5 PROJECT DESCRIPTION

5.1 Introduction

5.1 This section of the Environmental Statement (ES) details the Project and describes the following:

- Project timescale;
- Offshore and onshore infrastructure;
- Installation techniques;
- Operations and maintenance; and
- Decommissioning;

5.2 MeyGen proposes taking a Rochdale Envelope approach during the Environmental Impact Assessment (EIA) (see Sections 2 and 8) to address elements of uncertainty associated with the ongoing design and refinement of tidal technology and the overall design of the Project. The project description provided in this section discusses the options and a series of maximum extents or magnitudes for key aspects of the proposed Project, for which the significance of environmental effects have been assessed during the EIA.

5.3 At the start of each ES section the maximum project extents relevant to the specific assessment are defined. Potential variances in the impacts predicated based on the different design options have been summarised qualitatively following the main impact assessment.

5.4 There are clear difficulties in undertaking an accurate EIA if the parameters of the envelope are too flexible / too broad, however following in-depth consideration of the potential variances in environmental impact based on current design uncertainties, MeyGen are confident the project design presented here has enabled a robust and accurate EIA.

5.5 The Project will consist of a maximum of 86 fully submerged tidal turbines, with a maximum aggregate installed capacity of 86MW. Associated with the turbine array will be offshore and onshore infrastructure including subsea cables, landfall cables, a Power Conversion Centre (PCC) and cable connection to the national grid. The overall footprint of the Project is presented in Figure 5.2.

5.6 The Project is split into three distinct generating stations, each with turbines, Power Conversion Unit Building (PCUB) and export cable to the grid connection.

5.2 Project Timescale

5.7 The Project will be installed over a number of years, as shown in Table 5.1. There will be different schedules for offshore and onshore aspects of the Project; these are discussed in more detail in Section 5.5.6 and 5.6.4 respectively.

Year	Phase installed capacity (MW)	Total installed capacity (MW)	Maximum turbine number
Year 1	2 to 10MW	2 to 10MW	10
Year 2	10 to 20MW (dependant on year 1 installation)	12 to 30MW	20
Year 3	56 to 74MW	86MW	86

Table 5.1: Phased development of the Project

5.8 The build out of the Project in terms of overall capacity and number of turbines is dependent on the rated capacity of the turbine. During the first two years of the Project, there will be a maximum of 20 turbines installed with a maximum of 30MW capacity. In Year 3 the remaining project capacity will be installed.

5.3 Offshore Infrastructure

5.3.1 Site description

5.9 The Project is located in the Inner Sound, a body of water in the Pentland Firth between the north coast of Scotland and the island of Stroma. The Inner Sound is approximately 3km wide at the widest point between Mell Head on Stroma and Gills Bay on the Scottish mainland. The deepest part of the Sound is 48.6m and the Project is situated in the centre of the main channel where the useable water depths range from 31.5 to 38m at Lowest Astronomical Tide (LAT). The turbine deployment area is 1.1km^2 in the centre of the Agreement for Lease (AfL) area (Figure 1.3Figure 1.). A cable corridor to shore has been identified (Figure 5.2); of this area an estimated maximum area of 1.3km^2 is required.

5.3.2 Turbine specification

5.10 The Project proposes a maximum of 86 tidal turbines in the Inner Sound. However, the actual number of turbines installed will depend on the rated capacity of the selected tidal technology. Each turbine is fully submerged, seabed mounted and will consist of a rotor and a nacelle (which houses mechanical and electrical equipment). Each turbine will be supported by a Turbine Support Structure (TSS).

5.11 The devices will be single rotor, horizontal axis turbines with a rotor diameter of between 16 and 20m.

5.12 The turbines will always have a minimum clearance from the blade tip to sea surface at LAT of 8m. Figure 5.1 provides an indicative overview of turbine dimensions and position in the water column, while Table 5.2 gives greater detail on the turbine specification.

5.13 The turbines will convert kinetic energy from the flow of water through the Inner Sound into electrical energy via the turbine blades turning the generator. The turbines are able to extract energy from the easterly flood and westerly ebb tide in the Inner Sound by either rotating the turbine into the on-coming flow, or by using 180^o pitching or bi-directional blades which can generate from flows in opposite directions. The turbines will operate for an estimated 73% of the time.

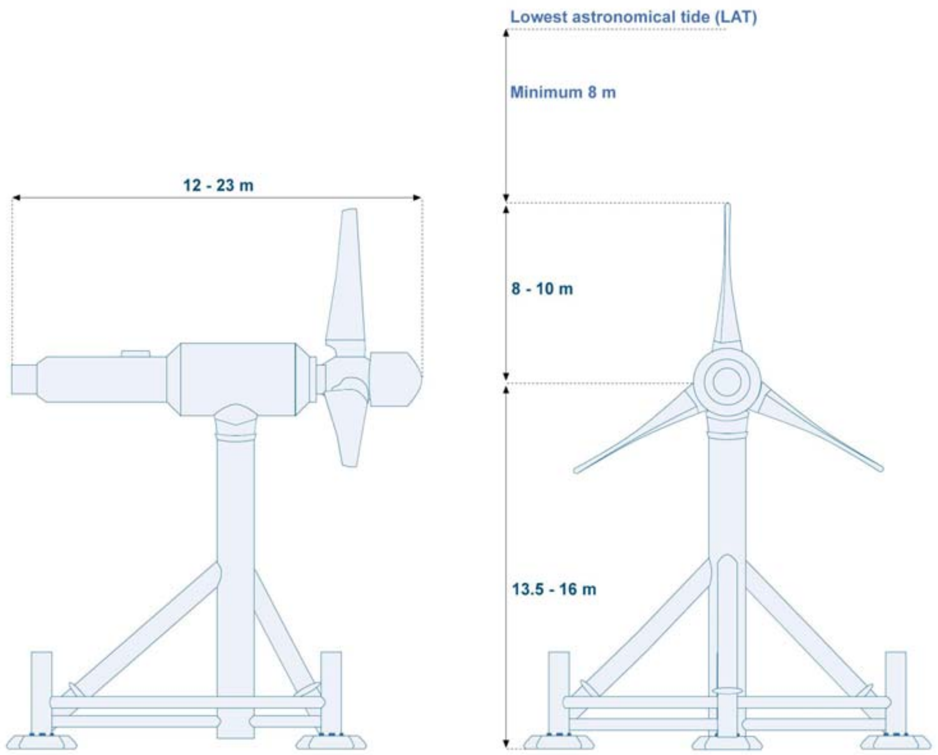

Figure 5.1: Schematic of turbine dimensions

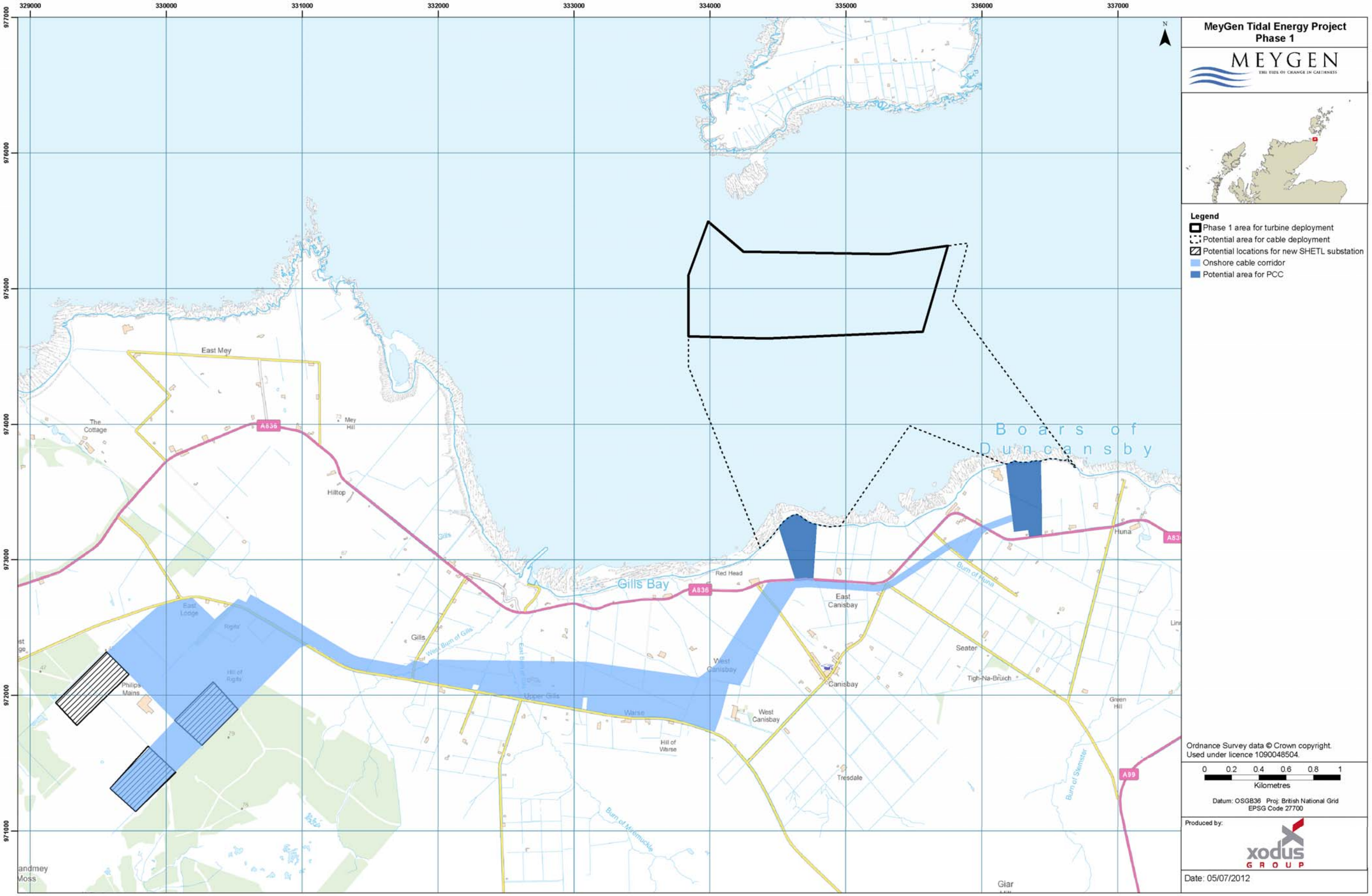

Figure 5.2: The Project area

Turbine Component	Specification
Rated Power	1.0 – 2.4MW[4]
Number of rotors	1
Number of blades per rotor	2 or 3
Rotor diameter	16 to 20m
Maximum blade swept area	201 to 314m^2
Height of structure above seabed (to centre of nacelle)	13.5 – 16m
Minimum clearance from blade tip to seabed	4.5m
Minimum clearance from blade tip to sea surface at LAT	8m
Length of turbine nacelle	12 – 23m
Design options for generation in ebb and flood tides	Mechanical/electrical system to rotate the nacelle into the principal flow direction Thruster in the nacelle tail to rotate the turbine into principal flow direction Bidirectional blades that can generate from flows in opposite directions Mechanical/electrical system to pitch blades 180^o to principle flow direction
Cut in flow speed	approximately 1.0m/s
Cut out flow speed	3.4 – 5.0m/s
Operating rotational speed	8-20rpm (3 bladed) 12-20rpm (2 bladed)
Options for power conditioning equipment	All power conditioning is onshore at the PCC Power conditioning within turbine nacelle and onshore transformer at the PCC
Options for transport of turbine to site location	On deck of dynamic positioning (DP) vessel, or Under tow by an installation vessel
Options for turbine installation	Installation vessel lowers nacelle to foundation, or Nacelle is pulled down onto foundation by a cable

Table 5.2: Specifications of tidal turbines

5.3.3 Turbine systems

Heating and cooling systems

5.14 Some equipment in the turbines, including generators, gearboxes, brakes and bearings, will produce heat in operation which will be directly cooled by the surrounding seawater.

5.15 The power conditioning systems in the turbine nacelle may also require a cooling system, which will involve a liquid cooled closed loop system expelling heat to the external seawater environment via a heat exchanger.

Hydraulic systems

5.16 The turbines may include hydraulically controlled mechanical brake, rotate system and a system for pitching of the rotor blades. Subsea electrical enclosures and cables may be oil filled and a grease pump will be required to lubricate the shaft seal. Only recognised marine standard fluids and substances will be used with due regard to the environment.

Electrical systems

5.17 The turbines will produce variable AC power from the generator for transmission to the onshore site at up to 6.6kV.

5.3.4 Turbine protection systems

Antifouling

5.18 The prevention of marine growth is an important consideration, even in a fast flow environment. Different approaches, including antifouling paints and copper coatings, are being explored on full scale prototype devices. These tests will inform the need for and type of antifouling system to be deployed for the Project.

Corrosion

5.19 Appropriate corrosion protection for the turbines is paramount in the harsh seawater environment. A combination of specialist paints and cathodic protection will be used as in other marine applications.

5.3.5 Lighting and marking

5.20 The turbines will be completely submerged during operation and therefore it is not possible to physically mark them individually. Consultation with the Northern Lighthouse Board (NLB) has indicated that they do not expect there to be any lighting requirements (buoys or onshore leading lights). Lighting and demarcation have therefore not been considered as part of EIA. However, the regulatory authorities will make their final recommendation for all charting, lighting or demarcation requirements following the submission of the consent application and the Navigational Risk Assessment (NRA).

5.3.6 Turbine Support Structure

5.21 Each turbine will be supported on the seabed via a TSS. There is as yet no single established TSS solution for tidal turbines in this kind of environment, but deployments at the European Marine Energy Centre (EMEC) have demonstrated the viability of monopile, pin pile and Gravity Based Structure (GBS) solutions. All three of these TSS options are presently under consideration for the Project.

5.22 The overall proposed installation methodology is designed for the efficient placement of multiple units within an acceptable time period. As far as practicable, the design must allow for the placement, maintenance and eventual removal of the turbine and support structure while giving due regard to the operational difficulties inherent in the offshore installation environment of the Inner Sound.

TSS Option 1: Gravity Based Structure (tripod)

5.23 A GBS (Figure 5.3) has been successfully installed at EMEC, consisting of a steel tripod with large steel weights on each of the three legs. The GBS will have a maximum footprint of 30m by 20m, and consist of approximately 1,350 tonnes of steel. Each component will weigh no more than 450 tonnes. The installation of the GBS requires the use of a Dynamic Positioning (DP) vessel.

[4] Phase 1 has an aggregate installed capacity of 86MW. Individual turbines can be between 1 and 2.4MW rated power.

Figure 5.3: Gravity Base Substructure

5.3.7 TSS Option 2: Drilled pin pile tripod

5.24 A drilled pin pile tripod (Figure 5.4) has been successfully installed at EMEC. The main structure is a braced steel tripod, secured to the seabed with three small diameter pin piles. Installation is possible from a DP vessel using a subsea drilling technique. A socket is drilled into the rock, into which the pile is inserted and fixed using high strength grout.

Figure 5.4: Pin-piled TSS

5.3.8 TSS Option 3: Monopile

5.25 The drilled monopile (Figure 5.5) has been successfully installed at EMEC. The main structure is a single pile. A larger diameter socket (compared to pin pile) is drilled into the rock using a temporary subsea frame, into which the pile is inserted and fixed using high strength grout. Installation is possible from a DP vessel using a subsea drilling technique.

Figure 5.5: Monopile TSS

5.3.9 Turbine layout

5.26 The hydrodynamic and computational fluid dynamics (CFD) flow modelling completed for the Inner Sound has enabled MeyGen to assess array configurations through the Project area in order to optimise the energy yield. The final array layout has not been finalised and will be determined through analysis of:

- Maximum and average current speeds;
- Current direction;
- Turbulence;
- Wave action;
- Bathymetry;
- Seabed topography;
- Turbine wake interaction;
- Installation and maintenance vessel operating requirements;
- Export cable layout;
- Environmental issues; and
- Navigational safety issues.

5.27 Although the final array configuration has not yet been confirmed, it is most likely the turbines will be placed in rows aligned perpendicular to the dominant flow direction. Array optimisation will continue as new data is collected on the site.

5.28 An indicative turbine layout has been produced for the purposes of this assessment based on an 86 turbine array with the minimum separation distance of 45m cross-flow and 160m down-flow spacing (Figure 5.6).

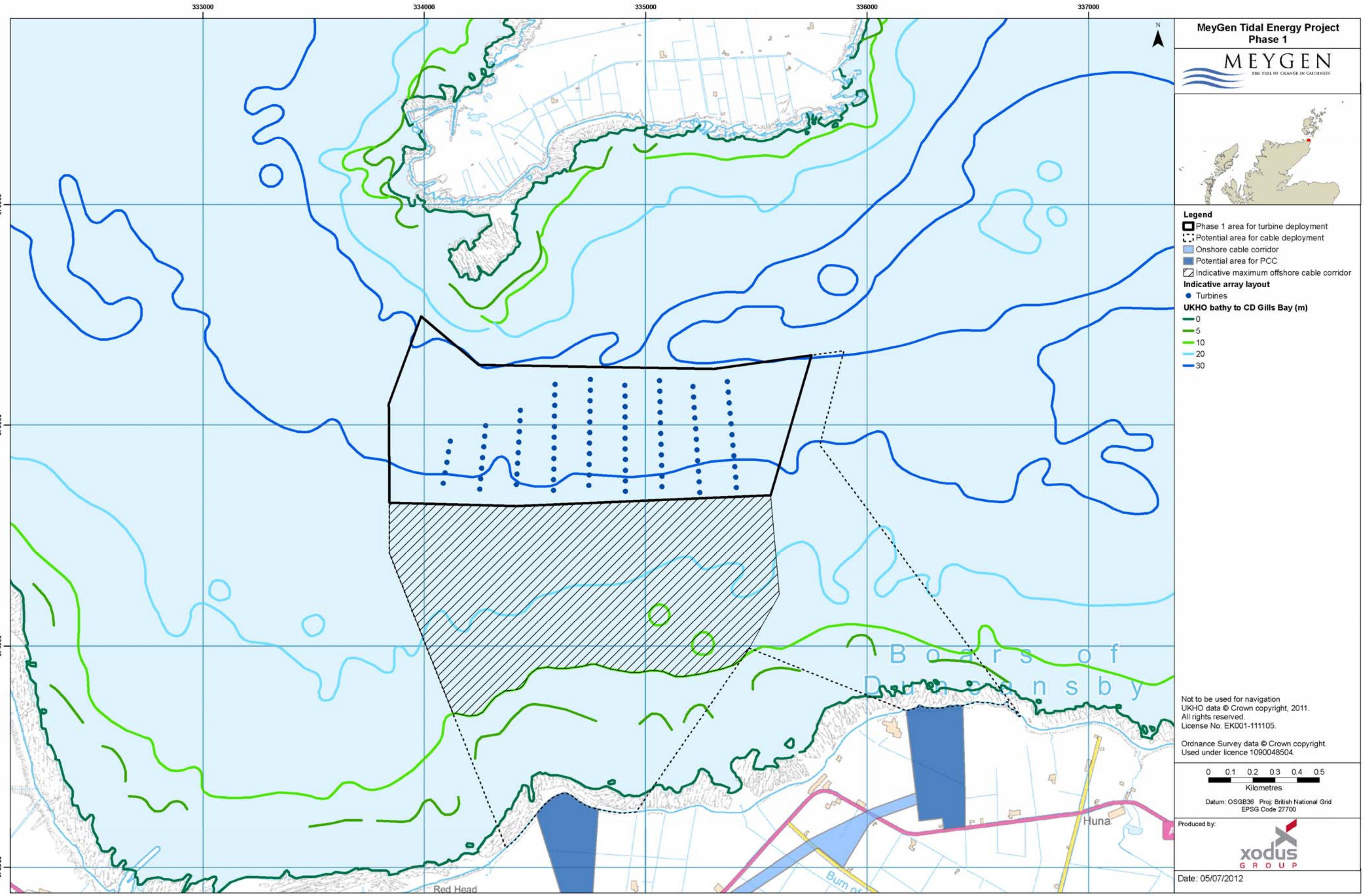

Figure 5.6: Indicative tidal turbine layout and offshore cable deployment area (for EIA assessment purposes)

5.3.10 Export cables

5.29 Each turbine will require a dedicated export cable to shore, with an external diameter of up to 120mm, including double armour. It is intended that these cables will be laid in groups of three to reduce marine operations and provide some mutual protection.

5.30 An alternative would be to use specially manufactured cables with multiple circuits that allow power from more than one turbine to be exported in a single cable. A three circuit cable and a five circuit cable will have a diameter of approximately 130mm and 250mm respectively.

5.31 Each export cable will have a wet mate connector on the offshore end. Either the wet mate will be connected to the TSS directly or much shorter jumper cables, of approximately 50m, will then run between the turbine base and the offshore cable wet mate connector (Figure 5.7). The shore cables will be landed using Horizontal Directionally Drilled (HDD) bores (further details in Section 5.6). Extreme wave and tidal conditions in the Inner Sound mean that the export cable is likely to experience significant hydrodynamic forces, but these forces can be reduced by running the cable in natural crevices and so it is planned to make use of the existing bathymetry as far as possible. Optimisation of the length of the HDD bores between the shore and turbine deployment area can also ensure that the cables receive protection where the natural bathymetry cannot provide shelter.

5.32 The closest distance to shore at which the HDD bores will emerge at the seabed is 700m. The maximum distance from shore is 2,000m. The length of cable laid on the seabed is between 100m and 1,300m depending on the length of the HDD bore. An indicative representation of the offshore cable area and layout is shown in Figure 5.6 and Figure 5.7.

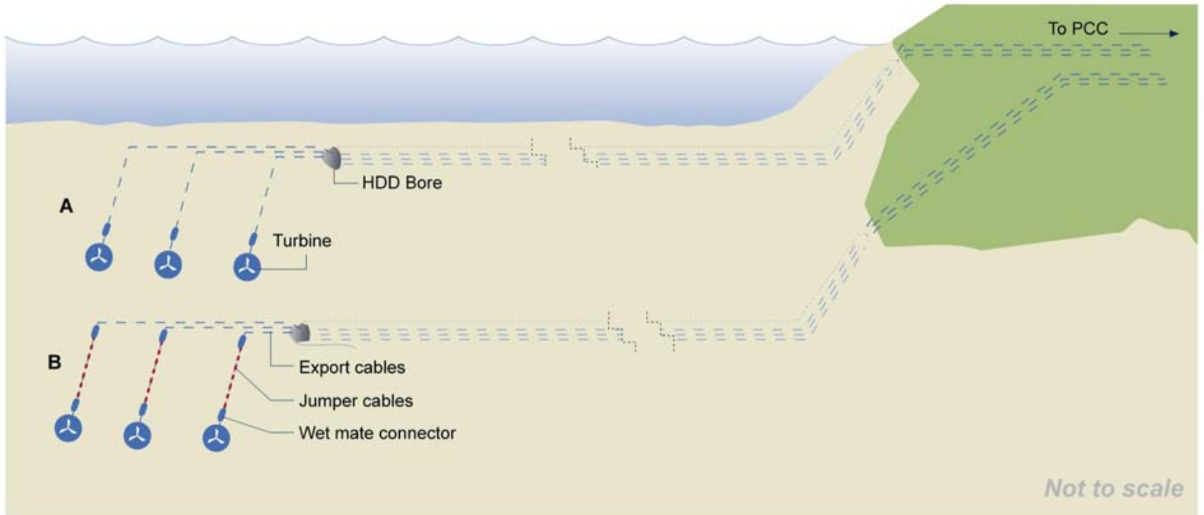

Figure 5.7: Indicative offshore cable layout

5.4 Onshore Infrastructure

5.4.1 Site description

5.33 MeyGen require an onshore site for:

- A PCC which comprises 3 PCUBs and a control building;
- Temporary HDD activities and cable landfall; and
- Cable routes from the PCC to the grid connection location.

5.34 At the time of writing, MeyGen has identified two options for the combined PCC and HDD site. This document covers both options. MeyGen has identified an underground cable route to export electricity generated from the PCC to the grid connection point from either of the two sites. The locations for the onshore infrastructure are illustrated in Figure 5.2.

5.35 Figure 5.2 also shows the potential locations for the SHETL substation. As SHETL are responsible for the consenting of the substation it does not form part of the applications submitted by MeyGen for this Project.

Ness of Quoys

5.36 The site is located roughly 1km from Canisbay village on the mainland coast 2km east of Gills Bay. The land is currently used for mixed agriculture.

Ness of Huna

5.37 The site is located on the mainland coast next to the hamlet of Huna, roughly 1.5km west of John o' Groats. The land is currently used for mixed agriculture.

5.4.2 Horizontal Directional Drilling site

5.38 The cables from the tidal turbines will be brought onshore via HDD bores. From the landing point the cables must be linked to the power conditioning equipment in the PCUB.

5.39 In the worst case scenario in which every turbine requires a single cable and a dedicated bore there will be 86 HDD bores required for the Project. The most likely scenario is that one bore will be sufficient for 3 cables resulting in 29 bores. The HDD bores will need to be spaced 5m apart to ensure integrity of the bores.

5.40 It is planned that the cables will be laid directly from the HDD bore to the PCUB. If the cables cannot be laid directly to the PCUB it will be necessary to construct a cable pit at the HDD site where the offshore cables will be spliced with onshore cables which will then go to the PCUB. The cable pit will be a buried concrete box with a locked manhole cover on the surface for access. The rest of the HDD site will be reinstated following construction.

5.41 To minimise de-rating (i.e. limit electrical and thermal stress) it may be necessary to space cable trenches to the PCUB in a corridor of up to 135m wide.

5.42 The HDD works will require temporary construction facilities and access roads off the permanent PCC access road. The topsoil on site will be stripped back and stored to prepare the temporary works area. The site will be reinstated once construction is complete. An indicative HDD site layout for the Ness of Quoys and Ness of Huna are shown in Figure 5.13 and Figure 5.14 respectively. The exact location of HDD pits will be determined following detailed design of the horizontal and vertical profile of the bores.

5.4.3 Power Conversion Centre

5.43 The PCC will contain;

- 3 PCUBs, each housing;
- power conversion equipment;
- switchgear for grid connection and offshore cable terminations;
- indoor transformers for connecting to the grid at 33kV; and
- A control building incorporating facilities for manual control and monitoring of the turbine array and metering equipment for the distribution network operator (DNO).

5.44 The PCC needs to be located as close to the HDD site as possible based on the following technical requirements:

- Offshore export cables will be rated at a maximum of 6.6kV. At these relatively low voltages, transmission loss between turbines and the PCC will be significant. For technical reasons the power cannot be transmitted at higher voltage subsea;

- Each turbine requires a single dedicated export cable. The multiple subsea cable approach will require a very wide cable corridor onshore, therefore it is necessary to increase the voltage and reduce the number of cables before exporting electricity to the grid connection;

- Each cable is directly installed from subsea to the PCUB with no transition pit/cable vault. This is proposed as it removes a spliced connection in the system and so increases reliability; and

- Export to grid is at 33kV and losses are negligible at this voltage. It is therefore not critical to locate the PCC near to the potential grid connection.

5.45 Each PCUB will be up to 30m wide, 45m long and a maximum of 13m high (Figure 5.8 and Figure 5.9).

5.46 The PCUBs are required to provide a number of functions including;

- Securely terminate each subsea turbine power cable;

- Provide all weather protection of the equipment inside;

- Permit protected access for maintenance and repair of all equipment;

- Provide cooling to the internal environment and limit the noise from operational equipment; and

- Provide security to the high voltage equipment.

5.47 The PCUBs have been designed following consultation with The Highland Council (THC) Planning and Development and Historic Environments Team and Scottish Natural Heritage (SNH).

5.48 The design evolution of the PCC started with the concept of a traditional barn structure commonly found in the region and a combination of standard modular building structures to provide the control room. The design workshop (6th September 2011), held on site involving MeyGen, THC and SNH was used to discuss the design of all onshore works.

5.49 The desire expressed by THC was that the buildings should be designed in the spirit of the North Highland Onshore Visioning work[5]. THC recommended that traditional barn structure would not be appropriate and the buildings needed to both celebrate the fact they are part of the new marine power industry as well as be sympathetic to their surroundings. MeyGen was prepared to support the design approach as long as it could be realised at a small additional cost. It should be noted that it is not the intention of MeyGen to attract uninvited visitors to the PCC as there are to be no facilities for visitors. All visitor information is planned to be located at John o' Groats.

5.50 The design brief was revised to specify a set of functional modern industrial buildings that compiled with all the Project requirements but also satisfied the statutory historic environment interests (i.e. scheduled monuments and their setting, category A listed buildings and their setting and Inventory designed landscapes). In addition, work was carried out to assess the indications of past anthropogenic activity on the two sites identified, to ensure building design and site layout was planned to avoid all potential archaeological sites.

5.51 The landowner's and local resident's views were also taken into account in the design and layout of the sites with particular respect to layout, visual impact, noise and access requirements. The result of all the consultations and considerations was an iterative design process resulted in a revised design for the PCUB which is essentially an economic steel enclosure, required to satisfy the functional requirements, but shaped to blend with the exposed landscape and softened by being partially clad in natural materials. The control building is a more traditional structure also clad in natural materials.

5.52 Features of the PCUB design includes:

- Limiting PCUB height and lowering the buildings by up to 1.5m in taking away superficial soil layers;

- A curved roof to reflect the surrounding landscape;

- Use of natural finishes as part of the cladding; and

- A site layout and PCUB orientation that minimises the PCC scale from key visual receptors.

5.53 For the initial years of Phase 1 i.e. years 1 and 2 (Table 5.1) only one PCUB and the control building will be required. The remaining 2 PCUB units will be required and constructed in year 3 of the Project.

5.54 The control building (Figure 5.10) is required to provide a temporary operations room during the initial commissioning of all onshore equipment and turbines. After commissioning it will provide an ongoing operations room facility for up to 4 people with associated facilities (e.g. meeting room and messing facilities). It is intended that ultimately the turbine array will be controlled remotely, so the PCC will only be visited when required.

5.55 In addition to the buildings themselves the site will require a permanent access road with a wide roadside entrance and cattle grid; a car parking for up to 12 cars; hard standing and turning area sufficient for two articulated lorries carrying a 40ft container; CCTV and limited external lighting. The area will have the appropriate drainage system and stock proof fencing around the perimeter.

5.56 The PCC will not be a permanently lit operational site, as it is intended to be an unmanned facility.

5.57 Site designs for both the Ness of Quoys and Ness of Huna are shown in Figure 5.11 and Figure 5.12 respectively.

5.4.4 Grid connection

5.58 The low voltage distribution network in the local area is managed by the DNO, Scottish Hydro Electric Power Distribution plc. (SHEPD). The current distribution network is made up of an 11kV line coming into Gills Bay.

5.59 MeyGen has secured a 15MW grid connection with SHEPD. Provision of this grid connection at the PCC site will be made by SHEPD via a single underground cable (shown as the pink cable route in Figure 5.11 and Figure 5.12) and as such is outwith the scope of this assessment.

5.60 The high voltage transmission network in the area is managed by Scottish Hydro Electric Transmission Ltd. (SHETL). As part of the drive to deliver renewable energy projects throughout Scotland, SHETL has produced a roadmap of transmission extensions and upgrades required to meet demand for project connections.

5.61 As part of the upgrades, SHETL has proposed an extension of the 132kV transmission network to Gills Bay. The extension will include a 132kV/33kV substation at one of the three option areas shown in Figure 5.2.

5.62 MeyGen has agreed for a connection to the transmission network that covers a large proportion of the remainder of the Project (beyond the 15MW already secured) capacity. The connection will require a maximum of four 33kV underground cables between the PCC site and the proposed SHETL 132kV/33KV substation (shown as the green cable route in Figure 5.11 and Figure 5.12).

5.63 Cables between the PCC and grid connection will be trenched and buried, with a required spacing of 3m to ensure thermal independence. If all four cables are laid in a flat formation, the worst case onshore cable

[5] http://www.highland.gov.uk/NR/rdonlyres/637F7B9A-0444-45F7-85A5-5860630255F5/0/OnshoreVisioningReportFinal160511c.pdf

corridor would be 20m wide. MeyGen does not propose to install any overhead lines from the PCC as part of the Project.

5.64 The proposed underground cable corridor route and SHETL substation is shown in Figure 5.2. As the exact location of the SHETL substation has yet to be confirmed it is not yet possible to finalise the cable route in this area.

5.65 **Following the completion of the EIA, landowner consultation has identified potential issues with small areas of the proposed cable route. It has therefore been necessary to include areas outside that surveyed for the onshore impact assessments. The area is 0.50km^2 and is shown in Figure 2.1. Unfortunately this issue was not identified at the time of ES compilation and therefore is not addresses in this document. Work to survey and assessment of any changes required to the original impact assessment as a result of the altered cable route is ongoing and will be provided in an ES addendum.**

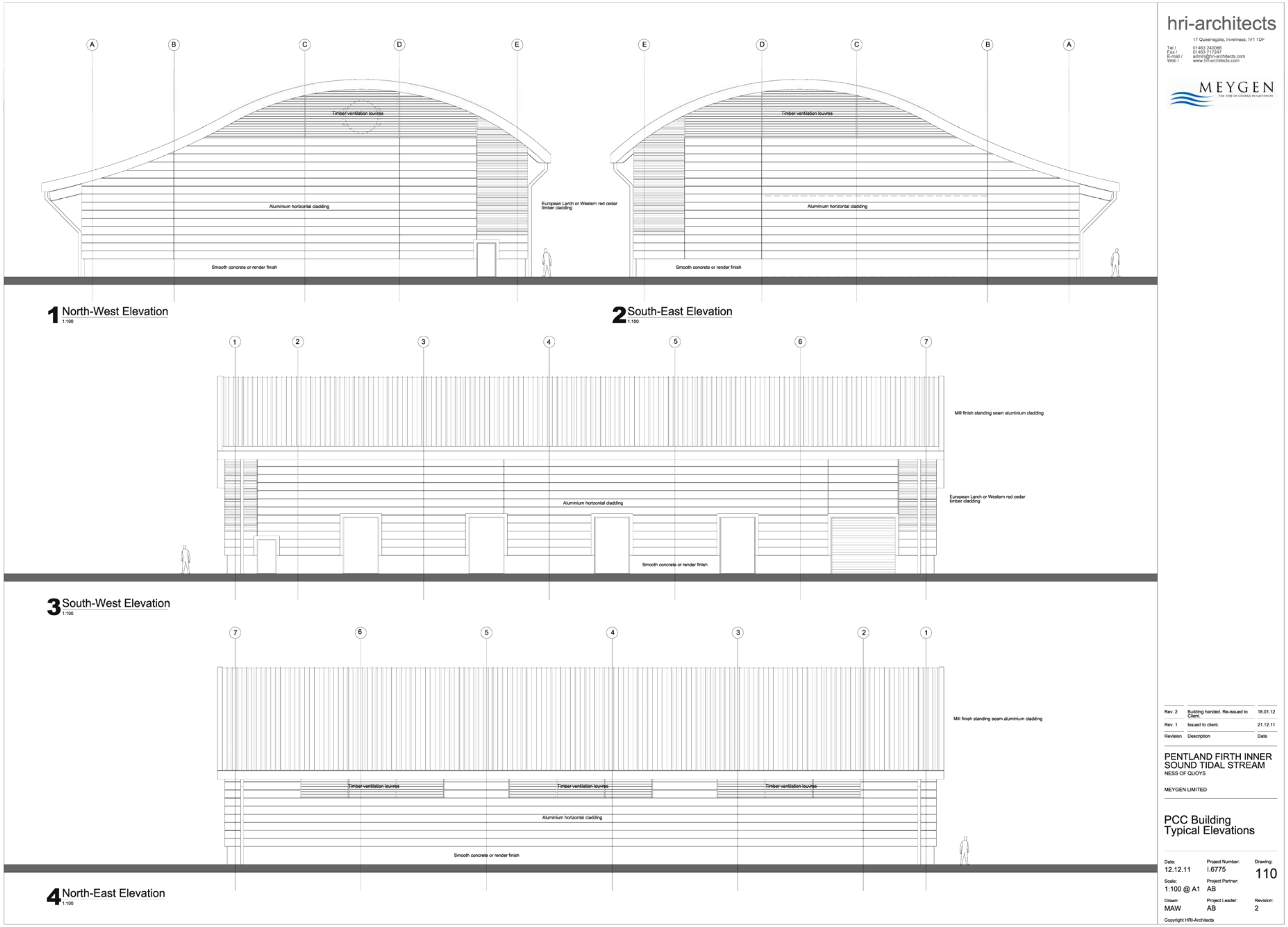

Figure 5.8: PCUB design

Figure 5.9: PCUB Design

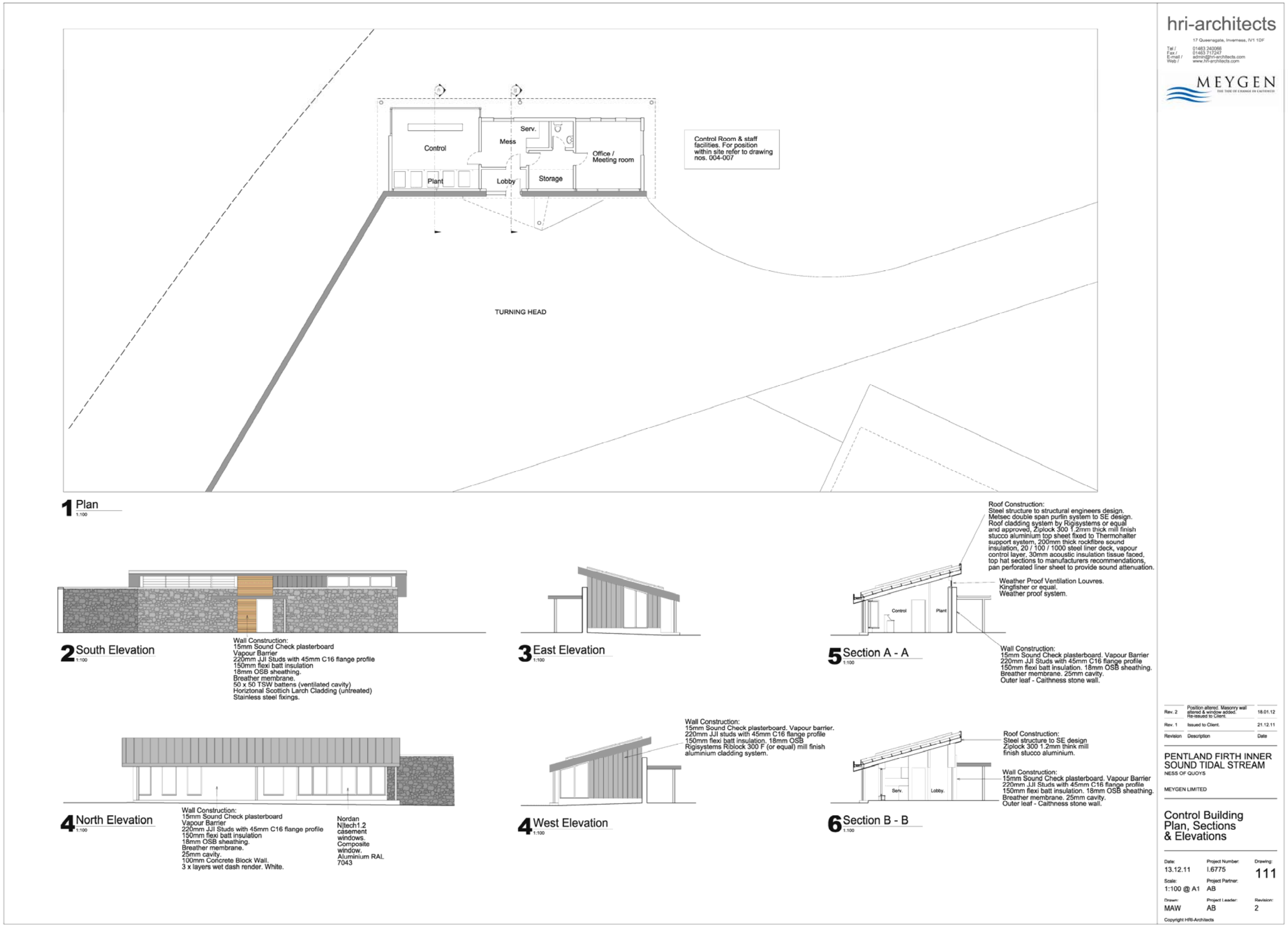

Figure 5.10: Control building design

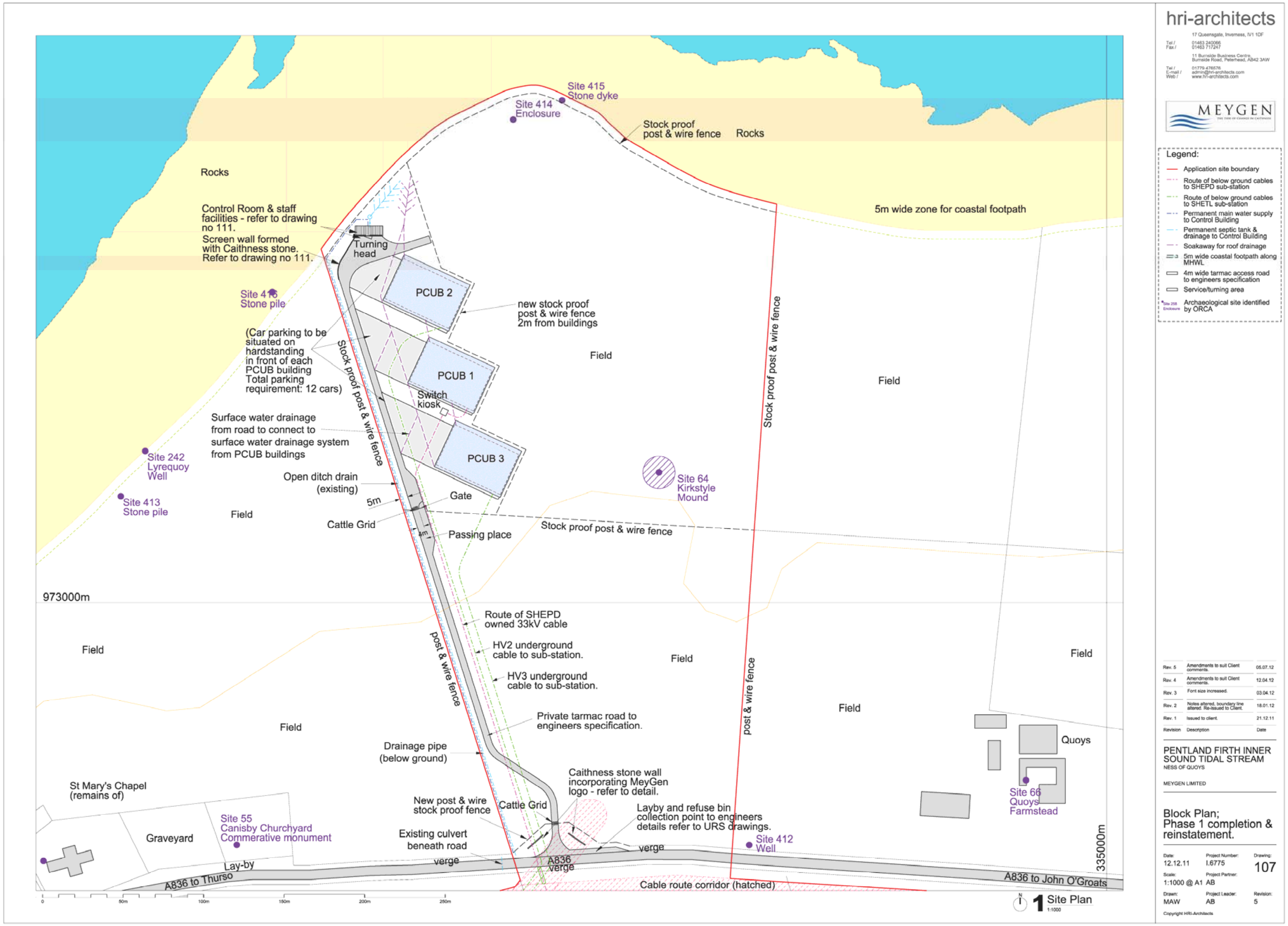

Figure 5.11: Ness of Quoys site layout

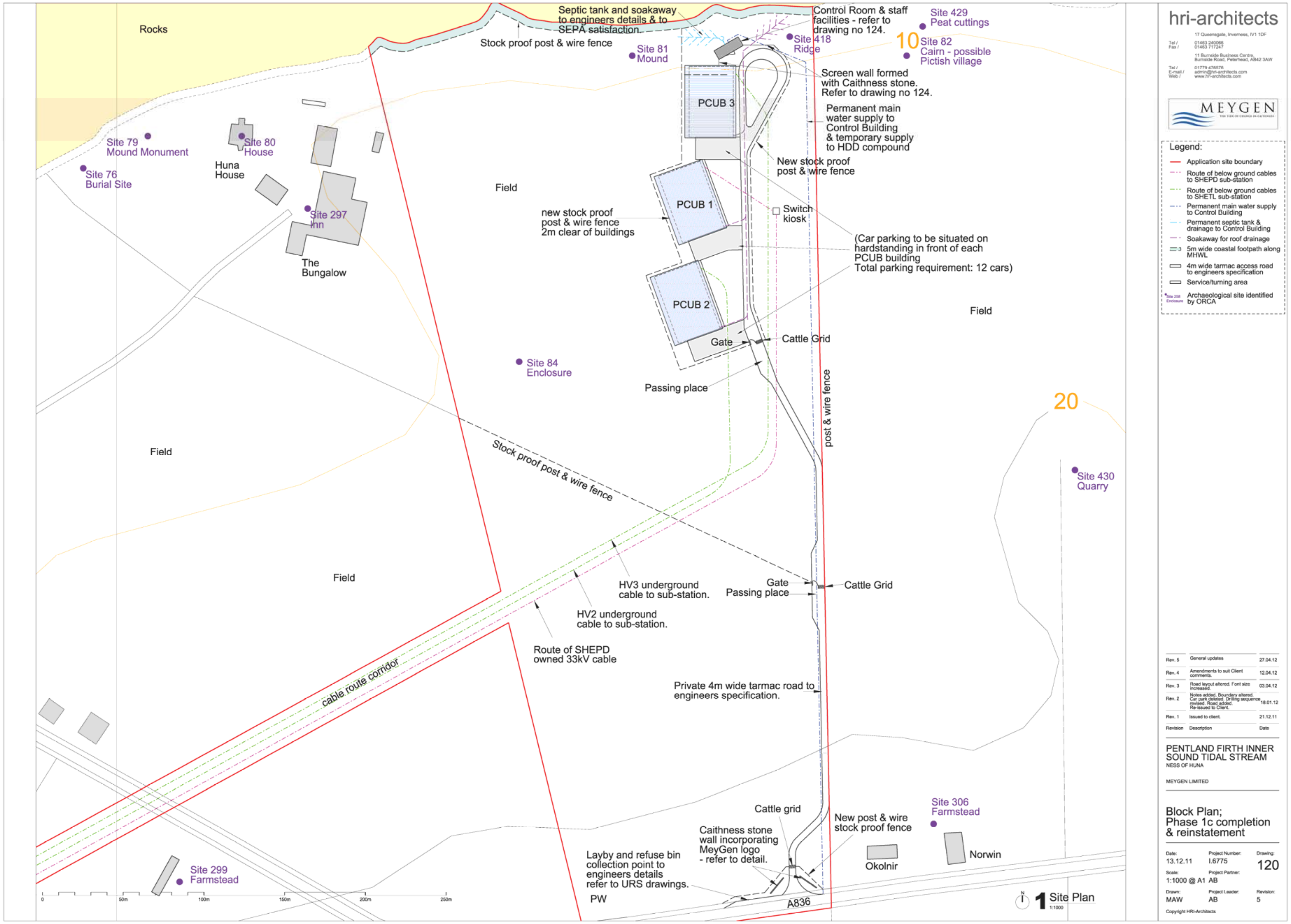

Figure 5.12: Ness of Huna site layout

5.5 Offshore Installation

5.66 The Inner Sound is an area of high tidal flow and impermeable seabed conditions presenting a challenge for offshore operations. MeyGen plans to use techniques and equipment trialled at EMEC to mitigate installation risks associated with in this environment.

5.5.1 Turbine Support Structure installation

5.67 The three types of TSS will have different installation approaches:

- The GBS which requires heavy lifting capacity and no seabed preparation;
- Pin pile tripod which requires specialist drilling equipment and multi-stage operations to grout the piles into the sockets; and,
- Monopile, which again requires specialist drilling equipment.

Gravity base

5.68 The gravity based option will need a DP vessel. No seabed preparation is required, and nor will there be a need for scour protection as the seabed consists of exposed bedrock. The positioning of the TSS will carried out with the assistance of Remotely Operated Vehicle (ROV) from the DP vessel.

5.69 This type of TSS is currently installed during slack water on a neap tide, but work is progressing to extend the operation window of installation to be less dependent on environmental conditions.

5.70 Gravity based installation operations will take approximately one to two days per TSS (assuming 24 hour working on site).

Pin pile

5.71 The pin pile drilling equipment will be deployed from a DP vessel.

5.72 Drilling operations will result in a direct release of drill spoil to the marine environment. Dimensions of the pin pile are approximately 900mm diameter, and between 5 and 8m length, and so up to 5m^3 of drill spoil could be released into the water column per socket, or 15m^3 per TSS.

5.73 There is no requirement for scour protection as seabed consists of exposed bedrock.

5.74 Pin pile operations will take approximately three to four days per TSS (assuming 24 hour working on site).

Monopile

5.75 The monopile drilling equipment will be deployed from a DP vessel.

5.76 Drilling operations will result in a direct release of drill spoil to the environment. Dimensions of the monopile are likely to be up to 3.5m diameter, and an estimated 15m length, up to 200m^3 of drill spoil could be released into the water column per socket.

5.77 There is no requirement for scour protection as seabed consists of exposed bedrock.

5.78 Monopile operations will take approximately two to three days per TSS (assuming 24 hour working on site).

5.5.2 Turbine installation

5.79 Depending on the turbine type the installation method will either use:

- A DP installation vessel that can safely hold station and work in up to 4 knots (2m/s) current speed. The DP vessel will have an Active Heave Compensated (AHC) system to lower the turbine through the water column and onto the TSS; or
- A towed system. The buoyant nacelle will be towed to site by a smaller DP vessel or tug and then attached to the TSS by a cable and will be winched down into position.

5.80 Installation of the turbines will take place over periods of slack tide.

5.5.3 Offshore cable installation

5.81 The installation of the export cables on the seabed will be conducted by either a modified DP construction vessel or a dedicated cable installation vessel.

5.82 In some areas it may be necessary to add additional weight to the cable during the installation process to provide on bottom stability. This additional weight is likely to be in the form of cast iron spilt pipes.

5.83 Depending on the length of the HDD bores, cables may need to be installed across an area of kelp forest. In this instance kelp would need to be cleared by diver from the seabed prior to cable installation.

5.84 An ROV may be required on the cable lay vessel to achieve sufficiently accurate laying of the cable, given the need to rely on seabed features to maintain cable stability. A vessel will also be required during cable landfall installation (cables pulled through the HDD bores, see below).

5.5.4 Marine installation operations

5.85 Marine installation works will be planned to take place during the spring, summer and autumn months when weather conditions are most favourable. To ensure that turbine installation time is maximised, operations are likely to be confined to periods when the tidal flows are lowest. To take advantage of the restricted tidal windows works will be undertaken at any time during the day or night.

5.5.5 Installation vessel requirements

5.86 The intended installation sequence is as follows:

1. A DP installation vessel will install the rows of TSS's.
2. A DP vessel or a cable laying vessel will install the export cables along the line between the rows of TSS's. The same vessel will either connect the export cables to the TSS or a smaller vessel with a Remotely Operated Vehicle (ROV) will then install the short lengths of jumper cable between the TSS and the export cables.
3. A DP vessel or tug will install the turbines onto the TSS's.

5.87 During year 1 and 2 of installation there will not be more than one large DP vessel on site at any one time. During year 3 there may be the requirement for two DP vessels to conduct TSS installation.

5.88 These vessels may require smaller vessels to be present for support services.

5.89 Table 5.3 provides details for the different vessel activities in the Project and the estimated number of operating days required (i.e. over 3 years). This takes into consideration the options for turbine and TSS deployments.

Activity	Vessel type	Maximum operating days
Laying cable bundles	DP cable laying vessel	260
Joining jumper cables to export cable	Lightweight vessel with ROV	100
Deploying gravity base, pin pile or monopile TSS and positioning turbines into support	DP construction vessel	345
Transporting turbines to site	DP vessel	170
Towing floating turbine to array site	Tug	20

Table 5.3: Vessel activities

5.5.6 Installation programme

5.90 The Project will be build out over a number of years as described in Table 5.1. The offshore installation will follow the same programme with activity on site taking place through spring, summer and autumn months when weather windows permit (Table 5.4).

Phase installed capacity (MW)	Total installed capacity (MW)	Offshore activity	Maximum no. of turbines installed	Year
2-10MW	2-10MW	Installation of 2-10 turbines and related TSS and cables	10	1
10-20MW	12-30MW	Installation of 4-18 turbines and related TSS and cables[6]	20	2
56-74MW	86MW	Installation of 23-74 turbines and related TSS and cables	86	3

Table 5.4: Offshore installation

5.6 Cable Landfall and Onshore Construction

5.6.1 Horizontal Directional Drilling

5.91 The offshore cables will be brought to shore via HDD bores, as previously described. Directional drilling is a steerable trenchless method of installing cables underground in a shallow arc along a prescribed bore path by using a surface launched drilling rig.

5.92 In the worst case scenario, in which every turbine requires a single cable and a dedicated cable bore, there would be 86 HDD bores required for the Project. However, the more likely scenario is that 3 cables sufficient for 3 turbines will pass through one bore. Construction of the HDD bores will be spread over the turbine installation programme. It is planned to terminate up to 3 separate HDD bores in a single shore pit in order to minimise the length of disturbed shoreline. Based on the above, there may be a requirement for between 10 and 29 HDD pits.

5.93 Directional drilling is carried out using a drilling fluid, typically bentonite, to lubricate the drilling process. All drill cuttings and associated drilling fluids are inert. Much of the equipment present on the site is to manage the drill fluid and cuttings which are returned to shore. Drill cuttings returned to shore will be reused, recycled or disposed of subject to consultation with Scottish Environment Protection Agency (SEPA).

5.94 Some drilling fluid/cuttings will be lost to the ocean at the offshore end of the bore during seabed breakthrough. It is estimated that the drill cuttings from the last 10m of the bore will be lost to sea.

5.95 No construction operations will be required in the intertidal zone.

5.96 Once started, drilling is a continuous process and 24 hour a day operation is required. Noise from the drilling rig and ancillary equipment will be kept below levels set under the conditions of consent for daytime and night-time activity. For safety reasons the HDD compound will be lit during the hours of darkness. The floodlights will be designed to minimise lighting spread.

5.97 A bunded fuel tank will be required for the HDD operation. This will be located away from and PCUB that has been built and any water courses on site to reduce fire and pollution risk. Appropriate procedures will be undertaken to ensure safety and minimal risk of pollution at all times whilst refuelling HDD equipment day tanks.

5.98 Following completion of the HDD bore, a bore liner will be installed and the cable(s) is pulled through the bore. It is intended to conduct the cable pull from the offshore end of the bore towards the shore. This will minimise the shore laydown area required and will facilitate onward cable laying towards the PCUBs.

5.99 It is intended that construction of the HDD bores will process concurrently with the other onshore works to minimise the total time required on site and level of disturbance.

5.100 The HDD works will require temporary construction compound and access roads off the permanent PCC access road. Construction works will be carried out using a light excavator and dumper truck. The topsoil on site will be stripped back to the bedrock and stored to prepare the temporary works area. Some rock breaking (by excavator breaker) may be required. The HDD compound will move to new positions to complete each different phase of drilling. A new compound area will be prepared for each phase and the old area reinstated.

5.101 HDD site preparation will only be during normal working hours.

5.102 Indicative layouts of the HDD area are presented in Figure 5.13 and Figure 5.14. The final position of the HDD pits will be determined following detailed design of the horizontal and vertical profiles of the bores.

5.103 For the purposes of volume of cuttings produced from the HDD operation, MeyGen has considered the options for 86 individual cable bores, 300mm diameter bores extending 2,000m from the shore and 29 multi-cable bores, 600mm diameter extending 700m from the shore.

5.104 Table 5.5 details drill cutting volumes associated with the drilling of the HDD bores. The numbers in bold represent maximum potential drill cuttings volumes returned to shore and discharged to sea.

Number of bores	Bore diameter (m)	Bore radius (m)	Cuttings returned to shore			Cuttings discharged to sea		
			Bore length (m)	Volume of cuttings per bore (m^3)	Total volume of cuttings (m^3)	Bore length (m)	Volume of cuttings per bore (m^3)	Total volume of cuttings (m^3)
86	0.3	0.15	1990	140.59	**12,091.04**	10	0.71	60.76
29	0.6	0.3	690	194.99	5,654.83	10	2.83	**81.95**

Table 5.5: Drill cutting volumes from HDD bores

5.6.2 Power Conversion Centre construction

5.105 The PCUBs, control building and access will be constructed using standard practices to minimise disturbance and pollution. Electrical components will be delivered pre-assembled to site for installation to limit the amount of laydown area required.

5.106 Construction of permanent access road, temporary hardstanding using a light excavator, dumper truck and roller. The topsoil will be stripped back to the bedrock and stored correctly before the PCUBs, control building, hard standing and access roads are constructed. Topsoil will either be used for landscaping purposes or removed from site to be re-used or recycled. Some rock breaking may be required to level the site for building foundations.

5.107 The PCUB and control building construction will include foundation and floor preparation, using a light excavator, dumper truck and roller. The steel structure will be erected and external cladding fitted using a single small crane and cherrypicker. PCC construction will only be during normal working hours.

[6] There will be a maximum of 20 turbines installed by the end of Year 2

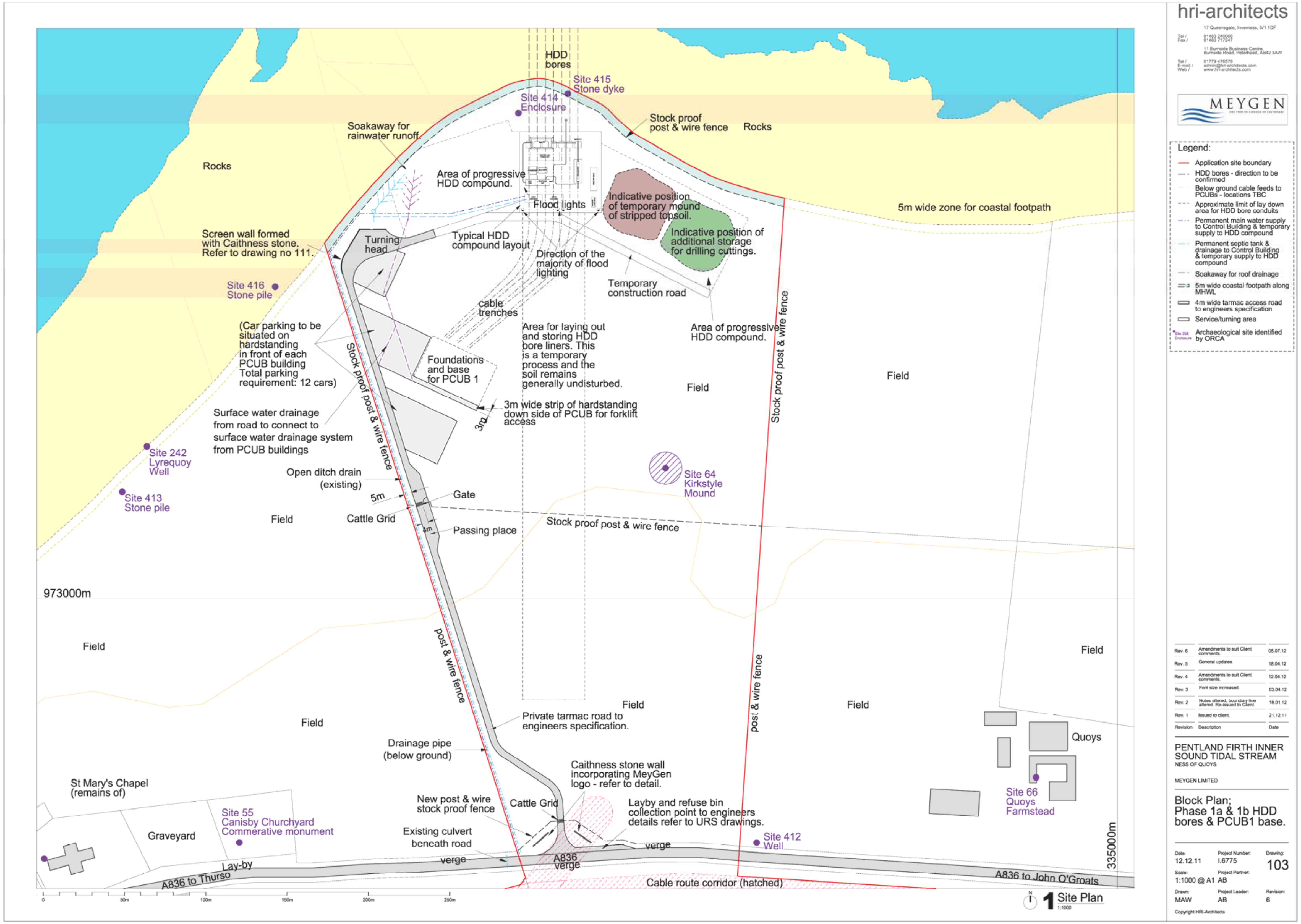

Figure 5.13: Indicative Ness of Quoys HDD site during construction phase

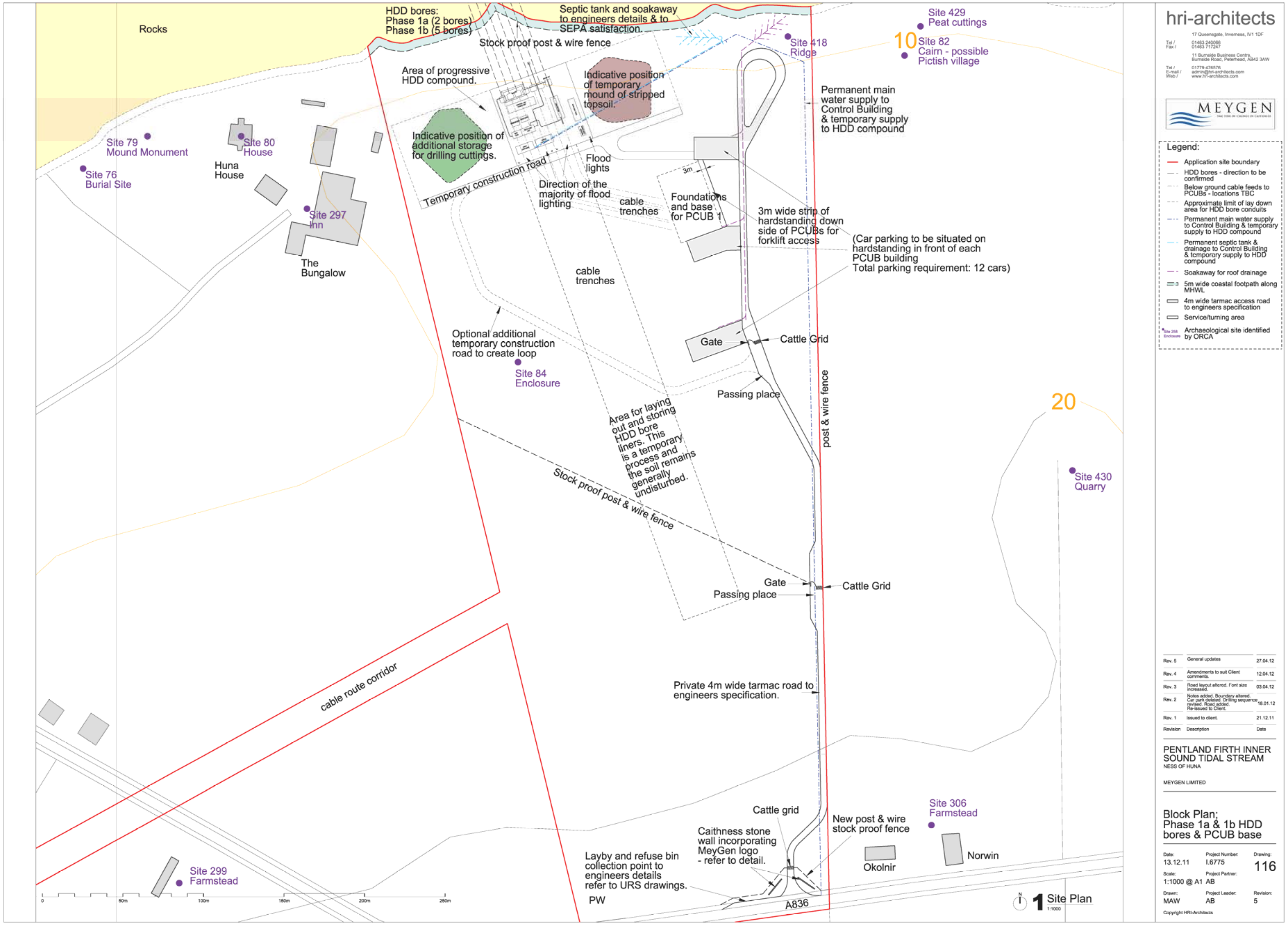

Figure 5.14: Indicative Ness of Huna HDD site during construction phase

5.108 Temporary works necessary for PCC construction include:

- Laydown area for equipment and materials;
- Fencing for public safety security;
- Storage of topsoil;
- Traffic management at entrance to work area; and
- Spoil and water management.

5.6.3 Grid connection works

5.109 Export cables from the PCC site to the grid connection will either be trenched using an excavation and back fill method, or using a cable plough.

5.110 If the cables are trenched then material will be stored and reinstated using the correct protocols. The cable corridor will be a maximum of 20m wide and require a total working width of 32m.

5.111 Water crossings may be required. Methods used for water crossings will depend on the exact location, the condition of the watercourse and other environmental constraints. MeyGen will use best available techniques and adhere to SEPA guidance for water crossings.

5.112 General considerations for the temporary works necessary to install the onshore cables are as follows:

- Laydown area for cable drums;
- Fencing for public safety and cable security;
- Storage of topsoil;
- Traffic management at entrance to work area;
- Interactions with other utilities – other services in the local area will be identified and mapped and the operator contacted; and
- Spoil and water management.

5.6.4 Construction programme

5.113 The Project will be build out over a number of years as described in Table 5.1. The onshore construction works will be completed in stages to match the build out of the offshore installation although some infrastructure will be built ready for future phases based on PCUB capacity. For example, for the initial 20MW (year 1 and 2) only one PCUB and the control building will be required (Table 5.6). The remaining 2 PCUB units will be required and constructed in year 3 of the Project.

5.114 In addition to the construction of the first PCUB and control building in year 1, the permanent access road and car park will be constructed for the Project. Other infrastructure such as hard-standing, fencing and lighting will be increased as the PCC footprint increases (Table 5.6).

5.115 The HDD bores will be completed in line with the requirements of the offshore programme and therefore each year new bores will be drilled from onshore.

5.116 All onshore construction activity will be carried out throughout the year.

Phase capacity (MW)	Total capacity (MW)	Onshore activity	Year
5 to 10MW	5-10MW	Construction of PCUB 1, control building, car park and permanent access road. Hard standing, fencing and lighting constructed for year 1 site only. HDD activity (max 2-10 bores). Temporary HDD site constructed. Cables trenched from HDD point to PCUB 1. Ground reinstated. SHEPD cable trenched to substation building.	1
10 to 20MW	15-30MW	HDD activity (max 4-20 bores). Temporary HDD site constructed. Cables trenched from HDD point to PCUB 1. Ground reinstated. 1 export cable trenched to SHETL substation, ground reinstated.	2
56 to 71MW	86MW	Construction of PCUB 2 and 3, Hard standing area increased, fencing and lighting constructed for complete PCC site. HDD activity (max 19-71 bores). Temporary HDD site constructed. Cables trenched from HDD point to PCUB 2 and 3. Ground reinstated. 2-4 export cables trenched to SHETL substation, ground reinstated.	3

Table 5.6: Onshore construction programme

5.7 Commissioning

5.117 In order to successfully commission the individual equipment and the entire power system, MeyGen will form a commissioning panel, the members of which will have defined roles and responsibilities. The commissioning process will be defined in detail by the commissioning panel and each stage would have appropriate certificates approved by competent personnel before the next stage commences.

5.118 MeyGen will appoint competent contractors to commission the tidal turbine array and the associated PCC in accordance with a written commissioning procedure. The key activities that will be undertaken during commissioning are:

- Health and safety management;
- Pre-commissioning inspection of all onshore and offshore equipment (will require survey with subsea camera);
- Off load commissioning testing;
- Pre-energisation inspection;
- Commissioning switching and on-load testing; and
- Post commissioning inspection/online monitoring.

5.8 Operations

5.119 The Project will have an operational life of 25 years. The turbines will be controlled using standard industrial power conversion equipment which is programmed to optimise the energy extracted or to control the power capture to a level dictated by the grid provider.

5.120 MeyGen will have remote access to the system for interrogation and data collection, but it is anticipated that the system will be unmanned and will run automatically. The control system is able to safely shut down turbines in emergency conditions.

5.9 Maintenance

5.9.1 Maintenance strategy

5.121 The maintenance requirements will necessarily escalate as the number of turbines increases over the installation phases. This will in turn dictate increased capacity requirements for infrastructure and services to support installation, maintenance and operations. The maintenance requirements for the turbines differ between the proposed candidate technologies. Based on recommendations from manufacturers, planned minor maintenance will take place every 2-5 years with a 10 yearly major maintenance intervention.

5.122 Full scale prototypes under test at EMEC and other facilities will provide information on reliability and failure mechanisms which will enable greater detailing of the maintenance strategy. Preliminary scheduling is a best estimate based on comparable experience of the types of components and their normally envisaged failure rates and inspection requirements. These schedules will then be continuously revised and improved based on actual findings from plant condition monitoring and data logging.

5.123 As well as planned maintenance, there may also be a requirement for unplanned maintenance interventions if turbines go offline. The level of unplanned maintenance required is difficult to quantify, however MeyGen recognises that with relatively new technology there will be this requirement. As the Project and technology develops the level of unplanned maintenance will reduce. The marine operations for unplanned maintenance are the same as for planned interventions.

5.124 The onshore equipment and facilities will also be maintained in accordance with manufacturers' recommendations, but pose fewer challenges as they are easily accessible.

5.9.2 Marine operations

5.125 Maintenance of the turbines requires a similar vessel as used in the initial installation of the devices. These vessels will recover the turbines from the TSS and transport them back to the maintenance facilities for onshore inspections and repairs. Repair work is unlikely to be feasible on board the vessels. Spare turbines may be used to immediately replace the retrieved devices to minimise the energy lost during down time in maintenance operations. Turbine retrieval for maintenance is planned to take place all year round, based on appropriate weather and tidal windows.

5.126 Based on a 2 year minor maintenance plan and with a predicted 95% availability for turbines, it is estimated that once the maximum 86 turbines are operational then maintenance activities will take place 2.5 times per week. Retrieval and deployment of a turbine will be completed in one slack water period.

5.127 The TSS will be designed such that they will not require to be recovered from the array site during the project lifetime, but ROV inspections may be carried out periodically to investigate the status of the corrosion protection systems in particular.

5.9.3 Port facilities

5.128 The Project requires significant supporting port and industrial infrastructure. Although the provision of these facilities is outside the scope of the EIA (and associated consent application), details of the likely requirements have been included here for completeness. Should there be any consenting requirements associated with any of these facilities they will be the subject of a separate application(s).

5.129 Logistics dictate that the chosen port facilities should be as close as possible to the array site to minimise vessel transit times and costs. It is likely that Scrabster, following the harbour's planned extension and improvement programme, would provide a suitable base for the early stages of the Project. However, additional capacity may ultimately be needed as the installation programme accelerates. Particular consideration must be given to the space required for the largest components, the TSS, and so further facilities, such as those at Wick and Lyness, may also be required. There may be the opportunity to use the Gills Bay harbour, which is very close to the array, for light support functions.

5.130 Throughout the offshore construction and installation period, the following facilities will be required at a local port facility:

- Final assembly areas for the turbine and TSS;
- Laydown area and marshalling yard close to a quayside;
- Quayside for installation vessels (for turbines and cables); and
- Quayside for offshore support services.

5.131 During the operations and maintenance period, an operations and maintenance base/quay will be required for the maintenance vessels with large sheds for maintenance of the turbines.

5.10 Transportation

5.132 Where practicable, MeyGen aims to carry out final assembly of large and heavy components at or close to the chosen harbour facilities to minimise the impact on the local transport infrastructure, whilst making use of existing and planned capabilities in the region. The facilities required for these assembly activities are not part of the present application/EIA.

5.133 However, there will remain a requirement to ship the component parts to the local assembly areas. The turbines used are a modular designs and so transport in sections is potentially achievable on the existing road infrastructure. Nonetheless, a detailed study of the constraints of the transport network is required to identify any areas of concern. In the event that large structures need to be transported to the mobilisation base from further afield, this can be done by sea.

5.134 Vessel movements in the area will necessarily increase when taking into consideration turbine transport, installation and maintenance activities. This will be primarily concentrated in the summer months to reduce the risk of operations in inclement weather conditions.

5.11 Decommissioning

5.135 MeyGen will develop a full decommissioning programme and strategy in compliance with both its statutory obligations and its obligations to the Crown Estate. Under the Energy Act 2004 MeyGen must submit a detailed decommissioning programme for approval to the Department of Energy and Climate Change (DECC) in respect of offshore works. Similar decommissioning requirements will apply to the onshore works under the onshore planning regime with The Highland Council.

5.136 All offshore infrastructure (turbines, TSS and cables) will be removed from the seabed. MeyGen will look to re-use, recycle all material. If neither option is available, MeyGen will dispose of the material in line with regulatory requirements.

5.137 If a piled TSS solution is used, piles will be cut at the seabed to allow the TSS to be removed. The bottom of the pile will remain in-situ.

5.138 Cables in the HDD bores will be removed and the bore openings capped.

5.139 All above ground onshore equipment will be removed from site. MeyGen will look to re-use, recycle all material. If neither option is available, MeyGen will dispose of the material in line with regulatory requirements. Following decommissioning, the onshore site will be reinstated to its former use.