8 GEOLOGY AND SEDIMENTS

8.1 Introduction

The 2001 Offshore EIS considered the impacts on the geology and surface sediments associated with the drilling of offshore wells, construction of an offshore pipeline and associated landfall terminating in an underground chamber. It also covered the issues surrounding the two crossings of Sruwaddacon Bay.

As detailed in Section 3, since 2001 much of the construction work has been undertaken on the pipeline route. This includes work in Broadhaven Bay undertaken during the summers of 2002 and 2005, which involved the construction and subsequent reinstatement of a marine trench leading to the proposed landfall site. During 2008 the landfall and nearshore areas were prepared for the installation of the offshore pipeline. This included the excavation by land-based and marine equipment of a trench extending approximately 2km into the bay from the landfall. In 2009 the trench in Broadhaven Bay was re-excavated using dredging vessels and the offshore pipeline and treated surface water discharge pipeline were fully installed. Also in 2009, construction works commenced for scour protection/stability measures for the offshore pipeline in Broadhaven Bay. These works were subsequently suspended, An initial filter layer of protected rock was placed over the offshore pipeline between KP 80 and 81.5, where an outcrop of rock had resulted in free spanning. Trenching was suspended in this area.

This section presents new data that has been acquired since 2001 as a result of further survey work that has been carried out during the development of the project. This includes information generated from surveys at the landfall, in the intertidal and nearshore area of the pipeline route through Broadhaven Bay, and in the area of the Corrib field. The potential impacts to the geology from installation and operation of the section of pipeline between the landfall (including the landfall valve installation (LVI)) and the terminal itself are discussed in the RPS Onshore Pipeline EIS 2010.

It is noted that nearshore construction activity was undertaken in Summer 2008 and subsequently suspended, and that works continued in 2009, when the majority of offshore works, including installation of the pipeline occurred. The remaining offshore construction work is planned for the forthcoming summer period (2010), and the umbilical installation between the field and the landfall is scheduled for 2011. It is therefore acknowledged that some construction-related impacts will have a greater duration than originally envisaged.

8.2 Study Methodology

A number of surveys have been undertaken during the development of the project including:

- 2000 – baseline surveys of Corrib Field and pipeline route (for 2001 Offshore EIS purposes);
- 2002 – pre-construction survey in Broadhaven Bay (to establish baseline for planned pipeline installation in 2002);
- 2005 - pre-construction survey (intertidal) in Broadhaven Bay and Sruwaddacon Bay;
- 2005 – baseline survey around permittted outfall location off Erris Head (to begin development of baseline data set);
- 2007 – repeat of 2000 survey along pipeline route, verifying to update baseline information (to support 2008 Onshore Pipeline and Section 40 Application);

- 2007 - additional baseline survey off Erris Head (providing further baseline information against which any future impacts from proposed discharge could be measured);
- 2008 – pre-construction survey of subtidal and intertidal (landfall) sediments in Broadhaven Bay (repeat of 2002 survey, to establish baseline for planned pipeline installation in 2008);
- 2008 – post-drilling survey in Corrib Field to monitor impact of operations;
- 2008 - additional baseline survey off Erris Head, establishing baseline against which any future impacts could be measured;
- 2009 – construction-related geophysical surveys of pipeline route; and
- 2009 – programme of post-construction monitoring of subtidal and intertidal (landfall) sediments in Broadhaven Bay. Whilst post construction monitoring commenced in 2009 these results are not yet available but will be reported in due course.

In 2000, baseline surveys were conducted along the proposed pipeline route and in the area of the offshore gas field as part of the 2001 Offshore EIS. Further pre-construction surveys were conducted in Broadhaven Bay in 2002 in advance of proposed pipelaying operations.

During 2007 and 2008, many of the sites along the proposed pipeline route, at the treated surface water outfall location, and in the area of the offshore gas field that were previously sampled in 2000 and 2002 were revisited using various vessels including the research vessel R/V *Prince Madog*, the M/V *Nomad* and the M/V *Deepworker* and additional samples were taken. The 2007 surveys were undertaken to verify the findings of the 2000 baseline surveys to support the 2008 Onshore Pipeline and Section 40 application. The 2008 surveys were undertaken to verify the findings of the 2002 baseline surveys as agreed with the Marine Institute and DCMNR in 2002. A number of additional surveys were undertaken in 2008 in order to supplement the baseline data previously collected.

Sampling in 2007 and 2008 consisted of grab sampling, the collection of soft surface sediment (for grain size and chemical analysis), and photography. Photography consisted of images of the intact seabed surface and sediment profile imagery (SPI), whereby an image of a vertical cross-section through the surface sediment is taken. The results of the survey work from 2007 along the offshore pipeline route and 2008 at the offshore gas field are presented in Appendix 7-1 and 7-2 respectively. Section 8.3 below, which describes the superficial sediments in the area of the Corrib offshore field, along the pipeline route, and at the treated surface water outfall location, has been updated to reflect the new information which has been collected. The sediment descriptions as defined by their class size are based on the Udden-Wentworth classification system, which is the preferred method for describing particle size distributions.

8.3 Receiving Environment

8.3.1 Quaternary Geology and Superficial Sediments

Figure 8.3 of the 2001 Offshore EIS presents the full overview of the superficial geology as it relates to the pipeline route. In 2007**,** an updated offshore pipeline route survey was carried out, the results of which are discussed below.

8.3.1.1 The Offshore Gas Field

Figure 8-1 shows the locations at the offshore field at which seabed sediment samples were taken for physico-chemical analysis in 2008.

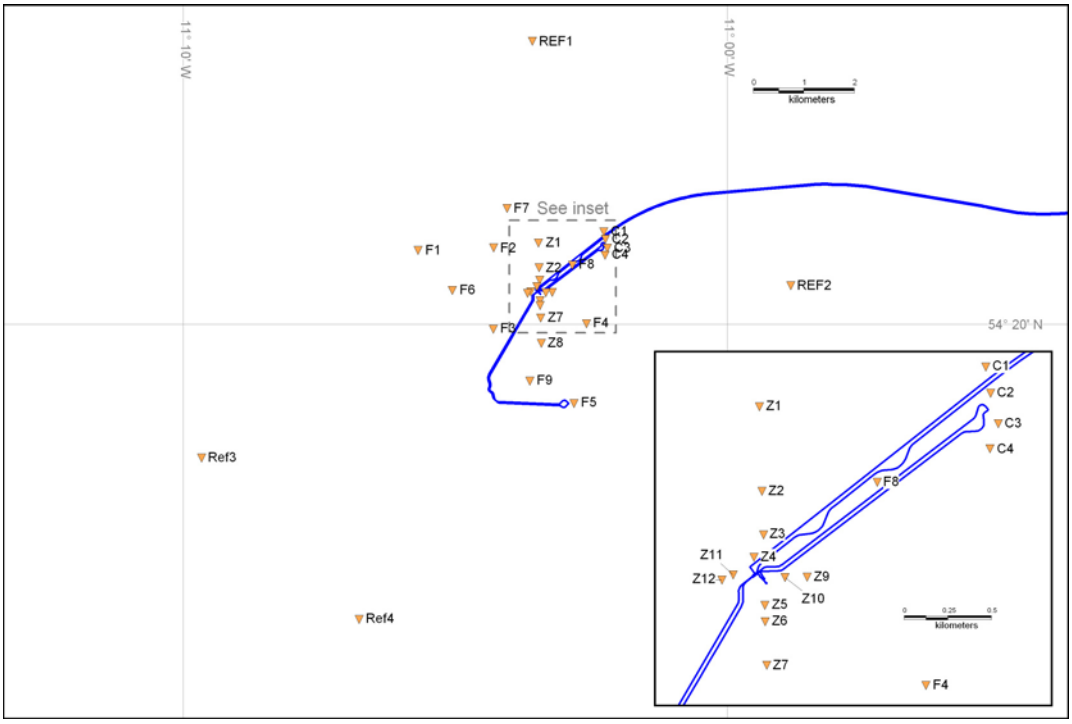

Figure 8-1: Seabed sediment sampling locations at the offshore gas field

As mentioned in Section 7, the benthic survey in 2008 comprised sediment sampling by grab sampler, and photographic sampling of the seabed primarily using a double Van-Veen grab of 0.2m^2 (2x0.1m^2) and a surface and sediment profile imagery (SPI) camera system. A total of twenty-nine locations were visited.

At each station, four replicate samples were obtained; sediment for physico-chemical analysis was subsampled from the 4th replicate.

Subsamples were taken for the following physico-chemical analyses:

- Particle Size Analysis;
- Organic Chemistry; and
- Inorganic Chemistry.

The predominant component of the sediment at the offshore gas field is sand (approximately two thirds in the majority of cases) while the remaining third is predominantly mud. Gravel was only recorded in small quantities at sample site F1.

The SPI photography tended to confirm the results of the particle size analysis in that all of the stations that were investigated at the offshore gas field were characterised by the presence of very fine sands.

Total organic carbon levels are generally low, as would be expected in sediments where there are low levels of fine material (mud).

Total organic extracts (TOE) were analysed to detect any saturated hydrocarbons (including anthropogenic hydrocarbons such as drilling related base-oils) that may be present in the sediment. Concentrations of TOE in the samples are considered consistent with 'background' levels as previously seen at the offshore gas field (Benthic Solutions Limited 2006, RSK 2007 and 2009 (Appendix 7-1 and 7-2).

TOE concentrations were higher than those found at inshore sites. All sites had values in excess of 0.005mg/kg (typically ca. 0.01mg/kg) whereas around the treated surface water outfall to the north of Erris Head, the concentrations, with the exception of site S10 (0.014mg/kg), were <0.005mg/kg and in one case <0.001 mg/kg.

Ecomul was only detected at two sites (Z4 and Z10) and Ecosol only at site F1; albeit all in low concentrations.

Most of the sites at the Corrib offshore field had metal concentrations very similar to those observed closer inshore, near Erris Head, with no readily discernable distribution pattern, which further reflects the pristine nature of the location. The marked exception however, was the significantly elevated concentrations of barium found at several sites: in some cases up to 200-fold greater than background values. These values are the consequence of local drilling activities. This is discussed in more detail in Section 8.3.1.5.

The data sets for metals and hydrocarbons reflect a pristine environment. With the limitations of differing pre-treatment and subsequent analytical methods, the data are in accordance with other published work. With the exception of barium (and possibly some PAHs) in the vicinity of the Corrib offshore field, there is little evidence of significant variations from typical background levels. The elevated concentrations are almost certainly a consequence of local drilling activities.

No determinants were found at concentrations that would give rise to concern regarding potential biological impacts.

8.3.1.2 The Offshore Pipeline Route

The 2007 verification survey locations along the pipeline route, and their positions relative to the pipeline end manifold (PLEM) in the Corrib offshore field (kilometre points – KPs) are presented in Figure 8.2. The 2007 offshore pipeline route verification survey was a repeat of the original survey undertaken in 2000, for the 2001 Offshore EIS.

The 2002 and 2008 nearshore surveys provided additional information regarding the benthic environment to that obtained from previous surveys. Both surveys were undertaken as pre-construction baseline surveys, scheduled to take place immediately prior to the summer 2002 and 2008 Broadhaven Bay construction periods. These surveys relate only to the section of the offshore pipeline route through Broadhaven Bay, which is described in the 2001 Offshore EIS between KP 77.0 – KP83.2. Figure 8.3 shows the sampling locations and transects sampled during the 2008 Broadhaven Bay survey, which revisits the same transects on the nearshore pipeline route that were sampled in 2002.

Descriptive text from the 2001 Offshore EIS is only presented where the section of the pipeline route to which it relates has been sampled more recently. The sedimentological descriptions follow the methodology used in the 2001 Offshore EIS.

It should be noted that the 2001 Offshore EIS also provided a baseline description for the “northern route”, an optional pipeline route that was investigated to provide an alternative route around what was considered a difficult area of seabed off Erris Head. The northern route has since been discounted as an option, as it has been possible to route the pipeline through the area off Erris Head, which is a more direct approach. The route shown in Figure 8.2 is the one along which the pipeline has been constructed.

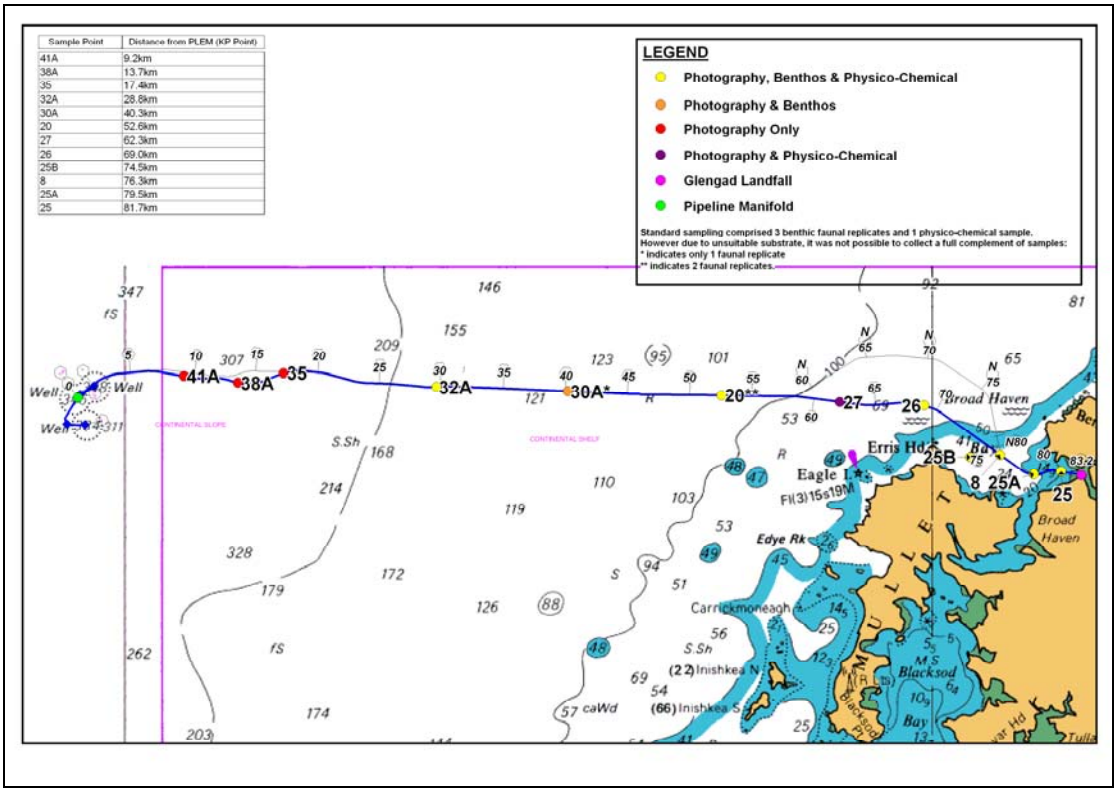

Figure 8.2: Offshore Pipeline Route Seabed Sample Locations - 2007

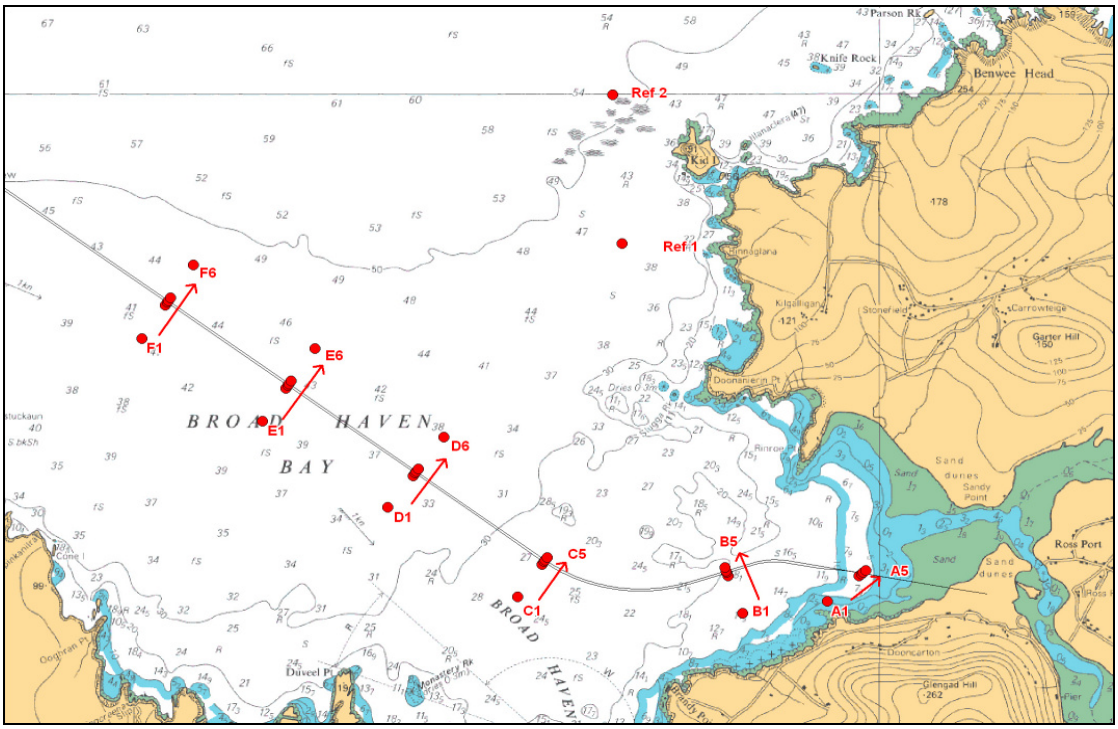

Figure 8.3: Locations of the Drop-Down Video and Grab Sample Sites in Broadhaven Bay from the 2008 nearshore pipeline survey

KP4.5–KP 28.0

Sampling was attempted at three locations (41A, 38A and 35, at KPs 9.2, 13.7 and 17.4 respectively) within this section of the pipeline route. Attempts at all three locations, even using two different types of grab, were relatively unsuccessful. This was due to small stones becoming trapped in the jaws of the grab, which allowed much of the finer material to be washed out during retrieval through the water column. At all three locations, however, photographs of the surface of the seabed were successfully taken (see Appendix 7-1). It can be seen from those photographs and SPI images (in the same Appendix) that the sediments are generally muddy, but also contained many small stones, sand and shell fragments.

These results compliment those from 2000, where the sediments are described in this area as muddy with gravel and occasional boulders.

KP28.0–KP45.1

In 2007, a grab sample was taken from station 32A, at KP 28.8. Data from that sample indicates that the sediment was classed as very coarse sand with some gravel. The seabed photography shows the sediment to comprise coarse sand, with many small stones and shell fragments. Repeated attempts to collect a sample at station 30A (KP 40.3) failed, with pebbles being trapped in the jaws of the grab. The seabed photographs from 30A recorded occasional cobbles (likely to be glacial erratics with the overall seabed sediment similar in nature to that at site 32A).

These observations correspond with those recorded in 2000 (for the area between KP 40.5–45.1), which were stated as coarse gravel, cobbles and small boulders with only an occasional sandy veneer and thicker sand patches in places.

KP50.45–KP58.0

In 2007, repeated sampling using two types of grab was attempted at station 20, at KP (52.6). No successful samples were obtained, with grabs invariably returning only pebbles; many grabs were returned empty, indicating a compact impenetrable seabed. One of the surface photographs taken shows gravelly sediment, while the remaining two record sandier sediment with shell fragments.

The 2007 results in this area generally concur with the 2000 assessment of the seabed, which was stated to be a weathered till material comprising a hard, gravelly sandy clay with coarse gravels/cobbles.

KP58.0–KP65.35

Small samples of surface sediment were collected at station 27 (KP62.3) in 2007, possibly indicating well-packed sediment. Samples were classified as medium sand. Imaging at this site indicated sandy sediments and some shelly gravel. Rippling indicated sediment transport in this area, which concurs with 2000 data. Overall, sediment data also agrees with the 2000 conditions of gravelly sand covered by a rippled veneer of sand.

KP66.7–KP70.55

Station 26 (at KP69) was successfully sampled in 2007, being classified as very coarse sand with some shells. Surface photography at this site clearly shows a coarse shelly sand and abundant intact shell material, with patchy finer sand.

2007 data therefore agree with 2000 data of sandy gravels covered by a slightly rippled sandy veneer, suggesting active sediment transport.

KP70.55–KP77.0

At station 8 (KP76.3), sediment was successfully sampled in 2007 and classified as fine sand. Waveforms of around 8cm were recorded photographically here, indicating significant sediment movement. Occasional shell material in the sand was also observed.

These results are in general agreement with 2000 data.

KP77.0–KP83.2 Broadhaven Bay

Sediment at stations 25A (KP79.5) and 25 (KP81.7, the most inshore of stations) within inner Broadhaven Bay were sampled successfully in 2007 and can be classified as sand (Folk) or medium sand (Udden-Wentworth). Photography at station 25a supported this data and also recorded some rippling of surface sediment; no apparent bedforms could be discerned from images at station 25.

2002 Broadhaven Bay – Baseline survey

In 2002, EcoServe was commissioned to sample seabed sediment along six transects (A-F), which were positioned across the route of the pipeline through Broadhaven Bay. There were 6 stations on each transect, positioned 10, 50 and 500m either side of the route. In addition to the 36 stations on the 6 transects, 2 further stations were sampled as reference stations.

Sediment grab samples & granulometric analysis

A sub-sample of sediment was taken from the first successful grab sample at each station, labelled and sent for further analysis in the laboratory. The results were then compared with standard sediment scales (Wentworth, 1922).

Analysis of the sediment grain size showed that the seabed of Broadhaven Bay is generally comprised of sand. When using the scale developed by Wentworth (1922), the seabed varies from very coarse sand to medium sand with very low or no 'silt' or 'mud' present. The majority of the sites towards the inner bay (Transects A – D) are medium sand apart from site A1, which is very coarse sand; at this station, the number of taxa recorded was also low. This A1 site is shallow (11.2m BSL) and adjacent to bedrock outcrops on the south side of the bay. It is likely that the close proximity of the hard substratum locally intensifies the water movement as a result of wave action causing an increase in mobility of the sediments and the consequent winnowing out of the finer fraction.

The granulometric analysis shows that there is a very slight gradient from medium sand to coarse sand towards the head of the bay, which is a common situation due to the higher energy regimes closer to the shoreline. An increase in sediment movement may result in the loss of the finer sediment particles resulting in generally coarser sediment than the rest of the bay.

The results of the granulometric analysis are given in full in Appendix 7-5. No sediment samples were analysed from stations B1, B6, D6, F6 and Ref 2, as the seabed comprised bedrock and boulders.

2008 Broadhaven Bay – Baseline survey

As described in Section 7, the 2008 survey of the nearshore seabed along the offshore pipeline route through Broadhaven Bay, involved seabed-sampling techniques using a $0.1m^2$ day grab, and the analysis of still images taken from a drop-down video camera system. This survey was a repeat of the 2002 nearshore pre-construction survey undertaken by EcoServe. The survey was scheduled to take place immediately prior to construction works in Broadhaven Bay in summer 2008.

Limited physico-chemical analyses comprising particle size analysis (PSA) and Total Organic Carbon (TOC), were undertaken on the sediment samples.

With the exception of site A1 (Figure 8.3), sites throughout the sampling area were predominantly comprised of sandy sediments, with over 70% of the sediment at each site being recorded as medium to fine sand. There was very little mud component, and where mud was encountered in samples, it was in extremely low proportions.

TOC levels were typically low, as would be expected in such sediments where only low levels of finer grained materials (the sediment fraction that tends to bind organic components) were encountered.

Analysis of the video footage tends to support the laboratory analysis of PSA in that the large majority of the seabed sediments observed along the pipeline transects appear to comprise fine sands with some shell fragments visible. Reference stations 1 and 2 both showed evidence of rocky outcrops with boulders and more gravelly sediments.

The results of the 2008 nearshore survey are appended to this report as Appendix 7-6.

In summary, the 2007 and 2008 sediment survey data along the route of the nearshore pipeline corresponds with the 2001 description of mainly featureless sand with intermittent gravels and also concurs with the results of the 2002 nearshore survey.

Rock Placement Works

In August 2008, a previously uncharted outcrop of exposed bedrock was identified in around 19m water depth, approximately SSE of Rinroe Point. This was subsequently confirmed by a geophysical survey of the nearshore area during summer 2009.

In order to reduce the risk of the pipeline free-spanning, approximately 10,000 $m^3$of graded rock with a specific density of approximately 2.7 tonnes/m^3 has been deposited onto the seabed over the pipe area to form a protective rock berm. The rock placed in 2009 forms a filter layer. Washed and graded rock material was deposited by the rock placement vessel *Tertnes,* which has a flexible fall pipe, in September and October 2009. Details of the rock placement are presented in Table 8-1 below. The overall extent of rock placement over the identified section of the nearshore pipeline in Broadhaven Bay is shown in Figure 8-4. This also covered the section west of the rock outcrop where trenching was suspended as result of boulder-rich sediment, inclement weather and mechanical wear and tear of the subsea trenching machine.

Table 8-1 Details of protective rock berm placed during 2009

Parameter	
Berm KP start/end	80.00/81.5
Berm length	1500m
Total Installed volume of rock berm	10,226 m^3
Rock origin	Quarry, Sløvag (Norway)
Rock type	Granite/gneiss
Rock particle diameter	25 mm and 200 mm

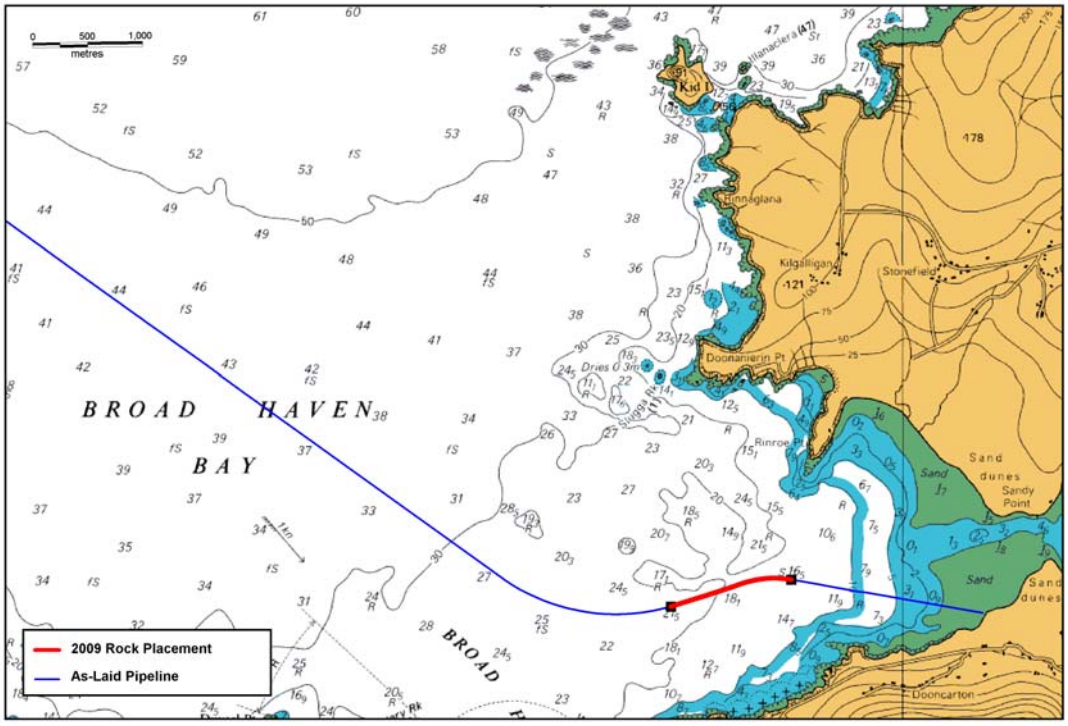

Figure 8-4: Extent of rock placement in Broadhaven Bay during 2009.

Further rock placement works, scheduled to take place during 2010/2011, are detailed in Section 8.4 and Section 3.

Intertidal

In 2005, Ecoserve undertook core sampling of surface sediments (see Appendix 7-7) along the route of the pipeline through the intertidal and on an adjacent transect on Glengad, which is intended to act as a control site. In 2008, RSK undertook repeat sampling at the landfall along these two transects, and at an additional transect between these two (Figure 8-5).

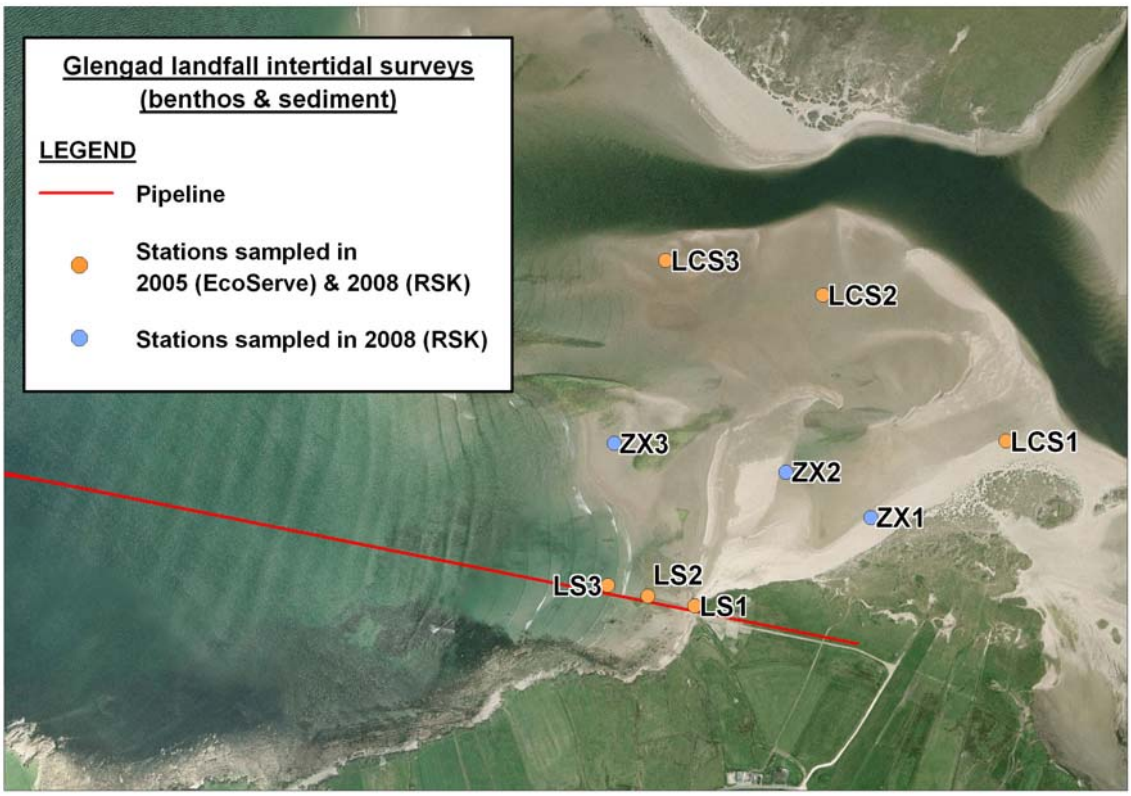

Figure 8-5: EcoServe 2005 and RSK 2008 offshore pipeline landfall sampling locations

In the 2005 survey, fine and medium sands dominated the substratum at all stations on both transects, with some coarser material at the lower shore stations (Figure 8-6). No Total Organic Carbon (TOC) data were collected in 2005.

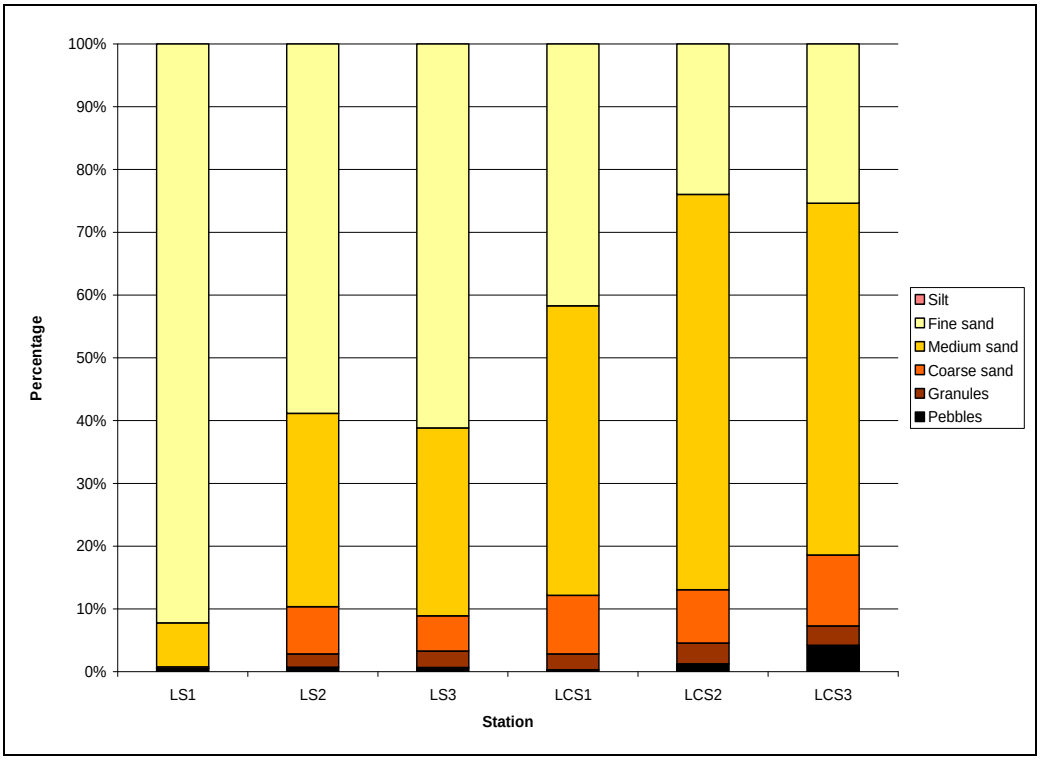

Figure 8-6: Grain Size Distribution at Intertidal Stations (2005)

In 2008, the results were broadly consistent with those from 2005. All sediment samples consisted entirely of medium sand, with no gravel (>2mm) or mud (<63µm) recorded. This reflects the high-energy environment and its high degree of sorting. Levels of TOC were below the detection limit of 0.1% at all stations (except at LCS1), reflecting the absence of fine sediment with which TOC is usually correlated. The higher levels of TOC observed at LCS1 are likely to be due to the presence of dead algal matter on the strandline.

As mentioned in Section 8.2, post construction monitoring surveys of the intertidal sediments at the landfall have commenced, and the results will be reported in 2010, following completion of the survey programme.

8.3.1.3 Treated Surface Water Outfall Location

Figure 8-7 shows seabed sediment sampling locations at the treated surface water outfall off Erris Head.

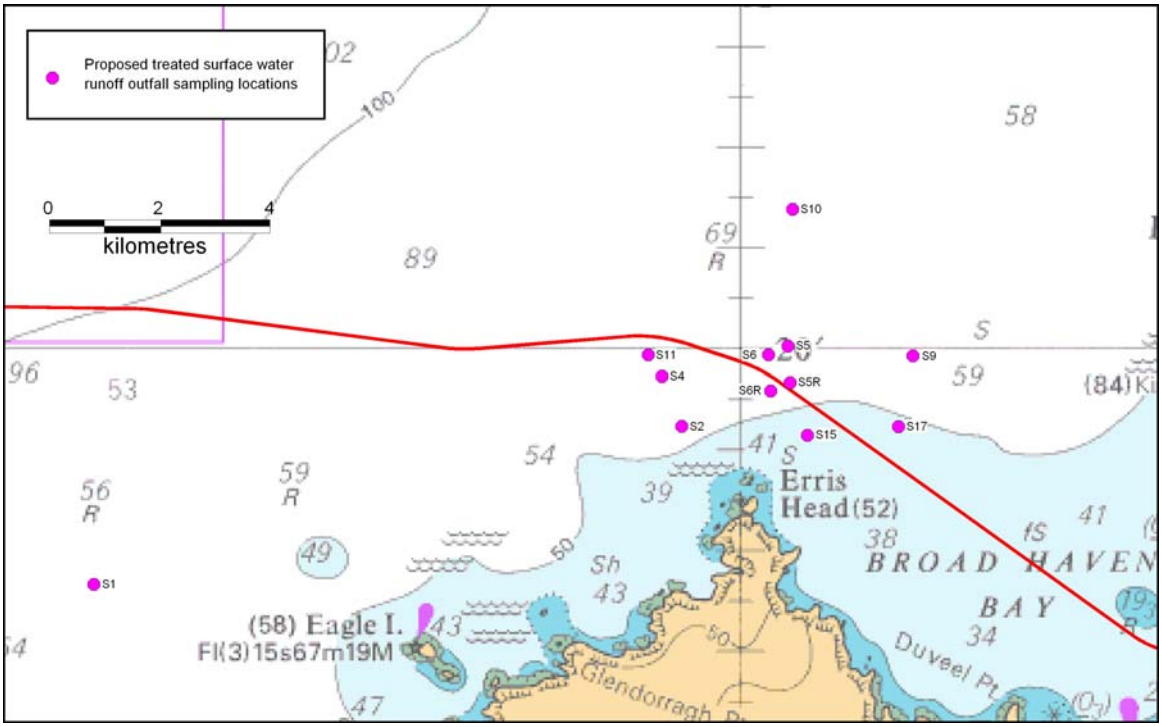

Figure 8-7: Location of Summer 2008 MV *Deepworker* Benthic Sampling Points at the treated surface water outfall off Erris Head

The techniques employed for seabed sample collection at these stations were the same as those used in the area of the Corrib offshore field, with the exception that no seabed photography was employed. The 2008 survey (Appendix 7-4) was a repeat of the 2007 survey undertaken at the treated surface water outfall (see Appendix 7-3), and the sampling methods undertaken were consistent between the two surveys.

Seabed sediments are characterised by sand as the predominant fraction present, with low levels of gravel , particularly at three sites (S1, S5 and S6R). Minimal levels of mud were recorded in several of the samples. Overall, sediments were coarser in nature at the sampling locations off Erris Head and rocks and cobbles were encountered much more frequently, compared with those at the Corrib offshore field. Sediment grain size results are broadly as expected given the previous sampling in the area. The sediment tends to be coarse in the nearshore areas and with reduced median grain size offshore, though no fine material was collected at any station.

TOC levels are low, in line with the predominance of coarse sediment material; there are no appreciable differences in the TOC levels at the treated surface water outfall stations compared with those at the Corrib offshore field.

The concentrations of TOE in the samples are considered consistent with 'background' levels as previously seen along the pipeline route and around the treated surface water outfall (Benthic Solutions Limited 2006, RSK 2007 (Appendix 7-1)). As expected, there was no evidence of anthropogenically-derived hydrocarbons in the sediments in the vicinity of the offshore sampling stations.

8.3.1.4 Landfall Topography and Geology

Information obtained from Borehole 1–02, located approximately 50m inland from the high water mark and drilled in September 2001, suggests that solid rock (quartzite and psammite) occurs at 4.40m below seabed, overlain by approximately 1m of weathered rock, which is in turn overlain by approximately 3m of sands and gravels.

8.3.1.5 Existing Pollutant Levels

In the 2001 Offshore EIS, sediment pollutant levels were only discussed in relation to the Corrib field itself, particularly with reference to the drilling activities that had taken place and the discharge of cuttings in the area. As discussed in Section 8.2, sediment samples were collected during 2007 and 2008 from a number of locations along the pipeline route, in the area of the Corrib field, and in the vicinity of the treated surface water outfall. These were analysed to determine the content of a number of metals and organic chemicals. Table 8-2 presents a summary of the range of metal concentration data in comparison with OSPAR and Environment Canada Guidelines. The full set of results for the 2007 pipeline and treated surface water outfall surveys are presented in Appendices 7-1 and 7-3 respectively, which also contains the results of the organic analyses.

As noted above, the sediments collected along the pipeline route were fairly coarse, and none of the sites contained material <63µm – the sediment fraction that is chosen frequently in studies to determine the extent of anthropogenic impact, as metals tend to be bound to the finer, predominantly clayey material in marine sediments. Under these circumstances, it is expected that the concentrations would be quite low, and this was generally found to be the case.

Appendix 7-1 also provides a comparison of the metal results with those from a number of other European areas. It can be seen from Table 8-2 and Appendix 7-1 that the levels of trace metals in the sediments along the pipeline route, at the field and treated surface water outfall locations are low, as would be expected for a site with little or no anthropogenic impact. The exception to this is certain sites in the Corrib Field (see Appendix 7-1 and 7-2), where localised elevated concentrations of barium are observed in the seabed sediments. These concentrations are observed up to 200 times background levels and are certainly due to drilling activities. Barium is the metal found in highest concentrations in drilling muds, in the form of barite ($BaSO_4$). Due to its low solubility and the fact that it is not toxic as a sulphate, the elevated barium concentrations in this location are not considered to be of toxicological concern.

Table 8-2: Observed Range of Metals in Sediments Along the Proposed Pipeline Route, at the Offshore Gas Field and at the proposed Treated Surface Water Outfall Location and Guideline Concentrations

Metal mg/kg	Corrib Pipeline range	Corrib Offshore Gas Field & Treated Surface Water Outfall		OSPAR BC*	OSPAR EAC lower limit	OSPAR EAC upper limit	Environment Canada TEL	Environment Canada PEL
Hg	<0.10	<0.001 - 0.0325		0.05	0.05	0.50	0.13	0.70
Cd	0.094-0.32	0.031- 0.285		0.2	0.10	1.00	0.676	4.21
Cr	11.2-39.2	3.84- 49.1		60	5.00	50.00	52.3	160
Pb	7.9-11.9	3.47-32.4		25	5.00	50.00	30.3	112
As	<1.0-12.7	0.43-17.1		15	1.00	10.00	7.24	41.6
Zn	10.2-38.6	5.3-66.1		90	10.00	100.00	124	271
Ba	0.67-11.0	2.59-1880		-	-	-	-	-
Ni	1.51-4.43	0.785- 9.75		30	5.00	50.00	15.9	42.8
Cu	0.54-1.87	1.52-16.5		20	5.00	50.00	18.7	108

Note: *BC background concentration, formerly termed background reference concentration (BRC). From OSPAR (2005).

Concentrations of all metals were within the OSPAR EAC limits, with the exception of arsenic levels at site S26, in the vicinity of Broadhaven Bay and at a number of locations off Erris Head. It is understood that concentrations of arsenic in the wider Donegal Bay area are elevated owing to the concentrations of this element in the natural geological strata in the area.

Organic material and hydrocarbons

Total Organic Carbon (TOC) levels in the sediments along the pipeline route, in the Corrib field, and at the treated surface water outfall location were generally very low (<0.5%), though at site 26 (KP69) a level of 5.9% TOC was recorded, which was greater than expected given the sediment material present. The low concentrations are to be expected because of the coarse nature of the seabed sediments. In general, there is a relationship between the percentage of fine sediments and the percentage of TOC, the number of binding sites for contaminants that fine material and TOC provide also usually correlates with the concentrations of metals and organic contaminants in sediments.

Hydrocarbon concentrations in the sediments analysed were typically very low. Polynuclear aromatic hydrocarbons (PAH) and their alkyl derivatives have been recorded in a wide range of marine sediments (Laflamme and Hites, 1978) with the majority of compounds produced from what is thought to be pyrolytic sources. These are the combustion of organic material such as forest fires (Youngblood and Blumer, 1975), the burning of fossil fuels and, in the case of offshore oilfields, flare stacks, etc. Concentrations of the 16 US EPA major PAHs in the sediments at all locations sampled are very low, all being less than relevant OSPAR designated background concentrations, further highlighting the overall pristine nature of the marine environment.

8.4 Characteristics of the Proposed Development

The characteristics of the proposed development in the context of this section are detailed in Section 8 of the 2001 Offshore EIS, except that it was since established that no requirement for blasting in Broadhaven Bay was required. The pipeline was placed on the seabed, and the resulting impact was just to the surface sediments beneath the invert of the pipeline, with the exception of the route in Broadhaven Bay. The pipeline was buried along the route through Broadhaven Bay by constructing a trench in the sediments onto which it was placed. It was then covered using the material extracted

from the trench. In other areas of the bay, the pipeline was buried using a trenching device.

The placement of rock to protect the pipeline from scour and potential free-spanning and aid pipeline stability in the near shore sections of Broadhaven Bay will be continued (from the works undertaken in 2009) during 2010 and 2011 when the umbilical is planned to be installed.

The rock placed in September and October 2009 comprised finer grades, forming a filter layer, which will be supplemented by heavier grades that will provide a protective armour and make the berm up to its design dimensions. Following a multibeam echosounder and visual survey of the berm in Spring 2010, continued rock placement will take place. Any remedial or additional rock placement of the filter layer, that may be required as a result of erosion during the 2009/2010 winter season will take place before placement of the heavier grade layer.

The section of the offshore pipeline in Broadhaven Bay that is highlighted above for rock placement is the main known section identified as requiring additional protection. There is the potential for further areas where rock placement may be required along the pipeline/umbilical route as mitigation, depending on the degree of scour that is experienced and the overall success of trenching works.

The umbilical will be trenched throughout its route from the landfall to the field, with the exception of sections with high concentrations of (sub) surface boulders and the umbilical will pass through a conduit at the shore crossing at Glengad. As detailed in Section 2, treated surface water run-off will be discharged through a HDPE pipeline co-located with the export pipeline between the terminal and a point approximately 12.5km from the landfall. The umbilical will be used to carry treated produced water to the Corrib field manifold where it will be discharged.

8.5 Potential Impacts of the Proposed Development

Taking the new data detailed above into consideration, the rock placement in Broadhaven Bay will disturb an area of seabed equivalent to the design footprint of the rock berm. Seabed geology over the berm footprint will be entirely covered. An estimate assuming worst case scenario calculates the footprint to range from 15000m^2 to 30,000m^2 in addition to the existing project footprint associated with the offshore pipeline/umbilical and seabed infrastructure at the offshore gas field . The total project footprint can only be verified after completion of the umbilical installation. With the exception of the additional impacts resulting from the rock placement there are no significant changes to the nature of the potential impacts as described in the 2001 Offshore EIS.

8.6 Do-Nothing Scenario

No change from 2001 offshore EIS. Further consideration of the do-nothing scenario is addressed in Section 13.7.

8.7 Mitigation Measures

The rock placement works during 2009 were undertaken using a fallpipe rock placement vessel. This allows for very precise placement of material, guided by the vessels own Remotely Operated Vehicle (ROV). Such accurate rock placement is not possible for the 2010 rock armour to be placed onto the protective berm, as the size grade of the material used necessitates the use of a side casting rock placement vessel. The number of vessels used in offshore works will be kept to a minimum, and an appropriate weather window to undertake the works utilised to minimise the duration of time needed for vessels to be present in the Bay.

All of the rock material that is to be deposited to protect the pipeline in the Bay will be inert hard rock that has been washed following quarrying and grading. As such, the potential for rock dust to be introduced into the water column is considered extremely low.

The majority of the seabed of the Bay is sandy in nature, and as such the rock berm will introduce hard substrate for colonisation by epibenthic species. This introduced hard geology will be consistent with the exposed bedrock that necessitates the rock placement, as well as the subtidal cliffs at the peripheries of the Bay.

Hard rock substrates are characterised by increased species richness compared with the sandy seabed.

There are no significant changes to the mitigation measures proposed in the 2001 Offshore EIS.

8.8 Predicted Impact of the Proposed Development

Taking into consideration the rock placement works in Broadhaven Bay programmed for 2010 the affected area of impact in terms of seabed geology has increased slightly. The area affected represents 0.017 to 0.033% of the area of Broadhaven Bay cSAC.

For the operation of the pipeline (including the piggy-backed discharge pipeline) and installation and operation of the umbilical, impacts to the geology of the area are expected to be influenced only by the placement of rock.

8.9 Monitoring

Monitoring will continue to be undertaken to document any impacts on the sediment in Broadhaven Bay, through the collection of sediment from a number of transects centred on the route through Broadhaven Bay. Samples will be analysed to determine the extent of the redistribution of sediment from disturbance to the seabed caused by pipeline installation. This monitoring programme includes a pre-construction survey (completed), as well as a programme of post construction surveys in compliance with the conditions associated with pipeline consents granted in 2002.

8.10 Reinstatement and Residual Impacts

Taking into consideration the rock placement works in Broadhaven Bay programmed for 2010, it is acknowledged that the area of impact in terms of seabed geology has increased slightly, although there is no change to the residual impacts as predicted in the 2001 Offshore EIS.