Brims Tidal Array Ltd

Baseline Physical Processes
Environment

5th August 2015

1 BACKGROUND

This Appendix provides an overview of the baseline physical process environment of the seabed and shoreline within the vicinity of the Area for Lease (AfL) of the Brims Tidal Array Limited (BTAL) development site and its associated three potential offshore cable corridors.

The approach taken in the characterisation of the baseline physical process environment has been to:

- Collate and review existing relevant data and reports;
- Acquire additional data to fill any gaps;
- Undertake numerical modelling of baseline tidal current flows; and
- Formulate a conceptual understanding of the baseline physical process environment, specific to the proposed BTAL project, using Expert Geomorphological Assessment (EGA).

It is important to recognise from the outset that the baseline physical process environment is not static, but instead exhibits considerable variability due to cycles or trends of natural change. These can include, for example, the daily patterns of high and low tides, the short-term effects of storms and surges, the well-observed medium-term patterns in the movement of tides during spring and neap cycles or lunar nodal cycles, and the longer term effects of sea-level rise associated with global climate change.

2 EXISTING INFORMATION

A vast quantity of publicly available information sources and data sets on offshore bathymetry, geology, seabed sediments and geotechnical properties within The Crown Estate's Pentland Firth and Orkney Waters (PFOW) strategic development area have previously been collated and analysed within a desk study analysis of ground conditions (Halcrow, 2009). This existing information, supplemented with additional ROV seabed video footage, was used to develop ground models and assess the quantity and quality of existing data sets with a view to helping to specify the needs for more detailed project-specific geophysical surveys. In that previous study, relevant existing data sets were identified, purchased and integrated into a GIS, and then reviewed and interpreted to provide a high-level overview of geomorphological and geotechnical properties.

The main data sets and information sources collated and included within the GIS are summarised in

Table 1. Further information was derived from a series of BGS commercial and research reports and a selection of peer-reviewed papers published in scientific journals. Earlier data, from between 1973 and 1993, was also mapped into the GIS from other reputable sources (e.g. NERC, BGS, UKHO).

Table 1: Principal Data Sources Collated and Used within a Desk Study Analysis of Ground Conditions (Halcrow, 2009)

Data Type	Source	Type	Date*	Comments
Bathymetry	SeaZone	Vector and raster	2005	Based on UKHO data
	FRS	Raster	2007-08	Surveyed using multi-beam echo sounder
	Aquatera	Raster	Undated	Including slope and roughness of the seabed
	BGS	Paper copy (analogue)	Undated	Echo sounder lines
Bedrock geology	BGS	DigRock250	2007	1:250k scale
	BGS	Paper copy (analogue)	Undated	Sparker and pinger lines
Seabed sediments	BGS	DigSBS250	2003-09	1:250k scale
	BGS	Survey logs	Various	Boreholes, vibrocores, sediment cores and grab samples
	FRS	ROV seabed video footage	Undated	DVDs
	Aquatera	ROV seabed video footage	2009	DVDs
Tidal currents	SeaZone	Tidal diamonds on Admiralty Chart 5058	2008	Based on UKHO data

* Digital publication date (actual survey date may differ)

Outputs from that earlier desk study specifically relating to the Pentland Firth in general and the BTAL project in particular have proved an effective starting basis for the development of an understanding of the baseline physical process environment.

In addition, there is also considerable published and 'grey' literature relating to the baseline physical process environment of the seabed and adjacent shoreline areas which has been collated and reviewed to further enhance the understanding. These information sources are listed in Table 2. Various charts and maps were also used, including Ordnance Survey Explorer Map 462, UK Hydrographic Office Admiralty Chart 2162 (Pentland Firth and Approaches) and Admiralty Chart 1954 (Cape Wrath to Pentland Firth including Orkney Islands) and British Geological Survey's DigBath2050 (bathymetry), DigRock250 (seabed geology) and DigSBS250 (seabed sediments). .

Table 2: Principal Data Sources Collated and Used in Developing an Understanding of the Baseline Physical Process Environment

Author / Publisher	Date	Title
Scottish Executive	2007	Scottish Marine Renewables SEA - Geology, Sea Bed Sediments and Sediment Transport
Scottish Executive	2007	Scottish Marine Renewables SEA - Marine and Coastal Processes
The Scottish Government, Marine Scotland, AECOM and METOC	2011	Pentland Firth and Orkney Waters Marine Spatial Plan Framework

Author / Publisher	Date	Title
The Scottish Government, Marine Scotland, AECOM and METOC	2011	Pentland Firth and Orkney Waters Regional Location Guidance for Marine Energy
Steers	1973	The Coastline of Scotland
Ramsay & Brampton	2000	Coastal Cells in Scotland: Cell 10 Orkney
Mather, Smith & Ritchie	1973	Beaches of Orkney
McKirdy	2011	Landscape Fashioned by Geology: Orkney and Shetland
Dargie	1998	Sand Dune Vegetation Survey of Scotland: Orkney (3 Volumes)
Scottish Power Renewables	2012	Proposed Ness of Duncansby Tidal Array – Request for a Scoping Opinion
MeyGen Ltd.	2011	MeyGen Phase 1 EIA Scoping Document
MeyGen Ltd.	2012	MeyGen Tidal Energy Project Phase 1 Environmental Statement – Physical Environment and Sediment Dynamics
HR Wallingford	2004	2D Modelling of the Effects of Opening the Churchill Barriers to Tidal Flow
Dounreay Particles Advisory Group	2006	Third Report of the Dounreay Particles Advisory Group
Leslie	2012	Shallow Geology of the Seabed in the Vicinity of Orkney and the Sutherland Coast
Hutchinson, Millar and Trewin	2001	Coast erosion at a nuclear waste shaft, Dounreay, Scotland

Thorough desk-based reviews of these literature sources has revealed a large quantity and high quality of existing data and information that has been used to develop the understanding of the baseline seabed and shoreline geology and sediments, tidal regime, wave regime, sediment regime and morphological features.

3 PROJECT SURVEYS

Following the aforementioned review of previous data sets and literature sources some gaps in the understanding of the baseline environment were highlighted. These gaps were subsequently filled through a series of metocean, geophysical and benthic surveys that now provide improved coverage and a more comprehensive understanding of the area of investigation. The project-specific surveys that are of direct relevance to the physical process environment are summarised in Table 3.

Table 3: Project-specific surveys

Dataset	Methodology	Reference
Bathymetry, shallow geology and seabed features	Single beam sonar transect survey.	Partrac, 2011
	Multi-beam echo sounder, side scan sonar, sub-bottom profiling and magnetometer survey within the AfL and within the Moodies Eddy and Aith Hope cable corridors (2012 – 2013).	Osiris Projects, 2014
	Multi-beam echo sounder survey within the Sheep Skerry cable corridor	Aquatera, 2015

Dataset	Methodology	Reference
Seabed sediments	ROV video footage collected to inform the preliminary seabed habitat assessment.	Aquatera, 2009
	Drop-down video camera survey. ROV video footage.	Partrac, 2011 Partrac, 2012
	1. ROV video footage within previously unsurveyed areas of seabed, namely the western area of the AfL and within the Melsetter (aka Moodies Eddy) and Aith Hope cable corridors.	Aquatera, 2014
	2. ROV video footage within the Sheep Skerry cable corridor.	Aquatera, 2015
Metocean conditions (currents, waves, winds)	Bottom-mounted ADCP surveys at two locations (both east of the present AfL).	Partrac, 2010
	Vessel-mounted ADCP surveys (covering 6 locations) to inform on suitable locations for deployment of bed-frames.	Partrac, 2011
	Bottom-mounted ADCP surveys at two locations offshore from Brims Ness.	Partrac, 2011
	Bottom-mounted ADCP surveys at six locations offshore from between Brims Ness and Tor Ness.	Partrac, 2013

4 BASELINE ENVIRONMENT

SEABED GEOLOGY

To the south of the Orkney Islands, bedrock outcrops occur on the seabed, which strongly influences the morphology of the seabed. The sea floor slopes away steeply from the west of Mainland and from the south-west of Hoy and is typically comprised of exposed bedrock.

In keeping with the above, general, characterisation, the seabed of the BTAL site largely consists of exposed bedrock, comprising sandstone with subordinate conglomerate, siltstone and mudstone.

Five of the eighty-five magnetic anomalies identified within the processed magnetometer data from a survey within the AfL in 2012-13 are located on the eastern side of the AfL and are thought to be related to the underlying geology, with the British Regional Geology guide (Mykura, 1976) indicating that a number of volcanic vents are present within the general area encompassing the islands of Hoy, South Ronaldsay and Mainland. These vent features are connected with a large number of igneous dykes, which are also likely to be present beneath the AfL area, although any linear magnetic anomalies associated with these features are unclear (Osiris Projects, 2014).

SHORELINE GEOLOGY

The Orkney archipelago is formed largely of Middle and Upper Old Red Sandstone rocks of Devonian age (417-354 Million Years Before Present). Locally, older sedimentary rocks, basement igneous and metamorphic rocks, as well as younger lavas, volcanic plugs and numerous dykes (mostly of Carboniferous age) are present.

High-cliff coastlines are a feature of the south-west tip of the island of Hoy, which provide some of the best examples in Europe of Old Red Sandstone cliffs and associated features. The rich variety of cliff and cliff-related forms along this coast include steep and overhung profiles; sea-stacks; arches; caves; and shore platforms, all reflecting the dominant geological control of horizontally bedded, fractured and faulted Devonian sandstone.

BATHYMETRY

Existing regional scale bathymetric data has been collated from various sources and interpreted. This information has been supplemented by two project-specific surveys, described below.

A single beam bathymetric survey was undertaken in April 2011 (associated with the location of the original AfL, which has subsequently been revised). The extent of the survey tracts is shown in Figure 1.

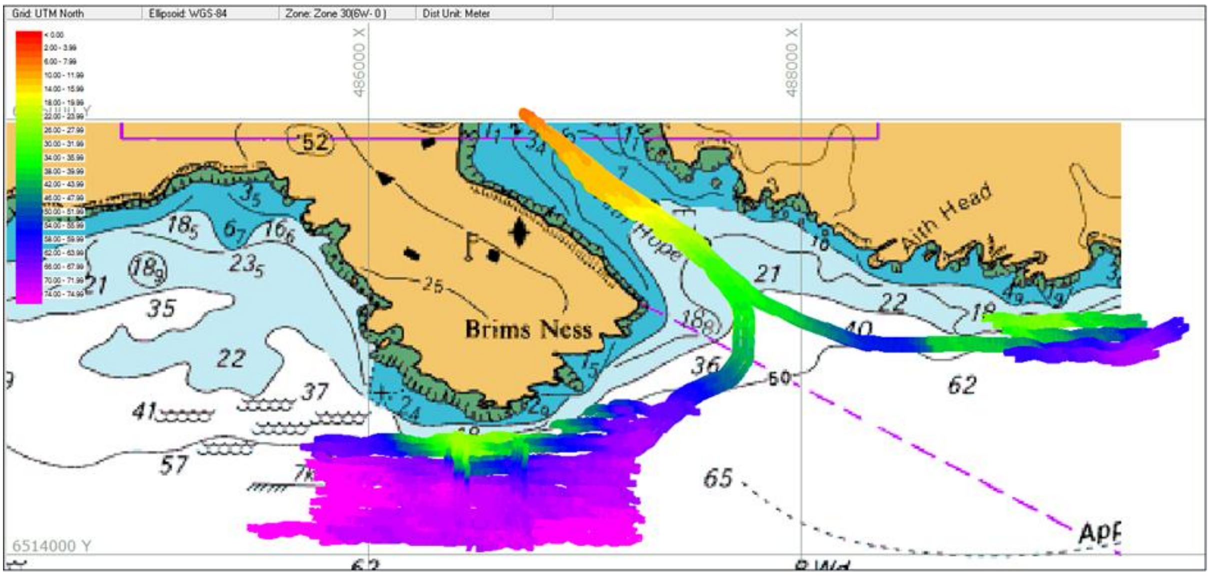


Figure 1: Extent of 2011 single beam bathymetric survey

A multi-beam bathymetric survey was then undertaken in phases between August – October 2012 and April – May 2013. This was more detailed than the previous single beam bathymetric survey, comprising a line spacing of 75m (with cross lines every 1km) in water depths greater than 30m and line spacing of 50m (with cross lines every 500m) in shallower waters. The extent of the survey area is shown in Figure 2 and comprises the (revised) AfL, located approximately 1.5km south of Hoy and measuring approximately 7.9km x 2.1km, and the two potential cable corridors that were being considered at that time, namely CR1, the Aith Hope Cable Route measuring approximately 2.66km in length, and CR2, the Melsetter Cable Route (now known as the Moodies Eddy Cable Route) measuring approximately 10.7km. Note: A third potential cable corridor, Sheep Skerry, has since been identified, but this was not covered by the survey.

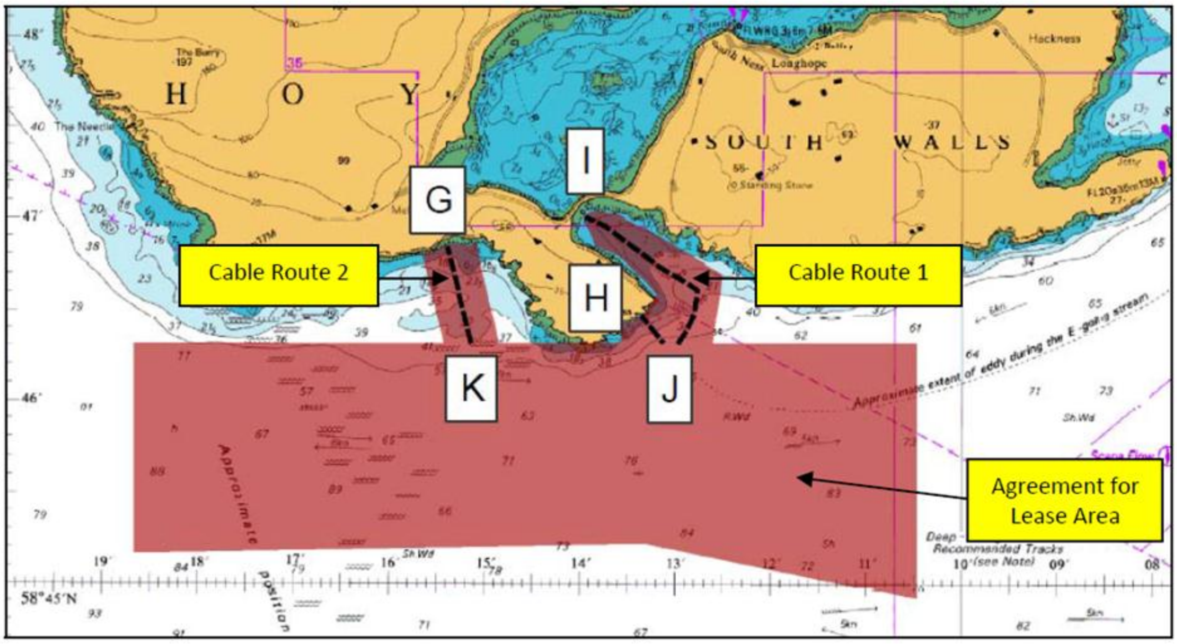


Figure 2– Extent of 2012-13 multi-beam bathymetric survey (source: Osiris Projects, 2014)

Whilst data were collected across the whole AfL during this survey, the data processing, quality control, analysis and interpretation has been focused on a 'high priority area' within the AfL, shown in **Error! Reference source not found.**, (as well as the then two potential cable corridors) as it is within this area of the AfL that the tidal devices are most likely to be deployed.

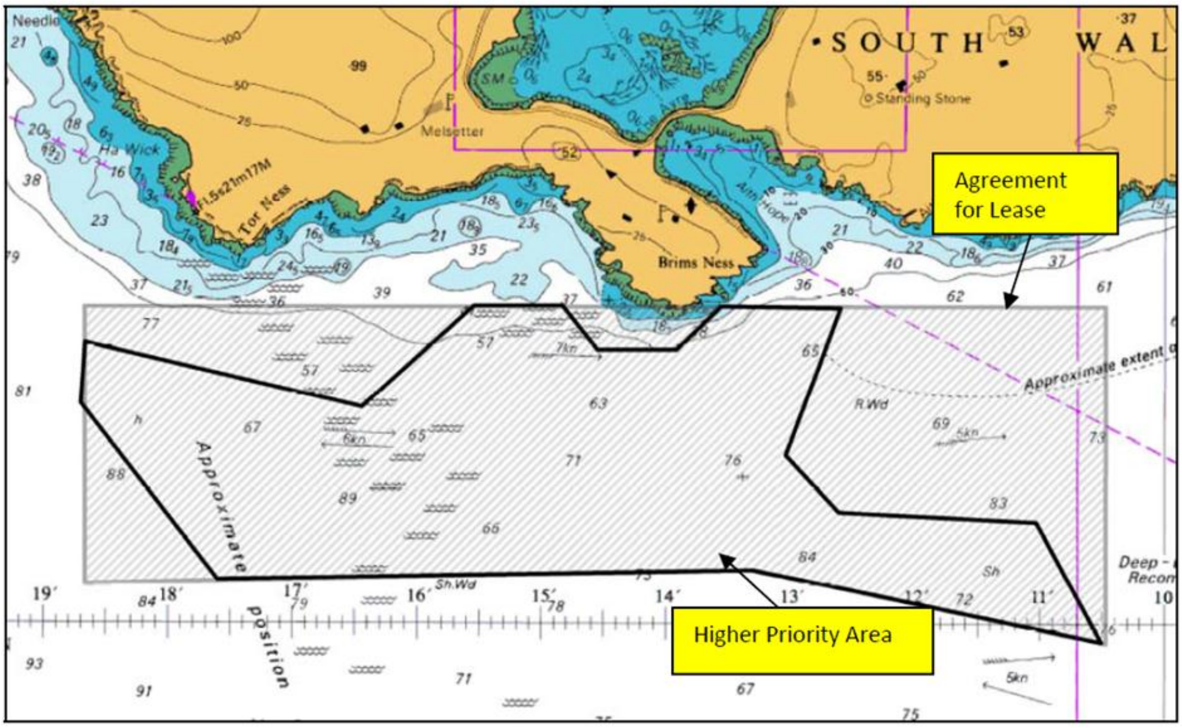


Figure 3 'High Priority Area' for Data Processing and Interpretation within the AfL (source: Osiris Projects, 2014)

AFL

Whilst water depths in the bays and channels around the Isles of Orkney are generally less than 25m, and rarely exceed 40m depth in any location, the Pentland Firth is significantly deeper, with depths in the main channel reaching typically between 60m to 80m, but increasing locally in the western part of the Firth, between Hoy and Dunnet Head, to more than 100m.

The project-specific surveys show that specifically within the AfL, water depths range from 15.2m below LAT at the north central inshore limit of the survey area, to a maximum of 110.0m below LAT in the central section of the site.

The seabed is characterised by exposed, differentially weathered bedrock across the majority of the AfL. Distinctive bedding, joints and fractures of this bedrock are clearly evident within the bathymetric data. The most shallow water depths occur in the northern portions of the site where bed levels drop steeply from an average of 17.5m below LAT to approximately 62m below LAT over a distance of 140m, with a maximum slope gradient of 37°.

The central and western portions of the site are dominated by steep-sided gullies and troughs associated with joints or fault lines within the bedrock (Figure 4 and Figure 5). The deepest gullies run north-east to south-west, are up to 60m wide and are up to 31m deeper than the surrounding seabed. The slopes associated with these gullies are steep sided with maximum slope angles of 32.8° in the northern slope of the gully.

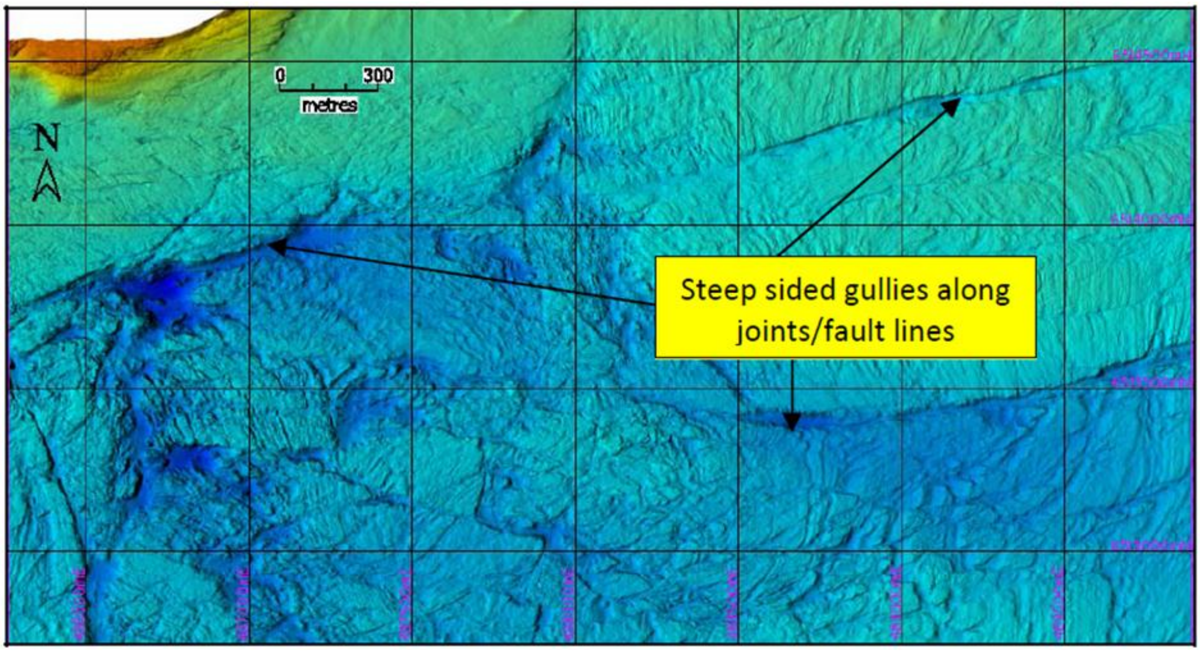


Figure 4: Channels in the Central and Western Part of the AfL (source: Osiris Projects, 2014)

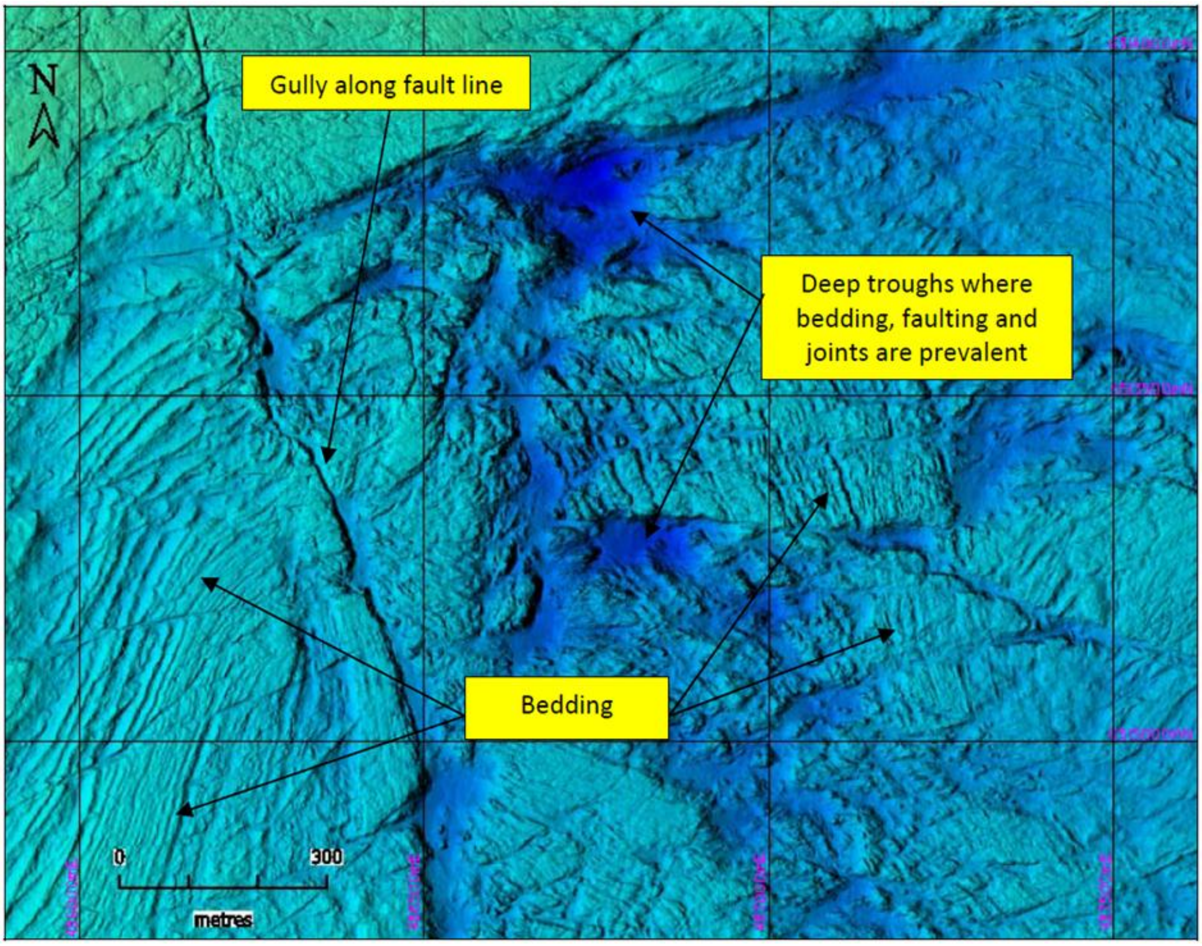


Figure 5: Bedding, Gullies and Troughs the Central and Western Part of the AFL (source: Osiris Projects, 2014)

Numerous faults are also evident in this area. The largest fault is evident in the central portion of the site and is orientated north-northwest to south-southeast, up to 20m wide and exhibits water depths along its axis that are up to 10m deeper than the surrounding seabed.

In the eastern part of the AfL, the seabed is characterised by a less irregular seabed, with narrow gullies cutting through the rocky seabed in NE-SW and E-W directions.

A single north-west to south-east orientated sand wave is evident in the north-west section of the AfL (Figure 6). The crest of this bed form lies approximately 10m above the surrounding seabed, with depths of 58m LAT along its crest. Megaripples associated with this feature are also evident in this area.

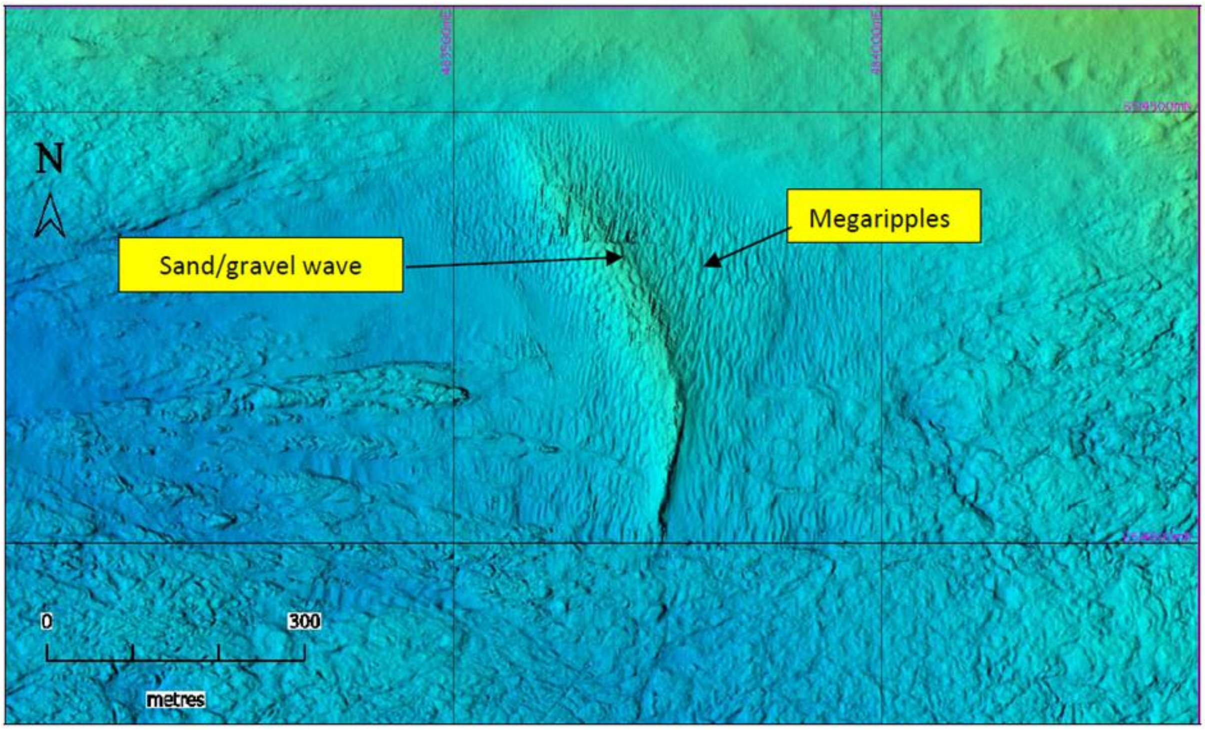


Figure 6: Sand/Gravel Wave in the Western Part of the AfL (source: Osiris Projects, 2014)

EXPORT CABLE CORRIDOR – AITH HOPE

Water depths along the CR1 corridor gradually increase from a minimum of 0.9m below LAT at the inshore limits of the data at KP0.146, to reach 40.0m below LAT at approximately KP1.91, at an average gradient of approximately 2.1°, before dipping more steeply at a maximum gradient of 8.0°, to reach 58.0m below LAT at KP2.066.

A steeply-sided rock outcrop is present to the west of the corridor between KP1.5 and KP2.0, where a minimum water depth of 19.6m below LAT was noted. Very steep localised gradients of up to 40° were noted across this rocky section.

EXPORT CABLE CORRIDOR – MELSETTER (AKA MOODIES EDDY)

Water depths along the CR2 corridor range from a minimum of 4.4m below LAT, near the inshore extents of the survey at KP0.095, to approximately 36.0m below LAT, close to the end of the proposed cable route at KP1.070. A shallowest depth of 0.6m below LAT was noted approximately 212m east of the proposed centre line, at the inshore limits of the data.

The seabed initially dips steeply towards the south across an area of outcropping bedrock, from 4.4m below LAT, close to the proposed centre line at KP0.095, to 18.0m below LAT at KP0.172, at an average gradient of 10.0°. Between KP0.172 and KP0.425, the bedrock surface is less irregular, dipping more gently southwards at an average gradient of less than 2.0°.

To the south of KP0.425, the proposed route centre line crosses an area of sand waves and associated troughs, with the steepest gradients along the proposed centre line noted between KP0.685 and KP0.292 and again between KP0.377

and KP0.510 (Figure 7). The sand waves stand up to 12.5m above the surrounding seabed and exhibit maximum slope gradients of 14.0°. Water depths within the associated seabed troughs deepen to approximately 32.0m below LAT. The proposed route crosses a localised trough feature, where water depths reach a maximum of 36.0m below LAT, before crossing a smaller, 4.0m high sand wave feature near the offshore end of the route, to the south of KP1.052.

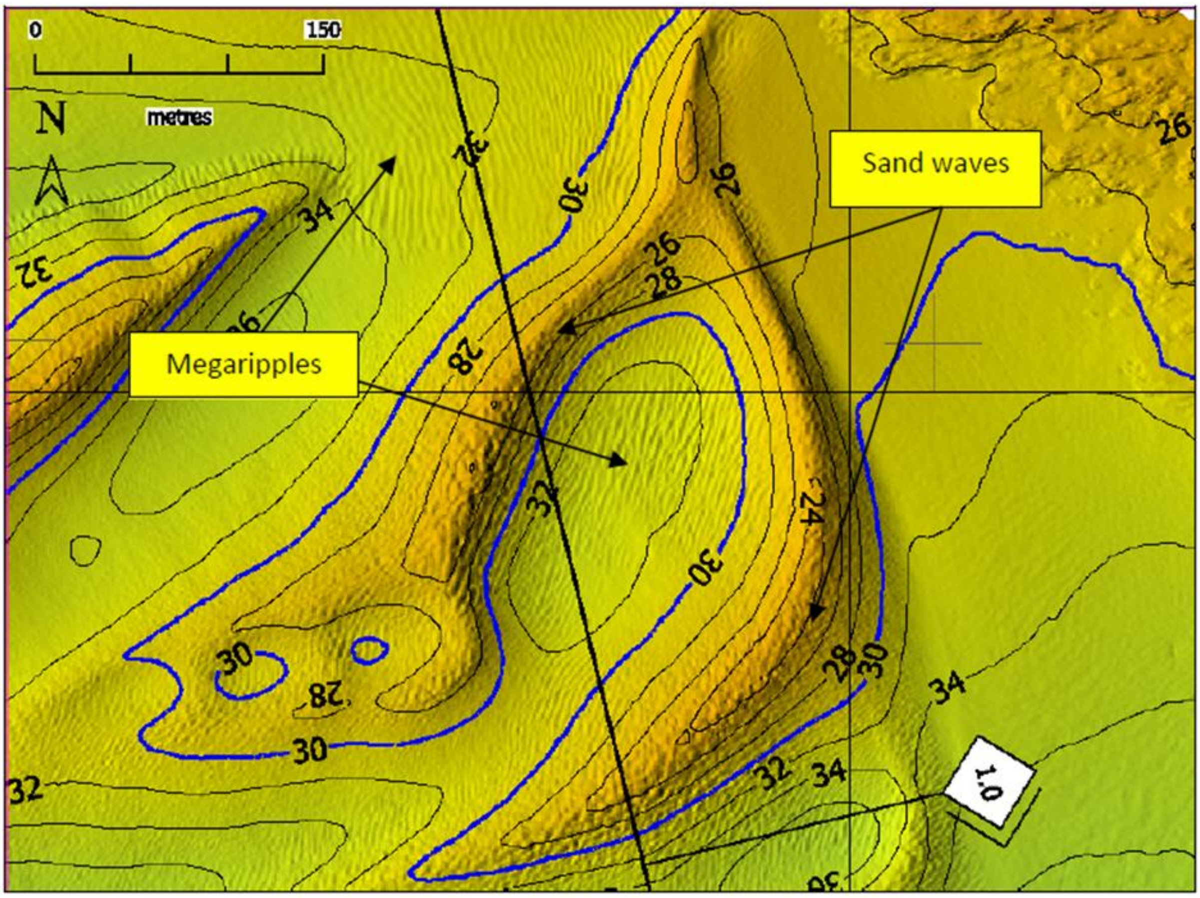


Figure 7: Sand Waves and Megaripples in the Central Melsetter (aka Moodies Eddy) Route

EXPORT CABLE CORRIDOR – SHEEP SKERRY

Water depths within the Sheep Skerry corridor increase from the inter-tidal shore to 60 m approaching the AfL area. Near the coast the seabed is predominantly irregular and rugged with pronounced geological fault line features and numerous igneous laval outcrops. However, areas of rippled sands are present in the sheltered area between Sheep Skerry and Tor Ness. The seabed in the southern part of the cable corridor is characterised by gently shelving mixed gravelly sediments and there is a large sandwave feature standing 6-8 m above the surrounding seabed is present near the AfL boundary, 1 km southeast of Tor Ness.

5 SEABED SEDIMENTS AND BEDFORMS

AFL

The 2012-2013 side scan sonar survey (Osiris Projects, 2014) indicates that the seabed across most of the AfL comprises exposed and occasionally fragmented bedrock, with frequent isolated boulders and areas of gravelly sands/sandy gravels close to its northern boundary. Megaripples are evident across these areas of granular sediments, together with a single, distinct sand wave feature shown in Figure 8. Numerous sonar targets are present, and these are interpreted to comprise mainly boulders.

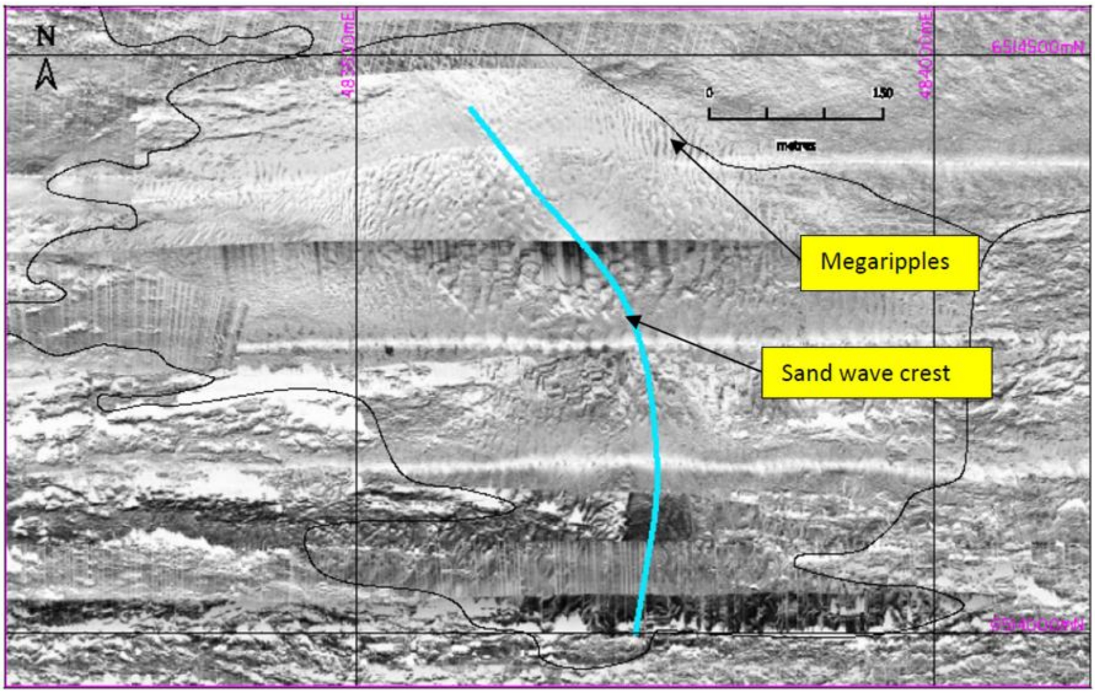


Figure 8: Sand Wave and Megaripples in the North - Western part of the AFL (source: Osiris Projects, 2014)

An area of gravel is present in the south-west section of the survey area and this is associated with numerous sonar targets, mainly interpreted as boulders. Also, the deep gullies associated with faults in the bedrock are in-filled with coarsely granular sediments (Figure 9).

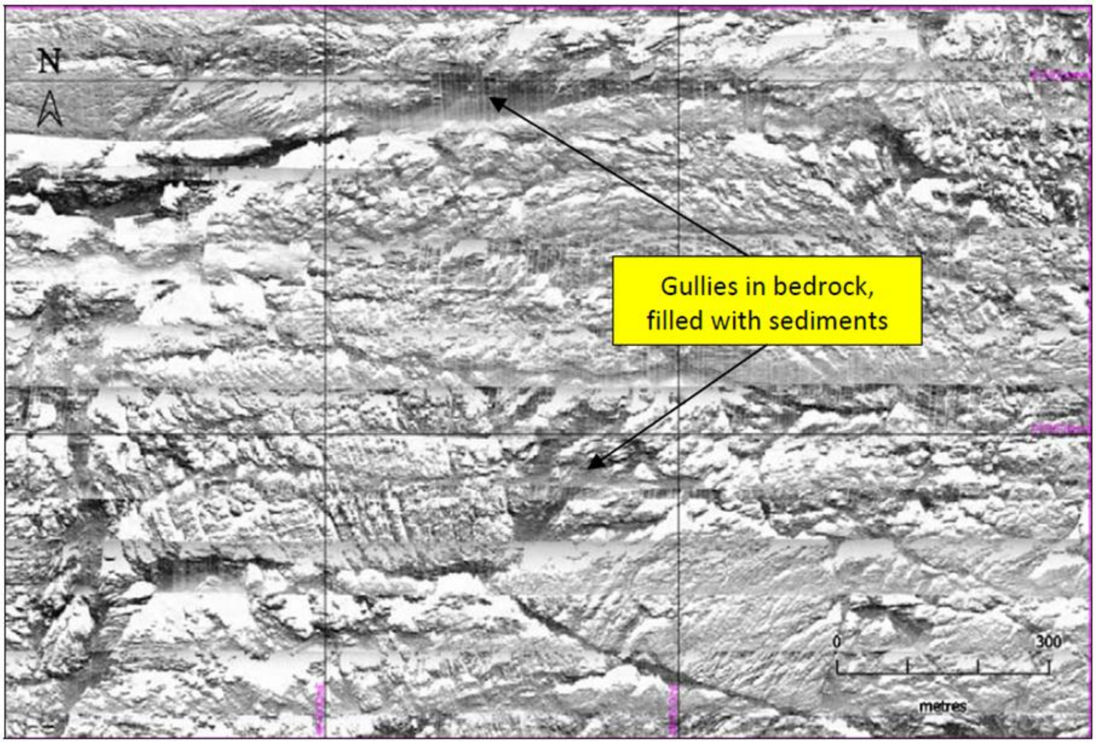


Figure 9: Sediment - filled Gullies in Bedrock (source: Osiris Projects, 2014)

A total of 299 sonar targets were identified within the AfL, the majority being interpreted as boulders, and most with lengths of between 1m and 2m, together with some very large boulders exhibiting maximum dimensions of between 7m and 8m. Eighty-two of these targets are within the 'high priority area'. Four items of linear debris are seen across the AfL, with lengths of between 16m and 140m. These are thought to represent items of discarded fishing gear. Two of these linear targets lie within the 'high priority area'. Four wrecks are charted in the general area, two of which lie within the AfL, but these were not identified on the side scan sonar data.

The results of the sub-bottom profiling survey show that the AfL consists predominantly of outcropping bedrock, with very little discernible sediment cover. Some areas of sediment cover are present along the northern boundary of the AfL, in particular where both the Melsetter (aka Moodies Eddy) and Aith Hope cable route corridors enter the AfL, together with a localised sediment patch in the southwestern corner of the AfL.

The sub-bottom profiler data indicate that sediment cover within the rock gullies that cut through the rock head is generally less than 1.0m. The thickest total sediment cover occurs near the junction of the AfL and the Melsetter inlet, with a maximum thickness of up to 33.0m noted. To the west of the Melsetter inlet a distinct sand wave has formed, with a maximum sediment thickness of 12.0m noted along the central axis of the sand wave, and with the gravelly sand surrounding this feature exhibiting a thickness of up to 8.0m.

Further to the east, where the Aith Hope cable corridor meets the northern edge of the AfL, sediment thicknesses of up to 6.0m were noted, although these thin rapidly towards the south. The patch of gravel in the south-western corner of the site exhibits a granular sediment cover of 1.0m – 2.0m.

ROV surveys undertaken by Aquatera over a broader area of survey indicate a number of large boulder fields in the west and centre of the AfL. Otherwise, sediment cover is sparse due to the strong tidal currents (> 2 m/s). Where sediment cover does exist, it is patchy, comprised of thin layers of sands and gravels. A grab sample containing only a very small quantity of coarse shell fragments collected by BGS supports sparse sediment deposition across the site and this is confirmed on nearby ROV footage taken by FRS (Halcrow, 2009).

A number of published sources document a sandwave field/transverse bedforms further to the west of the AfL (e.g. Holmes et al. 2003; Flinn, 1973). The Aquatera bathymetry dataset clearly shows large scale bedforms some 10 km to the west of the AfL, with minor bedforms resolvable in the datasets between that point and around 3km from the AfL. These features are indicative of westward-directed net bedload sediment transport from a parting zone located beyond the east of the AfL.

A drop-down camera survey was undertaken in April 2011. The extent of the survey tracts is shown in Figure 10: Extent of drop-down camera survey, April 2011 and tracts 1 and 2 are of relevance to the AfL. Results show that, generally, the AfL comprises exposed bedrock, consisting mainly of Permo-Triassic sandstones, siltstones and mudstones, with patchy thin sands and gravels (especially deposited within open rock fractures). Along the tract lines, the solid geology comprises near-horizontally stratified sedimentary rock with only shallow titling.

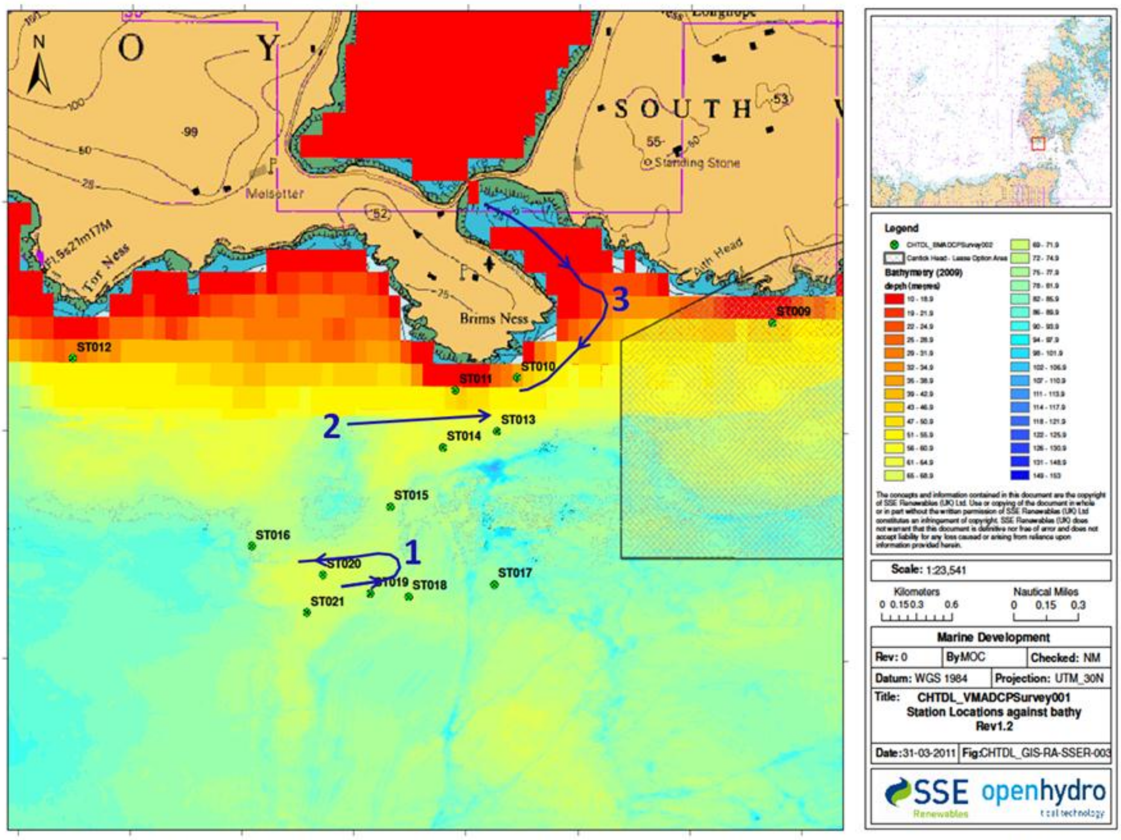
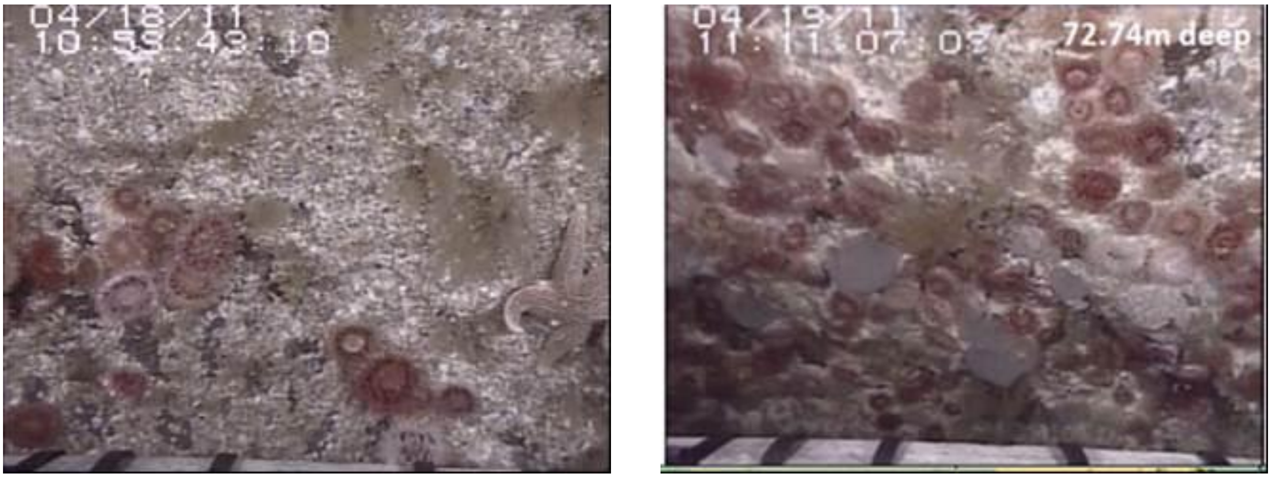


Figure 10: Extent of drop-down camera survey, April 2011

Typical findings from the drop-down camera video survey in April 2011 are shown in Figure 11. As can be seen on both the outer and inner plateaus uneven bedrock was predominantly found (with occasional gravels, coarse sand and broken shell shown on some images).



Survey tract 1 (Outer Plateau, 72m depth)

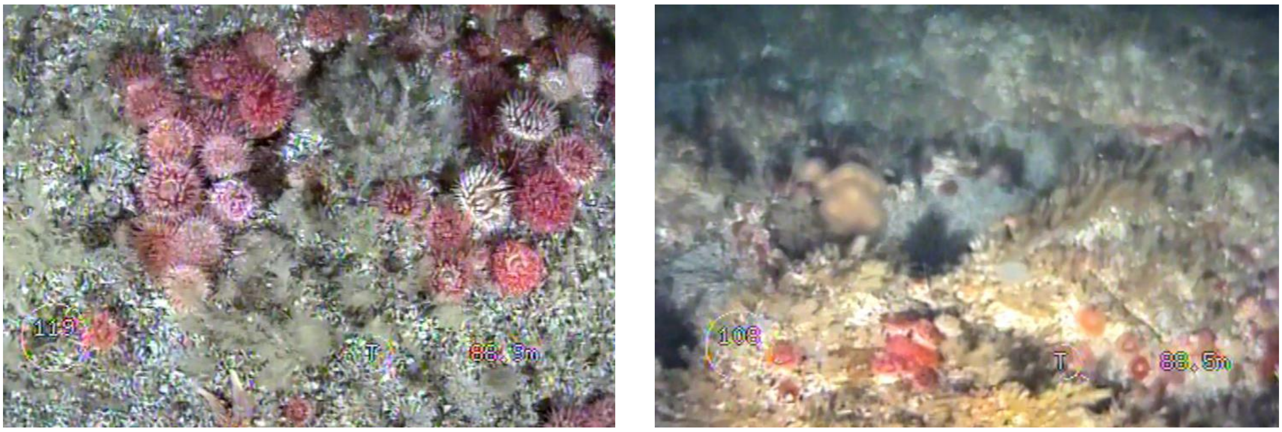
Survey tract 2 (Inner Plateau, 72m depth)

Figure 11: Typical imagery from the drop-down camera survey, April 2011, within AfL

A further ROV video survey undertaken was undertaken within the western area of the AfL in 2014 (Aquatera, 2014). Short transects were recorded at two stations (WB1 and WB2), identified in Figure 12.

Figure 12: Location of Short Transect ROV Video Survey, 2014

The seabed characteristics observed in the western part of the AfL area during the 2014 survey were fully consistent with the seabed types observed in this region of the Pentland Firth in previous studies. The seabed is primarily hard and rocky with occasional veneers of gravel and coarse sandy sediments in the more sheltered areas such as in rock crevices and between boulders. The rocky substrate is covered a range of algae, bryozoans, hydroids, soft corals and sponges.



Station WB1 (88m depth) Station WB2 (88m depth)

Figure 13: Typical imagery from the ROV Video Survey, 2014, within AfL

EXPORT CABLE CORRIDOR – AITH HOPE

A drop-down camera video survey was taken in April 2011 along the Aith Hope export cable corridor (see track 3 in the earlier Figure 10). Within the shallower region of the bay of Aith Hope, the imagery showed mainly coarse sand and broken shell. The survey indicated that, aside from an area of exposed bedrock at 24m depth, seabed sediment coverage was generally present and was noted in some areas as deep as 60m.

Further detail is available from the 2012-2013 side scan sonar survey (Osiris Projects, 2014), which indicates that the seabed across the Aith Hope cable corridor comprises mainly gravels or sandy gravels, with numerous boulders and irregular patches of finer grained sandy sediments, from its inshore limits out to approximately KP1.075. Outcropping bedrock is present along the south-western and north-eastern edges of this nearshore section of the corridor. The rock outcrops become more extensive to the south-east of KP1.00, crossing the proposed route centre-line between KP1.145 and KP1.402. To the south-east of KP1.402, the bedrock surface becomes covered by an irregular expanse of sandy gravels, with frequent boulders and patchy megaripples, with the proposed centre line turning sharply towards the south, then south-west, between KP1.475 and KP1.742.

Numerous sonar targets were noted within the CR1 route corridor, the majority of which are interpreted to be boulders, with several items of possible discarded fishing gear and associated debris. Two boulders, (targets S065 and S066), lie within 25.0m of the proposed centre line between KP0.807 and KP0.868. Sonar target S070 lies on the proposed cable route at KP1.477 (figure 9, below). It has dimensions of 1.8m x 0.5m x 1.1m. No other sonar targets lie within 25m of the proposed cable route.

Based upon the sub-bottom profiling data from 2012-13, interpreted sediment thicknesses along the nearshore section of the proposed cable route vary between 1.0m and 5.0m between KP0.288 and KP1.008.

Along the central section of the proposed route, between KP1.0008 and KP1.406, and between KP1.508 and KP1.83, sediment thicknesses are generally less than 1.0m, with intermittent areas of outcropping bedrock.

Offshore of KP1.83, sediment thicknesses increase to between 2.0m and 4.0m.

A further ROV video survey undertaken was undertaken along the Aith Hope cable corridor in 2014 (Aquatera, 2014). The Aith Hope video transect lines are shown in Figure 14 (along with two transects within the Melsetter (aka Moodies Eddy) cable corridor).

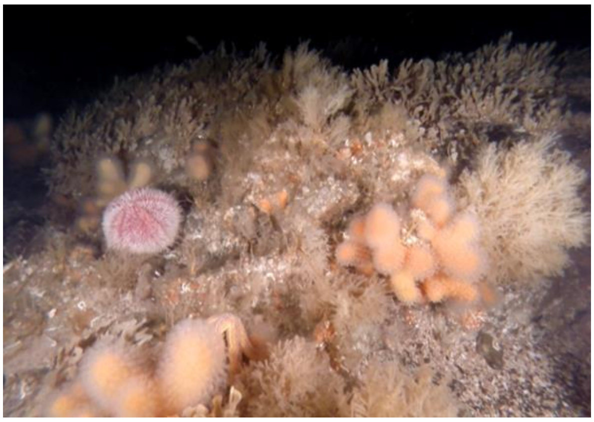
Figure 14: Potential export cable corridors at Aith Hope and Melsetter (aka Moodies Eddy) cable corridor

The seabed characteristics observed in the cable corridor during the 2014 survey (illustrated by examples in Figure 15) are fully consistent with the seabed types derived from analysis of the geophysical data collected in 2012-13. Gravelly sands, interspersed with rocky outcrops, were widespread. Increasing amounts of exposed bedrock and boulders were observed in the deeper water areas in the south of the cable corridor and approaching the Brims Head headland. The northern part of the cable corridor which was characterised by a gently shelving sandy seabed.

7m depth (sand with megaripples)

6m depth (gravel with boulders)

27m depth (sandy gravel with boulders)



63m depth (sandy gravel with boulders)

Figure 15: Typical imagery from the ROV survey, 2014, along the Aith Hope Cable Corridor

EXPORT CABLE CORRIDOR – MELSETTER (AKA MOODIES EDDY)

The seabed across the Melsetter (aka Moodies Eddy) cable corridor is shown by the 2012-2013 side scan sonar survey (Osiris Projects, 2014) to comprise an irregular area of outcropping bedrock at its inshore limits, extending southwards to KP0.327.

To the south of KP0.327, the bedrock surface becomes covered by a veneer of gravels, out to KP0.442, and then by a large expanse of gravelly sands to the offshore end of the proposed route at KP1.070.

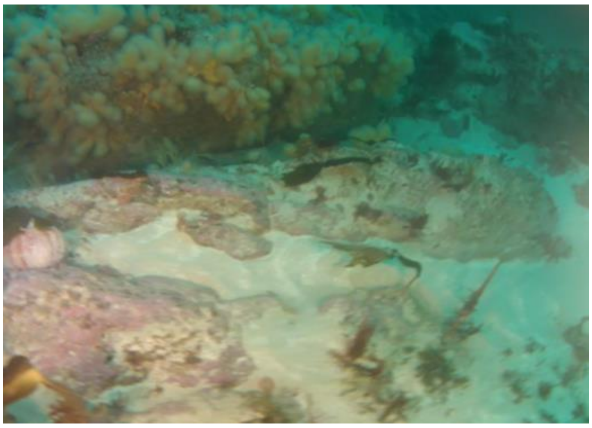
A total of eight sonar targets were identified within the CR2 corridor. One of these, with dimensions of 2.3m x 0.5m x 1.5m, lies 7.4m west of the proposed centre line at KP0.397. No other targets lie within 150m of the proposed centre line.

Based upon the sub-bottom profiling data from 2012-13, interpreted sediment thicknesses along the centre-line gradually increase from the edge of the area of outcropping bedrock, at KP0.327, from a general thin veneer to approximately 2.0m at KP0.463, before increasing rapidly to more than 34m at the offshore end of the proposed route.

A further ROV video survey undertaken was undertaken along the Melsetter (aka Moodies Eddy) cable corridor in 2014 (Aquatera, 2014). The video transect lines are shown in the earlier Figure 10 (along with the Aith Hope transect lines).

The seabed characteristics observed in the cable corridor during the 2014 survey (illustrated by examples in Figure 16) are fully consistent with the seabed types derived from analysis of the geophysical data collected in 2012-13. Gravelly sands, interspersed with rocky outcrops, were widespread. Increasing amounts of exposed bedrock and boulders were observed in the deeper water areas in the south of the cable corridor. The northern, nearshore, section of the cable corridor was characterised by uneven bedrock with water depths rapidly falling to around 20m within 200m of the coastline.

15m depth (bedrock)



26m depth (sand veneer over bedrock)

28m depth
(gravelly sand with megaripples)

38m depth
(sandy gravel with boulders)

Figure 16: Typical imagery from the ROV survey, 2014, along the Melsetter (aka Moodies Eddy) Cable Corridor

EXPORT CABLE CORRIDOR – MELSETTER

It is known from a draft geological Local Nature Conservation Site, known as Melsetter Coast, which extends between Sheep Skerry and Sands Geo (to the immediate east of Melberry) that the shoreline consists of a restricted outcrop of the Hoy Lavas. The lava forms a distinctive coastal platform in front of a small dune system at Melberry. It appears from the OS mapping that small deposits of sand exist at both Sheep Skerry and Melberry.

A video survey was undertaken by means of ROV and a diver in July 2015 to characterise the seabed within the Sheep Skerry cable corridor (Aquatera, 2015). Two transect lines were surveyed by ROV and one spot location by diver (Figure 16).

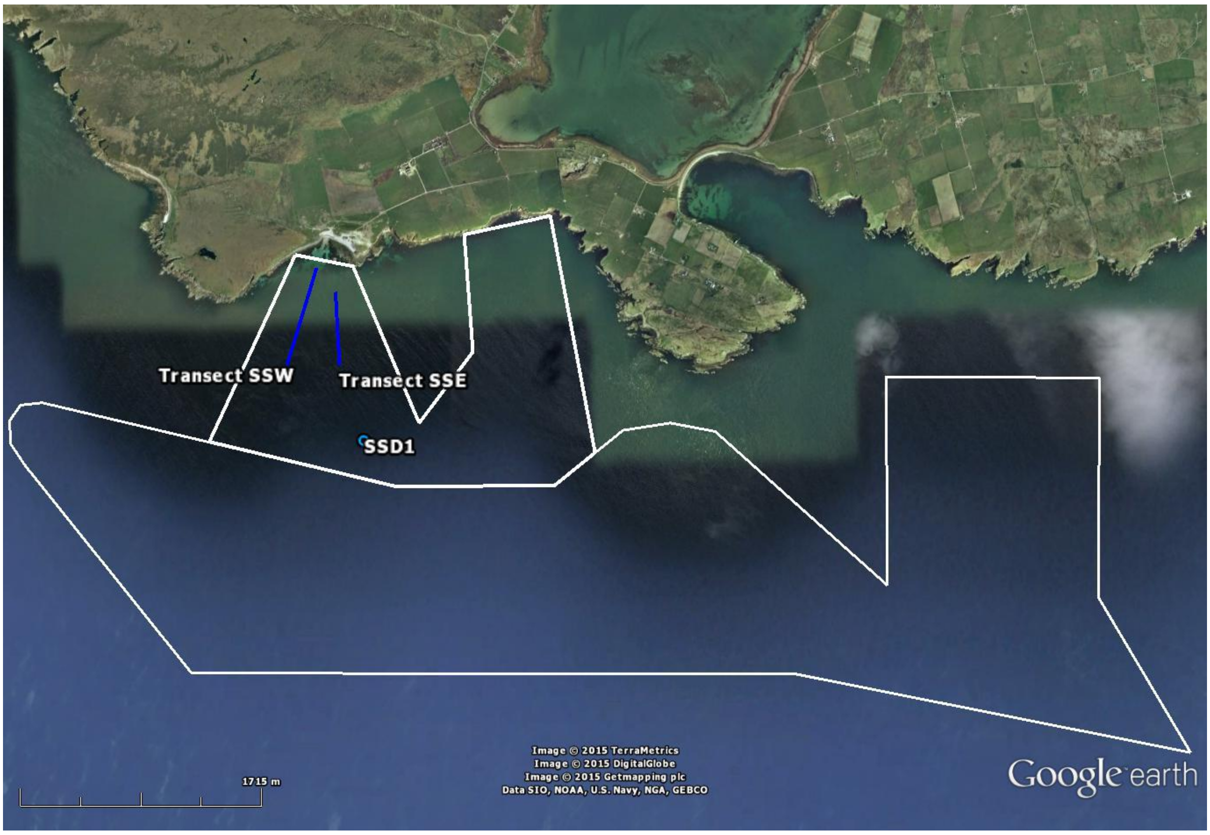


Figure 177: ROV and diver surveys at Sheep Skerry cable corridor

Results (illustrated by examples in Figure 16) were consistent with the data from the multibeam echo sounder bathymetric survey of the corridor from June 2015 in that the relatively sheltered nearshore part of the cable corridor was mainly composed of areas of gently-shelving fine rippled sand with occasional rocky outcrops, whilst larger rocky outcrops and raised platforms become more prevalent as distance from the shore, and hence water depth, increased. In water depths of greater than 30m, the seabed was composed of mixed sediments, boulders and rock outcrops with the quantity of sand present generally decreasing with increasing water depth. The proportion of sandy sediment in the deeper water areas appeared to be greater along the more eastern of the two transects within the cable corridor, probably due to the closer proximity of major sand wave bedforms present to the east of the Sheep Skerry cable corridor.

	
West ROV transect, 9m depth (fine rippled sand)	East ROV transect, 26m (rocky outcrops and raised platforms)

 West ROV transect, 29m depth (boulders and rock outcrops)	 Diver, 67m (boulders and rock outcrops)

Figure 18: Typical imagery from the ROV and diver survey, 2015, along the Sheep Skerry Cable Corridor

SHORELINE SEDIMENTS AND MORPHOLOGY

In Orkney, sand deposits are a coastal feature within the larger bays. They are often associated with dune systems and a machair type hinterland. Two documented dune systems are noted in close proximity to the landfall of the potential cable corridors of the of BTAL site, namely the bay-dune system of The Ayre (at the shore within the Aith Hope cable corridor) and the bay-dune and machair of Melberry (less than 1km to the west of the Moodies Eddy cable corridor).

Existing Ordnance Survey 1:25k scale mapping denotes the inter-tidal zone of the Aith Hope cable corridor to be predominantly characterised by rock outcrop at either end, with a short (250m) sandy frontage at The Ayre in between. Within the Melsetter (aka Moodies Eddy) cable corridor the inter-tidal is characterised as rock outcrop with, in places, occasional boulders.

THE ARYE

The Ayre of Hoy forms the road link between Hoy and South Walls. It is flanked by the bays of North Bay (to the north) and Aith Hope (to the south). The beach is a consequence of the construction of the road in its present alignment at the beginning of the 20th century. The original ayre consisted of two shingle spits building out towards each other, hinged on shore platforms at either end, and with an intervening narrow channel which was flooded at high tide. When the road was constructed, the natural throughway for sand transport into North Bay through this channel was closed and thus a sand beach began to accumulate on the Aith Hope side of The Ayre.

The Ayre is 0.4km long and is mostly a shingle-based feature, but with the sandy beach and dune present on the Aith Hope flank. The beach has a gradient of ~8° and the backing dune ridge remains low in height, typically at around 4mOD (i.e. only around 2mOD above the general road level). It is also relatively narrow, at its minimum only 2m wide. This has allowed sand to be blow across the road in places. The beach is relatively stable and the dune system is actively building up in general, although is constrained in developing beyond its embryonic character into a full dune-machair system by the presence of the backing road and North Bay.

The dune area is small (0.24ha), comprising only a dune ridge directly adjacent to the road, and contains an area near the strandline colonised by sea lyme grass. The vegetation is of virtually no nature conservation interest (Dargie, 1988) but is considered a successful stabiliser of the dunes (Mather *et al.* 1973).

MELBERRY

Melberry Links is situated on the south coast of Hoy in the lee of the promontory formed by the localised outcrop of the Devonian lavas, which form a small headland. This is the largest dune site on Hoy (47.4ha) and is exposed to a short (24km) south-west fetch across the Pentland Firth to the north coast of the Scottish Mainland. Two bays are present, one facing southwest and the other facing south, with sand blown over the intervening headland and inland. It is therefore a bay- dune and climbing dune complex of moderate size. There are small areas of mobile dune and modest amounts of semi-fixed dune. Most of the interior is improved grassland, which dominates the site, plus some arable ground. Overall nature conservation interest is moderate to low (Dargie, 1988).

The southwestern exposed shore is characterised by a fringing beach which has a steep gradient (~8°) and partially overlies the lava platform. It is characterised by a break-point bar near the high water mark, indicating the high energy environment within which it is set. Deep water lies relatively close inshore. Further east of the fringing beach the coastline is a low cliff coast of less than 10m in height, with a fragmented shore platform and cobble geos. The cliffs carry a capping of blown sand which is fixed by vigorous Marram grass growth and which, in turn, overlies a thin capping of till.

The foredune itself is relatively high, frequently exceeding 18m, with a gentle landward slope. Helped by the vigorous growth of Marram grass, it remains relatively stable despite the high energy exposure. The landward elements of the dune and machair system are extremely stable despite being heavily modified by agricultural practices and sand extraction.

The south facing shore is characterised by a thin veneer of sand coving a small area, typically associated with slumping and downcombing of the dune sands during storm conditions, but with outcrops of lava platform, a massive boulder beach and offshore rock skerries being the more extensive features.

6 TIDAL REGIME

The spring tidal range in the western Orkney Islands is around 3 - 4m. The tides around Orkney are the result of the interaction of two independent tidal systems, in the North Atlantic and the North Sea. The tidal waves of both systems have anti-clockwise rotations and the systems reach the Orkney coastline with similar strengths but moving in opposite directions. This produces a net flow of water from west to east and complex interactions among the island sounds and in Scapa Flow.

A local tidal flow modelling study (HR Wallingford, 1986) indicated a weak net easterly residual flow along the northern Scottish coast and within the Pentland Firth. To the west of islands, the east flowing tidal stream divides off Rora Head to form two diverging streams, one to the northeast and the other to the east. Tidal currents experienced can be significant and highly variable, particularly within the Pentland Firth where they can run at up to 5m/s on both the flood and ebb tide. Large eddies form in the lee of islands and can be sudden and extremely variable. However, the main tidal flows tend to be pushed offshore by the rocky headlands which occur around much of the southern Hoy coastline.

The sea region offshore from between Brims Ness and Tor Ness in the Pentland Firth is exposed and consequently complex in terms of the principal oceanographic dynamics. The interation of strong tidal currents through the seabed region with the hard coastline and rapidly shelving bathymetry develops both broad-scale and localised water circulation patterns. To further investigate the tidal regime within the AfL, a series of metocean surveys have been undertaken in three phases of activity, namely:

- Phase 1 – Covering Sites 6 and 8 (Figure), both within the original AfL and no longer of applicability for the revised AfL (and therefore not included in this assessment).
- Phase 2 – Covering Sites 14 and 20 (Figure), both within the revised AfL.
- Vessel-Mounted ADCP (VMADCP) survey (undertaken purely for informing on locations for further metocean surveys within the revised AfL, and therefore not included in this report).
- Phase 3 – Covering Sites 15, 18, 19, 21, 22 and 23 (Figure) within the revised AfL.

This section presents a summary of findings from phases 2 and 3 of metocean survey activity, covering a total of eight locations.

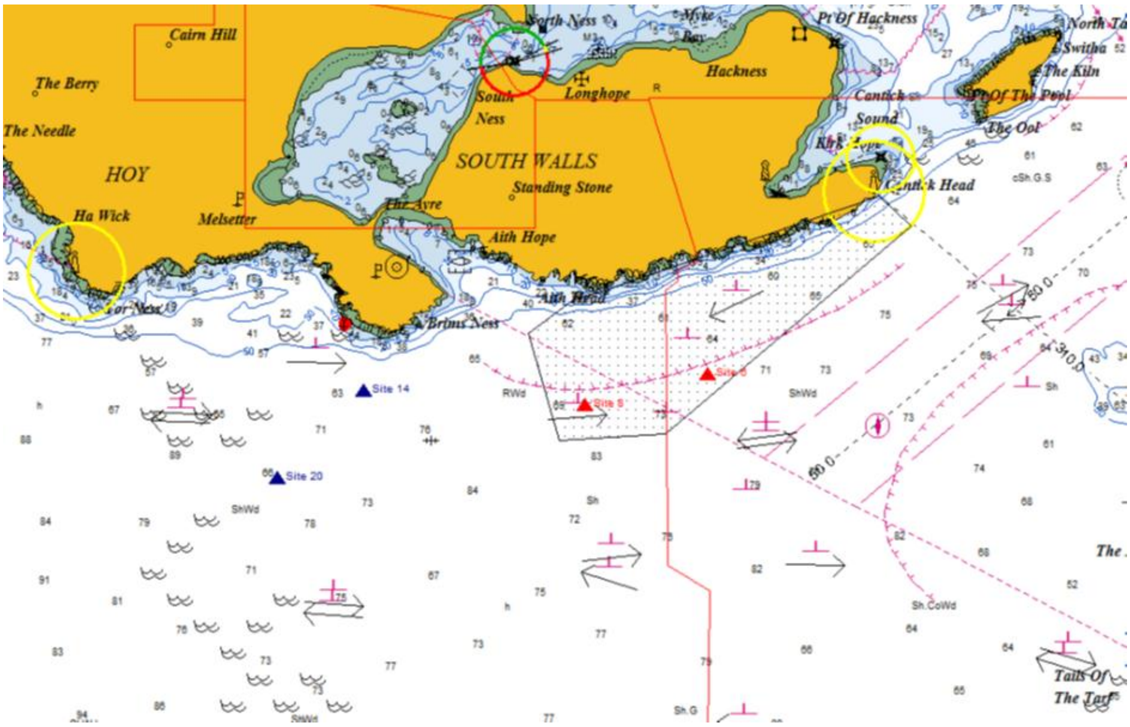


Figure 19: Phases 1 (Sites 6 and 8) and 2 of the Metocean Survey (Sites 14 and 20)

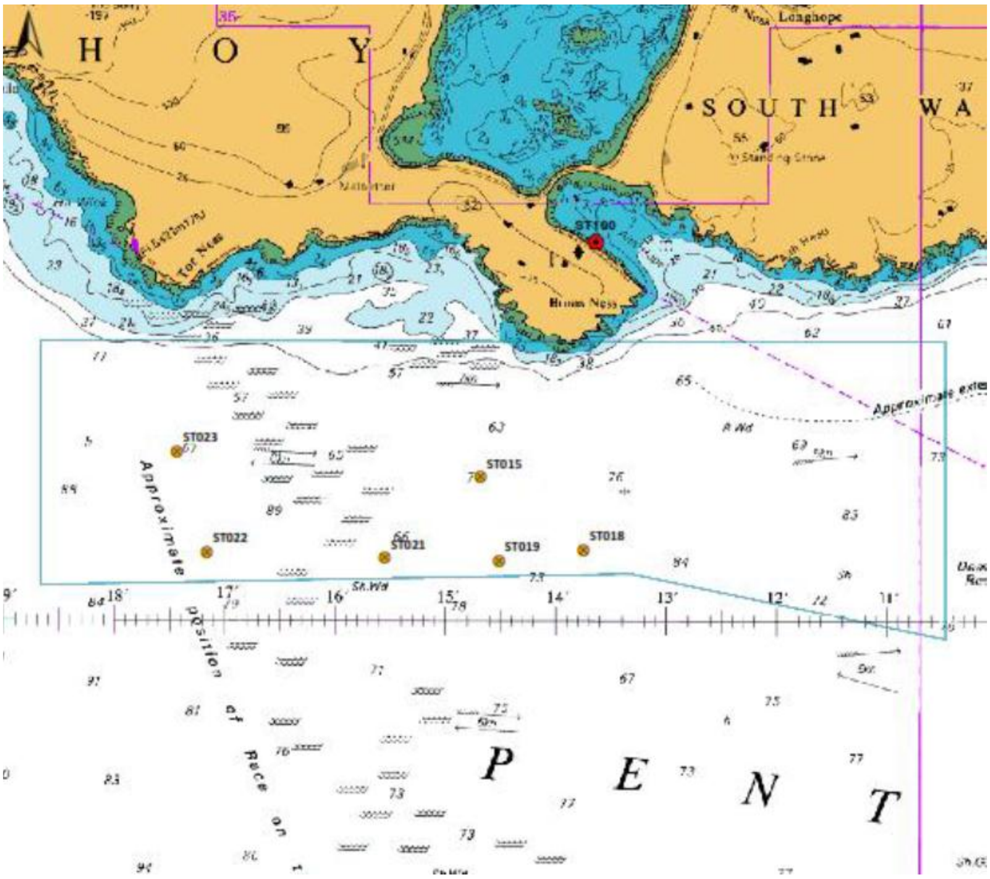


Figure 20: Phase 3 of the Metocean Survey

Instrumented, ballasted stainless steel bed-frames, each containing an upward-looking ADCP and a turbidity sensor, were deployed at each of the eight locations. Deployment details are provided in Table 4.

Table 4: Metocean Survey Deployment Details

Site	Latitude	Longitude	Mean water depth	Start	End
ST014	58° 45.944'N	003° 14.307'W	70m	11-13/06/2011	13/07/2011
ST020	58° 45.371'N	003° 15.388'W	69m	11-13/06/2011	13/07/2011
ST015	58° 45.660'N	003° 14.663'W	73m	31/05/2012	Remains on seabed
ST018	58° 45.331'N	003° 13.862'W	80m	02/07/2012	02/07/2012
ST019	58° 45.291'N	003° 14.528'W	75m	30/05/2012	30/06/2012
ST021	58° 45.292'N	003° 15.604'W	68m	02/07/2012	05/04/2013
ST022	58° 45.233'N	003° 17.100'W	85m	31/05/2012	30/06/2012
ST023	58° 45.820'N	003° 17.350'W	71m	31/05/2012	30/06/2012

No data was recovered from site ST015 due to the equipment not being recoverable from the seabed and no data was recorded at site ST018 due to problems with local creel fishermen.

At each site the instrumentation sensors were positioned 0.7m above the seabed and the instruments mounted on the bed-frames recorded:

- Tidal current velocities (magnitudes and directions) as profiles through the water column (1, 5 and 10 minute averages);
- Turbulent kinetic energy as profiles through the water column (5 minute averages);
- Water depths;
- Waves (wave heights, periods and directions) (30 minute averages); and
- Turbidity (phase 3 survey only).

This section covers aspects relating to the tidal regime. Wave conditions and turbidity are covered in sections 7 and 8, respectively.

As ADCP data can be affected by bedframe displacements, fish passage, ship wakes and turbulent cavitation, quality control analysis was undertaken of each dataset. Ancillary parameters (water temperature and instrument pitch, roll and heading) were recorded for such purposes.

The mean water depths and tidal ranges measured at each of the eight deployment locations are summarised in Table 5. These show a spring tidal range of around 4m.

Table 5: Water level measurements from metocean surveys

Parameter	Phase 2		Phase 3					
	Site 14	Site 20	Site 15	Site 18	Site 19	Site 21	Site 22	Site 23
Mean water depth	70m	69m	73m	80m	75m	68m	85m	71m
Neap tidal range	2.8m	2.8m	No data	No data	2.4m	2.8m	2.6m	No data
Spring tidal range	3.8m	3.9m	No data	No data	3.9m	4.4m	3.9m	No data

At all deployment sites, there was a clear correlation between tidal phase and measured currents through the water column. Additionally, current velocities were lowest at the bed and generally highest a few metres below the free water surface at all deployment sites. Depth-averaged current speeds, current roses, current velocity times series through the water column, current velocity profiles through the water column and turbulent kinetic energy density time series through the water column are presented for each site in the ADCP Data Reports (Partrac, 2011 & Partrac, 2013). Box A presents a summary of the characteristic tidal currents at each site and Box B presents the measured flow turbulence.

Box A – Tidal Currents

Site 14

Current speeds at 15m above the seabed reached a peak value of 3.20m/s on spring tides and 2.45m/s on neap tides, with mean values of 1.58m/s (spring) and 1.15m/s (neap). Peak currents are notably greater on the ebbing tide than on the flooding tide during both spring and neap tide cycles. The principal axis for tidal currents is aligned very strongly W-E.

The tidal signature at Site 14 shows an interesting multiple peak characteristic on the flooding tide and at times a complex flow pattern through the water column, with on occasion the top 20m or so of the water column starting to ebb whilst the rest of the water column exhibits continued flooding.

Site 20

Current speeds at 15m above the seabed reached a peak value of 3.27m/s on spring tides and 2.36m/s on neap tides, with mean values of 1.92m/s (spring) and 1.37m/s (neap). Peak currents are very slightly greater on the ebbing tide than on the flooding tide during spring tides, but very slightly greater on the flooding tide than the ebbing tide during neap tides. The principal axis for tidal currents is aligned strongly W-E. The tidal signature at Site 20 shows a more uniform current magnitude and direction with depth than was observed at Site 14. These tend to be more in keeping with broader-scale tidal dynamics.

Site 19

Depth-averaged current speeds reached a peak value of 3.63m/s on spring tides and 2.61m/s on neap tides, with mean values of 1.90m/s (spring) and 1.42m/s (neap). Peak currents are very slightly greater on the flooding tide than on the ebbing tide during neap tides, but the reverse during spring tides. The principal axis for tidal currents is aligned strongly W-E.

Box A – Tidal Currents

Site 21

Depth-averaged current speeds reached a peak value of 3.87m/s on spring tides and 2.91m/s on neap tides, with mean values of 1.93m/s (spring) and 1.29m/s (neap). Peak currents are slightly greater on the ebbing tide than on the flooding tide. The principal axis for tidal currents is aligned strongly W-E.

Site 22

Depth-averaged current speeds reached a peak value of 3.45m/s on spring tides and 2.36m/s on neap tides, with mean values of 1.75m/s (spring) and 1.33m/s (neap). Peak currents are slightly greater on the ebbing tide than on the flooding tide during sprint tides, but almost exactly symmetrical during neap tides. The principal axis for tidal currents is aligned generally W-E.

Site 23

Depth-averaged current speeds reached a peak value of 3.86m/s on spring tides and 2.66m/s on neap tides, with mean values of 2.04m/s (spring) and 1.50m/s (neap). Peak currents are very slightly greater on the flooding tide than on the ebbing tide during spring tides, and slightly stronger still during neap tides. The principal axis for tidal currents is aligned Wand WNW to ESE.

At both Sites 22 and 23, the tidal dynamics on the flood tide are complicated by the actions of the tide running along the south-west coast of Hoy, past the Needles and Ha Wick.

Box B – Turbulence

Short-term fluctuations in tidal stream flow resulting from turbulence are site-specific and temporally-variable phenomena. Nonetheless, they are important issues to consider for robust evaluation of the performance of a tidal turbine. Turbulence was assessed using the Reynolds stress tensor approach (sometimes known as the Variance Method) as presented in Lu & Lueck (1999) and Osalusi et al. (2009). The mean flow over a short duration (e.g. 10 minutes) was computed and then subtracted from instantaneous velocities using a Reynolds decomposition approach. The off-diagonal stress terms, which represent the vertical flux of the horizontal momentum deficit and depicts the transport of momentum within the flow (either towards or away from boundaries), are used to estimate the turbulent kinetic energy (TKE). The TKE density, which is equal to the standard deviation of the fluctuating velocities, is generated through the conversion of kinetic energy of the mean flow into TKE by shear-driven instabilities.

At all sites, the TKE gradient is relatively small in general, except for close to the seabed and near the free water surface, probably due to shear effects and wave-current interactions, respectively.

Site 14

The maximum observed TKE was 0.56m2/s2, with peaks generally associated with the stronger mean flows, for example during spring tides. Turbulence is greater on the ebb tide (due to the stronger current velocities) than on the flood and there is a strong correlation between the shear stress due to the combined effects of wave-current interaction and tidal phase, suggesting that the turbulence is largely due to fluctuation in the current velocity.

Box B – Turbulence

Site 20

The maximum observed TKE was 0.32m2/s2, with peaks generally associated with the stronger mean flows, for example during spring tides. As observed at Site 14, turbulence is greater on the ebb tide than on the flood, although the ebb and flood currents are more closely aligned at Site 20 than at Site 14 where ebb currents are notably stronger. Notable peaks in the turbulence occurred close to the water surface, suggesting the importance of wave-current interaction.

Site 19

The maximum observed TKE was 0.6m2/s2, with peaks generally associated with the stronger mean flows, for example during spring tides.

Site 21

The maximum observed TKE was 2.5m2/s2, with peaks generally associated with the stronger mean flows, for example during spring tides.

Site 22

The maximum observed TKE was 0.5m2/s2, with peaks generally associated with the stronger mean flows, for example during spring tides.

Site 23

The maximum observed TKE was 0.6m2/s2, with peaks generally associated with the stronger mean flows, for example during spring tides.

Results from the metocean surveys indicate that whilst the broad-scale tidal circulation patterns are predictable, given the dominance of the tidal signal at the site, shorter and more localised circulations patterns can be caused by more random water column structures. There is an usual multiple peak in currents during the ebb phase in particular which indicates the energetic and unsteady nature of the regional flows.

A phase difference in timing is apparent across the area, as demonstrated through use of data from the second survey campaign, covering Sites 14 and 20 (Figure 21: Comparison of tidal phases measured at Sites 14 (inshore) and 20 (offshore)). The tidal currents at the more inshore location (Site 14) change direction before those at the more offshore areas (Site 20), in particular at the onset of the ebbing phase. The phase difference is approximately 1 hour for both spring and neap tides and is consistent throughout the measured data record. Despite this lag at the turn of the tide, the tide at Site 20 'catches-up' with that at Site 14 as peak velocities are reached, synchronising with each of the multiple peaks on the ebbing tide.

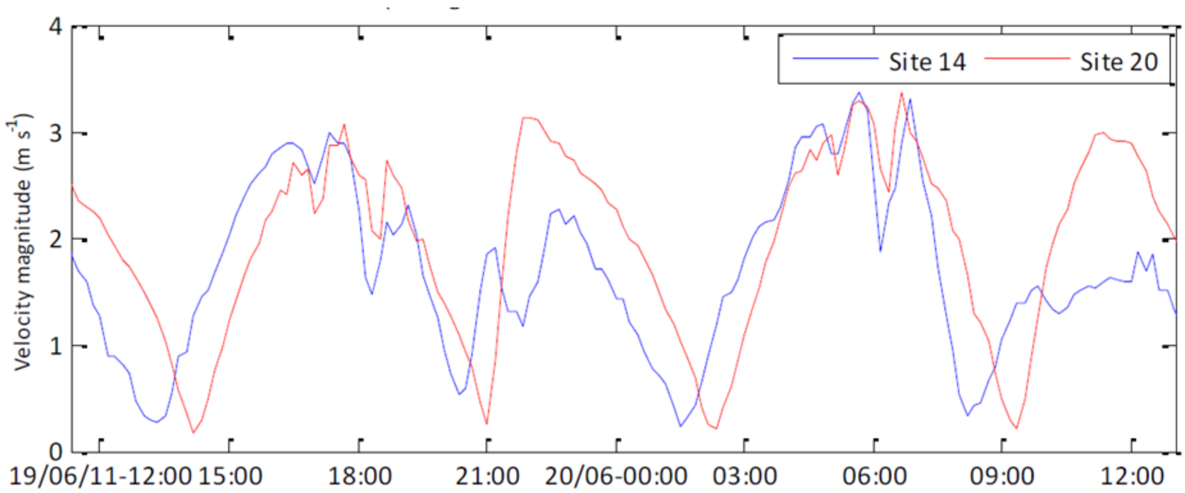


Figure 21: Comparison of tidal phases measured at Sites 14 (inshore) and 20 (offshore)

Figure provides a comparison of velocity magnitude over a single 24 hour period through two flood and ebb tidal cycles from the third survey phase, focusing on Sites 19, 22 and 23. All sites show multi peak velocities between (approximately) the last third of the ebb and the first third of the flood tide. In contrast, in the last third of the flood, single peak velocities are generally observed, with just a minor dip exhibited at Site 23.

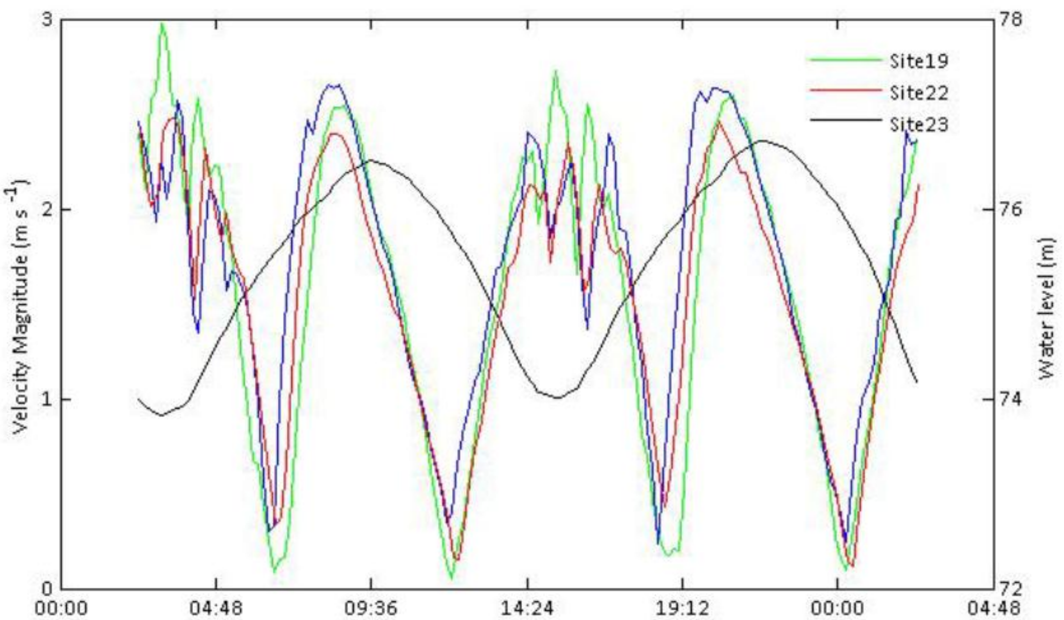
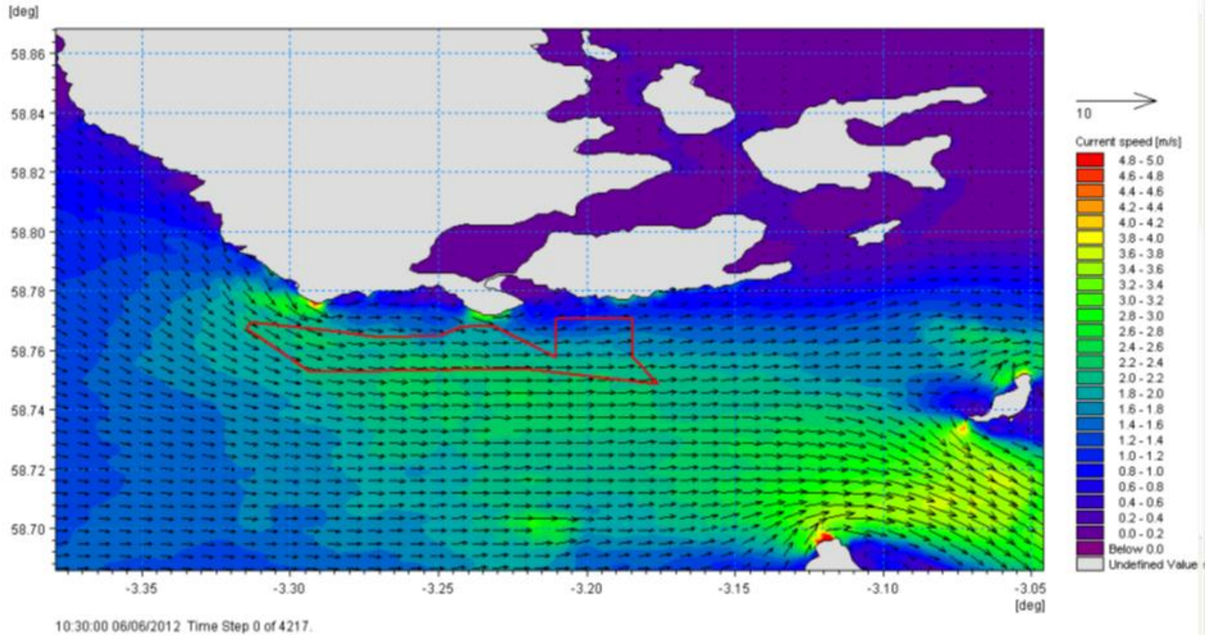
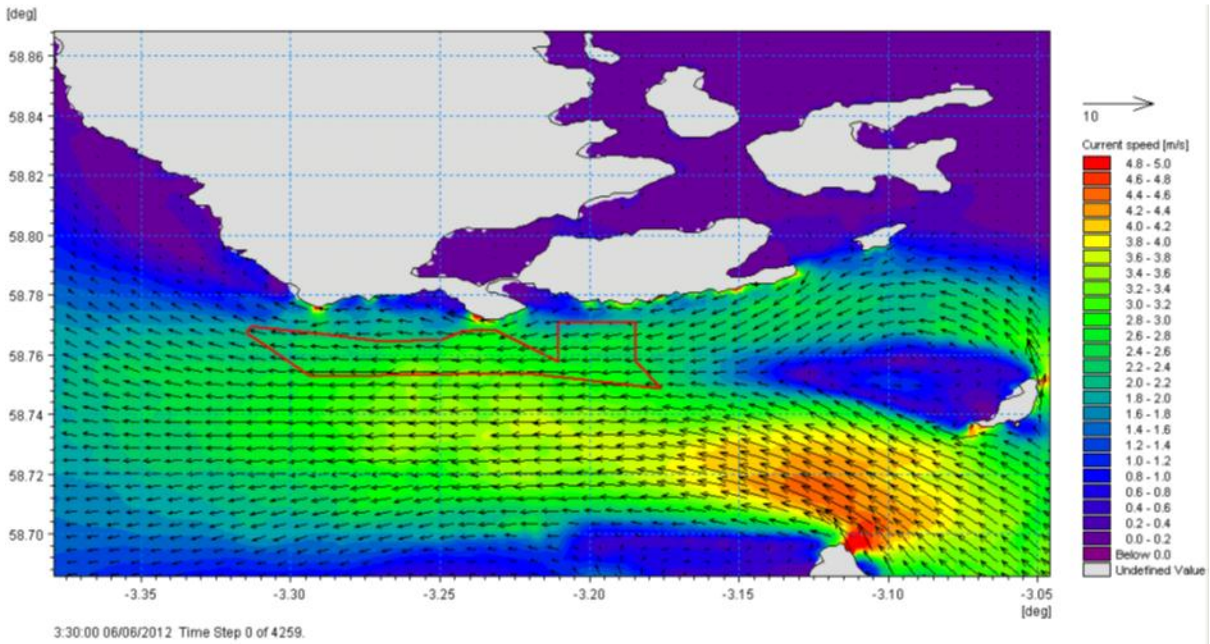


Figure 22: Comparison of tidal phases measured at Sites 19, 22 and 23

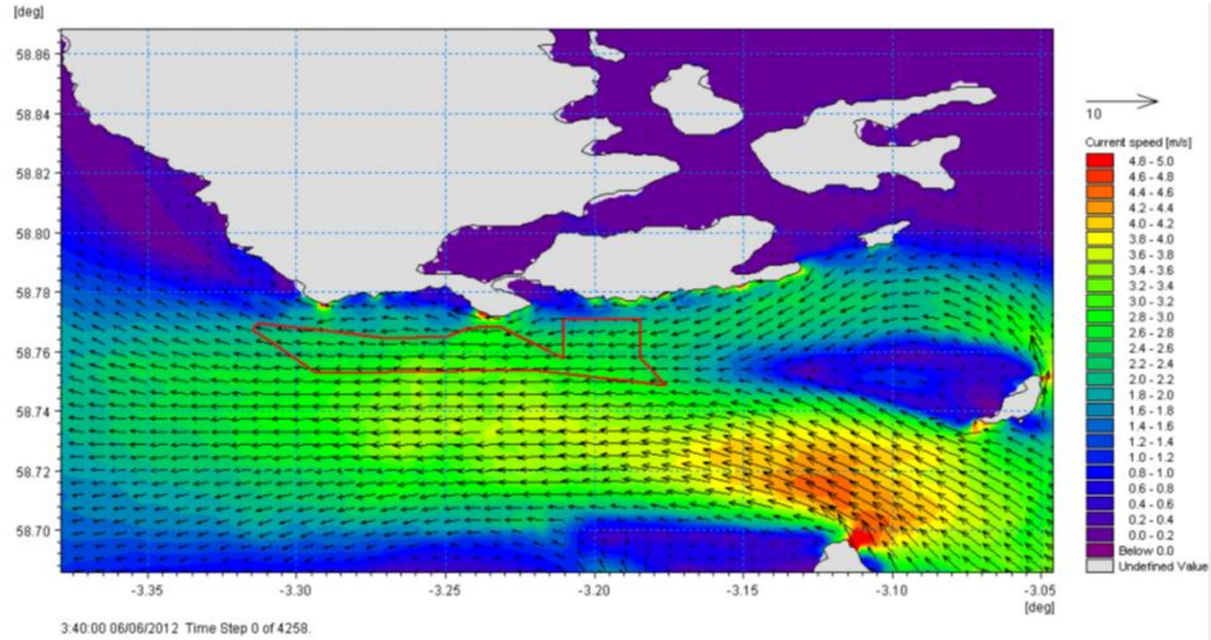
To provide further characterisation of the tidal regime at the AfL and surrounding seabed areas and adjacent shorelines, a MIKE21 hydrodynamic model was set up and run to simulate a spring – neap cycle. Modelled outputs were compared against measured data from the metocean surveys to ensure adequacy of the calibration in terms of water level, current speed and current direction. Figure shows the current velocities (speeds and directions) on a spring tide at the times of: (A) high water; (B) peak ebb; (C) low water; and (D) peak flood.



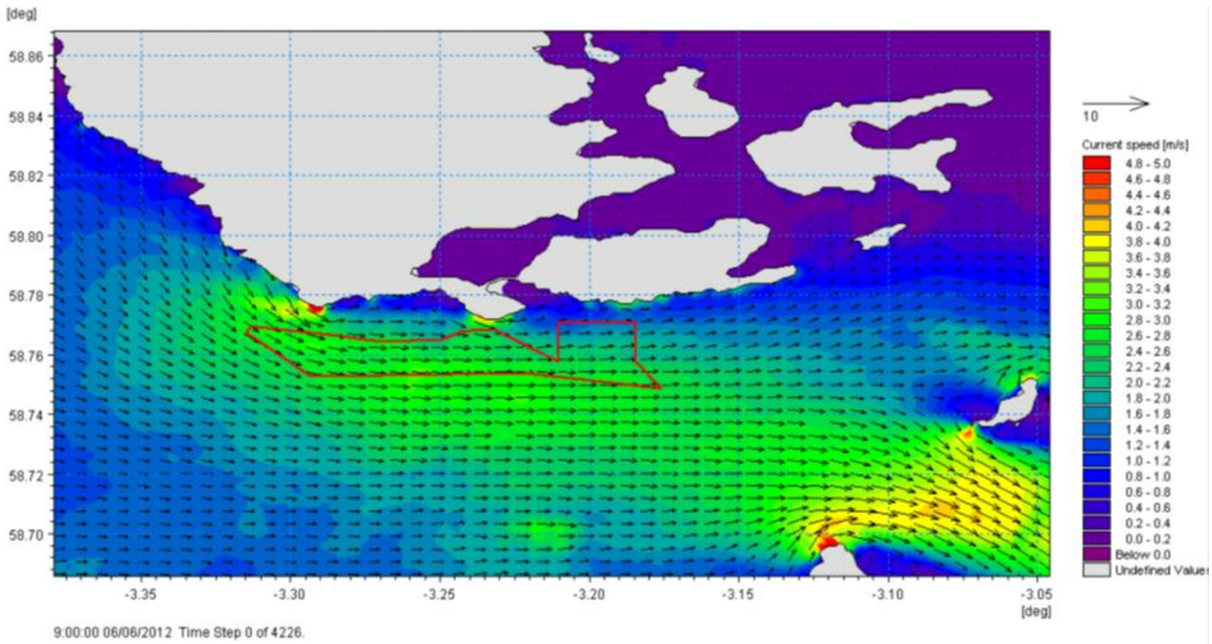
(A) High Water



(B) Peak Ebb



(C) Low Water



(D) Peak Food

Figure 23: Baseline tidal flows at different phases on a spring tide

In keeping with earlier metocean measurements, flows are aligned strongly W-E within the AfL and peak ebb flows are generally greater than peak flood floods, peaking within the AfL in excess of 3m/s but wider across the Pentland Firth exceeding 5m/s in places. There are notable exacerbations in flow around headlands, especially at the time of peak ebb and peak flood flows.

7 WAVE REGIME

Along the south-west coast of Hoy, a combination of deep open water and exposure to prevailing winds produces a high-energy wave climate, especially during north and north-west incident storms. Since the sea floor falls steeply away from the west to 60m, the coast is exposed to relatively high wave energies.

Severe wave conditions (>8m) can be incident from any sector, excluding the southeast. Extreme offshore significant waves heights and associated return periods, calculated using data from the Met Office model are presented in Table 6: Total extreme significant wave heights. It should be noted, however, that the Met Office model has a coarse grid and therefore the results at this point may not take full account of local bathymetry and local current effects.

Table 6: Total extreme significant wave heights

Return Period (years)	Significant wave height (m)
1	10.65
10	12.79
100	14.82

During the aforementioned project-specific metocean surveys, wave heights, periods and directions were also measured by the ADCPs at eight sites to help characterise the wave climate within the AfL. Timeseries of significant wave heights and mean wave periods as well as wave roses are presented for each site in the ADCP Data Reports (Partrac, 2011 & Partrac, 2013). Box C presents a summary of the characteristic waves at each site.

Box C – Waves

Site 14

Significant wave heights reached a maximum of 2.00m, with a mean value of 0.83m. Mean wave periods ranged from a minimum of 4.8s to a maximum of 13.8s. The predominant wave direction was from the W, with the greatest storm waves approaching from between WNW and WSW. The wave field changes according to the tidal phase (ebb or flood). Specifically, during the ebbing tides, waves from the west are higher and steeper. This effect is not seen during the flooding tide.

Site 20

Significant wave heights reached a maximum of 2.48m, with a mean value of 0.66m. Mean wave periods ranged from a minimum of 4.8s to a maximum of 16.4s. The predominant wave direction was from the W, with the greatest storm waves generally approaching from this direction also, but with storm waves also possible in any sector between WNW and SW.

Site 19

Significant wave heights reached a maximum of 1.72m, with a mean value of 0.84m. Mean wave periods typically ranged between 9.1 and 15.0s. The longer wave periods were generally approaching from the NW. The predominant wave direction was from the W, with waves common from between NW and SW. The greatest storm waves approach from these sectors, but can also approach from between SE and E.

Site 21

Significant wave heights reached a maximum of 4.81m, with a mean value of 1.20m. Mean wave periods typically ranged between 10.6 and 15.0s. The predominant wave direction was from the W.

Site 22

Significant wave heights reached a maximum of 1.98m, with a mean value of 0.88m. Mean wave periods typically ranged between 7s and 13.4s. The predominant wave direction was from the W.

Site 23

Significant wave heights reached a maximum of 1.58m, with a mean value of 0.80m. Mean wave periods ranged from a minimum of 7.1s to a maximum of 15.0s. The predominant wave direction was from the W.

Results from the metocean surveys show that waves are strongly modified by the tidal phasing. During the ebb tide, wave heights are seen to increase by up to 1m due to the tidal currents moving directly against the dominant wave direction, casing waves to steepen. This modulation is not evident during the flooding phase of the tide.

8 SEDIMENT TRANSPORT REGIME

Unconsolidated sediments laid down at the seabed since the sea transgressed across the area following the early Holocene rise in sea level have the potential to be transported as either bedload (‘rolled’ along the seabed) or suspended load (mobilised into the water column). Typically coarser sediment will be transported as bedload and finer sediment as suspended load, but this depends upon the grain size of the particles and the forces exerted on them by the combined effects of wave-induced currents and tidal currents.

BEDLOAD TRANSPORT ALONG THE SEABED

As has been previously stated, the AfL consists predominantly of outcropping bedrock, with very little discernible sediment cover. This is due to the very strong tidal currents which sweep mobile sediment away, unless it becomes deposited within faults and crevices in the rock structure. There are, however, some identifiable patches of sediment cover within the AfL, especially along the northern boundary of the AfL, in particular where both the Melsetter (aka Moodies Eddy) and Aith Hope cable route corridors enter the AfL and within a localised sediment patch in the southwestern corner of the AfL.

Importantly, it should also be recognised that the AfL is located within a broader-scale bedload sediment transport regime which covers a regional area of seabed, i.e. the wider Pentland Firth. This has previously been investigated based upon the collation and interpretation of existing data and information (Halcrow, 2009). It is important to understand this broader scale sediment transport regime since any significant change in the tidal or wave regimes could, potentially, have knock-on effects in terms of sediment transport within the regional scale context. There are several key components to this broader-scale system.

1. There is a field of sandwaves/transverse bedforms further to the west of the AfL. These are reported as being most identifiable at around 10 km to the west, but minor bedforms are resolvable in the datasets between that point and around 3km to the west of the AfL. These features are indicative of westward-directed net bedload sediment transport from a seabed parting zone (described below).
2. There is a large sandbank with three topographic highs on the seabed offshore from, and to the east of, South Ronaldsay, with sandy gravel or, especially, gravelly sand sediment cover over extensive areas of the seabed further to the east. There is a postulated eastward-directed net bedload sediment transport from a seabed parting zone (described below) to these areas of seabed.
3. Between these two sedimentary zones, there is a wide area within the Pentland Firth (including the seabed covered by the AfL) with no significant sediment cover and instead extensive areas of tide-swept exposed bedrock are evident. This area of seabed is characterised as a bedload sediment parting zone, with any sediment being rapidly transported either to the west or to the east from this parting.

BEDLOAD TRANSPORT ALONG THE SHORELINE

The existing beach sediments around the Orkney Islands (in general) are derived from a combination of eroded glacial till, erosion of sandstone cliffs and from shell material. Sands and gravels notable for their high biogenic carbonate content form the sea-bed sediments around the Orkney Islands. Much of the gravel around the islands, particularly to the north and east, is composed predominantly of shell debris. These carbonate deposits reflect the rich littoral and sublittoral fauna that exists around the Orkney Islands.

There is little documented detail on bedload transport patterns at the shoreline. The coastline is a high energy environment dominated by wave processes. In the south, the isles are rocky and subject to harsh wave conditions. Consequently most beaches experience long term coastal and cliff erosion.

The shoreline at the landfall of the Aith Hope cable corridor is predominantly characterised by rock outcrop at either end, with a short (250m) sandy frontage at The Ayre in between, which is backed by sand dunes. Given that the beach-dune system at The Ayre is confined between the rock outcrops at either end and, further, is protected against waves approaching from all directions except south-easterlies by the rocky land masses of Brims Head and South Walls, the beach sediment is considered relatively stable, except under south-easterly storms when foreshore lowering and dune front erosion is expected to occur. There is likely to be litte alongshore sediment movement, but measurable onshore-offshore sediment movement as a consequence, although during calmer wave conditions, sediment is likely to progressively return to the beach to slowly naturally replenish the foreshore and dunes over time.

The shoreline at the landfall of the Melsetter (aka Moodies Eddy) cable corridor is characterised as rock outcrop with, in places, occasional boulders. As a consequence, there is no significant bedload sediment transport along this frontage, other than the movement of occasional boulders during storms. Importantly, there is no sediment present on the shoreline at this location that is transported to feed the bay-dune and machair system of Melberry (located less than 1km to the west of the Melsetter (aka Moodies Eddy) cable corridor).

SUSPENDED LOAD TRANSPORT

During phase 3 of the metocean surveys undertaken within the AfL, turbidity in the water column was also measured by turbidity sensors at six sites. Sensors measured the turbidity of the water column at a distance of 0.7m off the seabed, recording raw data as Normal Turbidity Units (NTU). These values were converted into suspended sediment concentrations (SSC) through statistical calibration using sediment captured from the sediment traps on each bed-frame.

Timeseries of suspended sediment concentrations are presented in the ADCP Data Reports (Partrac, 2011 & Partrac, 2013). Box D presents a summary of the characteristic suspended sediment concentrations at each site.

Box D – Suspended Sediment Concentrations

Site 19

The total suspended sediment concentration in the water column was consistently <3mg/l except for one specific even when values temporarily reached 104mg/l, but quickly reduced back to nominal levels.

Site 22

The total suspended sediment concentration in the water column was consistently ~20mg/l except towards the end of the monitoring when they increased to a peak of 63mg/l.

Site 23

The total suspended sediment concentration in the water column was consistently <3mg/l except towards the end of the monitoring when they increased to ~70mg/l (although with a single localised peak of 109mg/l).

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