sea and expected concentrations for oil and gas installations. The majority of n-alkane concentrations were lower than the published mean values for this region of the North Sea. CPI values for total n-alkanes across the site ranged from 2.00 to 2.57. Pristane and phytane concentrations were generally low and consistent across the site and considered to be typical concentrations for this region of the North Sea. All the GC traces dominated by a UCM considered to relate to a combination of the degradation products of terrestrial n-alkanes from plant cuticular waxes and ubiquitous low-level hydrocarbon contamination from oil and gas exploration and production. Concentrations of total PAHs showed a similar trend to that of THC in that the higher concentrations were consistent with hydrocarbon contamination originating from the nearby well (well 20/2-3). The 2-6 ring PAH concentrations recorded at all stations were lower than the published mean values for the Central North Sea and considered representative of background concentrations.

Survey and year	Areas covered	Contaminant observations
		Higher levels of certain heavy and trace metals consistent with potential contamination from the historic well 20/2-3. Well plugged and abandoned in 1983 (data from UK DEAL Database), but higher levels of heavy and trace metals from drilling activities prior to 1983 have persisted in the surrounding sediments. Majority of heavy and trace metal concentrations were within published mean concentrations for the Central North Sea therefore are considered to represent background levels. The exceptions were barium, iron and lead which recorded concentrations above published values at the majority of stations. This is consistent with the generally elevated levels of oil and gas exploration in this region, with at least seven wells located within 4 km of the proposed Ettrick Drill Centre. PAH distribution consistent with a relatively uncontaminated site. Minor contribution by petrogenic PAHs as shown by the raised area around the alkyl homologues for PAHs 128 and 178.
Blackbird Development Environmental Statement. Sediment sampling in 2009/2010	Blackbird Development location	THC levels ranged from 1.9 to 6.0 mg/kg which are significantly lower than the levels expected for both offshore and oil and gas installation locations and generally comparable with natural background levels . At station close to the PB1 well, the THC level was 42.0 mg/kg, an elevated concentration resulting from the recent drilling activity. The UCM levels at all but one of the Blackbird Development location and Blackbird to Ettrick flowline route were within the normal background range for the Central North Sea. The UCM level at the sampling station close to the PB1 well was indicative of low-level but relatively recent low toxicity oil-based mud (LTOBM). Total alkane concentrations at all but one of the Blackbird Development location and Blackbird to Ettrick flowline route were within the normal background range for the central North Sea. The total alkane concentration was elevated close to the PB1 well. Total PAH concentrations were considered to be typical of the wider area. The distribution of the measured PAHs and their alkyl derivatives suggested that they were predominantly of pyrogenic (burning of fossil fuel) origin. At the sampling station close to the PB1 well, the distribution of the measured PAHs indicated petrogenic contamination. Overall, the hydrocarbon concentrations were typical for the region, indicating that the background organics were predominately from a natural biogenic origin as opposed to anthropogenic sources, e.g. drill cuttings, flare drop out, apart from at the PB1 well location where point source petrogenic contamination was apparent. Barium concentrations were generally below the background concentrations of barium expected in this area of the North Sea apart from sample taken close to the PB1 well (4,600 mg/kg) which showed clear evidence of barite rich drilling mud. Along the Blackbird to Ettrick flowline route, barium concentrations ranged from 450 mg/kg to 540 mg/kg.

63. Overall, chemical analysis on sediment samples from the Blackbird location show values to generally be within typical background levels for the North Sea. However, the levels of barium, alkanes, mercury, iron, lead and zinc were found to be above background levels in the sample taken close to the PB1 well, these elevated levels being attributed to historical drilling contaminants (Genesis 2016).

64. The sediments data for the Ettrick area show that concentrations of the majority of the heavy metals are within published mean concentrations for the central North Sea. The exceptions, barium, iron and lead, were moderately above these published values. THC and concentrations of n-alkanes and PAHs were considered to represent background levels for the central North Sea (Genesis, 2016).

65. A site-specific survey was undertaken at the Windfarm Site and Buzzard Export Cable Corridor in 2021 at which 14 sites were sampled for sediment chemistry as shown in **Figure 8.8**. The hydrocarbon data for the main indicator groups is analysed in detail in Gardline 2022 and summarised in **Table 8.14**.

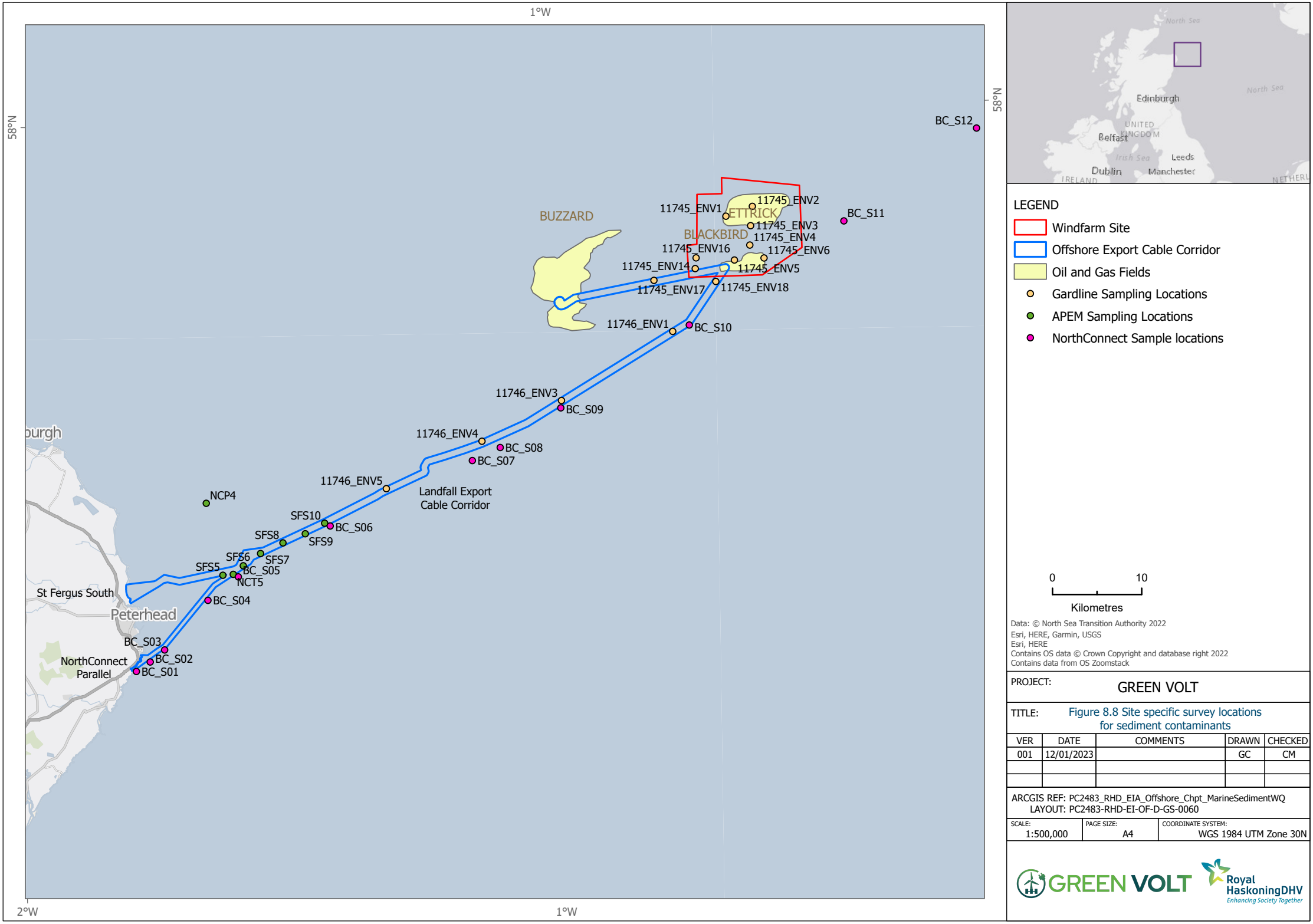
Table 8.14 Summary of site-specific data collected in 2021 within the Windfarm Site (Gardline, 2022) - hydrocarbons

Survey location	THC (mg/kg)	UCM (mg/kg)	n-alkanes (mg/kg)	CPI	Total PAH (µg/kg)	NPD (µg/kg)
11745 ENV1	6.8	4.7	0.221	2.7	0.113	0.024
11745 ENV2	8.2	5.8	0.224	3.1	0.092	0.016
11745 ENV3	10.7	7.9	0.310	2.5	0.163	0.034
11745 ENV4	8.1	6.4	0.196	2.7	0.111	0.019
11745 ENV5	5.8	4.5	0.146	3.4	0.060	0.012
11745 ENV6	8.9	6.4	0.244	3.7	0.134	0.028
11745 ENV14	6.0	4.3	0.085	2.9	0.036	0.005
11745 ENV16	8.2	5.6	0.173	2.1	0.074	0.016
11745 ENV17	4.6	3.5	0.058	1.6	0.011	-
11745 ENV18	8.8	6.0	0.180	3.5	0.100	0.017
11746 ENV1	13.1	8.5	0.285	1.8	0.116	0.023
11746 ENV3	5.6	4.1	0.054	2.1	0.010	-no data
11746 ENV4	4.3	2.9	0.038	-no data	0.004	-no data
11746 ENV5	11.0	6.3	0.169	-no data	0.033	0.009

66. Across the survey area THC concentrations (including n-alkanes, pristane, phytane, UCM and PAHs) ranged from 4.3µg/g to 13.1µg/g, with a mean of 7.9µg/g. When compared to UKOOA (2001) reported mean values, most stations are below the mean and therefore are comparable to background concentrations. When considering the distribution of hydrocarbons, Gardline (2022) report that they are considered typical of background levels of hydrocarbon inputs in areas of historic oil and gas exploration, such as the North Sea.

67. With respect to the CPI, Gardline (2022) conclude that values recorded indicate a mixture of biogenic and petrogenic inputs; with biogenic aliphatic hydrocarbons within the high molecular weight range, such as higher plant waxes being more dominant. The predominance of biogenic pristane over phytane suggest that primarily biogenic aliphatic hydrocarbons contributed to the THC concentrations at all stations. As with THC values, PAH values were relatively consistent across the site and indicated the predominance of sediment hydrocarbons from pyrogenic sources.

68. With respect to metal concentrations, the data is presented in **Table 8.15**.



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PROJECT: GREEN VOLT

TITLE: Figure 8.8 Site specific survey locations for sediment contaminants

VER	DATE	COMMENTS	DRAWN	CHECKED
001	12/01/2023		GC	CM

ARCGIS REF: PC2483_RHD_EIA_Offshore_Chpt_MarineSedimentWQ
LAYOUT: PC2483-RHD-EI-OF-D-GS-0060

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Table 8.15 Summary of site-specific data collected in 2021 within the Windfarm Site (Gardline, 2022) -metals. Coloured dots against each sediment quality guideline are used to indicate where there is an exceedance

Survey location/sediment guideline	Arsenic	Barium	Cadmium	Chromium	Copper	Mercury	Nickel	Lead	Zinc
TEL	7.24	-	0.7	52.3	18.7	0.13	15.9	30.2	124
PEL	41.6	-	4.2	160	108	0.7	42.8	112	271
BAC	25	-	0.31	81	27	0.07	36	38	122
ERL	-	-	1.2	81	34	0.15	-	47	150
AL1	20	-	0.4	50	30	0.25	30	50	130
AL2	70	-	4	370	300	1.5	150	400	600
11745 ENV1	3.2	368	<0.2	25.5	3.2	0.02	6.7	10.0	14.6
11745 ENV2	2.6	511		23.2	3.6	0.03	6.3	9.9	12.9
11745 ENV3	2.9	392		29.4	3.7	0.01	8.3	10.5	16.0
11745 ENV4	3.1	395		39.0	3.6	0.02	8.3	10.6	16.2
11745 ENV5	3.4	359		25.6	3.2	0.01	6.7	9.4	15.0
11745 ENV6	3.2	388		33.9	3.5	0.02	8.4	10.6	16.6
11745 ENV14	3.2	382		29.4	3.6	<0.01	7.9	10.5	15.2
11745 ENV16	3.1	364		29.6	3.2	<0.01	6.3	9.7	12.6
11745 ENV17	4.6	336		13.9	2.6	<0.01	3.8	9.6	9.7
11745 ENV18	2.8	372		29.6	3.3	<0.01	6.8	10.2	20.9
11746 ENV1	3.3	407		28.9	3.7	<0.01	8.4	11.5	16.9
11746 ENV3	5.0	286		14.4	2.5	<0.01	3.6	9.8	10.8
11746 ENV4	7.4	274		14.3	3.2	<0.01	3.6	11.2	12.7
11746 ENV5	5.6	308		19.5	3.9	0.01	4.5	10.6	14.0

69. As shown in **Table 8.15**, most samples are below the various guideline values, the exception was a marginal exceedance of arsenic at 11746 ENV4 which only exceeded the TEL but none of the other guideline standards applied. With respect to barium, Gardline (2022) conclude when concentrations are considered against UKOOA (2021) data that concentrations can be considered typical of background for sediments in close proximity to historic oil and gas exploration in the wider area.

70. It is therefore concluded that the sediments contain concentrations of contaminants in line with background concentrations within the wider area.

Offshore Export Cable Corridor Landfall Options

71. With respect to the NorthConnect Parallel Landfall, the NorthConnect project sampled sediments for chemical analysis at 17 locations along the NorthConnect corridor's length using a grab sampler as shown in **Figure 8.3**. The samples were analysed for metals and hydrocarbons, including PAHs and TPH.

72. Concentrations of metals from sediment samples along the consented NorthConnect cable corridor were generally low, as shown in **Table.8.16** and very few samples exceeded the various guideline standards. None of the metal concentrations exceeded the PEL threshold within Scottish Territorial Waters (STW) or the UK Exclusive Economic Zone (EEZ). Levels of lead, mercury and chromium did not exceed sediment guidelines at any sample location. However, three samples S03-S05, exceeded the arsenic TEL, the highest being 14.9 mg/kg at S03. This is well below the arsenic PEL, BAC and Action Levels. Nickel levels of 16.2 mg/kg present in S05 within the STW, also exceeded TEL, but

were below the PEL. One sample S06 exceeded the AL1 but only marginally. Only one site S13 exceeded the TEL and BAC for zinc but again only marginally.

Table.8.16 Metal concentrations from grab samples taken in the NorthConnect cable corridor compared to various sediment quality guideline values (units mg/kg). Coloured dots against each sediment quality guideline are used to indicate where there is an exceedance

Site number	Arsenic	Copper	Lead	Cadmium	Mercury	Chromium	Nickel	Zinc
TEL	7.24	18.7	30.2	0.7	0.13	52.3	15.9	124
PEL	41.6	108	112	4.2	0.7	160	42.8	271
BAC	25	27	38	0.31	0.07	81	36	122
ERL	-	34	47	1.2	0.15	81	-	150
AL1	20	30	50	0.4	0.25	50	30	130
AL2	70	300	400	4	1.5	370	150	600
S01	4.5	5.4	17.8	<0.1	0.01	20.4	8.4	30.1
S02	5	3.8	6.7	<0.1	<0.01	11.9	5.9	17.2
S03	14.9	4.1	10.4	<0.1	<0.01	9.1	8	23.5
S04	10.9	8.4	13.1	0.2	<0.01	13.8	7	103.5
S05	11.7	15.5	20.4	0.3	<0.01	29.8	16.2	93.9
S06	7.1	90.9	13.4	0.3	<0.01	18.2	30.6	119.9
S07	5	9.5	9.6	0.2	<0.01	14	4.4	85.6
S08	10	8	11.4	0.1	<0.01	17	4.6	78.2
S09	4.3	9.1	10	0.1	<0.01	15.3	3.9	88.1
S10	3	7	11.3	0.4	<0.01	22.9	8.4	77.1
S11	2.7	10.9	10.2	0.2	<0.01	21.6	8.4	80.9
S12	2.8	10.7	11.1	0.4	0.01	30.5	11.6	92.9
S13	5.1	13.5	20.1	0.5	0.02	49.1	21.7	135
S14	6.6	17	26.4	0.4	0.03	49.3	22.9	95.5
S15	5.1	10.9	25.3	0.4	0.02	46	20.4	65.3
S16	4.9	9.6	21.7	0.4	0.02	46.4	20.5	113
S17	4.1	9.1	16.7	0.4	0.02	37.9	16.5	77.1

73. With respect to PAHs, data are presented in **Table 8.17** against the sediment guidelines where levels are available. PAHs were generally very low at all sample locations and often fell below the limit of detection (LOD). Only two sample locations recorded PAH levels exceeding the TEL levels but these exceedances were marginal (i.e. only just above the TEL concentration).

74. Overall, the chemical analysis of grab samples conducted during the NorthConnect surveys found that contamination levels were very low.

Table 8.17 PAH data from the NorthConnect cable corridor (units in µg/kg). Coloured dots against each sediment quality guideline are used to indicate where there is an exceedance

.Site number	Naphthalene	Acenaphthylene	Acenaphthene	Fluorene	Phenanthrene	Anthracene	Fluoranthene	Pyrene	Benzo(a)anthracene	Chrysene	Benzo(b)fluoranthene	Benzo(k)fluorantene	Benzo(e)pyrene	Benzo(a)pyrene	Indeno(123)pyrene	Dibenzo(a,h)anthracene	Benzo(ghi)perylene	TPH
TEL	34.6	5.87	6.71	21.2	86.7	46.9	113	153	74.8	108	N/A	N/A	N/A	88.8	N/A	6.22	N/A	50000[3]
PEL	391	128	88.9	144	544	245	1494	1398	693	846	N/A	N/A	N/A	763	N/A	135	N/A	N/A
BAC	8	-	-	-	32	5	39	24	16	20	N/A	N/A	N/A	30	103	-	80	N/A
ERL	160	-	-	-	240	85	600	665	261	-	N/A	N/A	N/A	430	-	-	-	N/A
AL1[4]	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	10	100	N/A
S01	1.5	<1	<1	<1	4.6	1.7	10.7	10.4	6.7	8	8.2	4.4	-	8.2	6.9	1	7.3	7105
S02	1.2	<1	<1	<1	4.9	1.4	5.7	5.4	3.2	3.9	4.3	2.6	-	3.7	4	<1	4.2	10706
S03	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	<1	<1	<1	<1	2521
S04	<1	<1	<1	<1	1.0	<1	1.4	1.4	<1	1.4	1.4	1.0	1.2	<1	1.4	<1	1.5	2694
S05	<1	<1	<1	<1	1.1	<1	1.1	1.1	<1	1.3	3.6	1.3	2.4	2.5	4.2	<1	3.7	2874
S06	<1	<1	<1	<1	1.3	<1	2.3	2.3	2.0	2.6	4.3	2.0	3.2	3.4	4.9	<1	4.1	1653
S07	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1.7	<1	<1	<1	1.8	<1	1.7	2993
S08	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1.5	1.1	1.1	<1	2.4	<1	2.0	2224
S09	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1.7	<1	1.2	<1	2.6	<1	2.3	2626
S10	<1	<1	<1	<1	1.5	<1	1.8	1.7	1.3	1.8	5.2	2.7	3.4	2.1	6.5	<1	5.9	3722
S11	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	2.2	<1	1.4	<1	3.1	<1	2.8	2075
S12	2.2	<1	<1	1.1	7.0	<1	7.9	5.6	4.6	7.4	27.9	8.7	16.2	7.9	45.4	5.9	36.8	13348

[3] *Dutch guidelines*
[4] *There are no Action Level 2 for PAHs*

.Site number	Naphthalene	Acenaphthylene	Acenaphthene	Fluorene	Phenanthrene	Anthracene	Fluoranthene	Pyrene	Benzo(a)anthracene	Chrysene	Benzo(b)fluoranthene	Benzo(k)fluorantene	Benzo(e)pyrene	Benzo(a)pyrene	Indeno(123)pyrene	Dibenzo(a,h)anthracene	Benzo(ghi)perylene	TPH
S13	<1	<1	<1	<1	2.3	<1	3.4	2.4	1.7	2.5	9.0	4.9	6.9	3.3	14.3	1.9	12.4	5399
S14	4.0	<1	<1	1.7	11.0	1.4	13.0	9.4	7.9	12.7	44.0	19.3	26.4	12.7	75.6	9.6	59.3	20171
S15	2.2	<1	<1	1.1	7.1	-	8.3	6.1	4.7	7.4	27.8	11.0	16.9	8.1	43.8	5.5	35.0	16788
S16	4.5	<1	<1	1.8	10.9	1.7	13.4	9.9	8.1	12.3	45.0	20.4	27.1	13.8	74.0	9.5	60.5	19591
S17	2.5	<1	<1	1.2	7.3	1.0	8.8	6.5	5.3	7.8	28.7	11.2	17.8	9.2	51.8	6.2	39.9	16929

75. Data was also collected in 2022 by APEM (2022) for the St Fergus South Landfall Offshore Export Cable Corridor option at locations shown in **Figure 8.8.**

76. Data for metal contaminants is presented in **Table 8.18.** There were no exceedances of the OPSAR BAC or AL1. Data for PAHs indicated that all stations were below the LOD for total PAHs (0.034 mg/kg) with the exception of one site (SFS10) which recorded 0.055 mg/kg but this value is only just above the LOD. Data for individual PAHs also indicated very low concentrations with the majority below LOD. Data is provided in full in **Appendix 7.2.** Overall therefore, sediment contamination is considered to be very low.

Table 8.18 Metal concentrations from grab samples taken in the St Fergus South Cable Corridor Option compared to various sediment quality guideline values (units mg/kg). Coloured dots against each sediment quality guideline are used to indicate where there is an exceedance

Site number	Arsenic	Copper	Lead	Cadmium	Mercury	Chromium	Nickel	Zinc
TEL	7.24	18.7	30.2	0.7	0.13	52.3	15.9	124
PEL	41.6	108	112	4.2	0.7	160	42.8	271
BAC	25	27	38	0.31	0.07	81	36	122
ERL	-	34	47	1.2	0.15	81	-	150
AL1	20	30	50	0.4	0.25	50	30	130
AL2	70	300	400	4	1.5	370	150	600
SFS5	1.7	3.2	10.5	<0.2	<0.01	21.1	8.9	19.2
SFS6	9.6	3.2	8.9	<0.2	<0.01	17.9	12.2	14.6
SFS7	10.6	2.7	9.4	<0.2	<0.01	8.1	4.6	11.6
SFS8	11.9	2.9	10.8	<0.2	<0.01	19.3	6.6	20.1
SFS9	7.1	2.7	9.4	<0.2	<0.01	9	3.7	10.5
SFS10	4.9	3.1	8.6	<0.2	<0.01	10.3	2.9	11.5
NCP4	12.5	4.2	10.3	<0.2	<0.01	15.2	6.6	21.4
NCP5	10.8	2.9	9	<0.2	<0.01	10.7	4.7	18.1

8.7 Potential Impacts

77. The Project received a **Scoping Opinion** from MS-LOT in April 2022 (**Appendix 1.1**). **Table 8.19** presents the impacts that were proposed to be scoped out in the **Offshore Scoping Report** (**Appendix 1.2**) and the impacts that the **Scoping Opinion** require to be scoped in for the **Offshore EIA Report**. It is noted that in providing the Scottish Ministers' Scoping Opinion on whether the impacts identified in the Offshore Scoping Report are scoped in or out of the **Offshore EIA Report**, MS-LOT advises that "*the representations from consultees and advice from Marine Scotland Science (MSS), Marine Analytical Unit (a unit of Marine Scotland) (MAU) and Transport Scotland must be considered in conjunction with the Scoping Opinion and with the expectation that recommendations and advice as directed through this Scoping Opinion are implemented*". **Table 8.19** presents the impacts have been scoped in and out of the EIA.

Table 8.19 Potential Impacts scoped in (✓) and out (x) of the EIA for Marine Sediment and Water Quality

Potential Impact	Construction		O&M		Decommissioning	
	Scoping Report	Scoping Opinion	Scoping Report	Scoping Opinion	Scoping Report	Scoping Opinion
Increase in suspended sediment concentrations created by installation of turbine substructures, inter-array cables and OSP foundations	✓	✓	x	x	x	x
Increase in suspended sediment concentration associated with export cable installation	✓	✓	x	x	x	x
Increase in suspended solids concentrations due to works at landfall	✓	✓	x	x	x	x
Deterioration in water quality due to re-suspension of sediment bound contaminants offshore	✓	✓	x	x	x	x
Deterioration in water quality due to re-suspension of sediment bound contaminants along the Offshore Export Cable Corridor	✓	✓	x	x	x	x
Increase in suspended sediment concentrations due to mooring lines and erosion/ scour offshore	x	x	x	✓	x	x

Potential Impact	Construction		O&M		Decommissioning	
	Scoping Report	Scoping Opinion	Scoping Report	Scoping Opinion	Scoping Report	Scoping Opinion
Alteration of water column mixing associated from physical presence of wind farm structures and changes to surface wind speeds*	x	x	x	x	x	x
Increase in suspended sediment concentrations due to cable repairs/reburial	x	x	x	✓	x	x
Increase in suspended sediment due to decommissioning activities	x	x	x	x	✓	✓
Deterioration in water quality due to the release of contaminants during decommissioning activities	x	x	x	x	✓	✓

*Post submission of Offshore Scoping Report and post-receipt of the Scoping Opinion, additional impacts have been identified and included in the EIA.

78. A summary of the potential impacts assessed is provided in **Table 8.20.**

Table 8.20 Potential impact pathways on marine sediment and water quality receptors

Green Volt Project Phase	Potential Impact Pathways
Construction	• Increase in suspended sediment concentrations created by installation of turbine substructures, inter-array cables and OSP foundations • Increase in suspended sediment concentration associated with export cable installation • Increase in suspended solids concentrations due to works at landfall • Deterioration in water quality due to re-suspension of sediment bound contaminants offshore • Deterioration in water quality due to re-suspension of sediment bound contaminants along the Offshore Export Cable Corridor
O&M	• Increase in suspended sediment concentrations due to mooring lines and erosion/ scour offshore • Alteration of water column mixing associated from physical presence of wind farm structures and changes to surface wind speeds • Increase in suspended sediment concentrations due to cable repairs/reburial
Decommissioning	• Increase in suspended sediment due to decommissioning activities • Deterioration in water quality due to the release of contaminants during decommissioning activities

8.7.1 Embedded Mitigation

79. The following embedded mitigation is accounted for in the impact assessment for marine sediment and water quality:

- All Project vessels will follow the requirements set out in MARPOL.
- Drill mud discharge will be kept to a minimum and will be water-based, rather than oil-based, with minimum drilling lubricants used during the final exit phase onto the seabed.
- Horizontal Directional Drilling (HDD) will be used to connect the Landfall Export Cable to shore to avoid disturbance to the cliffs. This also results in no potential resuspension of sediments within the intertidal and near shore area.
- Prior to the last one to two metres of HDD drill out before punch out, the borehole will be flushed with water to minimise the risk of bentonite slurry entering the marine system.
- Localised dredge disposal sites for the Port of Peterhead have been avoided in all export cable routing options.
- The locations of the anchors and OSP foundations will be determined in advance using survey information, therefore the location of each anchor will be chosen to avoid the need for seabed preparation (i.e. avoiding pock marks or straddling through micrositing, see **Chapter 5: Project Description**).
- There is no agreed legal or regulator position regarding the need to apply defined exclusion zones between decommissioned oil and gas assets and newly installed wind farm assets. It is likely this stems from the fact the principles applied to oil and gas decommissioning requirements places primacy on returning the seabed to its original state for future marine users. It is also of note that considerable responsibility remains with the oil and gas operator after decommissioning with respect to any interaction with abandoned equipment left in-situ. Therefore, there should be provision to allow ongoing monitoring for potential for hazards to other users of the sea and to ensure there is recovery of the environment after decommissioning. The array pattern and position applied will deliberately avoid placing turbines and substructures directly above pipelines and umbilicals remaining in-situ, and abandoned well-centres at the seabed. The final offsets applied will be determined by collaboration with the oil and gas operator via a structured risk assessment approach. Positioning of wind farm equipment on the seabed such as moorings and inter-array cables will also avoid interaction where possible, however, there is a strong likelihood that crossings will be necessary. Such crossings will be finalised with the input and agreement with the oil and gas operator since they will be legally responsible for the notification process and the ongoing liability associated with the decommissioned equipment affected by the crossing.
- CEMP to be drafted and adhered to.
- Transition pits sited to avoid Marine Protected Areas (MPAs).

8.7.2 Worst Case

80. The worst case scenarios with regard to marine sediment and water quality are presented by impact in **Table 8.21**.

81. Detailed UXO and geophysical surveys will be completed prior to construction. There is the potential for a temporary increase in suspended sediment concentrations and a temporary deterioration in water quality due to re-suspension of sediment bound contaminants during both of these activities. The exact type, size and number of possible detonations and duration of UXO clearance operations and the exact number and locations of geophysical survey stations are not known at this stage but the effects on sensitive receptors are considered smaller than for other construction activities, which are assessed below.

Table 8.21 Worst Case Assumptions

Impact	Parameter	Notes
Construction		
Impact C1: Increase in suspended sediment concentrations created by installation of turbine substructures, inter-array cables and OSP foundations	**Area of sediment disturbed = 1.43km^2** • Total substructure moorings = 0.06825 km^2 (based on worst case for catenary system) • Total area of disturbance from ploughing/jetting inter-array cables = 1.34 km^2 • Total area of rock protection for crossings of inter-array cables = 0.0189 km^2 • Total area of disturbance for OSP foundations = 0.00724 km^2 (based on worst case for suction bucket foundation including scour protection) **Volume of sediment to be disturbed = 2,010,000 m^3** • Total length of cable = 134 km • Maximum depth of burial = 1.5 m • Maximum width of seabed disturbance = 10 m (jetting/ploughing) • Total maximum volume of sediment disturbed = 2,010,000 m^3	For turbine anchors and OSP foundations, a requirement for seabed preparation has not been identified. In most places, burial of the inter-array cables will be less than the 1.5 m maximum and could be as low as 0.6 m minimum depth. Width of disturbance could also be as low as 3 m depending on installation technique used.
Impact C2: Increase in suspended sediment concentration associated with export cable installation	**Area of sediment disturbed = 3.11 km^2** • Total area of disturbance from ploughing/jetting of export cables = 3.00 km^2 • Total area of rock protection for non-buried export cables = 0.800 km^2 • Total area of rock protection for crossings export cables = 0.0330 km^2 **Volume of sediment to be disturbed = 4,535,000 m^3** • Total length of cable = 300 km • Maximum depth of burial = 1.5 m • Maximum width of disturbance = 10 m (jetting/ploughing) • Total maximum volume of sediment disturbed = 4,500,000 m^3 • Max pre-sweep volume = 35,000 m^3 • Total maximum volume of sediment disturbed = 4,535,000 m^3	Within the Windfarm Site and along the Landfall Export Cable Corridor In most places, burial will be less than the 1.5 m maximum and could be as low as 0.6 m minimum depth. Width of disturbance could also be as low as 3 m depending on installation technique used.
Impact C3: Increase in suspended solids concentrations due to works at landfall	Two 20 m x 8 m transition pits required therefore total area to be disturbed 320 m^2. Seabed sediments are interpreted to comprise predominately silty sand with shell fragments in agreement with environmental sampling and legacy ground truthing results. Current and legacy environmental camera sampling show areas of increased sonar reflectivity may represent accumulations	Approximate Transition pit distance from shoreline is 750 m

Impact	Parameter	Notes
	of shell fragments/coarse material or local exposures of underlying clays.	
Impact C4: Deterioration in water quality due to re-suspension of sediment bound contaminants offshore	See Impact C1 – contaminant resuspension relates to predicted sediment disturbance	See Impact C1
Impact C5: Deterioration in water quality due to re-suspension of sediment bound contaminants along the export cable corridor	See Impact C2 – contaminant resuspension relates to predicted sediment disturbance	See Impact C2
Operation		
Impact O1: Increase in suspended sediment concentrations due to mooring lines and erosion/ scour offshore	Volume of sediment to be disturbed only associated with catenary drag footprint. • Maximum number of WTGs = 35 (16 MW) • Maximum number of anchors = 6 per turbine (210 total) • Anchor types will be drag embedment, torpedo, gravity based or suction piles (no driven or drilled piles) with a maximum seabed footprint of 10 m x 10 m per anchor (up to 600 m^2 total per WTG) Catenary drag footprint = 1,1,34 m^2 per turbine at low water when mooring line radius is at a maximum.	There is a low risk of sediment scour around the anchors for the floating turbines at the Windfarm Site. This has been ground truthed by the 2021 geophysical decommissioning survey data of the Ettrick and Blackbird oil and gas installations, and the placement of previous anchor systems on the seabed in this zone. Therefore, for substructure option 1 and option 2 (semi-submersible platform/barge using an asymmetric catenary mooring system), scour protection will not be required at the Windfarm Site. For substructure option 3 (tension leg platform secured using vertically moored tendons, attached to the seabed using a suction piled anchor system), the suction pile anchors are expected to require scour protection at an estimated total volume of 707 m^2 for the Windfarm Site. This impact therefore focusses on the catenary line drag footprint as outlined in consultation responses.
Impact O2: Alteration of water column mixing associated from physical presence of wind farm structures and changes to surface wind speeds	Wind farm capacity = 560 MW Maximum number of WTGs = 35 (16 MW)	Within Windfarm Site
Impact O3: Increase in suspended sediment concentrations due to cable repairs/reburial	No specific detail to inform worst case but anticipated to be significantly less than volumes potentially disturbed as a result of construction	
Decommissioning		
Impact D1: Increase in suspended sediment due to decommissioning activities	No specific detail to inform worst case but anticipated to be less than volumes potentially disturbed as a result of construction given that some infrastructure will be left in situ.	
Impact D2: Deterioration in water quality due to the release of contaminants during decommissioning activities	See impact D1 as impact relates to amount of material likely to be suspended	

8.7.3 Potential Impacts during Construction

8.7.3.1 Impact C1: Increase in suspended sediment concentrations created by installation of turbine substructures, inter-array cables and OSP foundations

82. Given that the locations of the anchors will be placed to avoid the need for advance physical seabed preparation, and that no seabed preparation has been identified for the OSP foundations, this impact is limited to the installation of the inter-array cables and drilling if pin piles are required for the OSP foundations.

83. For pin piles, the installation method would be to drive the piles to the required depth. For inter-array cabling, a range of techniques could be used including jet trenching, ploughing and mechanical trenching.

84. Given that OSP pile installation is only required for up to six legs of the OSP, the impact would be limited both in terms of extent and timescale over which the impact would occur. Where increases in suspended solid concentrations are observed, these would be temporary, localised to the activity and cease following completion of the OSP works. With respect to the inter-array cables, the nature of the seabed (sand) and low current speeds would reduce the risk of significant sediment plumes. Furthermore, with the construction affecting different sections progressively over time (rather than being instantaneous across the whole route at a single point in time) the impact is predicted to be localised to the area in which the installation is occurring.

85. Overall, therefore the magnitude of impact is assessed as being low. Given the sensitivity is considered to be low, an overall effect of **minor adverse** significance is predicted.

8.7.3.2 Impact C2: Increase in suspended sediment concentrations during installation of cables within the Landfall Export Cable Corridor

86. As for Impact C1, cable installation will utilise a range of techniques, potentially including jet trenching, ploughing and mechanical trenching.

87. For the Offshore Export Cable Corridors, samples indicated that sediments are dominated by sand with fractions of gravel and minor volumes of silt. Consequently, when disturbed, the larger sized and heavier sand and gravel particles will quickly resettle, decreasing the size of any resulting sediment plume. Additionally, an impact will only be noted from exit point of the HDD seawards.

88. As described in **Chapter 7: Marine Geology, Oceanography and Physical Processes**, a temporary increase in suspended solid concentrations is likely to occur but would be short term and over time, settle or disperse. The larger proportion of coarser sediments noted in the surveys indicates that settlement would occur relatively rapidly and close to the disturbance area. The increase in suspended sediment concentrations is therefore likely to be of low magnitude and within the range of natural variability in the system (e.g. that experienced during storms). Furthermore, as with Impact C1, the construction would affect different sections of the cable route progressively over time rather than being instantaneous across the whole route at a single point in time.

89. Overall, therefore, the magnitude of impact is assessed as being low. Given the sensitivity is considered to be low, an overall effect of **minor adverse** significance is predicted.

8.7.3.3 Impact C3: Increase in suspended solids concentrations due to works at landfall

90. Two potential landfall options are under consideration and landfall is anticipated to be installed through HDD. It is expected that for either location, HDD will be used to take the cable from the jointing pit to a location 750 m offshore. The jointing pit is then used to provide the connection point between the Offshore Export Cables and Onshore Export Cables.

91. HDD operations require the use of drilling fluids 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 thus reducing the risk to the environment. Some drilling fluid may however remain in the holes and will escape to the marine environment when the HDD breaks out through the seabed. However, this is likely to be relatively small amounts and only consist of drilling solids (bentonite drilling compound) and pulverised granite drill cuttings. Given bentonite is a mixture of water and naturally occurring non-toxic clay, environmental effects are limited.

92. As such the magnitude of impact is assessed as negligible resulting in an overall effect of **negligible** significance.

8.7.3.4 Impact C4: Deterioration in water quality due to re-suspension of sediment bound contaminants offshore

93. The array pattern and position applied will deliberately avoid placing turbines and substructures directly above abandoned well-centres at the seabed across the development site, which will likely represent the areas of highest potential seabed contamination where any drill arisings are present. Due to the nature of water-based mud drill arisings and their discharge being mostly within the water column rather than at the seabed it is more likely for the drill arisings to become widely dispersed as a thin veneer rather than forming piles, particularly when drilling is undertaken from a mobile offshore drilling unit rather than a fixed platform drilling package.

94. Analysis of sediment chemistry as part of the Ettrick and Blackbird decommissioning programme recorded that overall, contaminant values are generally within typical background levels for the North Sea, indicating that the background organics were predominately from a natural biogenic origin as opposed to anthropogenic sources, e.g. drill cuttings, flare drop out, etc, apart from at one well location where point source petrogenic contamination was recorded. The levels of barium, alkanes, mercury, iron, lead and zinc were found to be above background levels in the sample taken close to the well, with these elevated levels being attributed to historical drilling contaminants (Genesis, 2016). These observations were confirmed in the site-specific survey undertaken in 2021. As discussed in **Section 8.7.1** well locations are avoided in the proposed site layout.

95. Sediment resuspension associated with the various construction activities is predicted to be relatively low (see Impact C1), given the small areas of seabed potentially impacted and the higher proportion of sand as opposed to fine muds in the Windfarm Site. Overall, therefore, the magnitude of impact is predicted to be negligible, resulting in an overall effect of **negligible** significance.

8.7.3.5 Impact C5: Deterioration in water quality due to re-suspension of sediment bound contaminants along the Landfall Export Cable Corridor

96. Sediment data collected as part of the data gathering exercise to inform the NorthConnect project (NorthConnect, 2018) (NorthConnect Parallel Landfall option) and site-specific work carried out in the St Fergus South Landfall option does not indicate significant levels of contamination. As a result, the magnitude of impact is predicted to be negligible which results in an overall effect of **negligible** significance.

8.7.4 Potential Impacts during Operation

8.7.4.1 Impact O1: Increase in suspended sediment concentrations due to mooring lines and erosion/scouring offshore

97. The potential effect associated with this impact is assessed in **Chapter 7: Marine Geology, Oceanography and Physical Processes**. In summary, if there is surficial sediment present on the seabed (rather than exposed bedrock) then sweeping by the catenary mooring lines will entrain sediment into suspension. However, as described in the baseline (see **Section 8.6**) the sediment is likely to be sand or muddy sand and so much of this will fall to the seabed shortly after disturbance, with only the finest fractions residing in the water column and in lower water layers. The total volume of sediment that could be disturbed is relatively low and likely to be only a few tens or at most a few hundreds of cubic metres of material per WTG. This disturbance could, however, be frequent throughout the operational phase. Overall, however, the impact is likely to be localised and low in volume and as a result, the magnitude of impact is predicted to be low.

98. With respect to scouring around the anchors, the relatively small footprint, physical separation between anchors at each WTG location, and with the WTGs being located in water depths of between 100 m to 115 m, there is unlikely to be sufficient wave-generated current or tidal current acting on the seabed to generate significant quantities of scour around each of the mooring anchors. This is confirmed by the evidence from the Ettrick and Blackbird oil and gas decommissioning survey data. Based upon these considerations, this impact is also assessed to be of low magnitude. Overall, therefore the effect is predicted to be of **minor adverse** significance.

8.7.4.2 Impact O2: Alteration of water column mixing resulting from physical presence of structures and changes to near-surface windspeeds

99. This impact is assessed in **Chapter 7: Marine Geology, Oceanography and Physical Processes**. In summary, the assessment concludes that the extent of project infrastructure located below the waterline within the Windfarm Site is so limited for each WTG that there will be no measurable impact upon baseline metocean processes (waves and currents) that could significantly alter mixing in the water column. As a result, no impact is predicted on water column mixing. With respect to windspeed, the impact of wind energy extraction by the WTGs on wind-sea states (generated by near-surface wind speeds) will not be measurable within the Windfarm Site. The principal factor causing seasonal stratification is water temperature rather than metocean processes (including wind-generated waves) and the Project will not alter water temperature. Given these findings, the wind energy extraction by the WTGs is not predicted to impact on the regional-scale sea patterns of seasonal stratification.

100. Based on the above findings, there will be **no impact** on the water column, including upon regional-scale seasonal stratification processes.

8.7.4.3 Impact O3: Increase in suspended sediment concentrations due to maintenance

101. During the operational period, scheduled and unscheduled monitoring and maintenance of offshore infrastructure and some refurbishment or replacement of offshore infrastructure will be required. All offshore infrastructure will be included in monitoring and maintenance programmes.

102. O&M activities may be required at any time, 24 hours per day, 365 days per year. The majority of control activities will be undertaken remotely from shore using a control centre; however, offshore access and intervention will be required to maintain and potentially repair or refit plant and equipment. Maintenance can be generally separated into three categories:

- Planned maintenance: this includes general inspection and testing, investigation of faults and minor fault rectification, as well as replacement of consumables. Scheduled maintenance and inspection are likely to occur every six to twelve months. Inspections of subsea cables will be performed on a periodic basis.
- Unplanned maintenance: this applies to defects occurring that require rectification out-with the planned maintenance periods. The scope of such maintenance would range from small defects on non-critical systems to failure or breakdown of main components potentially requiring them to be repaired or replaced.
- Periodic overhauls: these will be carried out in accordance with equipment manufacturer's warranty and specifications. These are likely to be planned for execution in periods of the year with the best access conditions.

103. Given that it is possible that some cable repair and reburial could be needed, some sediment disturbance would be required. However, the disturbance areas for reburial and repairs of cables would likely be extremely small in comparison to sediment disturbance assessed in impacts C1, C2 and C3. Therefore, the impact is assessed as being of negligible magnitude. Combined with the low sensitivity of the water, the overall effect is considered to be of **negligible adverse** significance.

8.7.5 Potential Impacts during Decommissioning

8.7.5.1 Impact D1: Increase in suspended sediment due to decommissioning activities

104. Increases in suspended sediment could arise from decommissioning activities. For example, suction piles may be lifted and removed or cut below seabed level using techniques such as abrasive water jet cutter or diamond wire cutting. With respect to cables, discussions will be held with stakeholders and regulators to determine the exact locations where offshore cables should be removed or left in situ if considered appropriate, or they may be wholly or partially removed. Where removal is undertaken, cables would potentially be pulled out of the seabed or exposed by jetting the seabed material. Potential impacts on suspended sediment concentrations will therefore be similar, or less

than those predicted during the construction phase. The magnitude of impact is therefore predicted to be low giving rise to an effect of **minor adverse** significance.

8.7.5.2 Impact D2: Deterioration in water quality due to release of contaminants during decommissioning activities

105. As outlined in Impact D1, there may be sediment disturbance, but this will be similar or less to that predicted for the construction phase. Overall, therefore, the predicted impact is the same as that identified for the construction phase, i.e., of negligible magnitude giving rise to an overall effect of **negligible** significance.

8.8 Cumulative Impacts

106. The first step in the cumulative assessment is the identification of which residual effects assessed for the Project on its own have the potential for a cumulative effect with each other. This information is set out in **Table 8.22** below. **Table 8.22** indicates that there are no projects for which there is the potential for a cumulative impact to occur on marine sediment and water quality parameters.

Table 8.22 Potential Cumulative Impacts

Impact	Potential for cumulative impact	Rationale
C1: Increase in suspended sediment concentrations created by installation of turbine substructures, inter-array cables and OSP foundations	No	Impacts occur at discrete locations, are temporary in nature and are negligible or low in magnitude. Contaminant concentrations are considered to be within background levels found in the northern North Sea
C2: Increase in suspended sediment concentration associated with export cable installation	No	
C3: Increase in suspended solids concentrations due to works at landfall	No	
C4: Deterioration in water quality due to re-suspension of sediment bound contaminants offshore	No	
C5: Deterioration in water quality due to re-suspension of sediment bound contaminants along the export cable corridor	No	
O1: Increase in suspended sediment concentrations due to mooring lines and erosion/ scour offshore	No	Impacts are likely to be temporary and discrete to specific location in which the activity is occurring
O2: Alteration of water column mixing associated from physical presence of wind farm structures and changes to surface wind speeds	No	This impact is limited to the presence of the Windfarm Site structures only
O3: Increase in suspended sediment concentrations due to cable repairs/reburial	No	Impacts are likely to be temporary and discrete to specific location in which the activity is occurring
D1: Increase in suspended sediment due to decommissioning activities	No	Impacts are likely to be temporary and discrete to specific location in which the activity is occurring
D2: Deterioration in water quality due to the release of contaminants during decommissioning activities	No	

8.9 Inter-relationships

107. Some of the effects assessed within this chapter have the potential to manifest as impacts on other receptors assessed in other chapters. **Table 8.23** presents a cross-referencing to related chapters where potential for such impacts arises.

Table 8.23 Chapter Topic Inter-Relationships

Topic and description	Related Chapter	Where addressed in this Chapter
Construction: Increase in suspended sediment/concentrations of contaminants in the water column	**Chapter 9: Benthic Ecology** **Chapter 10: Fish and Shellfish Ecology** **Chapter 11: Marine Mammal Ecology** **Chapter 13: Commercial Fisheries**	**Section 8.7.3**
Operation: Increase in suspended sediment/concentrations of contaminants in the water column	**Chapter 9: Benthic Ecology** **Chapter 10: Fish and Shellfish Ecology** **Chapter 11: Marine Mammal Ecology** **Chapter 13: Commercial Fisheries**	**Section 8.7.4**
Decommissioning: Inter-relationships for impacts during the decommissioning phase will be the same as those outlined above for the construction phase.		

8.10 Summary

108. The magnitude of construction, operation and decommissioning of the Project impacts has been assessed using expert assessment, drawing from a wide science base that includes project-specific surveys for effects scoped in (see **Table 8.4**). Specifically, information provided in **Chapter 7: Marine Geology, Oceanography & Physical Processes** is integral to the determination of the assessment of impacts in this chapter. The impacts that have been assessed are all anticipated to result in either minor or negligible adverse effects and these are summarised in **Table 8.24** below.

Table 8.24 Potential Impacts Identified for marine sediment and water quality

Potential Impact	Receptor	Value/ Sensitivity	Magnitude of Impact	Significance of Effect	Mitigation	Residual Effect
Construction						
C1 - Increase in suspended sediment concentrations created by installation of turbine substructures, inter-array cables and OSP foundations	Water and Sediment Quality	Low	Low	Minor adverse	None required	Minor adverse – not significant
C2 - Increase in suspended sediment concentration associated with export cable installation	Water and Sediment Quality	Low	Low	Minor adverse	None required	Minor adverse - not significant
C3 - Increase in suspended solids concentrations due to works at landfall	Water and Sediment Quality	Low	Negligible	Negligible adverse	None required	Negligible adverse - not significant
C4 - Deterioration in water quality due to re-suspension of sediment bound contaminants offshore	Water and Sediment Quality	Low	Negligible	Negligible adverse	None required	Negligible adverse - not significant
C5 - Deterioration in water quality due to re-suspension of sediment bound contaminants along the export cable corridor	Water and Sediment Quality	Low	Negligible	Negligible adverse	None required	Negligible adverse - not significant
Operation & Maintenance						
O1 - Increase in suspended sediment concentrations due to mooring lines and erosion/ scour offshore	Water and Sediment Quality	Low	Low	Minor adverse	None required	Minor adverse - not significant
O2 - Alteration of water column mixing associated from physical presence of wind farm structures and changes to surface wind speeds	No impact					
O3 - Increase in suspended sediment concentrations due to cable repairs/reburial	Water and Sediment Quality	Low	Negligible	Negligible adverse	None required	Negligible adverse - not significant
Decommissioning						
D1 - Increase in suspended sediment due to decommissioning activities	Water and Sediment Quality	Low	Low	Minor adverse	None required	Minor adverse - not significant
D2 - Deterioration in water quality due to the release of contaminants during decommissioning activities	Water and Sediment Quality	Low	Negligible	Negligible adverse	None required	Negligible adverse - not significant

Potential Impact	Receptor	Value/ Sensitivity	Magnitude of Impact	Significance of Effect	Mitigation	Residual Effect
Cumulative						
None identified						
Transboundary						
Scoped out						

8.11 References

APEM (2022). Green Volt Benthic Analyses. APEM Scientific Report P000008889. Flotation Energy Plc, 17 June 2022, v1.0 Dratf, 19 pp.

CME (2002) Canadian Environmental Quality Guidelines (CEQGs) provide science-based goals for the quality of aquatic and terrestrial ecosystems.

Cefas (2001) Contaminant Status of the North Sea. Technical report produced for Strategic Environmental Assessment – SEA2 Microsoft Word - TR_004.doc (publishing.service.gov.uk). Accessed May 2022

Environment Agency (2017) Clearing the waters for all Water Framework Directive assessment: estuarine and coastal waters - GOV.UK (www.gov.uk)

Fugro (2006) RIG SITE SURVEY UKCS 20/2a & 20/3a ETTRICK DRILL SITES. Report No.: 68 - 8713.2 Volume II: Environmental Baseline Survey

Gardline (2007) UKCS 20/2a (Blackbird) Site Survey. January to February 2007. Survey Report. Gardline Reference (7143)

Gardline (2010). Regional Mapping Project over Golden Eagle, Blackbird, Ettrick and Buzzard Fields. Project Ref No. ECN-2003-1018

Gardline (2021) Survey Report for CNOOC International. Project: UKCS Blocks 19/10 to 19/15 and 20/2 to 20/7, Ettrick and Green Volt Site and Export Cable Routes. September 2021. Project number 11745.1

Gardline (2022) Survey Report for CNOOC International. Ettrick Debris Clearance and Green Volt Environmental Survey. Environmental Baseline Report. Project number 11745-6

Genesis (2016) Ettrick and Blackbird Decommissioning EIA Completion of ESIA for Blackbird and Ettrick Decommissioning Programme. J73319B-Y-RT-24006/D3 Genesis 2016

Marine Scotland (no date) Marine Scotland Information - Clean and Safe Clean and Safe | Marine Scotland Information Accessed May 2022

Marine Scotland (2015). Scotland's National Marine Plan: A Single Framework for Managing Our Seas. Available at: https://www.gov.scot/binaries/content/documents/govscot/publications/strategy-plan/2015/03/scotlands-national-marine-plan/documents/00475466-pdf/00475466-pdf/govscot%3Adocument/00475466.pdf. Accessed June 2020.

Marine Scotland (2017) Marine Scotland Pre-disposal Sampling Guidance Version 2 – November 2017. Accessed Pre-disposal+sampling+guidance.pdf (www.gov.scot) Accessed 13/05/22

MMT. (2018). Final Survey Report: NorthConnect - UK Nearshore, North Sea, and Norwegian Ford Survey - Revision C.

Nexen (2017) Ettrick and Blackbird Decommissioning Programmes. Final Version

NorthConnect. (2018). High Voltage Direct Current Cable Infrastructure, UK Environmental Impact Assessment Report, Volume 2. Available from: https://marine.gov.scot/ml/marine-licence-cable-installation-between-peterhead-scotland-and-simadalen-norway-06771-06870. Accessed 10/09/2021

OSPAR Commission 2014 Levels and trends in marine contaminants and their biological effects – CEMP Assessment report 2013. Found at OSPAR_MEETING_DOCUMENT

OSPAR Commission. (2017). Intermediate Assessment Intermediate Assessment 2017 - OSPAR-OAP (Prod) Accessed May 2022

Royal HaskoningDHV (2021) Green Volt Offshore windfarm - Offshore Environmental Impact Assessment Reference PC2483-RHD-ZZ-XX-RP-Z-0001

Scottish Government (2014a). Scotland's Third National Planning Framework. Available at: National Planning Framework 3 - gov.scot (www.gov.scot). Accessed May 2022

Scottish Government (2014b). Scottish Planning Policy. Available at: Scottish Planning Policy - gov.scot (www.gov.scot) Accessed May 2022.

SEPA (no date) Bathing water profiles Bathing Waters : Profiles (sepa.org.uk) Accessed May 2022

UKMMAS. (2010). Charting Progress 2 Feeder Report: Ocean Processes. Retrieved from London: https://webarchive.nationalarchives.gov.uk/ukgwa/20141203184508 mp_/http://chartingprogress.defra.gov.uk/feeder/OPEG-feeder.pdf Accessed May 2022

UKOOA (2001) Harries, D., Kingston, P. F., & Moore, C. (2001). An Analysis of UK Offshore Oil and Gas Environmental Gas Surveys 1975-95. The United Kingdom Offshore Operators Association.

van Leeuwen, S., Tett, P., Mills, D., & van der Molen, J. (2015). Stratified and non-stratified areas in the North Sea: Long-term variability and biological and policy implications. Journal of Geophysical Research-Oceans, 120(7), 4670-4686. https://doi.org/10.1002/2014JC010485