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**HAULBOWLINE EAST TIP –
EXPLORATORY GROUND INVESTIGATION
FACTUAL REPORT
NO. P12030**

Employer:

Cork County Council

Environmental Directorate,
Cork County Council,
Inniscara,
Co. Cork.

Employer's Representative:

WYG EPT Ltd.

Arndale Court,
Headingley,
Leeds,
United Kingdom,
LS6 2UJ



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REPORT CONTROL SHEET

Employer	Cork County Council, Environmental Directorate						
Employer's Representative	WYG EPT Ltd						
Project Name	Haulbowline East Tip, Exploratory Ground Investigation						
Report Name	Haulbowline East Tip, Exploratory Ground Investigation, Factual Report						
Project Number	P12030						
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1 INTRODUCTION

1.1 SCOPE OF WORKS

In April, 2012, WYG Ireland (WYG EPT) acting as Employer's Representative appointed Priority Geotechnical (PGL) on behalf of their Client, Cork County Council, to carry out exploratory ground investigation works at the East Tip, Haulbowline, Co. Cork. IE Consulting were appointed by PGL, being approved by WYG EPT, to act as specialist hydrogeological consultant for the works. Enviroglan Ltd. were appointed by PGL, being approved by WYG EPT, to act as specialist environmental consultant for the works.

The purpose of the exploratory ground investigation was to provide environmental and geotechnical information to allow for a detailed quantitative risk assessment to be completed for Haulbowline East Tip. The specific objectives were to:

- Drill and install boreholes to allow the sampling and testing of various soil horizons for chemical and geotechnical requirements;
- Determine the permeability of the underlying sediment horizons;
- Determine the relationship between vertical and lateral water flows across the site under different tidal conditions;
- Delineate the biodegradable waste deposits located in the north west;
- Assess the chemical and geotechnical properties within the playing field areas;
- Allow sampling and testing of bulk gas samples from selected locations; and
- Assess the chemical nature of pore water of underlying natural sediments.

The investigation as specified by WYG EPT, as tendered, comprised of twenty one (21) number cable percussive boreholes to a maximum depth of 35.0m, three (3) number rotary boreholes, twenty three (23) number trial pit excavations, all associated sampling (bulk disturbed and undisturbed samples, groundwater samples and gas samples), *in-situ* testing (30 number variable head permeability tests, packer tests), well installations, groundwater and gas monitoring, laboratory work (geotechnical and geo-environmental) and factual reporting.

This investigation was carried out in accordance with the contract Specification and relevant British Standards and Eurocodes.

The exploratory fieldwork was carried out between the 24th of April and the 12th of June, 2012. *In situ* permeability testing, groundwater and ground gas monitoring continued thereafter, until the 28th August, 2012.

1.2 REPORTING

This geotechnical/geo-environmental data report, P12030-Rp-F02 presents the factual records of the fieldwork with respect to the ground investigation contract for the East Tip, Haulbowline, Co. Cork.

This report may be reading conjunction with any other relevant historical investigations for the site e.g. (Glover, report ref: 05-395, 2005).

1.3 SITE LOCATION & DESCRIPTION

The East Tip (9ha) is situated within the Eastern portion of Haulbowline Island in Cork Harbour. The area is accessed via Ringaskiddy across a bridge from Paddy's Point, crossing Rocky Island and through an area controlled by the Irish Navy. The East Tip is located on a shallow island spit (Spit Bank) which was historically infilled with materials, the majority of the infilling took place from the 1960s, from the Irish Steel and ISPAT steelworks, located on the main portion of Haulbowline Island, having since been demolished.

The vast majority of made ground across the East Tip is steelworks related. This comprises unprocessed slag material which was encountered up to depths of between 5.0m and 10.0m below ground level (bgl). There are small localised areas where various materials relating to the steelworks process have been deposited. This included mill scale, refractory materials, scrap metal and construction and demolition waste/ rubble.

1.4 GEOLOGY

1.4.1 Solid

The Geological Survey of Ireland (GSI) 1:100,000 mapping (Sheet 25), indicated that the site is underlain Walsortian LIMESTONE (WA).

Limestone was previously identified from historical investigations by others as being fractured at the near surface, being shallower in the west and deeper in the east (12m bgl to 34m bgl). The GSI subsoil mapping indicated bedrock outcropping on the island.

The solid geology is described in greater detail within the exploratory logs associated with this and other ground investigation reports.

1.4.2 Superficial

Based on previous investigation work by others and the GSI subsoil mapping the ground condition at the site were such that the superficial deposits within the study area are characterised by made ground, glacial till derived from Sandstone (TDSs) and marine sediment (alluvial deposits).

Made ground was previously characterised as being mainly unprocessed steelworks slag waste some of which is weathered. Some of the slag is fused and some has been hot tipped and is very compact in certain areas of the site. Construction and demolition waste, scrap metal, refractory products, mill scale, sludge cake and flue dust were also encountered in localised areas of the site. Made ground varied from 4m to 11m deep. There was no historical evidence of large steel skulls.

Alluvial materials generally comprised sandy silts and were found from 5m to 10m bgl through to 12m to 24m bgl. The alluvial materials were thinner in the south west. Glacial Sand and Gravel were encountered from 13m to 25m below ground level and were up to 10m in thickness.

The superficial deposits are described in greater detail within the exploratory logs associated with this and other ground investigation reports.

2 FIELDWORK

2.1 GENERAL

The fieldwork was carried out in general accordance with BS 5930 (1999) Code of Practice for Site Investigation and Part 9 of BS 1377 (1990), Method of Tests for Soil for Civil Engineering Purposes and BS 10175:2011; Investigation of Potentially Contaminated Sites: Code of Practice. Details of the equipment and plant used are presented below. Further details of the methods used are detailed in the agreed method statements presented in **APPENDIX F** of this factual report.

SUMMARY OF EQUIPMENT AND PLANT

Operation	Equipment	Nominal diameter, mm	Flush	Comments
Cable percussion boring	Dando 3000	250mm and 200mm	N/A	Standard Penetration Test, N_{SPT} values. Bulk disturbed and undisturbed samples obtained. Visual assessment of ground conditions, groundwater observations, well installations, permeability testing and sampling. In some instances boreholes were unable to progress through the monolithic shallow slag and so casing was advanced using trial pit excavations (see below).
Rotary drilling	Soil Mech PSM 8G	131mm open hole 76mm double barrel	Air/ mist	Well installations and groundwater sampling, identification of bedrock.
Starter Trial Pits, trial trench excavations and backfilling historical open trial pits.	21t Tracked excavator and hydraulic breaker	Plan area - L x B x D	N/A	Excavation of starter trial pits to approximately 5m depth and installation of casing through slag deposits to progress boreholes. Excavation of trial trenches. Bulk disturbed samples obtained. Visual assessment of ground conditions and groundwater observations. Backfill of historical open trial pits (2005)

The exploratory locations were selected by WYG EPT and set out on site from the co-ordinates provided. A survey of the exploratory locations was undertaken using 5700/5800 Trimble GPS-RTK equipment, to the Irish National Grid (ING) system of co-ordinates and elevations (Malin Head). These locations are shown on the exploration location plan (drawing No. P12030-SI-01) presented in **APPENDIX E** of this factual report.

2.2 EXPLORATORY HOLES

The exploratory holes as completed during the ground investigation are listed in the following table:

SUMMARY OF EXPLORATORY HOLES

Type	Quantity	Depth Range	Remarks
Cable percussion boreholes	21No.	3.5m to 25.3m	BH301, BH301A, BH302, BH303, BH304, BH305, BH306A, BH306B, BH306D, BH307, BH308, BH309, BH310A, BH310B, BH311, BH312A, BH312B, BH313, BH314, BH315 and BH316.
Rotary boreholes - cored	3No.	32.5m to 49.2m	BH306C, BH310C and BH312C.
Rotary boreholes – open-hole	2No.	24.4m to 36.0m	BH117R and BH125R.
Trenches	2No.	2.9m to 3.5m	TP01 and TP02.
Open ¹ - Trial Pits	14No.	2.2m to 3.9m	OP01, OP02, OP03, OP04, OP05, OP06, OP07, OP08, OP09, OP10, OP11, OP12, OP13 and OP14.

The exploration records are presented in **APPENDIX A** and should be read in conjunction with the key sheets included. The records provide descriptions, in accordance with BS 5930 (1999), of the natural materials encountered and details of the samples taken, together with any observations made during the investigation. The descriptions of made ground were based on the materials origin and a visual assessment of its constituents as per the crib sheets produced by WYG EPT, accompanying the key sheet in **APPENDIX A**.

¹ Historical trial pits excavated by others (2008) and previously not backfilled. The strata were logged for record purposes by PGL. The pits were then backfilled by PGL.

2.3 GROUNDWATER MONITORING

Groundwater was recorded when encountered during boring and excavation. Groundwater levels were monitored over a period of 20 minutes noting any changes that occurred as well as at the start and end of each drilling shift.

It must be noted that the normal rate of cable percussion drilling may not permit the recording of equilibrium groundwater levels. Groundwater may be excluded from the boring as the casing progresses in fine grained soils. Groundwater levels were assessed from standpipe installations where constructed. Otherwise the exploratory boreholes were backfilled with arisings and bentonite grout (to seal the borehole from infiltration and surface water) as defined by the contract specification and detailed on the exploratory logs. Further details of groundwater are presented in Section 4.1.

Groundwater was continuously monitored by IE Consulting using Automatic Pressure Transducer Data loggers – (Solinst Levellogger Gold Model 3001, LTF100/M30) and Barometric Pressure Transducer – (Solinst Barologger Gold Model 3001) over periods of seven (7) days up to thirty five (35) days between the 04/05/2012 and the 06/07/2012. Groundwater was monitored manually by IE Consulting using a dipmeter (liquid level indicator) between the 26/04/2012 and the 05/07/2012, occasionally. Groundwater was also monitored manually by Enviroglan Ltd. after completion of the fieldworks up to 28/08/2012. The groundwater monitoring data is presented in **APPENDIX C** and digitally (CD:/ *.xls). The calibrated/ compensated groundwater levels presented were those adjusted for variation in barometric pressure and drift in the data logger data. Details of the agreed continuous groundwater monitoring procedures accompany this report in **APPENDIX F**.

2.4 GROUND GAS

Ground gas concentrations were monitored by Enviroglan Ltd. on behalf PGL using a GA2000 Gas monitor upon completion of boreholes and construction of well installations between the 30/05/2012 to the 28/08/2012. The gas monitoring data is presented in **APPENDIX C**. It should be noted that the use of the term 'Gas' with the exploratory location reference (BHxxx) refers to standpipe well installation constructed within the SLAG or Made ground specifically for the purpose of monitoring ground gas where multiple well installations were constructed at within a single borehole.

Further details of ground gas are presented in Section 4.2. Details of the agreed detailed ground gas monitoring procedures accompany this report in **APPENDIX F**.

2.5 SAMPLING

A total of two hundred and thirty (230) bulk disturbed samples (B), two hundred and twenty one (221) small disturbed samples (D), two hundred and twenty one (221) environmental soil samples (ES), forty six (46) environmental leachate from solid samples (ES), seven (7) number marine samples, inclusive of one (1) number for quality control, (HW), three (3) number foreshore seepage samples, two (2) surface water samples from existing lagoons with the East Tip site, forty five (45) split spoon samples (SPTLS) in association with the standard penetration tests, twenty three (23) undisturbed piston (thin wall) samples (P) and twenty one (21) undisturbed, U_{100} samples (U) were taken during the course of the site investigation along with continuous rotary core (C) during the direct investigation. Not all of the piston or U_{100} samples were successfully recovered (see logs for details).

Following the completion of the drilling and groundwater monitoring borehole installation works, seventy two (72) number additional groundwater samples were collected from historical boreholes and standpipe installations over the tidal cycle. Details of the sampling including the measured parameters; pH, temperature, electrical conductivity and dissolved oxygen are presented on the field sampling record sheets presented in **APPENDIX D.2**, preceding the test results.

Groundwater sampling was undertaken by IE Consultants on behalf of PGL, the samples being taken from the standpipe installations constructed in boreholes.

Details of the agreed sampling procedures accompany this report in **APPENDIX F**.

2.6 IN-SITU TESTING

Standard Penetration Test, N_{SPT} values were undertaken in the boreholes up to depths of 25.0m, as detailed on the exploratory logs presented in **APPENDIX A**. The Standard Penetration Test was carried out in accordance with Geotechnical Investigation and Testing, Part 3 Standard penetration test, BS EN ISO 22476-3:2005.

In-situ falling head permeability tests were carried out in accordance with BS5930: 1999, Section 4: Cl. 25.4, during cable percussion boring over a duration of one (1) hour, unless a longer period was specified by the WYG EPT supervising engineer, as detailed on the borehole logs presented in **APPENDIX A**. The falling head tests were scheduled in strata where it was not possible to install a groundwater standpipe in any given borehole. e.g., where the installation is screened in the alluvial silt, falling head tests were carried out in the slag and/or the sand/gravel horizons, depending on the instructions given to the driller for each particular borehole.

Rising head permeability tests were carried out in a number of monitoring boreholes, scheduled by WYG EPT, following the completion of the drilling works. The rising head tests were carried out over a maximum period of one (1) hour. Tests were carried out at high and low tide.

Both falling and rising head tests were performed by PGL and monitored by IE Consulting using data loggers to record groundwater levels along with manual dips at set intervals during the test. The test data was subsequently processed by IE Consulting on behalf of PGL. This processed test data is presented in **APPENDIX B** along with the data logger files (CD:/ BHxxx RH Test Analysis *.xls). The shape or intake factor, f was derived from the condition at the base of the borehole at the test depth, the casing depth and test geometry as per Hvorslev (1951).

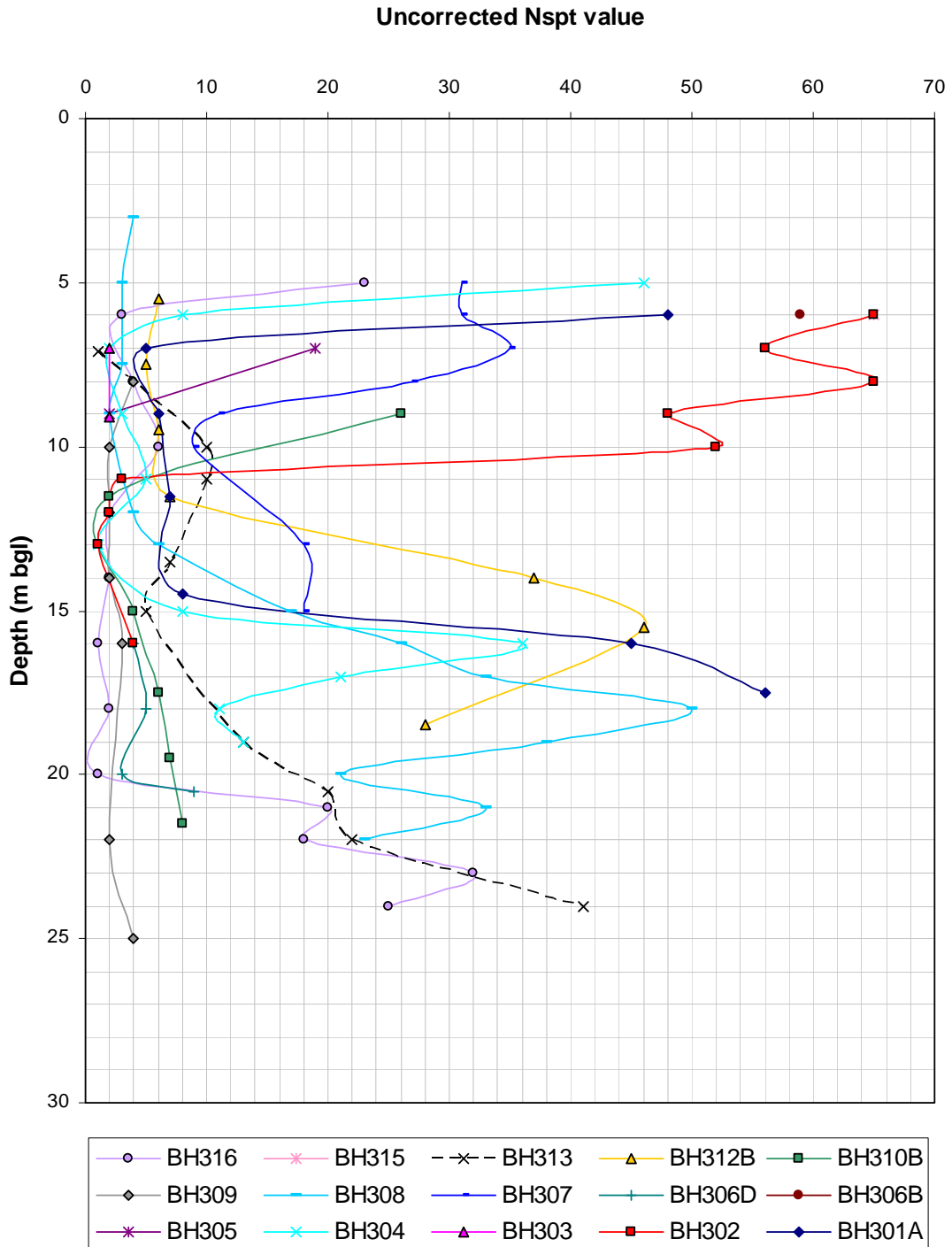
$$k = \frac{A}{fd} \frac{\log_e(H_0/H_1)}{t}$$

The ratio L/d was typically 1 to 2, giving a shape (or intake) factor, f of 0.5 to 1.7 for the falling head tests. A shape (or intake) factor, f of 2.2 to 7.5 was determined for the rising head tests. Permeability in the strata was assumed equal in both horizontal and vertical direction, $k_H/k_V = 1$ and L is the uncased borehole length over which the permeability was determined. Details of the test procedures accompany this report in **APPENDIX F**.

SUMMARY OF IN-SITU TESTING

Type	No.	Remarks
Standard Penetration Test, N_{SPT} value	125	N values ranging from $N_{SPT} = 0$ to 65 including refusals $N > 50$
Falling head permeability test	18	BH301 at 10m, BH302 at 6.5m, BH303 at 10.16m, BH304 at 17.66m, BH305 at 9.5m, BH306A at 6.4m, BH307 at 5.0m, BH307 at 14.5m, BH308 at 17.5m, BH309 at 6.88m (2No.), BH310B at 11.9m, BH310B at 23.74m, BH311 at 4.76m, BH312B at 18.9m (2No.), BH313 at 6.0m and BH315 at 5.3m.
Rising head permeability test	38	BH117 at 14.4m (2No.), BH122B at 23.9m (2No.), BH125R at 27.0m (2No.), BH128 at 2.0m, BH130 at 2.0m (2No.), BH301A at 16.3m (2No.), BH302 at 12.0m, BH304 at 7.2m, BH305 at 5.2m (2No.), BH306C at 28.5m (2No.), BH306D at 12.0m, BH307 at 5.5m (4No.), BH308 at 4.0m (2No.), BH309 at 8.2m (3No.), BH310B at 11.5m, BH310C at 39.6m (2No.), BH312B at 7.2m (2No.), BH312C at 25.5m, BH313 at 21.1m (2No.), BH315 at 5.4m (2No.) and BH316 at 6.0m.

The distribution of uncorrected Standard Penetration Test, N_{spt} values with depth, m below existing ground level (bgl) is presented below for cable percussion boreholes. Refusals, N_{spt}>50 where the complete set of 4 number 75mm increments were not achieved are not plotted.



3 LABORATORY TESTING

Prior to being couriered to a Specialist environmental analytical laboratory, Alcontrol Laboratories Ltd and ChemTest Ltd. for testing on behalf of PGL, all environmental solid samples (ES) were screened on site for radioactivity using a Minirad 1000, Portable Radiation Survey Monitor. The calibration certificate is presented in **APPENDIX F**. No radioactivity was detected above the meter detection limits in samples dispatched from site by PGL. Solid samples were dispatched within 48 hours of sampling. Initial asbestos screening was undertaken on all samples. In some instances where asbestos was positively identified further verification was undertaken on the sample to validate the presence or absence of asbestos. Subsequently eight laboratory quantitative analysis were undertaken for asbestos.

The groundwater samples were sampled from purged standpipe installations and dispatched to the specialist laboratory on the same day.

All rotary cores (C) were transported to PGL laboratory at Midleton, Co. Cork. Tests were scheduled by WYG EPT and were carried out by PGL in accordance with the ISRM suggested methods for rock characterisation, testing and monitoring.

All bulk disturbed samples (B, D, SPTLS) and undisturbed samples (P, U) remained in temporary storage on the East Tip. Following completion of the geoenvironmental analysis a selected number of samples were transported off-site by WYG EPT to Professional Soils Laboratory Ltd. (PSL UK) for geotechnical testing. The PSL UK report is included within this report for completeness. No geotechnical soil testing was undertaken by PGL.

One (1) number column upflow percolation test by the standard method was undertaken by Alcontrol on a composite sample from BH307. Subsequently one (1) number pH dependant leaching test (Arsenic, Boron, Cadmium, Chromium, Copper, Nickel, Lead, Selenium, Vanadium, Zinc and low level Mercury) was undertaken by ChemTest on the composite sample at a pH range 4 to 12.

Results for a modified column upflow percolation test are to date outstanding.

A summary of tests are detailed hereafter and presented in **APPENDIX D.1**, **APPENDIX D.2**, and **APPENDIX D.3** of this factual report.

3.1 ENVIRONMENTAL - SOLID

SUMMARY OF LABORATORY TESTING COMPLETED- ES

Solid samples (ES) Primary Contaminants		
Type	No.	Remarks
Arsenic-total	95	
Boron-water soluble	95	
Cadmium-total	95	
Chromium-total	95	
Chromium-hexavalent	93	
Copper-total	95	
Lead-total	95	
Mercury-total	95	
Nickel-total	95	
Selenium-total	95	
Zinc-total	96	
Cyanide, Complex	93	
Cyanide, Free	93	
Cyanide, Total	93	
Thiocyanate	93	
Sulphide	93	
Sulphate, Total	93	
Sulphate, water 2:1	93	
Sulphur-free	93	
pH	93	
Phenols-total	93	
Toluene extractable matter	38	Asbestos restricted testing, 94 number scheduled
PAH	93	
Asbestos - Screen All Samples	93	Inclusive of re-test (59)
Asbestos Quantification	8	
Phenols-monohydric	93	
Ammonical Nitrogen	93	
Moisture Content	93	
Fraction Organic Carbon	44	

SUMMARY OF LABORATORY TESTING COMPLETED- ES

Solid samples (ES) Soil Secondary Contaminants		
Type	No.	Remarks
Dioxins and Furans	5	Asbestos restricted testing. 9 samples scheduled.
PCBs	9	
Mineral Oils	17	
Speciated TPH	19	
SVOC including PAH and TICs	19	
VOC including TICs	19	
Acetone	9	
Anitomy total	93	
Barium Total	93	
Beryllium total	93	
Vanadium total	93	
Chloride	93	
Aluminum	93	
Calcium	93	
Magnesium	93	
Manganese	93	
Upflow percolation	1	BH307
pH dependence	1	BH307

SUMMARY OF LABORATORY TESTING COMPLETED- ES

Solid samples (ES) Leachate analysis		
Type	No.	Remarks
Aluminium	28	
Antimony	28	
Barium	28	
Calcium	28	
Cobalt	28	
Magnesium	28	
Manganese	28	
Molybdenum	28	
Tin	28	
Potassium	28	
Sodium	28	
Nitrate as NO ₃	28	
Chloride	28	
Fluoride	28	
Phosphorous	28	
Sulphate	28	
Boron	30	
Arsenic	30	
Cadmium	30	
Chromium	30	
Copper	30	
Iron	28	
Lead	30	
Mercury	30	
Nickel	30	
Selenium	30	
Thallium	28	
Vanadium	30	
Zinc	30	
Sulphide	28	
Hexavalent Chromium	28	
Phenols Total Monohydric	28	
Thiocyanate	28	
Total Cyanide	28	
Free Cyanide	28	
Complex Cyanide	28	

Solid samples (ES) Leachate analysis		
Type	No.	Remarks
Ammoniacal Nitrogen	28	
Free Sulphur	28	
Dissolved Organic Carbon	28	
Total TPH	28	
Total PAH	28	
PCBs	28	
Ph value	28	
Carbonate alkalinity as CaCo3	28	
Electrical Conductivity	28	
COD	28	
Total Dissolved Solids	28	
Speciated PAHs	28	

3.2 ENVIRONMENTAL - WATER

SUMMARY OF LABORATORY TESTING COMPLETED- EW

Water samples (EW)		
Type	No.	Remarks
Arsenic	84	
Cadmium	84	
Chromium-total dissolved	84	
Hexavalent chromium	76	
Lead-dissolved	84	
Mercury-dissolved	84	
Selenium-dissolved	84	
Boron-water soluble	84	
Copper-dissolved	84	
Nickel-dissolved	84	
Zinc-dissolved	84	
Cyanide-total	84	
Cyanide-complex	84	
Cyanide-free	84	
Thiocyanate	65	
Phenols total	42	
Sulphate	80	
Sulphide	84	
Sulphur free	84	
pH value	84	
Speciated Polyaromatic Hydrocarbons	82	
Antimony	84	
Barium	84	
Beryllium	45	
Vanadium	84	

Water samples (EW)																				
Type	No.	Remarks																		
Chloride	84																			
Ammoniacal Nitrogen as N	84																			
Nitrate as NO ₃	84																			
Chemical Oxygen Demand	84																			
Biological Oxygen Demand	84																			
Total Organic Carbon	84																			
Electrical Conductivity	84																			
Iron	84																			
Manganese	84																			
Calcium	84																			
Sodium	84																			
Magnesium	84																			
Hexavalent Chromium (Low Level)	-	<p><i>Sodium content restricted this test</i></p> <table> <thead> <tr> <th>Location</th> <th>Na, mg/l</th> </tr> </thead> <tbody> <tr> <td>BH305</td> <td>8560</td> </tr> <tr> <td>BH316</td> <td>12300</td> </tr> <tr> <td>BH310a</td> <td>10100</td> </tr> <tr> <td>BH311</td> <td>9510</td> </tr> <tr> <td>BH312c</td> <td>15600</td> </tr> <tr> <td>BH313</td> <td>9550</td> </tr> <tr> <td>SW1</td> <td>9390</td> </tr> <tr> <td>SW2</td> <td>9490</td> </tr> </tbody> </table> <p><i>The 8 samples selected all had > 9 times the permitted Na levels therefore the samples were unsuitable for testing where Cr III could not be separated from Cr VI due to Na blocking the filtration system.</i></p>	Location	Na, mg/l	BH305	8560	BH316	12300	BH310a	10100	BH311	9510	BH312c	15600	BH313	9550	SW1	9390	SW2	9490
Location	Na, mg/l																			
BH305	8560																			
BH316	12300																			
BH310a	10100																			
BH311	9510																			
BH312c	15600																			
BH313	9550																			
SW1	9390																			
SW2	9490																			
Potassium	84																			
Speciated TPH	84																			
VOCs including TICs	44																			
Aluminium	84																			
Cobolt	12																			
Molybdenum	16																			
Tin	12																			

Water samples (EW)		
Type	No.	Remarks
Fluoride	16	
Phosphorous - Dissolved	16	
Iron	16	
Thallium	12	
Speciated Phenols	16	
Carbonate Alkalinity as CaCO ₃	11	
PCBs	84	

3.3 GEOTECHNICAL - SOIL

SUMMARY OF LABORATORY TESTING COMPLETED- PSL

SUPERFICIAL		
Type	No.	Remarks
<i>Natural Moisture Content</i>	63	3% to 49%
<i>Bulk density</i>	8	1.76Mg/m ³ to 2.62Mg/m ³
<i>Atterberg Limit</i>	22	Liquid Limit 25% to 52% Plastic Limit 15% to 29% including non plastic NP soils Plasticity Index 8 to 26
<i>Particle Size Distribution</i>	22	
<i>Unconsolidated undrained triaxial compression UUT</i>	8	10kPa to 70kPa
<i>1-D consolidation, oedometer</i>	5	BH301A, BH303, BH307, BH310B, and BH312B.
<i>Laboratory hand vane</i>	7	4kPa to 28kPa

3.4 GEOTECHNICAL - ROCK

SUMMARY OF LABORATORY TESTING UNDERTAKEN

SOLID		
Type	No.	Remarks
Point Load Index	8	2.35MPa to 4.44MPa (2 No. values <1MPa omitted being unrealistically low).
Uniaxial Unconfined Compressive Strength, UCS	1	59MPa

4 GROUND CONDITIONS

The site was characterised by made ground consisting of: unprocessed slag waste (~5% steel and <5% refractory brick) up to 12.0m below existing ground level (bgl) (BH306D), typically 4.0m to 10.0m thick. Construction and demolition waste comprising of timber, glass, plastic, textiles and some hydrocarbon related products was encountered to 6.0m bgl being 0.3m to 4.2m thick and mixed with the unprocessed slag (BH312A, BH312B and BH314). Low concentrations of mill scale were identified to depths of 2.8m bgl, being 0.2m (OP06) to 2.8m (BH312B) thick and mixed with the unprocessed slag in isolated pockets within the site (BH301A, BH312B, OP06, OP14, TP01 and TP02). Flue dust and sludge were identified at (OP10) to 3.0m bgl, being 1.2m thick. Other sludges were identified at locations BH312A, OP01 and OP14 below a depth 0.05m bgl, being 0.1m to 1.06m thick.

The made ground was present up to depths of 5.8m bgl (BH312A) being underlain to depths by alluvial deposits. Slightly sandy SILT, slightly sandy slightly gravelly SILT and gravelly SILT were identified between depths of between 5.0m bgl (BH312C) and 24.4m bgl (BH306C) being up to 14.5m thick (BH316). CLAY deposits were encountered between depths of between 3.0m bgl (BH308) and 49.2m bgl (BH306C) being up to 10.1m thick (BH306C). Granular deposits, gravelly SAND, SAND AND GRAVEL and sandy GRAVEL were encountered to depths of between 1.3m bgl (OP12) and 43.1m bgl (BH310C) being up to 10.7m thick (BH125R). The granular deposits typically underlay the SILT deposits below 14.0m bgl (BH312B) to 23.5m bgl (BH310B). Slightly sandy slightly gravelly CLAY was also identified below the SILT (BH301A and BH304). Topsoil was identified at four locations (BH301, BH304, BH305 and BH308) being 300mm to 700mm thick.

Standard penetration test, N_{SPT} values (N_{SPT} 35 to 65) indicated dense to very dense Slag. The N_{SPT} values indicated very soft to firm SILT and CLAY deposits (N_{SPT} 0 to 9). The N_{SPT} values indicated firm to stiff CLAY underlying the SILT (N_{SPT} 11 to 56) at BH301A and BH304. The GRAVEL is described as medium dense to dense (N_{SPT} 21 to 46).

Weathered LIMESTONE was identified at depths of 23.8m bgl (BH117R) to 43.1m bgl (BH310C).

4.1 GROUNDWATER

Groundwater was noted during cable tool boring between depths of 0.5m bgl and 14.0m bgl, as summarised below. It should be noted that seasonal and tidal fluctuations in groundwater levels occur. Full details of the groundwater encountered are presented on the relevant borehole logs in **APPENDIX A**.

Thirty four (34) number 50mm diameter HDPE standpipe installations were constructed to allow for groundwater sampling and monitoring and ground gas monitoring. The well construction details were provided by WYG EPT such to isolate the groundwater and seal the well (using bentonite grout) from external influences. A tubular geotextile separator fabric was used as detailed on the borehole records in particular standpipe installations to minimise 'silting up' of the well. The pipework remained open at the surface to allow for groundwater monitoring. Groundwater was continuously monitored by IE Consulting using Automatic Pressure Transducer Data loggers. Subsequently having completed the continuous ground water monitoring, gas taps were fitted (26/07/2012) to monitor ground gas as specified locations.

SUMMARY OF GROUNDWATER STRIKES

Location	Groundwater strike, m bgl	Rose to m bgl	After , minutes	Comments
BH117R	4.5			3.68m see shift data Standpipe installed
BH125R	0.8			Standpipe installed
BH301A	3.4			See shift data BH log 2No. standpipes installed
BH302	3.9			2.4m to 3.5m see shift data 2No. standpipes installed
BH303	2.4			3.4m to 3.7m see shift data Standpipe installed
BH304	3.6			7.0m see shift data 2No. standpipes installed
BH305	3.2			2No. standpipes installed
BH306A				0.8m see shift data
BH306B	0.5			0.2m see shift data Standpipe installed
BH306C	1.2			0.98m to 1.2m See shift data Standpipe installed
BH306D	0.9			Standpipe installed
BH307	0.9			2No. standpipes installed
BH308				10.0m see shift data 2No. standpipes installed
BH309	2.5			2No. standpipes installed
BH310A	4.2	4.7	20	2.9m to 5.0m see shift data Standpipes installed
BH310A	6.0			
BH310B	5.1			3.0m see shift data 2No. standpipes installed

Location	Groundwater strike, m bgl	Rose to m bgl	After , minutes	Comments
BH310C	4.6			Steel casing and 125mm HDPE grouted in place to 39.6m.
BH311	3.1			3.0m see shift data Standpipes installed
BH312A	3.8			3.0m see shift data Standpipes installed
BH312B	3.4			4.5m to 7.8m see shift data Standpipes installed
BH312B	14.0	11.2	20	Standpipes installed
BH312C	2.5			Standpipes installed
BH313	2.5			1.8m to 4.0m see shift data 2No. standpipes installed
BH314	3.2			4.5m see shift data Standpipes installed
BH315	4.1			3.1m to 4.1m see shift data Standpipes installed
BH316	0.7			2.5m to 10.0m see shift data 2No. standpipes installed
OP02	2.6			Standing water level in open pit
OP03	2.2			Standing water level in open pit
OP04	1.5			Standing water level in open pit
OP05	3.3			Standing water level in open pit
OP07	3.4			Standing water level in open pit
OP08	2.1			Standing water level in open pit
OP09	3.3			Standing water level in open pit
OP10	2.8			Standing water level in open pit
OP11	3.1			Standing water level in open pit
OP12	2.9			Standing water level in open pit
OP13	1.5			Standing water level in open pit
OP14	2.6			Standing water level in open pit
TP01	2.8			
TP02	2.9			

Groundwater was monitored by Enviroglan Ltd manually using a dipmeter during the fieldworks between the 26th, April and the 05th July, 2012. This data is presented in **APPENDIX C**. Post-fieldworks groundwater was monitored manually using a dipmeter again by Enviroglan Ltd. on the following six (6) number occasions:

Date, dd, mm, yyyy
26 th July, 2012
30 th July, 2012
08 th August, 2012
13 th August, 2012
20 th August, 2012
28 th August, 2012

This data is presented in **APPENDIX C**, being inclusive of historical borehole installations. References to 'Gas' relate to the groundwater level within the gas monitoring well.

4.2 GROUND GAS

Ground gas was monitored (gas pressure, gas concentrations and gas flow rate measurements) using a GA2000 range gas analyser with flow measurement during the fieldworks phase. The calibration certificate is presented in **APPENDIX F**. This monitoring indicated no methane present at any of the boreholes locations as part of this phase of investigation works. However, Methane, CH₄ concentration, 10.8% to 65.4% were measured in historical borehole/well BH126 during the gas monitoring undertaken during the fieldworks period. Ground gas was monitored during the fieldworks by Enviroglan Ltd. on the following occasions:

Date, dd, mm, yyyy
11 th May, 2012
16 th May, 2012
30 th May, 2012
08 th June, 2012

Gas taps were fitted (26/07/2012) to monitor ground gas as specified locations. Ground gas was subsequently monitored post fieldworks by Enviroglan Ltd. on the following five (5) number occasions:

Date, dd, mm, yyyy
30 th July, 2012
08 th August, 2012
13 th August, 2012
20 th August, 2012
28 th August, 2012

The ground gas monitoring data is presented in **APPENDIX C**.

5 SUMMARY

1. The site was characterised by made ground consisting of dense unprocessed slag waste up to 12.0m below existing ground level (bgl). Construction and demolition waste comprising of timber, glass, plastic, textiles and some hydrocarbon related products was encountered to 6.0m bgl being 0.3m to 4.2m thick and mixed with the unprocessed slag.
2. Low concentrations of mill scale to depths 2.8m bgl to 5.0m bgl, being 0.2m to 2.0m thick were also encountered mixed with the unprocessed slag in isolated pockets within the site. Flue dust and sludge was identified at (OP10) to 3.0m bgl being 1.0m thick. Other sludges were identified at locations BH312A, OP01 and OP14 below a depth 0.05m bgl. Scrap metal was also present on site.
3. The made ground was underlain by alluvial deposits; very soft to firm slightly sandy SILT, slightly sandy slightly gravelly SILT and gravelly SILT were identified to depths of between 5.0m bgl and 24.4m bgl. Soft to stiff CLAY deposits were encountered between depths of between 1.1m bgl and 49.2m bgl. Medium dense to dense granular deposits were identified gravelly SAND, SAND AND GRAVEL and sandy GRAVEL to depths of between 1.3m bgl and 39.7m bgl being typically underlay the SILT deposits below 14.0m bgl. Firm to stiff slightly sandy slightly gravelly CLAY was also identified below the SILT.
4. Weathered LIMESTONE was identified at depth 23.8m bgl to 43.1m bgl.
5. Groundwater was encountered at depths of between 0.5m and 14.0m below existing ground level. Groundwater was monitored during and post fieldworks by IE Consulting between the 26th April and the 05th July, 2012. This data is presented in **APPENDIX C**.
6. Groundwater was monitored post fieldworks by Enviroglan Ltd. between the 26th July and 28th August, 2012. This data is presented in **APPENDIX C**.
7. Basic ground gas monitoring (concentration only) was undertaken by Enviroglan Ltd. using a GA2000 ground gas monitor during the fieldworks between the 11th May and the 08th June, 2012. Methane CH₄ was noted at the historical exploratory location, BH126, only. The ground gas monitoring data is presented in **APPENDIX C**.

-
8. More detailed (concentration, flow and pressure etc.) ground gas monitoring was undertaken by Enviroglan Ltd. post fieldworks between the 30th July and 28th August, 2012. This data is presented in **APPENDIX C**.
 9. Thirty four (34) number 50mm diameter standpipes (double and single installations) were constructed. A 125mm HDPE liner was placed at BH310C, extending to the depth of the bedrock. Details of groundwater strikes and standpipe/ well construction are presented graphically on the exploratory logs in **APPENDIX A**.
 10. A total of fifty six (56) number *in situ* permeability test (falling and rising head) were carried out. The test data is presented in **APPENDIX B**.
 11. Further details of the ground and groundwater conditions are presented on the exploratory logs and photographic records in **APPENDIX A** and groundwater monitoring data presented in **APPENDIX C**.
 12. Laboratory testing and environmental analysis was undertaken to assess the nature of the solids and groundwater, superficial deposits and solid geology encountered. The data is presented in **APPENDIX D.1**, **APPENDIX D.2** and **APPENDIX D.3**.
 13. The exploratory locations are presented in **APPENDIX E** of this factual report.
 14. The methodologies employed, agreed procedures and methods statements used during the fieldworks and subsequent monitoring and sampling, are presented in **APPENDIX F** of this factual report.

APPENDIX A

EXPLORATORY HOLE RECORDS AND PHOTOGRAPHIC RECORDS

Trenches/ Trial Pits

TP01 and TP02.

*OP01, OP02, OP03, OP04, OP05, OP06,
OP07, OP08, OP09, OP10, OP11, OP12,
OP13 and OP14.*

Cable percussion boreholes

BH301, BH301A, BH302, BH303, BH304,
BH305, BH306A, BH306B, BH306D,
BH307, BH308, BH309, BH310A, BH310B,
BH311, BH312A, BH312B, BH313, BH314,
BH315 and BH316.

Rotary Boreholes

BH306C, BH310C and BH312C.

BH117R and BH125R.

KEY TO SYMBOLS ON EXPLORATORY HOLE RECORDS

All linear dimensions are in metres or millimetres

DESCRIPTIONS

** Drillers Description
Friable Easily crumbled

SAMPLES

U() Undisturbed 102mm diameter sample, () denotes number of blows to drive sampler
U()F, U()P F- not recovered, P-partially recovered
U38 Undisturbed 38mm diameter sample
P(F), (P) Piston sample - disturbed
B Bulk sample - disturbed
D Jar Sample - disturbed
W Water Sample
CBR California Bearing Ratio mould sample
ES Chemical Sample for Contamination Analysis
SPTLS Standard Penetration Test S lump sample from split sampler

CORE RECOVERY AND ROCK QUALITY

TCR Total Core Recovery (% of Core Run)
SCR Solid Core Recovery (length of core having at least one full diameter as % of core run)
RQD Rock Quality Designation (length of solid core greater than 100mm as % of core run)
Where there is insufficient space for the TCR, SCR and RQD, the results may be found in the remarks column
lf Fracture Spacing in mm (Minimum/Average/Maximum) NI - non intact, NR - no recovery
AZCL Assumed Zone of Core Loss
NI Non intact

GROUNDWATER

▽ Groundwater strike
▼ Groundwater level after standing period
Date/Water Date of shift (day/month)/Depth to water at end of previous shift shown above the date and depth to water at beginning of shift given below the date

INSITU TESTING

S Standard Penetration Test - split barrel sampler
C Standard Penetration Test - solid 60° cone
SW Self Weight Penetration
Ivp, HVp (R) In Situ Vane Test, Hand Vane Test (R) demonstrates remoulded strength
K(F), (C), (R), (P) Permeability Test
HP Hand Penetrometer Test

MEASURED PROPERTIES

N Standard Penetration Test - blows required to drive 300mm after seating drive
x/y Denotes x blows for y mm within the Standard Penetration Test
x*/y Denotes x blows for y mm within the seating drive
 c_u Undrained Shear Strength (kN/m²)
CBR California Bearing Ratio

ROTARY DRILLING SIZES

Index Letter	Nominal Diameter (mm)	
	Borehole	Core
N	75	54
H	99	76
P	120	92
S	146	113

Source	Scale water (rolling mill and caster scale pits) clarifier system	
Waste Type	Flue Dust:	
Waste Code	10.09.09* / 10.09.10	
Waste Description	Colour	Black – dark grey
	Forms	Very fine powder, can also be found in pelletised form, and can be found as cake or sludge dependant on moisture
	Texture	Very loose
	General	Dense, heavy
	Source	Temporarily stockpiled in bags from bag filter houses and later pelletised forms. Main constituents iron and carbon



Waste Type	Refractories	
Waste Code	16.11.03* / 16.11.04	
Waste Description	Colour	Lighter browns and greys
	Forms	Powdery, fragmented brickwork
	Texture	Rubble
	General	Light coloured whole crushed and fragmented brickwork
	Source	Refractories are from the linings of the furnaces (usually as bricks) and mainly contain magnesium chloride



Waste Type	Slag: wastes from the processing of slag	
Waste Code	10.02.01	
Waste Description	Colour	Grey and mottled rusty brown
	Forms	Crushed – granular form
	Texture	Pockmarked
	General	Dense, heavy, conglomerated
	Source	Failed ladles, 'sculls', skimmed wastes from molten metal then crushed and graded for re-use



Waste Type	Slag: unprocessed slag, furnace slag	
Waste Code	10.02.02 & 10.09.03	
Waste Description	Colour	Grey and mottled rusty brown
	Forms	Unprocessed – fused, molten, angular, metallic
	Texture	Pockmarked
	General	Dense, heavy, conglomerated, difficult to drill and excavate through
	Source	Failed ladles, 'sculls', skimmed wastes from molten metal





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Trial Pit No
TP01
 Sheet 1 of 1

Project Name:
 Haulbowline East Tip

Project No.
 P12030

Co-ords: 179591E - 65493N
Level: 3.11 m AOD

Date
 05/06/2012

Location: Haulbowline, Co Cork

Dimensions: 16.00m

Scale
 1:25

Depth
 3.50m



Client: Cork County Council

Logged By
 PL

Samples & In Situ Testing				Level (m AOD)	Depth (m)	Stratum Description	Legend
Water	Depth (m)	Type	Results				
				2.61	0.50	Topsoil mixed with mill scale.	
				1.91	1.20	Mill Scale (approx. 60%) with dark grey, unprocessed Slag and metal (approx. 5%).	
				1.91	1.20	Oxidised brown, unprocessed SLAG with metal waste (approx. 10%), pockmarked cobbles, refractories (approx. 2%), metal waste including re-bar., gas cylinders (3No.), corrugated sheets (2No.), steel beams, IBC bag (1No.), car parts (approx <1%).	
				-0.39	3.50	Trial pit completed at 3.50 m	

Stability: Moderate.
Plant: 21t Tracked Excavator
Backfill: Arisings.

Groundwater: Standing at 2.8m.

Remarks: Trial pit terminated at required depth.



Number:

TP01

Project
Project No
Client

Haulbowline East Tip
P12030
Cork County Council



Number:

TP01

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<p>Number: TP01</p>	<p>Project Haulbowline East Tip Project No P12030 Client Cork County Council</p>	
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Number:

TP01

Project
Project No
Client

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Cork County Council



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Trial Pit No
TP02
Sheet 1 of 1

Project Name:
Haulbowline East Tip

Project No.
P12030

Co-ords: 179600E - 65465N
Level: 3.22 m AOD

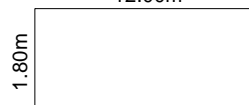
Date
05/06/2012

Location: Haulbowline, Co Cork

Dimensions: 12.00m

Scale
1:25

Depth
2.90m



Client: Cork County Council

Logged By
PL

Samples & In Situ Testing				Level (m AOD)	Depth (m)	Stratum Description	Legend
Water	Depth (m)	Type	Results				
				2.82	0.40	Topsoil with unprocessed SLAG.	
	0.40-0.90 0.40-0.90	ES ES				Grey, unprocessed SLAG in gravel form with molten and pockmarked cobbles.	
				2.32	0.90	Dark grey Mill Scale.	
	1.50-2.00 1.50-2.00	ES ES					
				1.22	2.00	Brown, clayey GRAVEL.	
	2.50-2.70 2.50-2.70	ES ES					
▽				0.32	2.90	Trial pit completed at 2.90 m	

Water Depth (m) Type Results Level Depth

Stability: Moderate.
Plant: 21t Tracked Excavator
Backfill: Arisings.

Groundwater: Standing at 2.9m.

Remarks: Trial pit terminated at required depth.



Number:

TP02

Project
Project No
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Haulbowline East Tip
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Cork County Council



Number:

TP02

Project
Project No
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Number:

TP02

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Number:

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Number:

TP02

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Slit Trench No

OP01

Sheet 1 of 1

Project Name:

Haulbowline East Tip

Project No.

P12030

Co-ords: 179644E - 65393N

Level: 3.19 m AOD

Date

29/05/2012

Location: Haulbowline, Co Cork

Dimensions: 5.00m

Depth

2.80m

1.80m



Scale

1:25

Client: Cork County Council

Logged By

PL

Water Strikes	Samples & In Situ Testing			Level (m AOD)	Depth (m)	Stratum Description	Legend
	Depth (m)	Type	Results				
				2.19	1.00	Very dark grey Sludge/ Filtercake.	
				1.49	1.70	Light grey, unprocessed SLAG with occasional plastics, metal (<1%) and small refractory bricks (<1%).	
				0.39	2.80	Unprocessed SLAG with occasional plastic, oily cloth and vegetation.	
						Slit Trench Complete at 2.80 m	3
Water	Depth	Type	Results	Level	Depth		

Remarks: Existing pit.



Number:

OP01

Project
Project No
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Haulbowline East Tip
P12030
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Number:

OP01

**Project
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Haulbowline East Tip
P12030
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Number:

OP01

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Slit Trench No

OP02

Sheet 1 of 1

Project Name:

Haulbowline East Tip

Project No.

P12030

Co-ords: 179645E - 65318N

Level: 3.16 m AOD

Date

29/05/2012

Location: Haulbowline, Co Cork

Dimensions: 5.00m

Depth

2.70m

2.00m



Scale

1:25

Client: Cork County Council

Logged By

PL

Water Strikes	Samples & In Situ Testing			Level (m AOD)	Depth (m)	Stratum Description	Legend
	Depth (m)	Type	Results				
				3.06	0.10	Compacted, unprocessed SLAG with in gravel and cobble form.	[Cross-hatched pattern]
						Light grey, unprocessed SLAG.	
				2.76 2.72	0.40 0.44	Thin, metallic layer.	[Cross-hatched pattern]
						Light grey, unprocessed SLAG in gravel and cobble form.	
				1.16	2.00	Refractory bricks (approx. 70%).	[Cross-hatched pattern]
				0.86	2.30	Dark grey, unprocessed SLAG with metal (approx <1%).	[Cross-hatched pattern]
				0.46	2.70	Slit Trench Complete at 2.70 m	

Remarks: Existing pit.



Number:

OP02

**Project
Project No
Client**

Haulbowline East Tip
P12030
Cork County Council



Number:

OP02

**Project
Project No
Client**

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P12030
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Number:

OP02

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Slit Trench No

OP03

Sheet 1 of 1

Project Name:

Haulbowline East Tip

Project No.:

P12030

Co-ords: 179690E - 65319N

Level: 2.99 m AOD

Date:

29/05/2012

Location: Haulbowline, Co Cork

Dimensions: 5.50m

Depth

3.20m

1.70m



Scale

1:25

Client: Cork County Council

Logged By

PL

Water Strikes	Samples & In Situ Testing			Level (m AOD)	Depth (m)	Stratum Description	Legend
	Depth (m)	Type	Results				
▽				2.89	0.10	Compacted, unprocessed SLAG.	1
						Grey, unprocessed SLAG with molten/ angular pieces.	
				2.19	0.80	Light grey, unprocessed SLAG.	2
				1.29	1.70	Dark, oxidised brown, unprocessed SLAG with metal waste (<1%).	
			-0.22	3.20	Slit Trench Complete at 3.20 m		3
Water	Depth	Type	Results	Level	Depth		

Remarks: Existing pit.



Number:

OP03

Project
Project No
Client

Haulbowline East Tip
P12030
Cork County Council



Number:

OP03

Project
Project No
Client

Haulbowline East Tip
P12030
Cork County Council



Number:

OP03

Project
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Slit Trench No

OP04

Sheet 1 of 1

Project Name:

Haulbowline East Tip

Project No.:

P12030

Co-ords: 179723E - 65317N

Level: 2.60 m AOD

Date:

29/05/2012

Location: Haulbowline, Co Cork

Dimensions: 5.00m

Depth:

2.30m

1.70m



Scale:

1:25

Client: Cork County Council

Logged By:

PL

Water Strikes	Samples & In Situ Testing			Level (m AOD)	Depth (m)	Stratum Description	Legend
	Depth (m)	Type	Results				
▽				2.30	0.30	Compact, molten, unprocessed SLAG.	
						Grey, unprocessed SLAG in gravel and cobble form.	
				1.80	0.80	Red/ brown, unprocessed SLAG with 600mm dia metal pieces and plastic.	
				0.30	2.30	Slit Trench Complete at 2.30 m	

Remarks: Existing pit.



Number:

OP04

Project
Project No
Client

Haulbowline East Tip
P12030
Cork County Council



Number:

OP04

Project
Project No
Client

Haulbowline East Tip
P12030
Cork County Council



Number:

OP04

Project
Project No
Client

Haulbowline East Tip
P12030
Cork County Council



Number:

OP04

Project
Project No
Client

Haulbowline East Tip
P12030
Cork County Council

