LLŶR FLOATING OFFSHORE WIND PROJECT

Llŷr 1 Floating Offshore Wind Farm

Environmental Statement

Volume 2: Chapter 11- Geology and Hydrogeology

August 2024

Prepared by: Llŷr Floating Wind Ltd

FLOVENTIS ENERGY

Document Status

Version	Authored by	Reviewed by	Approved by	Date
FINAL	AECOM	AECOM	AECOM	August 2024

Approval for Issue

Prepared by	AECOM
Prepared for	Llŷr Floating Wind Limited
Approved by	Jay Hilton-Miller

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Acronyms and abbreviations

Acronym or Abbreviation	Definition	Acronym or Abbreviation	Definition
ASSI	Area of Special Scientific Interest	MMP	Materials Management Plan
BGS	British Geological Survey	MSZ	Mineral Safeguarding Zones
BGW	Blue Gem Wind	NGR	National Grid Resources
BSI	British Standard Institute	NHBC	National House Building Council
CEA	Cumulative Effects Assessment	NNR	National Nature Reserves
CEMP	Construction Environmental Management Plan	NRW	Natural Resources Wales
CIEH	Chartered Institute of Environmental Health	NVZ	Nitrate Vulnerable Zones
CIRIA	Construction Industry Research and Information	PAH	Polycyclic Aromatic Hydrocarbons
CJB	Cable Joint Bays	PCB	Polychlorinated Biphenyls
CL:AIRE	Contaminated Land: Applications in Real Environments	PCC	Pembrokeshire County Council
COSHH	Control of Substances Hazardous to Health	PCL	Potential Contaminant Linkages
CSAI	Cranfield Soil and AgriFood Institute	PDS	Pembrokeshire Development Zone
CSM	Conceptual Site Model	PHE	Public Health England
DMRB	Design Manual for Roads and Bridges	PINS	Planning Inspectorate
DQRA	Detailed Quantitative Risk Assessment	PPE	Personal Protective Equipment
EC	Evaluation Criteria	PPG	Pollution Prevention Guidance
EEA	European Economic Area	PRA	Preliminary Risk Assessment
EIA	Environmental Impact Assessment	PWS	Private Water Supplies
ES	Environmental Statement	RBMP	River Basin Management Plan
GCR	Geological Conservation Review	RIGS	Regionally Important Geological and Geomorphological Sites
GDR	Geotechnical Design Report	SAC	Special Areas of Conservation
GIR	Ground Investigation Report	SPA	Special Protection Areas
GIS	Groundsure Insights Report	SPZ	Source Protection Zone
GPP	Guidance for Pollution Prevention	SSSI	Sites of Special Scientific Interest
GQRA	Generic Quantitative Risk Assessment	TJB	Transition Joint Bay
GWDTE	Groundwater Dependent Terrestrial Ecosystem	TPH	Total Petroleum Hydrocarbons
HDD	Horizontal Directional Drilling	UNESCO	United Nations Educational, Scientific and Cultural Organization
IAM	Impact Assessment Matrix	UXO	Unexploded Ordnance
IPC	Integrated Pollution Controls	VOC	Volatile Organic Compounds
LCRM	Land Contamination: Risk Management	WAC	Waste Acceptance Criteria
LDP	Local Development Plan	ZoI	Zone of Influence

Acronym or Abbreviation	Definition	Acronym or Abbreviation	Definition
MLT	Marine Licensing Team	WFD	Water Framework Directive
MLWS	Mean Low Water Springs	WLGA	Welsh Local Government Association

Glossary of project terms

Term	Definition
The Applicant	The developer of the Project, Llŷr Floating Wind Limited.
Array	All wind turbine generators, inter array cables, mooring lines, floating sub-structures and supporting subsea infrastructure within the Array Area, as defined, when considered collectively, excluding the offshore export cable(s).
Array Area	The area within which the wind turbine generators, inter array cables, mooring lines, floating sub-structures and supporting subsea infrastructure will be located.
Floventis Energy	The company developing the proposed Project, a joint venture between Cierco Ltd and SBM Offshore Ltd.
Landfall	The location where the offshore export cable(s) from the Array Area, as defined, are brought onshore and connected to the onshore export cables (as defined) via the transition joint bays.
Llŷr 1	The proposed Project, for which the Applicant is applying for Section 36 and Marine Licence consents. Including all offshore and onshore infrastructure and activities, and all project phases.
Marine Licence	A licence required under the Marine and Coastal Access Act 2009 for marine works which is administered by Natural Resources Wales (NRW) Marine Licensing Team on behalf of the Welsh Ministers.
Offshore Development Area	The footprint of the offshore infrastructure and associated temporary works, comprised of the Array Area and the Offshore Export Cable Corridor, as defined, that forms the offshore boundary for the S36 Consent and Marine Licence application.
Offshore Export Cable	The cable(s) that transmit electricity produced by the WTGs to landfall.
Offshore Export Cable Corridor (OfECC)	The area within which the offshore export cable circuit(s) will be located, from the Array Area to the Landfall.
Onshore Development Area	The footprint of the onshore infrastructure and associated temporary works, comprised of the Onshore Export Cable Corridor and the Onshore Substation, as defined, and including new access routes and visibility splays, that forms the onshore boundary for the planning application.
Onshore Export Cable(s)	The cable(s) that transmit electricity from the landfall to the onshore substation.
Onshore Export Cable Corridor (OnECC)	The area within which the onshore export cable circuit(s) will be located.
proposed Project	All aspects of the Llŷr 1 development (i.e. the onshore and offshore components).
Onshore Substation	Located within the Onshore Development Area, converts high voltage generated electricity into low voltage electricity that can be used for the grid and domestic consumption.
Section 36 consent	Consent to construct and operate an offshore generating station, under Section 36 (S.36) of the Electricity Act 1989. This includes deemed planning permission for onshore works.

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11. GEOLOGY AND HYDROGEOLOGY

11.1 Introduction

1. Floventis (hereafter the Applicant) is proposing development of the Llŷr 1 Floating Offshore Wind Farm (hereafter referred to as the proposed Project), located approximately 35 km off the coast of Pembrokeshire in the Celtic Sea.
2. The proposed Project is a test and demonstration wind farm, comprising up to 10 wind turbine generators (WTGs). The proposed Project includes landfall at Freshwater West before connecting into Pembroke Dock power station and the national grid network.
3. The Applicant is seeking a Section 36 consent and Marine Licence for Llŷr 1, and this chapter forms part of the Environmental Statement (ES) which is submitted in support of those consent applications. This chapter describes the potential impacts and effects of the proposed Project on geology and hydrogeology (which focusses on onshore geology, geological designated sites, mineral resources, hydrogeology, and land contamination) during the construction, operation and maintenance and decommissioning phases, and includes mitigation and good practice measures to reduce the impacts of the proposed Project on geology and hydrogeology.
4. **Section 11.9.2** of this ES chapter provides a summary of the impact assessment undertaken and any residual significant effects on geology and hydrogeology following consideration of any mitigation measures.
5. The assessment presented in this chapter should be read in conjunction with the following linked and supporting chapters:

    - **Chapter 04: Description of the Proposed Project** - provides further details of the project design parameters.
    - **Chapter 05: EIA Approach and Methodology** - provides further details of the general framework and approach to the EIA.
    - **Chapter 10: Water Environment** - considers some of the potential impacts and effects relating to hydrogeology not considered in this ES chapter (for example, groundwater flood risk, groundwater as a strategic water resource, as well as its behaviour in response to dewatering). This ES chapter considers the hydrogeological baseline condition and then groundwater as a receptor to any land contamination.

6. Additional information to support the assessment includes:

    - **Appendix 11A: Phase 1 Geo-environmental Desk Study;**
    - **Appendix 11B: Land Contamination Methodology Tables;**
    - **Appendix 11C: Potential Areas of Contamination: Site Rating and Further Risk and Impact Assessment;**
    - **Appendix 11D: Assessment of Effects and Significance; and**
    - **Project Erebus Environmental Statement' Chapter 19: Onshore Geology, Hydrology and Hydrogeology and associated appendices.**

7. The assessment has been undertaken by AECOM. Further details of the Project Team's competency are provided in **Appendix 1A: Statement of Competence**.

11.2 Legislation, Policy and Guidance

8. The following sections identify specific legislation and guidance that is applicable to the assessment of geology and hydrogeology.

9. There are no additional national, regional and local planning policies relevant to geology and hydrology over and above those discussed in **Chapter 02: Legislation Policy and Guidance**, which sets out further detail on the wider legislation, policy and guidance relevant to this ES.

11.2.1. Legislation

10. The legislation that is applicable to the assessment of geology and hydrogeology is summarised below.

- Environmental Liability Directive (2004/35/EC) (European Union, 2004): sets out the EU's liability regime based on the "polluter-pays" principle;
- Water Framework Directive (WFD) (2000/60/EC) (European Union, 2000): outlines the objective and measures to ensure qualitative and quantitative health of rivers, groundwater, and bathing waters;
- The Groundwater Directive (2006/118/EC) (European Union, 2006): describes the duties of the member states towards the protection of groundwater, including monitoring, definition of thresholds for pollutants and the reporting requirements;
- The Environmental Quality Standards (EQS) Directive (2008/105/EC) (European Union, 2008): defines the standards for the presence in surface waters of priority pollutants, in line with the strategy defined in the WFD;
- Environment Act 2021 (HM Government, 2021): aims to improve air and water quality, protect wildlife, increase recycling, and reduce plastic waste;
- The Environmental Protection Act (EPA) 1990 and Part IIA (the Contaminated Land Regime) (HM Government, 1990): introduced new regulations for improved management systems relating to waste and pollution. The EPA establishes legal responsibilities for pollution control for land, air, and water. The contaminated land regime under Part IIA of the Environmental Protection Act 1990 is one of the main policy measures used to deal with this legacy;
- The Water Act 2003 (HM Government, 2003): sets out regulatory controls for water abstraction, water impoundment and protection of water resources;
- The Water Resources Act 1991 (HM Government, 1991): states that it is an offence to cause or knowingly permit polluting, noxious, poisonous or any solid waste matter to enter controlled waters. The Act was revised by the Water Act 2003;
- The Building Act 1984 and the Building (Amendment) Regulations 2016 (HM Government, 2016): are key when considering structural and design aspects of a development in terms of the geotechnical properties of the ground;
- The Environment Act 1995 (HM Government, 1995): to provide for the transfer of functions, property, rights and liabilities to Natural Resources Wales and for the conferring of other functions on them; to make provision with respect to contaminated land; to make further provision for the control of pollution, the conservation of natural resources and the conservation or enhancement of the environment;
- The Town and Country Planning Act 1990 (HMSO, 1990): an act regulating the development of land in England and Wales;

- Environmental Permitting (England and Wales) Regulations 2016 (HMSO, 2016): streamlines the legislative system for industrial and waste installations into a single permitting structure for those activities which have the potential to cause harm to human health or the environment supporting implementation of the WFD;
- Hazardous Waste (England and Wales) (Amendment) Regulations 2016 (HMSO, 2016): makes provision for the controlled management of hazardous waste, which could include excavated soil waste, from the point of production to the final point of disposal or recovery;
- Contaminated Land (Wales) (Amendment) Regulations 2006 (HMSO, 2006): make provision for the identification and remediation of contaminated land under Part 2A of the Environmental Protection Act 1990;
- Contaminated Land Statutory Guidance for Wales 2012 (Welsh Government, 2012): is intended to explain how local authorities should implement the regime, including how they should go about deciding whether land is contaminated land in the legal sense of the term. It also elaborates on the remediation provisions of Part 2A;
- Environmental Damage (Prevention and Remediation) Regulations 2015 (HMSO, 2015): requirement to ensure that the Proposed Works will not cause damage to ecosystems, controlled waters, or land;
- Anti-Pollution Works Regulations 1999 (HMSO, 1999): defines the contents that the anti-pollution works notice should contain, and the procedure to follow to appeal against the notice;
- Control of Asbestos Regulations 2012 (HMSO, 2012): provide minimum standards for protecting employees from risks associated with exposure to asbestos; and
- Construction Design Management (CDM) Regulations 2015 (Health and Safety Executive (HSE), 2015): covers the management of health, safety and welfare when carrying out construction projects.

11.2.2. Guidance

11. Guidance that is applicable to the assessment of geology and hydrogeology is summarised below in **Table 11-1.**

Table 11-1. A summary of guidance relevant to geology and hydrogeology

Summary of Guidance	How and where it is considered in the chapter
Environment Agency's online guidance for the management of land contamination 'Land contamination: risk management' (LCRM) (gov.uk): provides the technical framework for the assessment of risk posed by land impacted by contamination.	Outlines the approach to contaminated land assessment. Throughout the chapter, and in particular **Sections 11.4.1 and 11.7.**
Welsh Local Government Association (WLGA), Welsh Land Contamination Working Group: The Development of Land Affected by Contamination: A Guide for Developers (Welsh Local Government Association and Environment Agency): guidance document for developers and advisers involved in assessment and management of land affected by land contamination in Wales; outlines the requirements by the Local Planning Authorities and describes good practices.	

Summary of Guidance	How and where it is considered in the chapter
National House Building Council (NHBC), EA, Chartered Institute of Environmental Health (CIEH) report R&D Publication 66 'Guidance for the Safe Development of Housing on Land Affected by Contamination' (National House Building Council (NHBC), 2008): provides advice on the development and redevelopment of land affected by land contamination, outlining good practices on data collection, interpretation, and presentation;	
BS 10175 (2011 + A2:2017), Investigation of Potentially Contaminated Sites - Code of Practice (British Standard Institute (BSI), 2017): outlines the standards for the investigation of potentially contaminated land;	Ground investigation is part of the approach to contaminated land assessment. **Sections 11.4.1 and 11.7.**
BS 5930 (2015 + A1:2020), Code of practice for site investigations (BSI, 2017): outlines the standards for ground investigations, including investigation to characterise the site for building works and inform the building design;	
BS 8576 (2013), Guidance on investigations for ground gas. Permanent gases and Volatile Organic Compounds (VOCs) (BSI, 2013): provides guidelines on monitoring and sampling of ground gases and VOCs;	
CIRIA C811, Environmental good practice on site guide. 5th edition. 2015 (CIRIA, 2023): provides guidance on the management of construction works to minimise impacts on the environment;	Embedded mitigation, **Section 11.7.**
BS 8485 (2019), Code of practice for the design of protective measures for methane and carbon dioxide ground gases for new buildings (BSI, 2019): provides guidelines for the design of measures to prevent the entry of ground gases within buildings;	Discussed with relevance to the proposed building (Onshore Substation) only, in **Appendix 11A: Phase 1 Geo-environmental Desk Study Report**.
Construction Industry Research and Information (CIRIA) C665, Assessing risks posed by hazardous ground gases to buildings, 2007 (CIRIA, 2007); outlines good practices in the data collection and assessment of risks from ground gases;	
Environment Agency (EA), Guidance Note on Piling and Penetrative Ground Improvement Methods on Land Affected by Contamination, NC/99/73, 2001 (Environment Agency, 2001): outlines the potential hazards caused by piling in contaminated soils, in particular to controlled waters.	
Design Manual for Roads and Bridges (DMRB), LA109 Geology and Soils (2019) (Highways England and Welsh Government, 2019): defines the requirements for the assessment of the effects of highway projects on soils and geology;	Guidance for the overarching Geology and Hydrogeology assessment methodology. Throughout the chapter, and in particular **Section 11.4.1.**
DMRB, LA104 Environmental assessment and monitoring (2020) (Highways England and Welsh Government, 2020): sets out the requirement for environmental assessment of highway projects;	
DMRB, LA113 Road drainage and the water environment (2020) (Highways England and Welsh Government, 2020): defines the requirements for the assessment of the effects of highway projects on the water environment;	
Contaminated Land: Applications in Real Environments (CL:AIRE), Definition of Waste: Development Industry Code of Practice (2011)	

Summary of Guidance	How and where it is considered in the chapter
(CL:AIRE, 2011): describes an approach for the management of soils and their appropriate re-use on development sites; and	Throughout the chapter, and in particular **Section 11.7.**
The Environment Agency's approach to groundwater protection (2018) (Environment Agency, 2018): defines the EA's risk-based approach for the prevention of pollution of groundwater.	

11.3 Stakeholder Engagement and Consultation

12. Consultation with statutory and non-statutory organisations is a key element of the EIA process. Consultation with regards to geology and hydrogeology has been undertaken to inform the approach to, and scope of, the assessment.

13. Stakeholders for the proposed Project include statutory consultees, landowners and local communities. In addition to the statutory consultation process, there has been ongoing engagement with statutory and non-statutory consultees to steer the development of the proposed Project and this is detailed in **Table 11-2** for the geology and hydrogeology topic.

11.3.1. Summary of Stakeholder Consultations

Table 11-2. Summary of the key issues raised by consultees and how each issue was addressed

Consultee	Consultation type and date	Comment raised	How issue has been addressed and location of response in chapter
Pre-application			
NRW	Meeting arranged on 25 April 2023 with NRW to explain the proposed Project and to outline the proposed approach to the environmental assessment.	Matter (1): Introduction to what the topic covers.	It was confirmed that the topic covers onshore geology and hydrogeology, geological designated sites, mineral consultation and / or safeguarding areas, and land contamination (throughout this chapter). It was explained that this topic considers hydrogeology from a groundwater sensitivity and quality perspective with the water topic (**Chapter 10: Water Environment**) considering groundwater as a strategic resource, including groundwater flow as well as potential for groundwater flooding (**see Section 11.1**).
		Matter (2): discussion of NRW's consultation comments on the topic's scoping chapter.	For a summary on what was discussed in terms of NRW's scoping chapter comments,

Consultee	Consultation type and date	Comment raised	How issue has been addressed and location of response in chapter
			see rows below under 'Scoping responses.'
		Matter (3): overview of proposed methodology.	NRW confirmed their acceptance of the methodology outlined. Methodology is described in **Section 11.4.1.**
		Other: NRW advised that information requests should be through the data distribution team but that most of what was being asked for was likely to be held by the local authority.	AECOM water team have requested licensed water abstraction information from the data distribution team (**Section 11.5**).
Pembrokeshire County Council	Email dated 23 June 2023 from Pembrokeshire County Council.	A meeting was requested to explain the proposed Project and to outline the proposed approach to the environmental assessment. The meeting also sought to agree an approach with regards to the production of a Phase 2 Land Contamination Assessment for the planning application for the Onshore Development Area. Further information was requested about landfills, water abstractions, contaminated land sites, geological sites.	Pembrokeshire County Council has agreed to the approach regarding the production of a Phase 2 Land Contamination Assessment for the planning application for the Onshore Development Area. Further information has not been received at time of writing.
Pembrokeshire Coast National Park Authority	Email dated 15 May 2023 from Pembrokeshire County Council	A meeting was requested to explain the proposed Project and to outline the proposed approach to the environmental assessment. Further information was requested about landfills, water abstractions, contaminated land sites, geological sites.	Response received from the Pembrokeshire Coast National Park Authority on 15 May 2023 to indicate that discussion has already taken place between Pembrokeshire Coast National Park Authority and Floventis on 11 May 2023 to discuss Llŷr 1. It was clarified in response that the meeting was intended to provide the opportunity to discuss the approach for the geology /

Consultee	Consultation type and date	Comment raised	How issue has been addressed and location of response in chapter
			soils / contaminated land assessment, which has already been discussed and agreed with NRW. If they were content that it has been agreed with NRW, it was advised that a meeting would not be required. Further information has not been received at time of writing.
Scoping responses			
NRW	Scoping opinion	Agrees with items that are scoped in and out.	N/A
		Recommend finalising the proposed landfall site and cable route to inform the proposal further. Expect changes to advice going forward.	An indicative cable route and proposed landfall forms the basis of the assessment in this chapter (presented in **Volume 5: Figure 11.1**). A summary description of the Onshore Development Area is indicated in **Section 11.4.3**, and the complete description is in **Chapter 04: Description of the Proposed Project**.
		We recommend that the following surveys are completed. The surveys should be supported by risk assessment to determine the level of risk to controlled waters from the Onshore Development Area infrastructure: 1. Water Feature Survey is completed with a 300m buffer either side of the cable route and around buildings and compounds (requirements detailed below). 2. Preliminary Risk Assessment to define historical land uses (details below).	The approach with regards to the Water Feature Survey is contained within **Chapter 10: Water Environment**. A preliminary risk assessment is presented as **Appendix 11A: Phase 1 Geo-environmental Desk Study Report.**

Consultee	Consultation type and date	Comment raised	How issue has been addressed and location of response in chapter
		Any use of Horizonal Directional Drilling (HDD) will require a groundwater risk assessment to ensure there are no risk to controlled waters from this construction method.	Groundwater (hydrogeological) risk assessment is included as part of the mitigation for the Onshore Development Area (**Section 11.7**).
		If the onshore cables will be fluid filled, we advise pollution prevention measures will need to be employed should leakage occur.	Cables will not be fluid filled, see **Chapter 04: Description of the Proposed Project**.
		We have a groundwater position statement regarding fluid fill cables – please consult the position statements C5 in "approach to groundwater protection" (an NRW adopted guidance from the Environment Agency).	N/A
		There appears to be an error in the numbering of sections in Section 4.4.1.9 on page 49 and page 50 section 4.4.3.1. Clarification is sought as to whether there are missing sections (e.g., 4.4.2) that should be available.	N/A
		Section 10.2.1 Groundwater Regulation 2009: note that these no longer exist and are now part of the EPR 2016 under schedule 22. This reference should therefore be updated.	Amended in **Section 7**.
		The applicant must undertake a water feature survey, which should include the following: • Identification of all water features both surface and groundwater (ponds, springs, ditches, culverts	The approach with regards to the Water Feature Survey is contained within **Chapter 10: Water Environment**.

Consultee	Consultation type and date	Comment raised	How issue has been addressed and location of response in chapter
		etc.) within a 300m radius of the site or either side of a linear development area, e.g., cabling route; • Use made of any of these water features. This should include the construction details of wells and boreholes and details of the lithology into which they are installed; • An indication of the flow regime in the spring or surface water feature, for example whether or not the water feature flows throughout the year or dries up during summer months; • Accessibility to the spring/well; • This information should be identified on a suitably scaled map (i.e. 1:10,000), tabulated and submitted to NRW. It would be useful for the applicant to photograph each of the identified water features during the survey.	
		NRW may require identified groundwater features to be monitored during the proposed workings. We would therefore recommend that the survey be undertaken as soon as possible to enable the developer to carry out suitable baseline monitoring prior to the commencement of workings at the site.	See **Chapter 10: Water Environment**.
		Requirement for Preliminary Risk Assessment for historical land use 1. Follow the risk management framework provided in LCRM.	Noted. This has been undertaken and the relevant guidance has been referred to throughout this chapter.

Consultee	Consultation type and date	Comment raised	How issue has been addressed and location of response in chapter
		2. Refer to 'Land Contamination: a guide for developers' (WLGA, 2017) for the type of information that we require in order to assess risks to controlled waters from the site. The Local Authority can advise on risk to other receptors, such as human health. 3. Refer to our groundwater protection advice on www.gov.uk.	

11.4 Approach to Assessment

14. The objective of this qualitative assessment is to define the significance of the environmental effects on geology and hydrogeology (including geologically designated sites, Mineral Safeguarding Zones (MSZ) and land contamination), during the construction / decommissioning and operational phases of the proposed Project.

15. The significance of environmental effect is typically a function of the sensitivity of a receptor and the magnitude of an impact. Effects can be beneficial, adverse, or negligible. The sensitivity of the receptor reflects the qualities of a receptor and its ability to absorb an effect without perceptible change; the magnitude of a potential effect considers the scale of the predicted change to the baseline condition, considering its duration.

16. To define the magnitude of the impacts from land contamination to human health, controlled waters and ecological receptors, a risk-based approach consistent with Environment Agency's online guidance for the management of land contamination 'Land contamination: risk management' (LCRM) (Environment Agency, 2020) has been followed. The risk levels at baseline have been compared the perceived risk levels for the construction/decommissioning and operation stages respectively, to determine the magnitude of the effects at each stage (see section on the 'Approach to Land Contamination Assessment' for more details).

11.4.1. Assessment Methodology

Establishing the Baseline for Geology and Hydrogeology

17. The baseline description for this chapter has been established through the completion of a Phase 1 Geo-environmental Desk Study for the whole of the Onshore Development Area (presented as **Volume 5: Figure 11.1**) and the associated Study Area (defined in **Section 11.4.3** and presented in **Volume 5: Figure 11.2**), in addition to a site inspection of selected key areas of the Onshore Development Area (see **Appendix 11A: Phase 1 Geo-environmental Desk Study Report**) carried out on 31st May 2022.

18. The Phase 1 Geo-environmental Desk Study has been completed to identify and provide an assessment of any potential hazards and constraints to the proposed Project deriving from the ground conditions, including the potential for land contamination and ground hazards. It

includes a ground model based on available published geological and hydrogeological information.

19. The results of the desk-based assessment, development of the ground model, initial conceptual site model (CSM) and preliminary risk assessment (PRA) will be used to assess data gaps and uncertainties, and where gaps or uncertainties exist an initial scope for ground investigation will be developed. Ground investigation would provide site specific data which can be used to validate the CSM and initial PRA findings and provide for a level of assessment equivalent to a Stage 1, Tier 2 generic quantitative risk assessment as defined by LCRM. Ground Investigation would support the development of the design, confirm the ground model, and mitigate ground conditions risk. This tiered approach to assessment is consistent with the EA LCRM guidance for the management of land contamination (Environment Agency, 2020) adopted by NRW in 2021. A Phase 2 Land Contamination Assessment (Stage 1, Tier 2 generic quantitative risk assessment) will be submitted later as part of a Ground Investigation Report (GIR). The Local Planning Authority (Pembrokeshire County Council) has agreed to this approach (**Section 11.3, Table 11-2**).

Approach to Land Contamination Assessment

20. In line with LCRM guidance (Environment Agency, 2020), formally adopted by NRW in February 2021, and in general accordance with the WLGA guidance (WLGA and Environment Agency, 2017), the assessment of land contamination takes the form of a tiered, risk-based approach, as summarised below:

- Tier 1: qualitative risk assessment based on a desktop study of available information to identify potential sources of contamination, receptors to contamination and potential pathways between them. The identified sources, pathways and receptors are presented in the form of a CSM showing the potential contaminant linkages (PCL);
- Tier 2: if PCL are identified, this means there is a theoretical risk to receptors from contamination and intrusive investigation should be used to provide data to inform a generic quantitative risk assessment (GQRA). The GQRA involves comparison of site-specific, laboratory analytical data against appropriate evaluation criteria (EC) for human health and / or controlled waters which represent minimal or tolerable risk; and
- Tier 3: detailed quantitative risk assessment (DQRA) to identify whether contamination identified above minimal or tolerable risk levels represents an unacceptable risk and therefore requires remediation.

Screening Assessment (undertaken within Tier 1)

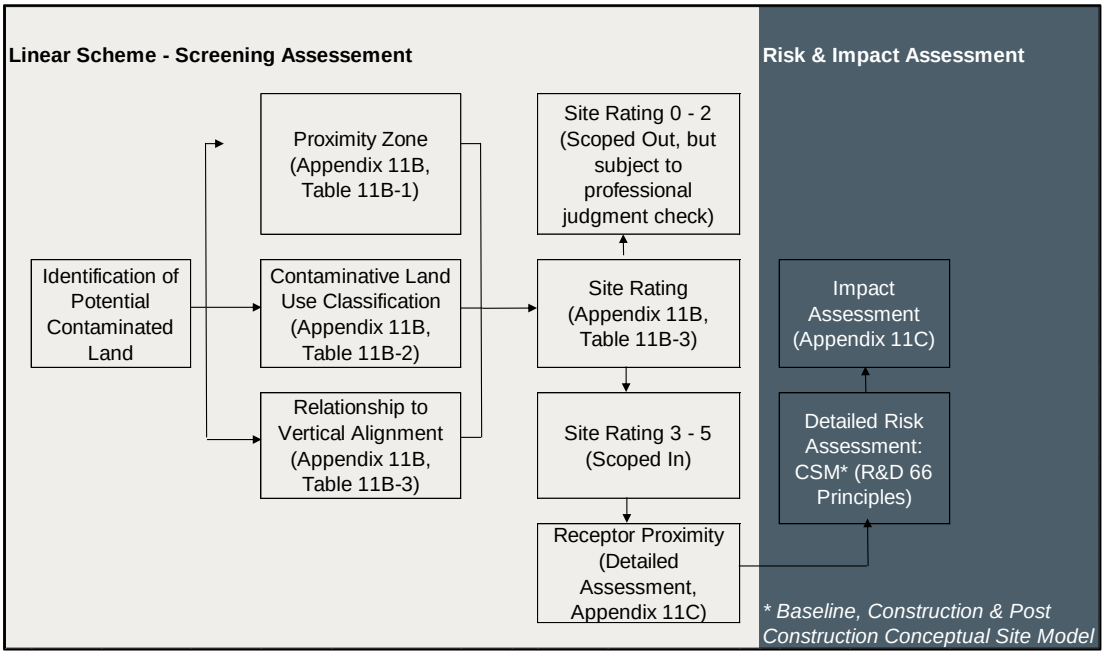
21. A qualitative assessment of the risks posed by land contamination within the Study Area has been undertaken as part of this EIA chapter by first assigning a 'site rating' to each identified historical or current area of potential land contamination, identified in the baseline review. The site rating has been determined using the tables provided in **Appendix 11B: Land Contamination Methodology Tables.** The site rating is partly based on the relationship between the identified area of potential land contamination and its proximity to the Onshore Development Area (**Appendix 11B, Table 11-B.1**) together with consideration of the level of ground disturbance (e.g., cut or fill) planned at its closest point (**Appendix 11B, Table 11-B.3**). The site rating also considers the nature of the identified current and / or historical land use, as certain land uses typically result in a greater potential for contamination of the ground to have occurred (**Appendix 11B, Table 11-B.2**). The lower the site rating then the lower the perceived level of risk.

22. Professional judgement has been applied in reviewing the generated site rating. Generally, site ratings of two or less are considered not to pose an unacceptable risk and were therefore scoped out of further assessment. Site ratings of three or more were considered for further risk and impact assessment.

23. The next stage of the screening assessment considers a review of sensitive receptors and their proximity to the potential area of land contamination. A combination of this review and the Site Rating then defines whether a potential land contamination site is taken forward for detailed risk and impact assessment. The review of sensitive receptors and their proximity in relation to the potential contaminated sites are presented in **Appendix 11C: Potential Areas of Contamination: Site Rating and Further Risk and Impact Assessment** and **Volume 5: Figure 11.4.**

24. A flow chart summarising the screening, risk and impact assessment steps that have been undertaken, and signposting to where relevant data and assessments is presented in **Figure 11-1.**

Figure 11-1 Land contamination assessment flow chart



Risk and Impact Assessment

25. The risk and impact assessment stage initially involves creating a baseline CSM for the potential contaminated land sites identified as part of the screening assessment (not the Onshore Development Area itself).

26. The first stage to developing baseline CSM considered whether it was appropriate to group any of the sites, based on common land uses, e.g., light industrial sites, farms, etc., and distance from the Onshore Development Area. Not all sites were grouped, and some key individual sites were assessed as standalone sites.

27. Potential risks were determined and assessed based on the likelihood (or probability) and consequence using the principles given in the R&D Publication 66 (NHBC, Environment Agency, CIEH, 2008). This provides guidance on development and application of the consequence and probability matrix to risk assessment and broad definitions of consequence. The risk classification matrix is presented in **Table 11-3.**

Table 11-3. Risk based on comparison of likelihood and severity

		Consequence			
		Severe	**Medium**	**Mild**	**Minor**
Probability	**High Likelihood**	Very high risk	High risk	Moderate risk	Low risk
	Likely	High risk	Moderate risk	Moderate / low risk	Low risk
	Low Likelihood	Moderate risk	Moderate / low risk	Low risk	Very low risk
	Unlikely	Moderate / low risk	Low risk	Very low risk	Very low risk

Impact Assessment Methodology

28. **Chapter 05: EIA Approach and Methodology** provides a summary of the general impact assessment methodology applied in this ES. The following sections provide further detail on the specific methodology used to assess the potential impacts on geology and hydrogeology.

29. The approach to the assessment of cumulative impacts, transboundary impacts and interrelated effects is provided in **Sections 11.10, 11.11, and 11.12**.

30. The significance of potential effects has been evaluated using a systematic approach together with the expert judgement of the specialist consultant. The systematic approach is based upon the identification of the importance/value of receptors and their sensitivity to the proposed Project together with the predicted magnitude of the potential impact.

31. The terms used to define receptor sensitivity and magnitude of impact are based on DMRB LA109 and LA113.

Methodology for Determining Construction and Decommissioning Effects

32. Note that in this chapter, the construction and decommissioning (temporary) phases have been combined as it is considered that the potential impacts / effects are the same for both of these phases.

Geology Assessment

33. With reference to **Section 11.5**, geological designations are present within the Onshore Development Area. The assessment of significance considers the sensitivity or importance of the asset and the magnitude of potential impact that might occur (**see Section 11.4.2**). This uses definitions based on DMRB LA109.

Mineral Safeguarding Zone Assessment

34. With reference to **Section 11.5**, MSZ are present within the Onshore Development Area. The construction / decommissioning (temporary) effects occur where construction compounds are proposed within the MSZ. In such cases, there will be a temporary sterilisation of the resource. The assessment of significance (using AECOM derived methodology) considers the sensitivity or importance of the resource and the magnitude of potential impact (see **Section 11.4.2**) that might occur during the construction / decommissioning phase.

Land Contamination Assessment

35. The methodology for determining construction / decommissioning (temporary) effects involved creating additional CSM for the construction / decommissioning stages for comparison against each baseline CSM that was created as part of the risk and impact assessment.

36. The approach to assessing the potential temporary construction / decommissioning impacts of the Onshore Development Area was undertaken by comparing the risk levels at baseline with the risk levels for the construction / decommissioning CSM, to determine any change in risk. The change in risk level identified in the comparison defines the 'magnitude of impact', described in see **Section 11.4.2**.

Methodology for Determining Construction and Decommissioning Effects

Geology Assessment

37. No further impacts on geological designations are anticipated to occur during the operational phase.

Mineral Safeguarding Zone Assessment

38. The operational (permanent) effects occur where the MSZ is underlying the footprint of the permanent works (Onshore Substation and cable route), with a strip of mineral becoming sterilised. The assessment of significance (using AECOM derived methodology) considers the sensitivity or importance of the resource and the magnitude of potential impact (see **Section 11.4.2**) that might occur during the operational phase.

Land Contamination Assessment

39. The methodology for determining post-construction / post-decommissioning (permanent) effects involved creating an additional CSM for the post-construction / post-decommissioning stage for comparison against each baseline CSM that was created as part of the risk and impact assessment.

40. The approach to assessing the potential permanent post-construction / post-decommissioning impacts of the proposed Project was then undertaken by comparing the risk levels at baseline with the risk levels for the post-construction / post-decommissioning CSM, to determine any change in risk. The change in risk level identified in the comparison defines the 'magnitude of impact', described in **Section 11.4.2.**

41. It is anticipated that other than permanent post-construction / post-decommissioning impacts resulting from contamination being removed, remediated, or mitigated leading to removal of contaminant sources from the source – pathway – receptor linkage, there will be no significant effects during the actual routine operation of the proposed Project as maintenance and operation of the proposed Project will be in accordance with environmental legislation and good practice.

11.4.2. Significance Criteria

Magnitude of Impact

42. The scale or magnitude of potential impacts (both beneficial and adverse) is determined by a combination of three criteria: scale of change, spatial extent of change and duration of change, as outlined in **Chapter 05: EIA Approach and Methodology, Section 5.4.9.**

43. The criteria for defining magnitude of impact for the purpose of the assessment on geology and hydrogeology are provided in **Table 11-4**. The summary of the magnitude criteria that

are associated to specific impacts are based on the DMRB LA109 and LA113. The DMRB guidance has been referred to for the geology and hydrogeology topic, as whilst this guidance is for road schemes, both roads and the proposed Project are comparable in that they have linear elements (i.e., cable routes) to the development. Furthermore, there is an absence of any other EIA guidance for this topic.

44. In the absence of any interpretation of ground investigation data at this stage, the interpretation of magnitude of impact, is conceptual and professional judgement has been used.

Table 11-4. A summary of the magnitude criteria that are associated to specific impacts

Magnitude Criteria	Definition	Demonstrated in the during and post-construction / decommissioning CSM as risk level changes defined as follows (also refer to Table 11-3).
Large	**Geology and Mineral Resources** Loss of geological feature / designation and / or quality and integrity, severe damage to key characteristics, features, or elements.	Not applicable
	Contamination 1) *human health:* significant contamination identified. Contamination levels significantly exceed background levels and relevant screening criteria (category 4 screening levels) within SP1010 with potential for significant harm to human health. Contamination heavily restricts future use of land; 2) *surface water:* refer to sensitivity criteria in LA113; and 3) *groundwater:* refer to sensitivity criteria in LA113.	**Large adverse:** An increase in contamination risk of 4 or 5 risk levels in the risk matrix, e.g., land that has a very low contamination risk in the baseline becoming a high or very high risk. **Large beneficial:** A reduction in contamination risk of 4 or 5 risk levels in the risk matrix, e.g., land that has a very high contamination risk in the baseline becomes a low or very low risk.
Medium	**Geology and Mineral Resources** Partial loss of geological feature / designation, potentially adversely affecting the integrity; partial loss of / damage to key characteristics, features, or elements.	Not applicable
	Contamination 1) *human health:* contaminant concentrations exceed background levels and are in line with limits of relevant	**Medium adverse:** An increase in contamination risk of 2 or 3 risk levels in the risk matrix, e.g., land that has a low

Magnitude Criteria	Definition	Demonstrated in the during and post-construction / decommissioning CSM as risk level changes defined as follows (also refer to Table 11-3).
	screening criteria (category 4 screening levels) in SP1010. Significant contamination can be present. Control / remediation measures are required to reduce risks to human health / make land suitable for intended use; 2) *surface water:* refer to sensitivity criteria in LA113; and 3) *groundwater:* refer to sensitivity criteria in LA113.	contamination risk in the baseline becomes a moderate or high risk. **Medium beneficial:** A reduction in contamination risk of 2 or 3 levels in the risk matrix, e.g., land that has a high contamination risk in the baseline becomes a moderate / low or low risk.
Small	**Geology and Mineral Resources** Minor measurable change in geological feature / designation attributes, quality, or vulnerability; minor loss of, or alteration to, one (maybe more) key characteristics, features, or elements.	Not applicable
	Contamination 1) *human health:* contaminant concentrations are below relevant screening criteria (category 4 screening levels) in SP1010. Significant contamination is unlikely with a low risk to human health. Best practice measures can be required to minimise risks to human health; 2) *surface water:* refer to sensitivity criteria in LA113; and 3) *groundwater:* refer to sensitivity criteria in LA113.	**Small adverse:** An increase in contamination risk of 1 risk level in the risk matrix, e.g., land that has a low contamination risk in the baseline becomes a moderate / low risk. **Small beneficial:** A reduction in contamination risk of 1 risk level in the risk matrix, e.g., land that has a moderate / low contamination risk in the baseline becomes a low risk.
Negligible	**Geology and Mineral Resources** Very minor loss or detrimental alteration to one or more characteristics, features, or elements of geological feature / designation. Overall integrity of resource not affected.	Not applicable
	Contamination 1) *human health:* contaminant concentrations substantially below levels	**Negligible adverse / beneficial:** No or very little change in contaminated land risks.

Magnitude Criteria	Definition	Demonstrated in the during and post-construction / decommissioning CSM as risk level changes defined as follows (also refer to Table 11-3).
	outlined in relevant screening criteria (category 4 screening levels) in SP1010. No requirement for control measures to reduce risks to human health / make land suitable for intended use; 2) *surface water;* refer to sensitivity criteria in LA113; and 3) *groundwater:* refer to sensitivity criteria in LA113.	

Sensitivity of Receptor

45. Receptor sensitivity is defined as the degree to which a receptor would be affected by an impact. The sensitivity of the receptor is characterised by three factors: vulnerability, recoverability and importance, as outlined in **Chapter 05: EIA Approach and Methodology**, **Section 5.4.10.**

46. The criteria for defining receptor sensitivity for the purpose of the assessment on geology and hydrogeology are provided in **Table 11-5** and are based on the DMRB LA109 and LA113.

Table 11-5. A summary of the criteria determining a receptor's sensitivity

Receptor Sensitivity Criteria	Definitions
Very High	**Geology** Very rare and of international importance with no potential for replacement (e.g., United Nations Educational, Scientific and Cultural Organization (UNESCO) World Heritage Sites, UNESCO Global Geoparks, SSSI and Geological Conservation Review (GCR) sites where citations indicate features of international importance). Geology meeting international designation citation criteria which is not designated as such. **Mineral resources**[1] Presence of significant mineral reserves and within a Mineral Buffer Zone or Safeguarding Zone. **Contamination** *Human health*: • Very high sensitivity land use such as residential or allotments. *Surface water*: • Watercourse having a WFD classification shown in a River Basin Management Plan (RBMP) and Q95 ≥ 1 .0 m^3/s. • Site protected / designated under EC or UK legislation (Special Area of Conservation (SAC), Special Protection Area (SPA), SSSI, Ramsar site, salmonid water). • Species protected by EC legislation Ecology and Nature Conservation. *Groundwater*:

Receptor Sensitivity Criteria	Definitions
	• Principal aquifer providing a regionally important resource and / or supporting a site protected under EC and UK legislation Ecology and Nature Conservation. • Groundwater locally supports Groundwater Dependent Terrestrial Ecosystem (GWDTE). • Source Protection Zone (SPZ) 1.
High	**Geology** Rare and of national importance with little potential for replacement (e.g., geological SSSI, Area of Special Scientific Interest (ASSI), National Nature Reserves (NNR)). Geology meeting national designation citation criteria which is not designated as such. **Mineral resources[1]** Within a Mineral Consultation or Safeguarding Zone. **Contamination** *Human health*: • High sensitivity land use such as public open space. *Surface water*: • Watercourse having a WFD classification shown in a RBMP and Q95 <1.0m^3/s. • Species protected under EC or UK legislation Ecology and Nature Conservation. *Groundwater*: • Principal aquifer providing locally important resource or supporting a river ecosystem. • Groundwater supports a GWDTE. • SPZ 2.
Medium	**Geology** Of regional importance with limited potential for replacement (e.g., RIGS). Geology meeting regional designation citation criteria which is not designated as such. **Mineral resources[1]** Some mineral potential but not within a Mineral Consultation or Safeguarding Zone. **Contamination** *Human health*: • Medium sensitivity land use such as commercial or industrial. *Surface water*: • Watercourses not having a WFD classification shown in a RBMP and Q95 >0.001m^3/s. *Groundwater*: • Aquifer providing water for agricultural or industrial use with limited connection to surface water. • SPZ 3.
Low	**Geology** Of local importance / interest with potential for replacement (e.g., non designated geological exposures, former quarry's / mining sites). **Mineral resources[1]** Limited potential for mineral reserves and site not within a Mineral Consultation or Safeguarding Zone. **Contamination** *Human health*:

Receptor Sensitivity Criteria	Definitions
	• Low sensitivity land use such as highways and rail. *Surface water*: • Watercourses not having a WFD classification shown in a RBMP and Q95 ≤0.001m^3/s. *Groundwater*: • Unproductive strata.
Negligible	**Geology** No geological exposures, little / no local interest. **Mineral resources**[1] No mineral extraction potential. **Contamination** *Human health*: undeveloped surplus land / no sensitive land use proposed.

[1] Sensitivity of mineral receptors is not described as part of the referenced DMRB guidance. Therefore, professional judgment has been used.

Significance of Effect

47. As set out in **Chapter 05: EIA Approach and Methodology**, an Impact Assessment Matrix (IAM) is used to determine the significance of effect which is a function of the sensitivity of the receptor and the magnitude of the impact, as shown in **Table 11-6.**

48. The matrix provides a framework for the consistent and transparent assessment of predicted effects across all receptor topics, however, it is important to note that the IAM acts as a guide and that assessments also allow for the application of expert judgement.

Table 11-6. Significance matrix

		Value / Sensitivity				
		Very High	**High**	**Medium**	**Low**	**Negligible**
Magnitude	**Large**	Major	Major / Moderate	Major / Moderate / Minor	Moderate / Minor	Minor / Negligible
	Medium	Major / Moderate	Major / Moderate	Moderate / Minor	Minor / Negligible	Negligible
	Small	Major / Moderate / Minor	Moderate / Minor	Moderate / Minor	Minor / Negligible	Negligible
	Negligible	Minor / Negligible	Minor / Negligible	Minor / Negligible	Negligible	Negligible

49. The IAM provides levels of effect significance ranging from major to negligible. Assignment of significance is carried out with consideration of embedded mitigation measures relevant to geology and hydrogeology. Embedded mitigation measures (including project design measures and best practice) are presented within **Section 11.7.** Details on additional

mitigation measures and associated definitions can be found in **Section 11.9.** For the purposes of this assessment, Moderate and Major levels of significance are defined as significant, and where relevant additional mitigation measures may be required, whilst Negligible or Minor impacts are defined as not significant. However, professional judgement will also be applied in reaching conclusions as to significance of effects.

50. The definitions of effect significance levels for the purpose of the assessment on geology and hydrogeology are provided in **Table 11-7.**

Table 11-7. A summary of the definitions of each significant of effect criteria

Significance Category	Definitions	Significant / Not Significant Effect
Major	A large and detrimental change to a valuable / sensitive receptor; likely or apparent exceeding of accepted (often legal) threshold. Or A large and beneficial change, resulting in improvements to the baseline result in previously poor conditions being replaced by new legal compliance or a major contribution being made to national targets. These effects may represent key factors in the decision-making process. Potentially associated with sites and features of national importance or likely to be important considerations at a regional or district scale. Major effects may relate to resources or features which are unique and which, if lost, cannot be replaced or relocated.	Significant
Moderate	A medium scale change which, although not beyond an acceptable threshold, is still considered to be generally unacceptable, unless balanced out by other significant positive benefits of a project. Likely to be in breach of planning policy rather than a legal statute. Or A positive moderate effect is a medium scale change that is significant in that the baseline conditions are improved to the extent that guideline targets (e.g. UK BAP targets) are contributed to. These effects, if adverse, are likely to be important at a local scale and on their own could have a material influence on decision making.	Significant (unless otherwise specified)
Minor	A small change that, whilst adverse, does not exceed legal or guideline standards. Unlikely to breach planning policy. Or A small positive change, but not one that is likely to be a key factor in the overall balance of issues. These effects may be raised as local issues and may be of relevance in the detailed design of a project but are unlikely to be critical in the decision-making process.	Not Significant
Negligible	A very small change that is so small and unimportant that it is considered acceptable to disregard. Effects which are beneath levels of perception, within normal bounds of variation or within the margin of forecasting error. These effects are unlikely to influence decision making irrespective of other effects.	Not Significant

11.4.3. Study Area

51. The Onshore Development Area (**Volume 5: Figure 11.1**) will comprise:

- Cable landfall (the Landfall), located at Freshwater West where up to two Offshore Export Cable(s) from the Array Area will be brought ashore via Horizontal Directional Drilling (HDD) and into the Transition Joint Bay (TJB);
- TJB where up to two offshore and up to two onshore cable circuit(s) will be spliced together (each circuit is made up of three cables in a trefoil or flat arrangement);
- Onshore cable circuit(s) (up to two), buried to a target depth of 1.8 m and laid in a maximum of two trenches each up to 1.2 m wide, subject to ground conditions and landowner requirements;
- Cable Joint Bays (CJBs) may be required if the onshore cable circuit(s) are installed in sections, to join the sections together;
- Onshore Substation covering an area of 95 m wide, 63 m length and 15 m in height, which is required to transfer the electricity from the proposed Project prior to connection into the grid at Pembroke Power Station; and

52. Onshore cable circuit from the substation to the grid connection point Pembroke Power Station, laid in trenches and/or ducts. A complete description of the proposed Project is reported in **Chapter 04: Description of the Proposed Project**.

53. For the purposes of determining the local baseline conditions with respect to geology and land contamination, a Study Area extending 250 m from the boundary of the Onshore Development Area will be adopted. This will be extended for hydrogeology to 1 km from the boundaries. This is indicated in **Volume 5: Figure 11.2.**

54. This Study Area is appropriate to assess the local geological and hydrogeological setting, and any influence that potential land contamination may have on the proposed Project or local sensitive receptors.

55. Note that the Study Area terminates at the Mean High Water Springs (MHWS) irrespective of whether this is 250 m or less from the Onshore Development Area.

11.4.4. Data Sources

Site Specific Surveys

56. To provide site specific information on which to base the impact assessment for geology and hydrogeology, a site inspection was completed from roads and public rights of way along the Onshore Development Area by a qualified AECOM engineer on 31st May 2022. The findings of the inspection are reported in **Appendix 11A: Phase 1 Geo-environmental Desk Study Report**.

Desk Study

57. A comprehensive desk-based review was undertaken to inform the baseline for geology and hydrogeology. The findings are reported in **Appendix 11A: Phase 1 Geo-environmental Desk Study Report** and in **Section 11.5.** Key data sources used to inform the assessment are set out in **Table 11-8.**

Table 11-8. Summary of key desktop sources

Title	Source	Year	Brief description	Author
Groundsure Insights Report (GIS)	Groundsure	2023	Historical mapping, water quality, pollution inventory, hydrology, and hydrogeology data, etc.	Groundsure

Title	Source	Year	Brief description	Author
Geological mapping and memoirs; Geoindex website	British Geological Survey website	Multiple	Geological data including geological mapping, borehole logs, linear features.	British Geological Survey
Interactive Map Viewer and Data Map Wales	Natural Resources Wales (NRW) website and Welsh Government website	Accessed 2023	Welsh Government website.	Multiple
Soilscapes website	Soilscapes website	Accessed 2023	1:250,000 scale soil dataset covering England and Wales.	Cranfield Soil and AgriFood Institute (CSAI)
UK Radon maps	UK Health Security Agency website	2022	Radon Affected Area maps for the whole of the United Kingdom.	UK Health Security Agency
Coal Authority mapping	Coal Authority website	Accessed 2023	Coal areas mapping, including development high risk areas and past and probable shallow coal mine workings.	Coal Authority
Project Erebus Environmental Statement' Chapter 19: Onshore Geology, Hydrology and Hydrogeology and associated appendices	-	2021	The proposed Project is approximately 4.85km east of a floating offshore windfarm within the Pembrokeshire Development Zone (PDZ), Project Erebus, developed by Blue Gem Wind (BGW), which secured a Marine License for this development on the 22 February 2022. The routing and location of Project Erebus' offshore and onshore site boundary was a key consideration in the finalisation of the proposed Project's siting and redline boundary. Refer to Chapter 03: Alternatives for more information.	Blue Gem Wind, ITP Energise, OWC, MarineSpace

58. It is understood that ground investigation has been undertaken in the area by Erebus, however the findings of this are not available at this stage.

11.5 Baseline

59. The following sections describe the baseline environment relating to geology and hydrogeology.

11.5.1. Existing Baseline

Soil Classification

60. Information obtained from the CSAI Soilscapes website (Cranfield Soil and AgriFood Institute, n.d.) (accessed December 2023) describes the soils underlying the Onshore Development Area as indicated in **Table 11-9.**

Table 11-9. CSAI soil classification

Soilscape Classifications	Descriptions of the Soilscape Classifications	Extent
Soilscape 7	Freely draining slightly acid but base-rich soils.	Pembroke Power Station (eastern-most extent of the Onshore Development Area).
Soilscape 4	Sand dune soils.	Portion of land from Angle Bay, south-west of the Pembroke Refinery, to Freshwater West Beach (western part of the Onshore Development Area).
Soilscape 17	Slowly permeable seasonally wet acid loamy and clayey soils.	Portion of land in the central-southern area of the Onshore Development Area, in proximity of Newton, east of Soilscape 4.
Soilscape 6	Freely draining slightly acid loamy soils	Remainder of Onshore Development Area, comprising the central area to Pembroke Power Station.

Geology

61. The BGS Geoindex website (British Geological Survey (BGS), n.d.) has been reviewed, alongside BGS geological map sheets 244 and 245 (Pembroke and Linney Head), solid and drift edition (1:50,000) (BGS, n.d.) and **Table 11-11** outline the anticipated geological succession underlying the Onshore Development Area and Study Area.

Made Ground

62. BGS mapping does not indicate the presence of Made Ground / artificial ground within the Study Area. However, it is expected to be present in areas around more developed areas such as the Pembroke Power Station.

Superficial Deposits

63. According to the aforementioned BGS maps, the extent of superficial deposits mapped across the Onshore Development Area is relatively isolated. These are present:

- Across the western portion of the Onshore Development Area, south of Angle Bay and the area surrounding Freshwater West Beach (mostly blown sand, with marine beach deposits in the Study Area along Freshwater West Beach, and small areas of alluvium in the Study Area around Neath Farm (north of the western section of Onshore Development Area); and
- On the eastern-most spur of the Onshore Development Area, close to the Pembroke Power Station (alluvium) and small areas in the south-east and east of the Study Area (till and tidal flat deposits).

64. A more detailed description of superficial deposits in the Study Area, together with the BGS descriptions, is reported in **Table 11-10.** A figure of the superficial deposits across the Study

Area is presented within **Appendix 11A: Phase 1 Geo-environmental Desk Study Report, Figure 11A.2.**

Table 11-10. Superficial deposits

Name	Location	BGS Description (British Geological Survey, n.d.)
Marine beach deposits – sand	Freshwater West Beach.	Shingle, sand, silt, and clay.
Blown sand	Located in the western portion of the Onshore Development Area and Study Area.	Sand that has been transported by wind, or sand consisting predominantly of wind-blown particles.
Alluvium	Mapped underneath and to the south-east of the Pembroke Power Station and in a small strip south-east of Angle Bay, extending within the Study Area around Neath (north of the western section of the Onshore Development Area).	Clay, silt, sand, and gravel. It is the unconsolidated detrital material deposited by a river, stream, or other body of running water.
Till, Mid Pleistocene	Small strip in the south-easternmost extent of the Study Area.	Not available.
Tidal flat deposits – sand, silt, and clay	Along the coastline east of the Pembroke Power Station, with very limited overlap into the eastern-most extent of the Study Area.	Mud flat and sand flat deposits, deposited on extensive nearly horizontal marshy land in the intertidal zone that is alternately covered and uncovered by the rise and fall of the tide.

Bedrock

65. The mapped bedrock underneath the Study Area consists of a complex sequence of strata. A figure of the bedrock geology across the Study Area is presented within **Appendix 11A: Phase 1 Geo-environmental Desk Study Report, Figure 11A.3.**

66. The Pembrokeshire peninsula is mostly comprised of sedimentary rocks of the Devonian and Carboniferous Periods (sandstone and limestone) with outcrops of Silurian and Ordovician rocks (shales and sandstones). Sequences of limestones interbedded with mudstones (Avon Group) outcrop in parts of the Onshore Development Area and are part of the Pembroke Limestone Group, which in turn are of the Carboniferous Limestone Supergroup. There are two axial plane traces of major anticlines / synclines located in the western extent of the Onshore Development Area and Study Area. A few faults and folds trending approximately in a north to south direction are located across the Study Area; due to the folding and faulting, depth and dip direction of strata is expected to vary significantly across the Study Area.

67. For the purposes of this section, the Onshore Development Area has been divided into two areas:

- From Freshwater West Beach to Wallaston Green village (western portion of the Onshore Development Area); and
- From Wallaston Green village to Pembroke Power Station (eastern portion of the Onshore Development Area).

From Freshwater West Beach to Wallaston Green village

68. This area is predominantly underlain by the Milford Haven Group along the Orielton Anticline, except for an area in the south-western spur, where the Ludlow Rocks and Aber Mawr Shale formations outcrop. A fault extends from Freshwater West Beach to Angle Bay Beach, in a southwest-northeast direction; the geological units either side of the fault dip roughly north at steep angles (around 60° – 65°), there is no information regarding dip or strike of the fault itself on the BGS geological map sheets reviewed (BGS, n.d.).

From Wallaston Green village to Pembroke Power Station

69. This area's bedrock geology comprises mostly the Milford Haven Group and outcrops of the Ridgeway Conglomerates, Skrinkle Sandstone, and the Avon Group. The Black Rock Subgroup and Gully Oolite Formation, forming the core of the Pembroke syncline, is mapped in the northeastern-most extent of the Onshore Development Area within the Pembroke Power Station footprint (as indicated on the **Appendix 11A: Phase 1 Geo-environmental Desk Study Report, Figure 11A.3**).

70. The mapped bedrock underneath the Study Area consists of a complex sequence of strata. These are summarised below in **Table 11-11**, reported roughly from south to north.

Table 11-11. Bedrock geology, in oldest- to- youngest order

Name	Location	BGS Description	Further information from the BGS memoirs (Dixon, 1921) and map sheets 244 and 245 (BGS, n.d.)
Aber Mawr Shale Formation – mudstone.	Slight overlap into the south-western portion of the Onshore Development Area.	Dark grey mudstones locally with interbedded tuffs.	Referred to in the BGS memoirs and map sheet as the Llanvirn formation (Bifidus Shales). Ordovician Period Thickness is unknown but may be considerable (Dixon, 1921).
Ludlow Rocks (undifferentiated) – sandstone.	South-western portion of the Study Area (north of the Aber Mawr Shale Formation).	Not available.	Referred to in the BGS memoirs and map sheet as the Ludlow Formation (chiefly sandstones). Silurian Period Described in the BGS memoir (Dixon, 1921) as 'sandstone with alternations of shale and lenticles of highly fossiliferous, sandy limestone'. Its thickness may exceed ~120 m but the maximum thickness exposed is less than ~75 m.
Milford Haven Group – argillaceous rocks and sandstone interbedded.	Majority of the Onshore Development Area and Study Area, except the north-eastern areas and a limited area in the southern-most portions of the Study Area.	Hard, red calcareous marls with sporadic red and green sandstones. Basal beds of green marl, conglomerate and breccia are also present.	Referred to in the BGS memoirs and map sheet as the Lower Old Red Sandstone Formation (red marls). Devonian Period BGS memoir (Dixon, 1921) indicates it varies in thickness between ~560 m at Freshwater West to ~1,220 m near Pembroke. Farther north, is thicker still.
Ridgeway Conglomerate Formation – conglomerate.	Along a band outcropping east west and crossing the Onshore Development Area and Study Area north of the Milford Haven Group.	Interbedded conglomerates and red mudstones.	Referred to in the BGS memoirs and map sheet as the Lower Old Red Sandstone Formation (Ridgeway Conglomerates). Devonian Period. Map sheet 244 and 245 indicates a thickness between 0 and 250m.
Skrinkle Sandstone Formation – sandstone.	Along a band outcropping east west and crossing the Onshore Development Area and Study Area north of the Ridgeway Conglomerate Formation.	Interbedded grey quarzitic and red lithic sandstones, conglomerates, red mudstones, and siltstones.	Referred to in the BGS memoirs and map sheet as the Upper Old Red Sandstone Formation (Skrinkle Sandstone). Late Devonian to early Carboniferous Periods. BGS memoir (Dixon, 1921) indicates it varies in thickness between ~75 m in the north to ~300 m at Freshwater West. Angle was indicated to have a general water supply from a spring in the Upper Old Red Sandstone (Skrinkle Sandstone) to the north of the village (Dixon, 1921).

Name	Location	BGS Description	Further information from the BGS memoirs (Dixon, 1921) and map sheets 244 and 245 (BGS, n.d.)
Avon Group – limestone and mudstone, interbedded.	Along two bands outcropping east west and crossing the Onshore Development Area and Study Area north of the Skrinkle Sandstone Formation.	Interbedded grey mudstones and thin- to medium-bedded skeletal packstones with one to several thick units of ooidal and skeletal grainstones. Thin units of calcite mudstone and mudstone locally present. Sparse thin ironstones. Represents mid to inner shelf / ramp deposits with coeval barrier, back barrier and coastal plain sediments.	Referred to in the BGS memoirs and map sheet as the Lower Limestone Shales (part of the Carboniferous Limestone Series). Carboniferous Period (Lower) BGS memoir [1] indicates an average thickness over much of the area of ~140-170 m. Angle was indicated to have a general water supply from near the base of the Lower Limestone Shales (Avon Group) to the south of the village [1].
Black Rock Subgroup and Gully Oolite Formation (undifferentiated) – limestone.	Located within the north-easternmost extent of the Onshore Development Area and Study Area, along a band outcropping east west between the two Avon Group bands.	Not available.	Referred to in the BGS memoirs and map sheet as the Main Limestone (part of the Carboniferous Limestone Series). Carboniferous Period (Lower)

Historical Borehole Records

71. No historical boreholes records are publicly available for the Onshore Development Area or Study Area. The closest historical boreholes from the Onshore Development Area are located at least 1.2 km away and therefore not considered to be relevant.

Geological Designated Sites

72. DEFRA's Magic Map application (Department for Environment, Food & Rural Affairs, n.d.), NRW (National Resources Wales, n.d.), and Data Map Wales (Welsh Government, n.d.) were reviewed to identify Special Scientific Interest Sites (SSSI) safeguarded for their geological features located within the Study Area. The SSSI Broomhill Burrows comprises the coastline in proximity of Freshwater West beach and extending inland and overlaps the Onshore Development Area along Freshwater West beach and between Freshwater West beach and the former tank farm. In the description of the Broomhill Burrows SSSI (Cyngor Cefn Gwlad Cymru - Countryside Council for Wales, 1987), it is noted that 'cliff and foreshore rock outcrops at the north-western end of this site provide exposures chiefly consisting of mudstones and sandstones of the Devonian Milford Haven Group'. This indicates that the main area of geological importance is in the area that overlaps into the northwestern-most extent of the Onshore Development Area, but the full extent is unclear from this description and available mapping.

73. The Freshwater West (North) Geological Conservation Review (GCR)[1] site overlaps slightly into the northwestern-most extent of the Onshore Development Area. This GCR protects 'Variscan structures of South Wales and the Mendips'. This is understood to roughly correspond to the area of the area of geological interest within the SSSI Broomhill Burrows site.

A walkover of the Broomhill Burrows SSSI was undertaken, and photos of the shoreline rock outcrops are indicated below (**Figure 11-2**). The photographs have been taken from Freshwater West beach (north-western direction).

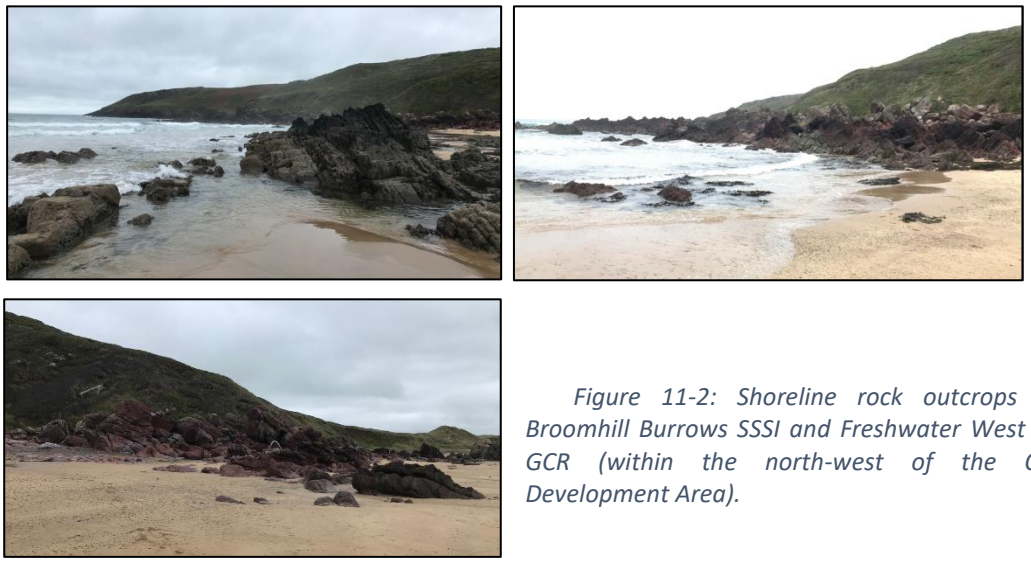


Figure 11-2: Shoreline rock outcrops of the Broomhill Burrows SSSI and Freshwater West (North) GCR (within the north-west of the Onshore Development Area).

[1] GCR sites: the sites selected provide the basis of statutory geological and geomorphological site conservation in Britain. Pembrokeshire has a rich geological diversity that needs protection from development that would damage it, including several GCR sites (Pembrokeshire Coast National Park, 2020) (Pembrokeshire County Council, 2013).

74. The eastern extent of the shoreline rock outcrops are located within the northwestern-most extent of the Onshore Development Area (overlap of approximately 100 m into this area).

75. The identified Geological Designated Sites are indicated in **Volume 5: Figure 11.3.**

Mineral Safeguarding Zones

76. The Study Area falls under both the Pembrokeshire Coast National Park and Pembrokeshire County Council with regards to Local Development policies.

77. The Pembrokeshire Coast National Park Local Development Plan (Pembrokeshire Coast National Park, 2020) was adopted in 2020 with an end date of 2031. The plan defines several MSZ located within the Onshore Development Area for:

- Sand and gravel; extending between Angle Bay, Freshwater West Beach and Castlemartin, this MSZ overlaps the Onshore Development Area, predominantly between Freshwater West Beach and the Valero refinery; and
- Hard rock; extending horizontally south of Valero refinery and east of Freshwater West beach; this MSZ overlaps the Onshore Development Area, predominantly in the central / western portion and between Freshwater West beach and the B4320 road.

78. The remainder area of the Study Area is in the Pembrokeshire County Council Local Development Plan (LDP) (Pembrokeshire County Council, 2013), adopted in 2013 and valid until 2021. It will remain in force until LDP 2 (the replacement plan) is adopted. The LDP 2 is currently under review and specific dates for when this will be adopted have not yet been identified. The currently adopted Local Development Plan defines MSZ located within the Onshore Development Area for;

- Sand and gravel; in proximity of the Pembroke Refinery and Pembroke Power Station and north of Castlemartin; this MSZ overlaps the Onshore Development Area in proximity of the Power Station for a limited extent; and
- Hard rock; in proximity of the Pembroke Refinery and Power Station, overlapping portions of the eastern area of the Onshore Development Area.

79. The Coal Authority Interactive Map (The Coal Authority) indicates Pembrokeshire is not within an area affected by coal mining.

80. The identified MSZ are reported in **Volume 5: Figure 11.3.**

Hydrogeology

Aquifer Designation

81. NRW aligns with the Environment Agency's Groundwater Protection Policy (Environment Agency, 2018) which adopts aquifer designations that are consistent with the Water Framework Directive (WFD) (WFD 2000/60/EC).

82. NRW have adopted the Environment Agency definitions for the aquifer designations, which are listed as follows:

- Principal aquifer: 'layers of rock or drift deposits that have high intergranular and / or fracture permeability – meaning they usually provide a high level of water storage. They may support water supply and / or river base flow on a strategic scale.';
- Secondary A aquifer: 'permeable layers that can support local water supplies and may form an important source of base flow to rivers.'; and

- Secondary B aquifer: 'lower permeability layers that may store and yield limited amounts of groundwater through characteristics like thin cracks (called fissures) and openings or eroded layers.'

83. Secondary undifferentiated aquifer: 'Secondary undifferentiated are aquifers where it is not possible to apply either a Secondary A or B definition because of the variable characteristics of the rock type.'

84. Aquifer designations for the Onshore Development Area are listed in **Table 11-12.**

Table 11-12. Aquifer designations

Geology	Aquifer Designation
Superficial deposits	
Tidal flat deposits, till deposits	Secondary undifferentiated aquifers
Marine beach deposits, alluvium, and blown sand	Secondary A aquifers
Bedrock formations	
Black Rock Subgroup and Gully Oolite Formation	Principal aquifer
Ludlow Rocks and the Aber Mawl Shale Formation	Secondary B aquifers
Remaining bedrock designations	Secondary A aquifers

Groundwater Vulnerability

85. Groundsure report outlines the vulnerability of groundwater to pollution. The definition of the groundwater vulnerability to pollution is as follows;

- High: 'Areas able to easily transmit pollution to groundwater. They are characterised by high leaching soils and the absence of low permeability superficial deposits'.
- Medium: 'Areas that offer some groundwater protection. Intermediate between high and low vulnerability'.
- Low: 'Areas that provide the greatest protection to groundwater from pollution. They are likely to be characterised by low leaching soils and / or the presence of low permeability superficial deposits'.

86. The groundwater vulnerability map obtained as part of the Groundsure report (**Annex 11A-A**), indicates that the combined groundwater vulnerability is classified as High for the whole Onshore Development Area and 250m Study Area, except for an area of limited extent within the western Onshore Development Area boundary north of Angle Road. The High vulnerability classification applies to the Secondary superficial aquifers, Principal bedrock aquifers and Secondary bedrock aquifers (i.e., across the Onshore Development Area and Study Area).

Source Protection Zones

87. NRW mapping (Welsh Government and Natural Resources Wales, n.d.) and the Groundsure report indicate that no Source Protection Zones are located within the Onshore Development Area or within a 1km radius from its boundary.

Groundwater Abstractions

88. Details of groundwater abstractions were requested from NRW who indicated that the information would be available online from Data Map Wales (Welsh Government, n.d.). This indicates that there are no groundwater abstractions present within the 1km Study Area.

89. Details of registered private water supplies (PWS) were requested from the local authority, Pembrokeshire County Council (PCC) and gleaned from the Project Erebus ES Chapter 19 (Onshore Geology, Hydrogeology and Hydrology) Appendix 19.1 Private Water Supply Assessment (Blue Gem Wind, 2021); the study area of Project Erebus overlaps in part with the Onshore Development Area. These are listed in **Table 11-13.**

90. The PWS data from Appendix 19.1 (Blue Gem Wind, 2021), has been re-evaluated and updated following some discrepancies in the data between the NGR's of the PWS and the names identified in Table 1 of Appendix 19.1. The re-evaluated data from Appendix 19.1 has been combined with the data received from PCC and a list of PWS with updated references and correct names is provided in **Table 11-13.**

91. PWS7 has been sampled historically but PCC could not confirm if these single domestic supplies are still in use or not.

92. The planned water feature survey will be undertaken to identify, confirm or deny the presence of any PWS in the study area, the results of which will be included below and in a technical appendix to the impact assessment chapter.

93. As water extracted from wells and springs is derived from groundwater, these have been considered as groundwater abstractions for domestic / potable use. This is a precautionary approach.

94. Note that the information presented in **Table 11-13** may be different to that presented in **Chapter 10: Water Environment** as different Study Areas are used.

Table 11-13. Groundwater abstractions (including PWS) within the Study Area

PWS ID	Name	Type	Use	Location	Data Source
PWS03a	Broomhill (i)	Borehole	Assumed domestic / potable	Approximately 70m north of the Project site, southeast of the tank farm	Project Erebus ES
PWS03b	Broomhill (ii)	Well	Assumed domestic / potable	Western portion of the Onshore Development Area	
PWS04	Cheveralton	Spring	Assumed domestic / potable	Approximately 630m northeast of the Onshore Development Area, south of Valero Refinery	
PWS05	Coreside Nursery	Spring	Assumed domestic / potable	Approximately 300m south of the Onshore Development Area, southeast of Newton Farm	
PWS06a	Moreston (i)	Borehole	Assumed domestic / potable	Approximately 470m south of the eastern portion of the Onshore Development Area	

PWS ID	Name	Type	Use	Location	Data Source
PWS06b	Moreston (ii)	Borehole	Assumed domestic / potable	Approximately 530m south of the eastern portion of the Onshore Development Area	
PWS7	Moreston Cottage	Spring	Assumed domestic / potable	Approximately 320m south of the eastern portion of the Onshore Development Area	Project Erebus ES and PCC
PWS12	Goldborough	Unconfirmed[1]	Assumed domestic / potable	Approximately 590m southeast of the eastern portion of the Onshore Development Area	PCC

[1]Where the type of abstractions is 'Unconfirmed', it has been considered as a groundwater abstraction. This is considered to be a precautionary approach.

Hydrology

Surface Watercourses

95. **Table 11-14** outlines the surface watercourses located within 250 m of the Onshore Development Area, at their closest point. There are no rivers, lakes or canals managed under the WFD mapped within 250 m of the Onshore Development Area. Most of the Study Area is not part of a river catchment and drains into coastal or estuarine waters, except for the southern-most area, which is part of a river catchment (Castlemartin Corse).

Table 11-14. Surface water features

Surface Water Feature Name	Category	Closest Distance to the Onshore Development Area and Direction	River Quality
Milford Haven Inner (mouth of the Pembroke River towards the Pennar Mouth)	Transitional (estuary) / coastal waters	Approximately 170 m east of the northeastern-most spur at its closest point.	Overall quality: moderate (2016).
Pembrokeshire South Coast	Coastal water	Adjacent to the west of the Onshore Development Area.	Overall quality: good (2016).
Green Hill Reservoir	Inland surface waters	Approximately 120 m north of the Onshore Development Area (eastern area).	Not applicable
Goldborough Pill	Inland surface waters	Approximately 90 m southeast, flowing towards Milford Haven	Not applicable
Unnamed streams, ponds, and reservoirs. The unnamed streams (ordinary watercourses) are indicated and numbered in **Chapter 10: Water Environment, Figure 10.5**.	Inland surface waters	On-site and in the Study Area.	Not applicable

Surface Water Abstractions

96. The following surface water abstractions have been identified within the Study Area as shown in **Table 11-15**. These are licenced water abstractions available on the Data Map Wales website (Welsh Government, n.d.). The surface water abstractions are reported in **Figure 10-1** within **Chapter 10: Water Environment**.

Table 11-15. Surface water abstractions within the Study Area

ID	Permit no.	Name	Type	Use	Location
32593	22/61/6/0014	Reservoir 'c' – fed by unnamed tributary of Daucleddau River.	Surface Water	Agriculture	70 m north of the western portion of the Onshore Development Area
32592	22/61/6/0014	Reservoir 'b' – fed by unnamed tributary of Daucleddau River.	Surface Water	Agriculture	140 m north of the western portion of the Onshore Development Area
32650	22/61/6/0113	Inland water unnamed tributary at Kilpaison Farm.	Surface Water	Impounding	60 m north of the western portion of the Onshore Development Area
32651	22/61/6/0014	Inland water unnamed tributary at Kilpaison Farm.	Surface Water	Agriculture	60 m north of the western portion of the Onshore Development Area
32657	22/61/6/0120	Impounding of un-named tributary of Daucleddau at Angle.	Surface Water	Agriculture	110 m north of the central portion of the Onshore Development Area
32659	22/61/6/0122	Impounding of un-named tributary of Daucleddau at Angle.	Surface Water	Impounding	110 m north of the central portion of the Onshore Development Area
32597	22/61/6/0021	Unnamed stream in field 154 at Neath Farm, Angle.	Surface Water	Agriculture	110 m north of the central portion of the Onshore Development Area
789	22/61/6/0156	Cleddau and Pembrokeshire Coastal Rivers	Surface Water	Non-evaporative Cooling	East of Pembroke Power Station, 220 m north of the eastern portion of the Onshore Development Area
32660	22/61/6/0123	Unnamed tributary of the Daucleddau River	Surface Water	Agriculture	300 m north of the Onshore Development Area, west of the tank farm[1]
32642	22/61/6/0105	Reservoir fed by land drains In Rhoscrowther	Surface Water	Agriculture	280 m west of the Onshore Development Area, east of the tank farm[1]

[1]*These abstractions are located out of the Study Area for hydrology; however, these are within 250 m from contaminated land sites and have therefore been included in this table for reference.*

Nitrate Vulnerability Zones

97. According to the Groundsure report, there are no nitrate vulnerable zones (NVZ) in the Study Area.

Land Contamination

Discharge Consents

98. **Table 11-16** summarises information on licensed discharges to controlled waters within the Study Area. The locations of the discharge consents are indicated within **Appendix 11A: Phase 1 Geo-environmental Desk Study Report, Figure 11A.4**.

Table 11-16. Summary of discharge consents

Location	Status	Description	Receiving waters
Pembroke Power Station, 20 m north of the north-easternmost spur of the Onshore Development Area (two entries).	Effective	Oil interceptor at Pembroke Power Station – trade discharges (process effluent).	Drain leading to Pennar Gut.
Pembroke Power Station, within the north-easternmost spur of the Onshore Development Area (two entries).	Revoked	Treated sewage discharges from Pembroke Power Station.	Unnamed tributary of Pembroke River.
Greenhill Farm and Pembroke Power Station, 160 m east of the north-easternmost spur of the Onshore Development Area.	Revoked	Sewage discharges – sewer storm overflow.	Pennar Gut.
The Burrows (residential), in the western area of the Onshore Development Area, 1 km south of Angle Bay.	Effective	Treated sewage discharges.	Unnamed ditch flowing towards Angle Bay.
Wollaston Green (presumably residential), 150 m south-east of the eastern area of the Onshore Development Area.	New consent	Treated sewage discharges.	Groundwater, via soakaway.

99. There are no List 1 or List 2 dangerous substances entries in the Study Area. However, there is a point mapped outside of the Study Area (450 m west of the north-easternmost spur) listed for Pembroke Power Station Site Drainage to Milford Haven; List 1 includes mercury and cadmium, and List 2 includes arsenic, copper, lead, nickel, pH, vanadium, and zinc. The location of the List 1 and 2 dangerous substance entry is indicated within **Appendix 11A: Phase 1 Geo-environmental Desk Study Report, Figure 11A.4**.

Waste Management Facilities

100. There are no active or recent landfills, historical landfills or historical waste sites, pollution inventory substances, pollution inventory waste transfers, or pollution inventory radioactive waste entries within the Study Area.

Hazardous Substances and Contaminated Land

101. An entry related to the storage / usage of hazardous substances is associated with Pembroke Power Station, for the chemical cleaning of boilers on site for commissioning (application 10/0373/HS, status ‘approved’). The location of the hazardous substance storage is indicated within **Appendix 11A: Phase 1 Geo-environmental Desk Study Report, Figure 11A.4**.

102. There are no Radioactive Substance Authorisations, Control of Major Accident Hazards Sites (COMAH), or Regulated Explosive Sites entries within the Study Area.

103. According to the Groundsure report, no sites were determined as Contaminated Land by the Local Authority within the Study Area.

Historical Tanks

104. The Groundsure report indicates that there are several known historical tanks indicated within the Study Area of the Onshore Development Area; their contents are not known. Other tanks, not reported within the Groundsure report, may be present in the Study Area. The locations of the historical tanks are indicated within **Appendix 11A: Phase 1 Geo-environmental Desk Study Report, Figure 11A.4**.

105. The known historical tanks within 250 m from the Onshore Development Area are indicated below:

- Within the Pembroke Power Station footprint; adjacent to the north-east of the north-easternmost boundary of the Onshore Development Area;
- At Lambeeth Farm, 50 m south-east of the easternmost boundary of the Onshore Development Area; and
- Within and around the former tank farm located at Angle Bay, adjacent to the north of the western boundary of the Onshore Development Area.

Current, Recent and Historical Industrial Activities

106. There are several current, recent, and historical commercial and industrial activities within the Study Area of the Onshore Development Area. **Table 11-17** provides a summary of those present up to 250 m, with more focus placed on those located within 50m from the Onshore Development Area boundary. Those that are thought to be significant in terms of being a potential contamination source are summarised in **Table 11-19** and their locations indicated in **Volume 5: Figure 11.4.**

Table 11-17. Summary of commercial and industrial activities entries

Category	Location	Description
Historical	Pembroke Power Station	Adjacent to the north-easternmost spur of the Onshore Development Area.
Historical	Sewage works	Adjacent to the north-easternmost spur of the Onshore Development Area.
Historical	Unspecified quarries / ground workings / pits	Off-site, multiple locations across the Onshore Development Area Study Area.
Historical	Burial chamber[2]	On-site, approximately 600m north-east of Freshwater West Beach.
Recent	Pylons and wind turbines	On-site, and in multiple locations off-site.
Recent	Solar farms	On-site for a limited extent, and adjacent to the Onshore Development Area.
Historical	Smithies	150m north and east of the Onshore Development Area boundary.
Recent	Dairy farming	250m south-west of the Onshore Development Area boundary.
Recent	Slurry bed	250m north-east of the Onshore Development Area boundary.

[2] Not considered to be a significant source of contamination, therefore not included in the assessment.

Category	Location	Description
Historical	Refuse heaps	120m south-east of the Onshore Development Area boundary.
Historical	Disused gun emplacement	50m north-west of the Onshore Development Area boundary, approximately 330m north-east of Freshwater West beach.
Historical	Unspecified tanks	Adjacent to the north of the Onshore Development Area boundary, between the Onshore Development Area and Angle Bay.

107. There are no recorded historical military land entries, historical licensed industrial activities (IPC) or licensed industrial activities (Part A (1)) entries within the Study Area.

108. No historical or current fuel stations were identified within the Onshore Development Area or in the Study Area according to the Groundsure report and Google Maps (Google, n.d.).

Pollution Incidents

109. There are two pollution incidents located within the Study Area for the Onshore Development Area. Details are as follows:

- One pollution incident located 180 m south of the western area of the Onshore Development Area, relating to pollution by 'inert materials and wastes (soils and clay)'. This was a minor (category 3) impact to air and no impact (category 4) to land and occurred in 2015; and
- One pollution incident located adjacent to the westernmost area of the Onshore Development Area, relating to pollution by 'oils and fuels (unidentified oil)'. This was a minor (category 3) impact to air and no impact (category 4) to land and occurred in 2015.

110. The locations of the pollution incidents are indicated within **Appendix 11A: Phase 1 Geo-environmental Desk Study Report, Figure 11A.4.**

111. There are no listed pollutant releases to surface water (Red List), pollutant releases to public sewer, or licensed pollutant releases (Part A(2)/B) within the Study Area of the Onshore Development Area.

Historical Development

112. The Onshore Development Area and its surroundings have undergone limited development, with predominantly agricultural areas and sporadic settlements. Several farms, a reservoir and old quarries were identified within 250 m from the Onshore Development Area.

113. The most significant development is the Pembroke Power Station, immediately adjacent to the north-easternmost spur of the Onshore Development Area: the current combined-cycle gas turbine station has operated since 2012, replacing the former oil-fired power station which was decommissioned in 1999 (RWE.com, n.d.). Immediately north of the Onshore Development Area, between the Onshore Development Area and Angle Bay is the former BP Angle Bay Oil terminal, now demolished.

114. Relevant historic features within 250 m of the Onshore Development Area are described in **Table 11-18.**

Table 11-18. Historical development

Area	Location, including Distance / Direction from Section
From north of Freshwater West Beach to Wallaston Green village.	1864-1866: Several 'old quarries' mapped within 250 m from the Onshore Development Area. 1864-1866: Smithy located within the Newton Cottage area, approximately 150 m southwest of the Onshore Development Area boundary. 1971-1972: Disused gun emplacement north of Freshwater Beach. Smithy no longer present. 1972: Tank farm located adjacent to the north of the western portion of the Onshore Development Area. A reservoir labelled as 'covered' is located immediately south of the tank farm. 2001: Tank farm no longer visible on mapping.
From Wallaston Green village to Pembroke Power Station	1864: Smithy north of Wallaston Green, on-site. 1864: A lime kiln and sporadic settlements are mapped to the north of the north-eastern spur of the Onshore Development Area. 1864: Farm named 'Lambeeth' is located in proximity of the easternmost spur of the Onshore Development Area. 1906: The lime kiln is no longer present. 1962: A reservoir, named Green Hill Reservoir, is located 25 m north of the Onshore Development Area. 1972-1976: The smithy north of Wallaston Green is no longer present. 1972-1976: The Pembroke Power Station has been constructed, with significant modifications of the coastline: multiple buildings, sewage works, a chimney, and jetties are visible on the 1976 mapping. 1972-1976: Lambeeth farm now includes tanks. 1989-1993: A sludge lagoon is visible immediately south-east of the Pembroke Power Station. 2010: The footprint of the Pembroke Power Station appears to have been significantly reduced, with the demolition of buildings and tanks in the northern area. This is presumably due to the decommissioning of the oil-fired station. 2022: Pembroke Power Station appears to have been expanded to the west, with the construction of new infrastructure.

Potential Land Contamination Sources

115. **Table 11-19** indicates potential on-site and off-site sources of contamination identified desk-based research. With reference to the Guidance for the Safe Development of Housing on Land Affected by Contamination: R&D Publication 66 (NHBC, Environment Agency, CIEH, 2008), **Table 11-19** also indicates the potential contaminants that may be associated with the potential sources identified.

Table 11-19. Potential sources of contamination

Feature	Associated Contaminants of Potential Concern (CoPC)
Pembroke Power Station, including sewage works, sludge lagoon, and historical tanks (adjacent).	Potential for metals and semi-metals; inorganic (sulphate, sulphide, asbestos, pH); oil / fuel hydrocarbons, polycyclic aromatic hydrocarbons (PAH), chlorinated aliphatic hydrocarbons, polychlorinated biphenyls (PCB).
Former tank farm (disused Angle Bay Oil Terminal). (adjacent)	Potential for metals and semi-metals; inorganic (sulphate, sulphide, asbestos, pH); oil / fuel hydrocarbons, PAH, chlorinated aliphatic hydrocarbons, PCB.
Historical tanks (off-site)	Potential for total petroleum hydrocarbons (TPH); PAH; hydrocarbons.
Farms (off-site)	Potential for metals; pesticides and herbicides; inorganic compounds; oil / fuel hydrocarbons.
Old quarries, potentially infilled land, historical refuse heaps (on-site and off-site)	Unknown. Potential for: metals; inorganics; organics including PAH and TPH. Potential for methane (CH_4), carbon dioxide (CO_2) and hydrogen sulphide (H_2S)
Former gun emplacement (off-site)	Potential for metals; inorganics; organics including PAH and TPH.
High pressure oil pipeline (on-site)[3]	Potential for TPH; PAH; hydrocarbons.

Potential Pathways

116. The following potential pathways have been identified which outline the mechanism through which any potential land contamination could impact upon a receptor:

- Direct contact / ingestion of contaminants within Made Ground / natural soils, in addition to soil derived dust, and groundwater;
- Inhalation of organic vapours from Made Ground / natural soils, soil derived dust and groundwater;
- Inhalation of asbestos fibres;
- Leaching of soluble contaminants and migration of mobile contaminants into shallow groundwater;
- Vertical migration of groundwater through Made Ground and superficial deposits into underlying bedrock aquifer;
- Lateral groundwater migration and direct run-off to nearby surface waters;
- Vertical migration of ground gases to indoor and outdoor air and migration of ground gases into enclosed spaces (inhalation / asphyxiation / explosion);
- Direct contact of buried infrastructure with contaminated Made Ground / natural soils and aggressive ground conditions (pH and sulphate) / direct contact of services and supply pipes (proposed cables) with contaminated soils; and

[3] Inferred from Project Erebus Environmental Statement (Blue Gem Wind, ITP Energise, OWC, MarineSpace, 2021)

- Indirect pathway: migration of hazardous gases / vapours via permeable strata into enclosed spaces and service / utility trenches and potential explosion risk.

Summary of Sensitive Receptors

117. Potential receptors associated with the Onshore Development Area are indicated in **Table 11-20**, along with their sensitivity (as defined in **Table 11-5**).

Table 11-20. Potential receptors

Receptor		Sensitivity
Human health	Residential users	Very high
	Commercial users (agriculture workers, power station workers, workers within proposed buildings at the Onshore Development Area)	Medium
	Road users	Low
	Public open space users (open areas)	High
Groundwater	Secondary undifferentiated aquifers (superficial deposits: tidal flat deposits and till deposits)	Medium[1]
	Secondary A aquifer (superficial deposits: marine beach deposits, alluvium and blown sand, bedrock: remaining bedrock designations)	Medium
	Secondary B aquifers (bedrock: Ludlow Rocks, and the Aber Mawl Shale Formation)	Medium
	Principal aquifer (bedrock: Black Rock Subgroup and Gully Oolite Formation)	High
	Private water abstractions (domestic and agricultural supply)	High
Surface water	Various unnamed streams **(Figure 10.5 of Chapter 10: Water Environment)** and ponds, Goldborough Pill	Medium
	Green Hill Reservoir	Medium
	Milford Haven	High
	Celtic Sea / Pembrokeshire South Coastal surface water body	Very high
	Surface water abstractions (agricultural / industrial)	Medium[1]
Buildings and infrastructure	Existing buildings and below ground infrastructure; Onshore Substation, cables	Medium
Ecological[3] / geological sites	SSSI - Milford Haven Waterway and Broomhill Burrows (both GWDTE)	Very high[2]
	SAC - Pembrokeshire Marine / Sir Benfro Forol and Limestone Coast of South West Wales / Arfordir Calchfaen De Orllewin Cymru (both GWDTE)	Very high
	SPA - Castlemartin Coast	Very high
	Ancient woodland	High
	National Parks - Pembrokeshire Coast National Park	High
	GCR	High
	RIGS	Medium
Minerals	MSZ	High

[1] The assigned receptor sensitivity for the purposes of this Chapter differs from the receptor importance assigned in Chapter 10: Water Environment. This is due to the different objectives of the respective assessments.

[2] *The assigned receptor sensitivity for the purposes of this Chapter differs from the receptor importance assigned in Chapter 08: Ecology and Biodiversity. This is due to the different objectives of the respective assessments.*

[3] *See **Appendix 11A: Phase 1 Geo-environmental Desk Study** and **Chapter 08: Ecology and Biodiversity** for further details.*

11.5.2. Future Baseline

118. This section considers any changes to the baseline conditions described above that might occur over the lifespan of the proposed Project, but in their absence (i.e. if they are not installed).

119. The geology and hydrogeology are unlikely to be altered over time without a significant change of land use.

120. With respect to land contamination, any future development within the Study Area is subject to requirements set out in the Town and Country Planning Act 1990 (HM Government, 1990). This requires consideration of the potential for contamination to be present. The developer would be required to carry out remediation to ensure the development is suitable for its proposed use.

121. Furthermore, natural attenuation processes have the potential to mitigate risks over time from existing sources of contaminants present within soil and groundwater.

122. Therefore, it is expected that there would be an overall beneficial effect on baseline geology and hydrogeology conditions, in the future with regards to land contamination.

123. Changes in groundwater abstractions could affect the groundwater flow regime and climate change could influence the future baseline conditions, due to changes on the rainfall regime, recharge, groundwater levels and flow. However, these changes are long-term and are not predictable at this stage.

11.6 Scope of the Assessment

124. An EIA Scoping Report for the proposed Project was submitted to NRW Marine Licensing Team (MLT) in April 2022. The Scoping Report was also shared with relevant consultees, inviting comment on the proposed approach adopted by the Applicant. A Scoping Opinion was provided to the Applicant by NRW MLT in July 2022. Based on the Scoping Opinion received and further consultation undertaken, potential impacts on geology and hydrogeology scoped into the assessment are listed below in **Table 11-21**. Impacts scoped out of the assessment are listed in **Table 11-22.**

125. As set out in **Section 11.4.1**, this assessment considers the design parameters of the proposed Project which are predicted to result in the greatest environmental impact, known as the 'realistic worst case scenario'. The realistic worst case scenario represents, for any given receptor and potential impact on that receptor, various options in the Design Envelope that would result in the greatest potential for change to the receptor in question. Given that the realistic worst case scenario is based on the design option (or combination of options) that represents the greatest potential for change, confidence can be held that the development of any alternative options within the design parameters will give rise to effects no greater or worse than those included in this impact assessment.

126. The design scenarios identified in **Table 11-21** have been selected as those having the potential to result in the greatest effect on an identified receptor or receptor group within the geology and hydrogeology Study Area. These scenarios have been selected from the details provided in **Chapter 04: Description of the Projects**.

Table 11-21. Design scenario considered for the assessment

Potential impact	Design scenario	Justification
Construction/decommissioning		
Damage, disturbance or removal of geological features of interest (RIGS and GCR).	Target burial depth of cable route up to 2.5 m and width up to 1.8 m. HDD depth currently unknown, potential impacts for depths between 0 and 30 m below ground level considered.	Reasonable worst case based on current design for cable burial depth. HDD depth unknown.
Compaction and degradation of soils.	Typical working width of onshore cable route of 35 m during construction. Target burial depth of cable route up to 2.5 m and width up to 1.8 m. The Onshore Substation is considered to occupy a plan area of 126 m by 109 m. Concrete pad foundations understood to be proposed.	Reasonable worst case based on current design information.
Mineral severance or sterilisation during construction.		
Potential reduction of flow to surface water bodies and change in hydrogeological and hydrological setting locally.	Utilisation of dewatering techniques.	There is potential for dewatering techniques to be used during construction as part of the cable installation due to the presence of excavations.
Mobilisation and migration of contamination to unsaturated soils, groundwater and surface water courses.	Target burial depth of cable route up to 2.5 m and width up to 1.8 m. Utilisation of dewatering techniques. HDD depth currently unknown, potential impacts for depths between 0 and 30 m below ground level considered. Concrete pad foundations (Onshore Substation).	Reasonable worst case based on current design information. There is potential for dewatering techniques to be used during construction as part of the cable installation due to the presence of excavations. HDD depth unknown.
Potential impacts on groundwater as a pathway may be created for drilling fluids or other fluids to reach sensitive groundwater receptors		
Potential for contaminants in unsaturated soils to be exposed to surface water run-off and to leach to groundwater in open excavations.		
Potential impacts from migration of contaminants from uncovered stockpiles to surface water and groundwater receptors.		
Creation of preferential pathways for the migration of soil contamination and gases.		

Potential impact	Design scenario	Justification
Migration of contamination to unsaturated soils, surface water and groundwater.	Target burial depth of cable route up to 2.5 m and width up to 1.8 m. HDD depth currently unknown, potential impacts for depths between 0 and 30 m below ground level considered. Embedded mitigation measures in place during construction.	Reasonable worst case based on current design for cable burial depth. There is potential for dewatering technique to be used during construction as part of the cable installation. HDD depth unknown.
Impacts from potential contamination in dust and fine particulate matter may impact ecological receptors.		
Impacts on human health from contamination within unsaturated soil (dust and fine particulate matter) and groundwater – construction workers.		
Impacts on human health from contamination within unsaturated soil (dust and fine particulate matter) and groundwater – adjacent land users.		
Operation and maintenance		
Any contamination removed, remediated, or mitigated leading to removal of contaminant sources from the source – pathway – receptor linkage; may result in potential beneficial impacts on human health, controlled waters, property receptors and ecological receptors.	Target burial depth of cable route up to 2.5 m and width up to 1.8 m.	Reasonable worst case based on current design for cable burial depth.

11.6.1. Impacts scoped out of assessment

127. Several impacts have been scoped out of the assessment for geology and hydrogeology during EIA scoping. These impacts are outlined, together with the justification for scoping them out, in **Table 11-22.**

Table 11-22. Potential impacts scoped out the assessment for geology and hydrogeology

Potential impact	Justification
Construction/decommissioning	
Impacts on human health from contamination within unsaturated soil (dust and fine particulate matter) and groundwater – construction workers.	There may be some temporary adverse effects during the construction/decommissioning period due to the introduction of human health receptors (construction/decommissioning workers). However, these receptors will be protected by H&S legislation and are therefore scoped out.
Operation and maintenance	
Impacts on human health from contamination within shallow unsaturated soil and groundwater.	Not likely, as maintenance and operation of the Project will be in accordance with environmental legislation and good practice.

Potential impact	Justification
The potential for impacts on unsaturated soil and groundwater deriving from pollution events bypassing the drainage system	Not likely, as maintenance and operation of the Project will be in accordance with environmental legislation and good practice.

11.6.2. Assessment Assumptions and Limitations

128. The information gathered provides the basis for the EIA. However, the following limitations and assumptions apply:

- The assessment undertaken for geology and hydrogeology has been based on the collation and evaluation of available documentation provided by the Environment Agency, BGS, Groundsure historical mapping and Groundsure GIS data, and other data sources as described in **Section 11.4.4;**
- Baseline information on ground stability is included in the Phase 1 Geo-environmental Desk Study **(Appendix 11A: Phase 1 Geo-environmental Desk Study Report**), although the assessment of structural and engineering geology will be undertaken as part of a GIR and Geotechnical Design Report (GDR). These will be prepared at detailed design of the proposed Project prior to construction which will include further details regarding ground stability, and how the proposed Project design will mitigate any effects;
- Any borehole data from BGS sources are included on the basis that 'The British Geological Survey accept no responsibility for omissions or misinterpretation of the data from their Data Bank as this may be old or obtained from non-BGS sources and may not represent current interpretation';
- This chapter should be read considering the legislation, statutory requirements and / or industry good practice applicable at the time the assessment was undertaken; and
- Details of registered PWS were taken from the Project Erebus ES Chapter 19 (Onshore Geology, Hydrogeology and Hydrology) Appendix 19.1 Private Water Supply Assessment (Blue Gem Wind, 2021); following some discrepancies in the data between the NGR's of the PWS and the names identified in Table 1 of Appendix 19.1, this data has been revaluated and updated as described in **Section 11.5.1**. Original information from the Erebus project is not currently available, therefore the locations of the PWS considered in this assessment are partially based on the interpretation of information included in the Private Water Assessment (PWS) and have not been confirmed.

11.7 Embedded Mitigation, Management Plans and Best Practice

129. As part of the project design process, several designed-in measures have been proposed to reduce the potential for impacts on geology and hydrogeology (see **Table 11-23**). The design of the proposed Project therefore includes embedded mitigation measures and reference to various management plans that will be produced as conditions of consent, and which will further mitigate potential impacts. This approach has been employed to demonstrate commitment to mitigation measures by including them in the design of the proposed Project and as such these measures have been considered within the assessment presented in **Section 11.8 below**. Assessment of sensitivity, magnitude and therefore significance includes the implementation of these measures.

Table 11-23. Mitigation Measures, management plans and best practice adopted as part of the proposed Project

Embedded Mitigation Measures, Management Plans and Best Practice	Justification
Design Embedded Measures	
Engagement with relevant parties with regards to geological designated areas and further investigation	It has been confirmed through a site walkover that there are some outcrops of the geologically designated area in the north-western extent of SSSI Broomhill Burrows and the Freshwater West (North) GCR, are located within the northwestern-most extent of the Onshore Development Area (see **Section 11.5.3**). The location of the HDD cable in this area is yet to be confirmed. If it is within or near the geological designated site, engagement will be required with relevant parties, particularly for potential impacts associated during the construction / decommissioning phases. The ground conditions will be investigated through intrusive survey. This data will be used to develop a ground model and an understanding of the engineering properties of the ground conditions which will be used to inform design development. Further investigation is required, particularly at Freshwater West, and this will include detailed HDD feasibility studies.
Intrusive surveys to investigate ground conditions	Earthworks including excavations and the construction of foundations, together with dewatering, that may be required, could adversely affect ground stability and, subsequently, any proposed and surrounding structures through uncontrolled settlement. There may be a requirement to provide temporary support for site excavations. Such support may include benching of excavations, shoring or the construction of retaining walls (e.g., sheet piles) or struts to mitigate the risk of settlement or excessive spalling. It is expected that the need for such control would be established during detailed design. The extent of bulk earthworks for the landfall, HDD, Onshore Substation, and for trenches for the cable installations will be determined as part of the detailed design. There will be a requirement to avoid creating pathways between potentially contaminated soils and / or groundwater within the underlying aquifers (including a Principal aquifer located adjacent to the north-eastern portion of the Onshore Development Area; Secondary B aquifer mapped in the southern portion of the Onshore Development Area; Secondary A aquifers underlying the vast majority of the Onshore Development Area; and a Secondary undifferentiated aquifer located approximately 50 m the south-westernmost spur of the Onshore Development Area).
Engagement with relevant parties with regards to mineral resource sterilisation	Construction of the proposed Project has the potential to affect existing mineral resources, and proposed areas of mineral exploitation. This could occur by sterilisation of the resource through direct excavation during construction of the proposed Project or through temporary and / or permanent severance or isolation that may occur during the construction phase of the proposed Project, possibly continuing through to its operational phase. A plan will be discussed in advance of the construction works with the landowner, the relevant mineral planning departments at Pembrokeshire

Embedded Mitigation Measures, Management Plans and Best Practice	Justification
	County Council and Pembrokeshire Coast National Park Authority, and any other relevant parties to assist in achieving an effective management of minerals within the affected areas of the MSZ. For example, it is possible that localised mineral extraction could be undertaken in advance of the construction of the proposed Project.
Ground Investigations and hydrogeological assessment	Desk study work has identified areas of potential soil and / or groundwater contamination and ground investigation and risk assessment of PCL will be undertaken alongside any geotechnical investigation. If unacceptable risks are identified, or encountered during construction, and where routeing through these areas is unavoidable, then remedial measures will be implemented. An understanding of groundwater throughout the proposed Project will be obtained from ground investigation and monitoring: including before, during and after construction. A more detailed hydrogeological assessment will be undertaken where HDD, trenchless techniques or dewatering is required in high sensitivity groundwater environments or where dewatering is required to facilitate open cut installation. Where dewatering is required, a dewatering scheme will be developed prior to construction to demonstrate that there is an effective strategy to manage water arising from the operations and, where required, sufficient proposals to treat the water prior to controlled discharge. Any such assessment will consider the effects of any draw down or impacts on nearby abstractions or resources. Interpretation of data from ground investigation will validate the assumptions made in the initial CSM and PRA **(Appendix 11A: Phase 1 Geo-environmental Desk Study)** and provide site-specific data upon which to base a land contamination risk assessment (Stage 1, Tier 2 under LCRM guidance (Environment Agency, 2020)). The ground investigation will be designed to target the key potential contaminative sources identified that overlap the Project area. Where risks are deemed to be unacceptable, further detailed quantitative risk assessment and if required, detailed remediation strategies will be developed accordingly, pursuant to the process set out by the planning authorities. Whilst the assessment acknowledges that the ground investigation and subsequent risk assessments will be undertaken, it is important to acknowledge that the outcome of these investigations will define whether additional assessment or mitigation may be required.
Minimisation of surplus material during design and construction	Assumptions have been adopted as to how the earthworks stage of the construction and the decommissioning of the proposed Project will be undertaken (see **Chapter 04: Description of the Proposed Project**). Additional information will be included as part of the detailed design. Consideration will be given as part of the design process as to what excavated materials could be reused or would be required for the various components of the proposed Project, and what materials would be surplus and would require either disposal or onward management to ensure appropriate re-use. The earthworks design will aim to achieve an optimal

Embedded Mitigation Measures, Management Plans and Best Practice	Justification
	cut-fill balance as far as practicable within the project constraints to avoid or minimise the creation of surplus material. The volume of disposal of soil waste, contaminated or otherwise, to landfill sites would be mitigated by minimisation during design of the overall quantities of surplus material generated during construction, and by optimising the cut to fill balance as part of the design.
Management Plans	
Construction Environmental Management Plan (CEMP).	The main mitigation measure to prevent adverse effects on geology and hydrogeology during all phases of the development of the proposed Project will be to ensure good site practice and management through the development and adherence to a CEMP. Measures contained within the CEMP will limit the potential for dispersal and accidental releases of potential contaminants, soil derived dusts and uncontrolled run-off to occur during construction. For example, the CEMP will set out how material is to be excavated, segregated, and stockpiled to minimise the potential for run-off, soil quality degradation and wind dispersal of dusts. The CEMP will also establish procedures for dealing with unexpected soil or groundwater contamination that may be encountered.
Pollution Prevention Management Plan	A Pollution Prevention Management Plan will be in place prior to the commencement of construction / decommissioning works. The plan will outline key pollution mitigation measures to be adopted including a Control of Substances Hazardous to Health (COSHH), fuel inventory and key contacts to be notified in the event of a significant pollution incident, which may subsequently lead to the contamination of controlled waters or soils. All bulk fuel and COSHH items will be stored in accordance with the relevant Environment Agency Guidance for Pollution Prevention (GPP) or where GPP are yet to be published, Pollution Prevention Guidance (PPG) notes (withdrawn but widely considered good practice) and storage regulations – refer to **Chapter 10: Water Environment**. Tanks and dispensing pumps will be locked when not in use to prevent unauthorised access.
Materials Management Plan (MMP)	The re-use of excavated materials during construction and decommissioning of the proposed Project will be governed by either a MMP developed in accordance with the CL:AIRE Definition of Waste: Development Industry Code of Practice (CL:AIRE, 2011), an environmental permit or a relevant exemption. The CL:AIRE Code of Practice is a voluntary framework for excavated materials management and re-use. Following this framework results in a level of information being generated that is sufficient to demonstrate to the regulator that, on the basis investigation and risk assessment, excavated material can be re-used appropriately and is suitable for its intended use. It demonstrates that material which has been used in the development is not waste. The MMP details the procedures and measures that will be taken to classify, test, excavate, track, store, verify, reuse and where necessary selectively dispose of excavated materials that will be encountered during the construction of the proposed Project.

Embedded Mitigation Measures, Management Plans and Best Practice	Justification
Drainage Management Strategy	The design of the proposed Project includes measures that would contain and control any releases of contaminants to ground and surface and foul drainage network. A Drainage Management Strategy for the proposed Project will be employed temporarily during the construction phase and permanent measures will remain in place during the operational phase of the Proposed project.
Best Practice	
Best practice during construction – impacts to construction workers	Potential impacts specific to construction workers during site preparation and construction / decommissioning works would be controlled and mitigated by the following measures and through working in accordance with CIRIA C811, Environmental good practice on site guide (CIRIA, 2023): • Measures to minimise dust generation; • Provision of Personal Protective Equipment (PPE), such as gloves, barrier cream, overalls etc. to minimise direct contact with soils; • Provision of adequate hygiene facilities and clean welfare facilities for all construction site workers; • Monitoring of confined spaces for potential ground gas accumulations, restricting access to confined spaces, i.e., to suitably trained personnel only, and use of specialist PPE, where necessary; and • Preparation and adoption of a site and task specific health and safety plan as is required under Health and Safety legislation.
Best practice during construction – hazardous materials	Any hazardous materials will be stored in designated locations with specific measures to prevent leakage and the release of their contents. This will include a requirement to position storage areas at least 10m away from surface water features / drains (and take into consideration the positions of any groundwater abstraction wells), on an impermeable base with an impermeable bund that has no outflow and is of adequate capacity to contain at least 110% of the contents. Valves and trigger guns will be protected from vandalism and kept locked when not in use.
Best practice during construction – spill from machinery and plant	Only well-maintained plant will be used during construction to minimise the potential for accidental pollution from leaking machinery or damaged equipment. Static machinery and plant are expected to be stored in hardstanding areas when not in use and, where necessary, to make use of drip trays beneath oil tanks / engines / gearboxes / hydraulics. Spill response kits containing equipment that is appropriate to the types and quantities of materials being used and stored during construction will be maintained within the Onshore Development Area for the duration of the works.
Best practice during construction – unexpected contamination	The CEMP will set out procedures for dealing with unexpected soil or groundwater contamination that may be encountered. This would typically require affected works to stop to enable appropriate people to be notified, and further characterisation and risk assessment to be undertaken before remediation or mitigation proposals are agreed with all stakeholders.

Embedded Mitigation Measures, Management Plans and Best Practice	Justification
	Specific mitigation measures may be required in the form of treating / remediating contamination encountered during construction (e.g., contamination that may be associated with potentially contaminative sites identified as part of the assessment, notably the areas of Pembroke Power Station and the former tank farm). This will be confirmed based on information gathered through ground investigation. Any remediation works, or the removal of contaminated soils or waters associated with the construction of the proposed Project would be expected to result in the enhancement of the local environment. Any such need will be defined by the ground investigations and interpretive assessments that follow.
Best practice during construction – handling of excavated soils	To minimise the effects on soil resources during any earthworks, including materials management following foundation construction and excavation for the proposed Onshore Cable Route, high standards of soil handling and management will be employed with a view to minimising where possible the double handling of soils and the extent to which exposed soils will be left vulnerable to erosional processes. Guidelines are published in documents such as DEFRA's Construction Code of Practice for the Sustainable Use of Soils on Construction Sites (2009) (DEFRA, 2009) and The Institute of Quarrying Good Practice Guide for Handling Soils in Mineral Works (The Institute of Quarrying, 2021).
Best practice during construction – asbestos	There is potential for asbestos to be present in any Made Ground within the Onshore Development Area. Any Made Ground found to be contaminated with asbestos will require suitable management if it is to be retained on-site or removed (in line with the Control of Asbestos Regulations, 2012 (HM Government, 2012)). As asbestos only presents a risk if it is disturbed, it is considered that the highest risk would be during the construction and decommissioning of the proposed Project. Asbestos management will be included within the CEMP.
Best practice during construction – disposal of soil waste	Where there is a requirement to dispose of surplus excavated materials off site as waste, the material will be characterised to determine firstly whether it is Hazardous or Non-Hazardous waste in accordance with the Environment Agency's Technical Guidance WM3 (Natural Resources Wales, Scottish Environment Protection Agency, Environment Agency, 2015) and then once this is established, the appropriate disposal facility will be determined through Waste Acceptance Criteria (WAC) analysis, as required.
Best practice during operation – material storage	Materials associated with the Onshore Substation activities (including fuels and other chemicals such as cement, paint, solvents, and mastic sealers) will be stored during operations. In common with other modern infrastructure development, secondary containment appropriate to the level of risk will be included in the detailed design.
Best practice during operation –	Good housekeeping and management practices (such as operating an accredited Environmental Management System which would detail procedures for chemical storage, spill response, pollution incident

Embedded Mitigation Measures, Management Plans and Best Practice	Justification
housekeeping and management practices	response etc) will be adopted and adhered to through the operational lifetime to minimise impacts to soil and groundwater.

11.8 Assessment of Environmental Effects

130. The impacts and effects (both beneficial and adverse) associated with the construction, operation and maintenance and decommissioning of the proposed Project are outlined in the sections below. The assessments consider the embedded mitigation measures described in **Section 11.7.**

11.8.1. Construction / Decommissioning Effects

Removal or disturbance of geological features – Broomhill Burrows SSSI and Freshwater West (North) GCR

131. Impacts on geologically designated sites like SSSI and GCR sites, may occur where construction activities, with particular reference to the HDD activities, interact directly within the designated site and in doing so removes or disturbs any aspect of the geological feature affording it the designated status.

Magnitude of impact

132. The SSSI and the GCR might be impacted by the HDD works with measurable changes to geological feature / designation attributes, quality, or vulnerability and minor loss of, or alteration to, key characteristics, features, or elements. The magnitude of impact is therefore considered to be **small**.

Sensitivity of the receptor

133. The sensitivity of Broomhill Burrows SSSI and Freshwater West (North) GCR is considered to be **high** as they are designation of national importance.

Significance of the effect

134. The sensitivity of Broomhill Burrows SSSI and Freshwater West (North) GCR is considered to be **high** and the magnitude of the impact is assessed as **small**.

135. As the geology features of the Broomhill Burrows SSSI and Freshwater West (North) GCR only overlap by less than 100m into the northeastern-most extent of the Onshore Development Area, and if the mitigation measures in **Section 11.7** are followed, the effect on the geological designated sites will be of **minor adverse** significance, which is **not significant** in EIA terms.

Temporary sterilisation of mineral resources on MSZ

136. Temporary adverse effects may occur where construction compounds are proposed within the MSZ. This is anticipated to be adjacent to the location of the Onshore Substation compound in the east of the Onshore Development Area. In such cases, there will be a temporary sterilisation of the resource during construction works.

Magnitude of impact

137. There will be a temporary sterilisation of the resource during construction works, with minor measurable effects. The magnitude of impact is therefore considered to be **small**.

Sensitivity of the receptor

138. The sensitivity of the hardrock and sand and gravel deposits is considered to be **high** as they are classified as a MSZ.

Significance of the effect

139. The sensitivity of the mineral resources is considered to be **high** and the magnitude of the impact is assessed as **small**. Therefore, the effect will, be of **minor adverse** significance, which is **not significant** in EIA terms.

Land Contamination

140. The potential areas of contamination and site rating are indicated in **Volume 5: Figure 11.4**. The full details of the identified impacts deriving from land contamination are reported in **Appendix 11D: Assessment of Effects and Significance.** No significant effects associated with land contamination have been identified for the construction / decommissioning stages of the proposed Project. All effects range from **negligible to minor adverse**.

11.8.2. Operation and Maintenance (O&M) Effects

Geological designated sites

141. There will be no further effects on geological designated sites during the operational phase.

Permanent sterilisation of mineral resources on MSZ

142. The effect from the operation of the proposed Project on the identified MSZ will be permanent where underlying the footprint of the permanent works (Onshore Substation and cable route including any required standoff), with a strip of mineral becoming sterilised. Earthworks planned for the construction of the Onshore Substation are unknown at this stage. The depth of the cable route is 1.8 to 2.5m and extent of the excavations for the cable route is expected to be 1.0 to 1.2m in width. Excavation for the construction of the Onshore Substation may impact the hardrock resource and the Onshore Substation will occupy the area, limiting the opportunity to use it for mineral extraction.

Magnitude of impact

143. There will be a permanent sterilisation of the resource during operations, however, as a proportion of the total MSZ area, the magnitude of the effects on the MSZ are generally considered minor. The magnitude of impact is therefore considered to be **small**.

Sensitivity of the receptor

144. The sensitivity of the hardrock and sand and gravel deposits is considered to be **high** as they are classified as MSZ.

Significance of the effect

145. The sensitivity of the mineral resources is considered to be **high** and the magnitude of the impact is assessed as **minor**. Therefore, the effect will, be of **minor adverse** significance, which is **not significant** in EIA terms. In addition, it is possible that mineral extraction could be undertaken in advance of the construction of the proposed Project. If required, this will be discussed in advance of the works with the Mineral Planning Authorities and the mineral owners.

Land Contamination

146. The full details of the identified impacts deriving from land contamination are reported in **Appendix 11D: Assessment of Effects and Significance**. No significant effects associated with

land contamination have been identified for the operational stage of the proposed Project. All impacts range from **negligible** to **minor beneficial** (because of potential remediation).

11.9 Summary of Additional Mitigation Measures

147. Additional mitigation and enhancement measures are not required for geology and hydrogeology over and above those listed in **Section 11.7.**

11.9.1. Monitoring

148. An understanding of groundwater throughout the Onshore Development Area will be obtained from ground investigation and subsequent monitoring: including before, during and after construction.

149. As part of ground investigation, ground gas monitoring may need to be undertaken at the Onshore Development Area, particularly in the area of the Onshore Substation as there is the potential for ground gas to accumulate (depending on the extent of Made Ground encountered in this area).

11.9.2. Summary of Effects and Conclusions

150. This section summarises the residual significant effects of the proposed Project on geology and hydrogeology following the implementation of mitigation.

Table 11-24. Assessment summary

Potential Impact	Receptor	Receptor Sensitivity	Magnitude of impact	Significance of effect	Additional Mitigation	Residual Significance of Effect
Construction/Decommissioning						
Temporary measurable changes to geological feature / designation attributes, quality, or vulnerability and minor loss of, or alteration to, key characteristics, features, or elements	Broomhill Burrows SSSI	High	Small	Minor adverse (N), as the site only overlaps by less than 100m of the eastern extent with the Onshore Development Area, and provided the mitigation indicated in Section 11.7 is followed. HDD potentially within this area.	None required	Minor (adverse) Not Significant
	Freshwater West (North) GCR	High	Small		None required	Minor (adverse) Not Significant
	MSZ – defined by the Pembrokeshire Coast National Park Local Development Plan – sand and gravel – between Freshwater West Beach and Valero refinery	High	Small	Minor adverse (N)	None required	Minor (adverse) Not Significant
	MSZ – defined by the Pembrokeshire Coast National Park Local Development Plan hardrock – south of former tank farm	High	Small	Minor adverse (N)	None required	Minor (adverse) Not Significant
	MSZ – defined by the Pembrokeshire Coast National Park Local Development Plan – hardrock – northeast of Freshwater West beach	High	Small	Minor adverse (N)	None required	Minor (adverse) Not Significant
	MSZ – defined by the Pembrokeshire County Council Local Development Plan – sand and gravel – at Pembroke Power Station	High	Small	Minor adverse (N)	None required	Minor (adverse) Not Significant

Potential Impact	Receptor	Receptor Sensitivity	Magnitude of impact	Significance of effect	Additional Mitigation	Residual Significance of Effect
	MSZ – defined by the Pembrokeshire County Council Local Development Plan – hardrock – eastern portion of the Onshore Development Area	High	Small	Minor adverse (N)	None required	Minor (adverse) Not Significant
Impacts from land contamination	Human Health, Groundwater, Surface Water, Ecological Receptors	See **Appendix 11-D: Assessment of Effects and Significance** for the full details		Negligible to minor adverse (N)	None required	Negligible to minor (adverse) Not Significant
Operation and Maintenance						
Permanent measurable changes to geological feature/designation attributes, quality, or vulnerability and minor loss of, or alteration to, key characteristics, features, or elements	MSZ – defined by the Pembrokeshire Coast National Park Local Development Plan – sand and gravel – between Freshwater West Beach and Valero refinery	High	Small	Minor adverse (N)	None required	Minor (adverse) Not Significant
	MSZ – defined by the Pembrokeshire Coast National Park Local Development Plan hardrock – south of former tank farm	High	Small	Minor adverse (N)	None required	Minor (adverse) Not Significant
	MSZ – defined by the Pembrokeshire Coast National Park Local Development Plan – hardrock – northeast of Freshwater West beach	High	Small	Minor adverse (N)	None required	Minor (adverse) Not Significant
	MSZ – defined by the Pembrokeshire County Council Local Development Plan – sand and gravel – at Pembroke Power Station	High	Small	Minor adverse (N)	None required	Minor (adverse) Not Significant

Potential Impact	Receptor	Receptor Sensitivity	Magnitude of impact	Significance of effect	Additional Mitigation	Residual Significance of Effect
	MSZ – defined by the Pembrokeshire County Council Local Development Plan – hardrock – eastern portion of the Onshore Development Area	High	Small	Minor adverse (N)	None required	Minor (adverse) Not Significant
Impacts from land contamination	Human Health, Groundwater, Surface Water, Ecological Receptors	See **Appendix 11-D: Assessment of Effects and Significance** for the full details		Negligible to minor beneficial (N) (as a result of potential remediation)	None required	Negligible to minor beneficial Not Significant

11.10 Cumulative Effects of the Project

11.10.1. Introduction

151. Cumulative effects are those effects upon receptors arising from the proposed Project alongside all existing, and/ or reasonably foreseeable projects, plans and activities that result in cumulative effects with any element of the proposed Project. Existing Projects are generally considered as part of the baseline and as such are considered within the impact assessment presented in **Section 11.6** above.

152. This section assesses potential cumulative effects on geology and hydrogeology from identified projects, plans and activities that have the potential to act cumulatively with the proposed Project.

153. PINS Advice 17: Cumulative Effects Assessment (2019) suggests that CEA follows a four-stage process. The aim of this approach is to accurately determine relevant projects and associated relationships with scoped in receptors identified in the ES, to be included within the interproject CEA.

154. The approach to the assessment of cumulative effects is detailed in **Appendix 5B: Approach to Cumulative Effects Assessment** and is also summarised in **Table 11-25**.

Table 11-25. PINS advice 17 stages of the CEA process

CEA Stage	Activity
Stage 1	Determine a zone of influence (ZoI) via desk study for each topic receptor scoped into the ES. This will establish a *long list* of projects within each ZoI that will be shortlisted in Stage 2. This list of plans and projects/activities is drawn up through a desk study of planning applications, development plan documents, relevant development frameworks and any other available sources to identify 'other development' within the ZoI. Information on each project (location, development type, status, etc.) is documented, along with the certainty or tier assigned to the 'other development' (i.e. confidence it will take place in the current form and when it will take place in relation to the project). PINS notes that the project should then consult with the relevant planning authority/ authorities and statutory consultees regarding the long list.
Stage 2	Screening of the long list identified in Stage 1, to establish a short list for the CEA. Screening is based on the criteria presented in the scoping report and subsequent comments by the regulator and statutory consultees. PINS has provided inclusions/ exclusion threshold criteria, against which the potential for 'other development to give rise to significant cumulative effects by virtue of overlaps in temporal scope, the scale and nature of the 'other developments' and /or receiving environment, or any other relevant factors is assessed. From this assessment, a shortlist of 'other developments' to be included in the CEA is produced. It is noted that documented information on each of the 'other developments' is likely to be high level at this stage, outlining the key issues to take forward.
Stage 3	Gathering of all information available on short listed projects generated in Stage 2. At this stage all available data and information about the shortlisted projects that will be included in the CEA is collected to inform the assessment. This should utilise the most current information for each project in the public domain, and assess the assumptions and limitations of the information collected on each shortlisted project.
Stage 4	Each of the shortlisted projects are reviewed in turn by the different topics to assess whether cumulative effects may arise and the nature of those effects (i.e. beneficial or adverse). The significance of the effects on environmental receptors

CEA Stage	Activity
	is established within each ES technical chapters. Where significant adverse cumulative effects are identified, mitigation measures are also considered within the CEA alongside the mechanism to secure that mitigation, e.g. consent condition requirements.

11.10.2. Scope of Cumulative Effects Assessment for geology and hydrogeology

155. The following impacts have been scoped into the CEA for geology and hydrogeology:

Construction / Decommissioning

- Impact on geological designated sites;
- Impact on MSZs; and
- Temporary impacts during construction from ground disturbance or where groundwater controls may inadvertently mobilise contamination or create preferential pathways.

Operation

- Beneficial impacts associated with remediation if the developments affect contaminated land that results in removal of potential contaminant sources or mitigation; and
- Impact on MSZs depending on the area of the resource permanently sterilized.

156. **Table 11-26** presents the short list of projects identified and included within the CEA for geology and hydrogeology. The maximum spatial extent of potential effects identified within this chapter are determined by the Study Area, which is 250m for geology and land contamination, extended to 1km for hydrogeology. Hence, plans or projects with potential to overlap spatially with this Zone of Influence have been subject to the cumulative assessment. These are presented in **Volume 5: Figure 11.5.**

Table 11-26. List of projects considered for the geology and hydrogeology cumulative effects assessment

Project Name/Developer	Project Type	Tier and Status	Approx. distance from the proposed Project
Erebus (Blue Gem Wind)	Offshore wind	Consent authorised	Within the Onshore Development Area
Valorous (Blue Gem Wind)	Offshore wind	Scoping opinion issued	Within the Onshore Development Area
Green Interconnector (Partners Group)	Interconnector	Under construction	Within the Onshore Development Area
Installation of an underground grid connection cable and associated infrastructure	Construction	Approved	1km north of the Onshore Substation, 1.2km north-east of the landfall, 3.9km north-east of the onshore cable

11.10.3. Cumulative Effect Assessment

Construction/Decommissioning

Impact on geological designated sites

157. Depending on their method of construction, other developments may have an impact on geological designated sites identified within the Onshore Development Area. It appears that the Erebus and Greenlink Interconnector do not intersect the Broomhill Burrows SSSI (geological area) and Freshwater West (North) GCR. The route of Valorous is unknown. If Valorous did intersect the geological designated site, the magnitude of impact would be dependent on the level of disturbance created. The sensitivity of the receptor is high, and the cumulative effects could range from neutral up to potentially major adverse (significant). However, it would be reasonable to assume that the sensitivity of the receptor has been considered, with a similar level of mitigation adopted to reduce any impacts to acceptable levels (**minor adverse** (**not significant**)).

Impact on MSZs

158. Other developments may cause temporary sterilisation of the MSZ resource during construction works (from construction compounds, for example), which may result in cumulative effects on this receptor. The magnitude of impact would be dependent on the extent of temporary features/structures but for schemes of this nature it would be expected to be small. The sensitivity of the receptor is high, and considering that this represents temporary sterilisation, the residual cumulative impact would be expected to be neutral to **minor adverse** (**not significant**).

Temporary impacts during construction from ground disturbance or where groundwater controls may inadvertently mobilise contamination or create preferential pathways

159. It is assumed that the developments listed in **Table 11-26** may require trenching for cable installations and minor dewatering during construction. Based on the contaminated land risk and impact assessment in this chapter, there may be some temporary minor adverse effects during construction from ground disturbance or where groundwater controls may inadvertently mobilise contamination or create preferential pathways. It is assumed that the developments listed in **Table 11-26** will have their own CEMP and conditions to mitigate impacts during construction and therefore, the residual cumulative impact would be expected to be neutral to **minor adverse (not significant)**.

Operation

Impact on geological designated sites

160. There will be no further effects from the schemes on geological designated sites during the operational phase.

Impact on MSZs

161. Other developments may cause permanent sterilisation of the resource during operation. For the schemes listed in **Table 11-26,** the magnitude of impact would be dependent on the extent of permanent development but is expected to be small for schemes of this nature. The sensitivity of the receptor is high, hence the residual cumulative permanent effects would be **minor adverse** (**not significant**).

Beneficial impacts associated with remediation if the developments affect contaminated land

that results in removal of potential contaminant sources or mitigation

162. There may be beneficial effects associated with remediation if the developments listed in **Table 11-26** affects contaminated land that results in removal of potential contaminant sources or mitigation. However, it is not considered that this will result in any significant beneficial effects, based on the assessment of land contamination undertaken within this chapter for the area within the Onshore Development Area, and on the distance of the 'Installation of an underground grid connection cable and associated infrastructure' from the Onshore Development Area. There is unlikely to be any potential for cumulative effects; the residual cumulative impact would be expected to be neutral to **minor beneficial (not significant)**.

Further mitigation and residual risk

163. Other than the mitigation measures already proposed (refer to **Section 11.7**), no further mitigation measures to reduce potential cumulative effects are required within this Application. It will be for the developments listed in **Table 11-26** to consider the need for additional mitigation.

164. No significant residual effects are anticipated for the geology and hydrogeology topic; therefore, no cumulative effects are anticipated.

11.11 Inter-related Effects of the proposed Project

165. The term 'Inter-related' considers the environmental interactions ('inter-relationships') with other receptors within the proposed Project. These are referred to in the Infrastructure Planning (Environmental Impact Assessment) Regulations 2009 and further described in **Chapter 31: Inter-related Effect Assessment.**

166. As set out in PINS Advice Note 17 (PINS), 2019, *inter-related -project effects*, or 'interrelationships between topics', derive from combinations of different project specific impacts which, when acting together on the same receptor, could result in a new or different effect, or an effect of greater significance than the project effects, when considered in isolation.

167. Inter-related effects comprise the following:

168. *Project lifetime effects*: effects that have the potential to occur during more than one phase of the proposed Project (i.e. construction, operation and maintenance and decommissioning) and to interact in a way that could potentially create a more significant effect than if it was assessed in isolation.

169. *Receptor-led effects*: effects that have the potential to interact, spatially and temporally, to create inter-related effects on a receptor.

170. **Chapter 31: Inter-related Effects Assessment** details the approach to the inter-related effects assessment and includes a description of the likely inter-related effects on geology and hydrogeology that may occur because of the proposed Project.

171. The assessment of inter-related effects on geology and hydrogeology has been scoped out of the inter-related effects assessment. The impacts set out and assessed in this chapter already take into consideration potential inter-relationships between impacts on geology and hydrogeology and impacts on the water environment, agriculture and soil, air quality, terrestrial ecology, noise and vibrations, as the effects assessed as the natural and physical processes behind them are inherently connected.

11.12 Transboundary Effects

172. A transboundary effect refers to the impacts or effects of a project that extend beyond the boundaries of the United Kingdom and have the potential to affect the environment of other countries within the European Economic Area (EEA). These effects can occur either from the proposed Project on its own or when combined with the effects of other projects or activities in the wider geographical area.

173. Transboundary effects are not anticipated for the geology and hydrogeology topic.

11.13 References

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