LLŶR FLOATING OFFSHORE WIND PROJECT

Llŷr 1 Floating Offshore Wind Farm

Environmental Statement

Volume 6: Appendix 3C - Landfall Assessment

August 2024

Prepared by: Llyr Floating Wind Ltd

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

This report has been prepared by AECOM on behalf of Llŷr Floating Wind Ltd. Llŷr Floating Wind Ltd has made reasonable efforts to ensure that the content is accurate, up to date and complete for the purpose of the Environmental Statement. Llŷr Floating Wind Ltd shall have no liability for any loss, damage, injury, claim, expense, cost or other consequence arising as a result of use or reliance upon any information contained in or omitted from this document.

Acronyms and abbreviations

Acronym or abbreviation	Definition	Acronym or abbreviation	Definition
ALC	Agricultural Land Classification	MLWS	Mean Low Water Springs
AOD	Above Ordnance Datum	META	Marine Energy Test Area
BGS	British Geological Society	MHPA	Milford Haven Port Authority
BGW	BlueGem Wind	MOD	Ministry of Defence
CBRA	Cable Burial Risk Assessment	MW	Megawatt
CEMP	Construction Environmental Management Plan	NGET	National Grid Electricity Transmission
COMAH	Control of Major Accident Hazards	NRW	Natural Resource Wales
CTMP	Construction Traffic Management Plan	OCT	Open Cut Trenching
DNO	Distribution Network Operator	OHL	Overhead Line
EIA	Environmental Impact Assessment	OTNR	Offshore Transmission Network Review
ES	Environmental Statement	PCC	Pembrokeshire County Council
FLOW	Floating Offshore Wind	PCNP	Pembrokeshire Coast National Park
GCR	Geological Conservation Review Site	PRoW	Public Right of Way
HDD	Horizontal Directional Drilling	RIGS	Regionally Important Geological Site
HND	Holistic Network Design	SAC	Special Area of Conservation
HVAC	High Voltage Alternating Current	SPA	Special Protection Area
HVDC	High Voltage Direct Current	SSSI	Site of Special Scientific Interest
INNS	Invasive Non-Native Species	SuDS	Sustainable Drainage System
JNCC	Joint Nature Conservation Committee	TCE	The Crown Estate
kV	Kilovolts	TPO	Tree Protection Order
KM	Kilometres	UG	Underground
M	Metres	UXO	Unexploded Ordinance
MHWS	Mean High Water Spring		

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	A joint venture company between Cierco Ltd and SBM Offshore Ltd of which Llŷr Floating Wind Limited is a wholly owned subsidiary.
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.

TABLE OF CONTENTS

TABLES

FIGURES

1. INTRODUCTION

1.1 The Development

1. Llŷr Floating Wind Limited (hereafter referred to as the Applicant) is proposing to develop the Llŷr 1 Floating Offshore Wind Farm, (hereafter referred to as the proposed Project), located 35 kilometres (km) from the northeastern corner of the Array Area to Linney Head (the closest location on the coast of Pembrokeshire) in the Celtic Sea.
2. The proposed Project is a test and demonstration wind farm development comprising up to 10 wind turbine generators (WTGs) and associated infrastructure. The proposed Project will make landfall at Freshwater West before connecting into the National Grid network at Pembroke Dock power station.
3. The Applicant is seeking a Section 36 consent and Marine Licence for the offshore components and deemed planning permission as part of the Section 36 consent for the onshore components of the proposed Project. This chapter forms part of the Environmental Statement (ES) which is submitted in support of those consent applications.

1.2 Project Llŷr Scoping Report

4. The Project Llŷr Scoping Report, which was submitted in April 2022, identified both an onshore and offshore scoping boundary for the Project Llŷr developments. Those scoping boundaries represent the footprint within which the development may take place and will be refined through the design and EIA process.

1.3 Aim of the Study

5. The aim of this study is to Identify and screen potential landfall options along the coastline between Freshwater West and West Angle Bay and select the most viable landfall options.

1.4 Legislation and Guidance

6. This study considers the statutory procedures set out in the following regulations:

    - The Electricity Works (EIA) (England and Wales) Regulations 2017 (the Electricity Works EIA Regulations); and
    - The Marine Works (EIA) Regulations 2007 (the Marine Works EIA Regulations).

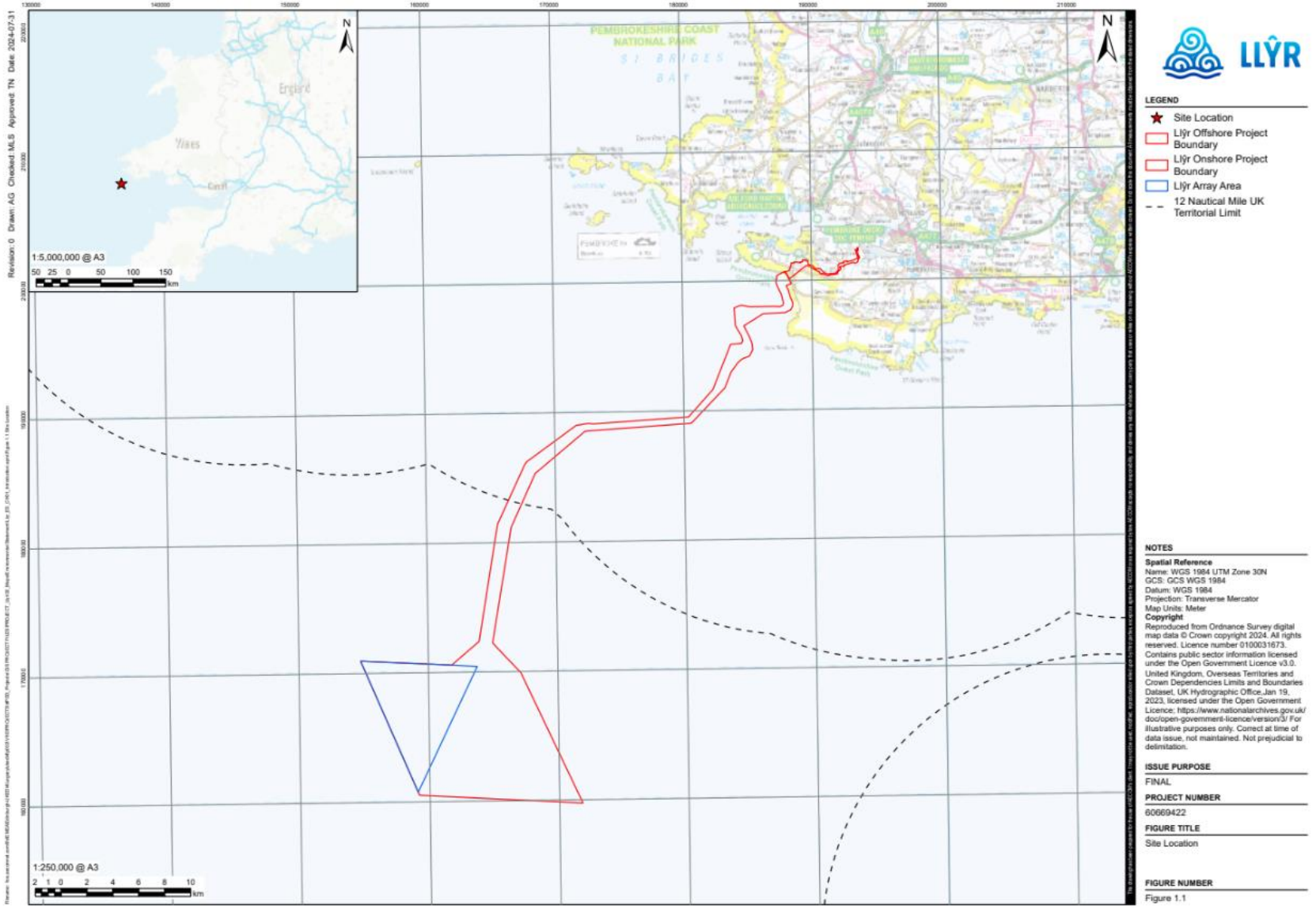


Figure 3C-1. Project location

2. ASSESSMENT OF LANDFALL SITES

2.1 Overview

7. Landfall sites were evaluated within a search area between West Angle Bay and Freshwater West, on the basis that the point of connection will be the National Grid substation at Pembroke (**Figure 3C-2**). It is noted that this search area was also defined by the extent of the offshore survey areas, which covered the land between West Angle Bay and Freshwater West, excluding Angle Bay. Angle Bay was not given further consideration as the Milford Haven Port Authority (MHPA) has raised concerns about the disruption to shipping, caused by laying subsea cables around the Angle Peninsula and into the estuary at Milford Haven. Angle Bay is also designated within the Milford Haven Waterway Site of Special Scientific Interest (SSSI) and Pembrokeshire Marine / Sir Benfro Forol Special Area of Conservation (SAC), with the bay largely compromising of Annex I mudflats and sandflats habitat.

8. At the landfall site, the subsea cable will be connected to the onshore cable in an underground transition joint bay (TJB). This TJB will typically be 20 metres long, 3 metres wide and 3 metres deep. Once constructed, the only visible sign of the TJB will be either a link box or a link pillar. Link pillars are more visible, whilst link boxes are buried in the ground. Their purpose is to provide local access to a circuit for integrity testing of the cable sheath.

9. Initial evaluation of the landfall search area identified seven potential locations between West Angle Bay and Freshwater West, excluding Angle Bay for the reasons mentioned previously. These locations are summarised in **Table 3C-1** and shown in **Table 3C-2.** Through preliminary analysis of the advantages and disadvantages of each landfall area, it was determined that whilst all locations are technically feasible, only sites at West Angle Bay and Freshwater West should be given further consideration. The reasoning for this is that the other locations would require cliff face landings, on a remote section of coastline, with limited access. This initial evaluation of all seven landfall sites is presented in Appendix A. To summarise this evaluation, remote, cliff face, landings sites were ruled out because of the cliff heights, complex geology, poor access to potential drilling sites and inaccessibility of the shoreline from these sites.

10. The remaining options of West Angle Bay and Freshwater West were then evaluated by mapping the various constraints at each of these site using publicly available and purchased data. A site walkover was also undertaken, on the 24th February 2023, to visually assess landfall options. Views of West Angle Bay and Freshwater West are shown in **Figure 3C-3** and **Figure 3C-4**.

Table 3C-1. Potential landfall sites

Location	Coordinates (X, Y)		Length of indicative offshore route (km)	Length of indicative onshore route (km)
West Angle Bay	185260.00	203367.00	43	11
Castle Bay	184589.00	201938.00	42	10
Whitedole Bay	184884.00	201843.00	42	10
Parsonquarry Bay	185164.00	201518.00	42	10
West Pickard Bay	186148.00	201275.00	43	8
East Pickard Bay	186624.00	201120.00	43	8
Freshwater West	188063.00	200532.00	45	7

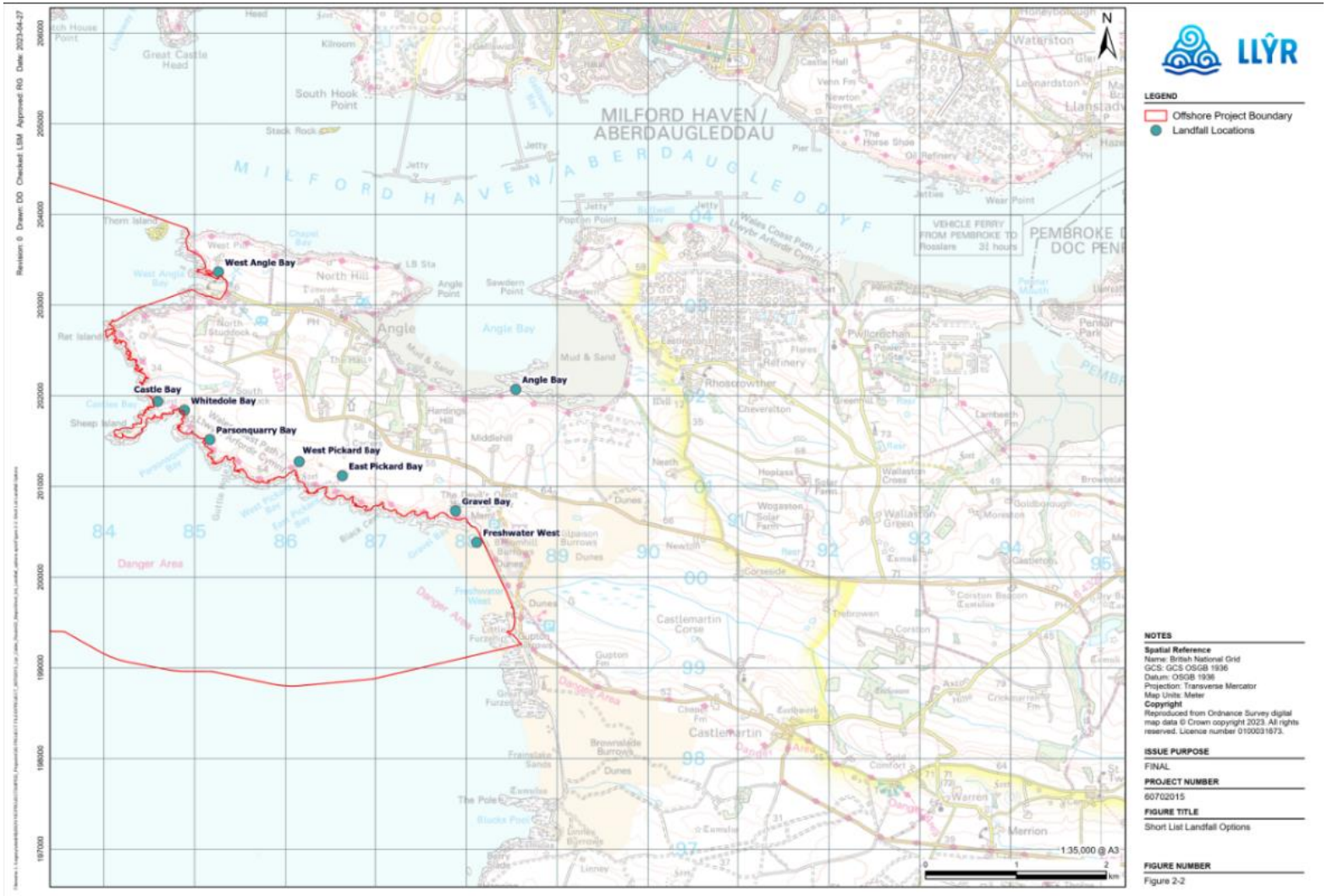


Figure 3C-2. Short list landfall options

Figure 3C-3. West Angle Bay

Figure 3C-4. Freshwater West

2.2 Available Landfall Engineering Methods

11. The primary aim of landfall design is to ensure the safe burial of the cable, to protect the cable from environmental and mechanical activities and to ensure it is not exposed during its operational lifetime. There are two engineering methods which are typically used at landfall:

- Open Cut Trenching (OCT); and
- Horizontal Directional Drilling (HDD).

12. The selection of the most appropriate method will typically depend on the environmental constraints, site topography, site geology, surrounding infrastructure, accessibility, and project constraints.

2.2.1. Open Cut Trenching

13. For sea to shore landfall construction, the OCT method requires the excavation of a trench which is then back-filled following installation of the cable. Whilst standard land based techniques can be employed for the onshore section of work, specialist dredging/trenching equipment will be required for the offshore section to successfully bury the cable..

14. The depth of excavation will depend on the site morphology and coastal processes, and whether the open trench will remain stable and 'open' long enough to achieve the cable installation. Once a trench has been formed, the offshore cable is usually installed from a cable laying vessel by a combination of floating and pulling the cable ashore using a pulling head from a land-based winch.

15. Installation can take between 12 and 24 hours dependant on terrain and logistics to trench and lay a cable. Typically, the preference is for the trench to be excavated and the cable laid during a single low tide.

2.2.2. Horizontal Directional Drilling

16. In coastal areas where OCT cannot be used to install cables from sea to land, HDD is required. HDD involves drilling a bore at depth through the ground between two locations; these are referred to as the entry and exit points, with the drilling rig usually being set up at the entry point.

17. For cable installation, a duct is normally installed within the bored hole first, and the cable pulled in afterwards. The subsurface geology and geotechnical conditions, size of duct and length of bore will be the main considerations in the selection of the drilling equipment including bits, reamers/hole openers, specialised tools and cable pulling devices. Additionally, because the bored hole is drilled, drilling muds[1] will be required to assist in maintaining the integrity of the bore and to transport the cutting material out as drilling progresses. The choice of the drilling mud and any required additives will be based on both drilling requirements and environmental constraints at the site.

18. There are two main options for the HDD work depending on the mechanical properties of the subsea cable and the shore and nearshore conditions to be drilled under. These include:

19. A 'short' HDD, which bores under cliffs or other obstacles to exit at a location on the beach between mean high water springs (MHWS) and mean low water springs (MLWS). Due to

[1] *Drilling mud, also called drilling fluid, is pumped down the hollow drill pipe to the drill bit, where it exits the pipe and then is flushed back up the borehole to the surface. It is used to lubricate the drill bit and transport drill cuttings to the surface*

distance, the shorter HDD in this case would rely on suitable access to the beach for the construction of an additional OCT on the beach to a point offshore.

20. A 'long' HDD duct allows the cable to be installed under both the intertidal littoral zone and sea cliffs to a point offshore. This may also be conducted from sea to shore using an offshore HDD, but either option avoids the need to access the beach. A typical working estimate for maximum length of cable pull is 500 metres – 1000 metres, however, this can be longer in certain situations, potentially up to 2 kilometres depending on geological conditions. For example, the Greenlink Interconnector (hereby called 'Greenlink') HDD at Freshwater West is 1.2 kilometres in length.

2.3 Comparison of Landfall Sites at West Angle Bay and Freshwater West

21. At West Angle Bay, the Project Erebus cable corridor allows for two alternatives landfall sites; one situated to the north side of the bay and the other to the south of the bay. These two landfall sites, identified in the Project Erebus Site Selection and Alternatives report[2], are the sites given consideration in this study at West Angle Bay. No further sites were identified at West Angle Bay due to multiple ecological, cultural heritage, and geological designations. At Freshwater West, two landfall sites are also identified within this study. These landfall sites are located to the north and south of the Greenlink TJB and are located outside the protected areas at Freshwater West.

22. Key attributes used to compare the landfall sites at West Angle Bay and Freshwater West were:

- Location and Accessibility;
- Landownership information;
- Length of indicative route;
- Geology;
- Existing Utilities;
- Interface with other subsea utilities, including Greenlink and Project Erebus, and users;
- Technical viability and methods;
- MOD Danger Areas - Castlemartin;
- High-density shipping lanes including anchorage and dredging, and commercial fishing;
- Habitats Directive Annex 1 habitat or Annex 2 species;
- Designations including SSSI, SAC, Special Protection Area (SPA), and Heritage Coast; and
- Social Impacts.

23. Evaluation and comparison of these landfall sites is presented in **Table 3C-2**.

[2]https://www.bluegemwind.com/wp-content/uploads/2020/07/Erebus-ES-Vol-1-Chapter-3-Site-Selection-and-Alternatives-final.pdf

Table 3C-2 Comparison of landfall criteria for West Angle Bay and Freshwater West

Criterion	West Angle Bay	Freshwater West	Preference
Location and accessibility of landfall sites	The Project Erebus cable corridor allows for two alternatives landfall sites at West Angle Bay; one situated to the north side of the bay and the other to the south of the bay. Access into West Angle Bay is via the B4320. Beyond the point where this road turns north towards Wallaston, it reverts to a minor road which in places narrows to a single-track road with passing places. The B4320 has been significantly improved between Pembroke and this junction to accommodate construction traffic accessing Pembroke Refinery and Pembroke Power Station. Above the village of Angle there is a tight hair pin bend where the road turns back on itself to head down into the village. Local access to both landfall sites would need to be along an access track within the cable corridor. This would be necessary to avoid construction traffic having to negotiate the B4320 on the approach to West Angle Bay and then pass through Angle Village. Although using an access track within the cable corridor is viable, access to the landfall sites at West Angle Bay is considered to be more difficult when compared with access to the landfall sites at Freshwater West.	Freshwater West also has two potential landfall sites; one located to the north of the Greenlink and one to the south of Greenlink. The proposed landfall sites are located outside of the protected areas at Freshwater West, in fields adjacent to the Greenlink landfall site. Access to these landfall sites would also be along the B4320. Greenlink has constructed a new junction which turns off the B4320 just before the junction with the B4319. This leads onto an upgraded farm track following a field boundary to their landfall site.	Freshwater West

Criterion	West Angle Bay	Freshwater West	Preference
Cable corridor length	For the landfall sites at West Angle Bay, the length of the onshore cable route, following the Project Erebus cable corridor, would be approximately 13 kilometres and approximately 7.5 kilometres of the route would be within the Pembrokeshire Coast National Park (PCNP). The associated length of the offshore cable route would be approximately 43 kilometres.	For the landfall sites at Freshwater West, the length of the onshore cable route, following the Project Erebus cable corridor, would be approximately 8.5 kilometres and approximately 2 kilometres of the route would be within the PCNP. The associated length of the offshore cable route would be approximately 45 kilometres for landing north of Greenlink and slightly longer (typically 46 kilometres) for a landing south of Greenlink. Therefore, landing at Freshwater West would reduce the length of the onshore cable route by approximately 4.5 kilometres, but increase the length of the offshore cable route by at least 2 kilometres.	Freshwater West
Geology	West Angle Bay is located along the Angle syncline, which trends in approximately a northwest to south east direction. The two landfall sites are located on either side of the syncline. The bedrock at the centre of the bay is limestones (Black Rock Subgroup) and extending either side are limestones and mudstones (Avon Group), comprising of interbedded grey mudstone and thin to medium bedded skeletal packstones. This is followed by the Skrinkle Sandstone Supergroup, which comprises interbedded grey quartzitic and red lithic sandstones, conglomerates, red mudstones, and siltstones. Next is the interbedded conglomerates and mudstones of the Ridgeway Conglomerate Formation. Lastly the Milford Haven Subgroup which comprises hard, red calcareous marls with	The geology of the Freshwater West sites is within a syncline with the axis trending in approximately a northwest to south east direction. The bedrock to be encountered within the two landfalls being considered at Freshwater West include the Aber Mawr Shale Formation, the Ludlow Rocks, and the Milford Haven Subgroup. The British Geological Society (BGS) describe the Aber Mawr Shale Formation as comprising dark grey mudstones locally with interbedded tuffs. The Ludlow Rock is a sandstone, and the Milford Haven Subgroup is a hard, red calcareous marls with sporadic red and green sandstones. Basal beds of green marl, conglomerate and breccia are also present.	Freshwater West

Criterion	West Angle Bay	Freshwater West	Preference
	sporadic red and green sandstones. Basal beds of green marl, conglomerate and breccia are also present. There are two faults recorded centrally along the same orientation as the axis of the syncline with a thrust-fault identified. This is where the limestones and mudstones (Avon Group) are pushed up and over the limestone (Black Rock). The northern landfall site is located immediately south of this fault zone, possibly along the boundary between the limestones of the Black Rock Group and the limestones and mudstones of the Avon Group. The southern landfall site is likely to be within the limestones and mudstones of the Avon Group. Observations from the site visit indicate the steeply dipping bedding of the rocks (approximately 45 degrees) outcropping along the foreshore, with the bedding orientated along the northwest to south east axis, at both landfall sites. The bedding at the northern landfall site is generally dipping to the southwest whilst the bedding at the southern landfall site is dipping to the north east (this is because the landfall sites are on opposites sides of the Angle syncline). The geology has the potential to present challenges during construction. At West Angle Bay, the rock local to the faulting is likely to be disturbed with irregular orientated bedding and can be expected to be fractured potentially with weak zones. This is likely to have a greater impact on the northern option.	A cable route leading to the northern landfall site is likely to pass through the sandstone of the Ludlow Rock and then the rocks of the Milford Haven Supergroup. A fault is identified which cuts through both these rocks and crosses the cable route diagonally. This route is also within a Geological Conservation Site (1663) although no specific site report is available. Site observations indicate that the bedding is very steeply dipping, of the order of 70-80 degrees. A cable route leading to the southern landfall site is likely to pass all three rock groups identified with no faulting indicated along its route. The geology has the potential to present challenges during construction. It noted that due to the orientation of the bedding and potential for weathering and open joints/fractures within the rock. Greenlink experienced drilling fluid breakout which is likely to have been due to the orientation of the bedding and potential for weathering and open joints/fractures within the rock. A similar occurrence could be expected along both of the routes being considered, especially where highly fractured and weak zones associated with faulting are encountered, particularly recorded in the northern Freshwater West HDD route.	

Criterion	West Angle Bay	Freshwater West	Preference
Existing utilities within the vicinity of the landfall sites	From the north landfall site, the onshore cables would need to cross a water main, underground electricity cables, underground telecommunication cables, electricity overhead lines (OHLs) and telecommunication OHLs within the vicinity of the landfall site. From the south landfall site, the onshore cables would need to cross a water main, electricity OHLs and telecommunication OHLs within the vicinity of the landfall site.	No existing utilities have been identified at the Freshwater West landfall sites. However, there is an electricity OHL to the north and underground telecommunication cables and water mains that run along the B4320. The onshore cables would need to cross these utilities.	Freshwater West
Interface with other subsea utilities (Greenlink and Project Erebus) and users	BGW has identified two sites within West Angle Bay for the Project Erebus landfall.[3] Once BGW has selected one of these two sites, then Project Llŷr could remain within the Project Erebus cable corridor by adopting the other site. If Project Llŷr also chooses West Angle Bay, the infrastructure for both Projects would need to be adequately separated and, ideally, any cable crossing points avoided. If crossing points were required, Project Llŷr would need to enter into a crossing agreement with Project Erebus. There could be the potential for a cumulative environmental impact resulting from the need to undertake construction work for both Project Erebus and Project Llŷr in the same locality. To mitigate against this, construction could be planned to take place at the same time and the cable routes shared.	At Freshwater West, Greenlink is now under construction and therefore the location of the landfall site and cable route is known. At the time of Project Llŷr's construction, the infrastructure for Greenlink will already be in place. The onshore and offshore cables and TJB for Project Llŷr would need to be adequately separated from Greenlink's infrastructure. Typically, a separation distance of up to 30 metres between the Greenlink and Project Llŷr onshore cables is likely to be required. Greenlink will be part of the existing environment so will not need to be considered as part of a cumulative impact assessment. If Project Llŷr made landfall at the Freshwater West north site and then utilised the Project Erebus corridor, the Project Llŷr cables could be positioned such that they only need to cross	No Preference

[3] https://www.bluegemwind.com/wp-content/uploads/2020/07/Erebus-ES-Vol-1-Chapter-3-Site-Selection-and-Alternatives-final.pdf

Criterion	West Angle Bay	Freshwater West	Preference
	If Project Llŷr made landfall at West Angle Bay and then closely followed the Project Erebus cables, the Project Llŷr cables would only need to cross Greenlink once, just south of Neath Farm, before needing to interact with Greenlink again on the approach to the connection point. Offshore, a cable corridor leading to a landfall site at West Angle Bay would only require crossing Greenlink once. Landfall at West Angle Bay would avoid the lease areas for Bombora Wavepower or Marine Energy Test Area (META) but would require the offshore cable corridor to pass through the closed Milford Haven Offshore Disposal Site and near to the closed St Ann's Head Offshore Disposal Site. Several other sea cables exist offshore which will also require crossing, (refer to Offshore Cable Assessment Report for further details). Project Valorous has submitted a Scoping Report which also considers landfall at West Angle Bay. No further details are available at present.	Greenlink once, just south of Neath Farm, before needing to interact with Greenlink again on the approach to the connection point. Alternatively, if the Project Llŷr cables followed a route north of the Project Erebus corridor, from the north landfall site, the Project Llŷr cables could be positioned such that they do not need to cross Greenlink before needing to interact with Greenlink on the approach to the connection point. If Project Llŷr made landfall at the Freshwater West south site and then utilised the Project Erebus corridor, the Project Llŷr cables would need to cross Greenlink in close proximity to the landfall and then again at Neath Farm before needing to interact with Greenlink again on the approach to the connection point. Alternatively, if the Project Llŷr cables followed a route north of the Project Erebus corridor, from the south landfall site, the Project Llŷr cables could be positioned such that they only need to cross Greenlink once, in close proximity to the landfall, before needing to interact with Greenlink again on the approach to the connection point. An offshore cable corridor for the north landfall site is likely to pass close to the lease areas for Bombora Wavepower and META, whilst an offshore cable corridor for the south landfall site will be further south and more remote from these lease areas. For both landfall sites, the offshore cable corridor would also have to pass through the closed Milford Haven Offshore Disposal Site.	

Criterion	West Angle Bay	Freshwater West	Preference
		Several other sea cables exist offshore which will also require crossing, (refer to Offshore Cable Assessment Report for further details). Project Valorous has submitted a Scoping Report which also considers landfall at Freshwater West. No further details are available at present.	
Construction method	The northern landfall site at West Angle Bay is located behind the wide sandy beach, above MHWS, where there is a relatively small differential between the beach elevation and the adjacent field elevation. The southern landfall site has a greater differential between the beach elevation and the adjacent field elevation. At both sites, there is judged to be sufficient space for a construction compound and TJB. At West Angle Bay, the preferred construction method for installing a duct to bring the subsea cables ashore is HDD as this will reduce the impact on shallow subtidal and intertidal marine habitats. The HDD offshore exit point is beyond MLWS. An initial assessment into the feasibility of HDD at West Angle Bay, based on several high-level assumptions, can be found in Appendix B.	The beach at Freshwater West is known for its exposed character, strong waves, and currents[4]. The beach is exposed to high wave energy during the winter months (November to April) where sediment is generally suspended and moved offshore. During the summer months, lower energy waves act upon the sediment to build up the beach to a fuller summer profile. Within the upper beach terrace (an elevated portion of land that is generally flat, level and overlooking a shoreline), an area of consolidated coarser sediment is covered by a sand veneer. Trenching through this feature could create a weakness after construction, potentially allowing a scour channel to form, which in turn could affect the way sediment is transported on and off the beach. Trenching through areas of bedrock reef could also result in a similar effect if they are identified in the survey results in the subtidal and / or intertidal region.	Freshwater West

[4] https://www.visitpembrokeshire.com/explore-pembrokeshire/beaches/freshwater-west

Criterion	West Angle Bay	Freshwater West	Preference
		Beyond the foreshore, the cable route would logically progress through the steep, extensive, environmentally significant, Broomhill Burrow dunes system which is designated as a SSSI. Given the environmental constraints at Freshwater West, the only viable construction method is to use HDD to install a duct through which the subsea cables can pass from an area beyond MLWS to a landfall site beyond MHWS and outside of the protected areas. This technique is required to avoid OCT on the beach and through the shallow subtidal and intertidal marine habitats. The landfall sites chosen are located either side of the landfill site for the Greenlink, above MHWS. At these locations there is judged to be sufficient space for a construction compound and TJB. An initial assessment into the feasibility of HDD at Freshwater West, based on several high-level assumptions, can be found in Appendix B.	
Military Operations – UXO and firing range	An offshore cable corridor for landfall sites at West Angle Bay would still pass through the Castlemartin Range Sea Danger Area.	An offshore cable corridor for landfall sites at Freshwater West is likely to encroach upon the Castlemartin Range Sea Danger Area within Freshwater West Bay. An offshore cable corridor leading to the southern landfall site is more likely to extended into the danger area, within the bay, when compared with an offshore cable corridor leading to the north landfall site.	West Angle Bay

Criterion	West Angle Bay	Freshwater West	Preference
Shipping traffic, anchorage, and commercial fishing	An offshore cable corridor for both landfall sites at West Angle Bay will encroach into the east shipping lane at the entrance to Milford Haven. Whilst known anchorage zones are located to the north of West Angle Bay at Dale Roads, this corridor could still be at risk from emergency anchoring. During installation, parts of the shipping lane may need to be closed to allow safe passage of the cable installation vessel. An offshore cable corridor would avoid Milford Haven Maintenance dredging zones. The offshore cable corridor in the vicinity of West Angle Bay may intersect with areas of commercial fishing activity particularly potting by small local vessels, the impacts of which would need to be adequately addressed within the ES.	An offshore cable corridor for both landfall sites at Freshwater West will encroach into the approach to Milford Haven, offshore, but not the east shipping lane at the entrance. During installation, parts of the shipping lane may need to be closed to allow safe passage of the cable installation vessel. An offshore cable corridor would avoid Milford Haven Maintenance dredging zones. The offshore cable corridor in the vicinity of Freshwater West may intersect with areas of commercial fishing activity, particularly potting by small local vessels, the impacts of which would need to be adequately addressed within the ES.	Freshwater West
Habitats Directive Annex 1 habitat or Annex 2 species	The proposed landfall sites at West Angle Bay are within the Pembrokeshire Marine / Sir Benfro Forol SAC[5] designated for a range of broadscale Annex I habitats: • Estuaries[6]; • Large shallow inlets and bays[7]; • Reefs[8]; • Sandbanks which are slightly covered by sea water all the time[9]; • Mudflats and sandflats not covered by seawater at low tide[10];	The proposed landfall sites at Freshwater West are within the Pembrokeshire Marine / Sir Benfro Forol SAC, designated for the following Annex I habitats: • Estuaries; • Large shallow inlets and bays; • Reefs; • Sandbanks which are slightly covered by sea water all the time; • Mudflats and sandflats not covered by seawater at low tide; • Coastal lagoon;	No Preference

[5] https://sac.jncc.gov.uk/site/UK0013116
[6] https://sac.jncc.gov.uk/habitat/H1130/
[7] https://sac.jncc.gov.uk/habitat/H1160/
[8] https://sac.jncc.gov.uk/habitat/H1170/
[9] https://sac.jncc.gov.uk/habitat/H1110/
[10] https://sac.jncc.gov.uk/habitat/H1140/

Criterion	West Angle Bay	Freshwater West	Preference
	• Coastal lagoon[11]; • Atlantic salt meadows[12]; and • Submerged or partially submerged sea caves[13]. • Designated Annex II species of the Pembrokeshire Marine SAC include: • Grey seals (Halichoerus grypus)[14]; • Shore dock (*Rumex rupestris*)[15]; • Sea lamprey (Petromyzon marinus)[16]; • River lamprey (Lampetra fluviatilis)[17]; • Allis shad (*Alosa alosa*)[18]; • Twaite shad (*Alosa fallax*)[19], and • Otter (*Lutra lutra*)[20]. At West Angle Bay, the offshore cable corridor would pass through a sandbank – Turbot Bank. It is likely that a cable burial risk assessment (CBRA) will need to minimise and mitigate the need for cable protection in this area, as the introduction of hard materials, such as cable protection, to this sandbank may not be acceptable by NRW, whilst still reducing the risk of future cable exposure, requiring additional maintenance work or cable protection. Reducing the use of cable protection when crossing this feature will	• Atlantic salt meadows; and • Submerged or partially submerged sea caves. • Annex II species that are also protected by the Pembrokeshire Marine SAC include: • Grey seal; • Shore dock; • Sea lamprey; • River lamprey; • Allis shad; • Twaite shad, and • Otter. At Freshwater West, the offshore cable corridor would pass through a sandbank – Turbot Bank. It is likely that a CBRA will need to minimise and mitigate the need for cable protection in this area, as the introduction of hard materials, such as cable protection, to this sandbank may not be acceptable by NRW, whilst still reducing the risk of future cable exposure, requiring additional maintenance work or cable protection. Reducing the use of cable protection when crossing this feature will minimise the introduction of new species to the Annex I habitat and changes in suspended sediment/smothering.	

[11] https://sac.jncc.gov.uk/habitat/H1150 /
[12] https://sac.jncc.gov.uk/habitat/H1330/
[13] https://sac.jncc.gov.uk/habitat/H8330/
[14] https://sac.jncc.gov.uk/species/S1364/
[15] https://sac.jncc.gov.uk/species/S1441/
[16] https://sac.jncc.gov.uk/species/S1095/
[17] https://sac.jncc.gov.uk/species/S1099/
[18] https://sac.jncc.gov.uk/species/S1102/
[19] https://sac.jncc.gov.uk/species/S1103/
[20] https://sac.jncc.gov.uk/species/S1355/

Criterion	West Angle Bay	Freshwater West	Preference
	minimise the introduction of new species to the Annex I habitat and changes in suspended sediment/smothering. However, a Marine Invasive Non-Native Species (INNS) Strategy may be required as well as commitments by the construction vessel and / or contractors. There is a risk of interaction/impact on the subtidal and intertidal reef features that are a key component of the Pembrokeshire Marine SAC. Both intertidal and subtidal benthic ecological and geophysical survey data will be required to assess the presence and potential extent of these features. Partial survey data has been provided at the time of writing this report; however, this excludes the nearshore area. HDD is proposed at landfall to minimise potential impacts on benthic ecology; an HDD depth of 3 to 5 metres below the potential reef habitat is assumed at this stage to limit fracturing and vibration effects. Offshore, stakeholder consultation would be required with Natural Resource Wales (NRW) and Joint Nature Conservation Committee (JNCC) to refine the cable route to avoid sensitive habitat including Annex I or to develop acceptable mitigation measures. Project Erebus previously consulted with the above stakeholders to define an offshore	However, a Marine Invasive Non-Native Species (INNS) Strategy may be required as well as commitments by the construction vessel and / or contractors. There is a risk of interaction/impact on the subtidal and intertidal reef features that are a key component of the Pembrokeshire Marine SAC. Both intertidal and subtidal benthic ecological and geophysical survey data will be required to assess the presence and potential extent of these features. Partial survey data has been provided at the time of writing this report; however, this excludes the nearshore area. The Freshwater West landfall to the north of Greenlink has a greater risk of interaction/impact on the intertidal reef features than the landfall to the south of Greenlink. The Greenlink Intertidal Survey Report[22] noted that all littoral rock biotopes encountered to the north of their survey area on Freshwater West beach correlated to Annex I reef habitat. The offshore cable corridor to Freshwater West could equally be limited by the unknown extent of reef habitats that could prevent a routing to landfall the avoids Annex I habitats. Stakeholder consultation will be required with NRW and JNCC to refine the cable route to avoid sensitive habitat or to develop acceptable mitigation measures. Greenlink identified a channel through a section of reef to landfall[23]. At this stage,	

[22] https://www.greenlink.ie/file-share/d12a2a91-7917-450d-aa03-90be2cf6924d
[23] https://www.greenlink.ie/file-share/ea639548-47a3-491a-8dbd-7cb031bc9d95

Criterion	West Angle Bay	Freshwater West	Preference
	cable corridor to West Angle Bay through a channel in the rocky subtidal reef. The Project Erebus survey data identified Annex I bedrock and stony reef habitat mostly in the nearshore survey area around the entrance to Milford Haven and in the shallow subtidal area close to West Angle Bay[21]. The rock identified appeared to have been eroded, creating an exposed channel feature which had been backfilled with fluvio-estuarine sediments. It has been inferred, from the pdf versions of the Project Erebus survey, that the channel width ranges between 40 and 140 metres in width. Without further cable assessments, it is unknown as to whether Project Llŷr could share this same corridor.	without the nearshore survey data, it is unknown as to whether Project Llŷr could share this same corridor or if another route that avoids Annex I habitats to landfall at Freshwater West exists. HDD is proposed at landfall to minimise potential impacts on benthic ecology; an HDD depth of 3 to 5 metres below the potential reef habitat is assumed at this stage to limit fracturing and vibration effects. An initial assessment into the feasibility of HDD at Freshwater West, based on several high-level assumptions, can be found in Appendix B.	
Designated sites and cultural heritage features	Landfall at West Angle Bay is constrained as multiple ecological, cultural heritage and geological designations are present, and the landscape character is particularly sensitive. The landfall location lies within two statutory ecological designations (Pembrokeshire Marine / Sir Benfro Forol SAC and Angle Peninsula Coast / Arfordir Penrhyn Angle SSSI) and is in close proximity to a third (West Wales Marine / Gorllewin Cymru Forol SAC). The Project Erebus cable route then passes close to a further three statutory ecological designations (Limestone Coast of South West Wales / Arfordir	Both landfall sites at Freshwater West are similarly constrained. Whilst the landfall sites are located outside of the protected areas at Freshwater West[24], the cable routes would still pass through two SACs (the Pembrokeshire Marine / Sir Benfro Forol SAC and Limestone Coast of South West Wales / Arfordir Calchfaen De Orllewin Cymru SACs), an SPA (Castlemartin Coast), and the particularly sensitive dune system of Broomhill Burrows SSSI. Also, near to the landfall locations is a scheduled monument (Devil's quoit Burial Chamber – approx. 200 metres north) and Listed Building (War Memorial – approx.200 m west). The	Freshwater West

[21] https://www.bluegemwind.com/wp-content/uploads/2020/07/Erebus-ES-Vol-3-Appendix-9.1-Integrated-Geophys-and-Habitat-Assessment-Technical-Report.pdf
[24] https://www.nationaltrust.org.uk/visit/wales/freshwater-west-and-gupton-farm

Criterion	West Angle Bay	Freshwater West	Preference
	Calchfaen De Orllewin Cymru SAC, Castlemartin Coast SPA and the Broomhill Burrows SSSI). The Project Erebus onshore cable corridor would also pass in close proximity to two Geological Conservation Review (GCR) sites (West Angle Bay and West Angle Bay (North)). The north landfall and onshore cable corridor will also interact with the Angle Conservation Area. There is also a scheduled monument (West Angle Bay Early Medieval Settlement) to the south of West Angle Bay. The entire West Angle Bay is designated as a Regionally Important Geological Site (RIGS).	north landfall options could interact with the Freshwater West (North) RIGS. Discussions with Greenlink have elucidated that there may be archaeological sites of interest at Freshwater West.	
Social Impacts – Recreational amenities and Proximity to residencies	The landfall location and cable route fall in proximity to the West Angle Beach and the West Angle Bay Caravan Park, with the potential for impacts upon these socio-economic and tourism receptors. Construction could take place outside of holiday periods and the summer months to reduce impact. Mitigation may be needed to reduce disruption to the village of Angle.	The landfall at the Freshwater West beach area is also a constraint in respect of potential impacts on tourism and recreation. Construction could take place outside of holiday periods and the summer months to reduce potential impacts.	Freshwater West

2.4 Summary of Landfall Assessment Decision

24. Whilst all seven landfall sites are considered technically feasible, only West Angle Bay and Freshwater West were given further consideration on the basis that the other locations would require cliff face landings on a remote section of coastline with limited access. At West Angle Bay, the Project Erebus cable corridor allows for two alternatives landfall sites; one situated to the north side of the bay and the other to the south of the bay. These two landfall sites are the sites given consideration in this study. At Freshwater West, two landfall sites are also considered. These landfall sites are located to the north and south of the Greenlink JTB and outside of the protected areas at Freshwater West.

25. Based on the findings of this study, both West Angle Bay and Freshwater West are considered to offer potential landfall sites for Project Llŷr. Further investigation is required at both locations, and this will typically need to include detailed HDD feasibility studies and geotechnical site investigation works. A detailed survey of the nearshore benthic habitat and seabed geomorphology will also be required to confirm whether an offshore cable can be routed to either of these landfall sites.

26. The preferred method of installing a duct to bring a subsea cable onto land at both West Angle Bay and Freshwater West is HDD. At Freshwater West this is considered the only option in order to mitigate the risk of disturbance to the intertidal reef and avoid the unintended formation of a scour channel on the beach. At West Angle Bay, the presence of intertidal reefs and important geological features suggests that trenching should also be avoided at this location.

27. Deploying HDD at Freshwater West is more technically complex and challenging due to the length (approx. 1300 m) and gradient of the bore. The Greenlink Project has demonstrated that cable ducts can be installed at Freshwater West using the HDD technique. Any drilling fluid breakout could have temporary, short term, effects on both the intertidal and/or subtidal habitat and Annex I habitats, requiring careful consideration of the type of drilling fluid and the depth of the bore.

28. At West Angle Bay, the cable route and landfall site will have to be adequately separated from the Project Erebus cable route and landfall site. Similar separation distances to Greenlink's infrastructure will also be required at Freshwater West. Once BGW has confirmed its landfall site, then Project Llŷr could look to utilise the alternative landfall option to remain within BGW's cable corridor.

29. Through a comparison of the two Project Erebus landfall sites at West Angle Bay, the south landfall site is considered preferable. This is due to the presence of a thrust zone along the north edge of West Angle Bay and the Angle Conservation Area. However, the constraints at this site are such that there is unlikely to be sufficient land to accommodate both Project Erebus and Project Llŷr in this location, should BGW decide to revert to the south landfall site. In this instance, Project Llŷr could revert to the north landfall site although this site is considered to be far less preferable.

30. At West Angle Bay, there could be the potential for a cumulative environmental impact resulting from the need to undertake construction work for both Project Erebus and Project Llŷr in the same locality. To mitigate this, construction could be planned to take place at the same time and the cable routes shared. As Greenlink will be part of the existing environment it will not need to be considered as part of a cumulative impact assessment.

31. The offshore cable corridor leading to the landfall sites at either West Angle Bay or Freshwater West will be confirmed after further benthic habitat and seabed geomorphology surveys in

the nearshore area. The purpose of these surveys will be to identify the extent of potential Annex I habitats, specifically sandbanks and subtidal reef that would need to be negotiated by the subsea cable.

32. The Project Erebus survey data identified mostly Annex I bedrock and stony reef habitat in the nearshore survey area. There is an exposed channel feature through the Annex I habitat, which Project Erebus have followed, that ranges between 40 and 140 metres in width. Without further cable assessments, it is unknown as to whether Project Llŷr could share this same corridor. Greenlink also identified a channel to follow through a section of reef to landfall at Freshwater West. However, the Greenlink survey data does not extend far enough north or south to confirm if a route that avoids Annex I habitat to landfall exist for Project Llŷr.

33. As both Greenlink and Project Erebus have selected an offshore cable corridor that follows a channel within a subtidal reef, to avoid the Annex I habitat, it is likely Project Llŷr would need to do the same. This has the potential to limit the landfall options for Project Llŷr if a route that avoids the reef, or a suitable mitigation measure is not identifiable.

34. In summary, the order of preference for landfall sites is the northern site at Freshwater West, the southern site at Freshwater West and the southern site at West Angle Bay, **Table 3C-3.** At all locations, the recommended construction method for installing a duct to bring a subsea cable ashore is HDD. However, it is noted that further surveys of the inshore benthic habitat and seabed geomorphology will be required.

Table 3C-3. Landfall summary

Criterion	Preference
Location and accessibility of landfall sites	Freshwater West
Landownership at the landfall sites.	Freshwater West
Cable corridor length	Freshwater West
Geology	Freshwater West
Existing utilities	Freshwater West
Interface with other subsea utilities (Greenlink and Project Erebus) and users	No Preference
Construction method	Freshwater West
Military Operations – UXO and firing range	West Angle Bay
Shipping traffic, anchorage, and commercial fishing	Freshwater West
Habitats Directive Annex 1 habitat or Annex 2 species	Freshwater West
Designated sites and cultural heritage features	Freshwater West
Social Impacts – Recreational amenities and Proximity to residencies	Freshwater West

3. CONCLUSION

35. The aim of this study was to Identify and screen potential landfall options along the coastline between Freshwater West and West Angle Bay. Of the seven landfall sites initially identified, only Freshwater West and West Angle Bay were evaluated in detail. The other five sites were screened out early on as they required cliff face landings on a remote section of coastline with limited access. At both Freshwater West and West Angle Bay two alternative landfall sites were evaluated. At West Angle Bay, the two alternatives landfall sites were the sites within the Project Erebus cable corridor, whilst at Freshwater West the landfall sites were located to the north and south of the Greenlink TJB.

36. Through comparison of the two landfall options at West Angle Bay, the southern landfall site is considered preferable due to the presence of a thrust zone along the northern edge of West Angle Bay and the Angle Conservation Area. This reduced the preferred landfall sites to three. In order of preference, these are the Freshwater West northern site, the Freshwater West southern site and the West Angle Bay southern site. Further investigation is required at each of these locations and this will typically need to include detailed HDD feasibility studies and geotechnical site investigation works. A detailed assessment of the nearshore benthic habitat and seabed geomorphology will also be required to confirm whether an offshore cable can be routed to these landfall sites.

37. In conclusion, the preferred option is for landfall is to the north of Greenlink at Freshwater West.

Appendix A. Preliminary Landfall Assessment

38. **Table 3C-4** below summaries the preliminary advantages and disadvantages for the initial seven landfall locations identified.

Table 3C-4. Preliminary summary for identified landfall locations

Landfall Location	Advantages	Disadvantages
West Angle Bay	• Significantly reduced risk from MOD firing range. • Avoids crossing Greenlink onshore. • Avoids the lease area for Bombora Wavepower and META. • Landfall has a lower elevation gradient.	• Longest indicative onshore cable corridor. • Bedrock could potentially restrict HDD. • Cable would require routing through a busy shipping lane, which has anchorage areas. Impacts on shipping would require further discussion with MHPA. • Potential for clashes with sunken vessels and marine debris. • Commercial fishing to investigate further. • The offshore sections of this route would require crossing of the planned Greenlink and Project Erebus. • Close proximity to Project Erebus landfall. May clash with Project Erebus cable corridor onshore. • Part of the offshore export cable route would be located in the Pembrokeshire Marine / Sir Benfro Forol SAC. • Landfall is close to / within Angle Peninsula Coast / Arfordir Penrhyn Angle SSSI, Pembrokeshire Marine / Sir Benfro Forol SAC, RIGS and GCR site.
Castle Bay	• Shortest indicative offshore cable corridor. • Significantly reduced risk from MOD firing range. • Avoids crossing Greenlink onshore. • Avoids the lease area for Bombora Wavepower and META.	• Longer indicative onshore cable corridor. • Poor accessibility via road for HDD installation. • Bedrock could potentially restrict HDD. • Landfall has a higher elevation gradient. • Cable would require routing through a busy shipping lane, which has anchorage areas. Impacts on shipping would require further discussion with MHPA. • Potential for clashes with sunken vessels and marine debris. • Commercial fishing to investigate further.

Landfall Location	Advantages	Disadvantages
		• The offshore sections of this route would require crossing of the planned Greenlink and Project Erebus. • May clash with Project Erebus cable corridor onshore. • Landfall is within Angle Peninsula Coast / Arfordir Penrhyn Angle SSSI, Pembrokeshire Marine / Sir Benfro Forol SAC. • Also near Scheduled Monument – Promontory Fort at Sheep Island.
Whitedole Bay	• Shortest indicative offshore cable corridor. • Avoids crossing Greenlink onshore. • Avoids the lease area for Bombora Wavepower and META. • Minimal disruption to shipping lanes.	• Longest indicative onshore cable corridor. • Poor accessibility via road for HDD installation. • Bedrock could potentially restrict HDD. • Landfall has a higher elevation gradient. • Offshore cable corridor close in proximity to MOD firing range, risks of clashes with military operations and UXO. • The offshore sections of this route would require crossing of the planned Greenlink. • May clash with Project Erebus cable corridor onshore. • Part of the offshore export cable route would be located in the Pembrokeshire Marine / Sir Benfro Forol SAC. • Landfall is within Angle Peninsula Coast / Arfordir Penrhyn Angle SSSI, Pembrokeshire Marine / Sir Benfro Forol SAC. • Also near Scheduled Monument – Promontory Fort at Sheep Island
Parsonquarry Bay	• Shortest indicative offshore cable corridor. • Avoids crossing Greenlink onshore. • Avoids the lease area for Bombora Wavepower and META. • Minimal disruption to shipping lanes.	• Poor accessibility via road for HDD installation. • Bedrock could potentially restrict HDD. • Landfall has a higher elevation gradient. • Offshore cable corridor close in proximity to MOD firing range, risks of clashes with military operations and UXO. • The offshore sections of this route would require crossing of the planned Greenlink. • May clash with Project Erebus cable corridor onshore.

Landfall Location	Advantages	Disadvantages
		• Part of the offshore export cable route would be located in the Pembrokeshire Marine / Sir Benfro Forol SAC. • Landfall is within Angle Peninsula Coast / Arfordir Penrhyn Angle SSSI, Pembrokeshire Marine / Sir Benfro Forol SAC.
West Pickard Bay	• Avoids crossing Greenlink onshore. • Minimal disruption to shipping lanes.	• Poor accessibility via road for HDD installation. • Bedrock could potentially restrict HDD. • Landfall has a higher elevation gradient. • Offshore cable corridor close in proximity to MOD firing range, risks of clashes with military operations and UXO. • The offshore sections of this route would require crossing of the planned Greenlink. • May clash with Project Erebus cable corridor onshore. • The offshore route would pass close to the lease areas for Bombora and META. • Part of the offshore export cable route would be located in the Pembrokeshire Marine SAC. • Landfall is within Angle Peninsula Coast / Arfordir Penrhyn Angle SSSI, Pembrokeshire Marine / Sir Benfro Forol SAC. • Landfall would be near Scheduled monument – West Pickard Camp.
East Pickard Bay	• Avoids crossing Greenlink onshore. • Minimal disruption to shipping lanes.	• Poor accessibility via road for HDD installation. • Bedrock could potentially restrict HDD. • Landfall has a higher elevation gradient. • Offshore cable corridor close in proximity to MOD firing range, risks of clashes with military operations and UXO. • The offshore sections of this route would require crossing of the planned Greenlink. • May clash with Project Erebus cable corridor onshore. • The offshore route would pass close to the lease areas for Bombora and META.

Landfall Location	Advantages	Disadvantages
		• Part of the offshore export cable route would be located in the Pembrokeshire Marine / Sir Benfro Forol SAC. • Landfall is within Angle Peninsula Coast / Arfordir Penrhyn Angle SSSI, Pembrokeshire Marine / Sir Benfro Forol SAC and RIGS. • Landfall would be near Scheduled monument - West Pickard Camp.
Gravel Bay	• Avoids crossing Greenlink onshore. • Minimal disruption to shipping lanes. • Minimal Bedrock restricting HDD.	• Poor accessibility via road for HDD installation. • Bedrock could potentially restrict HDD. • Landfall has a higher elevation gradient. • Offshore cable corridor close in proximity to MOD firing range, risks of clashes with military operations and UXO. • The offshore sections of this route would require crossing of the planned Greenlink. • The offshore route would pass close to the lease areas for Bombora and META. • Part of the offshore export cable route would be located in the Pembrokeshire Marine SAC. • Landfall would be located in Pembrokeshire Marine / Sir Benfro Forol SAC, Broomhill Burrows SSSI, Castlemartin SPA and GCR. • Also near Scheduled monument - Gravel Bay anti-aircraft battery.
Freshwater West	• Shorter onshore cable corridor. • Potentially avoids crossing Greenlink onshore into the north of planning corridor. • Minimal disruption to shipping lanes. • Minimal Bedrock restricting HDD. • Landfall has a lower elevation gradient. • Good accessibility via road for HDD Installation. • Greenlink has already achieved government and MOD approval for this area and the Greenlink HDD design and installation methods can be copied.	• Offshore cable corridor close in proximity to MOD firing range, risks of clashes with military operations and UXO. • The offshore sections of this route would potentially require crossing of the planned Greenlink. • The offshore route would pass close to the lease areas for Bombora and META. • Part of the offshore export cable route would be located in the Pembrokeshire Marine / Sir Benfro Forol SAC. • Landfall would be located in Pembrokeshire Marine / Sir Benfro Forol SAC, Broomhill Burrows SSSI, Castlemartin SPA and GCR.

Landfall Location	Advantages	Disadvantages
		• Also near scheduled monument – Devil's quoit Burial Chamber and Listed Building – War Memorial.

Appendix B. HDD Feasibility

39. The feasibility of HDD has been investigated for the West Angle Bay and Freshwater West landfall locations, shown in **Figure 3C-5**. No HDD contractor was consulted as part of this assessment.

40. As this is quite high-level, several assumptions have been made for the landfall HDD design, as follows:

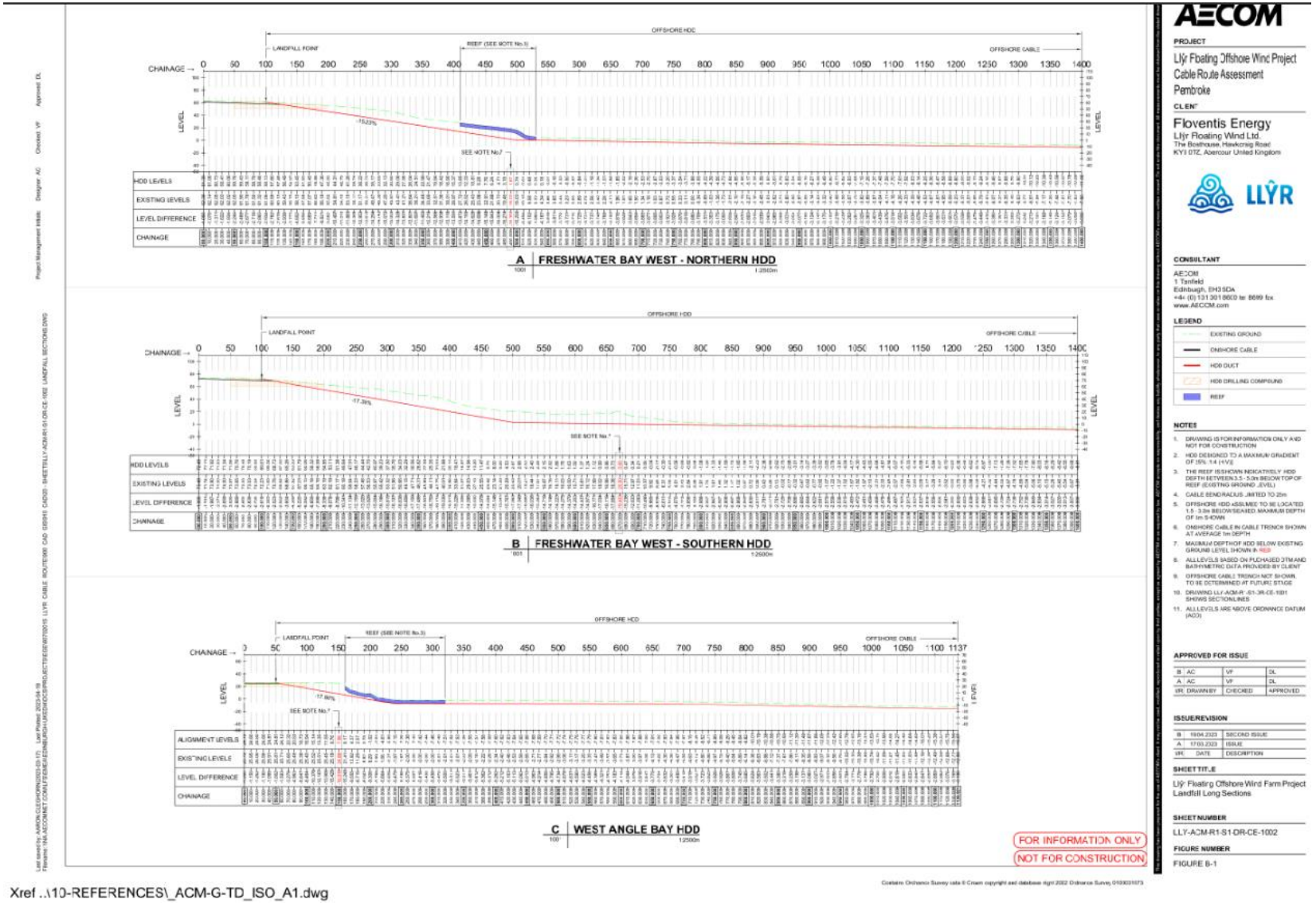
- Maximum gradient of 25% (1:4 / 14.04°) has been allowed;
- HDD depth is between 3.5 and 5.0 metres below the Annex I reef habitat to mitigate fracturing and vibration effects *[The geology cross-section was not reviewed as part of this study; ground investigations are required to understand the actual depths]*;
- Cable bend radius is limited to 25 metres minimum *[This is a general assumption applied to all high level HDD feasibility designs. Based on the cable parameters in Appendix C, it is assumed that the actual cable bend radius could be 2.3 metres minimum during laying and 1.4 metres minimum at terminations. Subject to confirmation of cable size and core material]*;
- Offshore HDD assumed to be located 1.5 to 3.0 metres below seabed *[The setback of the HDD onshore start point was determined by the required gradient to achieve a subsea exit point in the region of 1.5 metres, while maintaining a gradual gradient change from HDD entry to exit. Total HDD length was estimated at 1.2 kilometres, the same as Greenlink];*
- No electrical calculations have been allowed, note the maximum depths of each HDD below ground level in the following cross section; and
- All levels based on purchased DTM data and bathymetric data provided by the client.

41. The HDD feasibility has also been investigated from the north and south landfall locations at Freshwater West.

42. The following assumptions were made for the onshore HDD design:

- Maximum gradient of 25% (1:4 / 14.04°) has been allowed;
- Cable bend radius is limited to 25 metres minimum;
- Onshore cable trench shown at average 1 metre depth, with a 1 metre vertical clearance adhered to for drilling under public roads;
- No electrical calculations have been allowed; and
- All levels based on purchased DTM data.

43. The crossing of the valley to the north of Neath Farm has also been investigated. This indicates that OCT may be feasible in terms of engineering, however, this does not consider the substantial tree line that would need to be crossed. An HDD/ trenchless method would be preferred to minimise the environmental impact that would be caused by the removal of trees.



Xref ..\10-REFERENCES_ACM-G-TD_ISO_A1.dwg

Figure 3C-5. Landfall long sections (previously Figure B-1)

Appendix C. Cable Parameters

44. The offshore wind turbine generators are connected with various 66 kV submarine cables, with the parameters provided in **Table 3C-5** for offshore.

Table 3C-5. Offshore cable parameters

Parameter	Unit	Quantity
Cross section	mm^2	1000
Number of cores	-	Three
Conductor type	-	Al
Nominal voltage	kV	66
Circuit length – Llŷr 1	kilometres	48.00
Positive sequence resistance	Ω / kilometres	0.04
Positive sequence reactance	Ω / kilometres	0.08
Zero sequence resistance	Ω / kilometres	0.25
Zero sequence reactance	Ω / kilometres	0.36