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Shannon Technology and Energy Park (STEP) Power Plant

Appendix A6.1: 2007 Hydrological and Hydrogeological Impact Assessment

Shannon LNG Limited

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ARUP CONSULTING ENGINEERS

SHANNON LNG: TARBERT / BALLYLONGFORD TERMINAL

Hydrological and Hydrogeological Impact Assessment of the Proposed Shannon LNG (Liquid Natural Gas) Terminal Development at Ballylongford, Co. Kerry

Environmental Impact Assessment Report

MEL Brief 1946-C1
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Table of Contents

Appendices

Appendix	Title	Pages	MEL Doc. Ref.
Appendix A	Site Location Map	1 x A4	1946-008.wor
Appendix B1	Regional Bedrock Geology Map	1 x A4	1946-008.wor
Appendix B2	Regional Subsoils Geology Map	1 x A4	1946-008.wor
Appendix C1	Hydrology Map - Macro-Catchments with Primary Drainage Features	1 x A4	1946-008.wor
Appendix C2	Hydrology Map - Micro-Catchments and Primary and Secondary Drainage Features	1 x A4	1946-008.wor
Appendix D1	Regional Bedrock Aquifer Map	1 x A4	1946-008.wor
Appendix D2	Regional Bedrock Vulnerability Map	1 x A4	1946-008.wor
Appendix E	Depth to Bedrock (Subsoils Thickness) Map	1 x A4	1946-008.wor
Appendix F1	Special Area of Conservation (CSAC) & Natural Heritage Area (PNHA) Designated Areas	1 x A4	1946-008.wor
Appendix F2	Habitats of Concern within and peripheral to Designated Areas	1 x A4	1946-008.wor
Appendix G1	Groundwater and Surface Water Monitoring Network	1 x A4	1946-008.wor
Appendix G2	Groundwater Monitoring Network	1 x A4	1946-008.wor
Appendix G3	Surface Water Monitoring Network	1 x A4	1946-008.wor
Appendix H1	Groundwater Subsoils Phreatic Contour Map – April 2007	1 x A4	1946-008.wor
Appendix H2	Groundwater Bedrock Piezometric Contour Map – April 2007	1 x A4	1946-008.wor
Appendix H3	Groundwater Vertical Hydraulic Gradients Map – April 2007	1 x A4	1946-008.wor
Appendix I1	Groundwater Subsoils Phreatic and Surface Water Electrical Conductivity Map – April 2007	1 x A4	1946-008.wor
Appendix I2	Groundwater Subsoils Phreatic and Surface Water pH Map – April 2007	1 x A4	1946-008.wor
Appendix J1	Groundwater Bedrock Piezometric (P1) Electrical Conductivity Map – April 2007	1 x A4	1946-008.wor
Appendix J2	Groundwater Bedrock Piezometric (P1) pH Map – April 2007	1 x A4	1946-008.wor
Appendix K	Conceptual Model of Different Water Sources (based on Chemistry and Hydraulic Gradients)	1 x A4	1946-008.wor
Appendix L	Drainage Discharge (D1) Map – April 2007	1 x A4	1946-008.wor
Appendix M1	Water Level, Field Chemistry and Flow Gauging Database – (March to April 2007)	7 x A4	1946-011.xls

Appendix M3	Analytical Chemistry Results for IGSL Borehole Standpipe Installations – January 2007	1 x A4	1946-010.xls
Appendix N	Selected Photographs from Site Investigations and Surveys	10 x A4	1946-173.ppt
Appendix O1	MEL Site Investigation Logs and Groundwater Monitoring Point Installations	23 x A4	1946-024.ppt
Appendix O2	IGSL Site Investigation Logs and Groundwater Standpipe Installations	30 x A4	1946-055.pdf

List of Tables

1. INTRODUCTION

1.1 Scope and Purpose

Arup Consulting Engineers (Arup) on behalf of Shannon LNG contracted Minerex Environmental Ltd (MEL) on the 20th March 2007 to undertake a detailed hydrological and hydrogeological environmental impact assessment (EIA) of the potential direct and indirect impacts by the proposed Shannon LNG Terminal Development on designated and protected habitats within the Lower Shannon candidate Special Area of Conservation (cSAC) and within Ballylongford proposed National Heritage Area (pNHA).

The following items form part of the work scope:

(a) Review all geotechnical site investigation data completed by IGSL for the proposed Shannon LNG Terminal Development that may be relevant to the hydrology and hydrogeology of the designated and protected habitats. Carry out a site walkover, preliminary hydrochemical survey and identify requirements for further environmental site investigation (MEL Brief A1).

(b) Specify and scope environmental site investigation programme required to provide a robust data set for hydrological and hydrogeological impact assessment by the proposed Shannon LNG Terminal development (MEL Brief B1) on the protected wetland habitats.

(c) Produce a detailed hydrological and hydrogeological impact assessment report for inclusion in the Environmental Impact Statement (EIS), covering the potential direct and indirect impacts by the proposed Shannon LNG Terminal Development on designated and protected habitats.

Minerex has completed each of these work items, which are described in detail in this report.

1.2 Work Schedule

The following work schedule has been completed for the purpose of preparing this report:

- 20th to 23rd March 2007 – Review all technical data for the project, evaluate how relevant the data is and what additional data is required for impact assessment.
- 26th to 29th March 2007 – Preliminary site walkover, preliminary surface water hydrochemical survey, preliminary site investigation using Gouge Coring (GC) and Percussion Window Sampler (PWS) and installation of staff gauges along the site's main stream (D1) and in the lagoon.
- 9th to 14th April and 23rd April 2007 – Detailed site investigations peripheral to protected habitats within cSAC and pNHA using Air Flush Rotary Percussion and Symmetrix Open Hole Drilling (IGSL), detailed logging of returned subsoils and bedrock chippings, and supervision of groundwater monitoring phreatic and piezometer nest installations.
- 23rd to 26th April 2007 – Measurement of groundwater and surface water levels (MEL installations), discharge rates in D1 (flow gauging measurements), field hydrochemistry (both surface water and groundwater (from IGSL boreholes and MEL BR (Bedrock) Series

installations). This work coincided with the commissioning of the groundwater monitoring network.

- 21st to 24th May 2007 – Processing all site investigation and survey results, production of graphics and Draft EIA report.

The schedule demonstrates that an extensive fieldwork programme was executed to acquire all key hydraulic and hydrochemical data needed to undertake a full impact assessment for the site. Field results were typed up or processed (e.g. collating of water level and hydrochemistry data) after each field event into MEL standard templates, databases and maps.

1.3 Area of Study

For the purpose of the present study, specific environmental investigation has been confined to the immediate vicinity of the site, as shown in Appendix A. However, the site has also been considered in its wider environmental context based on other available information, including information gained during the geotechnical investigation of the site. The main focus of the study is, however, the areas of designated and protected habitat adjacent to the north-western part of the site, as shown in Appendix F2. In order to assess the potential impact of the development on these habitats, environmental investigation and monitoring work has been carried out specifically within and adjacent to these areas, extending to sufficient distance to encompass the 'zone of influence' around the habitats. The area within which this specific environmental investigation work has been carried out is shown in Appendix G1.

2. METHODOLOGY

2.1 Desk Study

The desk-based work items comprised the following:

- Acquisition of all relevant data to complete a conceptual hydrological / hydrogeological model.
- Consultation with the client and interrogation of available databases regarding water supplies within the potential impact zone of the proposed development (wells, springs and surface water sources).
- Construction of layers of information in a GIS Graphic database showing Geology, Hydrology, Hydrogeology, Ecology and the Proposed Development Layout.
- Processing of all data acquired into MEL's Variable and Non-Variable Database, with Graphics output in GIS MapInfo.
- Production of a Progress Report to the Client confirming findings, new data / information of note and any change to the planned site investigations programme arising from site reconnaissance.

The equipment and materials used during this desk study consisted of:

- MapInfo GIS
- Microsoft Excel
- Microsoft Word
- Microsoft Powerpoint

2.2 Field Investigations

Field investigations comprised:

- A site walkover to confirm details of the drainage network, drainage hierarchy, condition of existing borehole standpipes for use as groundwater monitoring points, groundwater seepage areas and catchment divides.
- Drainage hydrochemistry profiling (Electrical Conductivity (EC), pH and Temperature) along D1, in secondary drains and at spring discharge locations to determine sources of water (e.g. groundwater inflow / outflow and runoff).
- A lagoon and wetland open water survey to identify hydrochemical variability arising from spring discharge, groundwater seepage or seawater incursion.
- Selection of suitable locations, on completion of hydrochemical survey, for staff gauge installations, flow gauging stations and ongoing surface water chemistry monitoring.
- Flow gauging (discharge) measurements in the main drain (D1) at six (6) selected locations along its length within the Shannon LNG site boundary to determine baseline flow capacity.
- Water level monitoring and wellhead hydrochemical testing (EC, pH and Temperature) of existing IGSL groundwater standpipes (BH Series).

- Selection of suitable locations peripheral to protected habitats (cSAC and pNHA) for drilling and installation of phreatic / piezometer nest installations for the purpose of monitoring groundwater in relation to the proposed development (source of impact) and the designated habitats (potential target).
- Description and logging of subsoils and bedrock returns from Air Flush Rotary Percussion drilling to BS 5930 (Ref.1), for the purpose of determining subsoil and bedrock types, texture and permeability characteristics.
- Installation of secure wellhead completions for MEL BR Series installations on agricultural lands, to secure and protect wellheads for future monitoring.
- Purging and sampling of groundwater from the MEL BR Series installations (peripheral to cSAC and pNHA) for field parameter testing (EC, pH and Temperature).
- Survey in all monitoring point installations (groundwater and staff gauges for surface water) in order to correlate data.
- Recording of GPS co-ordinates for all surveyed items of note, and acquisition of digital photographs of all geo-referenced items for future reference.
- Confirmation of logistics for site access for site investigations and future monitoring programme.

The equipment and materials used during field investigations consisted of:

- Track Mounted 4 Tonne Air Flush Rotary Percussion Drilling Rig.
- Gouge Corer / Hand Auger and Percussion Window Sampler (PWS) for peat and overburden hand probing.
- Hanna Combo (Model no. HI 98129) pH/EC/Temp meter for hydrochemical measurements.
- Hanna Combo (Model no. HI 98130) pH/EC/Temp meter for saline hydrochemical measurements.
- Solinst Water Level Meter (Model 101 30m) for measuring water levels in groundwater installations.
- Solinst 410 Peristaltic Pump for withdrawing groundwater from BR Series monitoring points.
- WASP 2" 12v Submersible Pump for withdrawing groundwater from BH Series monitoring points.
- OTT C2 Impeller flow meter for drainage (D1) flow measurements.
- Handheld Garmin Etrex 12 channel Global Positioning System (GPS) for navigation and recording position of site investigation and monitoring points.
- GPS 500 and R125N Pentax Total Station for surveying
- Olympus Digital Camera FE-210 for taking photographs of all items of reference.

2.3 Impact Assessment Methodology

The present report provides a detailed impact assessment based on extensive surface and sub-surface investigation. Using the desk and field data acquired, the following assessment methodology has been

adopted in order to evaluate the potential impact of the proposed Shannon LNG Terminal Development on designated and protected habitats:

- Characterise the site's existing hydrological / hydrogeological regime based on the topographical, geological, geomorphological, hydraulic and hydrochemical data acquired.
- Determine the existing / baseline catchment size and catchment characteristics of the main stream on the Shannon LNG site (D1) and of the designated and protected wetland habitats.
- Determine the likelihood of any existing environmental trends / changes that are currently occurring at the Shannon LNG site.
- Determine any change to these catchments that is likely to occur as a result of the proposed Shannon LNG Terminal Development and identify potential impacts.
- Consider water quality changes resulting from the proposed Shannon LNG Terminal Development and its particular design features.
- Produce a clear conceptual hydrological / hydrogeological model for both the main stream (D1), where it crosses the Shannon LNG site, and for the designated and protected wetland habitats.
- Assess the total dataset acquired and evaluate the likely impacts of the proposed development on protected wetland habitats contained within the Shannon LNG site.
- If impacts are identified, consider measures that would prevent, mitigate or reduce the identified impact.
- Identify any residual impacts that would remain or arise from the mitigation measures identified/proposed.
- Present and report these findings in a clear and logical format that complies with EIS reporting requirements.

3. DEVELOPMENT DESCRIPTION

From an environmental standpoint, the key Shannon LNG Terminal Development infrastructure features are:

- The proposed development is a Liquefied Natural Gas (LNG) receiving terminal located at Tarbert - Ballylongford on the south side of the Shannon estuary.
- The site is enclosed within a landtake of 104 hectares.
- The project will comprise the construction of up to 4 LNG storage tanks, associated process equipment, a jetty to the east for LNG tankers and a second materials storage jetty in the west, administration buildings and two hardstand / construction laydown areas in the south and west of the site.
- Preliminary earthworks volume estimates for the construction of the plant will involve 1.1M m^3 of cut and fill.
- The plant will be constructed on proposed elevated ground at c.19mOD Malin (NW part of footprint) and c.10mOD (NE part of footprint). Preliminary estimates indicate that this will involve raising the ground level in this part of the site by +12m from c.7mOD in the NW and +4m from c.6mOD in the NE respectively.
- It is currently proposed to construct an embankment across the main stream (D1) that flows through the site (located west of the plant footprint); upon which the access road will be located. Preliminary design indicates that the embankment will reach c.19mOD in elevation at the proposed stream crossing. This involves an increase in elevation of +14m from baseline c.5mOD level.
- The reason for this embankment is to create a pond inline with the stream to supply water for the construction works, hydrotesting of the tanks and firewater during the operation of the terminal. After exploring the option of groundwater resource development which has proved insufficient and unsustainable yield for project requirements, the stream has been identified as a possible water source and will have a capacity of c.150,000m^3.

4. SITE DESCRIPTION

4.1 Location

The proposed Shannon LNG Terminal site is located at Irish national grid co-ordinates 102,000E 148,000N on the south side of the Shannon Estuary, approximately 4.5km west of Tarbert, and approximately 3.5km northeast of Ballylongford, County Kerry (Appendix A). Spatially the site occupies a total area of 104 hectares. The coastline on the northern side (between Ardmore Point and Knockfinglas Point) and on the northwestern side (between Knockfinglas Point and Richard's Rock) forms a total estuary frontage of approximately 1.96km, while to the southeast the site is bounded by the coast road and to the southwest by the local Kilcolgan Lower road.

Designated habitats lying adjacent to the site comprise part of both the Lower Shannon cSAC and the Ballylongford pNHA. They are located adjacent to the coastline and are either in the vicinity of the main stream (D1) running through the site (Coastal Lagoon and Salt Marsh) or immediately adjacent to the downstream section of D1 (e.g. Wet / Improved Agricultural Grassland, Reed and Large Sedge Swamp) (Appendix F2). The Coastal Lagoon habitat which is present on the site is listed as a Priority Habitat in Annex I of the Habitats Directive (Ref. 3).

The focus of MEL's impact assessment study at the Shannon LNG site is graphically portrayed in Appendix C2 (site hydrology), Appendix F2 (ecology) and Appendix G1 (subsurface site investigations and hydrogeology).

4.2 Topography

The topography forming the Shannon LNG site and its surroundings has been shaped by the Quaternary Midlandian and Munsterian glaciations and by subsequent post-glacial deposits and landforms, as detailed in the "Soils and Geology" section of the EIS. This topography consists of a series of multiple undulating hills oriented in a northwest to southeast direction, that fringe the main stream, D1 (Appendix C1). D1 where it crosses the site is aligned with a geological fault structure which is oriented northwest-southeast (labelled F1; Appendix B1).

It is within the valley of D1 that the designated wetland habitats of concern are located; with the exception of the coastal lagoon which is located outside of the main D1 catchment, approximately 170m to the southwest of where the D1 outlets to the Shannon Estuary. This coastal lagoon is contained within its own hydrological micro-catchment, which is separated from the D1 catchment by slightly higher ground with an elevation of approximately 5mOD elevation (Appendix C2 & F2). The low hills flanking the D1 valley reach elevations of c.12-21mOD, while the wetland areas immediately adjacent to D1 are between c.2-7mOD.

In the northeast part of the site, the topography is dominated by a sloping hillside, which reaches a maximum elevation of c.33mOD along the southern site boundary line. It slopes uniformly, with linear topographical contours, towards the Shannon Estuary, which forms the coastal boundary to the northwest. The site topography can be visualised in photos 1-4 in Appendix N.

4.3 Ecology

The Shannon LNG site is located adjacent to habitats which have been designated as candidate Special Areas of Conservation (cSAC) and proposed Natural Heritage Areas (pNHA).

The designated habitats adjacent to the Shannon LNG site comprise part of the Lower Shannon cSAC and the Ballylongford pNHA (Appendix F1 & F2) (Ref. 4). The habitats of particular concern are outlined in Table 1 and described according to their habitat codes as assigned by Fossitt 2000 (Ref. 5):

Table 1: Habitats with conservation / designation status adjacent to the Shannon LNG site.

Fossitt Code (Level 1)	Fossitt Code (Level 2)	Fossitt Code (Level 3)	Description	Relation to Lower Shannon cSAC	Relation to Ballylongford pNHA
C = Coastland	CW = Brackish Waters	**CW1**	Lagoon & Saline Lakes	Wholly within	Wholly within
C = Coastland	CM = Salt Marsh	**CM1**	Lower Salt Marsh	Outside	Wholly within
F = Freshwater	FS = Swamps	**FS1**	Reed and Large Sedge Swamps	Wholly within	Wholly within
C = Coastland	CW = Brackish Waters	**CW2**	Tidal River (lower section of D1)	Wholly within (south bank)	Wholly within (north bank)
F = Freshwater	FW = Watercourses	**FW2**	Depositing River (middle and upper sections of D1)	Wholly within	Wholly within (middle section of D1)
G = Grassland & Marsh	GM = Freshwater Marsh	**GM1**	Marsh	Outside	Outside
G = Grassland & Marsh	GS = Semi-natural Grassland GA = Improved Grassland	**GS4 / GA1**	Wet Grassland / Improved Agricultural Grassland	Partially within CSAC (1 large field marginal to FS1)	Outside
G = Grassland & Marsh	GS = Semi-natural Grassland GA = Improved Grassland	**GS1 / GA1**	Neutral Grassland / Improved Agricultural Grassland	Partially within CSAC (marginal to CW2)	Partially within PNHA (2 fields marginal to CM1 & CW1)

*Colour Shade illustrates Water Source:

	Freshwater Environment		Brackish Water Environment		Brackish to Saline Water Environment

* Note that the colour coding used in Table 1 relates to the different surface and groundwater types that sustain each habitat, and which are discussed in detail in Section 4.5.5.

The most important of these habitats is the **lagoon (CW1)** (cSAC & pNHA) (Appendix N, Photos 4, 5 and 6), which is a **priority habitat (coastal lagoons; 1150*)** and therefore of high conservation status under the EU Habitats Directive. It is characterised by roughly half open water toward the seaward side and half reed-dominated vegetation on the landward side. The lagoon is separated from the Shannon Estuary by a barrier beach composed of shingle, whose top elevation is slightly above high spring tide level. It is evident that wave overtopping of this barrier beach provides an intermittent source of saline water to the lagoon. In addition, what may become a more permanent connection to the sea, appears to be developing (naturally) in the northeast corner of the lagoon where accentuated marine erosion of the low cliff of glacial sands and gravels is creating a narrow channel through the coastal barrier. At present, the lagoon appears to be fed by seawater from the Shannon Estuary and by freshwater seepage from the landward (south-southeast) side; hence producing a mixed water environment (brackish) (Appendix I1 & K).

Other important habitats that require protection from direct and indirect hydrological / hydrogeological impact by the proposed development are the freshwater **reed and large sedge swamp (FS1)** (Appendix N, Photos 7 and 8), which occurs along the northern, low elevation boundary of the main stream (D1). This area is protected under cSAC and pNHA designation. The **tidal river (CW2)** (Appendix N, Photo 9), which occupies the lower section of D1 and **depositing river (FW2)** which occupies the remainder of D1 within the site boundary is also protected under both cSAC and / or pNHA designation, depending on location along the stream.

The third habitat of particular significance is the **lower salt marsh (CM1)** (Appendix N, Photo 10 and 11), that occurs between the lagoon (CW1) and the tidal river (CW2). This is protected under pNHA designation and is not part of the Lower Shannon cSAC.

Marginal habitats that occur within cSAC / pNHA designations are those of improved agricultural grassland (GA1) and wet grassland (GS4). These habitats are less significant in terms of their intrinsic conservation value, compared to the habitats outlined above; but they are very important in providing a buffer to hydrological / hydrogeological impacts on the more sensitive habitats that include priority habitats.

From Table 1 above, five of the habitats identified occur in freshwater environments, while two are mixed / brackish water environments, and one is a brackish / saline environment.

4.4 Geology

4.4.1 Bedrock Geology

The bedrock geology at the study site is discussed in the Geological Survey of Ireland (GSI) publication entitled “Geology of the Shannon Estuary” (Ref. 6). The 1:100,000 scale bedrock geology map of the area (Sheet 17) indicates that the study site is underlain by the Upper Carboniferous (Namurian) aged **Shannon**

Group (SHG). This is the only formation that underlies the proposed development site. The Shannon Group is undifferentiated and poorly mapped due to limited exposure in North Kerry. It consists of sandstone, siltstone, and mudstone and in places shale, and is dominated by turbidite sequences (rock sequences which fine upwards in cycles).

IGSL has provided site specific data on bedrock geology from dynamic probes, trial pits and coreholes for the northeast of the site for the proposed terminarl plant footprint. Results from these site investigations reveals fine grained Sandstone interbedded with argillaceous (siltstone and mudstone) bands. Sandstone and siltstone / mudstone at depth, is fresh to slightly weathered with variable fracture spacing depending on borehole location. Some borehole logs record iron oxide staining, indicating groundwater flow. Moderately weathered "rockhead" (top of bedrock) ranges from 0.5-0.6m thickness based on borehole logs.

MEL's BR Series investigations indicate the following with regard to bedrock geology in the west of the site proximal to the cSAC and pNHA areas (borehole logs of these investigations are presented in Appendix O1):

- The bedrock in the west of the site is predominantly a light to dark grey medium to fine grained SANDSTONE, with interbedding of siltstone and mudstone at the majority of the MEL BR Series. BR-1, BR-2, BR-3, BR-4, BR-8, BR-9 and BR-10 returned a Sandstone dominated lithology with occasional beds of Siltstone / Mudstone occurring at c.7-10m depth below ground level.
- BR-5, BR-6, BR-7 and BR-11 indicate a finer grained lithology dominated by dark grey SILTSTONE.
- Percentage weathering and associated iron oxide discolouration has been noted during drilling. The bedrock was found to be generally unweathered with the exception of BR-1 where a high degree of weathering of returned rock fragments was observed (c.50-80% of returns), BR-7 with moderately weathered returns (c.20-50%) and BR-4 with slightly weathered returns (c.2-10%). These boreholes are located close to D1, with BR-4 and BR-7 located along the mapped F1 fault structure (Appendix B1).
- BR-1 is located adjacent to a waterlogged area (Appendix N, Photo 15), which may be indicative of high water table and subsurface saturation, and may in turn account for the high degree of weathering noted.

A number of non-active faults have been mapped during the course of this environmental impact study, the full details of which are provided in Chapter 13 of Volume 2 of the EIS. Of the six (6) faults identified and illustrated in Appendix B1, two faults have significance for the hydrological and hydrogeological study of the cSAC and pNHA habitats. These faults have been labelled F1 and F2 and are described as follows:

- **F1** is the primary fault identified on the site. It transverses the centre of the site in a southeast-northwest orientation ($140^{O}/320^{O}$) and extends beyond both landward and coastal boundaries of the proposed development. The main stream that occurs on the site, D1 manipulates this fault alignment for a distance of c.800m within the site boundary. MEL's investigations points BR-2, BR-4 and BR-7 have been located along or proximal to the mapped F1 fault in order to determine its significance as a groundwater conduit and therefore water source for the cSAC and pNHA habitats.

The results of these investigations indicate variable weathering and permeability of the upper bedrock along the alignment of F1 that is coincident with the D1 stream. BR-7 located downstream near the cSAC habitats indicates moderate to high weathering at 20-50%, while further upstream at BR-2, the upper sandstone bedrock is fresh with no evidence of weathering (Appendix O1). It is noted that BR-1 (which is highly weathered) is located upstream on D1 and is offset from the F1 alignment (Appendix B1).

- **F2** is the second longest fault identified on the site and it runs essentially parallel to F1 for a distance of c.800m before changing to a western direction and truncating against F1 c.100m from the coastline. This fault is also significant for the protected habitats, in so far as F1 coincides with the northern boundary of the Reed & Large Swamp (FS1) habitat, and therefore it is a potential groundwater conduit and therefore water source for this area (Section 4.5.5). MEL's investigation points BR-6, BR-8, BR-9 and BR-11 have been located along and proximal to the mapped F2 fault. The results of these investigations indicate a fresh sandstone and in places mixed sandstone and siltstone sequence, with no evidence of weathering (Appendix O1).

Piezometer nests were installed in all the MEL BR Series in order to provide hydraulic information on the vertical and horizontal flow potential of groundwater along and proximal to F1 and F2, the results of which are discussed in Section 4.5.7 and 4.5.8.

4.4.2 Soils and Subsoils

The Environmental Protection Agency (EPA) / Teagasc Soils and Subsoils of Ireland database (Ref. 2) indicates that the site is underlain by the following subsoil types (Appendix B2):

- Glacial till derived from (Namurian) Shales and Sandstones is the main subsoil type that occurs at the site (TNSSs)
- Undifferentiated alluvium occurs along the stream D1 and underlying the reed and large sedge swamps adjacent to D1 (A).
- Bedrock outcrop and subcrop occurs along and proximal to the coastline and is likely to be associated with cliff and wave cut platform exposure (Rck).

The subsoils at the site are comprised of Munsterian (Quaternary Age) basal lodgement till (Lower Till) which is overlain by Midlandian (Quaternary Age) morainic deposits (Upper Till) that are less well consolidated than the lower lodgement till (see Soils and Geology Section of the EIS).

MEL's subsurface investigations (BR-Series) were carried out at the periphery of the cSAC and pNHA designated wetland areas as detailed in Section 2.2 and were positioned to obtain maximum hydrogeological data for interpretation and impact assessment. MEL's geological logs (BR-Series) are provided in Appendix O1, with spatial locations for the BR Series shown in Appendix G1. Preliminary "Subsoils" site investigations entailed percussion window sampling (PWS) and hand augering / gouge coring (GC) at selected locations

within and outside the cSAC and pNHA boundaries. Geological logs for the PWS and GC subsurface investigations are also provided in Appendix G1.

MEL's BR Series indicates the following with regard to the composition of subsoils within the investigated area:

- Medium-dark brown Boulder CLAY (Upper Till) occurs at BR-3, BR-4, BR-6, BR-8, BR-9, BR-10 and BR-11. This subsoil horizon varies in thickness from 2.0m at BR-3, BR-4, BR-6, BR-8 and BR-9; to 3.0m at BR-11 and a maximum thickness of 3.5m was noted at BR-10.
- At BR-1, BR-5 and BR-7 the Upper Till horizon is absent, presumably having been eroded away or not deposited in the first instance.
- The Upper Till is underlain by predominantly medium-dark grey Boulder CLAY (Lower Till) at BR-3, BR-4, BR-6, BR-8 and BR-9.
- The Lower Till horizon is absent at BR-10 and BR-11, most likely as a result of having been eroded during the subsequent glaciation.
- At BR-2 bedrock occurs close to the surface (at 1.0m depth), and neither of the two till horizons are present at this location.

The boulder clays (observed from Symmetrix drilling returns) are typically composed of c.40-70% grey or brown CLAY, with c.20% SAND component, c.20-40% GRAVEL, and grey sandstone pebbles and occasional cobbles and boulders.

Total depth of subsoils recorded from the BR Series investigations varies between 0.8m at BR-2 to a maximum of 10.0m recorded at BR-3. Two local geological fault structures occur on the site (see Appendix B1); one along the D1 valley (F1), and the other along the D2 valley to the northeast (F2). Adjacent to the F1 and F2 fault structures and within the respective valley features, subsoil thicknesses appear to be less than elsewhere; with thickness ranging between 0.8-3.1m (e.g. in BR-1, BR-2 and BR-11). PWS manual drilling was undertaken at a location (40m) southwest of BR-2 and 1.1m of light brown to grey CLAY was noted before refusal on presumed bedrock. In comparison, at other BR Series investigation points located on more elevated ground (e.g. BR-3, BR-8 and BR-6) the subsoils have greater thickness which varies from 3.5-10.0m. The relative thinness of the subsoils within the two fault-aligned valleys is consistent with localised valley erosion.

The majority of MEL's BR Series investigation points have been positioned proximal to the boundary of the cSAC / pNHA area (track mounted vehicles were restricted from entering the cSAC and pNHA areas). BR-5, BR-6, BR-8 and BR-10 are located to the northeast and north of the cSAC boundary. This part of the cSAC includes Reed and Large Sedge Swamp (FS1) and Wet grassland GS4 / Improved Agricultural Grasslands (GA1) as protected habitats. To the south, BR-4, BR-7 have been positioned proximal to D1 and associated Depositing River (FW2) habitat, while BR9 is located on the landward side of the lagoon and saline lake (CW1) habitat.

From these subsurface investigations, subsoil deposits peripheral to the cSAC and pNHA areas display the following characteristics (see Appendix O1):

- BR-5, BR-6, BR-8 and BR-10 in the north – north east of the cSAC / pNHA have subsoil thicknesses ranging from 3.5m to 8.6m. The thickest deposits coincide with locations where both the Upper and Lower Till occur together (e.g. BR-6 with 8.6m and BR-8 with 5.0m of subsoil). In comparison at BR-5 subsoil is comprised of Lower Till only, while at BR-10 only the Upper Till horizon occurs. The absence of either horizon is presumed to be due to non-deposition or glacial or post-glacial erosion.
- Close to the downstream / western end of D1, BR-4 and BR-7 indicate a subsoil thickness of 4.1-4.7m. BR-4 is located on the hillside up-gradient of D1 on elevated ground, and subsoils here comprise both Upper and Lower Till horizons. Closer to D1, BR-7 indicates that only the Lower Till is present, suggesting that Upper Till was either not deposited here or has been subsequently been eroded by the D1 stream or perhaps due to glacio-fluvial action prior to the formation of D1.
- BR-9 adjacent to the Lagoon indicates subsoil depth of 5.6m, composed of 2.0m of Upper Till which is underlain by 3.6m of Lower Till.

In summary the results of MEL's BR Series investigations indicate the presence of subsoils of varying thickness (0.8m to a maximum of 10.0m) around the periphery of the cSAC / pNHA wetland areas. Subsoils are composed of brown and grey CLAY with substantial components of SAND (c.20%), GRAVEL (c.20-40%), pebbles (c.20-50%) and occasional cobbles and boulders. This subsoil type is characterised by poor drainage and low infiltration properties, with low permeability. As a result, the glacial till subsoils that occur at the site act as a hydraulically confining horizon above the underlying bedrock.

Hand held augering (using a "Gouge Corer") has been carried out adjacent to D1 within wet grassland (GS4) / improved agricultural grassland (GA1) (GC-13), within Reed and Large Sedge Swamp (FS1) habitat (GC-14), adjacent to the Lagoon and Saline Lake (CW1) (GC-16) and within the Lower Salt Marsh (CM1) (GC-17) (see Appendix G1 and O1).

Logging of subsoils and peat from these gouge core locations indicate the following:

- GC-13 in wet grassland (GS4) / improved agricultural grassland (GA1): mottled dark brown 'peaty' CLAY (peat and clay mixture) occurring to a depth of 1.0m, underlain by grey sandy CLAY of 'marly' composition to a depth of 1.36m (refusal on cobble / boulder at 1.36m). These deposits indicate possible lacustrine conditions with the formation of deeper marly clay deposits overlain by more recent peaty-clay material which is indicative of the present marshy, waterlogged and anaerobic conditions on the south side of D1 at this location.
- GC-14 in Reed and Large Sedge Swamp (FS1): medium to dark brown PEAT, with plant remains / rootlets and fibrous texture to a depth of 1.0m. Peat is underlain by light to dark grey sandy / silty CLAY ('marly' composition) to a depth of 1.35m (refusal on gravel / cobbles at 1.35m). This

underlying clay deposit is indicative of lacustrine conditions prior to development of the Sedge Swamp and subsequent peat formation.

- GC-16 adjacent to Lagoon and Saline Lake (CW1): Light brown to orange CLAY with iron oxide 'mottling', underlain by light grey 'marly' CLAY to 0.83m (refusal on cobble / boulder at 0.83m). The presence of 'marly' clay (probable lacustrine deposit) at the base indicates that the lagoon area may have once extended further inland beyond its current position, as is also suggested further seaward by the exposures of peat which is visible on the upper beach (backshore) to the northwest of the lagoon (Appendix N: Photos 13 & 14).
- GC-17 within Lower Salt Marsh (CM1): Dark brown PEAT with plant remains / rootlets with interbedded grey / brown silty CLAY, underlain by light to medium brown / grey sandy, gravelly CLAY to a depth of 1.80m (refusal on cobble / boulder at 1.80m). The subsoils at this location are indicative of prior anaerobic conditions with perhaps prolonged periods of water inundation (either freshwater or brackish water) with more substantial vegetative cover than is presently the case, resulting in the formation of c.1.0m of peat. The presence of a layer of CLAY from 0.13-0.20m between peat horizons indicates that the area was temporarily inundated by water / occupied by a water body for a period long enough to enable deposition of this clay horizon.

4.5 Hydrology

4.5.1 Catchments

River and stream catchments for the site and surrounding areas are illustrated in Appendix C1 and C2. Hydrologically, the Shannon LNG site is dominated by the **D1 Catchment** which occupies the central area of the site. Neighbouring catchments that have been identified are the **Shannon Estuary Sub-Catchment** in the extreme north and northeast of the site, and the **Kilcolgan Catchment** to the south of the site whose boundary crosses the site boundary over a limited area (Appendix C1). The D1 catchment occupies a total area of a little over 3 sq. km. Within the Shannon LNG site itself the D1 catchment covers an area of 0.703 sq. km. On a micro scale the **Lagoon Catchment** occurs as a separate hydrological unit and is illustrated in Appendix C2.

4.5.2 Drainage

MEL has carried out detailed mapping of site drainage during the preliminary "Site Walkover and Site Hydrochemical Survey" stage. Drainage patterns, drain dimensions, flow rates and surface water hydrochemistry have been examined in detail in the field.

Three significant drains have been identified within the Shannon LNG site. These are:

- D1 (main central stream)
- D2 (secondary drain north of D1)
- D3 (tertiary drain north of D1)

4.5.2.1 Primary Site Drainage (D1)

D1 Location and Context:

Of these three drains, D1 is by far the most significant in physical size, flow yield and location within the Shannon LNG site. D1 flows along a natural course throughout its on-site length. Flow direction is westerly upstream of the site boundary. Once the stream enters the site it bends and flows in a northwest direction through the centre of the site. At approximately 330m downstream of the site boundary D1 occupies the relatively steep valley of the F1 geological fault structure. The drain dimensions and principal characteristics of D1 are given in Table 2.

D1 Dimensions and Substrate Characteristics:

At the site boundary D1 flows in a westerly direction and is characterised by relatively high banks on both sides (c.1.5-2.0m), substantial bank width (c.3-4m), and a wide drainage channel (1.5m) underlain by hard bedrock substrate (Appendix N, Photo 16). Flow rate at SG-1 was measured as 15.29 l/sec on 24/04/07. Moving downstream, D1 bends to flow NW and continues to flow over hard substrate at SG-2 (Appendix N, Photo 17). The substrate type changes to moderately hard cobbles and gravel by the time D1 reaches SG-3 (Appendix N, Photo 18), and this substrate type continues until SG-4 (Appendix N, Photo 19) which is approximately 580m downstream of the eastern site boundary. Through this section D1 has a width of c.1.0m and water depth of 0.2-0.3m. At SG-5, D1 has increased to a width of 1.5m while depth of water is consistently at 0.2-0.3m (Appendix N, Photo 20).

Through the section of D1 which is flowing adjacent to the Reed and Large Sedge Swamp (FS1) area (between c.70m downstream of SG-5 to c.30m downstream of SG-8) the substrate becomes considerably softer with an increased clay and gravel component with occasional cobbles (Appendix N, Photo 21, 22 and 23). The banks are generally clay rich, unstable and overhanging (Appendix N, Photo 18) through this section, typically 0.5-1.0m high and 1.0-2.0m wide. Drain width is consistent compared with the upstream section at c.1.0-1.5m, while water depth is also similar at 0.2-0.3m.

D1 continues across soft clay substrate until beyond the Lower Salt Marsh (CM1) habitat and across the shingle and cobbles before discharging to the coast near SG-9 (Appendix N, Photo 9) where it eventually enters the Shannon Estuary. At this point D1 is characterised by its shallowest depth of c.0.1m and broadest width of 2.4m.

Table 2: D1 (Primary Drainage) channel dimensions, substrate characteristics and flow rates*.

Drain ID	Associated Monitoring Point ID	Substrate Type	Discharge (l / sec)	Bank Height (m)	Bank Width (m)	Drain Width (m)	Water Depth (m)
D1	D1-SW-FG-SG1	Hard Bedrock with Cobbles / Boulders (Solid refusal)	15.29	1.5-2.0	3.0-4.0	1.5	0.3

D1	D1-SW-FG-SG2	Hard Boulder, Cobble and Gravel / Sand	16.47	0.5	1.0	1.0	0.3
D1	D1-SW-FG-SG3	Moderately Hard Cobble and Gravel	13.91	0.5	1.0	0.7	0.3
D1	D1-SW-SG4	Moderately Hard Cobble and Gravel	N/app**	0.5	1.0	1.0	0.2
D1	D1-SW-FG-SG5	Hard Bedrock with Cobbles / Boulders (Solid refusal)	11.81	0.5-1.0	1.5	1.5	0.2-0.3
D1	D1-SW-FG-SG6	Soft Pebble / Gravel / Clay	15.22	0.5-1.0	1.0-1.5	1.0	0.2
D1	D1-SW-FG-SG7	Moderately Soft Cobble / Gravel / Sand	16.50	0.5-1.0	1.0	1.0	0.2
D1	D1-SW-SG8	Soft Clay	N/app	1.0	1.5-2.0	1.5	0.5
D1	D1-SW-SG9	Moderately Hard Cobble	N/app	N/app	N/app	2.4	0.1-0.2

*Note: Drainage channel dimensions were measured on 27-29/03/07, D1 flow gauging / discharge measurements were carried out by impeller flow meter on 23-24/04/07.

**N/app = Not Applicable.

D1 Flow Gauging / Discharge:

The flow rates along the D1 stream have been measured by MEL at SG-1, SG-2, SG-3, SG-5, SG-6 and SG-7. Flow gauge results from the first monitoring event (on the 23-24 April 2007), although carried out during a brief period of wet weather, generally reflect baseflow conditions associated with the sustained dry weather experienced during early April 2007.

An average discharge value for the six flow gauging points of 14.87 l/sec was recorded. Discharge values for D1 are given in Table 2 and illustrated graphically in Appendix L. The results indicate a maximum value of 16.5 l/sec recorded at SG-7 and a minimum value of 11.81 l/sec at SG-5. This flow gauging event, in combination with the examination of D1 substrate characteristics indicates that flow rate is increasing (D1 stream is gaining water by groundwater outflow) along the eastern upstream section between SG-1 and SG-2. Subsequently, as D1 flows over more permeable soft substrate or fractured bedrock in the F1 fault area, a decrease in flow rate is noted between SG-2 and SG5 (D1 stream is losing water into the ground). There is a measured decrease of -4.66 l/sec along this section. By the time D1 reaches SG-6 flow rate has increased again by 3.41 l/sec. This phenomenon may be explained by a combination of upwelling from groundwater contributing to D1 and by the input of additional surface water from the secondary drain (D2) which has an estimated flow rate of 2-3 l/sec (see Table 3). At SG-7 flow rate has again increased by 1.28 l/sec compared with SG-6 suggesting additional input from groundwater since no surface water subsidiary drainage inputs occur over this section of D1. It has not been possible to flow gauge at SG-9 due to the shallow depth of water and unsuitable cross section profile at this location (c.0.1m) making it unsuitable for the impeller flow gauging method.

Surface water discharge was measured in D2 and D3 on 21st May 2007. Discharge measurement points were selected at locations close to the confluences with D1 where maximum flow was noted to be occurring (i.e. at D2-SW5 and D3-SW2). Discharge values of 0.16 l/sec were recorded for D2 and 0.04 l/sec for D3.

These discharge rates are substantially reduced compared with visual estimates made in late March 2007. This change may be explained by the fact that February and March were relatively wet months compared with May 2007. Future monitoring of drainage discharge rates will enable more detailed interpretation of the degree of input of surface water flow into D1 by subsidiary drainage D2 and D3.

4.5.2.2 Secondary and Tertiary Site Drainage (D2 to D9):

Secondary and tertiary drainage at the Shannon LNG site has been mapped by MEL during the preliminary site walkover survey between 26th and 29th March 2007. A number of minor man-made drainage ditches are present on the site, which have been labelled D2 through to D9 (see Appendix C2). Drain dimensions, substrate characteristics and discharge estimates are given in Table 3.

- **D2:** arises to the east of the site boundary and enters D1 downstream of SG-5 (at 101790E, 148344N). It is classed as a secondary drain because of its considerable spatial coverage to the NE of D1 and because of its apparent contribution of surface water flow to D1 (discharge visually estimated at 2-3 l/sec). In a similar fashion to D1, the pathway of D2 manipulates the alignment of a local fault labelled F2 for a distance of c.610m, which for the most part runs parallel to F1 (Section 4.4.1; Appendix B1). D2 has a width of 0.5m and water depth at time of site survey of 0.1-0.2m.

- **D3:** occurs further east of D2 and arises outside the site boundary and enters the D1 stream c.60m downstream of SG-2 (at grid reference 102112E, 148056N). D3 occupies a man-made drainage ditch which runs along existing field boundaries. The D3 channel has a hard cobble substrate and typically has a bank height of 0.1m, bank width of 1.0-2.0m, drain width of c.0.4m, while water depth is c.0.1-0.2m (Appendix N, Photo 24). Visual estimate of flow in D3 indicate a discharge of c.1-2 l/sec.

- **D4:** is a minor seasonal drain which feeds into D2 (at grid reference 102043E, 148309N). During the preliminary site survey (29th March 2007) this drain was observed to originate from a spring discharge / seepage point (SP-SW5) located c.70m upstream of its confluence with D2. Water was noted to flow across soil / grass at the base of the field boundary and not to occupy a defined drainage channel (Appendix N, Photo 25). At this time D4 had an estimated discharge of c.0.5 l/sec. However, during the field monitoring event of 23rd to 26th April this area was noted to be dry.

Table 3: Secondary and Tertiary Drainage channel dimensions, substrate characteristics and flow rate estimates in late March 2007*.

Drain ID	Associated Monitoring Point ID	Substrate Type	Discharge (l / sec)	Bank Height (m)	Bank Width (m)	Drain Width (m)	Water Depth (m)
D2	D2-SW2	Soft Sand / Gravel	0.2 (Visual Estimate)	0.5	1.5	0.5	0.2

D2	D2-SW4	Moderately Hard Cobble	N/app**	1.5	1.0-2.0	0.5	0.1
D2	D2-SW5	Gravel	2-3 (Visual Estimate)	0.3	0.7	0.5	0.1
D3	D3-SW2	Hard Cobble	1-2 (Visual Estimate)	0.1	1.0-2.0	0.5	0.1
D4	N/app	Soil / Grass	0.5 (Visual Estimate)	N/app	N/app	N/app	N/app
D6	D6-SW2	Soft Clay	N/app	0.2	0.4	0.4	0.1-0.2

*Note: Drainage channel dimensions were measured on 27-29/04/07, flow rate visual estimates were made on 27-29/03/07.
**N/app = Not Applicable.

- **D5:** originates from a waterlogged area west of SP-SW4, flows south-southwest and ponds substantially at D5-SW1 (Appendix N, Photo 26) and then flows southeast until it joins D2 at grid reference 101892 E, 148411N.

- **D6:** originates as diffuse drainage from the Reed and Large Sedge Swamp (FS1) habitat. It eventually forms a narrow streamlet at the western end of the swamp area, which flows west and joins D1 approximately 40m downstream of SG-8. D6 has a soft Clay substrate and has water depth of c.0.1-0.2m and drain width of c.0.4m (Appendix N, Photo 27).

- **D7:** feeds northwest into SP-SW2 and eventually into the lagoon. D7 flows along the field boundary on a seasonal basis. This drain contained water in late March 2007 during the initial site survey, but was dry in late April 2007 during the monitoring event.

- **D8:** flows northwest along a farm roadway on a seasonal basis. Flow discharges from SP-SW1 and generally occupies the southwest side of the roadway (Appendix N, Photo 32) until it reaches c.20m southeast of the beach. It then ponds at this point and possibly feeds into the lagoon to the northeast and also possibly into the smaller pond area to the southwest (i.e. adjacent to L2-SW1). It would appear that the flow in D8 is prevented from flowing into the sea due to the height of the cobble beach which blocks it, and causes water to pond around the vicinity of D8-SW2 (Appendix N, Photo 34).

- **D9:** flows seasonally northeast along a man-made ditch (field boundary) and into D1 adjacent to the location of SG-5. In March and April 2007 this drain contained water beneath dense grass growth but was not flowing visibly (Appendix N, Photo 28).

4.5.3 Springs

A number of springs have been mapped within the study area and are illustrated in Appendix G1. Photographs of these features are provided in Appendix N (Photos 29 to 34). These springs were identified during the field survey of 26th to 30th March 2007, after a period of wet weather. The three springs associated with the wetland areas adjacent to D1 generally occur in the northeast side of the study area (SP-

SW3, SP-SW4 and SP-SW5), while two spring discharges are associated with the coastal lagoon and saline lake (CW1) in the west (SP-SW1 and SP-SW2).

- **SP-SW1** occurs on the northwest side of the farm yard to the south of the lagoon and saline lake (CW1) (Appendix N, Photo 33) and drains seasonally along D8 toward the coast. This spring was flowing considerably in late March 2007 during the initial site survey, but was found to be dry in late April 2007 during the monitoring event.
- **SP-SW2** occurs at the eastern corner of the coastal lagoon and saline lake (CW1) at the base of D7 (Appendix N, Photo 35). Water depth here was noted to be c.0.2m depth in late March 2007 but had become dry when monitored in late April 2007.
- **SP-SW3** occurs in the north of the Reed and Large Sedge Swamp (FS1) area (Appendix N, Photo 31). This spring feeds the swamp area along with other groundwater seepages which occur along the northern and eastern boundary of the swamp, for example at SS-SW3 and SS-SW4. SP-SW3 is characterised by lush green vegetation on soft swampy ground underlain by a stony substrate base.
- **SP-SW4** was noted to have a water depth of c.0.3m in late March 2007. A dense mat of floating vegetation was noted adjacent to this point (Appendix N, Photo 29). An extensive area of marshy ground exists to the northeast and IGSL site investigation indicates that borehole BH-23 exhibits artesian groundwater conditions.
- **SP-SW5** discharges at the base of the field boundary and feeds into D4 (Appendix N, Photo 30). This spring was flowing in late March 2007 during the initial site survey, but was found to be dry in late April 2007 during the monitoring event.

4.5.4 Coastal Lagoon

The coastal lagoon and saline lake (CW1) (Appendix N, Photo 5) is located on the Shannon Estuary in the west of the site c.150m south of where D1 flows into the estuary, and covers an area of c.1.5ha of which c.0.2922ha is open water. It is separated from the sea by shingle bank, which at the time of the initial site survey (late March 2007), had a vertical elevation of c.0.5m (visual estimate) greater than the lagoon water level (Appendix N, Photo 6). Typically the normal high tide does not cross the upper beach, nor does it feed the lagoon on a regular basis. Inundation of the lagoon is limited to times of high spring tides, and would be augmented by wave overtopping. Dried seaweed is generally found along the uppermost section of this shingle bank indicating that inundation occurs occasionally. At the seaward side of the lagoon water depth was measured at c.0.4-0.8m (March – April 2007). Seepage of lagoon water seaward through the shingle bank was noted at the northern corner of the lagoon (adjacent to SG-10) during the initial site survey (Appendix N, Photo 36). The southeastern side of the lagoon is seasonally fed by the springs SP-SW1 and SW-SW2 and by D7 and D8 (Appendix G1). The input of both marine water and fresh water to the lagoon results in a brackish mixture of the two types of water. Discussion of the lagoon's chemistry is provided in Section 4.5.5.

4.5.5 Water Chemistry

MEL has undertaken detailed monitoring of groundwater and surface water chemistry (electrical conductivity, pH and temperature) at the Shannon LNG site in March and April 2007. This has consisted of initial monitoring of surface water and spring discharges during the preliminary site survey phase (26th to 29th March 2007), and a second event (23rd to 26th April 2007) to monitor surface waters, spring discharges and groundwater chemistry of the MEL BR-Series and IGSL BH-Series points. A comprehensive database has been compiled of water levels and chemistry for groundwater and surface water, and discharge flows for the main drain D1 (Appendix M1). At the time of preparation of this report, the hydrological assessment has been based on results obtained from a total of 48 surface water and 51 groundwater monitoring points. Reference is made to Appendix F2, I, J and M1 throughout this section.

4.5.5.1 Surface Water

Surface water quality was assessed from 48 monitoring points by measuring electrical conductivity, pH and temperature in the field. Along each of the drains identified above, as well as from spring discharges and standing water monitoring points (e.g. SS-SW1), these parameters were measured and geo-referenced for future monitoring. Monitoring IDs such as D1-SW2 and SP-SW1 for the drains and springs were given to measurement locations. Table 4 gives the ranges and averages in EC values recorded for surface waters across the site in late March and late April 2007.

Results of these measurements to date indicate the following with regard to surface water chemistry during the period investigated to date (March and April 2007):

Central Drain (D1):

- D1 is the central drain of the site and is the main focus of the present study and thus has the most chemistry monitoring points along its route within the site boundary (i.e. D1-SW1 to D1-SW3 and at each staff gauge location, i.e. 12 chemistry monitoring locations in total).
- The electrical conductivity values along D1 ranges from 357 to 721µS/cm. Average EC in D1 is 445µS/cm. The lowest value of electrical conductivity occurs at D1-SG6 adjacent to the Reed and Large Sedge Swamp (FS1) and the highest value was recorded at D1-SG9 adjacent to the coast. This elevated EC at SG-9 indicates that intrusion of saline water is occurring in the extreme downstream section of D1 near SG-9, but this incursion does not extend far upstream along D1, since EC at SG-8 is again low at an average of 429µS/cm.
- pH values recorded along D1 ranges from 6.64 to 8.30. Highest pH occurs at D1/SW3 (8.30) which is again located near the coast and reflects the influence of seawater (pH range of 7.5 to 8.4) while the lowest value is recorded at D1/SG1 (6.64) at the most upstream monitoring point location where D1 enters the site. Average pH recorded along D1 is 7.49.

Subsidiary Drainage (D2 to D9, <u>not including</u> D6):

- Subsidiary drainage at the site has a wide range in EC of 224 to 811µS/cm. The average EC in these drains is 464µS/cm. In general the following average values occur in the various drains; D2 - 477µS/cm, D3 - 345µS/cm, (D4 – not measured) D5 - 291µS/cm, (D6 – discussed separately below), (D7 – not measured), D8 - 810µS/cm, D9 - 361µS/cm. Hence, drains with average EC <400µS/cm are D3, D5 and D9. D3 and D9 most likely contain a significant surface water component, while D2 (average EC >400µS/cm) may experience a groundwater input through fractured bedrock associated with the F2 geological fault structure (see Section 4.4.1). D8 high EC values (810µS/cm average) may be explained by proximity to the coast and the possible accumulations of airborne salts blown in from the Shannon Estuary, or by high EC water discharging from SP-SW1 upstream (e.g. EC here was 1,065µS/cm in late March 2007).
- pH values in subsidiary drainage range from 5.90 to 7.57pH, with an average of 7.02 units between March and April 2007.

Table 4: Electrical Conductivity and pH maximum, minimum and average values for various sub-categories of surface water type (March and April 2007).

Surface Water Sub-Category Type	EC Min - Max (µS/cm)	EC Average (µS/cm)	pH Min - Max (pH units)	pH Average (pH units)
Central Drain (D1)	357 to 721	445	6.64 to 8.30	7.49
Subsidiary Drainage (D2-D9 not incl. D6)	224 to 811	464	5.90 to 7.57	7.02
Spring Discharge (SP)	266 to 1,065	465	6.05 to 7.98	6.93
Coastal Lagoon (L1 & L2)	303 to 1,624	876	6.70 to 9.91	8.13
Lower Salt Marsh (SM)	>20,000	>20,000	5.20 to 7.80	6.57
Reed and Large Sedge Swamp (incl D6) (SS)	258 to 5,680	1695	5.67 to 7.75	7.01

Spring Discharge:

- Spring discharge points show a wide range in measured EC values across the site (recorded between March and April 2007), from 266µS/cm (at SP-SW4) to 1,065µS/cm (at SP-SW1). SP-SW1 indicates the highest EC among the spring discharge points. In late April 2007 SP-SW2 and SP-SW5 were found to be dry.
- Spring discharge monitoring to date indicates a range of pH of 6.05 to 7.98 pH units with an average of 6.93.

Coastal Lagoon:

- The coastal lagoon is characterised by high EC (brackish water type) with a range of values between 303µS/cm (freshwater) and 1,624µS/cm (brackish). Highest values occur on the coastal side of the lagoon around SG-10, SG-11 and L1-SW1 (i.e. >1,000µS/cm). The lowest recorded value (303µS/cm) was that taken at the inland monitoring point of SG-12 in late March 2007 as a deep lagoon base sample from a depth of c.0.3m. A shallow surface sample taken at the same

monitoring point and on the same date recorded an EC value of 559µS/cm. This difference in EC (range of +/-256µS/cm) between deep and shallow lagoon samples is largely a function of temperature difference (EC increases by 1.7% per 1˚C change in temperature)

- pH values in the lagoon range from 6.70 to 9.91 pH units with an average of 8.13.

Lower Salt Marsh:

- Water hydrochemistry has been measured in March and April 2007 in the Lower Salt Marsh habitat from standing water at SM-SW1 and SM-SW2. On each occasion EC was >20,000µS/cm indicating considerable salt water incursion and influence of saline marine water throughout this area adjacent to D1. This high EC standing water (Lower Salt Marsh) is noted to extend up to at least the area of SG-8. However, in comparison the adjacent D1 surface water has an EC of only 423µS/cm. The low-lying areas adjacent to D1, i.e. Lower Salt Marsh, Sedge Swamp and Marsh area on the southwest side regularly experience inundation by sea water during high spring tides when standing water of up to c.0.5m occurs over this area. When high spring tide retreats water levels fall as sea water drains out again along D1, D6 and through the lower salt marsh area. (Per comm. Micheal O'Connor, local land tenant). This would explain the high EC values recorded in the lower salt marsh area, since residual salts would remain after the tide has gone out. Under these circumstances, salts would also tend to accumulate over time within the clay soils.
- pH values in the lower salt marsh range widely from 5.20 to 7.80 pH units.

Reed and Large Sedge Swamp (incl D6):

- The Sedge Swamp area displayed a wide range of EC values between 258 to 5680µS/cm, and with an overall average EC of 1695µS/cm.
- Standing water in the Sedge Swamp area has been noted along its peripheral north and northeast boundary at SS-SW3 and SS-SW4, where EC values are typically lower than the aforementioned average. Here the average EC value is 338µS/cm and represent seepage of groundwater along the line of the F2 geological fault structure, which coincides locally with a notable break in slope.
- SS-SW1 was sampled from the mid-west section of the Sedge Swamp area where EC values are typically high at c.1,900-2,400µS/cm. This elevated EC indicates sea water influence either through incursion along the F1 fault structure or as residual salts left after high spring tide incursions. D6, which flows through this western section of the Sedge Swamp, also exhibits elevated EC with values between 1,516-5,680µS/cm.
- At SS-SW2, closer to the centre of the Sedge Swamp, EC values are more similar to those recorded on the periphery of this area (average 341µS/cm). This change in EC across the swamp suggests that there is a spatial change in the primary influence on water type across this area. In the west there is a stronger marine influence with sea water incursion and thus a higher EC, creating a brackish water environment. On the eastern side there is greater flushing by groundwater (through seepage and spring discharge), and by surface water (rainfall runoff and

infiltration). This results in dilution and removal of salts which may occasionally be introduced to the system during high spring tide flooding events.

- pH values in the Sedge Swamp range from 5.67 to 7.75 pH units.

4.5.5.2 Groundwater

Groundwater chemistry was assessed in the field by extracting water from boreholes and installed piezometer nests / couples and by measuring indicator parameters, such as electrical conductivity (EC), pH and temperature. To date, one round of groundwater chemistry monitoring has been carried out for the BR-Series and the BH-Series installation (during the period 23rd to 26th April 2007). The results of hydrochemical testing for groundwater are discussed below under various hydrological and lithological groups and are also summarised in Table 5. For the purpose of categorisation, groundwater hydrochemistry has been subdivided according to subsoil and bedrock lithology type, i.e. CLAY subsoils (PH1 and P3), CLAY subsoils / weathered BEDROCK interface (P2), CLAY subsoils / BEDROCK (fresh) interface (PH1, P3 and P2), weathered BEDROCK (P3) and BEDROCK (fresh) (PH1, P3, P2 & P1). Details of nested piezometer installations in the BR-Series coreholes are given in Appendix F2. The data generally indicates a wide range in EC values within each lithology type. However, average EC groundwater values for both subsoil (588µS/cm), and bedrock (578µS/cm) were very similar based on recordings made in late April 2007. Groundwater pH average values in bedrock and subsoils show a narrow variation from c.6.40 to 6.90 pH units. Future monitoring will provide additional information enabling more detailed interpretation of the groundwater hydrochemistry at the site.

Subsoils Unit:

- The groundwater hydrochemistry of the subsoil **Clay** unit has been monitored in PH1 and P3 installations in the BR-Series. A range of EC values from 268 to 867µS/cm, with an average of 620µS/cm, was recorded for this unit in late April 2007. pH in the subsoils was 6.05 to 7.23 pH units with an average of 6.88 pH units in late April 2007.
- EC values recorded in late April 2007 from **phreatic** BR-Series installations in clay subsoils have been spatially illustrated in Appendix K. The available data indicates a phreatic groundwater EC of c.600-900µS/cm generally across the site, with the exception of BR-5 and BR-11 (c.250-400µS/cm) which are located in the northeast part of the study area near D2.
- The **Subsoils / Bedrock Interface** has been monitored by **piezometric and phreatic** installations in the BR-Series points. The results indicate a range in EC of 314 to 928µS/cm and an average of 556µS/cm. pH range is 5.11 to 7.35 pH units with an average of 6.42 pH units.

Table 5: Groundwater electrical conductivity and pH maximum, minimum and average values for various categories of subsurface lithology (April 2007).

Groundwater Sub-Category Type (BR-Series Installations)	EC Min - Max (µS/cm)	EC Average (µS/cm)	pH Min - Max (pH units)	pH Average (pH units)
Subsoil – CLAY	268 to 867	620	6.05 to 7.23	6.88
Subsoil - CLAY / BEDROCK	314 to 928	556	5.11 to 7.35	6.42
BEDROCK – Weathered	409 to 652	503	6.26 to 7.02	6.63
BEDROCK – Unweathered	217 to 1019	674	5.50 to 7.76	6.86

Bedrock Unit:

- The groundwater hydrochemistry of the **weathered Bedrock** unit has been monitored in BR-1 and BR-7. A range in EC values of 409 to 652µS/cm and an average of 503µS/cm was recorded for this unit in late April 2007. pH in the weathered bedrock was 6.26 to 7.02 pH units with an average of 6.63 pH units in late April 2007.
- The groundwater hydrochemistry of the **un-weathered Bedrock** unit has been monitored generally by means of 2 or 3 piezometer installations in the BR-Series points. A wide range in EC values from 217 to 1019µS/cm, with an average of 674µS/cm, was recorded for this unit in late April 2007. pH in the un-weathered bedrock was 5.50 to 7.76 pH units, with an average of 6.86 pH units in late April 2007.

Hydrochemistry of BH Series:

- BH Series groundwater hydrochemistry has been monitored by MEL in late April 2007 at BR-3, BR-5, BR-13, BR-19 and BR-23. These borehole standpipes cover both bedrock and bedrock / subsoil interface units in the northeast of the site (see Appendix E). BH-14 and BH-20 were found to be dry in late April 2007.
- **Bedrock / subsoils** monitoring points have EC average of 405µS/cm and pH average of 5.57 pH units.
- **Bedrock** hydrochemistry indicates an average EC value of 399µS/cm and pH average of 5.92 pH units.
- The results indicate that across this area of the site bedrock and subsoils units display similar EC and pH values.

Analytical Hydrochemical Testing of BH Series:

Groundwater samples were taken from a number of the BH-Series standpipes for laboratory water quality analysis in January 2007. Samples were taken from from BH-5, BH-10, BH-14, BH-20 and BH-23, and from PW1 (which is located c.60m south of BH-23). Analytical hydrochemistry results are given in Appendix L. In terms of groundwater quality, the analytical results have been compared with S.I. No. 106 of 2007 (Drinking Water Regulations) (Ref. 7) and the EPA Interim Guideline Values for groundwater (Ref. 8). Values in excess of SI 106 maximum admissible concentrations (MAC values) and / or EPA interim guideline values (IGV's) have been highlighted in yellow in Appendix L. The results indicate the following:

- Total alkalinity values are low at between 40-80mg/l, as would be expected for silicate base sandstone bedrock.

- EC values for the samples show an average of 358µS/cm, which compares with the average value of 402µS/cm recorded in the BH installations by MEL in late April 2007.
- pH is just above neutral, with an average of 7.72 pH units, which is higher than the slightly acidic average value of 5.71 pH units recorded in the BH installations by MEL in late April 2007.
- Both chloride and sodium values are low with a range of 40-54mg/l and 22-40mg/l, respectively, which are well below the MAC and IGV limits.
- The nitrate value at BH-5 (33.8mg/l) exceeds the EPA's IGV but is below the SI 106 MAC limit for drinking waters.
- Orthophosphate levels at each of the four boreholes sampled for this parameter are above the EPA's IGV of 0.03mg/l.
- The presence of elevated nitrates and phosphates in combination is indicative of fertilisers and most likely the result of agricultural activity in this area.

4.5.6 Water Levels

MEL has installed an extensive groundwater monitoring network comprising nested piezometric / phreatic installations as part of its BR-Series site investigations, in order to evaluate water levels and piezometric pressures and their variations across the site. The results of initial baseline monitoring at the site for both the free water table (phreatic surface) and the piezometric surface are summarised below and shown in Appendix J. Water levels are given in metres above ordnance datum Malin (mOD Malin) and, to date one round of water level monitoring has been undertaken, in late April 2007. Temporal changes in water level will become apparent once future rounds of water level monitoring have taken place. Reference is made to Appendices G, H and J throughout this section.

Phreatic Water Levels:

- Phreatic water levels beneath the site are strongly controlled by the presence of the D1 stream and by the overall topography, as illustrated in Appendix H1. Groundwater flow direction is predominantly towards the northwest, generally following the ground slope, and thus towards D1 and the Shannon Estuary.
- In the eastern part of the site phreatic groundwater level was recorded at 14.69mOD in BR-2, in late April 2007. Phreatic water levels decline, with the topographical contours, in a northwesterly direction, varying from 1.84mOD at GC17-PH1 to c.5.1mOD at BR10-PH1, which is located on slightly higher ground to the northeast of D1.
- "Composite Standpipe" water levels in the BH Series are 5.95mOD at BH-19 in the far northeast and between 11.49mOD and 12.28mOD on elevated ground in the west of the area of the BH Series monitoring points.

Piezometric Water Levels:

Piezometric water levels have been monitored in the BR-Series (P1, P2 and P3) nested piezometer installations on the periphery of the wetland cSAC and pNHA areas (see Appendix E and F2) in April 2007.

- The piezometric surface is less strongly influenced by surface water drainage compared to the phreatic water table. The contouring in Appendix H1 and H2 illustrate this for April 2007. Piezometric contours in Appendix H2 indicate that flow direction is to the northwest.
- The deepest piezometers are the P1 installations in the sandstone / siltstone bedrock. These indicate a range in piezometric elevation from 14.76 – 15.07mOD at BR-2 and BR-1, respectively, in the east of the study area; to 2.33 – 3.25mOD in BR-10 and BR-9, respectively, in the west of the study area.
- The mid-level piezometers are the P2 installations in subsoils and shallow sandstone / siltstone bedrock. These indicate a range in piezometric elevation from 14.49 – 15.07mOD at BR-2 and BR-1 respectively, in the east of the study area; to 2.32 – 3.22mOD in BR-10 and BR-9 respectively in the west of the study area.
- The shallowest piezometers are the P3 installations in the upper sandstone / siltstone bedrock. These indicate a range in piezometric elevation of 15.17mOD at BR-1 in the east of the study area; to 2.30 – 3.26mOD in BR-10 and BR-9, respectively, in the west of the study area.

4.5.7 Vertical Hydraulic Gradients

Upward vertical groundwater movement occurs when piezometric levels are higher than phreatic levels, while downward vertical groundwater movement occurs when piezometric levels are lower than phreatic levels. Upward discharge of groundwater at the surface (in the form of upwelling springs and seepages) signifying artesian conditions only occurs when piezometric levels are above the ground surface and when the phreatic level is at ground surface. In some places persistent downward recharge or upward discharge may occur throughout the year, while in other places the regime may changes on a seasonal basis. These changeable zones are named intermediate zones. In general, in intermediate zones, upward discharge occurs in winter and downward recharge occurs in summer.

Future monitoring at the site will enable seasonal variations in vertical hydraulic gradients to be studied in more detail. To date, one set of water level monitoring data from late April 2007 is available for interpretation, so temporal trends cannot yet be established. Vertical hydraulic gradients have been identified for the BR-Series nested piezometer / phreatic installations on the periphery of the wetland (see Appendix H3) and provide valuable information on the role of groundwater seepages in maintaining these wetland systems. The following summary interpretations are based on piezometric and phreatic water level data from late April 2007 (see Appendix H3):

- Upward hydraulic gradients occur at BR-8 and BR-10.
- Decoupled upward hydraulic gradient exists at BR-4. The P2 installations here indicate that groundwater is present under pressure along the subsoil / bedrock interface.

- Upward hydraulic gradient exists in the P2 and P3 installations at BR-6. The P2 and P3 at BR-6 are installed at the subsoil / bedrock interface and in the lower subsoil horizon respectively. The elevation of the piezometric surface here indicates that groundwater is contained under pressure along the subsoil / bedrock interface and in the lower subsoil horizon.
- Decoupled hydraulic gradient occurs at BR-9. There is a downward gradient between the PH1, P3 and P2 installations (i.e. from clay subsoils down to the shallow bedrock) and there is an upward gradient in the deeper bedrock (at 7.0-8.0mbGL) P1 installation.
- Downward hydraulic gradients exist at BR-1, BR-3, BR-7 and BR-11.

4.5.8 Horizontal Hydraulic Gradients

Horizontal hydraulic gradients generally occur at right angles to the topographical contours, with groundwater flow taking place in the direction of ground slope. In uniform permeability materials the rate of groundwater flow is generally a function of the ground slope, as evidenced from the relative distance between groundwater contour lines in Appendix H1 and H2. Horizontal gradients are relatively greater in the overburden and mineral soils on the more elevated and steeply sloping northeastern parts of the site, compared with those in the lower and flatter areas peripheral to the wetlands in the northwest. Clay overburden areas on the periphery of the low-lying wetlands will however have a relatively low hydraulic conductivity resulting in confinement of deeper groundwater and the possibility of localised spring discharges at the surface should (e.g. SP-SW5 and SP-SW3), where piezometric pressure become artesian. Such springs and seepages provide sources of recharge to the wetland system. Directionally, phreatic and piezometric groundwater flow is toward D1 as indicated by the contour maps in Appendix H1 and H2.

4.5.9 Surface Water Levels

Surface water levels have been recorded in the Lagoon at four (4) staff gauge installations (SG-10, SG-11, SG-12 and SG-13), and in D1 at nine (9) staff gauge installations; starting upstream at SG-1 near the eastern site boundary and through to SG-9 close to the outlet of D1 into the Shannon Estuary (see Appendix G1). Surface water levels for late March and April 2007 are given in Appendix J. To date, the levelling results indicates a decrease in water level in both the lagoon (drop in level of between c.0.01 and 0.2m) and in D1 (drop in level of between c.0.01 and 0.1m) during the period late March to late April 2007 (see Appendix M, Photo 37 to 40, which illustrate falling water levels in the Lagoon).

5. POTENTIAL IMPACTS

Probable or likely impacts by the proposed Shannon LNG Terminal development on the sensitive and protected wetland habitats of the Special Areas of Conservation c(SAC) and proposed National Heritage Areas p(NHA)), in the absence of adequate mitigation measures, are detailed in this section**.**

1. Groundwater Dewatering by Cuts

The proposed terminal plant will be located on sloping ground towards the Shannon Estuary Coastline. The sloping baseline topography necessitates removal of earth materials which will include subsoils as well as upper bedrock in the deeper cut locations. The deepest cuts will occur along the southern and inland boundary of the terminal plant coincident with higher elevation terrain. The maximum cut depth is anticipated to be at -13mbgl, upslope of Tank No. 1.

Evaluation of the significance of the cuts into the subsoils and upper bedrock confirms that the majority of the excavations occur within the Shannon Estuary Sub-catchment. Only the western and southwester part of the terminal plant which contains a designated landuse of “Future Equipment Area” is partially located within the D1 catchment. This part of the site will generally be built up with minimum excavation required for foundations.

Evaluation of the groundwater flow regime (Appendix H1 and H2), the hydrogeological properties of the subsoils and bedrock at the site, the different hydrological catchments in which the terminal plant and the wetland habitats occur, as well as the buffer distance of >150m at which the wetland habitats are located from the terminal plant indicates that the permanent excavation cuts, the majority of which will be backfilled to near present topographical levels, will have an imperceptible impact on the groundwater recharge to the designated wetlands.

2. Groundwater Diversion by Fills

In those areas where excavations are proposed, there will be a backfill with suitable bearing materials in order to support the structures proposed for the development. Fill materials such as broken rock and “clause 804” are characterised by higher permeability than the in-situ subsoils. The bulk emplacement of higher permeability materials can provide preferential pathways for groundwater flow which in turn cause local diversions of “inflections” of the groundwater flow paths and thus impacts on the flow equipotentials. Generally however, engineering design is applied to ensure that the majority of such foundation materials are unsaturated.

The hydraulic impact arising from groundwater diversion by fills is considered to be an imperceptible impact on the hydrogeological functioning of the protected wetlands.

3. Reduction in Water Supply to Wetland by Embankment

The proposed embankment and in-line ponding of D1 upstream of SG4 and the cSAC habitats boundary has the potential to reduce water flow in D1, which in turn may reduce the supply of freshwater to peripheral wetland habitats, the most significant of which are the Reed and Large Sedge Swamp (FS1) located along the lower reaches of D1 (Appendix F2). Extensive site investigations and monitoring of groundwater and surface water in the region of FS1 and associated habitats indicates that the FS1 is dependent on groundwater, freshwater runoff form adjacent lands, as well as periodic inundation by D1.

Evaluation of the hydrological and hydrogeological data acquired, indicates that the proposed embankment has the potential to have a moderate negative, long term impact on the freshwater wetland habitats in which FS1 is the most sensitive due to its location. Mitigation measures have been applied to the design of the embankment in order to reduce this impact to an imperceptible impact or potentially into a positive impact, the details of which are outlined in Section 6.

4. Release of Suspended Solids to Surface Water

During the extraction, stockpiling, and transport of earth materials for the construction phase of the development, it is likely that a high content of suspended solids will be entrained by sustained rainfall and surface water runoff.

Runoff of suspended solids will add turbidity to the surface water which can clog fish gills, smother spawning grounds, reduce light penetration for flora growth, add bacteria and algae to the water. Nutrients that are associated with the solids (inorganic nutrients such as phosphorus and organic such as hydrocarbons, sewage if present) can lead to eutrophication of the water environment and eventually to fish-kills due to lowering of oxygen supply.

For these reasons and in the context of protecting the water quality that surrounds and supplies the wetland complex, it is critical that water runoff from the construction phase of the development is controlled and attenuated before discharging to the existing drainage network. This is considered to be a short-term, temporary but significant negative impact. However, with appropriate environmental engineering controls and measures, this impact can be reduced to within water quality regulatory limits.

5. Risk of Pollution from Hydrocarbons Leakage

The majority of plant equipment used for construction phase will run on hydrocarbons (aside from direct electricity connection of non-mobile equipment). This poses the potential for spillage and leakage of hydrocarbons from plant equipment and associated refuelling locations during the construction phase of this project. An accidental hydrocarbon spillage would have a significant negative impact on both groundwater and surface water quality at and down-gradient of the site, which if it reached the wetland complex will have seriously adverse consequences.

Evaluation of the hydrogeological properties of the Shannon LNG site confirms that surface water pathways are the main risk posed to D1 and associated wetland habitats receptor. Release of hydrocarbons to the both the surface water and groundwater environment (in context of Water Framework Directive) is a significant negative impact during the construction and to a lesser degree the operation phase of the development.

6. Other Potential Pollutants

Other potential pollutants that may impact on groundwater and surface water quality as a function of excavation works and associated with entrained suspended solids from subsoils and bedrock are:

- Inorganic nutrients such as nitrogen and phosphorus compounds (if present in excavated sediment).
- Bacteriological contamination arising from availability of organic nutrients (e.g. livestock waste on acrotelm peat).
- Trace metals that may naturally be present and therefore potentially released from Dalradian meta-sediments (e.g. arsenic, chromium, copper, lead).

These contaminants are less likely to be introduced to the water environment, which in turn can impact on the water quality of the wetlands, and as a result are considered to be a minor to moderate negative impact.

6. MITIGATION MEASURES

1. Groundwater Dewatering by Cuts

Proposed excavations and cuts for the proposed scheme will have an imperceptible impact on the groundwater recharge to the designated wetlands, therefore no mitigation is required.

2. Groundwater Diversion by Fills

The hydraulic impact arising from groundwater diversion by fills will have an imperceptible impact on the hydrogeological functioning of the protected wetlands, therefore not mitigation is required.

3. Reduction in Water Supply to Wetland by Embankment

In order to mitigate the potentially moderate negative permanent impact by the proposed embankment structure and in-line pond on the water supply to D1 and downstream associated habitats, the embankment has been designed to include the following criteria:

- An outflow drain will be installed to provide a minimum discharge rate of 10l/s which has been calculated (See Chapter 13), as well as empirically provide to be slightly greater than the baseflow discharge rate in D1 (Section 4.5.2).
- The embankment foundation level will be 1-2m below the ground level, and will avoid interception of the underlying bedrock aquifer.
- The embankment and the entire area of the pond will be lined in order to hold the water within the pond with a maximum leakage rate of 2l/s.

The above design criteria will (a) maintain baseflow to D1, (b) prevent groundwater "flushing" of waters to the downstream habitats, and (c) avoid interception or disturbance to the groundwater flow regime.

These design measures above including will reduce the impact to an imperceptible level, and potentially depending on management of water budgets this impact can provide positive results for downstream habitats.

4. Release of Suspended Solids to Surface Water

In order to mitigate the impact posed by release of suspended solids to the surface water environment, the following mitigation measures are recommended:

(a) The drainage and pollution control measures should be installed prior to the main construction activities to control increased runoff and associated suspended solids loads in discharging waters from the construction areas. This involves the construction of drainage ditches, the installation of silt

traps, stilling ponds and the implementation of prescribed buffer zones. Where possible drainage control should be installed during dry weather conditions.

(b) A minimum of a 25m buffer zone has been applied to the cSAC and pNHA boundaries, such as from the embankment and the proposed landscaped area around the terminal plant. A 30m buffer zone has been applied for the laydown area located south of the Lagoon & Saline Lake (SW1).

(c) Water Quality Monitoring during the Construction Phase is recommended in order to confirm discharge water quality values from the construction areas as well as receptor water quality to confirm and provide a check on the effectiveness of pollution control measures installed. Compliance testing and reporting should be undertaken on a weekly basis.

5. Risk of Pollution from Hydrocarbons Leakage

To control and contain any potential hydrocarbon and other harmful substances spillage by vehicles during construction, it is recommended that discrete "fuel stations" be designated for the purpose of safe fuel storage and fuel transfer to vehicles. These fuel stations should be bunded to 110% volume capacity of fuels stored at the site. The bunded areas should be drained by an oil interceptor and this drainage will be controlled by a pent stock valve that will be opened to discharge storm water from the bund. A suitably qualified management company will take responsibility for management and maintenance of the oil interceptor and associated drainage on a regular basis, including decommissioning (Section 2.6.4.2.2).

There is also the risk of leakage from vehicles and plant equipment during construction activity, as opposed to refuelling. The plant and equipment used on site will require regular mechanical checks and audits to prevent spillage of hydrocarbons on the exposed ground (during construction). This should be part of the construction environmental management system.

6. Other Potential Pollutants

During the construction phase, self contained port-a-loos with an integrated waste holding tank will be used on site for toilet facilities. This will be maintained by the service contractor on a regular basis and will be removed from the site on completion of the construction phase.

The pollution control measures outlined for suspended solids and hydrocarbons will provide sufficient water quality control (once audited for compliance) to mitigate the majority of other identified "natural" and "introduced" pollutants.

7. RESIDUAL IMPACTS

Minerex confirms that having undertaken this impact assessment study that that the proposed development can proceed without having any significant negative residual impacts on any of the protected habitats located adjacent to the Shannon LNG site, particularly those wetland habitats located downstream of the proposed embankment structure across the main stream, D1.

In fact some of the mitigation measures proposed have the potential to benefit the habitats present in terms of improving water supply and water quality for the habitats, thus producing a positive residual impact.

8. REFERENCES

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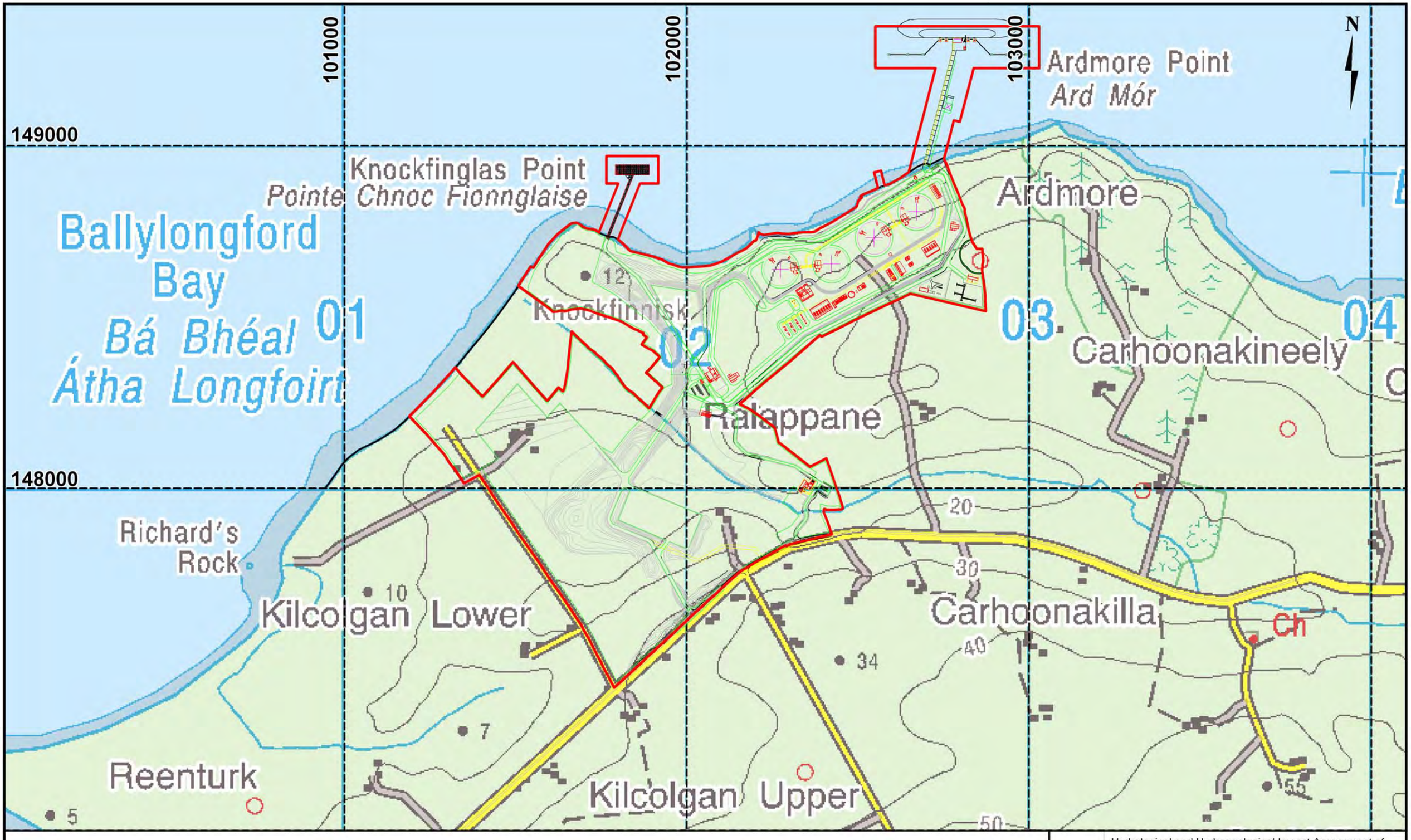


Legend

Site Boundary

Proposed Shannon LNG Terminal Layout

Background Mapping Compliments of OSI, 2007.

Project	Hydrological and Hydrogeological Impact Assessment of the Proposed Shannon LNG (Liquid Natural Gas) Terminal Development at Ballylongford, Co. Kerry.
Title	Appendix A: Site Location Map
Client	Arup Consulting Engineers
Drawing Ref.	1946-008.wor
Report Ref.	1946-156.doc
Drawn & Date	J.A.Hamilton (23/08/07)

Minerex Environmental Limited

101000

102000

148000

N

F1

F2

F3

F4

F5

F6

Legend

Site Boundary

F1 — Fault ID (Mapped from aerial photographs - Arup)

The entire area of the above graphic is occupied by Shannon Group - Namurian stage of Upper Carboniferous (Mudstone, Siltstone and Sandstone)

Project	Hydrological and Hydrogeological Impact Assessment of the Proposed Shannon LNG (Liquid Natural Gas) Terminal Development at Ballylongford, Co. Kerry.
Title	Appendix B1: Regional Bedrock Geology Map
Client	Arup Consulting Engineers
Drawing Ref.	1946-008.wor
Report Ref.	1946-156.doc
Drawn & Date	J. Allen-Hamilton (23/08/07)

Minerex Environmental Limited

101000

102000

103000

N

149000

148000

Ardmore Point
Ard Mór

Knockfinglas Point
Pointe Chnoc Fionnglaise

Ballylongford Bay
Bá Bhéal Átha Longfoirt

01

Richard's Rock

Rck

TNSSs

MGs

A

Mesc

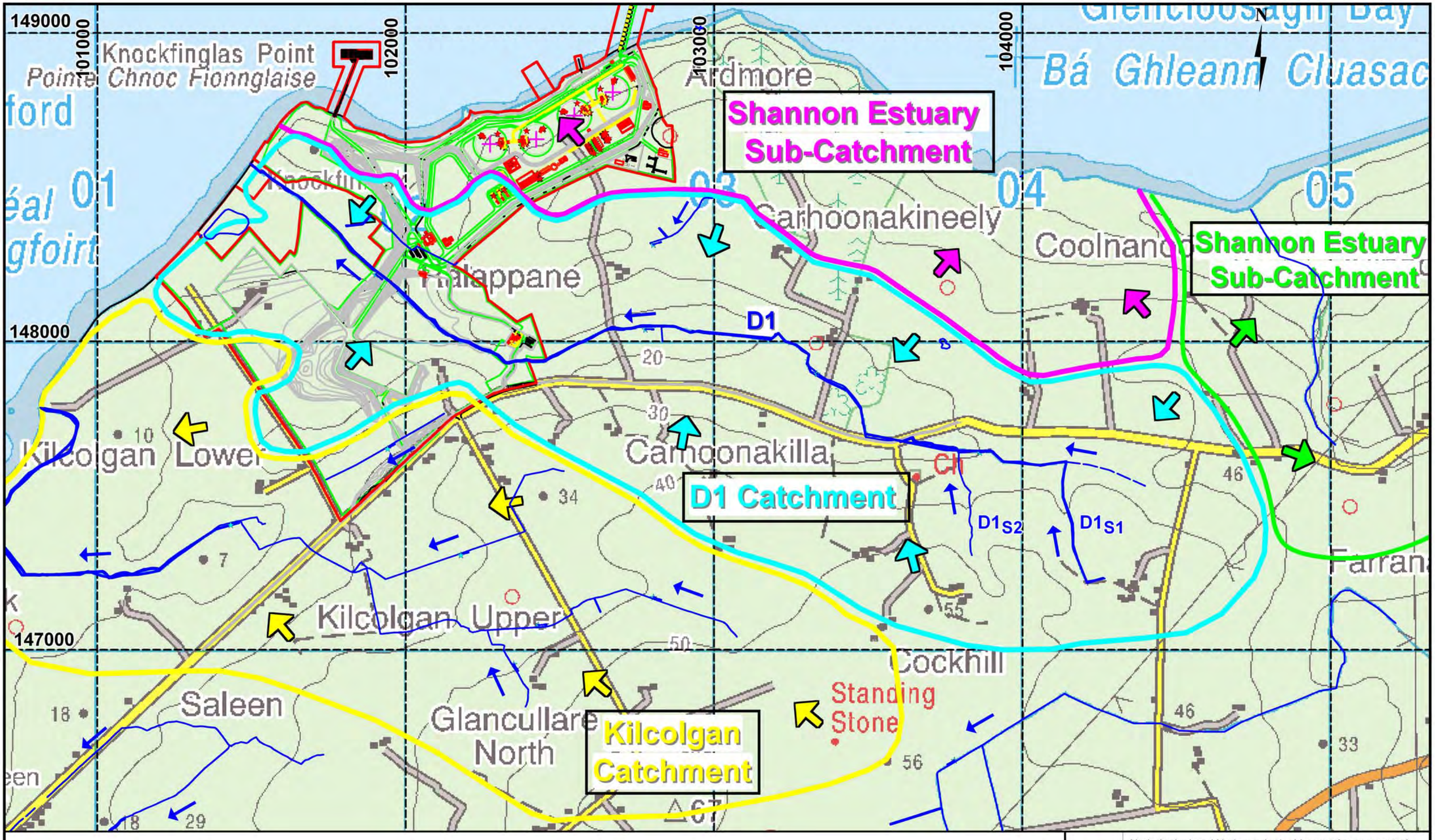
Legend

- Site Boundary
- A: Alluvium Undifferentiated
- TNSSs: Shales and Sandstones Till (Namurian)
- Mesc: Estuarine Sediments (Silts/Clays)
- Rck: Bedrock Outcrop and Subcrop
- MGs: Raised Beach Sands and Gravels

Background Mapping Compliments of EPA/Teagasc, 2006.

Project	Hydrological and Hydrogeological Impact Assessment of the Proposed Shannon LNG (Liquid Natural Gas) Terminal Development at Ballylongford, Co. Kerry.
Title	Appendix B2: Regional Subsoils Geology Map
Client	Arup Consulting Engineers
Drawing Ref.	1946-008.wor
Report Ref.	1946-156.doc
Drawn & Date	J. Allen-Hamilton (23/08/07)

Minerex Environmental Limited



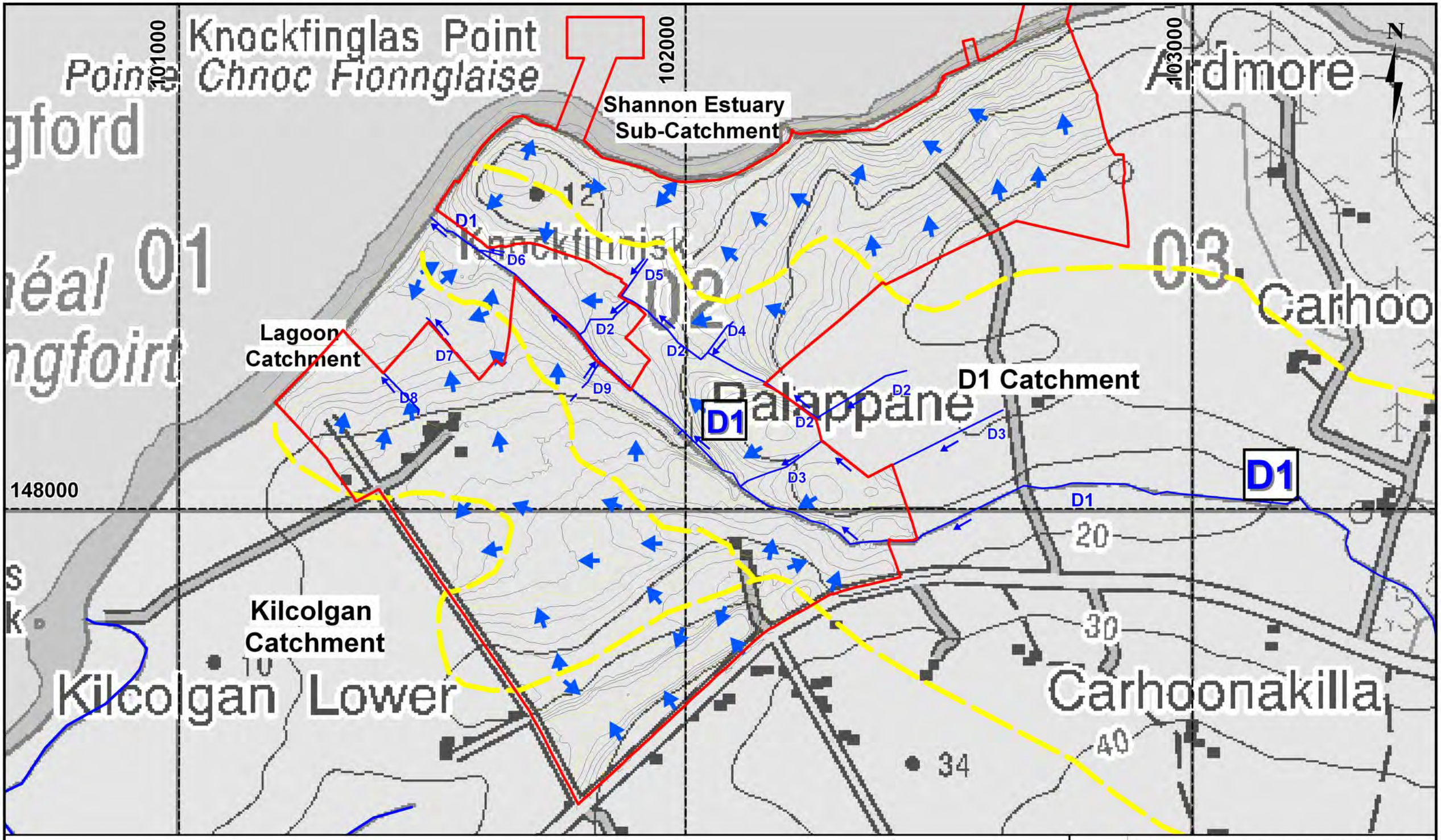
Legend

- Site Boundary
- D1 — Primary Drainage and Flow Direction
- Macro-Catchment Boundary
- Runoff Flow Direction
- Dry Valley

Background Mapping Courtesy of OSI, 2007

Project	Hydrological and Hydrogeological Impact Assessment of the Proposed Shannon LNG Terminal Development at Ballylongford, Co. Kerry.
Title	Appendix C1: Hydrology Map - Macro-Catchments with Primary Drainage Features
Client	Arup Consulting Engineers
Drawing Ref.	1946-008.wor
Report Ref.	1946-156.doc
Drawn & Date	J. Allen-Hamilton (24/08/07)

Minerex Environmental Limited



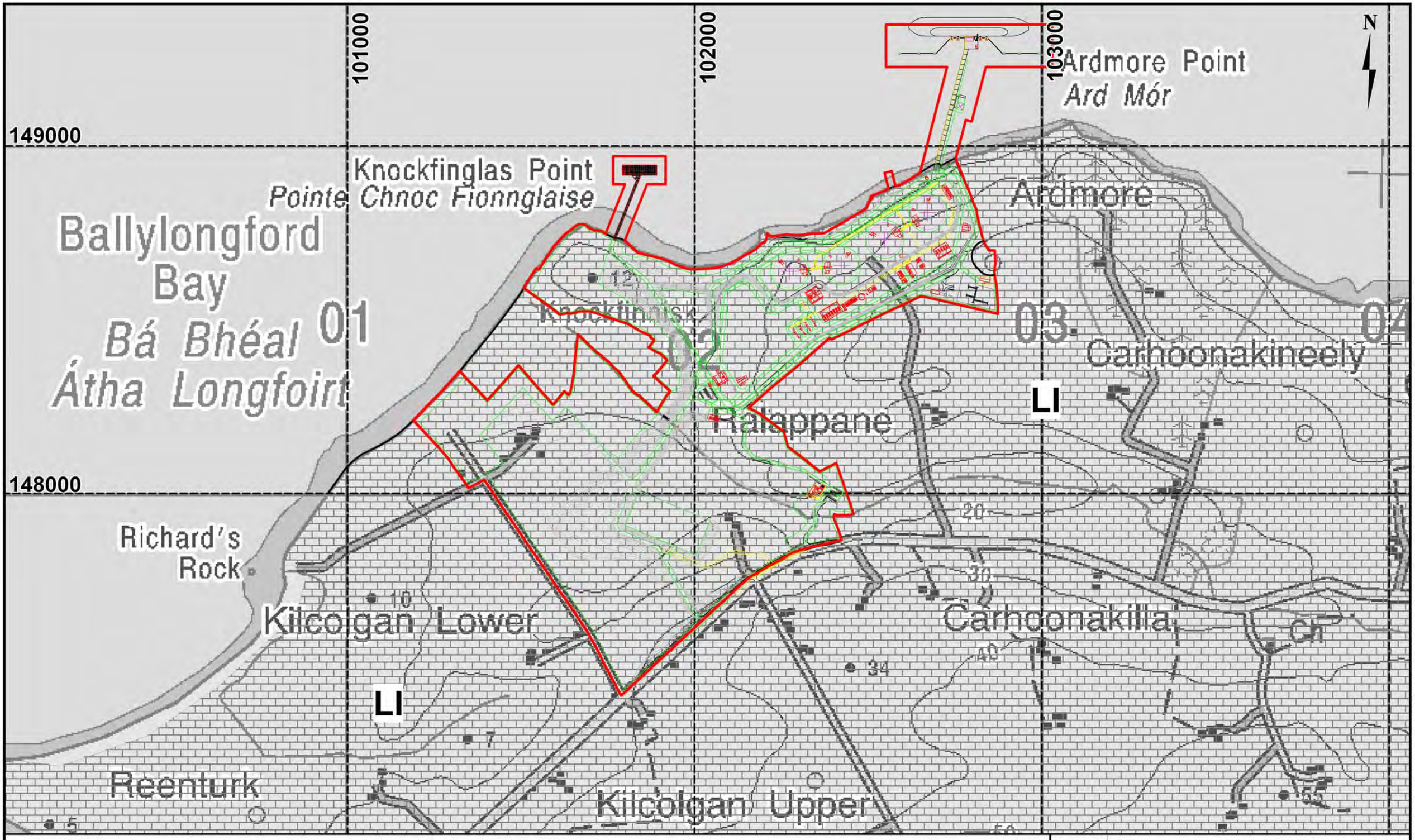
Legend

- Site Boundary
- Micro-Catchment Boundary
- D1 Drainage and Flow Direction
- Runoff Flow Direction

Background Mapping Compliments of OSI, 2007

Project	Hydrological and Hydrogeological Impact Assessment of the Proposed Shannon LNG Terminal Development at Ballylongford, Co. Kerry.
Title	Appendix C2: Hydrology Map - Micro-Catchments and Primary and Secondary Drainage Features
Client	Arup Consulting Engineers
Drawing Ref.	1946-008.wor
Report Ref.	1946-156.doc
Drawn & Date	J. Allen-Hamilton (24/08/07)

Minerex Environmental Limited



Legend

Site Boundary

Locally Important Aquifer that is Moderately Productive, only in Local Zones. **(LI)**

Background Mapping Compliments of OSI, 2007

Project	Hydrological and Hydrogeological Impact Assessment of the Proposed Shannon LNG Terminal Development at Ballylongford, Co. Kerry.
Title	Appendix D1: Regional Bedrock Aquifer Map
Client	Arup Consulting Engineers
Drawing Ref.	1946-008.wor
Report Ref.	1946-156doc
Drawn & Date	J. Allen-Hamilton (24/08/07)

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E(Bedrock at Surface)

E

H - L

Legend

Site Boundary

High to Low Vulnerability:
Unmapped - only an Interim Study has been completed.

E- Extreme Vulnerability

Extreme Vulnerability (Rock near Surface or Karst)

Mapping Information Compliments of GSI, 2007.

Project	Hydrological and Hydrogeological Impact Assessment of the Proposed Shannon LNG Terminal Development at Ballylongford, Co. Kerry.
Title	Appendix D2: Regional Bedrock Vulnerability Map
Client	Arup Consulting Engineers
Drawing Ref.	1946-008.wor
Report Ref.	1946-156.doc
Drawn & Date	J. Allen-Hamilton (24/08/07)

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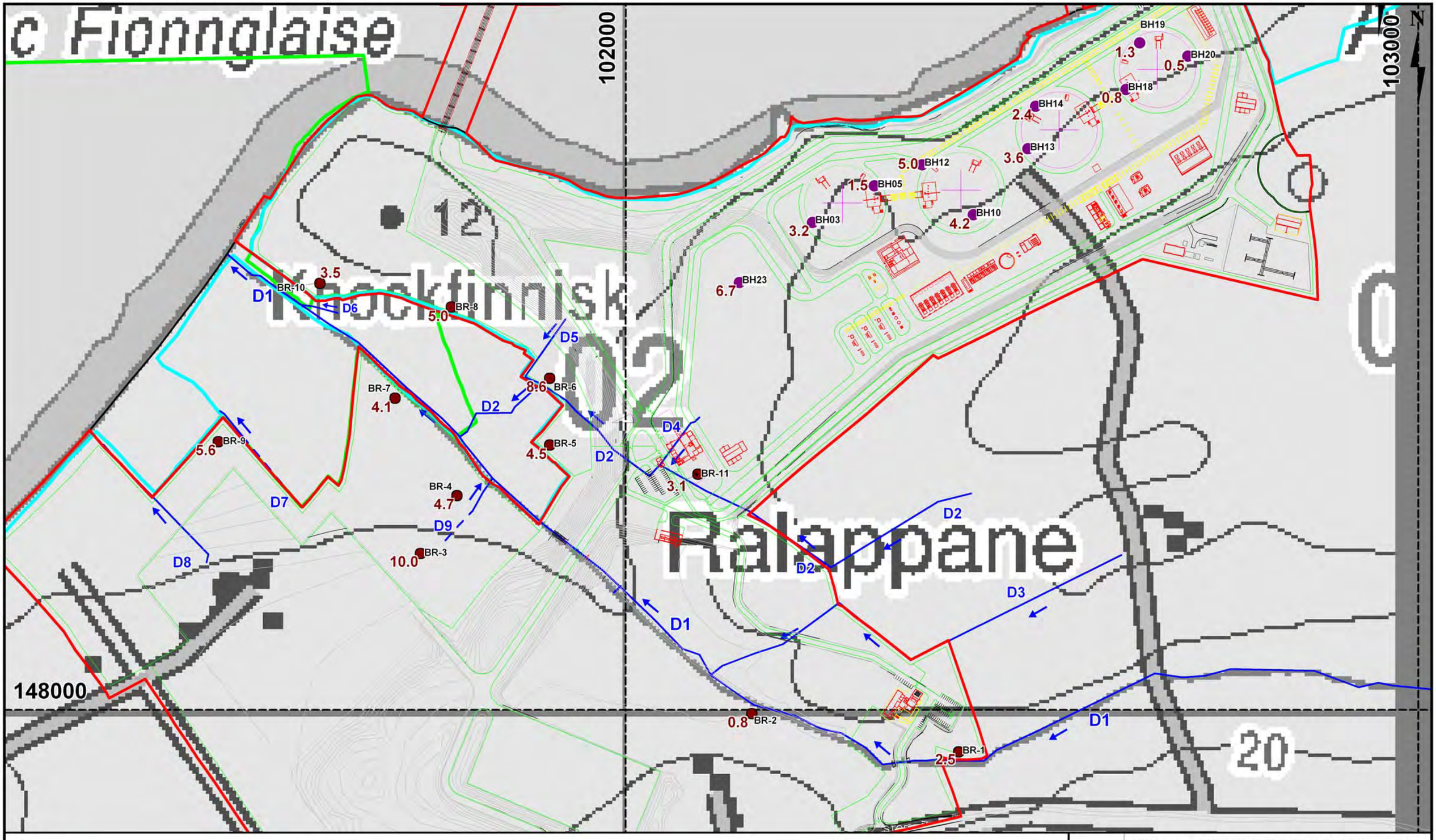

Legend

Site Boundary

BH03 — IGSL SI (Rotory Core) with Composite Standpipe

BR-7 — MEL SI (Rotary Percussion) with Piezometer / Phreatic Nest

5.6 — Depth to Bedrock (mbGL)

Lower Shannon cSAC

Ballylongford pNHA

Project	Hydrological and Hydrogeological Impact Assessment of the Proposed Shannon LNG Terminal Development at Ballylongford, Co. Kerry.
Title	Appendix E: Depth to Bedrock (Subsoils Thickness) Map
Client	Arup Consulting Engineers
Drawing Ref.	1946-008.wor
Report Ref.	1946-156.doc
Drawn & Date	O. Madden (24/08/07)

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cSAC &
pNHA

cSAC

cSAC &
pNHA

pNHA

cSAC

cSAC

Knockfinglas Point

Knockfinnisk

HWM

RALAPPANE

Legend

- Site Boundary
- Lower Shannon cSAC
- Ballylongford pNHA

Project	Hydrological and Hydrogeological Impact Assessment of the Proposed Shannon LNG Terminal Development at Ballylongford, Co. Kerry.
Title	Appendix F1: Special Area of Conservation (cSAC) & Natural Heritage Area (pNHA) Designated Areas
Client	Arup Consulting Engineers
Drawing Ref.	1946-008.wor
Report Ref.	1946-156doc
Drawn & Date	J. Allen-Hamilton (23/08/07)

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Knockfinglas Point

Salmon Weir

Knockdinnish

UND

RALAPPANE

Legend

- Site Boundary
- Area cleared by Local Farmer 2007 ED2 / Spoil or Bare ground
- Lower Saltmarsh CM1
- Reed and Large Sedge Swamps FS1
- Shingle and gravel banks CB1
- Depositing River FW2/Tidal River CW2
- Improved Agricultural Grassland GA1
- Lagoons & Saline Lakes CW1 (with reedbeds & wet grassland)
- Wet grassland GS4 / Improved Agricultural grassland GA1
- Lower Shannon cSAC
- Ballylongford pNHA

Project	Hydrological and Hydrogeological Impact Assessment of the Proposed Shannon LNG Terminal Development at Ballylongford, Co. Kerry.
Title	Appendix F2: Habitats of Concern within and peripheral to Designated Areas
Client	Arup Consulting Engineers
Drawing Ref.	1946-008.wor
Report Ref.	1946-156doc
Drawn & Date	J. Allen-Hamilton (23/08/07)

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BH19
BH20
BH18
BH14
BH13
BH12
BH05
BH10
BH03
BH23

D6-SW1
SS-SW1
D1-SW3
D1-SW-SG9
BR-10
D1
SS-SW3
D6-SW2
D6
SS-SW2
BR-8
SP-SW3
SP-SW4
D1-SW-SG8
D5
SM-SW1
SM-SW2
D1-SW-FG-SG7
GC14-PH1
D5-SW1
L1-SW-SG10
GC17-PH1
SS-SW4
L1-SW1
L1-SW-SG13
BR-7
D1-SW-FG-SG6
BR-6
L1-SW-SG12
D2
D2-SW4
GC13-PH1
SP-SW5
SP-SW2
D1-SW2
D2-FG-SW5
D2-SW3
D4
L1-SW-SG11
BR-9
D1-SW1
BR-5
L2-SW1
D8-SW2
D7-SW1
M-SW2
D2
D1-SW-FG-SG5
D2-SW2
BR-11
BR-4
M-SW1
D2-SW1
D8-SW1
D7
D9
D9-SW1
D1-SW-SG4
D2
BR-3
D8
SP-SW1
D1-SW-FG-SG3
D2
D3
M-SW3
D1
D3-SW1
D3-FG-SW2
D1-SW-FG-SG2
BR-2
D1
BR-1
D1-SW-FG-SG1

Legend

- Site Boundary
- SP-SW2 — MEL Spring Discharge Water Chemistry Monitoring Point
- D3-SW2 — MEL Surface Water Chemistry Monitoring Point
- D1-SW-FG-SG1 — MEL Staff Gauge, Flow Gauge Station & Surface Water Monitoring Point
- D1-SW-SG1 — MEL Staff Gauge & Surface Water Monitoring Point
- D3-FG-SW2 — MEL Flow Gauge Station & Surface Water Monitoring Point
- BH03 — IGSL SI (Rotory Core) with Composite Standpipe
- BR-7 — MEL SI (Rotary Percussion) with Piezometer / Phreatic Nest
- GC17-PH1 — MEL SI (Gouge Core) Point with Phreatic Installation
- Lower Shannon cSAC
- Ballylongford pNHA

Project	Hydrological and Hydrogeological Impact Assessment of the Proposed Shannon LNG Terminal Development at Ballylongford, Co. Kerry.
Title	Appendix G1: Groundwater and Surface Water Monitoring Network
Client	Arup Consulting Engineers
Drawing Ref.	1946-008.wor
Report Ref.	1946-156.doc
Drawn & Date	J. Allen-Hamilton (24/08/07)

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Legend

Site Boundary

BH03 — IGSL SI (Rotory Core) with Composite Standpipe

BR-7 — MEL SI (Rotary Percussion) with Piezometer / Phreatic Nest

GC17-PH1 — MEL SI (Gouge Core) Point with Phreatic Installation

Lower Shannon cSAC

Ballylongford pNHA

Project	Hydrological and Hydrogeological Impact Assessment of the Proposed Shannon LNG Terminal Development at Ballylongford, Co. Kerry.
Title	Appendix G2: Groundwater Monitoring Network
Client	Arup Consulting Engineers
Drawing Ref.	1946-008.wor
Report Ref.	1946-156.doc
Drawn & Date	J. Allen-Hamilton (24/08/07)

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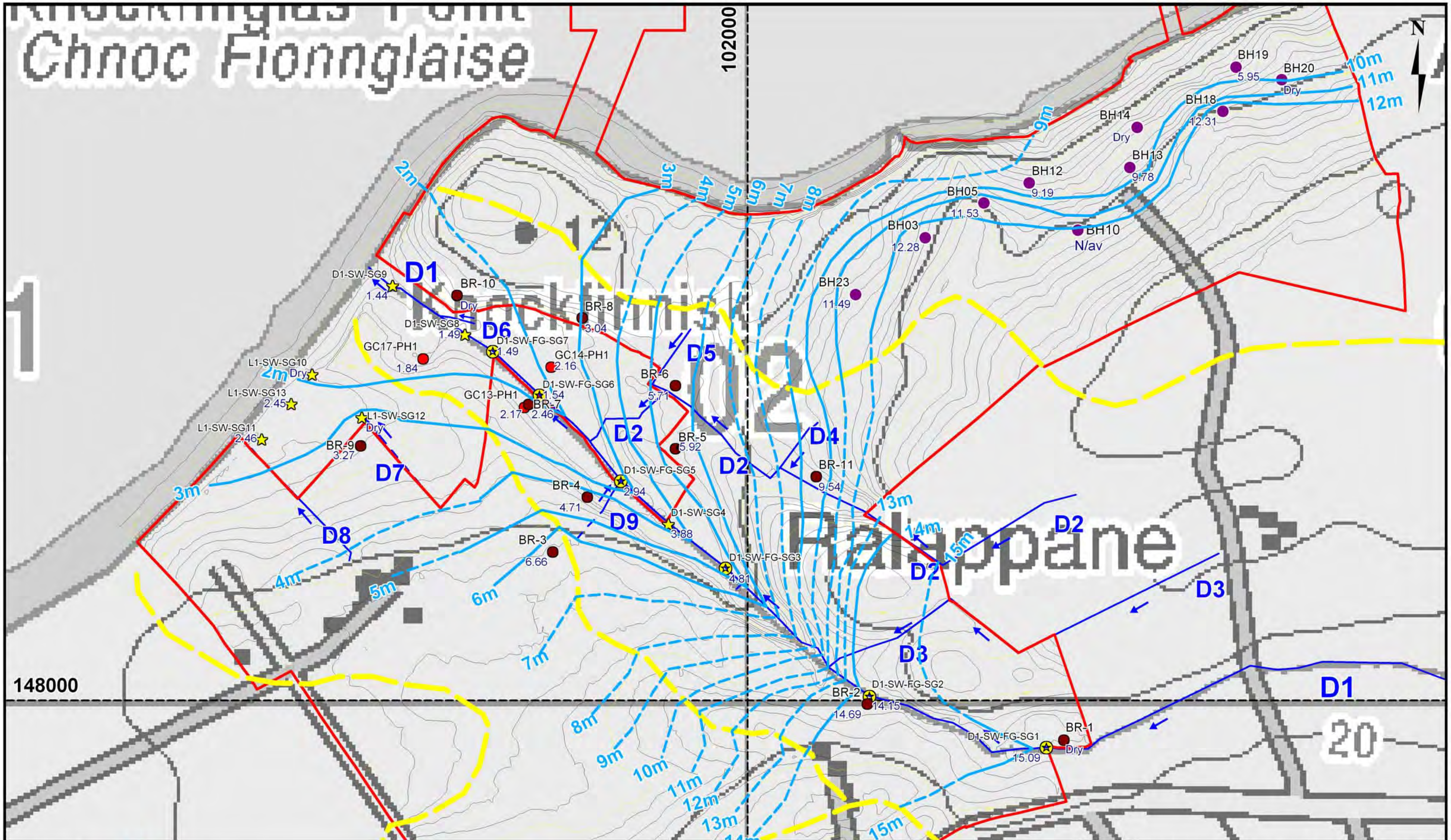

Legend

Site Boundary

D1 Drainage and Direction of Flow

4m Groundwater Contour for Phreatic Water Table Reduced to mOD (Malin)

1.60 Phreatic Water Level mOD from 23-26.04.07

Micro-Catchment Boundary

4m Inferred Groundwater Contour for Phreatic Water Table Reduced to mOD (Malin)

D1-SW-SG1 MEL Staff Gauge & Surface Water Monitoring Point

BR-7 MEL SI (Rotary Percussion) with Phreatic Installation

GC17-PH1 MEL SI (Gouge Core) Point with Phreatic Installation

BH12 IGSL SI (Rotory Core) with Composite Standpipes

Project	Hydrological and Hydrogeological Impact Assessment of the Proposed Shannon LNG Terminal Development at Ballylongford, Co. Kerry.
Title	Appendix H1: Groundwater Subsoils Phreatic Contour Map - April 2007
Client	Arup Consulting Engineers
Drawing Ref.	1946-008.wor
Report Ref.	1946-156.doc
Drawn & Date	J. Allen-Hamilton (24/08/07)

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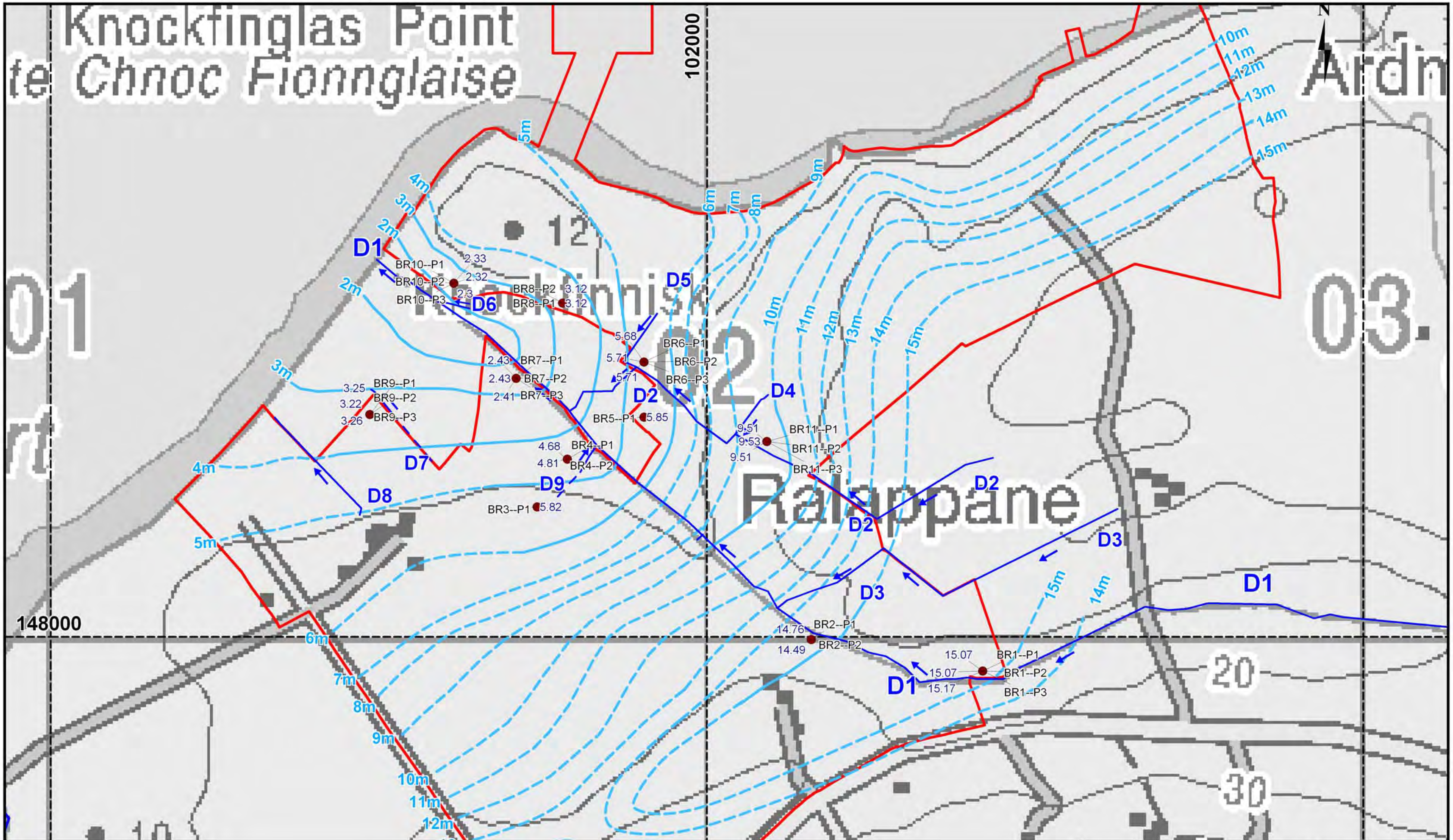

Legend

Site Boundary

D1 Drainage and Direction of Flow

4m Groundwater Contour for Piezometric Water Table Reduced to mOD (Malin)

4m Inferred Groundwater Contour for Piezometric Water Table Reduced to mOD (Malin)

BR7-P1 MEL SI (Rotary Percussion) with Piezometric Installations

1.60 Piezometric Water Level mOD from 23-26.04.07

Background Mapping courtesy of OSI 2007

Project	Hydrological and Hydrogeological Impact Assessment of the Proposed Shannon LNG Terminal Development at Ballylongford, Co. Kerry.
Title	Appendix H2: Groundwater Bedrock Piezometric Contour Map - April 2007
Client	Arup Consulting Engineers
Drawing Ref.	1946-008.wor
Report Ref.	1946-156.doc
Drawn & Date	J. Allen-Hamilton (23/08/07)

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BH19
BH20
BH18
BH14
BH13
BH12
BH05
BH10
BH03
BH23

SINGLE STANDPIPE INSTALLATIONS ONLY

BR-10
BR-8
GC17-PH1
GC14-PH1
BR-6
BR-7
GC16
GC13-PH1
BR-9
BR-5
BR-11
BR-4
BR-3
BR-2
PWS-3
BR-1

Legend

- Site Boundary
- Lower Shannon SAC
- Ballylongford NHA
- BR-7 — MEL SI (Rotary Percussion) with Piezometer/ Phreatic Nest
- GC17-PH1 — MEL SI (Gouge Core) Point with Phreatic Installation
- BH03 — IGSL SI - Open Boreholes with Composite Standpipes
- Upward Vertical Hydraulic Gradient (Piezometer Nest)
- Downward Vertical Hydraulic Gradient (Piezometer Nest)

Project	Hydrological and Hydrogeological Impact Assessment of the Proposed Shannon LNG Terminal Development at Ballylongford, Co. Kerry.
Title	Appendix H3: Groundwater Vertical Hydraulic Gradients Map - April 2007
Client	Arup Consulting Engineers
Drawing Ref.	1946-008.wor
Report Ref.	1946-156.doc
Drawn & Date	J. Allen-Hamilton (24/08/07)

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Legend

- Site Boundary
- 325 — Electical Conductivity - uS/cm microSiemens (23-26/04/07)
- D3-SW2 — MEL Surface Water Chemistry Monitoring Point
- BR-7 — MEL SI (Rotary Percussion) with Piezometer / Phreatic Nest
- GC17-PH1 — MEL SI (Gouge Core) Point with Phreatic Installation
- BH03 — IGSL SI (Rotary Core) with Composite Standpipe
- SP-SW2 — MEL Spring Discharge Water Chemistry Monitoring Point
- D1-SW-SG1 — MEL Staff Gauge & Surface Water Monitoring Point
- D1-SW-FG-SG1 — MEL Staff Gauge, Flow Gauge Station & Surface Water Monitoring Point

Project	Hydrological and Hydrogeological Impact Assessment of the Proposed Shannon LNG Terminal Development at Ballylongford, Co. Kerry.
Title	Appendix I1: Groundwater Subsoils Phreatic and Surface Water Electrical Conductivity Map - April 2007
Client	Arup Consulting Engineers
Drawing Ref.	1946-008.wor
Report Ref.	1946-156.doc
Drawn & Date	J. Allen-Hamilton (24/08/07)

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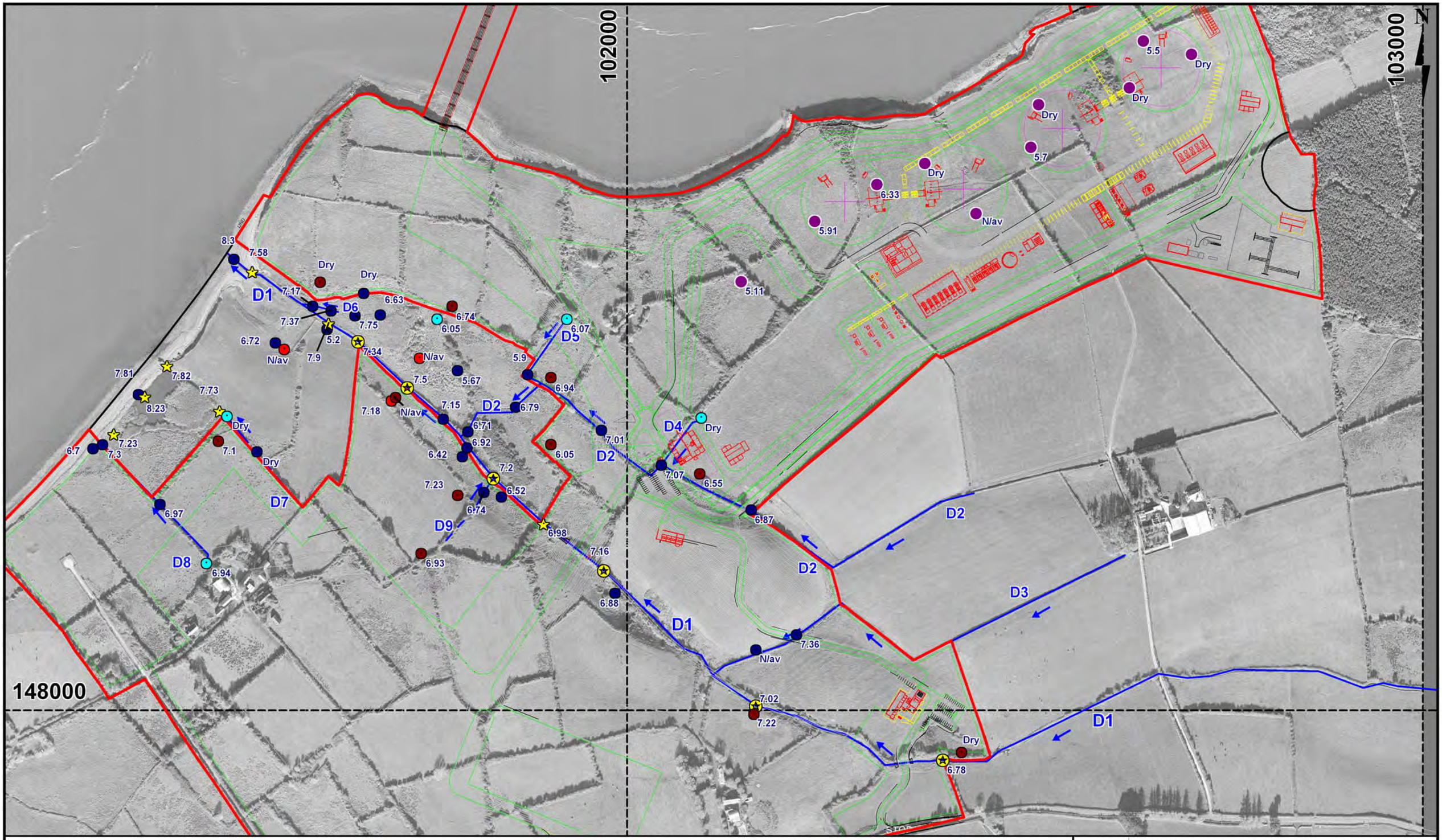

Legend

	Site Boundary	BR-7	MEL SI (Rotary Percussion) with Piezometer / Phreatic Nest	D1-SW-SG1	MEL Staff Gauge & Surface Water Monitoring Point
6.25	pH (23-26/04/07)	GC17-PH1	MEL SI (Gouge Core) Point with Phreatic Installation	D1-SW-FG-SG1	MEL Staff Gauge, Flow Gauge Station & Surface Water Monitoring Point
D3-SW2	MEL Surface Water Chemistry Monitoring Point	BH03	IGSL SI (Rotary Core) with Composite Standpipe		
		SP-SW2	MEL Spring Discharge Water Chemistry Monitoring Point		

Project	Hydrological and Hydrogeological Impact Assessment of the Proposed Shannon LNG Terminal Development at Ballylongford, Co. Kerry.
Title	Appendix I2: Groundwater Subsoils Phreatic and Surface Water pH Map - April 2007
Client	Arup Consulting Engineers
Drawing Ref.	1946-008.wor
Report Ref.	1946-156.doc
Drawn & Date	J. Allen-Hamilton (24/08/07)

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D1

D2

D3

D4

D5

D6

D7

D8

D9

957

840

652

520

994

372

341

1,019

887

947

429

STOP

Legend

Site Boundary

325 Electical Conductivity - uS/cm microSiemens (23-26/04/07)

BR-7 MEL SI (Rotary Percussion) with Piezometer / Phreatic Nest

Project	Hydrological and Hydrogeological Impact Assessment of the Proposed Shannon LNG Terminal Development at Ballylongford, Co. Kerry.
Title	Appendix J1: Groundwater Bedrock Piezometric (P1) Electrical Conducitvty Map - April 2007
Client	Arup Consulting Engineers
Drawing Ref.	1946-008.wor
Report Ref.	1946-156.doc
Drawn & Date	J. Allen-Hamilton (24/08/07)

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Legend

Site Boundary

6.25 pH (23-26/04/07)

BR-7 MEL SI (Rotary Percussion) with Piezometer / Phreatic Nest

Project	Hydrological and Hydrogeological Impact Assessment of the Proposed Shannon LNG Terminal Development at Ballylongford, Co. Kerry.
Title	Appendix J2: Groundwater Bedrock Piezometric (P1) pH Map - April 2007
Client	Arup Consulting Engineers
Drawing Ref.	1946-008.wor
Report Ref.	1946-156.doc
Drawn & Date	J. Allen-Hamilton (24/08/07)

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Knockfinglas Point

Salmon Weir

Knocktinnisk

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Groundwater Upward Vertical Seepage

Seawater Intrusion

Freshwater - Runoff and Overland Flow

Seawater Intrusion Boundary Based on EC >1,000uS/cm in April 2007

Groundwater Throughflow

Freshwater - Runoff and Overland Flow

Freshwater - Drainage

Legend

- Site Boundary
- Area cleared by Local Farmer 2007 ED2 / Spoil or Bare ground
- Lower Saltmarsh CM1
- Reed and Large Sedge Swamps FS1
- Shingle and gravel banks CB1
- Depositing River FW2/Tidal River CW2
- Improved Agricultural Grassland GA1
- Lagoons & Saline Lakes CW1 (with reedbeds & wet grassland)
- Wet grassland GS4 / Improved Agricultural grassland GA1
- Lower Shannon cSAC
- Ballylongford pNHA
- Freshwater - Drainage
- Freshwater - Runoff and Overland Flow
- Groundwater Upward Vertical Seepage
- Groundwater Throughflow
- Boundary of Saline Intrusion

Project	Hydrological and Hydrogeological Impact Assessment of the Proposed Shannon LNG Terminal Development at Ballylongford, Co. Kerry.
Title	Appendix K: Conceptual Model of Different Water Sources (based on Chemistry and Hydraulic Gradients)
Client	Arup Consulting Engineers
Drawing Ref.	1946-008.wor
Report Ref.	1946-156doc
Drawn & Date	J. Allen-Hamilton (23/08/07)

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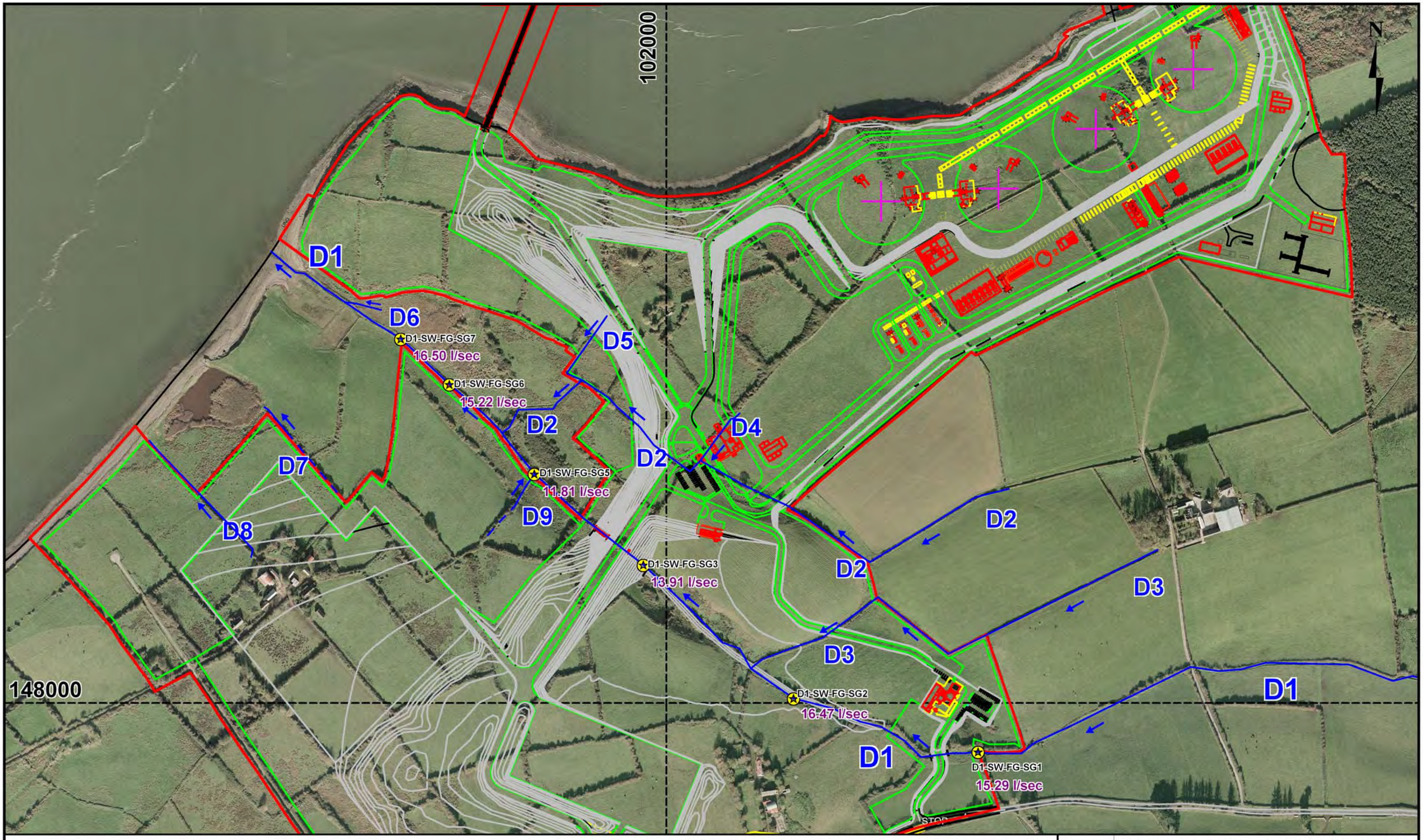

Legend

Site Boundary

D1-SW-FG-SG1
15.29 l/sec

MEL Staff Gauge, Surface Water Monitoring Point, Flow Gauge Station and Flow Rate in Litres per Second (l/sec) (measured on 23rd & 24th April 2007)

Project	Hydrological and Hydrogeological Impact Assessment of the Proposed Shannon LNG Terminal Development at Ballylongford, Co. Kerry.
Title	Appendix L: Drainage Discharge (D1) Map - April 2007
Client	Arup Consulting Engineers
Drawing Ref.	1946-008.wor
Report Ref.	1946-156.doc
Drawn & Date	J.A.Hamilton (23/08/07)

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Non-variable Monitoring Data							Variable Monitoring Results									
GENERAL	Monitoring Point ID	Monitoring point type	GEO-UNIT Monitored	HABITATS & DESIGNATION			Date	Time	Water levels			Chemistry			Flow Gauging	Comments
Surface Water (SW) or Groundwater (GW)				Habitat Monitored	Fossitt Habitat Code	Designation (SAC, NHA, SAC & NHA, None)			Ref mOD (top of Plastic Casing / top of SG)	WL mbRef	WL mOD (Malin)	microSiemens/cm @ 25°C (µS/cm)	pH	Temperature (°C)	Discharge (litres / second)	
SW	L1--SW1	Lagoon Chemistry	LAGOON	Lagoon & Saline Lake	CW1	SAC & NHA	28/03/07		N/app	N/app	N/app	878	7.76	13.4	N/app	Surface sample.
SW	L1--SW1	Lagoon Chemistry	LAGOON	Lagoon & Saline Lake	CW1	SAC & NHA	28/03/07		N/app	N/app	N/app	799	8.17	12.7	N/app	Deep base sample (0.44m).
SW	L1--SW1	Lagoon Chemistry	LAGOON	Lagoon & Saline Lake	CW1	SAC & NHA	23/04/07	14:30	N/app	N/app	N/app	1096	7.81	14.9	N/app	Surface sample. Evidence of recent inundation by sea water since wet / fresh seaweed on upper beach berm.
SW	L2--SW1	Lagoon Chemistry	LAGOON	Lagoon & Saline Lake	CW1	None	28/03/07		N/app	N/app	N/app	549	8.74	15.4	N/app	
SW	L2--SW1	Lagoon Chemistry	LAGOON	Lagoon & Saline Lake	CW1	None	25/04/07		N/app	N/app	N/app	681	6.70	13.5	N/app	
SW	D1--SW1	Drainage Chemistry	DRAINAGE	Depositing River	FW2	SAC	29/03/07		N/app	N/app	N/app	610	7.80	12.5	N/app	Deep base sample c.0.6m depth. Further sample taken c.10m u/s. EC=462,
SW	D1--SW1	Drainage Chemistry	DRAINAGE	Depositing River	FW2	SAC	25/04/07	14:09	N/app	N/app	N/app	426	6.92	11.2	N/app	Surface sample.
SW	D1--SW2	Drainage Chemistry	DRAINAGE	Depositing River	FW2	SAC & NHA	29/03/07		N/app	N/app	N/app	483	7.93	10.4	N/app	
SW	D1--SW2	Drainage Chemistry	DRAINAGE	Depositing River	FW2	SAC & NHA	25/04/07	13:26	N/app	N/app	N/app	442	7.15	11.0	N/app	
SW	D1--SW3	Drainage Chemistry	DRAINAGE	Tidal River	CW2	SAC & NHA	29/03/07		N/app	N/app	N/app	500	8.17	13.2	N/app	
SW	D1--SW3	Drainage Chemistry	DRAINAGE	Tidal River	CW2	SAC & NHA	23/04/07	10:48	N/app	N/app	N/app	698	8.30	14.1	N/app	
SW	D2--SW1	Drainage Chemistry	DRAINAGE	Drainage Ditch	FW4	None	25/04/07	03:36	N/app	N/app	N/app	514	6.87	12.8	N/app	
SW	D2--SW2	Drainage Chemistry	DRAINAGE	Drainage Ditch	FW4	None	29/03/07		N/app	N/app	N/app	353	7.07	10.5	N/app	
SW	D2--SW2	Drainage Chemistry	DRAINAGE	Drainage Ditch	FW4	None	25/04/07	10:33	N/app	N/app	N/app	569	7.07	12.5	N/app	
SW	D2--SW3	Drainage Chemistry	DRAINAGE	Drainage Ditch	FW4	None	25/04/07	01:40	N/app	N/app	N/app	568	7.01	12.1	N/app	
SW	D2--SW4	Drainage Chemistry	DRAINAGE	Drainage Ditch	FW4	SAC	28/03/07		N/app	N/app	N/app	315	7.54	10.9	N/app	
SW	D2--SW4	Drainage Chemistry	DRAINAGE	Drainage Ditch	FW4	SAC	25/04/07	11:05	N/app	N/app	N/app	563	6.79	10.3	N/app	
SW	D2--SW5	Drainage Chemistry	DRAINAGE	Drainage Ditch	FW4	SAC	28/03/07		N/app	N/app	N/app	315	7.54	10.9	N/app	
SW	D2--SW5	Drainage Chemistry	DRAINAGE	Drainage Ditch	FW4	SAC	25/04/07	00:43	N/app	N/app	N/app	617	6.71	11.4	N/app	
SW	D3--SW1	Drainage Chemistry	DRAINAGE	Drainage Ditch	FW4	None	23/04/07	12:30	N/app	N/app	N/app	372	7.36	12.6	N/app	
SW	D3--SW2	Drainage Chemistry	DRAINAGE	Drainage Ditch	FW4	None	29/03/07		N/app	N/app	N/app	318	7.30	11.7	N/app	
SW	D3--SW2	Drainage Chemistry	DRAINAGE	Drainage Ditch	FW4	None	25/04/07		N/app	N/app	N/app				N/app	HC n/av.
SW	D5--SW1	Drainage Chemistry	SPRING	Drainage Ditch	FW4	None	29/03/07		N/app	N/app	N/app	358	7.57	9.7	N/app	
SW	D5--SW1	Drainage Chemistry	SPRING	Drainage Ditch	FW4	None	25/04/07	06:57	N/app	N/app	N/app	224	5.90	16.1	N/app	
SW	D6--SW1	Drainage Chemistry	DRAINAGE	Drainage Ditch	FW4	SAC & NHA	29/03/07		N/app	N/app	N/app	1516	7.11	9.7	N/app	
SW	D6--SW1	Drainage Chemistry	DRAINAGE	Drainage Ditch	FW4	SAC & NHA	23/04/07	18:35	N/app	N/app	N/app	3640	7.37	14.6	N/app	
SW	D6--SW2	Drainage Chemistry	DRAINAGE	Drainage Ditch	FW4	SAC & NHA	29/03/07		N/app	N/app	N/app	1668	6.97	11.2	N/app	
SW	D6--SW2	Drainage Chemistry	DRAINAGE	Drainage Ditch	FW4	SAC & NHA	23/04/07	18:30	N/app	N/app	N/app	5680	7.17	15.4	N/app	
SW	D7--SW1	Drainage Chemistry	DRAINAGE	Drainage Ditch	FW4	NHA	25/04/07		N/app	N/app	N/app				N/app	Dry.
SW	D8--SW1	Drainage Chemistry	DRAINAGE	Drainage Ditch	FW4	None	25/04/07	11:22	N/app	N/app	N/app	808	6.97	13.2	N/app	
SW	D8--SW2	Drainage Chemistry	DRAINAGE	Drainage Ditch	FW4	None	25/04/07	11:26	N/app	N/app	N/app	811	7.30	13.2	N/app	
SW	D9--SW1	Drainage Chemistry	DRAINAGE	Drainage Ditch	FW4	None	28/03/07		N/app	N/app	N/app	313	6.59	12.2	N/app	

Non-variable Monitoring Data							Variable Monitoring Results									
GENERAL	Monitoring Point ID	Monitoring point type	GEO-UNIT Monitored	HABITATS & DESIGNATION			Date	Time	Water levels			Chemistry			Flow Gauging	Comments
Surface Water (SW) or Groundwater (GW)				Habitat Monitored	Fossitt Habitat Code	Designation (SAC, NHA, SAC & NHA, None)			Ref mOD (top of Plastic Casing / top of SG)	WL mbRef	WL mOD (Malin)	microSiemens/cm @ 25°C (µS/cm)	pH	Temperature (°C)	Discharge (litres / second)	
SW	D9--SW1	Drainage Chemistry	DRAINAGE	Drainage Ditch	FW4	None	24/04/07	10:22	N/app	N/app	N/app	408	6.74	13.8	N/app	Drain not flowing.
SW	Sea--SW1	Marine Chemistry	SEA	Shingle & Gravel Shore	LS1	SAC & NHA	28/03/07		N/app	N/app	N/app	>3999	7.99	11.9	N/app	
SW	Sea--SW1	Marine Chemistry	SEA	Shingle & Gravel Shore	LS1	SAC & NHA	23/04/07	14:30	N/app	N/app	N/app	>20,000	8.35	13.4	N/app	
SW	M--SW1	Standing Water Chemistry	MARSH	Wet Grassland / Improved Agricultural Grassland	GS4 / GA1	None	28/03/07		N/app	N/app	N/app	200	6.92	10.6	N/app	Standing water in Marsh.
SW	M--SW1	Standing Water Chemistry	MARSH	Wet Grassland / Improved Agricultural Grassland	GS4 / GA1	None	24/04/07	12:10	N/app	N/app	N/app	344	6.52	16.2	N/app	Standing water in Marsh.
SW	M--SW2	Standing Water Chemistry	MARSH	Wet Grassland / Improved Agricultural Grassland	GS4 / GA1	None	29/03/07		N/app	N/app	N/app	343	7.04	10.0	N/app	Standing water in Marsh.
SW	M--SW2	Standing Water Chemistry	MARSH	Wet Grassland / Improved Agricultural Grassland	GS4 / GA1	None	24/04/07	11:00	N/app	N/app	N/app	359	6.42	12.6	N/app	Standing water in Marsh.
SW	M--SW3	Drainage Chemistry	SPRING	Wet Grassland / Improved Agricultural Grassland	GS4 / GA1	None	29/03/07		N/app	N/app	N/app	314	7.12	11.9	N/app	
SW	M--SW3	Drainage Chemistry	SPRING	Wet Grassland / Improved Agricultural Grassland	GS4 / GA1	None	24/04/07	12:35	N/app	N/app	N/app	379	6.88	14.0	N/app	
SW	M--SW3	Drainage Chemistry	SPRING	Wet Grassland / Improved Agricultural Grassland	GS4 / GA1	None	24/04/07	12:35	N/app	N/app	N/app	504	7.48	18.7	N/app	
SW	SM--SW1	Standing Water Chemistry	SALT MARSH	Lower Salt Marsh	CM1	NHA	29/03/07		N/app	N/app	N/app	>20,000	7.80	16.6	N/app	Standing water in Salt Marsh.
SW	SM--SW1	Standing Water Chemistry	SALT MARSH	Lower Salt Marsh	CM1	NHA	23/04/07	15:00	N/app	N/app	N/app	>20,000	6.72	17.5	N/app	Standing water in Salt Marsh.
SW	SM--SW2	Standing Water Chemistry	SALT MARSH	Lower Salt Marsh	CM1	NHA	23/04/07	15:00	N/app	N/app	N/app	>20,000	5.20	16.3	N/app	Standing water in Salt Marsh.
SW	SS--SW1	Standing Water Chemistry	SEDGE SWAMP	Reed & Large Sedge	FS1	SAC & NHA	29/03/07		N/app	N/app	N/app	2485	7.34	8.6	N/app	Standing water in Sedge Swamp.
SW	SS--SW1	Standing Water Chemistry	SEDGE SWAMP	Reed & Large Sedge	FS1	SAC & NHA	23/04/07	18:40	N/app	N/app	N/app	1960	7.75	14.7	N/app	Standing water in Sedge Swamp.
SW	SS--SW2	Standing Water Chemistry	SEDGE SWAMP	Reed & Large Sedge	FS1	SAC & NHA	29/03/07		N/app	N/app	N/app	272	6.95	10.1	N/app	Standing water in Sedge Swamp.
SW	SS--SW2	Standing Water Chemistry	SEDGE SWAMP	Reed & Large Sedge	FS1	SAC & NHA	23/04/07	18:45	N/app	N/app	N/app	409	6.63	14.3	N/app	Standing water in Sedge Swamp.
SW	SS--SW3	Standing Water Chemistry	SEDGE SWAMP	Neutral Grassland / Improved Agricultural Grassland	GS1 / GA1	SAC & NHA	28/03/07		N/app	N/app	N/app	450	7.03	10.1	N/app	
SW	SS--SW3	Standing Water Chemistry	SEDGE SWAMP	Neutral Grassland / Improved Agricultural Grassland	GS1 / GA1	SAC & NHA	25/04/07	18:50	N/app	N/app	N/app				N/app	Dry.
SW	SS--SW4	Standing Water Chemistry	SEDGE SWAMP	Reed & Large Sedge	FS1	SAC & NHA	28/03/07		N/app	N/app	N/app	258	7.17	8.7	N/app	
SW	SS--SW4	Standing Water Chemistry	SEDGE SWAMP	Reed & Large Sedge	FS1	SAC & NHA	26/04/07	10:50	N/app	N/app	N/app	307	5.67	11.1	N/app	
SW	SP--SW1	Spring Discharge	SPRING	Wet Grassland / Improved Agricultural Grassland	GS4 / GA1	None	28/03/07		N/app	N/app	N/app	1065	7.21	13.3	N/app	
SW	SP--SW1	Spring Discharge	SPRING	Wet Grassland / Improved Agricultural Grassland	GS4 / GA1	None	25/04/07	11:17	N/app	N/app	N/app	593	6.94	11.9	N/app	
SW	SP--SW2	Spring Discharge	SPRING	Neutral Grassland / Improved Agricultural Grassland	GS1 / GA1	None	28/03/07		N/app	N/app	N/app	310	7.00	10.6	N/app	
SW	SP--SW2	Spring Discharge	SPRING	Neutral Grassland / Improved Agricultural Grassland	GS1 / GA1	None	23/04/07	14:50	N/app	N/app	N/app				N/app	Dry.
SW	SP--SW3	Spring Discharge	SPRING	Neutral Grassland / Improved Agricultural Grassland	GS1 / GA1	SAC & NHA	28/03/07		N/app	N/app	N/app	336	7.33	9.2	N/app	
SW	SP--SW3	Spring Discharge	SPRING	Neutral Grassland / Improved Agricultural Grassland	GS1 / GA1	SAC & NHA	26/04/07	10:47	N/app	N/app	N/app	372	6.05	12.1	N/app	
SW	SP--SW4	Spring Discharge	SPRING	Neutral Grassland / Improved Agricultural Grassland	GS1 / GA1	None	29/03/07		N/app	N/app	N/app	266	6.84	12.1	N/app	
SW	SP--SW4	Spring Discharge	SPRING	Neutral Grassland / Improved Agricultural Grassland	GS1 / GA1	None	25/04/07	14:43	N/app	N/app	N/app	390	6.07	19.7	N/app	
SW	SP--SW5	Spring Discharge	SPRING	Neutral Grassland / Improved Agricultural Grassland	GS1 / GA1	None	29/03/07		N/app	N/app	N/app	388	7.98	11.4	N/app	
SW	SP--SW5	Spring Discharge	SPRING	Neutral Grassland / Improved Agricultural Grassland	GS1 / GA1	None	25/04/07	12:01	N/app	N/app	N/app				N/app	Dry.
SW	D1-SW-FG-SG1	Staff guage / Drainage	DRAINAGE	Depositing River	FW2	None	29/03/07	16:15	15.99	0.85	15.14	425	6.64	14.4		

Non-variable Monitoring Data							Variable Monitoring Results									
GENERAL	Monitoring Point ID	Monitoring point type	GEO-UNIT Monitored	HABITATS & DESIGNATION			Date	Time	Water levels			Chemistry			Flow Gauging	Comments
Surface Water (SW) or Groundwater (GW)				Habitat Monitored	Fossitt Habitat Code	Designation (SAC, NHA, SAC & NHA, None)			Ref mOD (top of Plastic Casing / top of SG)	WL mbRef	WL mOD (Malin)	microSiemens/cm @ 25°C (µS/cm)	pH	Temperature (°C)	Discharge (litres / second)	
SW	D1-SW-FG-SG1	Staff guage / Drainage	DRAINAGE	Depositing River	FW2	None	14/04/07		15.99	0.88	15.11					
SW	D1-SW-FG-SG1	Staff guage / Drainage	DRAINAGE	Depositing River	FW2	None	24/04/07	15:46	15.99	0.90	15.09	363	6.78	15.8	15.29	
SW	D1-SW-FG-SG2	Staff guage / Drainage	DRAINAGE	Depositing River	FW2	None	29/03/07	13:20	14.90	0.66	14.24	443	7.40	13.1		
SW	D1-SW-FG-SG2	Staff guage / Drainage	DRAINAGE	Depositing River	FW2	None	14/04/07		14.90	0.72	14.18					
SW	D1-SW-FG-SG2	Staff guage / Drainage	DRAINAGE	Depositing River	FW2	None	24/04/07	14:46	14.90	0.75	14.15	363	7.02	15.4	16.47	
SW	D1-SW-FG-SG3	Staff guage / Drainage	DRAINAGE	Depositing River	FW2	None	29/03/07	12:10	5.67	0.82	4.85	468	7.73	12.1		
SW	D1-SW-FG-SG3	Staff guage / Drainage	DRAINAGE	Depositing River	FW2	None	14/04/07		5.67	0.85	4.82					
SW	D1-SW-FG-SG3	Staff guage / Drainage	DRAINAGE	Depositing River	FW2	None	24/04/07	12:40	5.67	0.86	4.81	390	7.16	14.4	13.91	
SW	D1-SW-SG4	Staff guage / Drainage	DRAINAGE	Depositing River	FW2	None	28/03/07	12:05	4.78	0.84	3.94	468	8.00	10.9	N/app	
SW	D1-SW-SG4	Staff guage / Drainage	DRAINAGE	Depositing River	FW2	None	14/04/07		4.78	0.88	3.90				N/app	
SW	D1-SW-SG4	Staff guage / Drainage	DRAINAGE	Depositing River	FW2	None	24/04/07	12:15	4.78	0.90	3.88	373	6.98	14.5	N/app	
SW	D1-SW-FG-SG5	Staff guage / Drainage	DRAINAGE	Depositing River	FW2	SAC	28/03/07	15:20	3.82	0.85	2.97	400	7.45	13.5		
SW	D1-SW-FG-SG5	Staff guage / Drainage	DRAINAGE	Depositing River	FW2	SAC	14/04/07		3.82	0.87	2.95					
SW	D1-SW-FG-SG5	Staff guage / Drainage	DRAINAGE	Depositing River	FW2	SAC	24/04/07	10:24	3.82	0.88	2.94	365	7.20	12.6	11.81	
SW	D1-SW-FG-SG6	Staff guage / Drainage	DRAINAGE	Depositing River	FW2	SAC & NHA	28/03/07	17:20	2.38	0.74	1.64	357	7.64	13.6		
SW	D1-SW-FG-SG6	Staff guage / Drainage	DRAINAGE	Depositing River	FW2	SAC & NHA	14/04/07		2.38	0.82	1.56					
SW	D1-SW-FG-SG6	Staff guage / Drainage	DRAINAGE	Depositing River	FW2	SAC & NHA	23/04/07	18:30	2.38	0.84	1.54	360	7.50	14.2	15.22	
SW	D1-SW-FG-SG7	Staff guage / Drainage	DRAINAGE	Depositing River / Tidal River (Transition)	FW2 / CW2	SAC & NHA	28/03/07	17:00	2.35	0.80	1.55	371	8.06	13.7		
SW	D1-SW-FG-SG7	Staff guage / Drainage	DRAINAGE	Depositing River / Tidal River (Transition)	FW2 / CW2	SAC & NHA	14/04/07		2.35	0.84	1.51					
SW	D1-SW-FG-SG7	Staff guage / Drainage	DRAINAGE	Depositing River / Tidal River (Transition)	FW2 / CW2	SAC & NHA	23/04/07	17:00	2.35	0.86	1.49	387	7.34	14.5	16.50	
SW	D1-SW-SG8	Staff guage / Drainage	DRAINAGE	Tidal River	CW2	SAC & NHA	28/03/07	16:54	2.01	0.48	1.53	435	7.84	14.0	N/app	
SW	D1-SW-SG8	Staff guage / Drainage	DRAINAGE	Tidal River	CW2	SAC & NHA	14/04/07		2.01	0.50	1.51				N/app	
SW	D1-SW-SG8	Staff guage / Drainage	DRAINAGE	Tidal River	CW2	SAC & NHA	24/04/07	15:10	2.01	0.52	1.49	423	7.90	13.9	N/app	
SW	D1-SW-SG9	Staff guage / Drainage	DRAINAGE	Tidal River	CW2	SAC & NHA	27/03/07	14:30	2.28	0.82	1.46				N/app	
SW	D1-SW-SG9	Staff guage / Drainage	DRAINAGE	Tidal River	CW2	SAC & NHA	28/03/07	16:40	2.28	0.82	1.46	399	7.26	14.1	N/app	
SW	D1-SW-SG9	Staff guage / Drainage	DRAINAGE	Tidal River	CW2	SAC & NHA	14/04/07		2.28	0.84	1.44				N/app	
SW	D1-SW-SG9	Staff guage / Drainage	DRAINAGE	Tidal River	CW2	SAC & NHA	23/04/07	15:45	2.28	0.84	1.44	721	7.58	13.7	N/app	Water depth = c.0.10m - too shallow for flow gauging.
SW	L1-SW-SG10	Staff guage / Lagoon	LAGOON	Lagoon & Saline Lake	CW1		27/03/07	13:30	3.45	0.85	2.60				N/app	
SW	L1-SW-SG10	Staff guage / Lagoon	LAGOON	Lagoon & Saline Lake	CW1		28/03/07	15:19	3.45	0.86	2.59	681	7.63	12.5	N/app	Surface sample.
SW	L1-SW-SG10	Staff guage / Lagoon	LAGOON	Lagoon & Saline Lake	CW1		28/03/07	15:19	3.45	0.86	2.59	1624	7.71	13.6	N/app	Deep base sample (c.0.4m).
SW	L1-SW-SG10	Staff guage / Lagoon	LAGOON	Lagoon & Saline Lake	CW1		28/03/07	20:10	3.45	0.86	2.59				N/app	WL measured at Low Tide.
SW	L1-SW-SG10	Staff guage / Lagoon	LAGOON	Lagoon & Saline Lake	CW1		14/04/07		3.45						N/app	WL n/av. Area around base of staff guage drying out since water level last monitored.

Non-variable Monitoring Data							Variable Monitoring Results									
GENERAL	Monitoring Point ID	Monitoring point type	GEO-UNIT Monitored	HABITATS & DESIGNATION			Date	Time	Water levels			Chemistry			Flow Gauging	Comments
Surface Water (SW) or Groundwater (GW)				Habitat Monitored	Fossitt Habitat Code	Designation (SAC, NHA, SAC & NHA, None)			Ref mOD (top of Plastic Casing / top of SG)	WL mbRef	WL mOD (Malin)	microSiemens/cm @ 25°C (µS/cm)	pH	Temperature (°C)	Discharge (litres / second)	
SW	L1-SW-SG10	Staff guage / Lagoon	LAGOON	Lagoon & Saline Lake	CW1		23/04/07	14:30	3.45			1060	7.82	15.5	N/app	WL n/av. Area around base of staff guage dried out.
SW	L1-SW-SG11	Staff guage / Lagoon	LAGOON	Lagoon & Saline Lake	CW1		27/03/07	13:08	3.36	0.70	2.66				N/app	
SW	L1-SW-SG11	Staff guage / Lagoon	LAGOON	Lagoon & Saline Lake	CW1		28/03/07	16:00	3.36	0.70	2.66	711	9.09	14.8	N/app	Surface sample.
SW	L1-SW-SG11	Staff guage / Lagoon	LAGOON	Lagoon & Saline Lake	CW1		14/04/07		3.36	0.84	2.52				N/app	Area drying out since last monitored.
SW	L1-SW-SG11	Staff guage / Lagoon	LAGOON	Lagoon & Saline Lake	CW1		23/04/07	14:30	3.36	0.90	2.46	1123	7.23	14.7	N/app	Area drying out.
SW	L1-SW-SG12	Staff guage / Lagoon	LAGOON	Lagoon & Saline Lake	CW1		27/03/07	14:00	3.34	0.70	2.64				N/app	
SW	L1-SW-SG12	Staff guage / Lagoon	LAGOON	Lagoon & Saline Lake	CW1		28/03/07	15:34	3.34	0.71	2.63	559	9.91	15.1	N/app	Surface sample.
SW	L1-SW-SG12	Staff guage / Lagoon	LAGOON	Lagoon & Saline Lake	CW1		28/03/07	15:34	3.34	0.71	2.63	303	9.27	14.7	N/app	Deeper base sample (c.0.3m).
SW	L1-SW-SG12	Staff guage / Lagoon	LAGOON	Lagoon & Saline Lake	CW1		14/04/07		3.34	0.84	2.50				N/app	Area drying out, Water Level just at base of Alluminium Staff Guage.
SW	L1-SW-SG12	Staff guage / Lagoon	LAGOON	Lagoon & Saline Lake	CW1		23/04/07	14:40	3.34			575	7.73	15.5	N/app	Area dried out.
SW	L1-SW-SG13	Staff guage / Lagoon	LAGOON	Lagoon & Saline Lake	CW1		23/04/07	14:35	3.05	0.60	2.45	1618	8.23	14.8	N/app	New Staff Gauge installed. Water depth = 0.5m. Deep water sample.
GW	GC13--PH1	Phreatic	PEAT	Wet Grassland / Improved Agricultural Grassland	GS4 / GA1	None	14/04/07		3.22						N/app	WL n/av - installation removed to check if ok & re-installed.
GW	GC13--PH1	Phreatic	PEAT	Wet Grassland / Improved Agricultural Grassland	GS4 / GA1	None	25/04/07		3.22	1.05	2.17				N/app	No Water available for HC.
GW	GC14--PH1	Phreatic	PEAT	Reed & Large Sedge	FS1	SAC & NHA	14/04/07		3.58	1.36	2.22				N/app	
GW	GC14--PH1	Phreatic	PEAT	Reed & Large Sedge	FS1	SAC & NHA	23/04/07		3.58	1.42	2.16				N/app	No Water available for HC.
GW	GC17--PH1	Phreatic	PEAT	Lower Salt Marsh	CM1	NHA	14/04/07		3.06	1.20	1.86				N/app	
GW	GC17--PH1	Phreatic	PEAT	Lower Salt Marsh	CM1	NHA	23/04/07		3.06	1.22	1.84				N/app	No Water available for HC.
GW	BR1--P1	Piezometer	BEDROCK - Weathered	Neutral Grassland / Improved Agricultural Grassland	GS1 / GA1	None	12/04/07		16.34	1.12	15.22				N/app	
GW	BR1--P1	Piezometer	BEDROCK - Weathered	Neutral Grassland / Improved Agricultural Grassland	GS1 / GA1	None	14/04/07		16.34	1.16	15.18				N/app	
GW	BR1--P1	Piezometer	BEDROCK - Weathered	Neutral Grassland / Improved Agricultural Grassland	GS1 / GA1	None	24/04/07	16:30	16.34	1.27	15.07	429	6.26	12.8	N/app	10 litres purged. Sample clear. Good recharge.
GW	BR1--P2	Piezometer	BEDROCK - Weathered	Neutral Grassland / Improved Agricultural Grassland	GS1 / GA1	None	12/04/07		16.21	1.02	15.19				N/app	
GW	BR1--P2	Piezometer	BEDROCK - Weathered	Neutral Grassland / Improved Agricultural Grassland	GS1 / GA1	None	14/04/07		16.21	1.04	15.17				N/app	
GW	BR1--P2	Piezometer	BEDROCK - Weathered	Neutral Grassland / Improved Agricultural Grassland	GS1 / GA1	None	24/04/07	16:32	16.21	1.14	15.07	411	6.33	13.4	N/app	Purged 10 litres. Sample slightly cloudy. Good recharge.
GW	BR1--P3	Piezometer	BEDROCK - Weathered	Neutral Grassland / Improved Agricultural Grassland	GS1 / GA1	None	12/04/07		16.36	1.15	15.21				N/app	
GW	BR1--P3	Piezometer	BEDROCK - Weathered	Neutral Grassland / Improved Agricultural Grassland	GS1 / GA1	None	14/04/07		16.36	1.19	15.17				N/app	
GW	BR1--P3	Piezometer	BEDROCK - Weathered	Neutral Grassland / Improved Agricultural Grassland	GS1 / GA1	None	24/04/07	16:34	16.36	1.19	15.17	409	6.54	13.7	N/app	
GW	BR1--PH1	Phreatic	Subsoils - CLAY	Neutral Grassland / Improved Agricultural Grassland	GS1 / GA1	None	12/04/07		16.40	1.19	15.21				N/app	
GW	BR1--PH1	Phreatic	Subsoils - CLAY	Neutral Grassland / Improved Agricultural Grassland	GS1 / GA1	None	14/04/07		16.40						N/app	Dry.
GW	BR1--PH1	Phreatic	Subsoils - CLAY	Neutral Grassland / Improved Agricultural Grassland	GS1 / GA1	None	24/04/07	16:36	16.40						N/app	Dry.
GW	BR2--P1	Piezometer	BEDROCK	Neutral Grassland / Improved Agricultural Grassland	GS1 / GA1	None	12/04/07		16.12	1.51	14.61				N/app	
GW	BR2--P1	Piezometer	BEDROCK	Neutral Grassland / Improved Agricultural Grassland	GS1 / GA1	None	14/04/07		16.12	1.52	14.60				N/app	

Non-variable Monitoring Data							Variable Monitoring Results									
GENERAL	Monitoring Point ID	Monitoring point type	GEO-UNIT Monitored	HABITATS & DESIGNATION			Date	Time	Water levels			Chemistry			Flow Gauging	Comments
Surface Water (SW) or Groundwater (GW)				Habitat Monitored	Fossitt Habitat Code	Designation (SAC, NHA, SAC & NHA, None)			Ref mOD (top of Plastic Casing / top of SG)	WL mbRef	WL mOD (Malin)	microSiemens/cm @ 25°C (µS/cm)	pH	Temperature (°C)	Discharge (litres / second)	
GW	BR2--P1	Piezometer	BEDROCK	Neutral Grassland / Improved Agricultural Grassland	GS1 / GA1	None	24/04/07	14:11	16.12	1.36	14.76	947	7.11	13.6	N/app	Purged 10 litres. Sample cloudy. Good recharge.
GW	BR2--P2	Piezometer	BEDROCK	Neutral Grassland / Improved Agricultural Grassland	GS1 / GA1	None	12/04/07		16.07	1.26	14.81				N/app	
GW	BR2--P2	Piezometer	BEDROCK	Neutral Grassland / Improved Agricultural Grassland	GS1 / GA1	None	14/04/07		16.07	1.31	14.76				N/app	
GW	BR2--P2	Piezometer	BEDROCK	Neutral Grassland / Improved Agricultural Grassland	GS1 / GA1	None	24/04/07	14:15	16.07	1.58	14.49	770	6.90	12.9	N/app	Purged 10 litres. Sample cloudy. Good recharge.
GW	BR2--PH1	Phreatic	BEDROCK	Neutral Grassland / Improved Agricultural Grassland	GS1 / GA1	None	12/04/07		16.37	1.52	14.85				N/app	
GW	BR2--PH1	Phreatic	BEDROCK	Neutral Grassland / Improved Agricultural Grassland	GS1 / GA1	None	14/04/07		16.37	1.60	14.77				N/app	
GW	BR2--PH1	Phreatic	BEDROCK	Neutral Grassland / Improved Agricultural Grassland	GS1 / GA1	None	24/04/07	14:17	16.37	1.68	14.69	912	7.22	12.2	N/app	Purged 10 litres. Sample cloudy. Good recharge.
GW	BR3--P1	Piezometer	BEDROCK	Neutral Grassland / Improved Agricultural Grassland	GS1 / GA1	None	14/04/07		11.42	1.50	9.92				N/app	
GW	BR3--P1	Piezometer	BEDROCK	Neutral Grassland / Improved Agricultural Grassland	GS1 / GA1	None	24/04/07	11:40	11.42	5.60	5.82	887	6.96	12.7	N/app	Purged 30 litres. Sample cloudy. Good recharge.
GW	BR3--PH1	Phreatic	Subsoil - CLAY / BEDROCK	Neutral Grassland / Improved Agricultural Grassland	GS1 / GA1	None	14/04/07		11.55	0.27	11.28				N/app	
GW	BR3--PH1	Phreatic	Subsoil - CLAY / BEDROCK	Neutral Grassland / Improved Agricultural Grassland	GS1 / GA1	None	24/04/07	11:40	11.55	4.89	6.66	928	6.93	12.5	N/app	Purged 30 litres. Sample cloudy. Good recharge.
GW	BR4--P1	Piezometer	BEDROCK	Neutral Grassland / Improved Agricultural Grassland	GS1 / GA1	None	14/04/07		6.43						N/app	WL n/av. Pipe blocked at 1.90mbRef.
GW	BR4--P1	Piezometer	BEDROCK	Neutral Grassland / Improved Agricultural Grassland	GS1 / GA1	None	24/04/07	09:23	6.43	1.75	4.68	1019	7.70	13.3	N/app	Purged 10 litres. Sample very cloudy. Good recharge.
GW	BR4--P2	Piezometer	Subsoil - CLAY / BEDROCK	Neutral Grassland / Improved Agricultural Grassland	GS1 / GA1	None	14/04/07		6.38	1.51	4.87				N/app	
GW	BR4--P2	Piezometer	Subsoil - CLAY / BEDROCK	Neutral Grassland / Improved Agricultural Grassland	GS1 / GA1	None	24/04/07	09:22	6.38	1.57	4.81	635	7.35	12.3	N/app	Purged 10 litres. Sample cloudy. Good recharge.
GW	BR4--PH1	Phreatic	Subsoils - CLAY	Neutral Grassland / Improved Agricultural Grassland	GS1 / GA1	None	14/04/07		6.14	1.37	4.77				N/app	
GW	BR4--PH1	Phreatic	Subsoils - CLAY	Neutral Grassland / Improved Agricultural Grassland	GS1 / GA1	None	24/04/07	09:21	6.14	1.43	4.71	637	7.23	11.8	N/app	Purged 10 litres. Sample slightly cloudy. Good recharge.
GW	BR5--P1	Piezometer	BEDROCK	Wet Grassland / Improved Agricultural Grassland	GS4 / GA1	None	12/04/07		6.98	1.20	5.78				N/app	
GW	BR5--P1	Piezometer	BEDROCK	Wet Grassland / Improved Agricultural Grassland	GS4 / GA1	None	14/04/07		6.98	1.24	5.74				N/app	
GW	BR5--P1	Piezometer	BEDROCK	Wet Grassland / Improved Agricultural Grassland	GS4 / GA1	None	25/04/07	12:15	6.98	1.23	5.75	372	6.21	11.5	N/app	Purged 15 litres. Sample moderately cloudy. Good recharge.
GW	BR5--P2	Piezometer	Subsoil - CLAY / BEDROCK	Wet Grassland / Improved Agricultural Grassland	GS4 / GA1	None	12/04/07		6.92	1.09	5.83				N/app	
GW	BR5--P2	Piezometer	Subsoil - CLAY / BEDROCK	Wet Grassland / Improved Agricultural Grassland	GS4 / GA1	None	14/04/07		6.92	1.14	5.78				N/app	
GW	BR5--P2	Piezometer	Subsoil - CLAY / BEDROCK	Wet Grassland / Improved Agricultural Grassland	GS4 / GA1	None	25/04/07	12:16	6.92	1.12	5.80	387	6.13	11.0	N/app	Purged 15 litres. Sample moderately cloudy. Good recharge.
GW	BR5--PH1	Phreatic	Subsoils - CLAY	Wet Grassland / Improved Agricultural Grassland	GS4 / GA1	None	12/04/07		6.72	0.79	5.93				N/app	
GW	BR5--PH1	Phreatic	Subsoils - CLAY	Wet Grassland / Improved Agricultural Grassland	GS4 / GA1	None	14/04/07		6.72	0.84	5.88				N/app	
GW	BR5--PH1	Phreatic	Subsoils - CLAY	Wet Grassland / Improved Agricultural Grassland	GS4 / GA1	None	25/04/07	12:17	6.72	0.80	5.92	268	6.05	11.5	N/app	Purged 10 litres. Sample moderately cloudy. Good recharge.
GW	BR6--P1	Piezometer	BEDROCK	Wet Grassland / Improved Agricultural Grassland	GS4 / GA1	None	14/04/07		6.91	1.23	5.68				N/app	
GW	BR6--P1	Piezometer	BEDROCK	Wet Grassland / Improved Agricultural Grassland	GS4 / GA1	None	25/04/07	14:09	6.91	1.23	5.68	520	7.07	13.2	N/app	Purged 15 litres. Sample slightly cloudy. Good recharge.
GW	BR6--P2	Piezometer	Subsoil - CLAY / BEDROCK	Wet Grassland / Improved Agricultural Grassland	GS4 / GA1	None	14/04/07		6.85	1.17	5.68				N/app	
GW	BR6--P2	Piezometer	Subsoil - CLAY / BEDROCK	Wet Grassland / Improved Agricultural Grassland	GS4 / GA1	None	25/04/07	14:11	6.85	1.14	5.71	514	6.80	12.2	N/app	Purged 15 litres. Sample slightly cloudy. Good recharge.
GW	BR6--P3	Piezometer	Subsoils - CLAY	Wet Grassland / Improved Agricultural Grassland	GS4 / GA1	None	14/04/07		6.76	1.09	5.67				N/app	
GW	BR6--P3	Piezometer	Subsoils - CLAY	Wet Grassland / Improved Agricultural Grassland	GS4 / GA1	None	25/04/07	14:12	6.76	1.05	5.71	545	6.95	12.1	N/app	Purged 15 litres. Sample moderately cloudy. Good recharge.

Non-variable Monitoring Data							Variable Monitoring Results									
GENERAL	Monitoring Point ID	Monitoring point type	GEO-UNIT Monitored	HABITATS & DESIGNATION			Date	Time	Water levels			Chemistry			Flow Gauging	Comments
Surface Water (SW) or Groundwater (GW)				Habitat Monitored	Fossitt Habitat Code	Designation (SAC, NHA, SAC & NHA, None)			Ref mOD (top of Plastic Casing / top of SG)	WL mbRef	WL mOD (Malin)	microSiemens/cm @ 25°C (µS/cm)	pH	Temperature (°C)	Discharge (litres / second)	
GW	BR6--PH1	Phreatic	Subsoils - CLAY	Wet Grassland / Improved Agricultural Grassland	GS4 / GA1	None	14/04/07		6.79	1.05	5.74				N/app	
GW	BR6--PH1	Phreatic	Subsoils - CLAY	Wet Grassland / Improved Agricultural Grassland	GS4 / GA1	None	25/04/07	14:14	6.79	1.08	5.71	735	6.94	13.4	N/app	Purged 10 litres. Sample moderately cloudy. Good recharge.
GW	BR7--P1	Piezometer	BEDROCK - Weathered	Wet Grassland / Improved Agricultural Grassland	GS4 / GA1	None	14/04/07		2.77	0.40	2.37				N/app	
GW	BR7--P1	Piezometer	BEDROCK - Weathered	Wet Grassland / Improved Agricultural Grassland	GS4 / GA1	None	25/04/07	10:24	2.77	0.34	2.43	652	7.01	11.5	N/app	Purged 10 litres. Sample moderately cloudy. Good recharge.
GW	BR7--P2	Piezometer	BEDROCK - Weathered	Wet Grassland / Improved Agricultural Grassland	GS4 / GA1	None	14/04/07		2.73	0.38	2.36				N/app	
GW	BR7--P2	Piezometer	BEDROCK - Weathered	Wet Grassland / Improved Agricultural Grassland	GS4 / GA1	None	25/04/07	10:25	2.73	0.30	2.43	613	7.02	11.7	N/app	Purged 10 litres. Sample clear. Good recharge.
GW	BR7--P3	Piezometer	BEDROCK	Wet Grassland / Improved Agricultural Grassland	GS4 / GA1	None	14/04/07		2.63	0.28	2.35				N/app	
GW	BR7--P3	Piezometer	BEDROCK	Wet Grassland / Improved Agricultural Grassland	GS4 / GA1	None	25/04/07	10:26	2.63	0.22	2.41	623	7.07	12.1	N/app	Purged 10 litres. Sample slightly cloudy. Good recharge.
GW	BR7--PH1	Phreatic	Subsoils - CLAY	Wet Grassland / Improved Agricultural Grassland	GS4 / GA1	None	14/04/07		2.57	0.20	2.37				N/app	
GW	BR7--PH1	Phreatic	Subsoils - CLAY	Wet Grassland / Improved Agricultural Grassland	GS4 / GA1	None	25/04/07	10:27	2.57	0.11	2.46	640	7.18	11.8	N/app	Purged 10 litres. Sample cloudy. Good recharge.
GW	BR8--P1	Piezometer	BEDROCK	Neutral Grassland / Improved Agricultural Grassland	GS1 / GA1	None	14/04/07		5.77	2.58	3.19				N/app	
GW	BR8--P1	Piezometer	BEDROCK	Neutral Grassland / Improved Agricultural Grassland	GS1 / GA1	None	25/04/07	15:10	5.77	2.65	3.12	840	6.98	11.9	N/app	Purged 15 litres. Sample moderately cloudy. Good recharge.
GW	BR8--P2	Piezometer	Subsoil - CLAY / BEDROCK	Neutral Grassland / Improved Agricultural Grassland	GS1 / GA1	None	14/04/07		5.63	2.43	3.20				N/app	
GW	BR8--P2	Piezometer	Subsoil - CLAY / BEDROCK	Neutral Grassland / Improved Agricultural Grassland	GS1 / GA1	None	25/04/07	15:12	5.63	2.51	3.12	642	6.95	11.6	N/app	Purged 15 litres. Sample moderately cloudy. Good recharge.
GW	BR8--PH1	Phreatic	Subsoils - CLAY	Neutral Grassland / Improved Agricultural Grassland	GS1 / GA1	None	14/04/07		5.55	2.36	3.19				N/app	
GW	BR8--PH1	Phreatic	Subsoils - CLAY	Neutral Grassland / Improved Agricultural Grassland	GS1 / GA1	None	25/04/07	15:13	5.55	2.51	3.04	684	6.74	12.9	N/app	Purged 10 litres. Sample very cloudy. Average / moderate recharge.
GW	BR9--P1	Piezometer	BEDROCK	Wet Grassland / Improved Agricultural Grassland	GS4 / GA1	None	14/04/07		4.24	0.96	3.28				N/app	
GW	BR9--P1	Piezometer	BEDROCK	Wet Grassland / Improved Agricultural Grassland	GS4 / GA1	None	23/04/07	19:00	4.24	0.99	3.25	994	7.04	11.4	N/app	Purged 10 litres. Sample clear. Good recharge.
GW	BR9--P2	Piezometer	Subsoil - CLAY / BEDROCK	Wet Grassland / Improved Agricultural Grassland	GS4 / GA1	None	14/04/07		4.15	0.87	3.28				N/app	
GW	BR9--P2	Piezometer	Subsoil - CLAY / BEDROCK	Wet Grassland / Improved Agricultural Grassland	GS4 / GA1	None	23/04/07	19:00	4.15	0.93	3.22	890	7.15	11.4	N/app	Purged 10 litres. Sample clear. Good recharge.
GW	BR9--P3	Piezometer	Subsoils - CLAY	Wet Grassland / Improved Agricultural Grassland	GS4 / GA1	None	14/04/07		4.08	0.79	3.29				N/app	
GW	BR9--P3	Piezometer	Subsoils - CLAY	Wet Grassland / Improved Agricultural Grassland	GS4 / GA1	None	23/04/07	19:00	4.08	0.82	3.26	867	7.21	11.3	N/app	Purged 10 litres. Sample clear. Good recharge.
GW	BR9--PH1	Phreatic	Subsoils - CLAY	Wet Grassland / Improved Agricultural Grassland	GS4 / GA1	None	14/04/07		4.03	0.74	3.29				N/app	
GW	BR9--PH1	Phreatic	Subsoils - CLAY	Wet Grassland / Improved Agricultural Grassland	GS4 / GA1	None	23/04/07	19:00	4.03	0.76	3.27	794	7.10	11.3	N/app	Purged 10 litres. Sample very cloudy. Good recharge.
GW	BR10--P1	Piezometer	BEDROCK	Neutral Grassland / Improved Agricultural Grassland	GS1 / GA1	None	14/04/07		7.13	4.92	2.21				N/app	
GW	BR10--P1	Piezometer	BEDROCK	Neutral Grassland / Improved Agricultural Grassland	GS1 / GA1	None	25/04/07	15:40	7.13	4.80	2.33	957	7.76	16.9	N/app	Water level too low to purge, small sample available for HC only.
GW	BR10--P2	Piezometer	BEDROCK	Neutral Grassland / Improved Agricultural Grassland	GS1 / GA1	None	14/04/07		7.06	4.85	2.21				N/app	
GW	BR10--P2	Piezometer	BEDROCK	Neutral Grassland / Improved Agricultural Grassland	GS1 / GA1	None	25/04/07	15:40	7.06	4.74	2.32	546	7.36	16.7	N/app	Water level too low to purge, small sample available for HC only.
GW	BR10--P3	Piezometer	BEDROCK	Neutral Grassland / Improved Agricultural Grassland	GS1 / GA1	None	14/04/07		6.96	5.78	1.18				N/app	
GW	BR10--P3	Piezometer	BEDROCK	Neutral Grassland / Improved Agricultural Grassland	GS1 / GA1	None	25/04/07	15:40	6.96	4.66	2.30	576	7.36	12.3	N/app	Water level too low to purge, small sample available for HC only.
GW	BR10--PH1	Phreatic	Subsoil - CLAY / BEDROCK	Neutral Grassland / Improved Agricultural Grassland	GS1 / GA1	None	14/04/07		6.91	1.75	5.16				N/app	
GW	BR10--PH1	Phreatic	Subsoil - CLAY / BEDROCK	Neutral Grassland / Improved Agricultural Grassland	GS1 / GA1	None	25/04/07	15:40	6.91						N/app	Dry.

Non-variable Monitoring Data							Variable Monitoring Results									
GENERAL	**Monitoring Point ID**	**Monitoring point type**	**GEO-UNIT Monitored**	**HABITATS & DESIGNATION**			**Date**	**Time**	**Water levels**			**Chemistry**			**Flow Gauging**	**Comments**
				Habitat Monitored	**Fossitt Habitat Code**	**Designation** (SAC, NHA, SAC & NHA, None)			**Ref mOD (top of Plastic Casing / top of SG)**	**WL mbRef**	**WL mOD (Malin)**	**microSiemens/cm @ 25°C (µS/cm)**	**pH**	**Temperature (°C)**	**Discharge (litres / second)**	
Surface Water (SW) or Groundwater (GW)																
GW	**BR11--P1**	Piezometer	BEDROCK	Neutral Grassland / Improved Agricultural Grassland	GS1 / GA1	None	**25/04/07**	18:00	10.85	1.34	**9.51**	341	6.07	11.4	N/app	Purged 15 litres. Sample moderately cloudy. Good recharge.
GW	**BR11--P2**	Piezometer	BEDROCK	Neutral Grassland / Improved Agricultural Grassland	GS1 / GA1	None	**25/04/07**	18:00	10.83	1.30	**9.53**	354	5.98	11.1	N/app	Purged 15 litres. Sample moderately cloudy. Good recharge.
GW	**BR11--P3**	Piezometer	Subsoil - CLAY / BEDROCK	Neutral Grassland / Improved Agricultural Grassland	GS1 / GA1	None	**25/04/07**	18:00	10.66	1.15	**9.51**	351	6.14	11.4	N/app	Purged 15 litres. Sample moderately cloudy. Good recharge.
GW	**BR11--PH1**	Phreatic	Subsoils - CLAY	Neutral Grassland / Improved Agricultural Grassland	GS1 / GA1	None	**25/04/07**	18:00	10.61	1.07	**9.54**	407	6.55	12.5	N/app	Purged 10 litres. Sample very cloudy. Good recharge.
GW	**BH3**	Phreatic	Subsoil - CLAY / BEDROCK	Neutral Grassland / Improved Agricultural Grassland	GS1 / GA1	None	**26/04/07**		17.01	4.73	**12.28**	556	5.91	10.8	N/app	Purged 75 litres. Sample moderately clear. Good recharge.
GW	**BH5**	Phreatic	BEDROCK	Neutral Grassland / Improved Agricultural Grassland	GS1 / GA1	None	**26/04/07**		18.19	6.66	**11.53**	581	6.33	12.2	N/app	Purged 75 litres. Sample moderately clear. Good recharge.
GW	**BH10**	Phreatic	Subsoil - CLAY / Top of BEDROCK	Neutral Grassland / Improved Agricultural Grassland	GS1 / GA1	None	**26/04/07**		20.21						N/app	WL not available.
GW	**BH12**	Phreatic	Subsoil - CLAY / BEDROCK	Neutral Grassland / Improved Agricultural Grassland	GS1 / GA1	None	**26/04/07**		13.44	4.25	**9.19**				N/app	
GW	**BH13**	Phreatic	Subsoil - CLAY / BEDROCK	Neutral Grassland / Improved Agricultural Grassland	GS1 / GA1	None	**26/04/07**		17.17	7.39	**9.78**	344	5.70	11.9	N/app	Field inaccessible with vehicle due to ditch break being reinstated, borehole not purged, sampled
GW	**BH14**	Phreatic	Subsoil - CLAY / BEDROCK	Neutral Grassland / Improved Agricultural Grassland	GS1 / GA1	None	**26/04/07**		13.46						N/app	Dry.
GW	**BH18**	Phreatic	BEDROCK	Neutral Grassland / Improved Agricultural Grassland	GS1 / GA1	None	**26/04/07**		19.25	6.94	**12.31**				N/app	WL only. Standing water inside metal casing.
GW	**BH19**	Phreatic	BEDROCK	Neutral Grassland / Improved Agricultural Grassland	GS1 / GA1	None	**26/04/07**		13.12	7.17	**5.95**	217	5.50	12.4	N/app	Field inaccessible with vehicle due to ditch break being reinstated, borehole not purged, sampled
GW	**BH20**	Phreatic	Subsoils - CLAY	Neutral Grassland / Improved Agricultural Grassland	GS1 / GA1	None	**26/04/07**		17.98						N/app	Dry.
GW	**BH23**	Phreatic	Subsoil - CLAY / BEDROCK	Neutral Grassland / Improved Agricultural Grassland	GS1 / GA1	None	**26/04/07**		13.18	1.69	**11.49**	314	5.11	11.4	N/app	Purged 45 litres. Sample moderately clear. Good recharge.

PARAMETER / SUBSTANCE	Units	DRINKING WATER REGULATIONS S.I. No. 106 of 2007 Parameter No.	Parameter Category	Parametric Value	Interim Guideline Values (IGV's) - EPA, 2004	Date sampled	Investigation Point ID BH5	BH10	BH14	BH20	BH23	PW1 (Step Test)	PW1 (Pump Test)
Alkalinity - total	mg/l				No abnormal change	Jan-07	-	70	80	-	-	40	-
Chloride - total	mg/l	31	C	250		Jan-07	40	-	40	-	-	41	54
Electrical conductivity (EC)	uS/cm	34	C	2500 @20°C	1000.00	Jan-07	-	359	360	-	-	-	355
Nitrate	mg/l	20	B	50.00	25.00	Jan-07	33.8	-	-	34	10.5	11.5	-
pH	pH units	35	C	>6 & <9.5	>6.5 <9.5	Jan-07	7.70	7.92	7.86	7.05	8.26	7.38	7.88
Orthophosphate	mg/l				0.03	Jan-07	0.6	-	-	0.27	0.04	0.04	-
Sodium	mg/l	41	C	200	150.00	Jan-07	23	-	22	-	-	32	40
Sulphate	mg/l	40	C	250	200.00	Jan-07	16	-	-	15	14	16	19

= Exceedences of SI 106 "MAC" values or EPA "IGV" values

No. 1 – View NW toward D1 Valley and SAC area from GPS E101838, N148227.

No. 2 – View W-NW of D1 valley from GPS E102155, N148155.

No. 3 – View N-NW from GPS E102155, N148155 with D1 valley and SAC area in left middle ground of photo.

No. 4 – Cliff exposures along coast N of Lagoon and cobble beach adjacent to Lagoon at GPS E101400, N148420.

No. 5 – Coastal Lagoon (looking E from GPS: E101339, N148337).

No. 6 – Coastal Lagoon and cobble beach at SG-10 (looking SW from GPS: E101422, N148434).

No. 7 – Reed and Large Sedge Swamp (looking SE toward D1 valley from GPS: E101640, N148530.

No. 8 – Reed and Large Sedge Swamp (in middleground), D1 in left foreground. Looking E-SE toward D1 valley from GPS: E101640, N148530.

No. 9 – Tidal River, looking up stream (SE) at D1 flowing across cobble beach at GPS: E101497, N148576).

No. 10 – Lower Salt Marsh, looking SW from GPS: E101580, N148540.

No. 11 – Southwest side of Lower Salt Marsh habitat at GC17-PH1 installation (looking NW from GPS: E101570, N148450.

No. 12 – Wet Grassland that fringes the south side of D1 – looking SE from GPS: E101676, N148412

No. 13 – Peat exposure on Beach at northwest side of Lagoon at GPS: E101370, N148400 (approx.).

No. 14 – Close up of Peat exposure on Beach at northwest side of Lagoon at GPS: E101370, N148400 (approx.).

No. 15 – Waterlogged area adjacent to D1 at BR-1 at GPS: E102380, N147974

No. 16 – D1 at SG1 at the eastern site boundary where D1 enters site (GPS: E102397, N147938).

No. 17 – D1 looking downstream at SG-2 (GPS: E102162, N148006).

No. 18 – D1 at SG-3 (GPS: E101971, N148176).

No. 19 – D1 at SG-4 (GPS: E101895, N148235).

No. 20 – D1 at SG-5 looking downstream (GPS: E101832, N148292).

No. 21 – D1 looking upstream from SG-6 (GPS: E101724, N148406).

No. 22 – D1 looking upstream from SG-7 (GPS: E101662, N148464).

No. 23 – D1 looking upstream from SG-8 (GPS: E101625, N148487).

No. 24 – D3 drain looking upstream at GPS: E102162, N148077.

No. 25 – D4 flowing along field boundary toward D2 at GPS: E102060, N148330.

No. 26 – Ponding of water at D5-SW1 at GPS: E101875, N148423.

No. 27 – D6 draining west out of Reed and Large Sedge Swamp habitat, looking upstream at GPS: E101605, N148509.

No. 28 – D9 along field boundary at GPS E101820, N148275.

No. 29 – SP-SW4: Extensive spring / seepage area with wet marshy ground and standing water c.0.3m deep at GPS: E101924, N148493.

No. 30 – SP-SW5: Location at base of field boundary from which spring discharge is occurring (GPS: E102093, N148369).

No. 31 – SP-SW3: spring adjacent to Sedge Swamp area at GPS: E101761, N148493.

No. 32 – D8 flowing NW along roadway, looking downstream NW of GPS: E101471, N148186.

No. 33 – SP-SW1 discharging at base of ditch close to farmyard at GPS: E101471, N148186.

No. 34 – Water pooling along road at base of D8 near beach (D8-SW2) at GPS: E101341, N148335.

No. 35 – SP-SW2 at base of D7, adjacent to lagoon, looking upstream at GPS: E101497, N148371.

No. 36 – Seepage from lagoon across cobble beach on west side of lagoon adjacent to SG-10.

No. 37 – Lagoon water level relatively high at SG-11 on 27th March 2007.

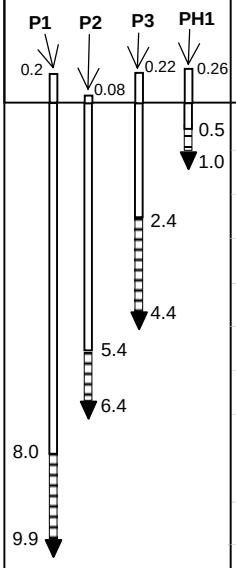
No. 38 – Lagoon water level at SG-11 on 14th April 2007 having dropped considerably since March 2007.

No. 39 – Lagoon water level relatively high at SG-10 on 27th March 2007.

No. 40 – Lagoon Water level at SG-10 on 14th April 2007 having dropped considerably since March 2007.

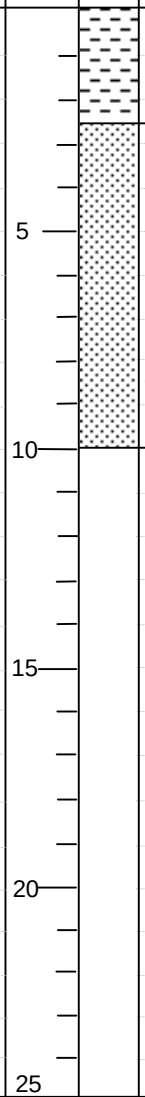
AIR FLUSH ROTARY PERCUSSION LOGS and INSTALLATIONS

BH No.	**BR1**
Total Depth (m)	10.0
Date drilled:	10/04/07
Logged by:	O. Madden
Drawn by:	S. Regan
Drilling Equipment	Rotary Core
Drilling Company	IGSL / Millenium Drilling
Grid Coordinates	E102420 N147948



Yield / SWL

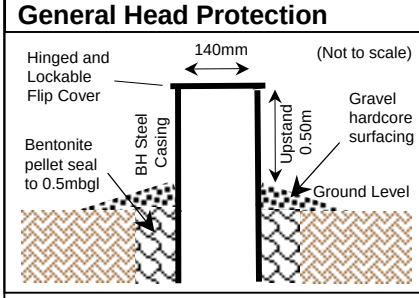
Groundwater Occurrence



Lithology (%)	Chip Shape	Max. Chip Size (cm)	% Weathering	Geology
No return				Dark Grey Boulder Clay (Lower Till)
Gy d Sa, Gl (40), Sd (10), Cy (50)	Fl Rd	20	5	
Gy d Sa, Pb (30), Gl (30), Sd (20), Cy (20)	Bl/ Fl Rds	25	0	Dark Grey Sandstone
Gy l Sa, Pb (50), Gl (30), Sd (20)	Bl An	40	0	
Gy l Sa, Cb (30), Pb (20), Gl (30), Sd (20)	Fl An	50	50	
Gy d Sa, Cb (60), Pb (30), Gl (10)	Fl Rds	80	80	
Gy d Sa, Cb (50), Pb (30), Gl (20)	Fl/ Bl Ans	60	70	
Gy d Sa, Cb (50), Pb (30), Gl (20)	Bl An	50	70-80	
Gy d Sa, Cb (50), Pb (30), Gl (20)	Bl An	50	70-80	
Waterstrike@ 2.5mbGL			**EOH**	**10.0m**

Groundwater Chemistry:
EC = 401uS/cm,
pH = 7.00
Temp = 12.9ºC

General Head Protection



Legend

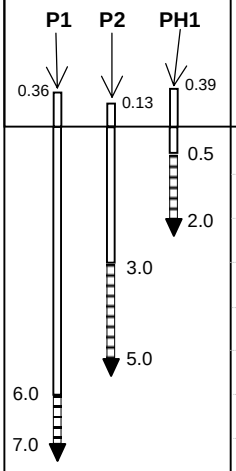
- Backfilled with drill chippings
- Bentonite pellets
- Slotted (1-2mm) uPVC screen

Title	Hydrological and Hydrogeological Impact Assessment of the Proposed Shannon LNG Terminal Development at Ballylongford, Co. Kerry
Client	Arup Consulting Engineers
MEL Document No.	1946-024.ppt

Minerex Environmental Limited

Notes:
- Marsh/ pond located c.20m NW from BR1

BH No.	**BR2**
Total Depth (m)	8.0
Date drilled:	10/04/07
Logged by:	O. Madden
Drawn by:	S. Regan
Drilling Equipment	Rotary Core
Drilling Company	IGSL / Millenium Drilling
Grid Coordinates	E102159 N147996



Yield / SWL

Groundwater Occurrence

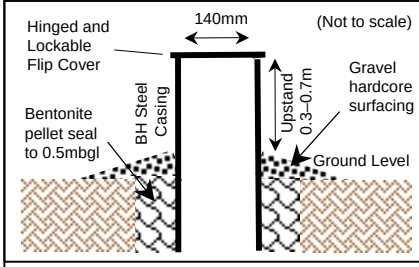
Dry

Wet

Depth (m)	Lithology (%)	Chip Shape	Max. Chip Size (cm)	% Weathering	Geology
	Soft clay soil – no return				
	Gy l Sa, Pb (50), Gl (25), Sd (25)	Fl An	20	0	
	Gy l Sa, Pb (20), Gl (40), Sd (40)	Fl Ans	8	0	Light Grey Sandstone
	Gy l Sa, Pb (20), Gl (40), Sd (40)	Fl Rds	10	0	
	Gy d Sa, Pb (20), Gl (20), Sd (60)	Fl Rd	6	0	
	Gy d Sa, Gl (30), Sd (30), Cy (40)	Fl Rd	5	0	Dark Grey Sandstone
	Gy d Sa, Gl (10), Sd (60), Cy (30)	Pl Rd	5	0	
	Gy d Sa, Gl (20), Sd (70), Cy (10)	Pl Rds	5	0	
				EOH	**8.0m**
	Waterstrike@ 4.7mbGL				

5
10
15
20
25

General Head Protection



Legend

- Backfilled with drill chippings
- Bentonite pellets
- Slotted (1-2mm) uPVC screen

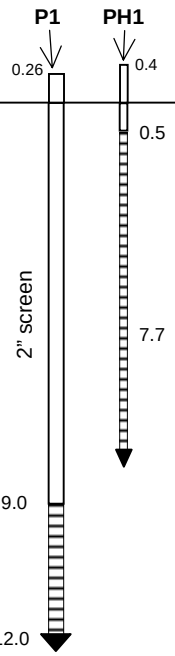
Title	Hydrological and Hydrogeological Impact Assessment of the Proposed Shannon LNG Terminal Development at Ballylongford, Co. Kerry
Client	Arup Consulting Engineers
MEL Document No.	1946-024.ppt

Minerex Environmental Limited

Notes:

BH No.	**BR3**
Total Depth (m)	12.0
Date drilled:	14/04/07
Logged by:	O. Madden
Drawn by:	S. Regan
Drilling Equipment	Rotary Core
Drilling Company	IGSL / Millenium Drilling
Grid Coordinates	E101741 N148198

Borehole Design & Completion



Groundwater occurrence, yield and formation/unit boundaries

Yield / SWL

Groundwater Occurrence

Dry

Wet

Depth (m)

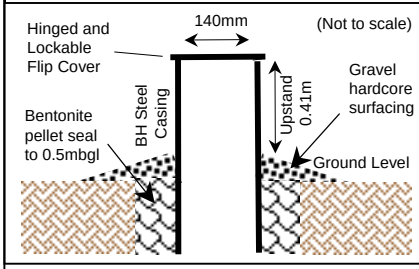
5
10
15
20
25

Geology - graphical log

Lithology (%)	Chip Shape	Max. Chip Size (cm)	% Weathering	Geology
Bn m, Gl (30), Sd (10), Cy (60)	Bl Rd	20	0	Brown Boulder Clay (Upper Till)
Bn m, Gl (20), Sd (20), Cy (60)	Bl Rds	15	0	
Gy m Sa, Gl (30), Sd (30), Cy (40)	Bl Ans	20	5	
Gy m Sa, Gl (30), Sd (40), Cy (30)	Bl Rds	18	0	
Gy m Sa, Gl (10), Sd (20), Cy (70)	Bl Rds	25	0	Grey Boulder Clay (Lower Till)
Gy m Sa, Gl (30), Sd (40), Cy (30)	Fl/ Bl An/ Rd	30	0	
Gy m Sa/ Si, Gl (30), Sd (30), Cy (40)	Bl Ans	20	0	
Gy d Sa, Gl (30), Sd (30), Cy (40)	Ob Rd	15	0	
Gy d Sa/ Si, Gl (30), Sd (30), Cy (40)	Bl An/ Rd	22	0	
Gy d Sa, Gl (30), Sd (30), Cy (40)	Bl/ Fl An	25	0	
Gy d Sa, Gl (60), Sd (20), Cy (20)	Bl Ans	12	0	Dark Grey Sandstone
Gy d Sa/ Si, Gl (40), Sd (30), Cy (30)	Fl An	20	0	
			EOH	**12.0m**

Waterstrike@ 9.9mbGL

General Head Protection



Legend

- Backfilled with drill chippings
- Bentonite pellets
- Slotted (1-2mm) uPVC screen

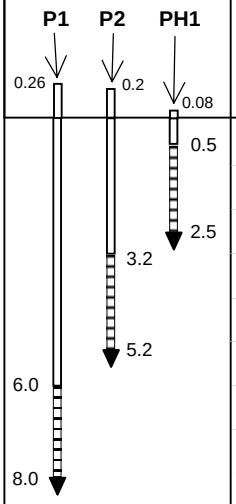
Notes:

- Westland pea gravel used for installation

Title	Hydrological and Hydrogeological Impact Assessment of the Proposed Shannon LNG Terminal Development at Ballylongford, Co. Kerry
Client	Arup Consulting Engineers
MEL Document No.	1946-024.ppt

Minerex Environmental Limited

BH No.	**BR4**
Total Depth (m)	8.0
Date drilled:	13/04/07
Logged by:	O. Madden
Drawn by:	S. Regan
Drilling Equipment	Rotary Core
Drilling Company	IGSL / Millenium Drilling
Grid Coordinates	E101787 N148271



Yield / SWL

2.04mbgl 13/04/07

Groundwater Occurrence: Dry / Damp / Wet

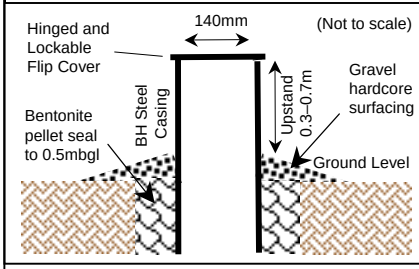
Depth (m): 5, 10, 15, 20, 25

Lithology (%)	Chip Shape	Max. Chip Size (cm)	% Weathering	Geology
Bn / Dk-m, Cy (90), Sd (10)				Brown Boulder Clay (Upper Till)
Bn m, Pb (30), Gl (20), Sd (20), Cy (30)	Ob Rds	32	0	
Bn/ Gy m, Pb (10), Gl (40), Sd (20), Cy (30)	Fl/ Bk Rds	10	0	Grey Boulder Clay (Lower Till)
Gy l, Pb (30), Gl (40), Cy (30)	Fl Rds	30	0	
Gy d Sa, Pb (40), Gl (40), Sd (20)	Bl Rds	50	10	Dark Grey Sandstone
Gy d Sa, Pb (40), Gl (40), Sd (20)	Fl	30	2	
No Return				
			EOH	8.0m

Waterstrike@ 3.8mbGL

Groundwater Chemistry @ 5-6mbGL:
EC = 612uS/cm,
pH = 7.86
Temp = 14.5ºC

General Head Protection



Legend

- Backfilled with drill chippings
- Bentonite pellets
- Slotted (1-2mm) uPVC screen

Title	Hydrological and Hydrogeological Impact Assessment of the Proposed Shannon LNG Terminal Development at Ballylongford, Co. Kerry
Client	Arup Consulting Engineers
MEL Document No.	1946-024.ppt

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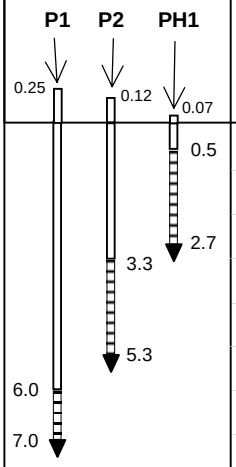
Notes:
- Invert of marsh and D1 @ 2 – 3m below ground level

BH No.	**BR5**
Total Depth (m)	7.0
Date drilled:	11/04/07
Logged by:	O. Madden
Drawn by:	S. Regan
Drilling Equipment	Rotary Core
Drilling Company	IGSL / Millenium Drilling
Grid Coordinates	E101904 N148335



Yield / SWL

Groundwater Occurrence

Dry

Wet

Dry

5

10

15

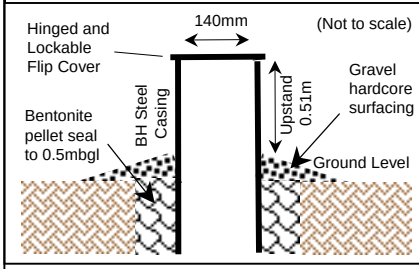
20

25

Lithology (%)	Chip Shape	Max. Chip Size (cm)	% Weathering	Geology
S - Sf Cy (70), Gl (20), Sd (10)	Fl An	10	0	
Gy m Sa, Pb (60), Gl (20), Cy (20)	Bl An	20	50	Grey Boulder Clay (Lower Till)
Gy m Sa, Pb (20), Gl (30), Cy (50)	Bl An	25	5	
Gy m Sa, Pb (20), Gl (30), Cy (50)	Bl An	25	5	
Gy d Si, Gl (50), Sd (25), Cy (25)	Fl An	15	0	Dark Grey Siltstone / Mudstone
Gy d Si, Gl (50), Sd (20), Pb (20), Cy (10)		25	0	
No Return				
			EOH	8.0m

Waterstrike@ 4.0-4.5mbGL

General Head Protection



Legend

- Backfilled with drill chippings
- Bentonite pellets
- Slotted (1-2mm) uPVC screen

Title	Hydrological and Hydrogeological Impact Assessment of the Proposed Shannon LNG Terminal Development at Ballylongford, Co. Kerry
Client	Arup Consulting Engineers
MEL Document No.	1946-024.ppt

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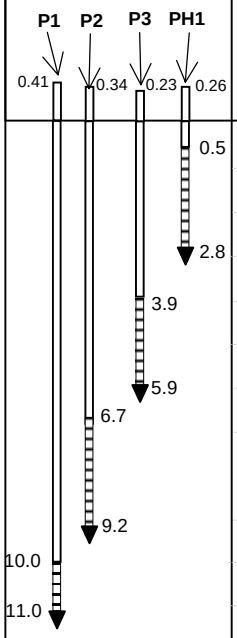
Notes:

- Weathered bedrock between 4.5 and 5.8m

BH No.	**BR6**
Total Depth (m)	11.0
Date drilled:	12/04/07
Logged by:	O. Madden
Drawn by:	S. Regan
Drilling Equipment	Rotary Core
Drilling Company	IGSL / Millenium Drilling
Grid Coordinates	E101904 N148419



Yield / SWL

Groundwater Occurrence

Dry

Wet

Dry

Wet

Depth (m)

5

10

15

20

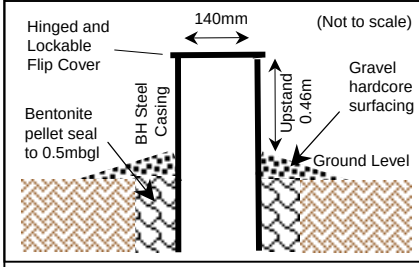
25

Geology - graphical log

Lithology (%)	Chip Shape	Max. Chip Size (cm)	% Weathering	Geology
Bn m, Gl (10), Sd (20), Cy (70)	El An	17	0	Brown Boulder Clay (Upper Till)
Bn m, Gl (30), Sd (30), Cy (40)	Ob Rds	32	0	
Gy d Sa, Pb (20), Gl (40), Sd (20), Cy (20)	Fl Rd	22	10	
Gy d Sa, Pb (10), Gl (30), Sd (20), Cy (40)	Fl Rd	25	0	
Gy d Sa, Pb (10), Gl (40), Sd (10), Cy (40)	Bl Rd	20	0	Grey Boulder Clay (Lower Till)
Gy m Sa, Pb (10), Gl (40), Sd (40), Cy (10)	Bl Ans	34	2	
Gy d Sa, Pb (10), Gl (10), Sd (40), Cy (40)	Bl Ans	28	0	
Gy d Sa, Pb (10), Gl (40), Sd (20), Cy (30)	Bl Rd	20	0	
Gy d Sa, Gl (50), Sd (20), Cy (30)	Fl An	20	0	
Gy d Sa/Si, Gl (60), Cy (20), Sd (20)	Fl An	15	0	Dark Grey Sandstone/ Siltstone
Gy d Sa/Si, Sd (40), Gl (30), Cy (30)	Fl An	7	0	
			EOH	**11.0m**

Water strike@ 4.0-4.2mbGL and @ 7.0mbGL

General Head Protection



Legend

- Backfilled with drill chippings
- Bentonite pellets
- Slotted (1-2mm) uPVC screen

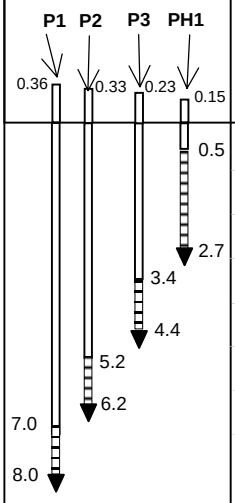
Title	Hydrological and Hydrogeological Impact Assessment of the Proposed Shannon LNG Terminal Development at Ballylongford, Co. Kerry
Client	Arup Consulting Engineers
MEL Document No.	1946-024.ppt

Minerex Environmental Limited

Notes:

BH No.	**BR7**
Total Depth (m)	8.0
Date drilled:	13/04/07
Logged by:	O. Madden
Drawn by:	S. Regan
Drilling Equipment	Rotary Core
Drilling Company	IGSL / Millenium Drilling
Grid Coordinates	E101709 N148394

Borehole Design & Completion



Groundwater occurrence, yield and formation/unit boundaries

Yield / SWL

Groundwater Occurrence

Damp

Wet

Depth (m)

5
10
15
20
25

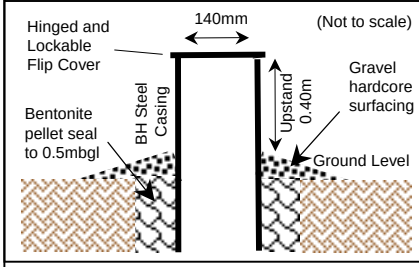
Geology - graphical log

Lithology (%)	Chip Shape	Max. Chip Size (cm)	% Weathering	Geology
No Return				
Gy l/ Bn m, Gl (5), Sd (5), Cy (90)	Fl An	7	0	Grey Boulder Clay (Lower Till)
Gy m, Gl (20), Sd (10), Cy (70)	Bl Rd	10	0	
Gy d Sa, Gl (70), Sd (10), Cy (20)	Bl Ans	32	0	
Gy d Sa, Gl (50), Sd (20), Cy (30)	Fl An	15	0	Dark Grey Sandstone
Gy d Si, Gl (60), Sd (30), Cy (10)	Bl An	22	20	
Gy d Si, Pb (10), Gl (90)	Bl An	30	50	Dark Grey Siltstone
Gy d Si, Pb (30), Gl (70)	Bl An	23	50	
				EOH 8.0m

Waterstrike@ 2.5mbGL

Groundwater Chemistry @ 6-7mbGL:
EC = 693uS/cm,
pH = 7.61
Temp = 16.1ºC

General Head Protection



Legend

- Backfilled with drill chippings
- Bentonite pellets
- Slotted (1-2mm) uPVC screen

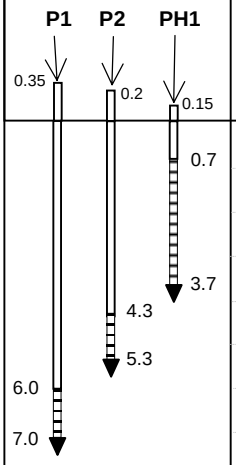
Title	Hydrological and Hydrogeological Impact Assessment of the Proposed Shannon LNG Terminal Development at Ballylongford, Co. Kerry
Client	Arup Consulting Engineers
MEL Document No.	1946-024.ppt

Minerex Environmental Limited

Notes:

-Ditch break at E101696 N148388
- Artesian flow from 6 – 7mbGL

BH No.	**BR8**
Total Depth (m)	7.0
Date drilled:	11/04/07
Logged by:	O. Madden
Drawn by:	S. Regan
Drilling Equipment	Rotary Core
Drilling Company	IGSL / Millenium Drilling
Grid Coordinates	E101780 N148509



Yield / SWL

Groundwater Occurrence

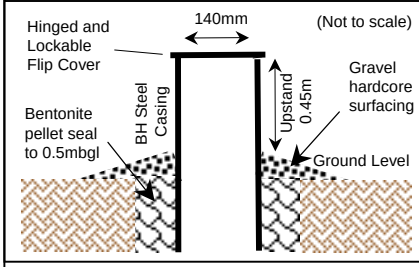
Dry

Wet

Damp

Depth (m)	Lithology (%)	Chip Shape	Max. Chip Size (cm)	% Weathering	Geology
	Bn m, Gl (10), Sd (10), Cy (80)	Bl Rd	20	80	Brown Boulder Clay (Upper Till)
	Gy l / Bn m, Pb (30), Gl (30), Sd (20), Cy (20)	Bl Rd	20	80	
	Gy l / Bn m, Pb (10), Gl (20), Sd (20), Cy (50)	Ob Rd	30	50	
	Gy m / Bn l, Pb (10), Gl (20), Sd (10), Cy (60)	Bl Rds	20	10	Grey Boulder Clay (Lower Till)
5	Gy l Sa, Gl (50), Sd (25), Cy (25)	Bl Ans	20	0	
	Gy d Sa, Gl (80), Sd (10), Cy (10)	Bl An	30	0	Dark Grey Sandstone / Siltstone
	Gy d Sa / Si, Gl (80), Sd (10)	Fl An	25	0	
				EOH	**7.0m**
	Waterstrike@ 5.0-5.5mbGL				
10					
15					
20					
25					

General Head Protection



Legend

- Backfilled with drill chippings
- Bentonite pellets
- Slotted (1-2mm) uPVC screen

Title	Hydrological and Hydrogeological Impact Assessment of the Proposed Shannon LNG Terminal Development at Ballylongford, Co. Kerry
Client	Arup Consulting Engineers
MEL Document No.	1946-024.ppt

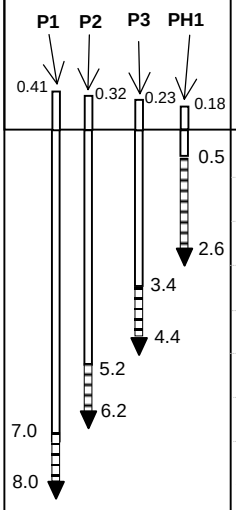
Minerex Environmental Limited

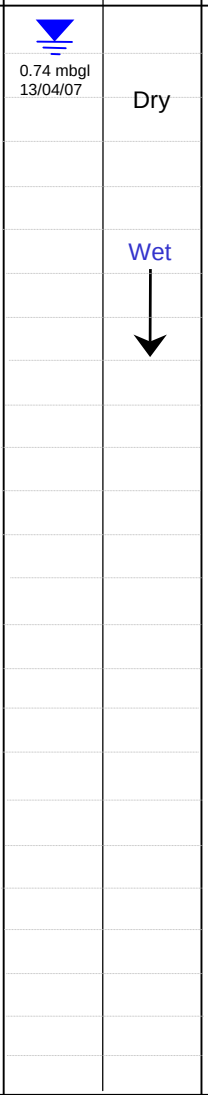
Notes:

-Ditch break at E101696 N148388

- Artesian flow at 6 – 7m

BH No.	**BR9**
Total Depth (m)	8.0
Date drilled:	12-13/04/07
Logged by:	O. Madden
Drawn by:	S. Regan
Drilling Equipment	Rotary Core
Drilling Company	IGSL / Millenium Drilling
Grid Coordinates	E101486 N148339

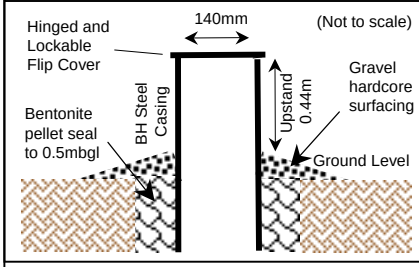




Lithology (%)	Chip Shape	Max. Chip Size (cm)	% Weathering	Geology
Bn m, Sd (10), Cy (90)			0	Brown Boulder Clay (Upper Till)
Gy m / Bn m, Gl (30), Sd (20), Cy (50)	Bl Rd	16	0	
Gy m, Gl (30), Sd (20), Cy (50)	Bl Rd	10	0	Grey Boulder Clay (Lower Till)
Gy m, Gl (30), Sd (30), Cy (40)	Bl Rd	15	10	
Gy m Sa, Gl (30), Sd (30), Cy (40)	Bl Ans	10	0	
Gy m Sa, Gl (60), Sd (20), Cy (20)	Ob An	27	0	Dark Grey Sandstone / Siltstone
Gy d Sa / Si, Gl (80), Sd (10), Cy (10)	Ob An	15	0	
No Return				
			EOH	**8.0m**

Waterstrike@ 5.5mbGL

General Head Protection



Legend

- Backfilled with drill chippings
- Bentonite pellets
- Slotted (1-2mm) uPVC screen

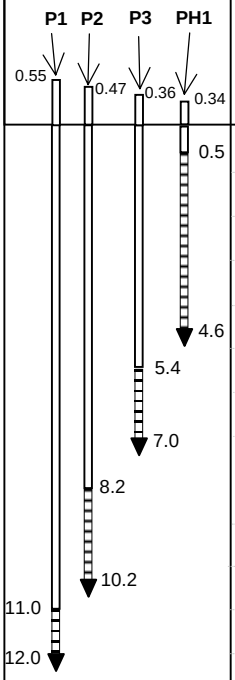
Title	Hydrological and Hydrogeological Impact Assessment of the Proposed Shannon LNG Terminal Development at Ballylongford, Co. Kerry
Client	Arup Consulting Engineers
MEL Document No.	1946-024.ppt

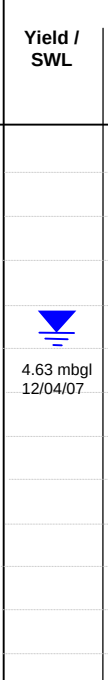
Minerex Environmental Limited

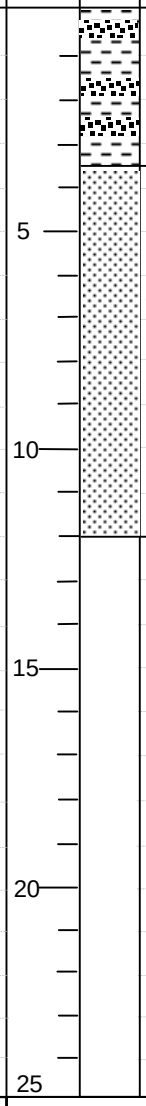
Notes:

-Ditch break at E101696 N148388
- Artesian flow at 6 – 7m

BH No.	**BR10**
Total Depth (m)	12.0
Date drilled:	12/04/07
Logged by:	O. Madden
Drawn by:	S. Regan
Drilling Equipment	Rotary Core
Drilling Company	IGSL / Millenium Drilling
Grid Coordinates	E101614 N148539





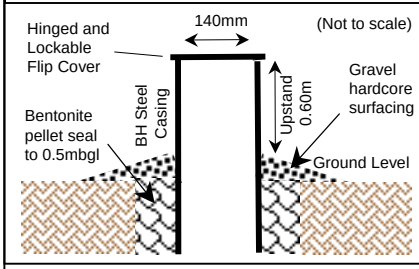


Lithology (%)	Chip Shape	Max. Chip Size (cm)	% Weathering	Geology
Bn l/ Gy l Sa Gl (50), Sd (10), Cy (40)	Bl Rds	30	20	Brown Boulder Clay (Upper Till)
Bn m/ Gy m Sa, Gl (40), Sd (20), Cy (40)	Ob Rds	20	20	
Bn m/ Gy l Sa, Gl (40), Sd (20), Cy (40)	Bl Ans	30	20	
Gy l Sa, Pb (10), Gl (60), Sd (30)	El Ans	23	0	Dark Grey Sandstone
Gy l Sa, Pb (10), Gl (50), Sd (40)	El Ans	25	0	
Gy l Sa, Gl (40), Sd (60)	Ob Rds	12	0	
Gy l Sa, Gl (30), Sd (50), Cy (20)	Ob Rd	6	0	
Gy l Sa, Gl (30), Sd (60), Cy (10)	Ob Rd	8	0	
No Return				
Gy l Sa, Gl (20), Sd (50), Cy (30)	Pl An	5	0	Dark Grey Sandstone / Siltstone
Gy d Sa / Si, Gl (10), Sd (40), Cy (50)	Pl Rds	5	0	
			EOH	**12.0m**

Waterstrike@ 9.0mbGL

Groundwater Chemistry @ 9-10mbGL:
EC = 490uS/cm,
pH = 7.60
Temp = 16.7°C

General Head Protection



Legend

- Backfilled with drill chippings
- Bentonite pellets
- Slotted (1-2mm) uPVC screen

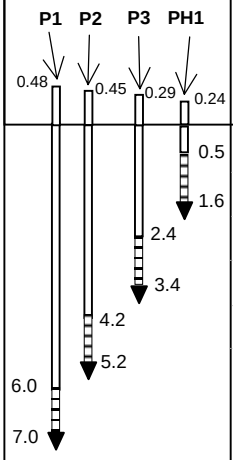
Title	Hydrological and Hydrogeological Impact Assessment of the Proposed Shannon LNG Terminal Development at Ballylongford, Co. Kerry
Client	Arup Consulting Engineers
MEL Document No.	1946-024.ppt

Minerex Environmental Limited

Notes:

BH No.	**BR11**
Total Depth (m)	7.0
Date drilled:	23/04/07
Logged by:	O. Madden
Drawn by:	S. Regan
Drilling Equipment	Rotary Core
Drilling Company	IGSL / Millenium Drilling
Grid Coordinates	E102091 N148298

Borehole Design & Completion



Groundwater occurrence, yield and formation/unit boundaries

Yield / SWL

Groundwater Occurrence

Dry

Wet

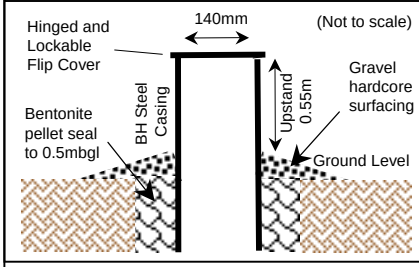
Depth (m)

Geology - graphical log

Lithology (%)	Chip Shape	Max. Chip Size (cm)	% Weathering	Geology
Bn m Sa, Pb (10), Gl (30), Sd (20), Cy (40)	Fl Rd/ An	28	60	Brown Boulder Clay (Upper Till)
Bn m Sa, Pb (20), Gl (30), Sd (20), Cy (30)	Bl Rd	25	20	
Bn m Sa, Pb (10), Gl (50), Sd (10), Cy (30)	Bl Ans	22	10	
Gy d Si, Pb (10), Gl (60), Sd, (10), Cy (20)	Fl An	30	0	
Gy d Si, Gl (60), Sd, (20), Cy (20)	Fl An	5	0	Dark Grey Siltstone
Gy d Si, Gl (50), Sd, (20), Cy (30)	Fl An	5	0	
Gy d Si, Gl (30), Sd, (40), Cy (30)	Fl An	3	0	
			EOH	**7.0m**

Waterstrike@ 3.1mbGL

General Head Protection



Legend

- Backfilled with drill chippings
- Bentonite pellets
- Slotted (1-2mm) uPVC screen

Title	Hydrological and Hydrogeological Impact Assessment of the Proposed Shannon LNG Terminal Development at Ballylongford, Co. Kerry
Client	Arup Consulting Engineers
MEL Document No.	1946-024.ppt

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Notes:

PERCUSSION WINDOW SAMPLING LOGS

BOREHOLE LOG — PWS3

Client	Arup Consulting Engineers
Job	1946 – B1
Page No.	1 of 1
Date drilled: / Logged by:	26/03/07 / Orlagh Madden
Equipment used	PWS
Document No.	1946-156

Borehole Design & Completion	Soil/Water/ Vapour Sample No.	Soil/Water/ Vapour Sample Depth Interval	Groundwater occurrence (dry, damp, wet)	Depth (m)	Geology - graphical log (Use approved MEL legend)	Strength/ Compactness	Bedding & Discontinuities	Weathering/ Freshness	Colour	Gravel shape & composition	Grading & plasticity (fine St & Cl)	Hydro Content	Soil name, e.g. SAND	Additional info: interpretations
	S2	0.0 – 0.4				L s F			L Bn/ Gy		Gp	D	Clay	
	S1	0.4 – 1.0		0.5		Sf		Dis	L Bn	Rds Sd	Gp	D	Clay	
	S3	1.0 – 1.1		1.0										
				1.5		Refusal on Boulder / Bedrock?								
				2.0										

Well Head Completion

-Covered with well head
-No installation

(Measurements in metres) Not to scale

Remarks

Legend

- Water inflow
- Static water table
- Push on cap
- Cone tip
- Gravel pack, nominal 2-5mm in diameter
- Collapsed Formation with cavities
- Bentonite pellets

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GOUGE CORE LOGS and INSTALLATIONS

Borehole Design & Completion	Soil (S) / Water (W) /Vapour (V) Sampling			Depth (mbGL)	Geology - graphical log	BOREHOLE LOG	GC-13
	No.	Depth/interval (mbGL)	Groundwater occurrence			Client	Arup Consulting Engineers
						MEL work item	1946 – B1
						Page No.	1 of 1
						Date drilled:	27/03/07
						Logged by:	Orlagh Madden
						Equipment used	Hand Auger
						MEL Doc. Ref.	1946-156
						Grid Coordinates	E101707 N148394
						Description	
				0.5		Soft, dark brown, peaty CLAY (mottled organic & peat mixture)	
				1.0		Sandy, grey, 'marly' CLAY	
				1.5		Refusal on Cobble / Boulder	EOH 1.36m
				2.0			
				2.5			
				3.0			
				3.5			
				4.0			

Notes:

-Refusal on cobble/ pebble
-Located on dry grassy ground, adjacent to river

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Borehole Design & Completion	Soil (S) / Water (W) /Vapour (V) Sampling			Depth (mbGL)	Geology - graphical log	BOREHOLE LOG	GC-14
						Client	Arup Consulting Engineers
						MEL work item	1946 – B1
						Page No.	1 of 1
						Date drilled:	26/03/07
						Logged by:	Orlagh Madden
						Equipment used	Hand Auger
						MEL Doc. Ref.	1946-156
						Grid Coordinates	E101739 N148444
PH1 Upstand: 1.17m	No.	Depth/interval (mbGL)	Groundwater occurrence			**Description**	
1.35m End of Hole				0.5		Medium brown, wet, slightly firm PEAT with rootlets	
				1.0		Dark brown, wet, fibrous PEAT	
						Dark grey, soft, wet, 'silty' CLAY	
						Light grey, sandy – silty CLAY (marl)	
				1.5		Refusal on Gravel / Cobbles EOH 1.35m	
				2.0			
				2.5			
				3.0			
				3.5			
				4.0			

Notes:

-Refusal on gravel/ cobble
-Phreatic located on a line with SAC

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Borehole Design & Completion	Soil (S) / Water (W) /Vapour (V) Sampling			Depth (mbGL)	Geology - graphical log	BOREHOLE LOG	GC-16
	No.	Depth/interval (mbGL)	Groundwater occurrence			Client	Arup Consulting Engineers
						MEL work item	1946 – B1
						Page No.	1 of 1
						Date drilled:	27/03/07
						Logged by:	Orlagh Madden
						Equipment used	Hand Auger
						MEL Doc. Ref.	1946-156
						Grid Coordinates	E101488 N148368
						Description	
			Wet	0.5		Light brown, silty, stiff, dry, dense CLAY with oxide spotting and some angular quartz gravels	
						Orange, silty CLAY with oxide spotting	
						Sandy, grey, 'marly' CLAY with some organic material (black mottling) – gravel at base	
				1.0		Refusal on Cobble / Boulder	EOH 0.83m
				1.5			
				2.0			
				2.5			
				3.0			
				3.5			
				4.0			

Notes:

-Refusal on cobble/ boulder

Minerex Environmental Limited

Borehole Design & Completion	Soil (S) / Water (W) /Vapour (V) Sampling			Depth (mbGL)	Geology - graphical log	BOREHOLE LOG	GC-17
						Client	Arup Consulting Engineers
						MEL work item	1946 – B1
						Page No.	1 of 1
						Date drilled:	27/03/07
						Logged by:	Orlagh Madden
						Equipment used	Hand Auger
						MEL Doc. Ref.	1946-156
						Grid Coordinates	E101569 N148455
OB17 - PH1 Upstand: 0.1m	No.	Depth/interval (mbGL)	Groundwater occurrence			**Description**	
0.47m						Dark brown, damp, PEAT with rootlets (H2)	
						Grey – brown, stiff, silty CLAY	
				0.5		Dark brown, soft PEAT with plant debris (H5)	
				1.0		Dark brown, soft PEAT with plant debris (H8)	
						Light – medium brown, sandy CLAY	
				1.5		Sandy / gravelly, grey, ‘marly’ CLAY	
				2.0		Refusal on Cobble / Boulder EOH 1.80m	
				2.5			
				3.0			
				3.5			
				4.0			

Notes:

-Refusal on boulders

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Common Legend

Outline of Troels-Smith Classification Scheme (1955) and Von Post Humification Scale (1922)

Troels-Smith: Methods of Description

Physical Characteristics

The Physical characteristics of a sediment are described using a five point scale (i.e. from 0 to 4) for each of the properties outlined below.

(a) - Nig (Nigror/degree of darkness)
- Nig 0 = lightest shades (e.g. white)
- Nig 1 = light shades
- Nig 2 = medium shades
- Nig 3 = dark shades
- Nig 4 = darkest shades (e.g. black)

(b) - Strf (Straticato/degree of stratification)
- Strf 0 = complete homogeniety
- Strf 1-3 = intermediate stages
- Strf 4 = very thin minor layers

(c) - Elas (Elasticitas/degree of elasticity)
- Elas 0 = total absence
- Elas 1-3 = intermediate stages
- Elas 4 = high elasticity

(d) - Sicc (Siccitas/degree of dryness)
- Sicc 0 = clear water
- Sicc 1 = fully saturated
- Sicc 2 = saturated
- Sicc 3 = not saturated
- Sicc 4 = air dry sediment

(e) - Lim (limes/boundaries)
- Lim 0 = diffuse (>10 mm)
- Lim 1 = very gradual (<10 mm but >2 mm)
- Lim 2 = gradual (<2 mm but >1 mm)
- Lim 3 = sharp (<1 mm but >0.5 mm)
- Lim 4 = very sharp (<0.5 mm)

Sediment Composition

From the physical characteristics outlined above and by close examination of the constituent particles or materials within a deposit, an overall deposit composition can be selected from the six basic sediment components outlined below.

(a) - Turfa = a macroscopic structure consisting of mosses and/or roots of woody or herbaceous plants.
(b) - Detritus = consists of 'supra'-terranean (i.e. above ground) plant structures that are not directly attached to root systems.
(c) - Limus = a microscopic structure consisting of micro-organisms and/or plant fragments, and/or carbonates, and/or iron oxides. All particles or colloids are <0.1 mm. Essentially this is an aquatic deposit known also by the term "gyttja".
(d) - Argilla = consists of mineral particles <0.06 mm.
(e) - Grana = consists of mineral particles >0.06 mm.
(f) - Substantive humosa = humous substance consisting of completely disintegrated or decomposed organic substances or precipitated humic acids.

Von Post: Outline of Humification Scale

H1	Completely unhumified plant remains, from which only colourless water can be squeezed
H2	Almost unhumified plant remains; water squeezed from the peat is light brown in colour
H3	Very poorly humified plant remains; water squeezed from this peat is cloudy and brown
H4	Poorly humified plant remains; peaty substance does not escape from between fingers when squeezed
H5	Moderately humified plant remains; the structure is however still very clearly visible; the squeeze water is dark brown and very cloudy while some peat escapes through the fingers*
H6	Strongly humified plant remains; the structure is unclear, about a third of the squeeze escapes through the fingers. The part remaining in the hand has a more defined plant structure
H7	Highly humified plant remains. About half the material escapes through the fingers when squeezed. The water which may escape is dark brown in colour
H8	Very highly humified plant remains. Two thirds of the material escapes through the fingers when squeezed. The remainder consists mainly of resistant bits of roots and wood
H9	Almost completely humified plant remains; almost all the peat escapes through the fingers when squeezed. Structure is almost absent
H10	Totally humified plant remains; amorphous peat, all peat escapes through the fingers when squeezed with no loss of water

* Note: H1-H5 describes the clarity and colour of the water emitted when the sample is squeezed, while H5-H10 estimates the amount of peat passing through the fingers when squeezed, as well as remaining plant structure.

Text based on the following:

•Troel-Smith, J. (1955). Characterisation of unconsolidated sediment. In Dann. Geol. Unders. IV Series. Vol. 3 (10)

•Von Post, L. (1922). SGU (Seriges Geologiska Undersoknings) peat inventory and some preliminary results, Sweden, **36**, 1-37

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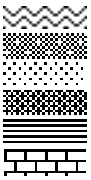
GENERAL LEGEND, ABBREVIATIONS AND INSTALLATION DETAILS

BEDROCK

Metamorphic bedrock
Igneous bedrock
Sandstone bedrock
Siltstone bedrock
Mudstone bedrock
Limestone bedrock



COLOUR

Light Grey	Gy_l
Medium Grey	Gy_m
Dark Grey	Gy_d
Blue/grey	Bl-Gy
Orange/Brown	Or-Bn
Black	Bk

GRAIN SIZE (Soil)

Clay (% of)	C(20)
Silt (% of)	St(20)
Sand (% of)	Sd(20)
Gravel (% of)	G(20)
Sand (Fine to Medium)	Sd_{F-M}
Gravel (Fine to Coarse Subangular to angular)	$G_{F-C\ SA-A}$

MONITORING POINT COMPLETIONS

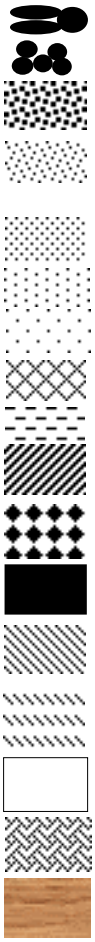
TS/C1/PH1 Terminal Site/Couple no./Phreatic no.
PR/C2/P2 Peat Repository/Couple no./Piezometer no.
H7 Von Post humification scale
Push-on cap
18mm ID / 27mm OD screen
18mm ID / 27mm OD casing
18mm ID / 27mm OD tip
Drive cone
P2 PH1 Piezometer no. and Phreatic tube no.
Bentonite pellets
Gravel pack, nominal 2-5mm in diameter
Wet and damp
Static water table

PLAN SKETCHES

PWS1 Percussion Window Sampler (PWS) boreholes
TP1 Hand dug trial pits / Shallow pit excavations (JCB)
100 BG FID in ppm Hydrocarbons with BG = background
99.791 Reduced levels - maOD Malin
Oil pipeline
Storage tanks (Overground and underground)

OVERBURDEN (Description uses BS 5930 and GSI guidelines)

BOULDER(S) (>200mm)
COBBLES (60 to 200mm)
GRAVEL (Homogeneous larger sized particles from 2 to 60 mm)
SAND (General, if without grain size description) Particle sizes: 2 to 0.06mm. Three sub-categories distinguishable to the eye)
Coarse **SAND** (2-0.6mm)
Medium **SAND** (0.6-0.2mm)
Fine **SAND** (0.2-0.06mm)
SILT (0.06 - 0.002mm)
CLAYS (<0.002mm)
CONCRETE
CRUSHED STONE or AGGREGATE or TARMACADAM
LANDFILL (eg plastic, glass, wood, domestic waste, concrete etc.)
FILL (unspecified)
COLLAPSED FORMATION (with possible voids)
LOSS (Blank - white)
TOP SOIL
PEAT (General) (with descriptions such as colour, plant remains evident, distinct H_2S smell etc) (H (Von Post) value associated commonly)



MONITORING POINT DESIGN FOR PEAT SUBSOILS

Push-on, female cap

The cap is loosely fitted to allow easy removal. The piezometer is labelled using indellible ink inside and outside the cap. A small hole is drilled in the side to enable air movement in and out of the piezometer.

Casing up-stand

The upstand is the height of the casing above ground level in meters. The height depends on local groundwater and surface water circumstances. The piezometer number is scrapped onto the side of the casing near the cap as with time the writing on the cap wears off. Upstands vary from 0.3 to 1.0m in height. The convention is allow a higher upstand for those piezometers positioned at a higher level.

Casing

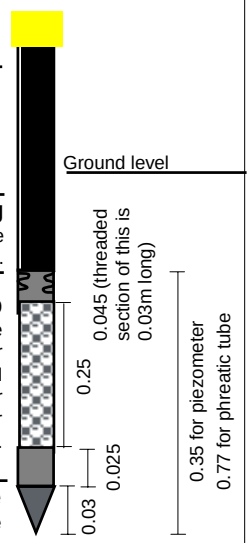
The casing is black or dark grey coloured, flush-threaded, uPVC. The OD is 26.80mm and the ID is 18.40. The casing is flush-threaded to the piezometer tip.

Tube or Piezometer tip

This section is installed opposite the required formation. There are two sections to the piezometer tip. The inner tube section is 18.40mm ID, white in colour and involves extruded microporous polyethylene. The outer comprises grey or black coloured uPVC with 10 x 0.013m diameter holes per 0.10m of piezometer tip. Therefore the surface area exposed to the formation (peat) is small. The piezometer tube tip is flush-threaded, either male or female, to the piezometer casing. Threaded part is 0.03m long. The phreatic tube tip is longer than the piezometer tube tip to allow for greater water level fluctuations.

Drive cone

This is grey coloured, solid, uPVC, pushed or screwed into the tube or piezometer tip. No glue has been used. If the ground is soft, a push-in button cap may be used instead of a drive cone.



NOTES:-
The phreatic tubes are pushed by hand into the peat. The piezometers are pushed or driven into the peat and mineral soil after a narrow diameter hole has been formed using overburden drilling (Cobra or Percussion Window Sampler) / coring equipment (Gouge corer). The tubes and piezometers have three main functions: water table measurements, water sampling, permeability measurements

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GEOTECHNICAL CORE LOG RECORD

REPORT NUMBER 12239

CONTRACT	Tarbert/Ballylongford Onshore SI	DRILLHOLE NO	RC03
		SHEET	Sheet 1 of 3
CO-ORDINATES(_)	102,235.72 E 148,616.25 N	GROUND LEVEL (m)	17.01
		CORE DIAMETER (mm)	102
		DATE STARTED	20/11/2006
		DATE COMPLETED	22/11/2006
CLIENT	Shannon LNG	INCLINATION	-90
ENGINEER	Arup Consulting Engineers	FLUSH	AIR/MIST
		DRILLED BY	Millennium
		LOGGED BY	IGSL

Downhole Depth (m)	Core Run Depth (m)	T.C.R.%	S.C.R.%	R.Q.D.%	Fracture Spacing (mm) 0 250 500	Legend	Description	Depth (m)	Discontinuities	Elevation	Standpipe Details	SPT (N Value)
0							SYMMETRIX OPEN HOLE DRILLING: Observed by driller as returns of clay and gravel.					
1												N = 12 (3, 2, 4, 2, 3, 3)
2												
3								3.20				N = 18 (4, 2, 4, 5, 3, 6)
							SYMMETRIX OPEN HOLE DRILLING: Observed by driller as gravel size returns of sandstone/siltstone . Probable bedrock.			13.81		
4	3.80	100	82	76				3.80		13.21		
	4.30						Strong to locally very strong and very locally moderately strong, thin to medium bedded, grey, fine grained SANDSTONE, interbedded with fine-grained siltstone. Fresh to slightly weathered.		Discontinuities are rough to smooth and planar to locally undulose. Apertures are open to locally tight to moderately open with locally clay smeared (4.46m, 6.82m-6.86m) surfaces. Dips are 10° and locally 90° (7.9m-8.11m) & 45° (4.9m, 6.42m, 6.52m).			
5		100	69	48								
6	5.90	100	51	14								
7	7.50	100	75	41								
8	8.30							8.30		8.71		
		100	73	37			Moderately strong to strong and locally moderately weak, thin to medium bedded, black/dark grey, fine grained SILTSTONE/MUDSTONE. Fresh to locally slightly weathered.					
9	9.30											

REMARKS

Waterstrike at 3.0m (20/11/06); Water at 2.4m (21/11/06). 12 Core boxes.

INSTALLATION REMARKS

GROUNDWATER DETAILS

Date	Hole Depth	Casing Depth	Depth to Water	Comments
20-11-06			3.00	Waterstrike
21-11-06			2.40	Standing

INSTALLATION DETAILS

Date	Tip Depth	RZ Top	RZ Base	Type
22/11/2006	7.50	2.00	7.50	50mm SP

RC NEWLOG 10M PER PG 12239.GPJ IGSL.GDT 9/3/07

GEOTECHNICAL CORE LOG RECORD

REPORT NUMBER 12239

CONTRACT	Tarbert/Ballylongford Onshore SI	DRILLHOLE NO	RC03
		SHEET	Sheet 2 of 3
CO-ORDINATES(_)	102,235.72 E 148,616.25 N	GROUND LEVEL (m)	17.01
		CORE DIAMETER (mm)	102
		DATE STARTED	20/11/2006
		DATE COMPLETED	22/11/2006
CLIENT	Shannon LNG	INCLINATION	-90
		DRILLED BY	Millennium
ENGINEER	Arup Consulting Engineers	FLUSH	AIR/MIST
		LOGGED BY	IGSL

Downhole Depth (m)	Core Run Depth (m)	T.C.R.%	S.C.R.%	R.Q.D.%	Fracture Spacing (mm) 0 250 500	Legend	Description	Depth (m)	Discontinuities	Elevation	Standpipe Details	SPT (N Value)
10		100	93	43			Moderately strong to strong and locally moderately weak, thin to medium bedded, black/dark grey, fine grained SILTSTONE/MUDSTONE. Fresh to locally slightly weathered. *(continued)*		Discontinuities are smooth and planar to locally undulose. Apertures are tight to moderately open and locally open with locally iron oxide stained (8.3m-9.3m) and locally clay smeared (10.85m-10.95m, 14.28m, 15.86m-15.92m) surfaces. Dips are 10° and locally 90° (10.95m-11.71m, 12.05m-12.12m, 14.28m-14.35m, 16.45m-16.54m, 20.11m-20.19m, 23.95m-24.1m, 24.6m-24.75m). *(continued)*			
11	10.90	100	41	9								
12	12.50	100	68	6								
13												
14	14.10	100	86	21								
15												
16	15.70	100	75	30								
17												
18	17.30	100	97	56								
19	18.90	100	74	61								

REMARKS

Waterstrike at 3.0m (20/11/06); Water at 2.4m (21/11/06). 12 Core boxes.

INSTALLATION REMARKS

GROUNDWATER DETAILS

Date	Hole Depth	Casing Depth	Depth to Water	Comments

INSTALLATION DETAILS

Date	Tip Depth	RZ Top	RZ Base	Type
22/11/2006	7.50	2.00	7.50	50mm SP

RC NEWLOG 10M PER PG 12239.GPJ IGSL.GDT 9/3/07

GEOTECHNICAL CORE LOG RECORD

REPORT NUMBER 12239

CONTRACT	Tarbert/Ballylongford Onshore SI	DRILLHOLE NO	RC03
		SHEET	Sheet 3 of 3
CO-ORDINATES(_)	102,235.72 E 148,616.25 N	GROUND LEVEL (m)	17.01
		CORE DIAMETER (mm)	102
		INCLINATION	-90
		FLUSH	AIR/MIST
		DATE STARTED	20/11/2006
		DATE COMPLETED	22/11/2006
CLIENT	Shannon LNG	DRILLED BY	Millennium
ENGINEER	Arup Consulting Engineers	LOGGED BY	IGSL

Downhole Depth (m)	Core Run Depth (m)	T.C.R.%	S.C.R.%	R.Q.D.%	Fracture Spacing (mm) 0 250 500	Legend	Description	Depth (m)	Discontinuities	Elevation	Standpipe Details	SPT (N Value)
20	20.30						Moderately strong to strong and locally moderately weak, thin to medium bedded, black/dark grey, fine grained SILTSTONE/MUDSTONE. Fresh to locally slightly weathered. *(continued)*		Discontinuities are smooth and planar to locally undulose. Apertures are tight to moderately open and locally open with locally iron oxide stained (8.3m-9.3m) and locally clay smeared (10.85m-10.95m, 14.28m, 15.86m-15.92m) surfaces. Dips are 10° and locally 90° (10.95m-11.71m, 12.05m-12.12m, 14.28m-14.35m, 16.45m-16.54m, 20.11m-20.19m, 23.95m-24.1m, 24.6m-24.75m). *(continued)*			
21		100	91	81								
22	21.90	100	80	61								
23	23.00	100	73	69								
24	24.40	100	53	53								
25	25.10						End of Corehole at 25.1 (m)	25.10		-8.09		
26												
27												
28												
29												

REMARKS

Waterstrike at 3.0m (20/11/06); Water at 2.4m (21/11/06). 12 Core boxes.

INSTALLATION REMARKS

GROUNDWATER DETAILS

Date	Hole Depth	Casing Depth	Depth to Water	Comments

INSTALLATION DETAILS

Date	Tip Depth	RZ Top	RZ Base	Type
22/11/2006	7.50	2.00	7.50	50mm SP

RC NEWLOG 10M PER PG 12239.GPJ IGSL.GDT 9/3/07

GEOTECHNICAL CORE LOG RECORD

REPORT NUMBER 12239

CONTRACT	Tarbert/Ballylongford Onshore SI	DRILLHOLE NO	RC05
		SHEET	Sheet 1 of 3
CO-ORDINATES(_)	102,313.82 E 148,662.47 N	GROUND LEVEL (m)	17.91
		CORE DIAMETER (mm)	102
		DATE STARTED	22/11/2006
		DATE COMPLETED	23/11/2006
CLIENT	Shannon LNG	INCLINATION	-90
ENGINEER	Arup Consulting Engineers	FLUSH	POLYMER GEL
		DRILLED BY	Millennium
		LOGGED BY	IGSL

Downhole Depth (m)	Core Run Depth (m)	T.C.R.%	S.C.R.%	R.Q.D.%	Fracture Spacing (mm) 0 250 500	Legend	Description	Depth (m)	Discontinuities	Elevation	Standpipe Details	SPT (N Value)
0							SYMMETRIX OPEN HOLE DRILLING: Observed by driller as returns of clay and gravel.	1.50				
1.50	1.50	100	0	0			Moderately strong to locally moderately weak, thinly bedded (thickly laminated), grey/dark grey/black, fine grained SILTSTONE/MUDSTONE. Fresh to slightly weathered.		Discontinuities are smooth and planar to undulose and locally rough. Apertures are tight to locally open (especially 1.5m-3.5m), with iron oxide stained and locally clay/silt smeared surfaces. Dips are sub-horizontal and locally 90° fractures (5.92-6.24m, 8.4m-8.47m, 8.78m-9.02m, 9.28m-9.54m). Discontinuities are rough and undulose, locally planar. Apertures are moderately open with commonly iron oxide stained and locally clay/sand smeared (4.29m, 4.55m) surfaces. Dips are 20°-45° and locally sub-vertical fractures (4.84m-4.9m, 6.11m-6.5m).	16.41		(25, 50)
3.50	3.50	100	40	0								
5.00	5.00	100	20	0								
6.50	6.50	100	90	24								
8.10	8.10	100	30	7								
9.60	9.60							10.00				

REMARKS

Waterstrike at 4.2m (22/11/06); Water at 1.3m (23/11/06). 17 coreboxes

INSTALLATION REMARKS

GROUNDWATER DETAILS

Date	Hole Depth	Casing Depth	Depth to Water	Comments
22-11-06			4.20	Waterstrike
23-11-06			1.30	Standing

INSTALLATION DETAILS

Date	Tip Depth	RZ Top	RZ Base	Type
23/11/2006	9.50	2.00	9.50	50mm SP

RC NEWLOG 10M PER PG 12239.GPJ IGSL.GDT 9/3/07

GEOTECHNICAL CORE LOG RECORD

REPORT NUMBER 12239

CONTRACT	Tarbert/Ballylongford Onshore SI	DRILLHOLE NO	RC05
		SHEET	Sheet 2 of 3
CO-ORDINATES(_)	102,313.82 E 148,662.47 N	GROUND LEVEL (m)	17.91
		CORE DIAMETER (mm)	102
		DATE STARTED	22/11/2006
		DATE COMPLETED	23/11/2006
CLIENT	Shannon LNG	INCLINATION	-90
		DRILLED BY	Millennium
ENGINEER	Arup Consulting Engineers	FLUSH	POLYMER GE
		LOGGED BY	IGSL

Downhole Depth (m)	Core Run Depth (m)	T.C.R.%	S.C.R.%	R.Q.D.%	Fracture Spacing (mm) 0 250 500	Legend	Description	Depth (m)	Discontinuities	Elevation	Standpipe Details	SPT (N Value)
10		100	78	58			Strong to locally moderately strong and locally very strong, thin to medium bedded, grey/dark grey, fine grained SILTSTONE/MUDSTONE (possible fine-grained sandstone lenses at 23.0m-27.5m). Fresh to slightly weathered.		Discontinuities are smooth and planar to undulose and locally slightly rough. Apertures are tight to moderately open and locally open with locally iron oxide stained (10.0m-11.1m). Dips are -0°-30° and locally 90° fractures (10.82-10.9m, 11.14m-11.24m, 18.28m-18.41m, 19.05m-19.42m, 21.13m-21.22m).	7.91		
11	11.10											
12		100	80	74								
13	12.60	100	98	81								
14	14.10											
15		100	97	76								
16	15.70	100	82	80								
17	17.00											
18		100	89	78								
19	18.60	100	67	64								

REMARKS

Waterstrike at 4.2m (22/11/06); Water at 1.3m (23/11/06). 17 coreboxes

INSTALLATION REMARKS

GROUNDWATER DETAILS

Date	Hole Depth	Casing Depth	Depth to Water	Comments

INSTALLATION DETAILS

Date	Tip Depth	RZ Top	RZ Base	Type
23/11/2006	9.50	2.00	9.50	50mm SP

RC NEWLOG 10M PER PG 12239.GPJ IGSL.GDT 9/3/07

GEOTECHNICAL CORE LOG RECORD

REPORT NUMBER 12239

CONTRACT	Tarbert/Ballylongford Onshore SI	DRILLHOLE NO	RC05
		SHEET	Sheet 3 of 3
CO-ORDINATES(_)	102,313.82 E 148,662.47 N	GROUND LEVEL (m)	17.91
		CORE DIAMETER (mm)	102
		DATE STARTED	22/11/2006
		DATE COMPLETED	23/11/2006
CLIENT	Shannon LNG	INCLINATION	-90
ENGINEER	Arup Consulting Engineers	FLUSH	POLYMER GEL
		DRILLED BY	Millennium
		LOGGED BY	IGSL

Downhole Depth (m)	Core Run Depth (m)	T.C.R.%	S.C.R.%	R.Q.D.%	Fracture Spacing (mm) 0 250 500	Legend	Description	Depth (m)	Discontinuities	Elevation	Standpipe Details	SPT (N Value)
20	20.20	100	91	83			Strong to locally moderately strong and locally very strong, thin to medium bedded, grey/dark grey, fine grained SILTSTONE/MUDSTONE (possible fine-grained sandstone lenses at 23.0m-27.5m). Fresh to slightly weathered. *(continued)*		Discontinuities are smooth and planar to undulose and locally slightly rough. Apertures are tight to moderately open and locally open with locally iron oxide stained (10.0m-11.1m). Dips are -0°-30° and locally 90° fractures (10.82-10.9m, 11.14m-11.24m, 18.28m-18.41m, 19.05m-19.42m, 21.13m-21.22m). *(continued)*			
21	21.70	100	97	89								
22	23.30	100	95	88	630							
23	24.90	100	100	100								
24	26.50	100	75	84				27.50				
25	27.50	100	73	58	680		Strong to very strong, thin to medium bedded, grey and locally dark grey, fine grained SANDSTONE (with minor siltstone). Fresh to slightly weathered.		Discontinuities are rough to locally smooth and undulose. Apertures are open to moderately open. Dips are 10° and locally 90° fractures.	-9.59		
26	29.40						End of Corehole at 29.4 (m)	29.40		-11.49		
27												
28												
29												

REMARKS

Waterstrike at 4.2m (22/11/06); Water at 1.3m (23/11/06). 17 coreboxes

INSTALLATION REMARKS

GROUNDWATER DETAILS

Date	Hole Depth	Casing Depth	Depth to Water	Comments

INSTALLATION DETAILS

Date	Tip Depth	RZ Top	RZ Base	Type
23/11/2006	9.50	2.00	9.50	50mm SP

RC NEWLOG 10M PER PG 12239.GPJ IGSL.GDT 9/3/07

GEOTECHNICAL CORE LOG RECORD

REPORT NUMBER 12239

CONTRACT	Tarbert/Ballylongford Onshore SI	DRILLHOLE NO	RC10
		SHEET	Sheet 1 of 4
CO-ORDINATES(_)	102,438.56 E 148,626.09 N	GROUND LEVEL (m)	19.59
		CORE DIAMETER (mm)	84
		DATE STARTED	06/12/2006
		DATE COMPLETED	07/12/2006
CLIENT	Shannon LNG	INCLINATION	-90
ENGINEER	Arup Consulting Engineers	FLUSH	AIR/MIST
		DRILLED BY	Millennium
		LOGGED BY	IGSL

Downhole Depth (m)	Core Run Depth (m)	T.C.R.%	S.C.R.%	R.Q.D.%	Fracture Spacing (mm) 0 250 500	Legend	Description	Depth (m)	Discontinuities	Elevation	Standpipe Details	SPT (N Value)
0							SYMMETRIX OPEN HOLE DRILLING: Observed by driller as returns of clay and gravel.					
1												
2												N = 28 (4, 4, 6, 6, 7, 9)
3												N = 29 (3, 5, 5, 7, 8, 9)
4								4.20				
	4.40						SYMMETRIX OPEN HOLE DRILLING: Observed by driller as gravel size returns of sandstone. Probable sandstone bedrock.	4.40		15.39		
5		100	81	62			Strong to very strong, thin to thickly (locally thinly laminated) bedded, grey blue to dark grey, fine grained SANDSTONE interbedded with thinly bedded/laminated siltstone and weaker dark grey mudstone. Fresh to slightly and locally moderately weathered.		Discontinuities are smooth and planar to locally undulose. Apertures are tight to open with locally clay smeared surfaces. Dips are 45° and locally 90° fractures.	15.19		
6	5.90	100	96	84								
7	7.30											
8		100	87	64	530							
9	8.80	100	100	88								

REMARKS

Water at 4.65m (6/12/06), 6.72m (7/12/06) & 5.7m (7/12/06). 12 Core boxes.

INSTALLATION REMARKS

GROUNDWATER DETAILS

Date	Hole Depth	Casing Depth	Depth to Water	Comments
06-12-06			4.65	Standing
07-12-06			5.70	Standing

INSTALLATION DETAILS

Date	Tip Depth	RZ Top	RZ Base	Type
07/12/2006	4.40	0.00	4.40	50mm SP

RC NEWLOG 10M PER PG 12239.GPJ IGSL.GDT 9/3/07

GEOTECHNICAL CORE LOG RECORD

REPORT NUMBER 12239

CONTRACT	Tarbert/Ballylongford Onshore SI	DRILLHOLE NO	RC10
		SHEET	Sheet 2 of 4
CO-ORDINATES(_)	102,438.56 E 148,626.09 N	GROUND LEVEL (m)	19.59
		CORE DIAMETER (mm)	84
		DATE STARTED	06/12/2006
		DATE COMPLETED	07/12/2006
CLIENT	Shannon LNG	INCLINATION	-90
		DRILLED BY	Millennium
ENGINEER	Arup Consulting Engineers	FLUSH	AIR/MIST
		LOGGED BY	IGSL

Downhole Depth (m)	Core Run Depth (m)	T.C.R.%	S.C.R.%	R.Q.D.%	Fracture Spacing (mm) 0 250 500	Legend	Description	Depth (m)	Discontinuities	Elevation	Standpipe Details	SPT (N Value)
10	9.90											
		100	86	67			Strong to very strong, thin to thickly (locally thinly laminated) bedded, grey blue to dark grey, fine grained SANDSTONE interbedded with thinly bedded/laminated siltstone and weaker dark grey mudstone. Fresh to slightly and locally moderately weathered. *(continued)*		Discontinuities are smooth and planar to locally undulose. Apertures are tight to open with locally clay smeared surfaces. Dips are 45° and locally 90° fractures. *(continued)*			
11	11.50											
		100	96	84	550							
12	13.00											
		100	100	74								
13	14.50											
		100	100	100	540 860							
14	16.00											
		100	97	84	530							
15	17.60											
		100	96	68	560							
16	19.20											
17												
18												
19												

REMARKS

Water at 4.65m (6/12/06), 6.72m (7/12/06) & 5.7m (7/12/06). 12 Core boxes.

INSTALLATION REMARKS

GROUNDWATER DETAILS

Date	Hole Depth	Casing Depth	Depth to Water	Comments

INSTALLATION DETAILS

Date	Tip Depth	RZ Top	RZ Base	Type
07/12/2006	4.40	0.00	4.40	50mm SP

RC NEWLOG 10M PER PG 12239.GPJ IGSL.GDT 9/3/07

GEOTECHNICAL CORE LOG RECORD

REPORT NUMBER 12239

CONTRACT	Tarbert/Ballylongford Onshore SI	DRILLHOLE NO	RC10
		SHEET	Sheet 3 of 4
CO-ORDINATES(_)	102,438.56 E 148,626.09 N	GROUND LEVEL (m)	19.59
		CORE DIAMETER (mm)	84
		INCLINATION	-90
		FLUSH	AIR/MIST
		DATE STARTED	06/12/2006
		DATE COMPLETED	07/12/2006
CLIENT	Shannon LNG	DRILLED BY	Millennium
ENGINEER	Arup Consulting Engineers	LOGGED BY	IGSL

Downhole Depth (m)	Core Run Depth (m)	T.C.R.%	S.C.R.%	R.Q.D.%	Fracture Spacing (mm) 0 250 500	Legend	Description	Depth (m)	Discontinuities	Elevation	Standpipe Details	SPT (N Value)
20		100	88	59			Strong to very strong, thin to thickly (locally thinly laminated) bedded, grey blue to dark grey, fine grained SANDSTONE interbedded with thinly bedded/laminated siltstone and weaker dark grey mudstone. Fresh to slightly and locally moderately weathered. *(continued)*		Discontinuities are smooth and planar to locally undulose. Apertures are tight to open with locally clay smeared surfaces. Dips are 45° and locally 90° fractures. *(continued)*			
	20.80											
21		100	98	71	700							
22												
	22.40											
23		100	97	84								
24	24.00											
		100	94	82								
25												
	25.60											
26		100	99	77	780 620							
27	27.10	100	100	40								
	27.40											
28		100	100	100	770							
	28.90											
29		100	97	97	860							

REMARKS

Water at 4.65m (6/12/06), 6.72m (7/12/06) & 5.7m (7/12/06).
12 Core boxes.

INSTALLATION REMARKS

GROUNDWATER DETAILS

Date	Hole Depth	Casing Depth	Depth to Water	Comments

INSTALLATION DETAILS

Date	Tip Depth	RZ Top	RZ Base	Type
07/12/2006	4.40	0.00	4.40	50mm SP

RC NEWLOG 10M PER PG 12239.GPJ IGSL.GDT 9/3/07

GEOTECHNICAL CORE LOG RECORD

REPORT NUMBER 12239

CONTRACT	Tarbert/Ballylongford Onshore SI	DRILLHOLE NO	RC10
		SHEET	Sheet 4 of 4
CO-ORDINATES(_)	102,438.56 E 148,626.09 N	GROUND LEVEL (m)	19.59
		CORE DIAMETER (mm)	84
		DATE STARTED	06/12/2006
		DATE COMPLETED	07/12/2006
CLIENT	Shannon LNG	INCLINATION	-90
ENGINEER	Arup Consulting Engineers	FLUSH	AIR/MIST
		DRILLED BY	Millennium
		LOGGED BY	IGSL

Downhole Depth (m)	Core Run Depth (m)	T.C.R.%	S.C.R.%	R.Q.D.%	Fracture Spacing (mm) 0 250 500	Legend	Description	Depth (m)	Discontinuities	Elevation	Standpipe Details	SPT (N Value)
30					770							
	30.50							30.50				
							End of Corehole at 30.5 (m)			-10.91		
31												
32												
33												
34												
35												
36												
37												
38												
39												

REMARKS

Water at 4.65m (6/12/06), 6.72m (7/12/06) & 5.7m (7/12/06). 12 Core boxes.

INSTALLATION REMARKS

GROUNDWATER DETAILS

Date	Hole Depth	Casing Depth	Depth to Water	Comments

INSTALLATION DETAILS

Date	Tip Depth	RZ Top	RZ Base	Type
07/12/2006	4.40	0.00	4.40	50mm SP

RC NEWLOG 10M PER PG 12239.GPJ IGSL.GDT 9/3/07

GEOTECHNICAL CORE LOG RECORD

REPORT NUMBER 12239

CONTRACT	Tarbert/Ballylongford Onshore SI	DRILLHOLE NO	RC12
		SHEET	Sheet 1 of 3
CO-ORDINATES(_)	102,373.94 E 148,688.95 N	GROUND LEVEL (m)	13.06
		CORE DIAMETER (mm)	84
		DATE STARTED	15/12/2006
		DATE COMPLETED	16/12/2006
CLIENT	Shannon LNG	INCLINATION	-90
		DRILLED BY	Millennium
ENGINEER	Arup Consulting Engineers	FLUSH	AIR/MIST
		LOGGED BY	IGSL

Downhole Depth (m)	Core Run Depth (m)	T.C.R.%	S.C.R.%	R.Q.D.%	Fracture Spacing (mm) 0 250 500	Legend	Description	Depth (m)	Discontinuities	Elevation	Standpipe Details	SPT (N Value)
0							SYMMETRIX OPEN HOLE DRILLING: Observed by driller as returns of clay and gravel.					
1												N = 20 (7, 6, 4, 8, 3, 5)
2												
3												N = 25 (6, 7, 5, 8, 5, 7)
4												N = 20 (3, 4, 3, 5, 4, 8)
5								5.00		8.06		
	5.50						SYMMETRIX OPEN HOLE DRILLING: Observed by driller as gravel size returns of sandstone. Probable sandstone bedrock.	5.50		7.56		
6		100	23	0			Strong to very strong, thickly to locally thinly bedded, grey/dark grey, fine grained SANDSTONE interbedded with siltstone layers (5.5m-10.0m, 17.0m-17.5m). Fresh to locally slightly weathered.		Discontinuities are smooth to locally rough and planar to locally undulose. Apertures are tight to locally open with commonly moderately iron oxide stained and locally clay smeared surfaces. Dips are sub-horizontal and locally 45°-60° fractures.			
	6.50											
7		80	60	12								
	7.50											
		100	18	0								
8	8.10											
		100	88	0								
	8.60											
9		100	46	9								
	9.70											

REMARKS

Waterstrike at 5.0m. 6 Core boxes.

INSTALLATION REMARKS

GROUNDWATER DETAILS

Date	Hole Depth	Casing Depth	Depth to Water	Comments
15-12-06			5.00	Waterstrike

INSTALLATION DETAILS

Date	Tip Depth	RZ Top	RZ Base	Type
16/12/2006	5.50	1.00	5.50	50mm SP

RC NEWLOG 10M PER PG 12239.GPJ IGSL.GDT 9/3/07

GEOTECHNICAL CORE LOG RECORD

REPORT NUMBER 12239

CONTRACT	Tarbert/Ballylongford Onshore SI	DRILLHOLE NO	RC12
		SHEET	Sheet 2 of 3
CO-ORDINATES(_)	102,373.94 E 148,688.95 N	GROUND LEVEL (m)	13.06
		CORE DIAMETER (mm)	84
		DATE STARTED	15/12/2006
		DATE COMPLETED	16/12/2006
CLIENT	Shannon LNG	INCLINATION	-90
		DRILLED BY	Millennium
ENGINEER	Arup Consulting Engineers	FLUSH	AIR/MIST
		LOGGED BY	IGSL

Downhole Depth (m)	Core Run Depth (m)	T.C.R.%	S.C.R.%	R.Q.D.%	Fracture Spacing (mm) 0 250 500	Legend	Description	Depth (m)	Discontinuities	Elevation	Standpipe Details	SPT (N Value)
10		100	88	68			Strong to very strong, thickly to locally thinly bedded, grey/dark grey, fine grained SANDSTONE interbedded with siltstone layers (5.5m-10.0m, 17.0m-17.5m). Fresh to locally slightly weathered. *(continued)*		Discontinuities are smooth to locally rough and planar to locally undulose. Apertures are tight to locally open with commonly moderately iron oxide stained and locally clay smeared surfaces. Dips are sub-horizontal and locally 45°-60° fractures. *(continued)*			
11	11.10	100	100	79	740							
12	12.20	100	98	81	960							
13	13.70	100	90	81	620							
14	14.70	100	94	91								
15	16.20	100	98	62								
16	17.50	100	100	0								
17	17.80	100	73	0								
18	18.50	100	91	91	890							
19												

REMARKS

Waterstrike at 5.0m. 6 Core boxes.

INSTALLATION REMARKS

GROUNDWATER DETAILS

Date	Hole Depth	Casing Depth	Depth to Water	Comments

INSTALLATION DETAILS

Date	Tip Depth	RZ Top	RZ Base	Type
16/12/2006	5.50	1.00	5.50	50mm SP

RC NEWLOG 10M PER PG 12239.GPJ IGSL.GDT 9/3/07

GEOTECHNICAL CORE LOG RECORD

REPORT NUMBER 12239

CONTRACT	Tarbert/Ballylongford Onshore SI	DRILLHOLE NO	RC12
		SHEET	Sheet 3 of 3
CO-ORDINATES(_)	102,373.94 E 148,688.95 N	GROUND LEVEL (m)	13.06
		CORE DIAMETER (mm)	84
		DATE STARTED	15/12/2006
		DATE COMPLETED	16/12/2006
CLIENT	Shannon LNG	INCLINATION	-90
ENGINEER	Arup Consulting Engineers	FLUSH	AIR/MIST
		DRILLED BY	Millennium
		LOGGED BY	IGSL

Downhole Depth (m)	Core Run Depth (m)	T.C.R.%	S.C.R.%	R.Q.D.%	Fracture Spacing (mm) 0 250 500	Legend	Description	Depth (m)	Discontinuities	Elevation	Standpipe Details	SPT (N Value)
20	20.00											
		100	91	79								
21								21.50				
	21.50						End of Corehole at 21.5 (m)			-8.44		
22												
23												
24												
25												
26												
27												
28												
29												

REMARKS

Waterstrike at 5.0m. 6 Core boxes.

INSTALLATION REMARKS

GROUNDWATER DETAILS

Date	Hole Depth	Casing Depth	Depth to Water	Comments

INSTALLATION DETAILS

Date	Tip Depth	RZ Top	RZ Base	Type
16/12/2006	5.50	1.00	5.50	50mm SP

RC NEWLOG 10M PER PG 12239.GPJ IGSL.GDT 9/3/07

GEOTECHNICAL CORE LOG RECORD

REPORT NUMBER 12239

CONTRACT	Tarbert/Ballylongford Onshore SI	DRILLHOLE NO	RC13
		SHEET	Sheet 1 of 3
CO-ORDINATES(_)	102,507.35 E 148,709.38 N	GROUND LEVEL (m)	17.08
		CORE DIAMETER (mm)	84
		DATE STARTED	08/12/2006
		DATE COMPLETED	10/12/2006
CLIENT	Shannon LNG	INCLINATION	-90
		DRILLED BY	Millennium
ENGINEER	Arup Consulting Engineers	FLUSH	AIR/MIST
		LOGGED BY	IGSL

Downhole Depth (m)	Core Run Depth (m)	T.C.R.%	S.C.R.%	R.Q.D.%	Fracture Spacing (mm)	Legend	Description	Depth (m)	Discontinuities	Elevation	Standpipe Details	SPT (N Value)
0					0 250 500		SYMMETRIX OPEN HOLE DRILLING: Observed by driller as returns of clay and gravel.	3.60				N = 44 (3, 4, 7, 10, 12, 15)
1												
2												
3												N = 37/150 mm (7, 7, 10, 12, 15)
4	3.90	100	0	0			SYMMETRIX OPEN HOLE DRILLING: Observed by driller as gravel size returns of siltstone/mudstone/sandstone. Probable bedrock.	3.90		13.48		
	4.20						Strong to very strong and locally moderately strong (within 3.9m-12.6m), thickly to locally thinly (3.9m-12.6m) bedded, grey/dark grey, fine grained SANDSTONE/SILTSTONE interbedded with mudstone siltstone layers (3.9m-12.6m). Fresh to locally slightly weathered and locally moderately weathered (within 3.9m-6.4m).		Discontinuities are rough to smooth and undulose. Apertures are tight to moderately open and locally open with iron oxide stained (between 3.9m-12.6m & 20.9m, 22.52m) and locally clay smeared (5.08m-5.23m, 5.32m-5.36m, 12.56m-12.6m) surfaces. Dips are sub-horizontal to 10° and locally 45°.	13.18		
5		100	48	16								
6	5.80	100	48	22								
	6.40											
7		100	90	80								
8	8.00	100	95	84	670							
9	9.50											

REMARKS

Waterstrike at 0.65m (9/12/06); Water at 5.25m (10/12/06). 9 Core boxes.

INSTALLATION REMARKS

GROUNDWATER DETAILS

Date	Hole Depth	Casing Depth	Depth to Water	Comments
09-12-06			0.65	Waterstrike
10-12-06			5.25	Standing

INSTALLATION DETAILS

Date	Tip Depth	RZ Top	RZ Base	Type
10/12/2006	9.00	1.00	9.00	50mm SP

RC NEWLOG 10M PER PG 12239.GPJ IGSL.GDT 9/3/07

GEOTECHNICAL CORE LOG RECORD

REPORT NUMBER 12239

CONTRACT	Tarbert/Ballylongford Onshore SI	DRILLHOLE NO	RC13
		SHEET	Sheet 2 of 3
CO-ORDINATES(_)	102,507.35 E 148,709.38 N	GROUND LEVEL (m)	17.08
		CORE DIAMETER (mm)	84
		INCLINATION	-90
		FLUSH	AIR/MIST
		DATE STARTED	08/12/2006
		DATE COMPLETED	10/12/2006
CLIENT	Shannon LNG	DRILLED BY	Millennium
ENGINEER	Arup Consulting Engineers	LOGGED BY	IGSL

Downhole Depth (m)	Core Run Depth (m)	T.C.R.%	S.C.R.%	R.Q.D.%	Fracture Spacing (mm) 0 250 500	Legend	Description	Depth (m)	Discontinuities	Elevation	Standpipe Details	SPT (N Value)
10		100	100	97			Strong to very strong and locally moderately strong (within 3.9m-12.6m), thickly to locally thinly (3.9m-12.6m) bedded, grey/dark grey, fine grained SANDSTONE/SILTSTONE interbedded with mudstone siltstone layers (3.9m-12.6m). Fresh to locally slightly weathered and locally moderately weathered (within 3.9m-6.4m). *(continued)*		Discontinuities are rough to smooth and undulose. Apertures are tight to moderately open and locally open with iron oxide stained (between 3.9m-12.6m & 20.9m, 22.52m) and locally clay smeared (5.08m-5.23m, 5.32m-5.36m, 12.56m-12.6m) surfaces. Dips are sub-horizontal to 10° and locally 45°. *(continued)*			
11	11.00	100	71	59								
12												
	12.60	100	100	93								
13												
14	14.10	100	100	100								
15					560							
	15.50	100	100	99								
16												
17	17.00	100	100	92	570							
18												
	18.60	100	100	94	760							
19												

REMARKS

Waterstrike at 0.65m (9/12/06); Water at 5.25m (10/12/06). 9
Core boxes.

INSTALLATION REMARKS

GROUNDWATER DETAILS

Date	Hole Depth	Casing Depth	Depth to Water	Comments

INSTALLATION DETAILS

Date	Tip Depth	RZ Top	RZ Base	Type
10/12/2006	9.00	1.00	9.00	50mm SP

RC NEWLOG 10M PER PG 12239.GPJ IGSL.GDT 9/3/07

GEOTECHNICAL CORE LOG RECORD

REPORT NUMBER 12239

CONTRACT	Tarbert/Ballylongford Onshore SI	DRILLHOLE NO	RC13
		SHEET	Sheet 3 of 3
CO-ORDINATES(_)	102,507.35 E 148,709.38 N	GROUND LEVEL (m)	17.08
		CORE DIAMETER (mm)	84
		DATE STARTED	08/12/2006
		DATE COMPLETED	10/12/2006
CLIENT	Shannon LNG	INCLINATION	-90
		DRILLED BY	Millennium
ENGINEER	Arup Consulting Engineers	FLUSH	AIR/MIST
		LOGGED BY	IGSL

Downhole Depth (m)	Core Run Depth (m)	T.C.R.%	S.C.R.%	R.Q.D.%	Fracture Spacing (mm) 0 250 500	Legend	Description	Depth (m)	Discontinuities	Elevation	Standpipe Details	SPT (N Value)
20	20.10	100	100	100	800		Strong to very strong and locally moderately strong (within 3.9m-12.6m), thickly to locally thinly (3.9m-12.6m) bedded, grey/dark grey, fine grained SANDSTONE/SILTSTONE interbedded with mudstone siltstone layers (3.9m-12.6m). Fresh to locally slightly weathered and locally moderately weathered (within 3.9m-6.4m). *(continued)*		Discontinuities are rough to smooth and undulose. Apertures are tight to moderately open and locally open with iron oxide stained (between 3.9m-12.6m & 20.9m, 22.52m) and locally clay smeared (5.08m-5.23m, 5.32m-5.36m, 12.56m-12.6m) surfaces. Dips are sub-horizontal to 10° and locally 45°. *(continued)*			
21	21.60	100	97	79								
22												
23	23.30	100	100	100	600							
24	24.50	100	100	100								
25					1200							
26	26.00	100	98	98								
27	27.50							27.50				
28							End of Corehole at 27.5 (m)			-10.42		
29												

REMARKS

Waterstrike at 0.65m (9/12/06); Water at 5.25m (10/12/06). 9 Core boxes.

INSTALLATION REMARKS

GROUNDWATER DETAILS

Date	Hole Depth	Casing Depth	Depth to Water	Comments

INSTALLATION DETAILS

Date	Tip Depth	RZ Top	RZ Base	Type
10/12/2006	9.00	1.00	9.00	50mm SP

RC.NEWLOG 10M PER PG 12239.GPJ IGSL.GDT 9/3/07

GEOTECHNICAL CORE LOG RECORD

REPORT NUMBER 12239

CONTRACT	Tarbert/Ballylongford Onshore SI	DRILLHOLE NO	RC14
		SHEET	Sheet 1 of 3
CO-ORDINATES(_)	102,517.06 E 148,762.88 N	GROUND LEVEL (m)	13.46
		CORE DIAMETER (mm)	84
		DATE STARTED	12/12/2006
		DATE COMPLETED	13/12/2006
CLIENT	Shannon LNG	INCLINATION	-90
ENGINEER	Arup Consulting Engineers	FLUSH	AIR/MIST
		DRILLED BY	Millennium
		LOGGED BY	IGSL

Downhole Depth (m)	Core Run Depth (m)	T.C.R.%	S.C.R.%	R.Q.D.%	Fracture Spacing (mm) 0 250 500	Legend	Description	Depth (m)	Discontinuities	Elevation	Standpipe Details	SPT (N Value)
0							SYMMETRIX OPEN HOLE DRILLING: Observed by driller as returns of clay and gravel.	1.50				
1							SYMMETRIX OPEN HOLE DRILLING: Observed by driller as returns of clayey gravel.	2.40		11.96		N = 33 (4, 4, 6, 7, 9, 11)
2							SYMMETRIX OPEN HOLE DRILLING: Observed by driller as gravel size returns of sandstone. Probable sandstone bedrock.	2.80		11.06		
3	2.80	100	98	26			Strong to very strong, thickly to thinly bedded and locally laminated, grey blue/dark grey, fine grained SANDSTONE interbedded with sandstone/siltstone layers (2.8m-3.9m, 8.6m-8.8m, 13.3m-14.0m) and locally weaker mudstone layers (4.66m-5.47m, 5.62m-6.5m, 6.64m-7.83m, 9.0m-9.25m, 10.0m-10.26m). Fresh to locally slightly weathered.		Discontinuities are smooth to locally rough and planar to locally undulose. Apertures are tight to locally open with locally moderately iron oxide stained and locally clay smeared surfaces. Dips are sub-horizontal and locally 45°-90° fractures.	10.66		
4	4.10	100	56	0								
5	5.30	100	45	0								
6	6.40	100	62	11								
7	7.70	100	89	67								
8												
9	9.30											

REMARKS

Waterstrike at 4.65m (12/12/06); Water at 7.35m (13/12/06). 8 Core boxes.

INSTALLATION REMARKS

GROUNDWATER DETAILS

Date	Hole Depth	Casing Depth	Depth to Water	Comments
12-12-06			4.63	Waterstrike
13-12-06			7.35	Standing

INSTALLATION DETAILS

Date	Tip Depth	RZ Top	RZ Base	Type
13/12/2006	6.00	1.00	6.00	50mm SP

RC NEWLOG 10M PER PG 12239.GPJ IGSL.GDT 9/3/07

GEOTECHNICAL CORE LOG RECORD

REPORT NUMBER 12239

CONTRACT	Tarbert/Ballylongford Onshore SI	DRILLHOLE NO	RC14
		SHEET	Sheet 2 of 3
CO-ORDINATES(_)	102,517.06 E 148,762.88 N	GROUND LEVEL (m)	13.46
		CORE DIAMETER (mm)	84
		DATE STARTED	12/12/2006
		DATE COMPLETED	13/12/2006
CLIENT	Shannon LNG	INCLINATION	-90
ENGINEER	Arup Consulting Engineers	FLUSH	AIR/MIST
		DRILLED BY	Millennium
		LOGGED BY	IGSL

Downhole Depth (m)	Core Run Depth (m)	T.C.R.%	S.C.R.%	R.Q.D.%	Fracture Spacing (mm) 0 250 500	Legend	Description	Depth (m)	Discontinuities	Elevation	Standpipe Details	SPT (N Value)
10		100	92	64			Strong to very strong, thickly to thinly bedded and locally laminated, grey blue/dark grey, fine grained SANDSTONE interbedded with sandstone/siltstone layers (2.8m-3.9m, 8.6m-8.8m, 13.3m-14.0m) and locally weaker mudstone layers (4.66m-5.47m, 5.62m-6.5m, 6.64m-7.83m, 9.0m-9.25m, 10.0m-10.26m). Fresh to locally slightly weathered. *(continued)*		Discontinuities are smooth to locally rough and planar to locally undulose. Apertures are tight to locally open with locally moderately iron oxide stained and locally clay smeared surfaces. Dips are sub-horizontal and locally 45°-90° fractures. *(continued)*			
11	10.90	100	100	95	550							
12	12.20	100	97	82	640							
13	13.80	100	97	76	520							
14	15.10	100	93	93	520							
15	16.00	100	100	100								
16	17.50	100	97	94	820							
17	19.10	100	100	94	710							
18												
19												

REMARKS

Waterstrike at 4.65m (12/12/06); Water at 7.35m (13/12/06). 8 Core boxes.

INSTALLATION REMARKS

INSTALLATION DETAILS

Date	Tip Depth	RZ Top	RZ Base	Type
13/12/2006	6.00	1.00	6.00	50mm SP

GROUNDWATER DETAILS

Date	Hole Depth	Casing Depth	Depth to Water	Comments

RC NEWLOG 10M PER PG 12239.GPJ IGSL.GDT 9/3/07

GEOTECHNICAL CORE LOG RECORD

REPORT NUMBER 12239

CONTRACT	Tarbert/Ballylongford Onshore SI	DRILLHOLE NO	RC14
		SHEET	Sheet 3 of 3
CO-ORDINATES(_)	102,517.06 E 148,762.88 N	GROUND LEVEL (m)	13.46
		CORE DIAMETER (mm)	84
		DATE STARTED	12/12/2006
		DATE COMPLETED	13/12/2006
CLIENT	Shannon LNG	INCLINATION	-90
ENGINEER	Arup Consulting Engineers	FLUSH	AIR/MIST
		DRILLED BY	Millennium
		LOGGED BY	IGSL

Downhole Depth (m)	Core Run Depth (m)	T.C.R.%	S.C.R.%	R.Q.D.%	Fracture Spacing (mm) 0 250 500	Legend	Description	Depth (m)	Discontinuities	Elevation	Standpipe Details	SPT (N Value)
20							Strong to very strong, thickly to thinly bedded and locally laminated, grey blue/dark grey, fine grained SANDSTONE interbedded with sandstone/siltstone layers (2.8m-3.9m, 8.6m-8.8m, 13.3m-14.0m) and locally weaker mudstone layers (4.66m-5.47m, 5.62m-6.5m, 6.64m-7.83m, 9.0m-9.25m, 10.0m-10.26m). Fresh to locally slightly weathered. *(continued)*		Discontinuities are smooth to locally rough and planar to locally undulose. Apertures are tight to locally open with locally moderately iron oxide stained and locally clay smeared surfaces. Dips are sub-horizontal and locally 45°-90° fractures. *(continued)*			
21	20.70	100	94	84	890							
22	22.30	100	99	82	610							
23	23.80	100	100	100	760							
24	24.50						End of Corehole at 24.5 (m)	24.50		-11.04		
25												
26												
27												
28												
29												

REMARKS

Waterstrike at 4.65m (12/12/06); Water at 7.35m (13/12/06). 8 Core boxes.

INSTALLATION REMARKS

GROUNDWATER DETAILS

Date	Hole Depth	Casing Depth	Depth to Water	Comments

INSTALLATION DETAILS

Date	Tip Depth	RZ Top	RZ Base	Type
13/12/2006	6.00	1.00	6.00	50mm SP

RC NEWLOG 10M PER PG 12239.GPJ IGSL.GDT 9/3/07

GEOTECHNICAL CORE LOG RECORD

REPORT NUMBER 12239

CONTRACT	Tarbert/Ballylongford Onshore SI	DRILLHOLE NO	RC18
		SHEET	Sheet 1 of 3
CO-ORDINATES(_)	102,631.08 E 148,783.91 N	GROUND LEVEL (m)	19.00
		CORE DIAMETER (mm)	86
		DATE STARTED	07/12/2006
		DATE COMPLETED	08/12/2006
CLIENT	Shannon LNG	INCLINATION	-90
		DRILLED BY	Millennium
ENGINEER	Arup Consulting Engineers	FLUSH	AIR/MIST
		LOGGED BY	IGSL

Downhole Depth (m)	Core Run Depth (m)	T.C.R.%	S.C.R.%	R.Q.D.%	Fracture Spacing (mm)	Legend	Description	Depth (m)	Discontinuities	Elevation	Standpipe Details	SPT (N Value)
0					0 250 500		SYMMETRIX OPEN HOLE DRILLING: Observed by driller as returns of clay and gravel.	0.80				
1	0.80	100	0	0			Moderately weak, thin to medium bedding, grey, fine grained SANDSTONE. Moderately weathered.	1.20	Discontinuities are rough to planar and undulose. Apertures are tight to moderately open. Dips are sub-horizontal and with sub-vertical fractures.	18.20		
	1.20	0	0	0			Recased: observed by driller as rock	2.20		17.80		
2	2.20	150	38	0			Strong to very strong, grey, fine grained SANDSTONE interbedded with thin argillaceous bands. Fresh to slightly weathered		Discontinuities are rough to planar and undulose. Apertures are tight. Dips are sub-horizontal and locally sub-vertical fractures.	16.80		
	2.60	80	64	0								
3	3.10	100	67	53								
4	4.60	100	83	60								
5												
6	6.10	100	84	59	700							
7	7.60	100	100	85	940							
8												
9	9.10	100	100	87	650							

REMARKS

Water overnight (12-13/12/06) at 8.4m. 10 Core boxes.

INSTALLATION REMARKS

GROUNDWATER DETAILS

Date	Hole Depth	Casing Depth	Depth to Water	Comments
07-12-06			8.40	Overnight

INSTALLATION DETAILS

Date	Tip Depth	RZ Top	RZ Base	Type
08/12/2006	10.00	1.00	10.00	50mm SP

RC NEWLOG 10M PER PG 12239.GPJ IGSL.GDT 9/3/07

GEOTECHNICAL CORE LOG RECORD

REPORT NUMBER 12239

CONTRACT	Tarbert/Ballylongford Onshore SI	DRILLHOLE NO	RC18
		SHEET	Sheet 2 of 3
CO-ORDINATES(_)	102,631.08 E 148,783.91 N	GROUND LEVEL (m)	19.00
		CORE DIAMETER (mm)	86
		DATE STARTED	07/12/2006
		DATE COMPLETED	08/12/2006
CLIENT	Shannon LNG	INCLINATION	-90
		DRILLED BY	Millennium
ENGINEER	Arup Consulting Engineers	FLUSH	AIR/MIST
		LOGGED BY	IGSL

Downhole Depth (m)	Core Run Depth (m)	T.C.R.%	S.C.R.%	R.Q.D.%	Fracture Spacing (mm) 0 250 500	Legend	Description	Depth (m)	Discontinuities	Elevation	Standpipe Details	SPT (N Value)
10							Strong to very strong, grey, fine grained SANDSTONE interbedded with thin argillaceous bands. Fresh to slightly weathered *(continued)*		Discontinuities are rough to planar and undulose. Apertures are tight. Dips are sub-horizontal and locally sub-vertical fractures. *(continued)*			
11	10.60	100	100	86								
12	11.30	100	100	89								
13	12.80	100	100	100								
14	14.30	100	100	67								
15	15.80	100	100	92	550							
16	17.20	100	100	100	580							
17	18.70	100	100	93	570							
18												
19												

REMARKS

Water overnight (12-13/12/06) at 8.4m. 10 Core boxes.

INSTALLATION REMARKS

GROUNDWATER DETAILS

Date	Hole Depth	Casing Depth	Depth to Water	Comments

INSTALLATION DETAILS

Date	Tip Depth	RZ Top	RZ Base	Type
08/12/2006	10.00	1.00	10.00	50mm SP

RC NEWLOG 10M PER PG 12239.GPJ IGSL.GDT 9/3/07

GEOTECHNICAL CORE LOG RECORD

REPORT NUMBER 12239

CONTRACT	Tarbert/Ballylongford Onshore SI	DRILLHOLE NO	RC18
		SHEET	Sheet 3 of 3
CO-ORDINATES(_)	102,631.08 E 148,783.91 N	GROUND LEVEL (m)	19.00
		CORE DIAMETER (mm)	86
		DATE STARTED	07/12/2006
		DATE COMPLETED	08/12/2006
CLIENT	Shannon LNG	INCLINATION	-90
ENGINEER	Arup Consulting Engineers	FLUSH	AIR/MIST
		DRILLED BY	Millennium
		LOGGED BY	IGSL

Downhole Depth (m)	Core Run Depth (m)	T.C.R.%	S.C.R.%	R.Q.D.%	Fracture Spacing (mm)	Legend	Description	Depth (m)	Discontinuities	Elevation	Standpipe Details	SPT (N Value)
20	20.10	100	100	94	1100		Strong to very strong, grey, fine grained SANDSTONE interbedded with thin argillaceous bands. Fresh to slightly weathered *(continued)*		Discontinuities are rough to planar and undulose. Apertures are tight. Dips are sub-horizontal and locally sub-vertical fractures. *(continued)*			
21	21.30	100	90	90								
22	22.60	100	78	78								
23	23.50	100	100	93								
24	25.00	100	100	77								
25	25.70	100	100	67	690							
26	26.30	100	100	95	740							
27	27.80	85	85	85	670 640							
28												
29	29.10						End of Corehole at 29.1 (m)	29.10		-10.10		

REMARKS

Water overnight (12-13/12/06) at 8.4m. 10 Core boxes.

INSTALLATION REMARKS

GROUNDWATER DETAILS

Date	Hole Depth	Casing Depth	Depth to Water	Comments

INSTALLATION DETAILS

Date	Tip Depth	RZ Top	RZ Base	Type
08/12/2006	10.00	1.00	10.00	50mm SP

RC NEWLOG 10M PER PG 12239.GPJ IGSL.GDT 9/3/07

GEOTECHNICAL CORE LOG RECORD

REPORT NUMBER 12239

CONTRACT	Tarbert/Ballylongford Onshore SI	DRILLHOLE NO	RC19
		SHEET	Sheet 1 of 3
CO-ORDINATES(_)	102,648.52 E 148,842.78 N	GROUND LEVEL (m)	12.97
		CORE DIAMETER (mm)	84
		DATE STARTED	05/12/2006
		DATE COMPLETED	06/12/2006
CLIENT	Shannon LNG	INCLINATION	-90
ENGINEER	Arup Consulting Engineers	FLUSH	AIR/MIST
		DRILLED BY	Millennium
		LOGGED BY	IGSL

Downhole Depth (m)	Core Run Depth (m)	T.C.R.%	S.C.R.%	R.Q.D.%	Fracture Spacing (mm) 0 250 500	Legend	Description	Depth (m)	Discontinuities	Elevation	Standpipe Details	SPT (N Value)
0							SYMMETRIX OPEN HOLE DRILLING: Observed by driller as returns of clay and gravel.	1.30				
1							SYMMETRIX OPEN HOLE DRILLING: Observed by driller as gravel size returns of siltstone/sandstone . Probable bedrock.	1.80		11.67		N = 36 (9, 11, 10, 6, 8, 12)
2	1.80	100	100	49			Strong to very strong, thin to thickly bedded, grey/blue/pale grey, fine grained SANDSTONE with siltstone/sandstone layers (3.0m-3.4m, 4.0m-6.7m, 16.9m-19.2m). Fresh to locally slightly weathered.		Discontinuities are smooth to locally rough and planar to locally undulose. Apertures are tight to open with commonly iron oxide stained and locally clay smeared surfaces. Dips are sub-horizontal and locally 60°-90°.	11.17		
3	2.50	100	97	51								
	3.40	100	70	0								
4	3.80	100	94	35								
5	5.30	100	94	46								
6	6.70	100	100	52								
7	8.20	100	100	85	590							
8	9.70											
9												

REMARKS

8 Core boxes.

INSTALLATION REMARKS

GROUNDWATER DETAILS

Date	Hole Depth	Casing Depth	Depth to Water	Comments

INSTALLATION DETAILS

Date	Tip Depth	RZ Top	RZ Base	Type
06/12/2006	7.00	1.00	7.00	50mm SP

RC NEWLOG 10M PER PG 12239.GPJ IGSL.GDT 9/3/07

GEOTECHNICAL CORE LOG RECORD

REPORT NUMBER 12239

CONTRACT	Tarbert/Ballylongford Onshore SI	DRILLHOLE NO	RC19
		SHEET	Sheet 2 of 3
CO-ORDINATES(_)	102,648.52 E 148,842.78 N	GROUND LEVEL (m)	12.97
		CORE DIAMETER (mm)	84
		DATE STARTED	05/12/2006
		DATE COMPLETED	06/12/2006
CLIENT	Shannon LNG	INCLINATION	-90
		DRILLED BY	Millennium
ENGINEER	Arup Consulting Engineers	FLUSH	AIR/MIST
		LOGGED BY	IGSL

Downhole Depth (m)	Core Run Depth (m)	T.C.R.%	S.C.R.%	R.Q.D.%	Fracture Spacing (mm) 0 250 500	Legend	Description	Depth (m)	Discontinuities	Elevation	Standpipe Details	SPT (N Value)
10		100	100	59			Strong to very strong, thin to thickly bedded, grey/blue/pale grey, fine grained SANDSTONE with siltstone/sandstone layers (3.0m-3.4m, 4.0m-6.7m, 16.9m-19.2m). Fresh to locally slightly weathered. *(continued)*		Discontinuities are smooth to locally rough and planar to locally undulose. Apertures are tight to open with commonly iron oxide stained and locally clay smeared surfaces. Dips are sub-horizontal and locally 60°-90°. *(continued)*			
11	11.20	100	99	84	600							
12	12.60	100	90	64								
13	13.50	100	91	53								
14												
15	15.00	100	97	88								
16	16.40	100	100	94	800 690							
17												
18	17.90	100	97	89	990							
19	19.40				540							

REMARKS

8 Core boxes.

INSTALLATION REMARKS

GROUNDWATER DETAILS

Date	Hole Depth	Casing Depth	Depth to Water	Comments

INSTALLATION DETAILS

Date	Tip Depth	RZ Top	RZ Base	Type
06/12/2006	7.00	1.00	7.00	50mm SP

RC NEWLOG 10M PER PG 12239.GPJ IGSL.GDT 9/3/07

GEOTECHNICAL CORE LOG RECORD

REPORT NUMBER 12239

CONTRACT	Tarbert/Ballylongford Onshore SI	DRILLHOLE NO	RC19
		SHEET	Sheet 3 of 3
CO-ORDINATES(_)	102,648.52 E 148,842.78 N	GROUND LEVEL (m)	12.97
		CORE DIAMETER (mm)	84
		DATE STARTED	05/12/2006
		DATE COMPLETED	06/12/2006
CLIENT	Shannon LNG	INCLINATION	-90
		DRILLED BY	Millennium
ENGINEER	Arup Consulting Engineers	FLUSH	AIR/MIST
		LOGGED BY	IGSL

Downhole Depth (m)	Core Run Depth (m)	T.C.R.%	S.C.R.%	R.Q.D.%	Fracture Spacing (mm) 0 250 500	Legend	Description	Depth (m)	Discontinuities	Elevation	Standpipe Details	SPT (N Value)
20		100	100	81			Strong to very strong, thin to thickly bedded, grey/blue/pale grey, fine grained SANDSTONE with siltstone/sandstone layers (3.0m-3.4m, 4.0m-6.7m, 16.9m-19.2m). Fresh to locally slightly weathered. *(continued)*		Discontinuities are smooth to locally rough and planar to locally undulose. Apertures are tight to open with commonly iron oxide stained and locally clay smeared surfaces. Dips are sub-horizontal and locally 60°-90°. *(continued)*			
21	20.90	100	87	77								
22	22.40						End of Corehole at 22.4 (m)	22.40		-9.44		
23												
24												
25												
26												
27												
28												
29												

REMARKS

8 Core boxes.

INSTALLATION REMARKS

GROUNDWATER DETAILS

Date	Hole Depth	Casing Depth	Depth to Water	Comments

INSTALLATION DETAILS

Date	Tip Depth	RZ Top	RZ Base	Type
06/12/2006	7.00	1.00	7.00	50mm SP

RC NEWLOG 10M PER PG 12239.GPJ IGSL.GDT 9/3/07

GEOTECHNICAL CORE LOG RECORD

REPORT NUMBER 12239

CONTRACT	Tarbert/Ballylongford Onshore SI	DRILLHOLE NO	RC20
		SHEET	Sheet 1 of 3
CO-ORDINATES(_)	102,709.25 E 148,826.11 N	GROUND LEVEL (m)	18.10
		CORE DIAMETER (mm)	84
		DATE STARTED	01/12/2006
		DATE COMPLETED	04/12/2006
CLIENT	Shannon LNG	INCLINATION	-90
		DRILLED BY	Millennium
ENGINEER	Arup Consulting Engineers	FLUSH	AIR/MIST
		LOGGED BY	IGSL

Downhole Depth (m)	Core Run Depth (m)	T.C.R.%	S.C.R.%	R.Q.D %	Fracture Spacing (mm) 0 250 500	Legend	Description	Depth (m)	Discontinuities	Elevation	Standpipe Details	SPT- (N Value)
0							SYMMETRIX OPEN HOLE DRILLING: Observed by driller as returns of clay and gravel.	0.50		17.60		
	0.80	100	36	20			SYMMETRIX OPEN HOLE DRILLING: Observed by driller as gravel size returns of sandstone/siltstone. Probable bedrock.	0.80		17.30		
1	1.50	100	0	0			Strong to locally moderately strong, thin to medium bedding, grey to dark grey, very fine grained cross bedded SANDSTONE with SILTSTONE. Fresh to locally slightly and moderately weathered.		Discontinuities are rough to smooth and planar to undulose. Apertures are tight to open with iron oxide stained and locally clay smeared surfaces. Dips are sub-horizontal and locally sub-vertical fractures (1.58m-1.96m, 3.13m-3.27m[laminated and heavily iron-oxide stained], 6.32m-6.38m).			
2	2.50	100	85	63								
3	4.00	100	75	53								
4	5.50	100	69	48								
5	6.40	100	88	25								
6	7.70	100	92	63				7.90				
7	9.00	100	95	86			Strong to very strong, medium to thick bedding, grey to dark grey, very fine grained SANDSTONE with minor siltstone. Fresh to locally slightly weathered.		Discontinuities are rough and planar to undulose. Apertures moderately open with locally iron oxide stained surfaces. Dips are sub-horizontal and locally sub-vertical fractures (10.83m-10.93m).	10.20		
8												
9												

REMARKS

Waterstrike at 3.4m and standing to 4/12/06. 15 Core boxes.

INSTALLATION REMARKS

INSTALLATION DETAILS

Date	Tip Depth	RZ Top	RZ Base	Type
04/12/2006	0.80	0.00	0.80	50mm SP

GROUNDWATER DETAILS

Date	Hole Depth	Casing Depth	Depth to Water	Comments
01-12-04			3.40	Waterstrike
14-12-06			3.40	Over 3 days

RC NEWLOG 10M PER PG 12239.GPJ IGSL.GDT 9/3/07

GEOTECHNICAL CORE LOG RECORD

REPORT NUMBER 12239

CONTRACT	Tarbert/Ballylongford Onshore SI	DRILLHOLE NO	RC20
		SHEET	Sheet 2 of 3
CO-ORDINATES(_)	102,709.25 E 148,826.11 N	GROUND LEVEL (m)	18.10
		CORE DIAMETER (mm)	84
		DATE STARTED	01/12/2006
		DATE COMPLETED	04/12/2006
CLIENT	Shannon LNG	INCLINATION	-90
		DRILLED BY	Millennium
ENGINEER	Arup Consulting Engineers	FLUSH	AIR/MIST
		LOGGED BY	IGSL

Downhole Depth (m)	Core Run Depth (m)	T.C.R.%	S.C.R.%	R.Q.D.%	Fracture Spacing (mm) 0 250 500	Legend	Description	Depth (m)	Discontinuities	Elevation	Standpipe Details	SPT (N Value)
10	10.50						Strong to very strong, medium to thick bedding, grey to dark grey, very fine grained SANDSTONE with minor siltstone. Fresh to locally slightly weathered. *(continued)*		Discontinuities are rough and planar to undulose. Apertures moderately open with locally iron oxide stained surfaces. Dips are sub-horizontal and locally sub-vertical fractures (10.83m-10.93m). *(continued)*			
11		100	92	82								
12	12.00	100	91	79	540							
13	13.50	100	92	81	550							
14	14.70	100	100	93								
15	16.20	100	100	97	650							
16	17.70	100	100	69								
17	19.20				1390							
18												
19												

REMARKS

Waterstrike at 3.4m and standing to 4/12/06. 15 Core boxes.

INSTALLATION REMARKS

GROUNDWATER DETAILS

Date	Hole Depth	Casing Depth	Depth to Water	Comments

INSTALLATION DETAILS

Date	Tip Depth	RZ Top	RZ Base	Type
04/12/2006	0.80	0.00	0.80	50mm SP

RC NEWLOG 10M PER PG 12239.GPJ IGSL.GDT 9/3/07

GEOTECHNICAL CORE LOG RECORD

REPORT NUMBER 12239

CONTRACT	Tarbert/Ballylongford Onshore SI	DRILLHOLE NO	RC20
		SHEET	Sheet 3 of 3
CO-ORDINATES(_)	102,709.25 E 148,826.11 N	GROUND LEVEL (m)	18.10
		CORE DIAMETER (mm)	84
		DATE STARTED	01/12/2006
		DATE COMPLETED	04/12/2006
CLIENT	Shannon LNG	INCLINATION	-90
		DRILLED BY	Millennium
ENGINEER	Arup Consulting Engineers	FLUSH	AIR/MIST
		LOGGED BY	IGSL

Downhole Depth (m)	Core Run Depth (m)	T.C.R.%	S.C.R.%	R.Q.D.%	Fracture Spacing (mm) 0 250 500	Legend	Description	Depth (m)	Discontinuities	Elevation	Standpipe Details	SPT (N Value)
20		100	100	90			Strong to very strong, medium to thick bedding, grey to dark grey, very fine grained SANDSTONE with minor siltstone. Fresh to locally slightly weathered. *(continued)*		Discontinuities are rough and planar to undulose. Apertures moderately open with locally iron oxide stained surfaces. Dips are sub-horizontal and locally sub-vertical fractures (10.83m-10.93m). *(continued)*			
	20.70											
21		100	100	87	1770							
22	22.10											
		100	96	96								
23												
	23.50											
24		100	100	86	1180							
25	25.00											
		100	92	71								
26												
	26.50				570							
27		100	99	84	770							
								28.00				
28	28.00						End of Corehole at 28 (m)			-9.90		
29												

REMARKS

Waterstrike at 3.4m and standing to 4/12/06. 15 Core boxes.

INSTALLATION REMARKS

GROUNDWATER DETAILS

Date	Hole Depth	Casing Depth	Depth to Water	Comments

INSTALLATION DETAILS

Date	Tip Depth	RZ Top	RZ Base	Type
04/12/2006	0.80	0.00	0.80	50mm SP

RC NEWLOG 10M PER PG 12239.GPJ IGSL.GDT 9/3/07

GEOTECHNICAL CORE LOG RECORD

REPORT NUMBER 12239

CONTRACT	Tarbert/Ballylongford Onshore SI	DRILLHOLE NO	RC23
		SHEET	Sheet 1 of 2
CO-ORDINATES(_)	102,143.35 E 148,540.51 N	GROUND LEVEL (m)	13.11
		CORE DIAMETER (mm)	102
		INCLINATION	-90
		FLUSH	AIR/MIST
		DATE STARTED	16/11/2006
		DATE COMPLETED	17/11/2006
CLIENT	Shannon LNG	DRILLED BY	Millennium
ENGINEER	Arup Consulting Engineers	LOGGED BY	IGSL

Downhole Depth (m)	Core Run Depth (m)	T.C.R.%	S.C.R.%	R.Q.D.%	Fracture Spacing (mm) 0 250 500	Legend	Description	Depth (m)	Discontinuities	Elevation	Standpipe Details	SPT (N Value)
0							SYMMETRIX OPEN HOLE DRILLING: Observed by driller as returns of clay and gravel and cobbles.					N = 27 (2, 5, 4, 7, 6, 10)
1												
2												N = 15 (1, 2, 3, 1, 4, 7)
3												
4												N = 35 (3, 5, 8, 9, 8, 10)
5												
6								6.70				N = 41 (19, 6, 11, 7, 10, 13)
7	7.00	100	21	0			SYMMETRIX OPEN HOLE DRILLING: Observed by driller as gravel size returns of . Probable bedrock.	7.00		6.41		
8	7.90	100	42	42			Moderately weak to moderately strong, thin to medium bedding, dark grey, very fine grained MUDSTONE/SILTSTONE. Moderately to locally slightly weathered.	8.00	Discontinuities are smooth and undulose. Apertures are open to locally moderately open with commonly clay smeared surfaces. Dips are 10° and irregular fractures.	6.11 5.11		
9	9.40											

REMARKS

Waterstrike at 6.7m. 6 Core boxes.

INSTALLATION REMARKS

GROUNDWATER DETAILS

Date	Hole Depth	Casing Depth	Depth to Water	Comments
16-11-06			6.70	Waterstrike

INSTALLATION DETAILS

Date	Tip Depth	RZ Top	RZ Base	Type
17/11/2006	7.50	5.00	7.50	50mm SP

RC NEWLOG 10M PER PG 12239.GPJ IGSL.GDT 9/3/07

GEOTECHNICAL CORE LOG RECORD

REPORT NUMBER 12239

CONTRACT	Tarbert/Ballylongford Onshore SI	DRILLHOLE NO	RC23
		SHEET	Sheet 2 of 2
CO-ORDINATES(_)	102,143.35 E 148,540.51 N	GROUND LEVEL (m)	13.11
		CORE DIAMETER (mm)	102
		DATE STARTED	16/11/2006
		DATE COMPLETED	17/11/2006
CLIENT	Shannon LNG	INCLINATION	-90
		DRILLED BY	Millennium
ENGINEER	Arup Consulting Engineers	FLUSH	AIR/MIST
		LOGGED BY	IGSL

Downhole Depth (m)	Core Run Depth (m)	T.C.R.%	S.C.R.%	R.Q.D.%	Fracture Spacing (mm) 0 250 500	Legend	Description	Depth (m)	Discontinuities	Elevation	Standpipe Details	SPT (N Value)
10		100	79	73			Strong to locally moderately strong, thin to medium bedding, grey, fine to medium grained SANDSTONE with lenses of siltstone. Fresh to locally slightly weathered. *(continued)*		Discontinuities are rough and undulose to planar and locally smooth. Apertures are open to moderately open. Dips are 10° and locally sub 90° and irregular fractures. *(continued)*			
11	10.90	100	93	77								
12	12.40							12.60				
13		100	77	34			Strong to moderately strong and very locally moderately weak, thinly bedded (cross stratified), grey/dark grey, fine to locally medium grained SILTSTONE/MUDSTONE with lenses of sandstone. Fresh to locally slightly weathered.		Discontinuities are smooth and planar to undulose. Apertures are open to locally tight with commonly clay smeared surfaces. Dips are 10° and locally 90° fractures.	0.51		
14	13.90	100	96	34								
15	15.50	100	85	63								
16	16.10	100	67	23				16.70				
17	16.70						End of Corehole at 16.8 (m)			-3.59		
18												
19												

REMARKS

Waterstrike at 6.7m. 6 Core boxes.

INSTALLATION REMARKS

GROUNDWATER DETAILS

Date	Hole Depth	Casing Depth	Depth to Water	Comments

INSTALLATION DETAILS

Date	Tip Depth	RZ Top	RZ Base	Type
17/11/2006	7.50	5.00	7.50	50mm SP

RC NEWLOG 10M PER PG 12239.GPJ IGSL.GDT 9/3/07