# dublin array

An Offshore Wind Farm
on the Kish and Bray Banks

# Environmental Impact Statement

January 2012 - Revision 1

Reviewed and Updated by

MRG CONSULTING ENGINEERS LIMITED

Prepared by

SAORGUS ENERGY LTD

Volume 3 of 5 - Appendix B
Physical Environmental Impact Assessment

# Geological Report on the Environmental Impact of the Proposed Kish & Bray Banks Wind Farm Development.

*Dr. J. R. Graham*

*February 2009*

# Contents

## List of Figures

# Introduction

This report attempts to identify and quantify the sedimentological impacts of the proposed development of an offshore wind farm, potentially consisting of 145 turbines, on the Kish and Bray Banks (Figure 1). The proposed site is situated approximately 10km east of the Irish coastline, off the coasts of counties Dublin and Wicklow (Figure 2). The report deals only with the potential impact of the main site and does not address any of the impacts associated with the installation of the related cable needed to link the development into the onshore electricity grid.

Data used is derived from that presented in the published geological, marine and environmental impact literature for the area. Additional information was incorporated from a number of site surveys undertaken on behalf of Saorgus Energy Ltd.

The proposed site for the development exists in a region characterised by a series of coast-parallel north-south trending offshore banks, and NNE-SSW trending sedimentary bedforms reflecting the control of the principal tidal current direction. These banks stand in shallow water and in places rise to within a few meters of the surface.

The banks occur in a punctuated line along the east coast of Ireland, with breaks maintained by strong current activity and sediment movement. The banks serve an important role in offering wave protection to the coast and controlling tidal flow. The overall bank structures are stable in nature, whereas surface sediments exist in dynamic equilibrium with tidal and current conditions.

Seabed surface sediment maps, published by the British Geological Survey (BGS) and the Geological Survey of Ireland (GSI), indicate the substrate as being composed of sand. This is corroborated by marine charts of the area (Admiralty chart No. 1468).

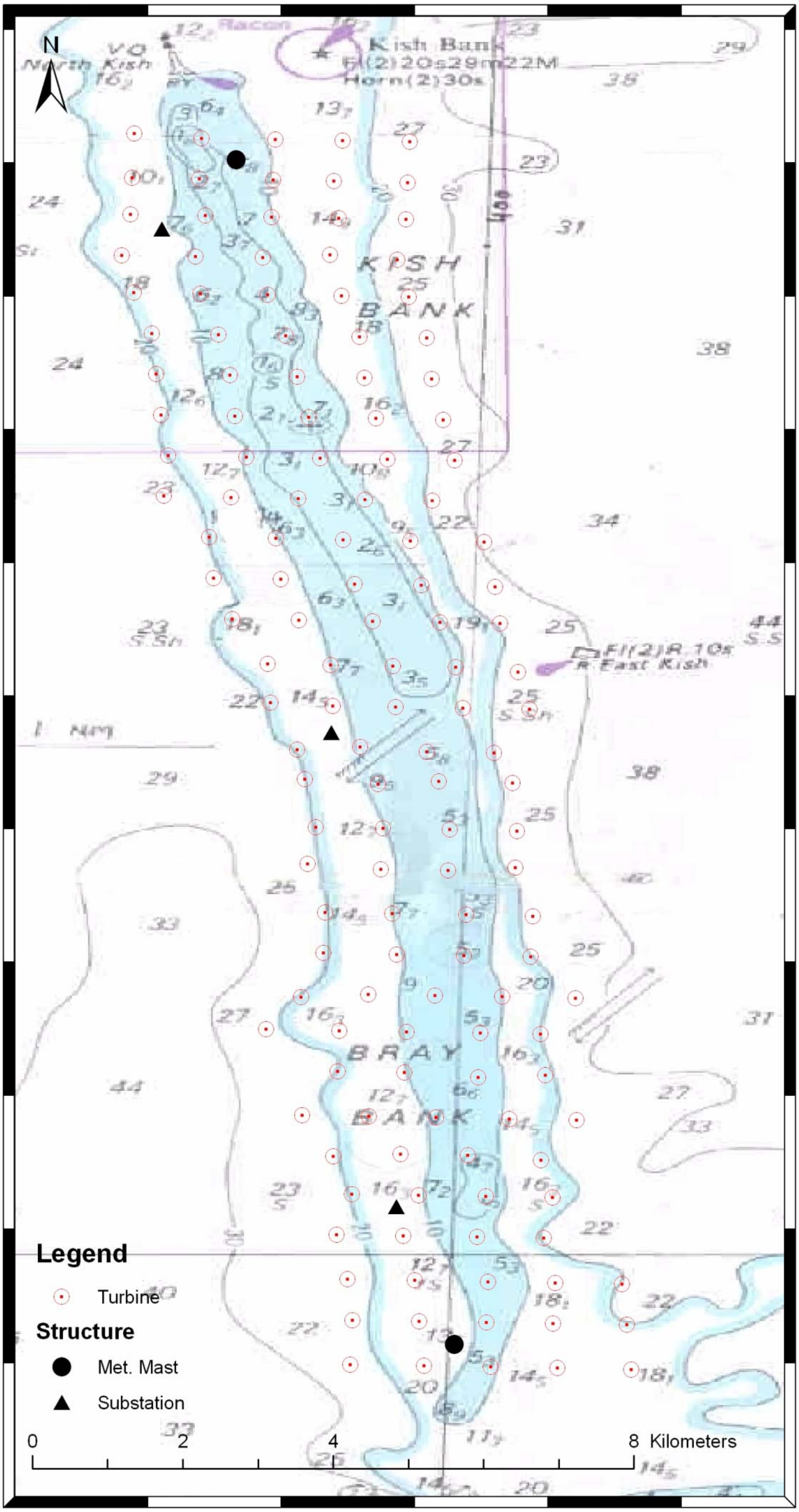



**Figure 1: Turbine layout over the proposed development. Depths presented in meters.**

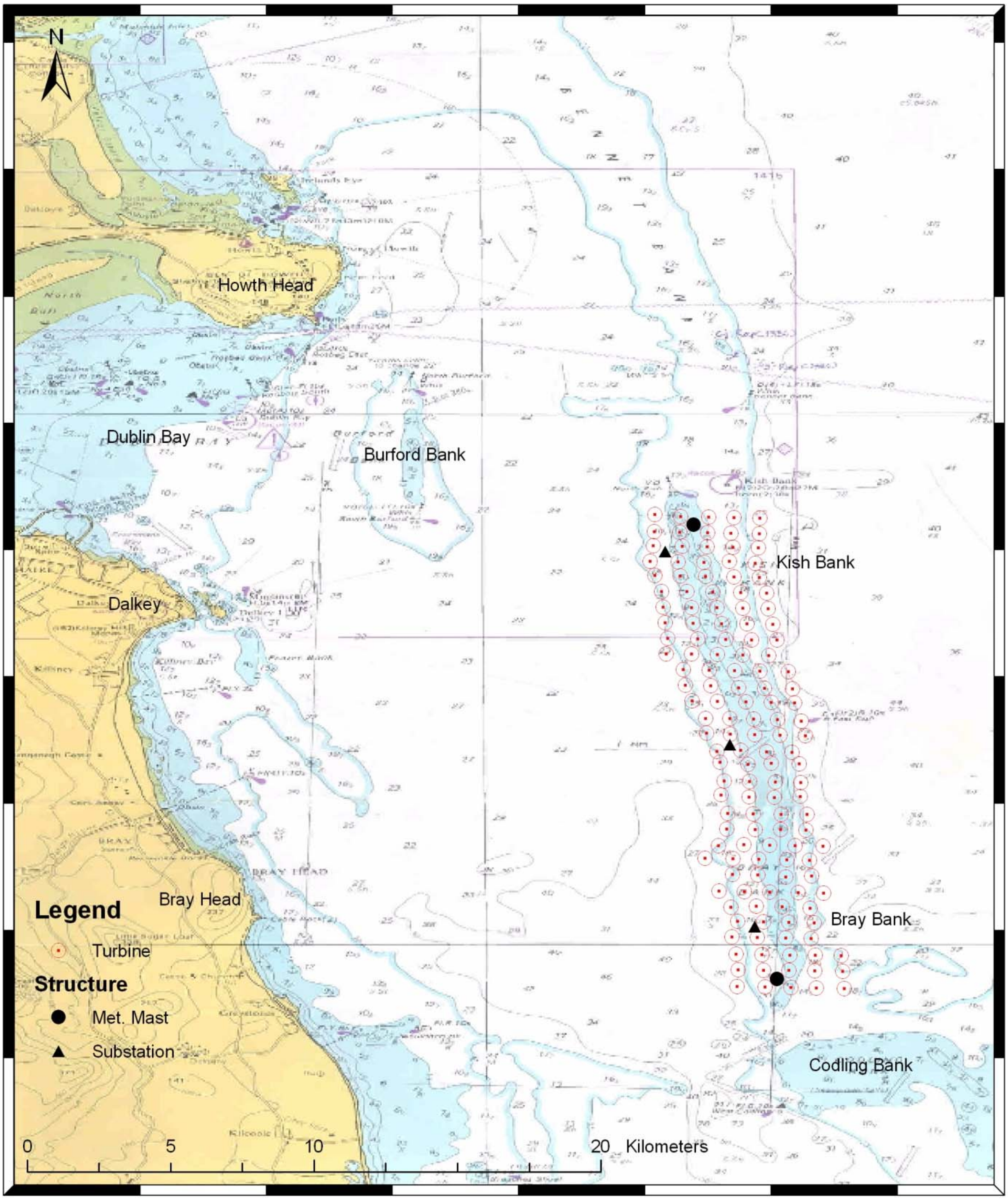



**Figure 2: Site location in relation to surrounding region. Depths presented in meters.**

## Bathymetry

Existing bathymetric data is represented on Admiralty Chart No. 1468 and was acquired between 1843 and 1911, using traditional sounding (lead-line) and navigation systems. The published chart indicates water-depths of 2-26m (Chart Datum) within the region of the proposed site. The planned site is located along a North-South section, with shallower (in places approximately 1m) depths being observed to the north of the site.

More recent bathymetric data for the region is presented in Wheeler *et al.* 2000. A series of profiles, with a mean line separation of 2kms, were acquired across the proposed site, using a single-beam echo-sounder for depth determination and Differential GPS for navigation. Line density from this study is greatest towards the north of the proposed site and reduces towards the south. The data acquired was reduced to chart datum through reference to onshore tide-gauges. A comparison of the data acquired and that presented on the Admiralty Chart for the area was performed, revealing a close correlation between the two datasets for the deeper isobaths on the Kish and Bray Banks, but less so in the shallower areas and towards the crests of the banks (Figure 3). This may suggest that there has been some migration of the banks in historical time; however the authors note that the markedly different technologies and techniques used in the generation of the datasets and formulation of isobaths limits their usefulness as "time-series".

In 2008, Saorgus Energy Ltd. commissioned a hydrographic and geophysical survey of the proposed site (Hydrographic Surveys Ltd., 2009). A key element of this work program was the acquisition of 115 pre-planned bathymetric profiles crossing the Kish and Bray Banks, with a line spacing of 150m. This work was performed between $13^{th}$ June and $11^{th}$ September 2008 by using a digital single-beam echo-sounder, with positioning provided via Differential GPS and an onshore tide-gauge facilitating reduction to chart datum.

The improved sounding and track density provided by this survey has allowed accurate water-depths to be determined for each proposed turbine location and facilitated more detailed descriptions of the surface morphology of the proposed site. Additionally, as the data is available in digital format and is of sufficient sounding density, Digital Elevation Models (DEM's) are easily derived in addition to traditional chart products, easing visualisation and interpretation (Figure 4).

Immediately apparent from these digital representations is that the bank complex is more sinuous than the representation provided on the Admiralty Chart for the area. This observation is in agreement with the depiction of the 10m isobath in Figure 3.

Figure 5 presents the distributions of slopes over the proposed site. Towards the north of the proposed site, slopes are steepest on the western face of the banks. Going south, the slope on the western face of the banks reduces while that on the eastern face becomes more prominent. Further south, the slope of the eastern face decreases while that of the western face increases, leading to a more symmetrical appearance. In this region, a broad shoal is evident in the 2008 acquired data, but is poorly reflected in the Admiralty Chart or Wheeler *et al.* (2000) isobaths. To the very south of the proposed site, the bank complex remains symmetrical but the crest narrows substantially.

No evidence of rock exposure is evident on the bathymetric data presented.

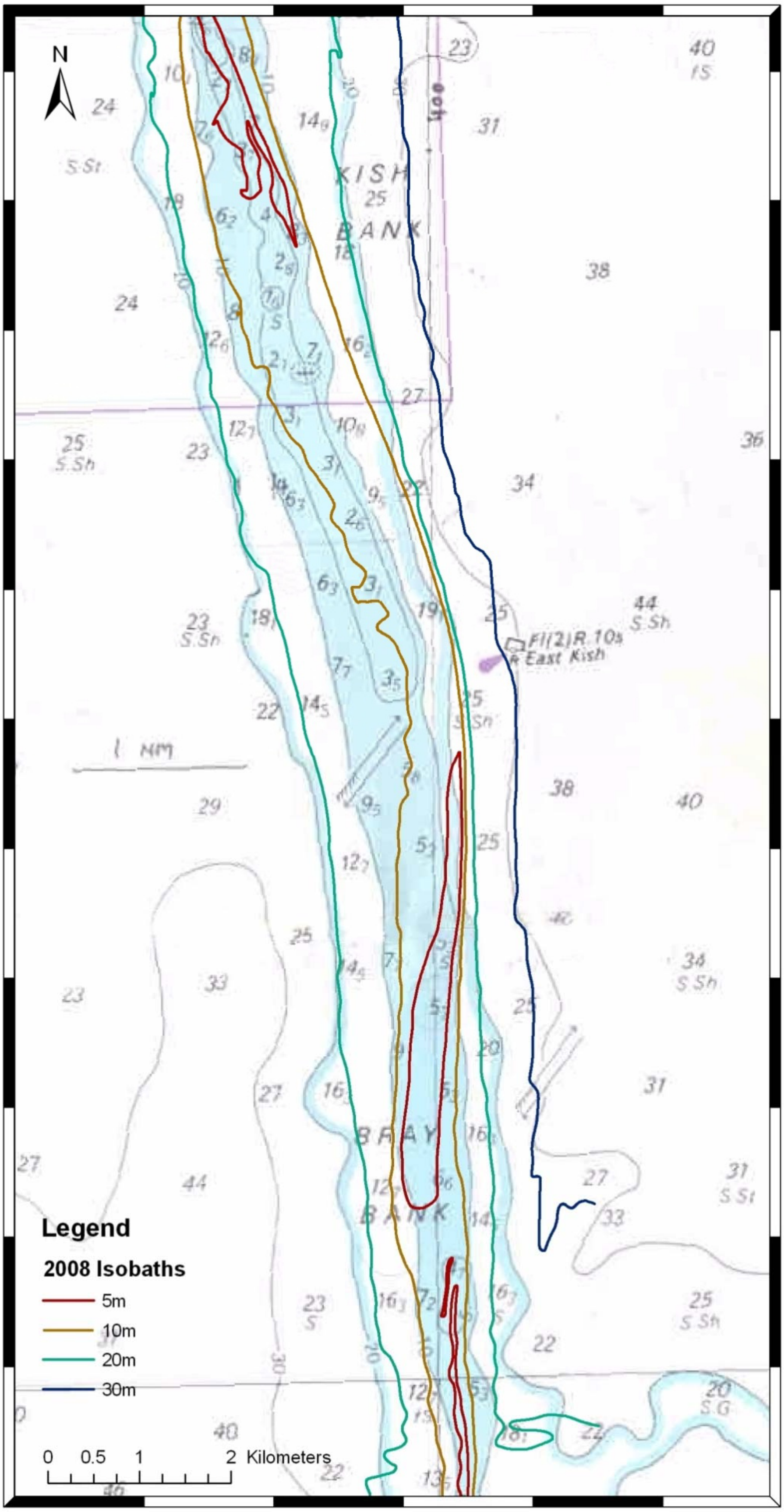



**Figure 3: Comparison of recently acquired (2008) and historical bathymetric data [after Wheeler *et al.*, 2000]. Depths depicted in metres.**

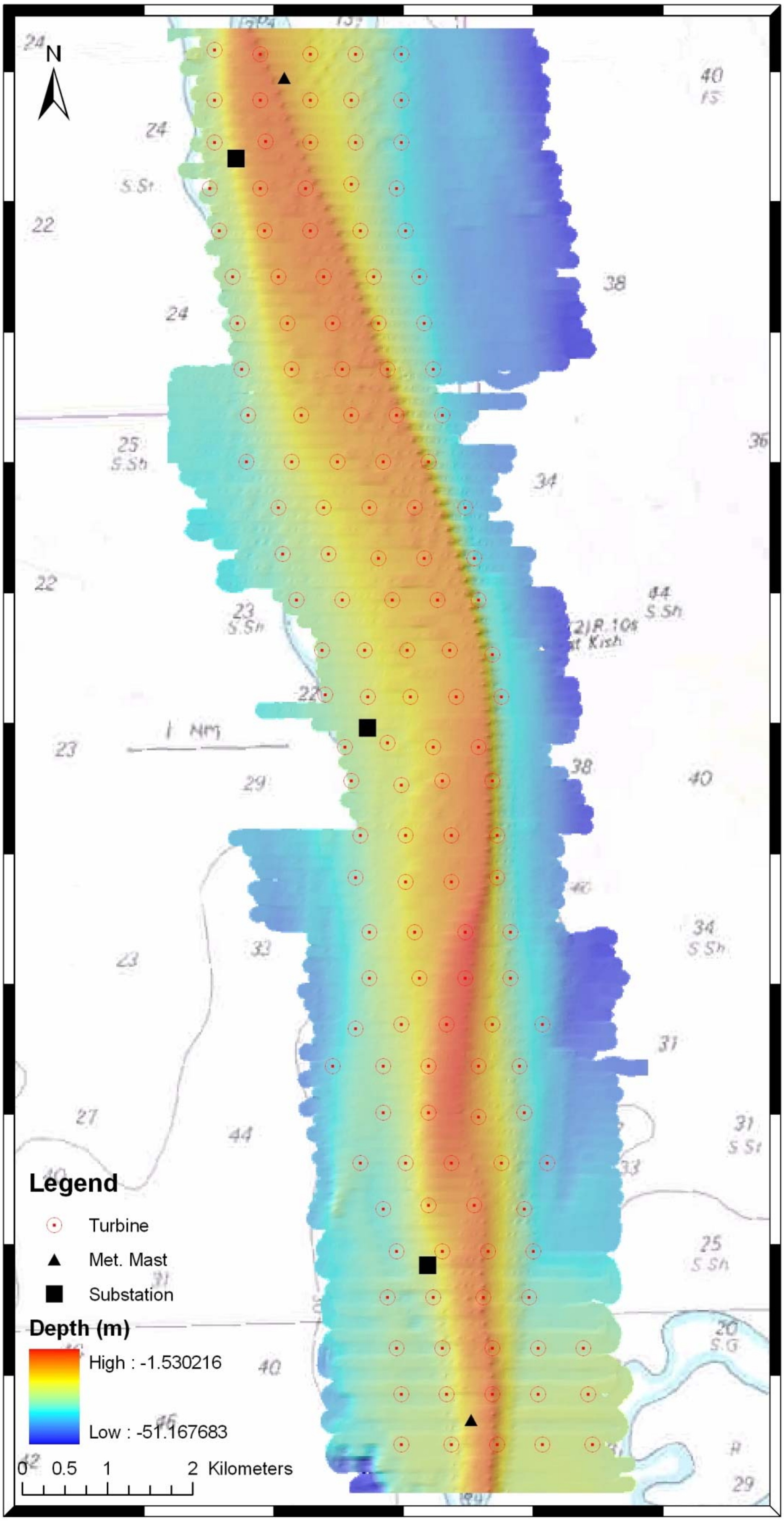



**Figure 4: Digital Elevation Model derived from soundings collected during the 2008 survey of the proposed site. East-West trending lines represent minor tidal shifts, magnified by the griding algorithm. Depths depicted in metres.**

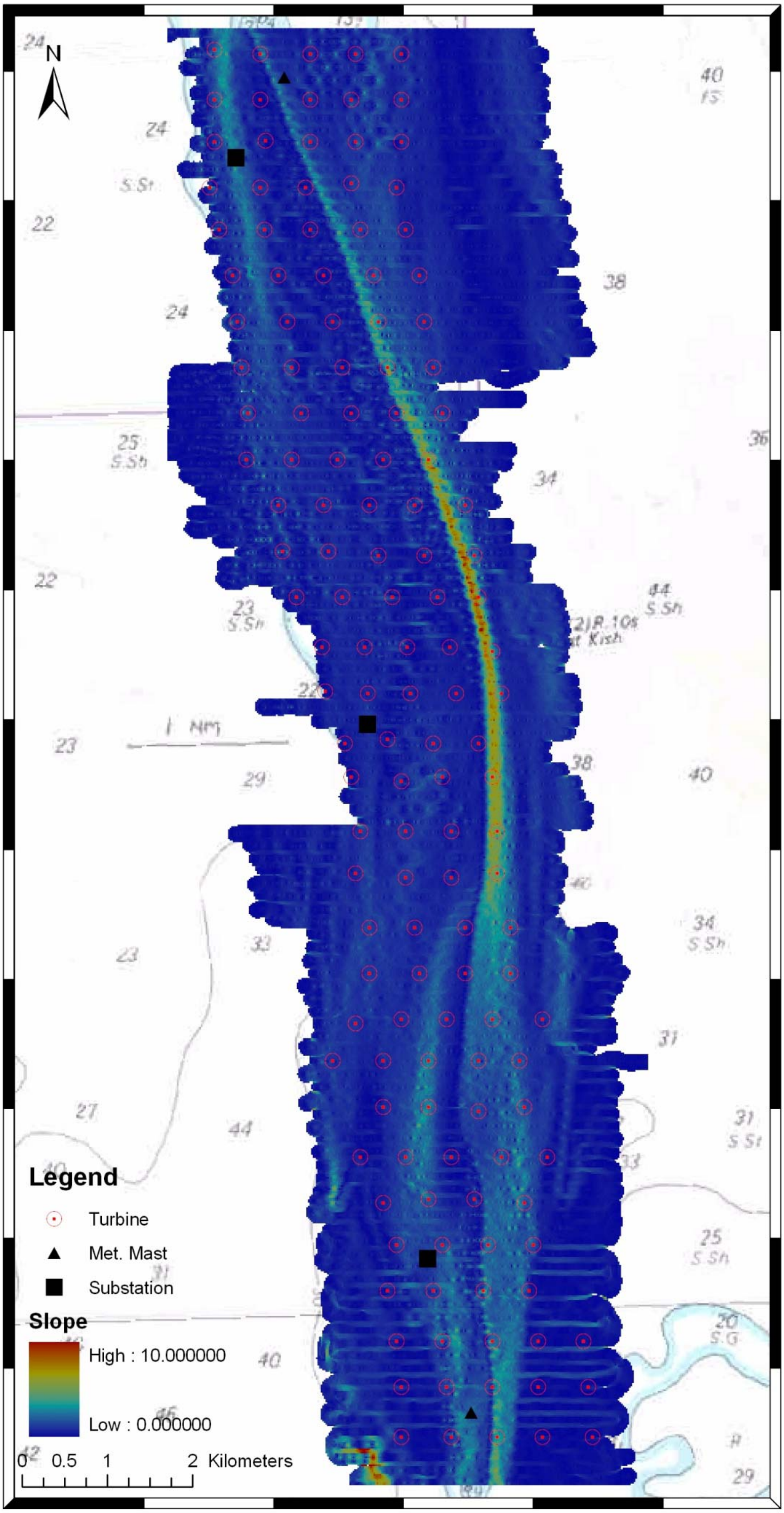



**Figure 5: Slope distribution over the proposed site. Warm colours represent areas of steepest slope (10 degrees). East-West trending lines represent minor tidal shifts, magnified by the griding algorithm and slope computation.**

# Hydrography

## Wave Environment

Wave data for the period 03rd May 2001 to 30th September 2004, was obtained through Met Eireann, for a nearby Marine Institute operated data-buoy (Data-buoy M2 - 53° 28.8'N 5°25.5'W). This data consisted of hourly wave height, period and wind direction readings. Summary statistics from this data set are presented in Figure 6.

In addition, the wind direction data has been used as a proxy for possible wave direction, with the resulting data being presented in the form of wave climate roses, indicating the frequency of waves coming from varying directions. Figure 8 represents all the data obtained in this format, while the second display represents a subset of the data – wave events with a height greater than 2.5m.

Additional data, previously presented (Natural Power, 2002), is also included for comparison. This data is derived from the UK Meteorological Office wave model. In contrast, this dataset covers a ten year period (1992 – 2001), but provides wind and wave data on a three hourly basis. Data was analysed for two points near the site (located at 53.00°N, 5.66°W and 53.25°N, 5.66°W). This data is also presented in the form of wave climate roses. Figure 9 shows the distribution of all waves during an average year for each point, while Figure 10 shows the orientation of those wave events with wave heights of greater than 2.5m.

The data indicates that the larger waves originate predominantly from the South to Southeast direction, with some input from the Northeast. This is consistent with the concept that waves arriving from the south are a result of channelling from the Atlantic, whereas those from other orientations are a result of the relatively short fetch of the Irish Sea.

Though wave conditions experienced closer to the proposed development are likely to be influenced by bathymetric and coastal factors, the close approximation between both datasets, suggests the data provides an accurate proxy for conditions experienced by the Kish and Bray Banks site.

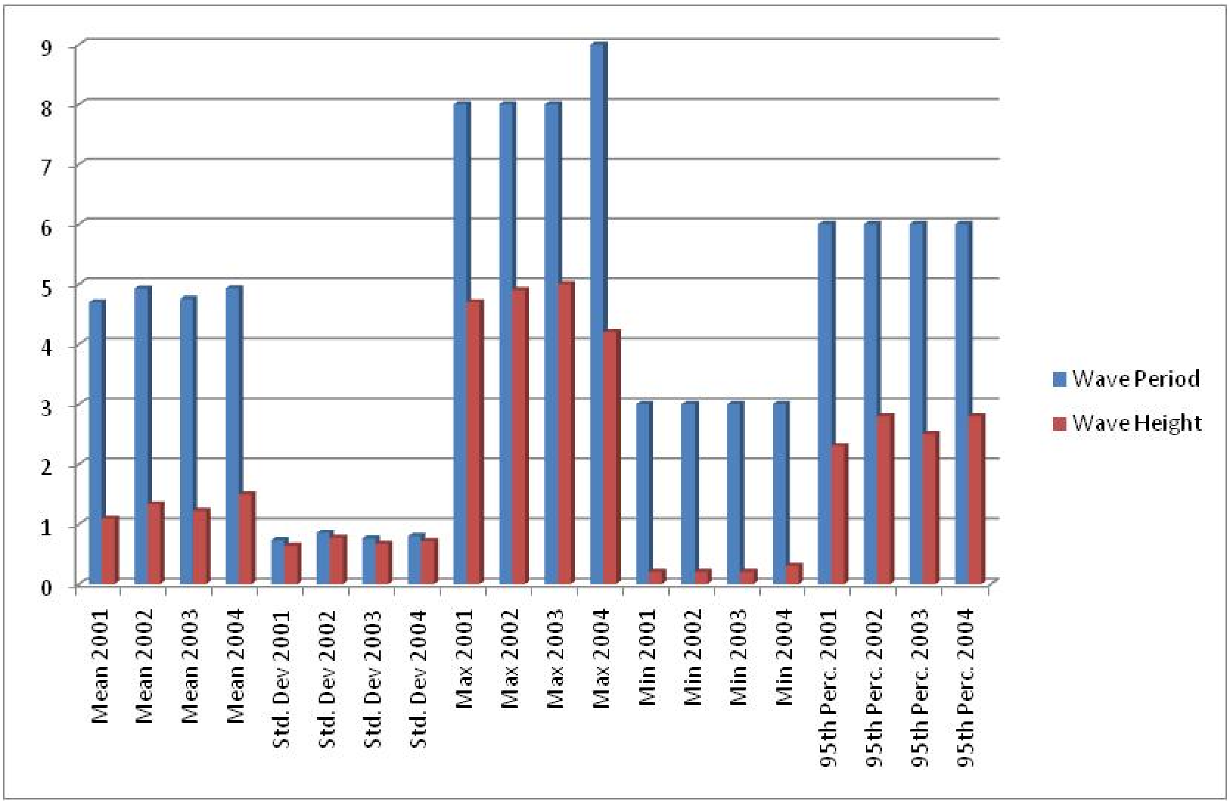



**Figure 6: Summary statistics calculated from wave data recorded at M2 Data Buoy.**

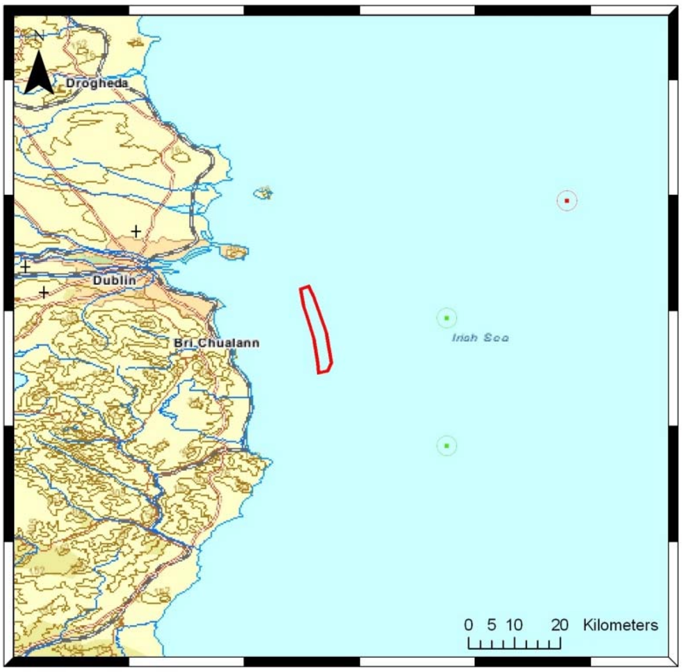



**Figure 7: Location of M2 data-buoy [red] and UK Meteorological Office Wave Model data points [green].**

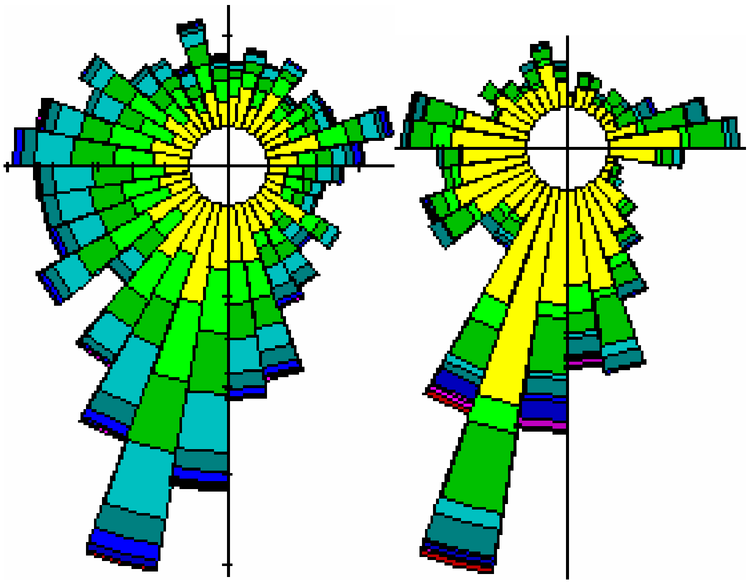


**Figure 8: Rose diagram for all waves recorded at M2 data-buoy (left) and those with a wave height greater than 2.5m (right). Observed wind direction was used to infer wave orientation.**

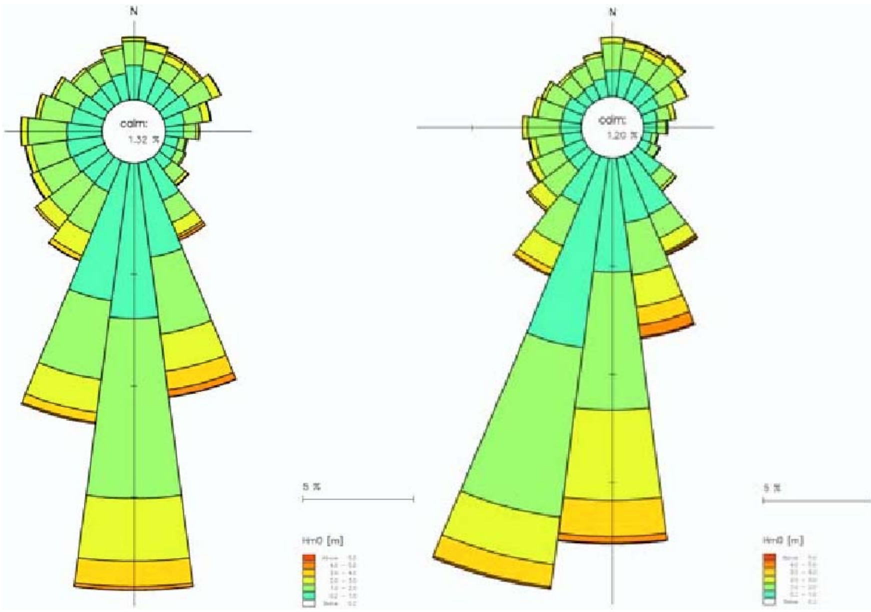



**Figure 9: Annual average wave roses – North [left] and South [right] (Natural Power, 2002).**

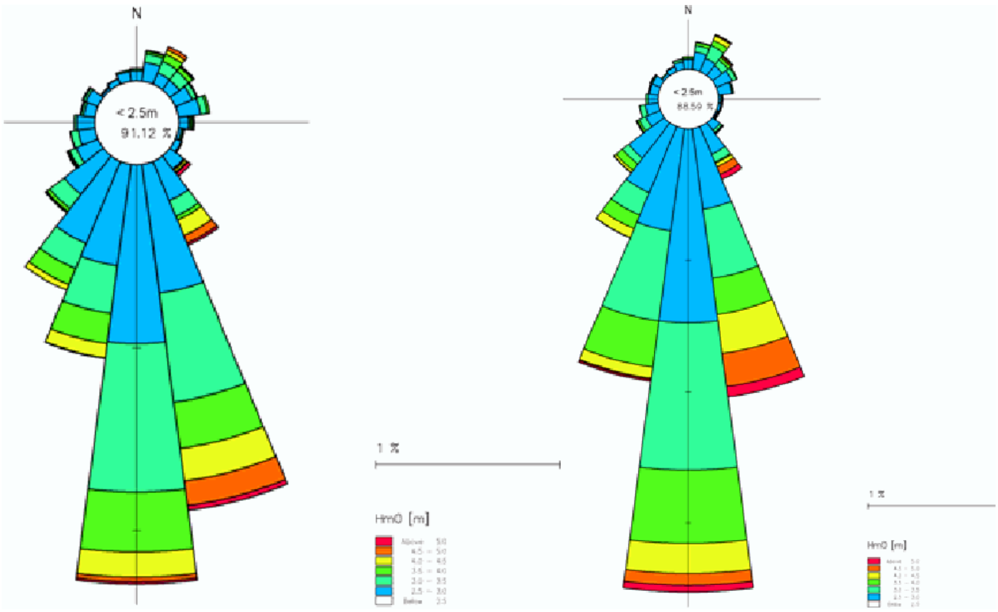


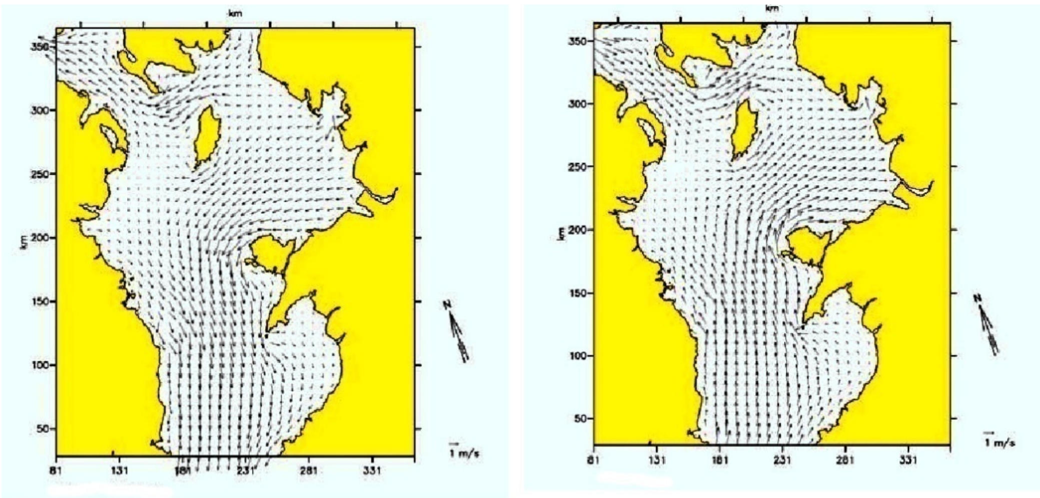

**Figure 10: Annual wave roses for wave events with heights greater than 2.5m -- North [left] and South [right] (Natural Power, 2002).**

## Tidal Amplitude

The Admiralty chart for the area indicates a mean high water spring tide of 4.1m above chart datum. This correlates well with tidal data previously presented from Dublin, which indicated a 1 in 50 year return period extreme water level of 5.32m above chart datum (Natural Power 2002). This can be extended to the proposed site.

## Tidal Flows

The proposed site experiences approximately southern flow during the Ebb tide and a northern flow direction during the Flood tide as shown on the Admiralty chart for the area. Data presented on the chart (Tidal Diamond C – 53°19'3N 5°44'5W) indicates a maximum tidal velocity of 2.2 knots (1.13 m/s) with an approximately North – South flow orientation. Further tidal flow markers located along and adjacent to the Kish Bank indicate a more NNE – SSW orientation. Data previously published for the adjacent Codling Bank area, shows a maximum recorded current velocity of 1.67m/s, but also interpreted that the Kish Bank area would experience lower flow velocities than that of the Codling Bank (Natural Power, 2002). More detailed evidence of local flow conditions can be elucidated with reference to the geological bed-forms observable at the proposed site.




Ebb

Flood

**Figure 11: Representation of Ebb and Flood tidal flow in the Irish Sea (Natural Power, 2002).**

# Present Baseline Sedimentary Conditions

## Overview

Current knowledge indicates that the overall bank structure exists in a stable state. Sedimentary bedforms observed both visually (Max *et al.*, 1976) and through the use of side-scan sonar (Wheeler *et al.*, 2000; Hydrographic Surveys Ltd., 2009) indicates that surficial sediment on the banks is actively mobile and migrating northwards. Sediment mapping, based on both sampling and sonar techniques indicate that the banks are composed of extensive thicknesses of sand to gravel sized material.

## Bedform Distribution

The surficial sedimentary conditions of the proposed site are indicated primarily through available sidescan sonar records and sediment samples.

Wheeler *et al.* (2000) produced a regional interpretation covering the proposed development on the basis of a loose network of sidescan sonar profiles (Figure 12). They identified five echo-facies covering the proposed development, on the basis of echo intensity and bedform character:

- **Stippled Bank Crest Facies –** Occurs in the north of the proposed development, on the crest of the Kish Bank. Represents a transition from sandwave dominated sediments on the bank margins, to environs dominated by planar beds with scattered patches of more highly reflective sediments – interpreted to represent more gravel rich deposits. The morphology of sandwaves observed in this echo-facies was interpreted to indicate a northwardly transport direction.
- **Bank-crest Facies –** This echo-facies occurs on the crest of the Bray Bank, as is described as being similar in character to the previously detailed unit, but lacking the patches of increased reflectivity.
- **Stippled Sandwave Facies –** This unit occurs on the margins of the Kish Bank and represents areas dominated by sandwaves but also displaying areas of increased reflectivity, interpreted to represent more gravel rich deposits.
- **Sandwave Facies –** This unit describes a highly mobile seafloor environment occurring on the margins of the bank complex. The facies is characterised by widespread sandwaves and other bedforms, with bedform development decreasing with distance from the bank complex. Bedform morphology implies a northerly net transport of sediment, with stronger tidal flows adjacent to the banks.
- **Stable Seabed Facies –** The final facies is found at greater distances from the bank complex and represents regions where no bedforms were imaged. The unit is interpreted to represent a stable or non-mobile seafloor. While no bedforms were imaged, small scale ripples below the resolution of

the sonar instrument may exist. Ground-truthing of this facies type indicates a sandy to silty composition.

Further sidescan data was recently acquired on behalf of Saorgus Energy Ltd. within the same site survey as that detailed for the bathymetric data and employing the same line density (Hydrographic Surveys Ltd., 2009). In general, the data acquired shows a similar distribution of bedforms as reported above, though additional small scale bedforms are observed on the bank crests.

The bedform patterns described can be used to give an indication of the flow conditions experienced at the proposed site. Analogue modelling has determined the flow conditions necessary to generate a range of bedforms for sediments of a given size. Although the conditions experienced by the proposed site differ somewhat, from those used in experiments (experiments were carried out based on unidirectional flow; while the proposed site experiences bi-directional flow – sediments responding to both the Ebb and Flood tides and wave action), they still serve to provide an approximation of the conditions experienced, as the strongest ebb and flood flows follow differing pathways. For sediments with a grain size of approximately 0.5mm (medium sand), sand waves (dunes) are observed to form under flow velocities of approximately 0.6 m/s and gradually change to high-energy planar bed features at velocities above 1 m/s (Leeder, 1999). Under flow velocities of less than 0.6 m/s, such sediments are observed to form ripples.

As a result, the pattern of bedforms observed suggests that the strongest tidal flow conditions are found closest to the banks, due to the acceleration of tidal flows around the obstruction which the banks present.

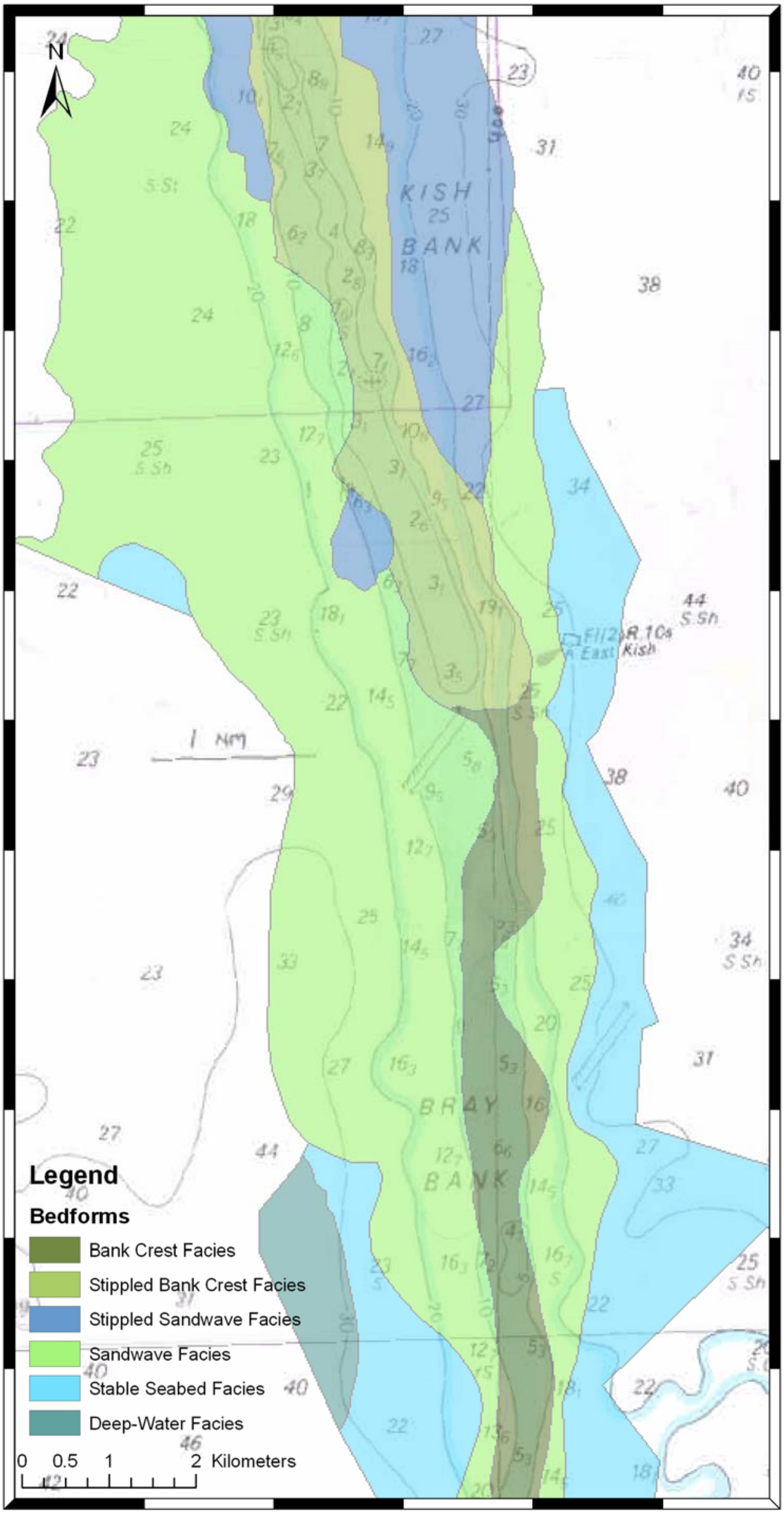



**Figure 12: Seafloor facies distribution at proposed site (as mapped by Wheeler *et al.*, 2000).**

## Sediment Distribution Patterns

Available sediment sampling data (Max *et al.*, 1976 & Wheeler *et al.*, 2000) indicates that the surficial sediments of the banks and surrounding area are composed primarily of sand-sized particles, with coarser gravely material concentrated on the bank crests. The limited number of sample stations suggests a degree of sediment fining towards the north.

Further information relating to the sediments of the area can be found in the biological report carried out as part of the development. A series of trawls were run over the site using a biological dredge fitted with a 1cm mesh bag, any sediment samples recovered were briefly described based on hand sample appearance. The report based on this work goes on to state:

> *"The survey showed that the shallower parts of the Kish and Bray banks consisted of fine sand with some shell. Along the western edge of the Kish Bank the seabed was predominantly coarse shell with sand, which graded into shell with pebbles, gravel and stones along the west of the Bray Bank and larger cobbles and stones at the southern end of the Bray Bank. The eastern side of the Kish Bank consisted of fine sand and coarse shell. It was likely that areas of hard substratum occurred at these sites due to the presence of Alcyonium digitatum in the samples. The substratum towards the south east of the Bray Bank consisted of pebbles, stones and mud"* (EcoServe, 2008).

However, caution must be used when integrating this data with other sources. The samples obtained as part of this work contain an unknown "skew" in sediment size distribution due to the means used to acquire them. The 1cm mesh bag will allow quite large sediment particles to pass through, and the samples gathered are that portion of the seabed effectively trapped and retained by organic matter. In addition, the trawls were run over significant distances, as such, the sample may represent inputs from several bottom-types. A further potential source of error is the method used to describe the sample (visual estimation of grain size vs. granulometry as used by Wheeler *et al.*, 2000). With these caveats, locations for several of these shorter trawls are presented in Figure 13 along with accompanying details (Figure 14).

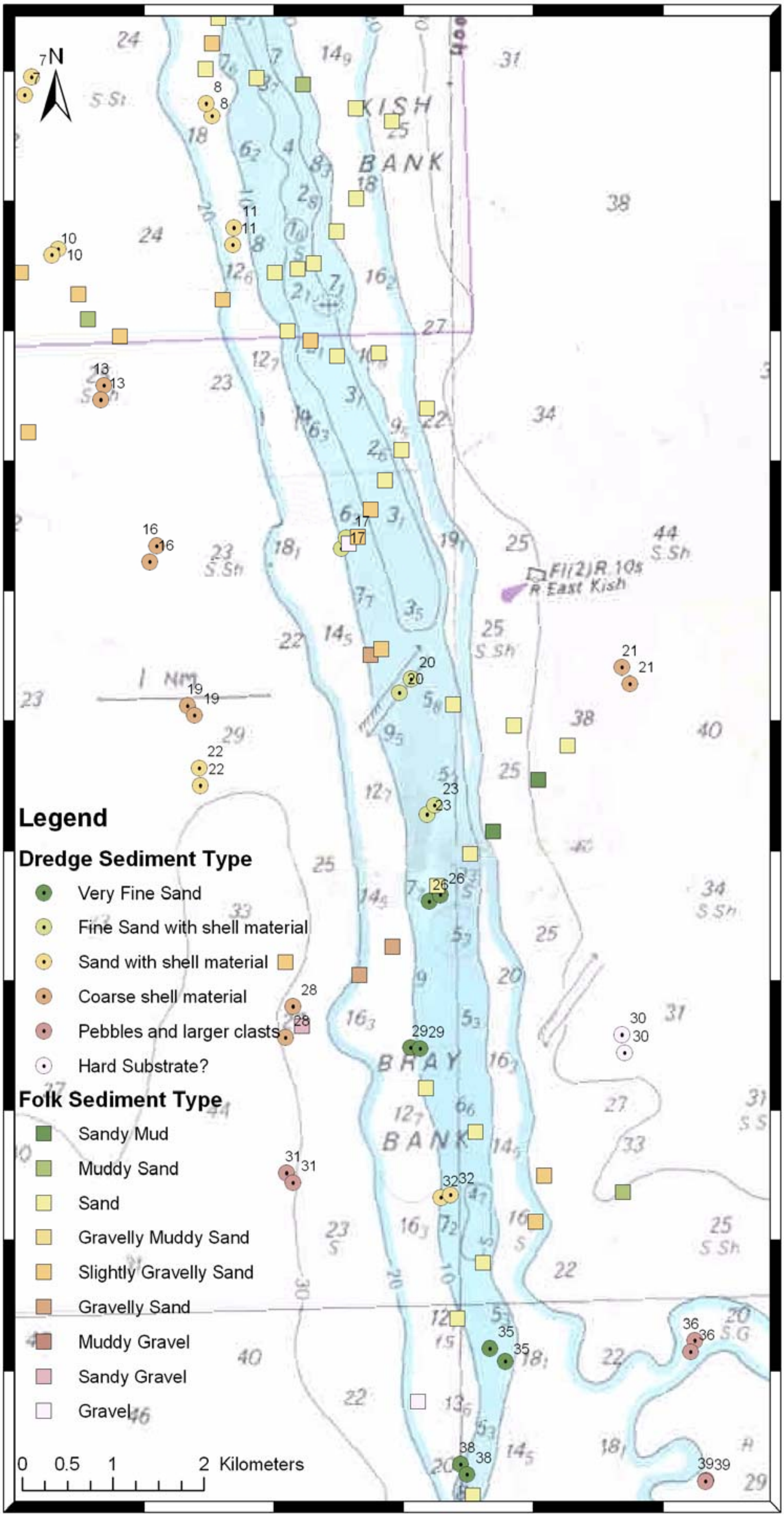

N
KISH BANK
BRAY BANK
Fl(2)R.10s
East Kish
1 NM
Legend
Dredge Sediment Type
Very Fine Sand
Fine Sand with shell material
Sand with shell material
Coarse shell material
Pebbles and larger clasts
Hard Substrate?
Folk Sediment Type
Sandy Mud
Muddy Sand
Sand
Gravelly Muddy Sand
Slightly Gravelly Sand
Gravelly Sand
Muddy Gravel
Sandy Gravel
Gravel
0 0.5 1 2 Kilometers

**Figure 13: Locations of biological trawls traversing proposed development (geological description abbreviated to facilitate display) and samples presented in Wheeler *et al.* (2000).**

| Site no. | Site name | Substratum | Distance (m) |
|---|---|---|---|
| 1 | North west of Kish Bank | Predominantly shell. Must also be rock as *Alcyonium digitatum* recorded. | 180 |
| 2 | North of Kish Bank | Fine sand with some shell. | 180 |
| 7 | North west of Kish Bank | Coarse shell with sand. | 160 |
| 8 | On Kish Bank – northern half | Sand with some shell. | 160 |
| 10 | West of Kish Bank | Sand with coarse shell. | 100 |
| 11 | On Kish Bank – middle of Bank | Sand and broken shell. | 180 |
| 13 | West of Kish Bank | Coarse broken shell. | 160 |
| 16 | South west of Bank | Coarse shell. | 190 |
| 17 | On Kish Bank – south of Bank | Fine sand and broken shell. | 130 |
| 19 | North west of Bray Bank | Very coarse shell. | 130 |
| 20 | On Bray Bank – northern tip | Fine sand and broken shell. | 210 |
| 21 | North east of Bray Bank | Very coarse shell. | 200 |
| 22 | North west of Bray Bank | Coarse shell with sand. Mainly live *Nucula* sp. | 190 |
| 23 | On Bray Bank – northern half | Fine sand with some shell. | 150 |
| 26 | On Bray Bank – middle of Bank | Very fine sand. | 150 |
| 28 | West of Bray Bank | Very coarse shell. | 130 |
| 29 | On Bray Bank – middle of Bank | Very fine sand. | 120 |
| 30 | East of Bray Bank | Coarse shell but also must be rocky as *Alcyonium digitatum* recorded. | 210 |
| 31 | South west of Bray Bank | Stones, gravel, shell and sand. | 120 |
| 32 | On Bray Bank – southern half | Sand with broken shell and some pebbles. | 110 |
| 35 | On Bray Bank – southern half | Very fine sand. | 220 |
| 36 | South east of Bray Bank | Pebbles, stones and mud. | 150 |
| 38 | On Bray Bank – southern tip | Very fine sand. | 130 |
| 39 | South east of Bray Bank | Sandy mud with pebbles, shell and gravel. | 13 |
| 41 | South of Bray Bank | Pebbles and stones covered in bryozoan crusts with some sand. | 170 |

**Figure 14: Sediment descriptions from Short Biological Trawls**

## Subsurface Stratigraphy

The subsurface stratigraphy of the proposed site is detailed through reference to available borehole information, shallow seismic data acquired from the area and the established seismostratigraphic succession for the region.

Three boreholes were undertaken on behalf of Saorgus Energy Ltd. during 2008 (Glover Site Investigations Ltd., 2008). On the basis of sediment descriptions and geotechnical measurements provided, a sequence of 3 units can be determined:

- **Unit 1: Seafloor to 3-6m –** Uppermost unit of loose silty fine to medium sands with traces of gravel and occasional shells.
- **Unit 2: 3-6m to 12-15m –** Dense silty fine to medium sands with traces of fine gravel and occasional shells
- **Unit 3: 12-15m to 20m –** Very dense silty fine to medium sands with occasional shells.

This succession correlates closely with data reported from a borehole in the vicinity of the Kish Lighthouse by Wheeler *et al.* (2000). They describe a sequence of 15m of fine sands overlying 11m of cohesive silts with some sand content. They note the existence of a layer of 'stiff clay' separating these units.

Wheeler *et al.* (2000) go on to define a working schema of echo-facies for the area on the basis of boomer seismic profiles, identifying three units and correlating these with the established regional nomenclature. Within this schema, echo-facies A seems to correlate with borehole Units 1 & 2, while echo-facies C potentially correlates with borehole Unit 3. Echo-facies B is depicted as a relatively thin unit, inferred to correlate with the 'stiff clay' described from the Kish Lighthouse borehole, but absent from the 2008 series of boreholes. Based on the regional stratigraphy, echo-facies C is inferred to be underlain by glacial till deposits.

Additional boomer profiles were acquired for Saorgus Energy Ltd. by Hydrographic Surveys Ltd., though at a reduced line density in comparison to bathymetric profiles (Figure 15). A similar sequence to that previously reported is observed on these profiles, though continuity of reflectors beneath the bank crests is not readily apparent. This is likely to be due to a combination of insufficient source energy, the density and thickness of the overlying sediments and the masking effect due to water-column multiples inherent in shallow-water surveys.

Echo-facies A has a mean thickness of approximately 20m over the survey area, but thins noticeably towards the south. Correlation of the available borehole information and the acoustic character of this unit suggest a predominantly sand based composition with minor silt and gravel content. Hyperbolic events in the near surface delineate localised patches of coarser sediment.

Towards the base of several profiles, reflections with an irregular profile / eroded appearance become apparent. Due to the density of the overlying media, it is difficult to determine if these reflections represent bedrock or an eroded underlying till. However, considering the regional geology of the area, a glacial origin is suggested. None of the boreholes available intersect this unit. Towards the north of the site, these reflections are at sufficient depth to be of no concern, but may need to be taken into account during emplacement of foundations towards the south of the proposed development.

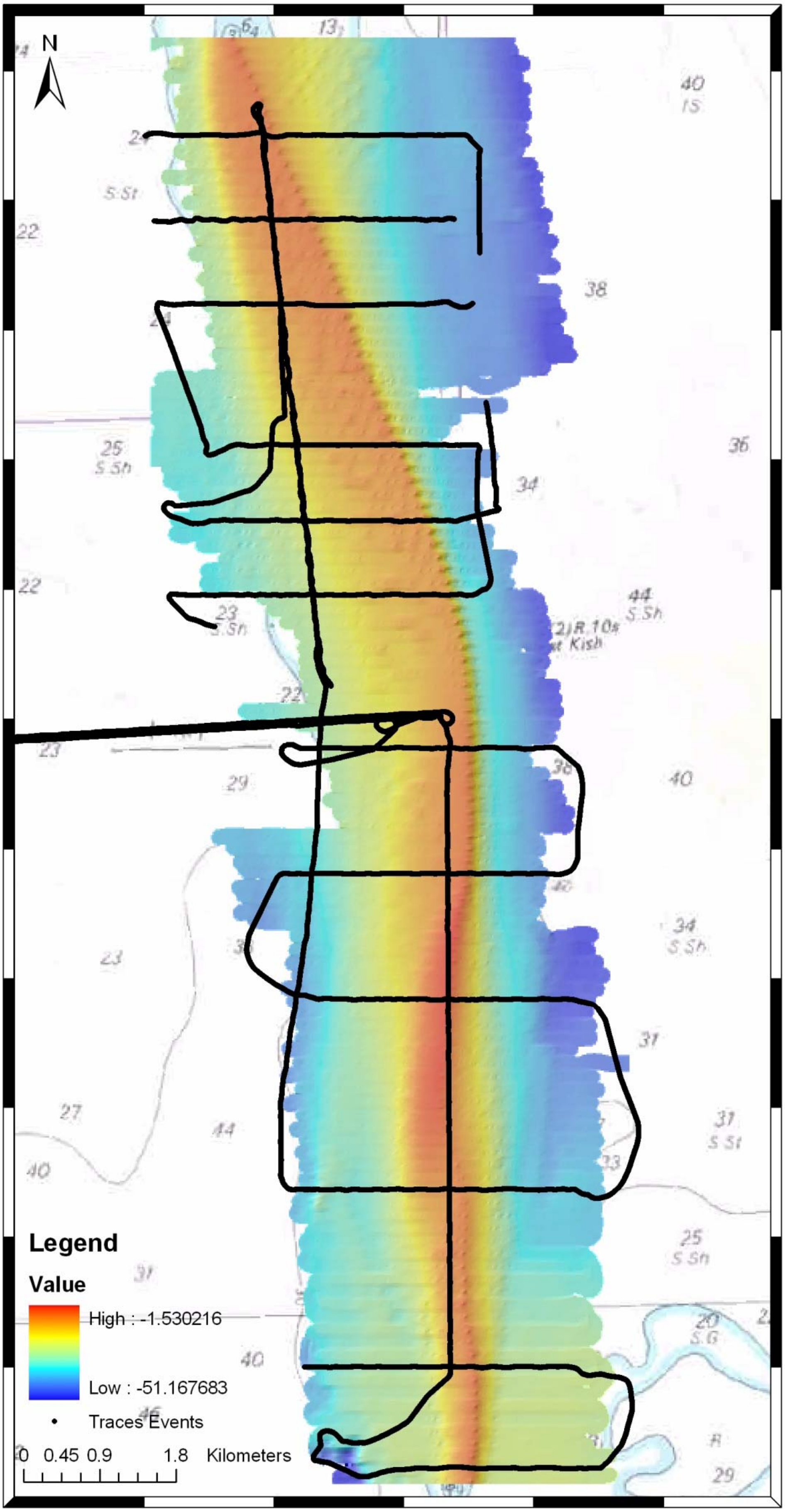



**Figure 15: Trackplot of boomer profiles acquired in 2008, across the proposed development. Depths depicted in metres.**

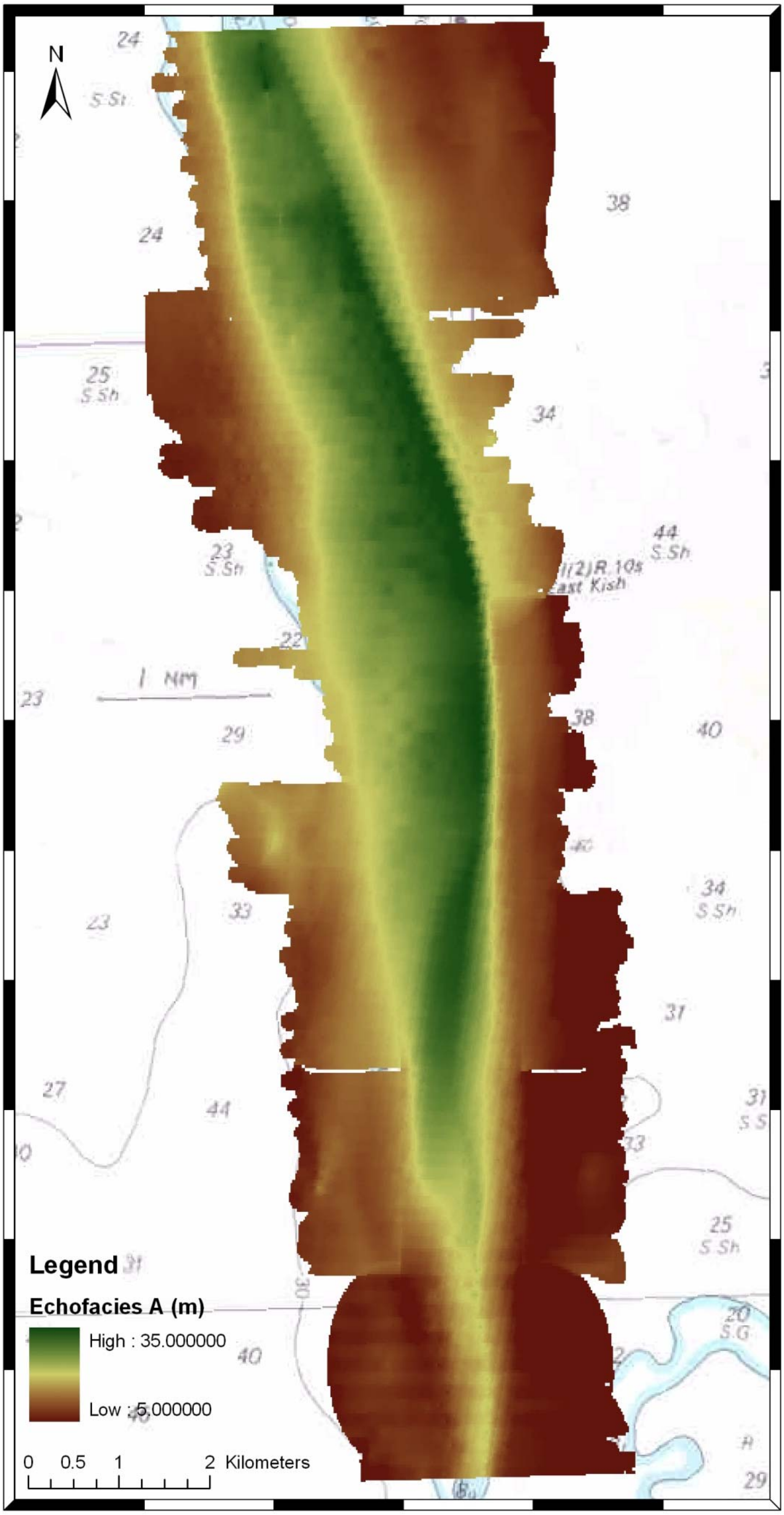



**Figure 16: Estimated Sediment thickness to base of Echo-facies A in meters.**

## Flow, Wave and Scour Modelling

Various models have been derived to model the interaction of water depth, flow vectors, wave conditions and sediment transportation. These range from manual calculations based on a limited number of variables to complex computer simulations, which utilize a range of datasets, employ nesting of scenarios at varying scales to improve accuracy and prevent edge effects. All such models involve some degree of simplification of real-world conditions. As such, caution must be used when relying on their predictions.

Additionally, the quality of a model's predictions is controlled by the accuracy of the data on which it is based. In many respects, data for the offshore environment lags far behind that of the onshore environment in terms of both quantity and quality. This is partially due to inaccessibility and also the high cost of offshore activities. While dense echo sounding in shallow water can provide bathymetric data at a comparable resolution to that obtainable on land; sediment sample retrieval, borehole drilling and flow measurement remain costly and time-consuming endeavours. As a result, data collected from relatively sparse control points is extrapolated to a greater degree than would likely be performed for onshore activities. This has a potential impact on the accuracy and reliability of any models based on these variables.

It is considered in this case, that the erection of a numerical model is not justified in terms of the reliability of predictions that could be derived. However, it is interesting to note that where such numerical modelling has been carried out for other offshore wind farms, the models do not predict significant sedimentological impacts due to the construction and presence of turbine foundations (Natural Power, 2002; Seascape Energy Ltd., 2002).

## Expected Environmental Impact of Proposed Development during Construction Phase

During the construction and decommissioning phases, it is expected that appropriate engineering plant and support vessels will operate at the proposed site for a relatively short period of time, to install and remove the various turbine foundations, support structures and other necessary infrastructure. The largest obstacle envisaged to be involved in this process is likely to be the turbine support structure, with a potential diameter of up to 5.5m if monopile foundations are used; if multi-pile or gravity based foundations are used this value is increased up to approximately 30 –35m.

### Site Preparation

The extent of site preparation required, prior to foundation emplacement, is minimised if monopile foundations are used. In such a scenario, site preparations are likely to be limited to local levelling and removal of any large clasts, with minimal opportunity for sediment suspension. Where multi-pile or gravity based foundations are deployed, more intensive site preparation will be required, the magnitude and extent of which will be dependent on foundation design. In this scenario, the potential exists for greater quantities of sediment to be released into the water column. The likely usage of monopile foundations for the proposed development will lead to such ground preparations having no significant impact.

### Foundation Emplacement

Dependent on the method used to install each turbine foundation, there is likely to be a requirement to drill or pile into the sediment. This will inevitably lead to the short-term release of small, localised volumes of sediment into the water column.

The potential worst-case scenario for this release of sediment would be through the utilisation of drilling or augering to emplace the foundation for a monopile turbine base. For example, a monopile foundation of 20m depth, 4m diameter and 0.1m wall thickness would require an excavation of approximately 250m$^3$, rising to perhaps 20% above this to account for over-excavation.

However, a monopile foundation is hollow and if driven, sediment will occupy the interior of the structure. In the case of a driven pile, as is the expected method in these unconsolidated sediments, the displacement of sediment is relatively minor, on the order of 25m$^3$.

Published data suggests that the volume of material released per foundation for a similar construction operation would be in the order of 700-800m$^3$. Modelling carried out on the basis of these values suggests that the suspended sediment load only exceeds a background value (50mg/l) for short periods of time during augering in sand, and only then in close proximity (200m) to the foundation position (Natural Power, 2002). If augering encounters significant deposits of finer material, such as clay, this material is likely to remain in suspension for longer time periods and be dispersed over a larger area as a result.

The combination of the short-timescales and limited volumes of sediment involved in this process, provide minimal concern for elevated suspended sediment concentrations and the potential impacts associated with foundation emplacement are considered negligible.

## Cable Laying

In addition to the turbines and their supporting structures, interconnecting cables between the turbines are required. These may potentially be buried beneath the seabed to ensure satisfactory protection against erosion and other activities that may compromise the integrity of the cables. Using modern ploughing techniques for cable burial, the seabed settles back in place over the cable as it is laid. However, during installation localised increases in suspended sediment concentrations may occur due to the release of finer fractions of the overlying sediment, but the extent of this is considered to be limited both spatially and temporally.

Alternatively, the cables may be left free-lying, assuming they are not at risk from trawling and other maritime activities. In such a scenario, the high-energy conditions experienced at the site are expected to lead to rapid burial of the cables, and a return to background sedimentological conditions.

Sediment released as a result of the above activities, is likely to result in only very thin deposits (apart from in the immediate vicinity of the installation sites). The natural high-energy conditions experienced at the site, will lead to these deposits being quickly reworked and integrated into the natural sedimentological regime.

In addition, the high costs of vessels & plant needed for cable laying and foundation installation suggests that foundation and cable laying activities will be staggered on a temporal basis with possibly one or two instances of such activities occurring at a given time. This “staggered” approach will facilitate a return to normal conditions and cause lesser impact than if a “blitz” approach was adopted.

As a result of these factors, installation of the turbines and associated infrastructure is likely to have a negligible impact on the sedimentary regime of the banks. In the immediate vicinity of foundation and cable installation activities, there will be a localised and limited change in conditions while installation activities are underway. This is not expected to alter the sedimentary regime of the site or the stability of the banks.

## Expected Environmental Impact of Proposed Development during Operational Phase

During the operational phase it is anticipated that 145 turbines, ancillary cables and structures will be installed as part of the proposed development (Figure 1).

The impact of these structures on the sediment regime is considered in reference to:

- Potential for localised scour and sediment dispersal.
- The potential effect of the proposed development in changing local sedimentary conditions with consideration to the changes in the flow and hydrodynamic regimes.

## Scour

All physical obstructions, whether naturally occurring or man-made, have the potential to initiate scour. Scour can be subdivided into general scour and local scour on the basis of temporal and spatial scale. General scour typically occurs over longer time scales and affects a larger area, whereas local scour results from the impact that an obstruction makes on its immediate surrounding area.

The presence of any structure (such as a turbine foundation) provides a local obstruction to flows, which would otherwise not occur. This results in an increase in local turbulence of the flow regime; the head-on flow slows down in front of the obstacle and then bifurcates to find an alternative path around it. As the bifurcated flow joins with adjacent flow at the sides of the obstacle, local velocity and turbulence (and the associated ability to potentially move sediments) increases (Figure 17). The separated flows rejoin in the wake of the structure and velocity decreases again.

Where this occurs in surface waters, the effects are expected to dissipate over short distances downstream of the structure. However, for flows on and just above the sediment surface, this local increase in velocity may exceed that required to mobilise sediment (dependent on sediment size and compaction) leading to the initiation of local scour. Due to bottom-friction, the changes to the flow regime due to an obstruction are expected to dissipate over short distances.

The following general relationships for scour can be expected:

1) Scour development is rapid in the initial phase following construction & then continues at a decreased rate until an equilibrium scour depth is reached.

2) The scour effects created by waves alone are generally small.

3) The typical shape of scour development is an inverted cone.

The principal concerns in relation to scour are the sediment plumes released due to the mobilisation of sediment and the potential for excessive scour to undermine the structural integrity of foundations. Where several structures exist in close proximity, the effect they have on flow conditions and scour may merge and lead to significant changes in the flow regime and general scour.

The magnitude of scour that occurs around an object is dependent on a number of conditions:

- Velocity of baseline flows.
- Local sediment conditions (grain size, compaction and other factors which affect its capacity for erosion).
- The footprint size and structure of the obstruction.

In general, monopile foundations will cause less scour due to their limited footprint size (4 to 5.5m). In contrast, multi-pile foundations would be expected to have a footprint of approximately 30-35m at the seabed and gravity foundations somewhere in the order of 20-25m (Figure 18).

Data observed in the North Sea, gives an indication of the approximate extent of local scour created due to the emplacement of a monopile structure. The placement of a 1.5m diameter structure, under similar sedimentary and slightly greater tidal flow velocities (average 1.4m/s), resulted in the formation of a scour pit with an equilibrium depth of 2.2m and a lateral extent of 14-20m (Noormets *et al.*, 2003).

Where necessary, scour protection can be deployed to minimize the effect of scour on the seabed, the design dependent on local geotechnical and engineering constraints. Scour protection can be implemented using a number of different means; these include, but are not limited, to the methods outlined below:

- **Flow Energy Reduction Systems –** These consist of artificial seaweed and similar devices, which are placed on the seabed, in order to reduce flow velocity. Such a system is expected to be of limited use under the high-energy conditions experienced at the proposed development.
- **Concrete Filled Geosynthetic Mattress –** Geosynthetic mattresses are much like large sandbags which are filled with concrete to form a flexible concrete mattress. While suitable for environments with a mild wave climate, this method of scour protection may prove difficult to deploy at the proposed site.
- **Solid Apron or Collar –** This method consists of precast concrete blocks that are placed around the pile – for instance, in the shape of two half moons.
- **Rock Armour –** Rock armour consists of large rocks that are placed around the pile, with the goal of reducing flow velocities and shielding the softer sediments beneath. Rock armour can be deployed at three stages:
    - **Prior to piling –** using this method the rock armour is placed on the seafloor prior to piling; the foundations are then driven through the rock armour and into the underlying seabed.

- **Piling followed by immediate placement of Rock Armour –** This method involves placing the rock armour protection around the pile immediately after the pile has been driven into the seabed.
- **Piling followed by placement of rock armour after the scour hole has been given some time to develop –** Using this method, the pile is put in place and the local scour hole allowed some time to develop around it; the rock armour is then deployed, some of it being placed within the scour hole. In a high-energy environment with sandy seabed conditions, it would be possible to place the rock armour in the scour hole developed after a few tides. This method has the advantage that the scour protection causes fewer disturbances to the hydrodynamic flow, as changes in the local topography of the seabed are minimised. This helps to reduce secondary scour effects. This is the method of scour protection that was deployed on the Arklow Bank Wind Farm.

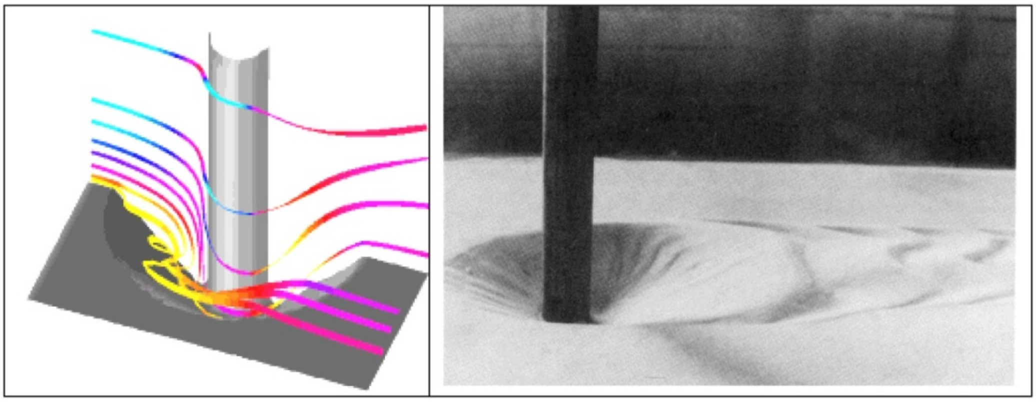


**Figure 17: Flow modification and scour development around a vertical object (blue represents background flow velocity, whereas reds and yellows indicate areas of increased velocity) [from Cooper & Beiboer, 2002].**

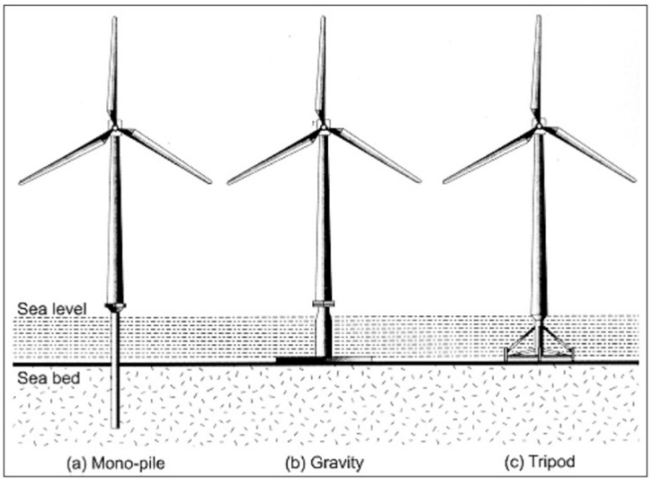



**Figure 18: Various turbine foundation types.**

## Potential for Localised Scour around Structures at Proposed Site

A degree of localised scour is predicted to occur when any large artificial structure is placed on the seabed, but with appropriate management and foresight this can be limited and controlled.

The likely usage of monopile foundations (considered the most suitable for soft sediments in shallow water with actively mobile beds) as the preferred foundation type will limit the occurrence of scour due to the reduced obstruction they present to flows than other foundation types.

Scour rates are expected to be greatest in areas with highest flow rates; principally the crest of the Kish Bank; and the quantity of sediment removed before an equilibrium state is reached will be greater. The sedimentary bedforms observed in the area, indicate that flow rates are lower on the sides of the banks, implying that scour will occur to a lesser extent.

Scour protection will be designed and implemented to reduce and prevent this. This is likely to consist of a graded profile of rock fragments and coarse sediment placed around the base of the foundation, providing a shield to the underlying finer sediments, similar to the schemes outlined in the previous section. However the final design remains dependent on local engineering and geotechnical constraints.

In addition, the wide spacing of the turbine foundations in relation to their size – approximately 500m spacing between turbines with an expected diameter of about 5m – prevents the creation of cumulative effects due to the interaction of local scour from individual turbines.

In summary, local scour is likely to occur around the turbine foundations, but if appropriate measures are taken this can be prevented. The wide spacing planned between turbines is not envisaged to create a potential for global scour at the proposed site.

## Impact of Proposed Development on Tidal Regimes and Wave Conditions

Each turbine foundation will form a local obstruction to tidal flows and wave patterns, leading to local modification of conditions. Tidal currents will accelerate around the obstacle, while waves will rebound from it.

However, the turbines themselves will occupy only a very small area of the proposed site, due to the large differences between their diameter and the spacing between individual turbines. Even in a worst-case scenario of gravity-based foundations (20 x 20m), the area of seabed occupied is under 1%. The 500m spacing between turbine sites is sufficient to allow flow conditions to return to a state approximate to their base level. This limits the opportunity for the effects from an individual turbine to interact and merge with those of its neighbours and lead to a widespread alteration in conditions.

As a result, the development will lead to localised and insignificant changes in flow and wave regime within the site area. In addition, the proposed development is not envisaged to lead to any regional changes in tidal and wave conditions. Immediately adjacent to the site, slight increases in tidal flow rates and decreases in wave height may be expected, but these are likely to return to background levels within a relatively short distance.

It is interesting to note that where numerical modelling has been carried out for similar developments (Natural Power, 2002; Seascape Energy Ltd., 2002), no change in tidal or wave conditions has been predicted for areas outside the planned site and its immediate vicinity. In addition, changes predicted within the area of the site have not been significant.

## Impact of Proposed Development on Sedimentary Regime and Bank Stability

The localised changes in tidal flow and wave regime within the site of the proposed development will potentially lead to increased sediment mobility in the vicinity of individual turbines. However, assuming that appropriate scour protection is utilised, this will be limited in both extent and volume. Available evidence suggests that the sediments of the bank are presently quite mobile. As a result, any increased mobility due to the presence of the development is not viewed as being significant.

Outside the site and its immediate surroundings, very little change in sedimentary conditions is expected. Sedimentary pathways are expected to continue as before.

Bank stability is not expected to be altered due to the expected slight increase in sediment mobility. The large spacing between turbine sites and their relatively small footprint in comparison to the banks area, limits the extent of their effect. Even allowing for scour and increased sediment mobility adjacent to individual turbines, only a very small proportion of the bank can be affected. As a result, the proposed development is not viewed as posing a significant risk to bank stability.

## Impact of Proposed Development on Coastal Stability and Erosion

Coastal erosion and instability on the east coast poses a major concern to planners both on a regional and national scale. The potential economic and social effects due to land and structure loss, disruption of transport networks and the potential for loss of lives make this a very serious issue.

As the proposed development is not envisaged to have a significant regional impact on either the wave, tidal or sedimentary regimes of the area, and is located several kilometres from shore, it is not expected to have any significant impact on coastal stability or erosion processes. Indeed, the minor obstruction the development poses to waves and the associated reduction in wind velocities might afford the coastline a very limited degree of protection.

Coastal erosion will continue regardless of the proposed development, with hydraulic forces such as waves continuing to erode and remove headlands such as Bray and Howth Head. An unknown and unquantifiable risk of change in the future exists due to the potential influence of global warming on climate conditions and sea level. The production of emissions-free electricity from the Kish and Bray Banks would ameliorate any such risk.

## Impact of Proposed Development in Relation to Aggregate Extraction

The Kish and Bray Banks have long been recognised as a potential source of material for the aggregates industry. Their location (approximately 10km from the Dublin metropolitan areas) and the shallow depths prevalent around the banks make them ideal for this purpose. However, no plans for offshore aggregate extraction currently exist.

The utilisation of the banks as a site for offshore wind farms is not compatible with their usage for aggregate extraction, as this may lead to the potential destabilisation of turbine foundations. Following the working lifetime of the proposed wind farm development and any necessary restoration, the site will once again be available as a potential source of aggregates.

The environmental impact of the proposed wind farm development is considered to be far less than the potential impact of wholesale aggregate extraction.

## Impact of Proposed Development in Relation to Petroleum Resources

Currently, no economic deposits of petroleum resources have been identified in the area of the development.

The proposed wind farm site is not envisaged to cause any significant obstruction in the future development and potential extraction of petroleum resources.

## Impact of Proposed Development in Relation to Coal Extraction

The existence of coal bearing strata has been recognised in the Kish Bank Basin since the 1970's. Details of these resources and potential means for extracting them are contained in GSI Report Series 86/3. No plans exist, as yet, to further explore or begin extraction of this resource. Extraction using the methods outlined therein is unlikely to be economically viable in the current climate.

The proposed wind farm site is not envisaged to cause any significant obstruction in the future development and potential extraction of this resource. In addition, the environmental impact of the proposed wind farm site is considered to be significantly less than that likely to result from any future development of the Kish Bank Basin coal deposits (taking into account both the onshore and offshore impacts of the methods outlined in the aforementioned report and the impact of carbon and sulphur emissions resulting from the utilisation of material extracted).

## Impact of Proposed Development in Relation to the Potential for Release of Sediment Trapped Contaminants

The installation of wind turbines at the proposed site will inevitably lead to the release and remobilisation of limited amounts of sediment during emplacement of the foundations. A small potential exists that some of the sediment disturbed may harbour potentially toxic compounds which may be released into the environment.

No studies for this have been carried out in the area. A potential source of such contaminants is the release of sewage and other material into Dublin Bay. Sediments closer to the source would be considered more at risk of containing such contaminants and the finer, low-energy sediments observed closer to shore are more likely to be suitable for harbouring such contaminants than the coarser sands and gravels of the banks. In addition, the high-energy conditions experienced at the proposed site, would be expected to lead to rapid dispersal of any contaminants prior to entrapment in the sediment.

As such, potential for the release of contaminants during installation at the proposed development is considered minimal.

## Impact of Proposed Development in Relation to Earthquake Activity

Areas around the Irish Sea and the associated landmasses of Ireland and Wales, have historically experienced several minor earthquakes, though the epicentre of known events are all generally focused to the East of the planned site, closer to Wales. Historic earthquakes in the region have been of low magnitude and only caused relatively minor structural damage.

There are a series of N-S trending faults near the proposed site, which could potentially accommodate crustal movements associated with earthquakes. However, none of these are currently believed to be active or experiencing significant strain. Though this may change in the future, they are unlikely to become reactivated during the lifetime of the planned wind farm.

All the evidence suggests that the likelihood of earthquakes leading to a significant environmental impact at the proposed site is low.

## Conclusions

- Installation of turbine foundations and associated infrastructure will lead to the release of small volumes of sediment into the surrounding environment. This will lead to local increases in suspended sediment concentrations. Such increases will be temporally and spatially limited. The high energy conditions experienced at the proposed site will lead to rapid reworking and dispersal of such sediment into the natural sedimentary regime of the banks. Installation of such structures will have minimal environmental impact with regard to sedimentation.
- Turbine foundations and any free lying cables will provide limited obstructions to tidal flows. This could lead to localised scouring around such structures, though this may be prevented through the deployment of scour protection measures. Spacing between structures is sufficient to prevent interaction of scour from individual foundations.
- The proposed wind farm will provide a limited obstruction to tidal flows, potentially leading to localised increases or decreases in flow rates. The small size of the turbine structures and the spacing between turbine locations imply that such changes will be limited in magnitude. The overall effect of the proposed development on tidal flows, apart from in the immediate vicinity of the site, is deemed insignificant.
- The proposed wind farm would provide a limited obstruction to waves, potentially leading to changes in height and orientation. The small size of the turbine structures and the large spacing between turbine locations imply that such changes will be very limited in magnitude. This conclusion is supported by modelling carried out for a number of adjacent wind farm developments. The overall effect of the proposed development on wave conditions, apart from in the immediate vicinity of the site, is deemed insignificant.
- The proposed wind farm development would have a limited impact on the sites natural sedimentary processes. The sites sediments exist in quite a high-energy state, and the development is not likely to obstruct or alter the banks sediment pathways. The slight local changes in flow conditions will cause some modification of sedimentary conditions, but the overall activities of the bank and its interaction with the shoreline are not likely to be significantly affected.
- The environmental impact of the proposed development is less than the expected impact of some other potential uses of the area.

## Recommendations

- Further studies may be required in order to facilitate the design of optimal scour prevention measures.
- Subject to engineering constraints, monopile foundations should be used in preference to other foundation types, due to their reduced footprint and the reduced ground preparation required prior to emplacement
- Where feasible, driving should be used in preference to augering for the emplacement of monopile foundations, due to the smaller volumes of sediment potentially released.
- Monitoring following emplacement of the first turbines will allow the effectiveness of deployed scour prevention measures to be assessed and modified if required.
- Careful consideration is required regarding the methods used to protect the cable deployed during the proposed development.
    - Within the main turbine site, the seabed is characterised by highly mobile sands. It is expected, that following construction, this area will be noted on nautical charts and potentially excluded from trawling and non-emergency vessel anchoring, precluding the most common causes of cable failure. In such an environment the cable may be left free-lying or trenched.
        - If these cables are left free-lying, it is expected that they will be 'absorbed' into the background sedimentary patterns, becoming periodically buried and uncovered, dependent on sediment migration patterns. Cable design needs to be sufficiently armoured to resist the abrasive effects resulting from such sediment mobility.
        - Where trenching is employed, burial depth needs to be of sufficient magnitude to account for this sediment mobility. Planned and achieved burial depths should be measured from the troughs of identified sandwaves, rather than crests, due to the mobility of such features over time.
    - The proposed cable route represents more heterogenous sedimentary conditions. The offshore portion of this route appears to consist of sandy sediments with small-scale bedforms (ripples) whose magnitude increases landward. Closer to shore, coarser grained sediments become dominant. Along this route, cables are considered more likely to be impacted by fishing or vessel anchoring, than within the main development. As a result, entrenching the cables is suggested as the most suitable method. Again, planned and achieved burial depths should be measured from the troughs of sedimentary bedforms present in the area, allowing for the mobility of such features.

Consultation with experienced marine cable-laying contractors is recommended to further establish the particulars of cable-laying operations.

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# Proposed Kish & Bray Banks
# Offshore windfarm

## Preliminary site investigation

**Report No: 08-0585**

**Client: Saorgus Energy Ltd**

**November 2008**

# Proposed Kish & Bray Banks offshore windfarm
# Preliminary site investigation

**CONTENTS** **Page No.**

# Document Control Sheet

## Report No.: 08-0585

## Project title: Proposed Kish & Bray Banks offshore windfarm Preliminary site investigation

## Client: Saorgus Energy Ltd

| Revision | Status | Report prepared by: | Report reviewed by: | Issue date |
|---|---|---|---|---|
| | Final | David Cameron<br>BSc CEng MIEI | Gabriel Gallagher<br>BSc (Hons) PhD CEng MICE MIHT | |

The works were conducted in accordance with:

*Specification and related documents for ground investigation in Ireland* (Engineers Ireland, 2006)

British Standards Institute (1999) *BS 5930:1999, Code of practice for site investigations*. Incorporating Amendment No. 1 of December 2007

## Methods of describing soils and rocks

Soil and rock descriptions are based on the guidance in Section 6 of BS 5930: 1999, *The Code of Practice for Site Investigation*, with the following exceptions:

1. The following terms are used in the description of fine-grained soils, where applicable:
   - soft to firm: fine-grained soil with consistency description close to the boundary between soft and firm soil (Table 13 of BS5930).
   - firm to stiff: fine-grained soil with consistency description close to the boundary between firm and stiff soil (Table 13 of BS5930).

| **Abbreviations used on exploratory hole logs** | |
|---|---|
| **U** | Nominal 100mm diameter undisturbed open tube sample |
| **P** | Nominal 100mm diameter undisturbed piston sample |
| **B** | Bulk disturbed sample |
| **D / J** | Small disturbed sample |
| **W** | Water sample |
| **ES / EW** | Soil sample for environmental testing / Water sample for environmental testing |
| **SPT** | Standard penetration test using a split spoon sampler (small disturbed sample obtained) |
| **CPT** | Standard penetration test using 60 degree solid cone |
| **X,X/X,X,X,X** | Blows per increment during the standard penetration test. The initial two values relate to the seating drive (150mm) and the remaining four to the 75mm increments of the test length. |
| **N=X** | SPT blow count 'N' given by the summation of the blows 'X' required to drive the full test length (300mm) |
| **X*/Y** | Incomplete standard penetration test where the seating drive could not be completed. The blows 'X' represent the total blows for the given length of seating drive 'Y' (mm) |
| **X/Z** | Incomplete standard penetration test where the seating drive was achieved but the full test length was not. The blows 'X' represent the total blows for the given test length 'Z' (mm) |
| **V**<br>**VR** | Shear vane test (borehole) Hand vane test (trial pit) Shear strength stated in kPa<br>V: undisturbed vane shear strength VR: remoulded vane shear strength |
| **dd/mm/yy: 1.0**<br>**dd/mm/yy: dry** | Date & water level at the borehole depth at the end of shift and the start of the following shift |
| **Abbreviations relating to rock core – reference Clause 44.4.4 of BS 5930: 1999** | |
| **TCR (%)** | **Total Core Recovery**: Ratio of rock/soil core recovered (both solid and non-intact) to the total length of core run. |
| **SCR (%)** | **Solid Core Recovery**: Ratio of *solid core* to the total length of core run. *Solid core* has a full diameter, uninterrupted by natural discontinuities, but not necessarily a full circumference and is measured along the core axis between natural fractures. |
| **RQD (%)** | **Rock Quality Designation**: Ratio of total length of *solid core* pieces greater than 100mm to the total length of core run. |
| **FI** | **Fracture Index**: Number of natural discontinuities per metre over an indicated length of core of similar intensity of fracturing. |
| **NI** | **Non Intact**: Used where the rock material was recovered fragmented, for example as fine to coarse gravel size particles. |
| **DIF** | **Drilling induced fracture:** A fracture of non-geological origin brought about by the rock coring. |

# Proposed Kish & Bray Banks offshore windfarm
# Preliminary site investigation

## 1 AUTHORITY

On the instructions of the Client Saorgus Energy Ltd, a ground investigation was undertaken at a site on and adjacent to Kish & Bray Banks to establish the ground conditions with regard to the proposed construction of an offshore windfarm.

## 2 SCOPE

The extent of the investigation was as directed by Glover Site Investigations Ltd and included boreholes, sampling, insitu and laboratory testing, and the preparation of a report on the findings, including recommendations for construction.

## 3 DESCRIPTION OF SITE

It is proposed to construct 145 wind turbines on and around Kish and Bray Banks off the coast of Co. Dublin and Co. Wicklow; location as shown on the plan in shown in Appendix A.

Bed levels at the location of the boreholes were in the range of 4.5-13.1m below Chart Datum.

## 4 SITE OPERATIONS

The Site Operations, conducted during the period 13 to 26 September 2008, comprised:

- three boreholes by cable percussion boring methods

The number and location of the exploratory holes were as instructed by the Engineer. Their locations are shown on the exploratory hole location plan in Appendix A.

### 4.1 Boreholes by light percussion methods

Three boreholes were sunk by means of a Dando 2000 rig using shell and auger techniques. The boreholes were bored in 200mm diameter using temporary casing and boring tools and extended to depths of 19.1-20.0m.

The boreholes were bored from a large jack-up capable of working in 28m of water. The jack-up was moved around the site by means of a large tug.

Disturbed (small bag and bulk bag) samples were taken, representative of the strata encountered.

Standard penetration tests were carried out at regular intervals, where appropriate. The borehole logs report whether the split spoon sampler (SPT) or solid cone (CPT) was used. The overall penetration is stated for those tests for which the full 450mm drive was not possible.

The borehole logs are provided in Appendix C.

## 5 LABORATORY WORK

Upon their receipt in the laboratory, all disturbed samples were carefully examined and accurately described and their descriptions incorporated into the preliminary borehole logs. The logs were revised, where necessary, based on the results of the laboratory tests.

Laboratory testing, conducted as scheduled by the Engineer, comprised the following:

- classification tests: particle size distribution by wet sieving.
- soil chemistry tests: pH and water soluble sulfate content.

The test results are presented in Appendix D. Unless noted otherwise, tests were conducted in accordance with BS 1377:1990, *Methods of test for soils for civil engineering purposes. Parts 1 to 9.*

# 6 GROUND CONDITIONS

## 6.1 General geology of the site

Appendix B presents excerpts of the 1:1,000,000 scale Solid and Quaternary geology maps of the area (British Geological Survey, 1991 and 1994) These show:

- Permian-Triassic rocks overlain by Quaternary glacial deposits.

The soil strata are of sand (>50% sand, <5% gravel) belonging to the Late Pleistocene to Early Holocene periods.

## 6.2 Ground types

The soils encountered in each of the three boreholes, to their maximum depth of 20m, were marine sand deposits, typically slightly silty – silty, predominantly fine to medium sand.

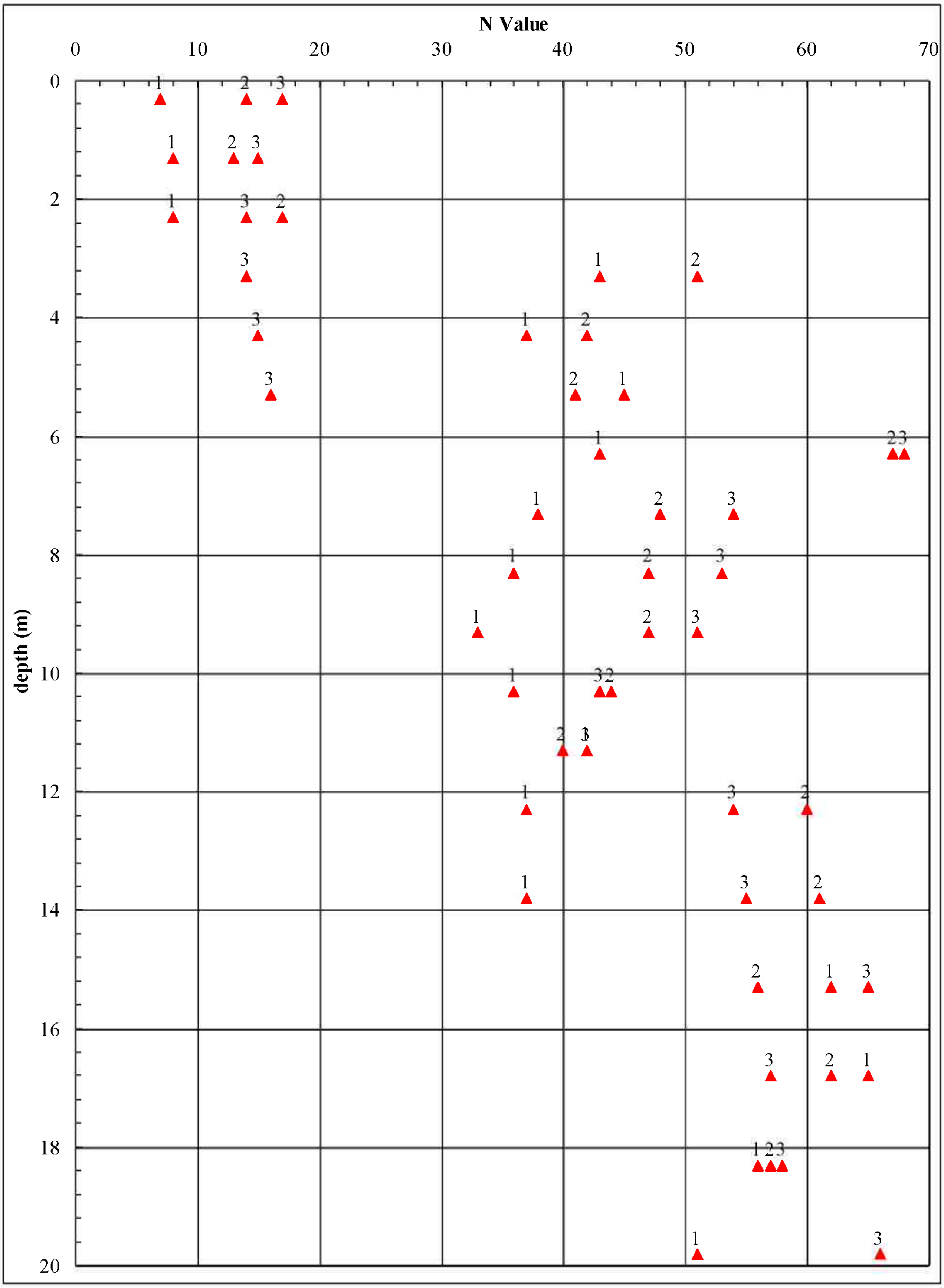
The plot on the following page shows the variation of standard penetration test *N*-value with depth. The label above each data point is the borehole number.

The plot shows a trend of increasing *N*-value with depth with the soil and the following:

- loose to medium dense soil in the upper 2.5-6m

- becoming medium dense at greater depth

- and very dense below approximately 12m depth.




**Variation of standard penetration test *N*-value with depth in the three boreholes**

# 7 DISCUSSION

## 7.1 Proposed construction

It is proposed to construct 145 wind turbines on the Kish and Bray Banks.

The proposed tip height is 160m above mean sea level.

The recommendations for construction below should be read in conjunction with the non-intrusive geophysical surveys carried out by Hydrographic Surveys.

## 7.2 Recommendations for construction

### 7.2.1 Foundations to turbine tower

Expert opinion should be sought as to what depth of marine sands must be discounted due to the possibility of shifting sediment patterns.

The foundations for the turbines can be installed either as gravity foundations or using steel monopiles.

Gravity foundations, placed on the seabed and stabilised by sand or water, should be founded below the depth that could be affected by shifting ground and on dense sands, as encountered below 2.5-6m in the three boreholes. Adopting a design *N*-value of 40, and applying the method of Burland and Burbidge (1984) allows derivation of the following:

| diameter of circular foundation (m) | allowable bearing pressure limiting settlements to 25mm (kPa) |
|---|---|
| 10 | 350 |
| 15 | 275 |
| 20 | 225 |
| 25 | 200 |

Monopiles, formed by installation of hollow steel tubes by driving, drilling or vibration, should be designed in conjunction with specialist contractors. The method of pile installation and the resultant length of the pile is fundamental to the capacity of the pile.

Chemical tests (pH and water soluble sulfate contents) on soil samples indicate Design Sulfate Class DS-1 for the site and ACEC Class AC-1 – reference Table C1 of BRE Special Digest 1 (Building Research Establishment, 2005). The Digest indicates that no special measures are required in the mix design for underground concrete.

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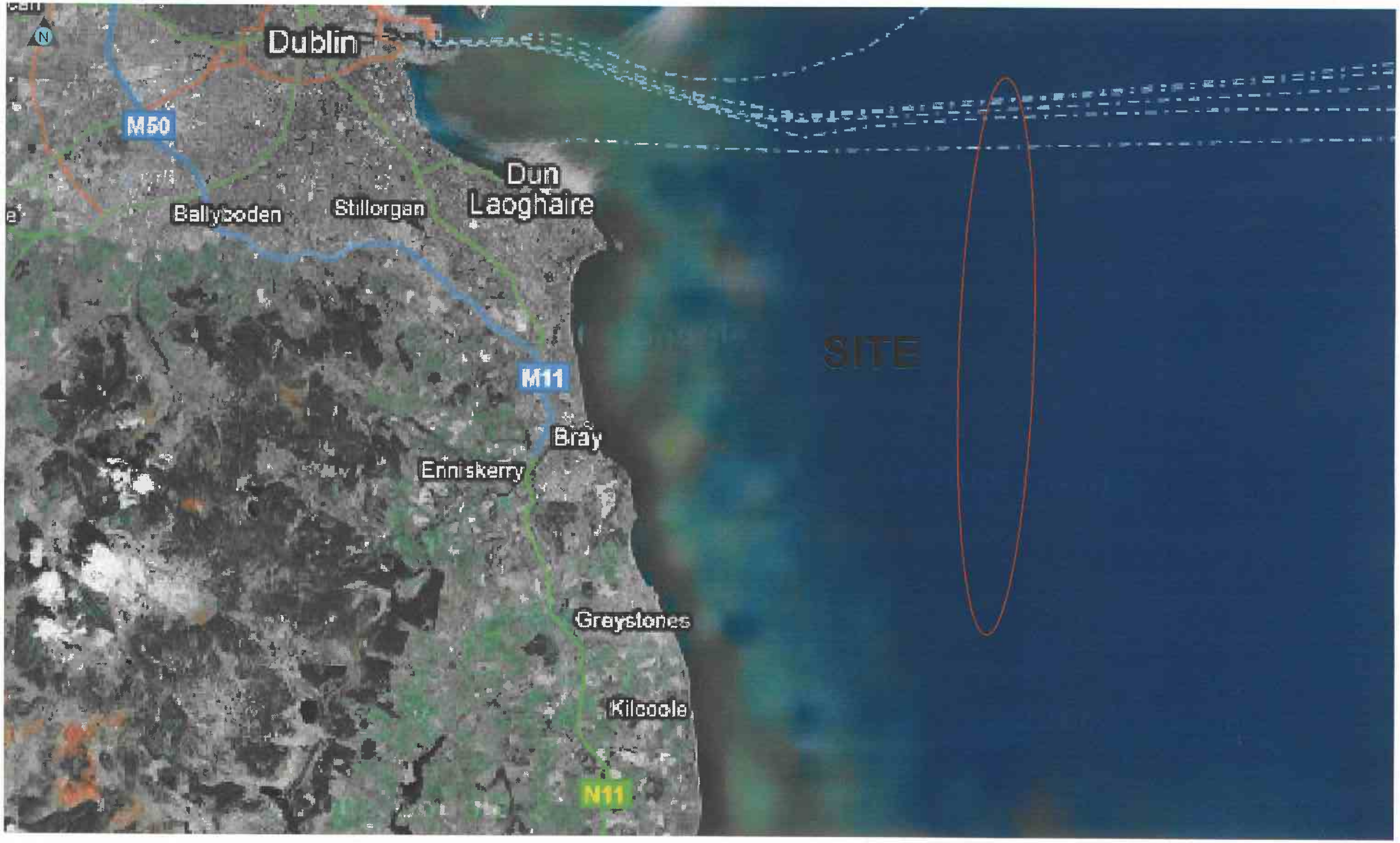
## Appendix A

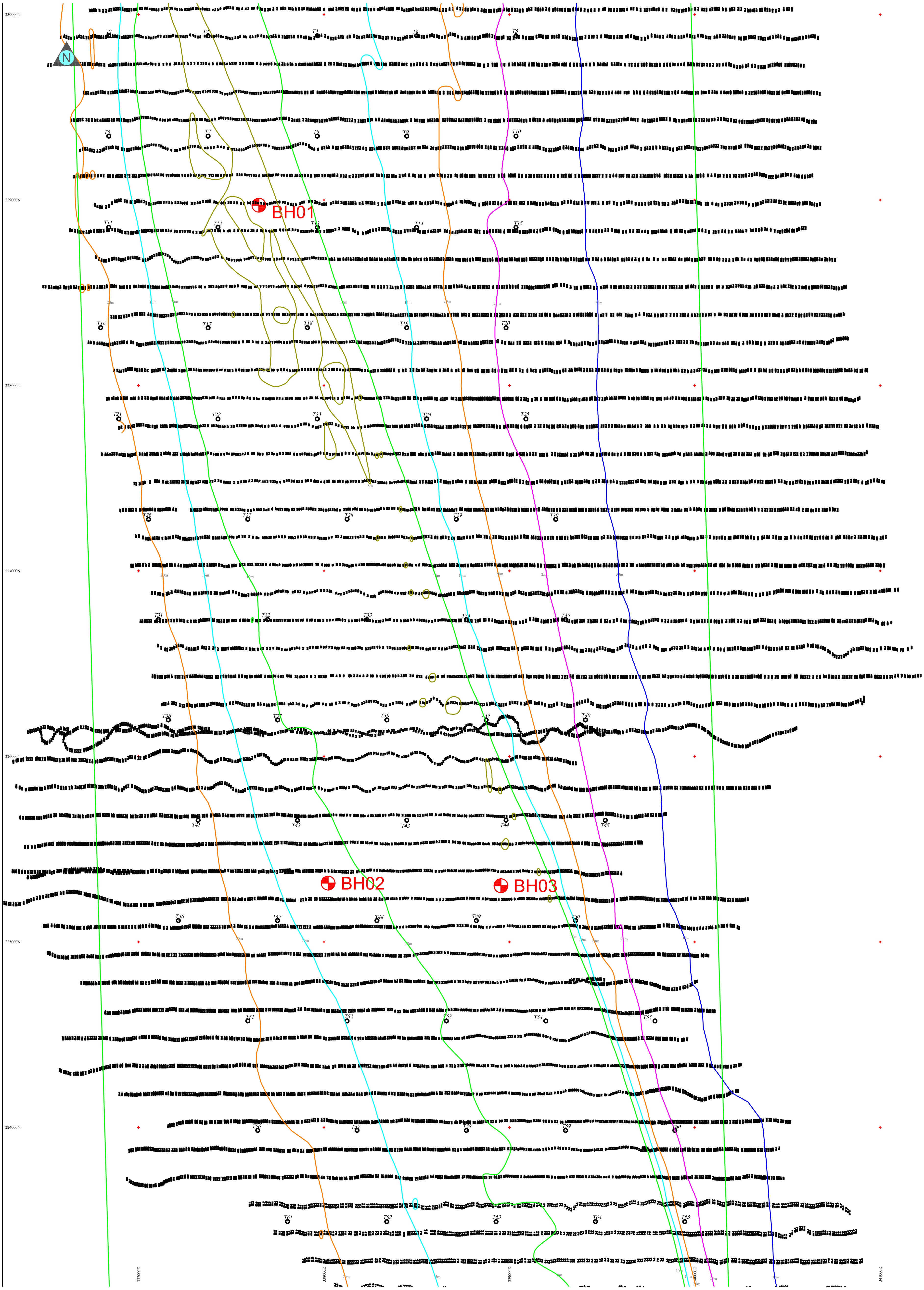
## Site and exploratory hole location plans

GLOVER SITE INVESTIGATIONS LIMITED




| | | | | | |
|---|---|---|---|---|---|
| PROJECT: Proposed Kish and Bray Banks Offshore Windfarm | | | | GLOVER SITE INVESTIGATIONS LIMITED | TITLE: Site location plan |
| CLIENT: Saorgus Energy Ltd | SCALE: NTS | | SERIES: 1 of 1 | | KEY: |
| ENGINEER: | DRWN: | BS | DATE: 10/11/08 | | DWG No: 08-0585-SLoc-001 |
| | CHCK: | DC | | | REV: |

| REV: | DATE: | DETAILS: | DRW: | CHK: |
|---|---|---|---|---|
| | | | | |

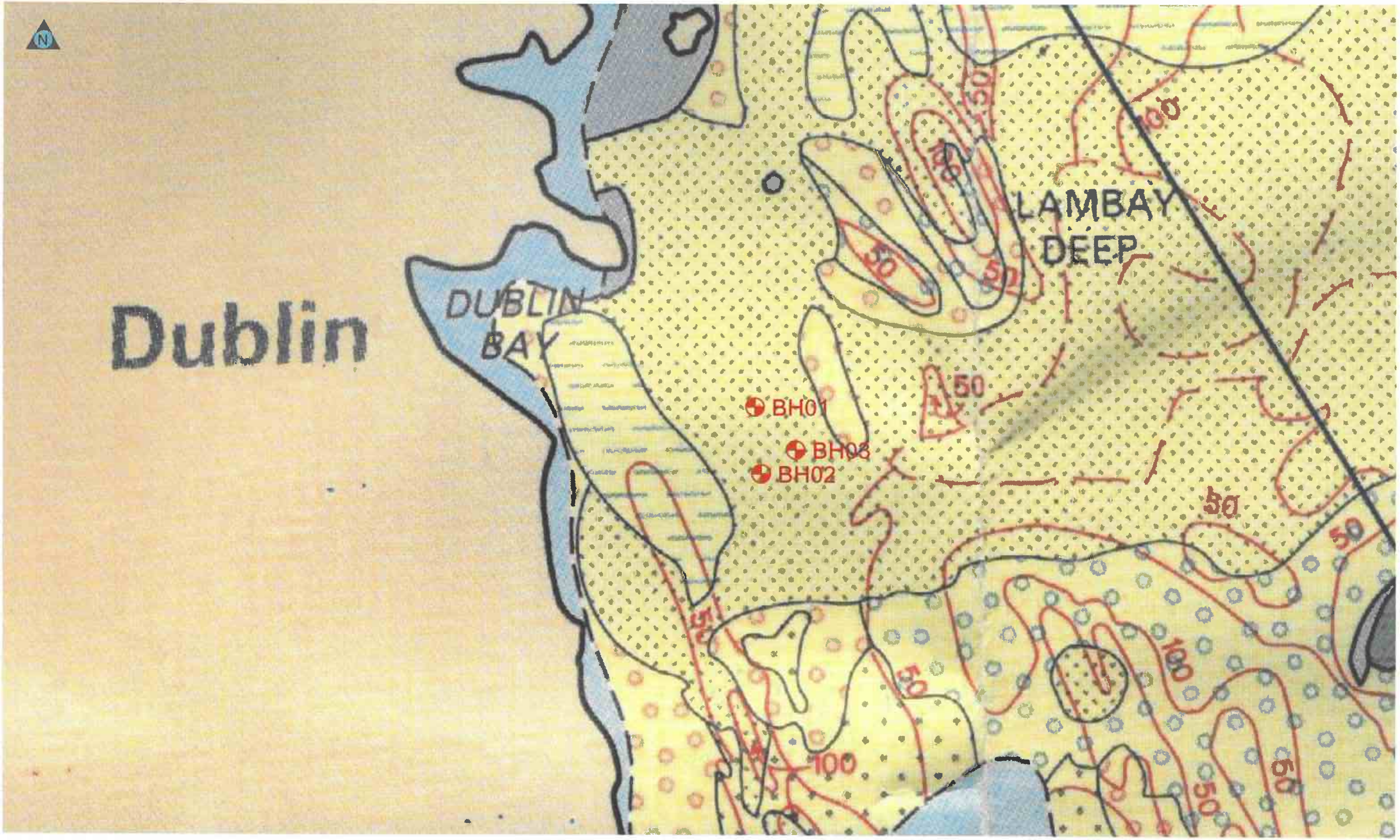



| | | | | |
|---|---|---|---|---|
| PROJECT: Proposed Kish and Bray Banks, Offshore Windfarm | | | | TITLE: Exploratory hole location plan |
| CLIENT: Saorgus Energy Ltd. | SCALE: 1:20,000 @ A3 | SERIES: 1 of 1 | GLOVER SITE INVESTIGATIONS LIMITED | KEY: BH Cable percussion boreholes |
| ENGINEER: | DRWN: OC | DATE: 23/01/09 | | DWG No: 08-0585-EHDL001.A |
| | CHCK: DC | | | REV: |

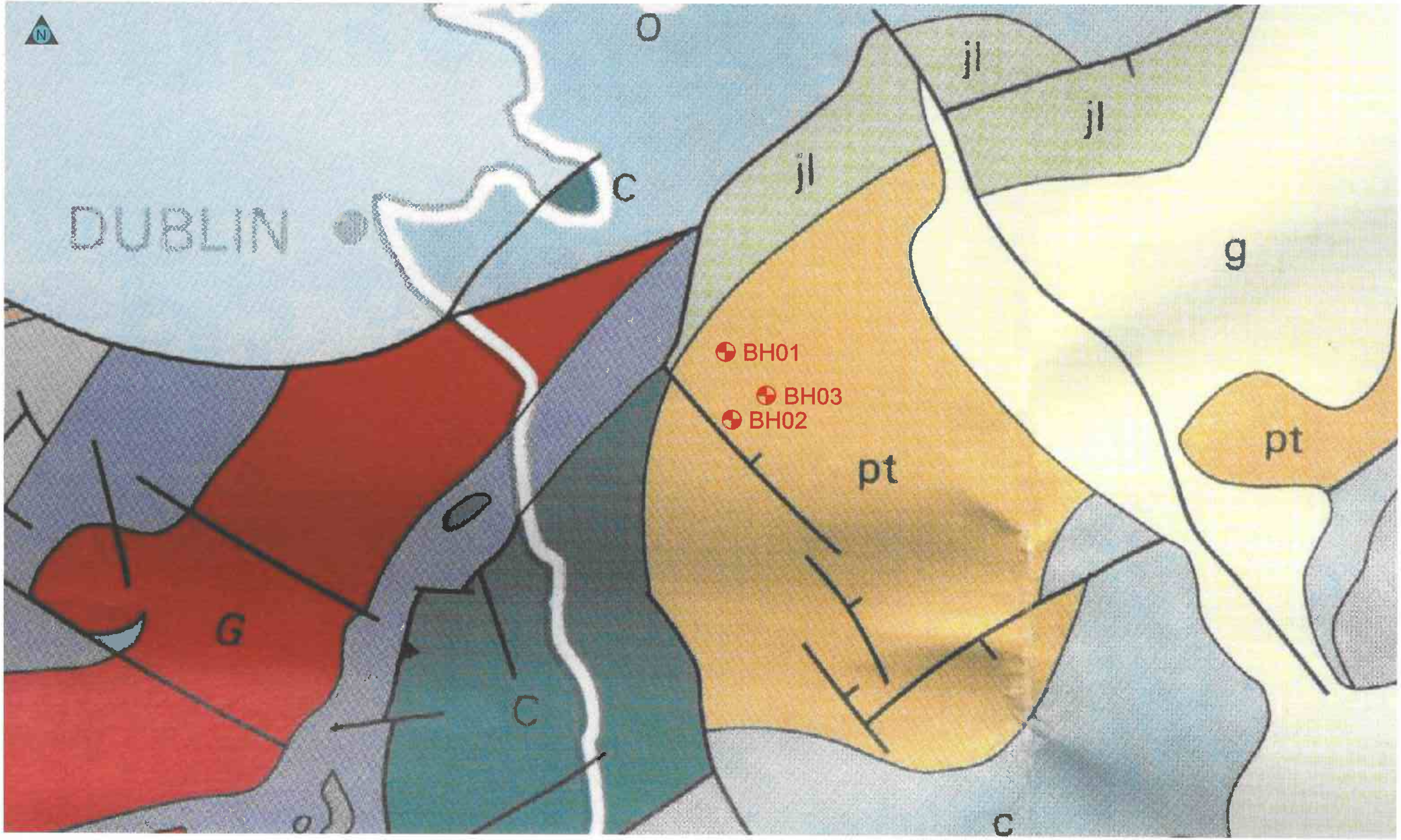
## Appendix B

## Excerpt of geology maps

GLOVER SITE INVESTIGATIONS LIMITED




| | | | | | |
|---|---|---|---|---|---|
| PROJECT: | Proposed Kish and Bray Banks Offshore Windfarm | | | GLOVER SITE INVESTIGATIONS LIMITED | TITLE: Quaternary geology location plan |
| CLIENT: | Saorgus Energy Ltd | SCALE: NTS | SERIES: 1 of 1 | | KEY: Late weichselian to early holocene sand (very soft to soft); Late weichselian to early holocene sand (Sand) |
| ENGINEER: | | DRWN: BS / CHCK: DC | DATE: 10/11/08 | | REV: DATE: DETAILS: DRW: CHK: / DWG No: 08-0585-SLoc-002 / REV: |




| | | | |
|---|---|---|---|
| PROJECT: | Proposed Kish and Bray Banks Offshore Windfarm | TITLE: | Geology of the UK, Ireland and continental shelf location plan |
| CLIENT: Saorgus Energy Ltd | SCALE: NTS | SERIES: 1 of 1 | KEY: Permian-triassic |
| ENGINEER: | DRWN: BS / CHCK: DC | DATE: 10/11/08 | DWG No: 08-0585-SLoc-003 |

| REV: | DATE: | DETAILS: | DRW: | CHK: |
|---|---|---|---|---|
| | | | | |

REV:

GLOVER SITE INVESTIGATIONS LIMITED

# Appendix C

# Borehole logs

GLOVER SITE INVESTIGATIONS LIMITED

# Glover Site Investigations Ltd

| Site | Borehole Number |
|---|---|
| Proposed Windfarm Kish & Bray Banks off Co Dublin and Co Wicklow | BH01 |

| Boring Method | Casing Diameter | Ground Level (mCD) | Client | Job Number |
|---|---|---|---|---|
| Cable Percussion | 200mm cased to 20.00m | -4.50 | Saorgus Energy Ltd | 08-0585 |
| | **Location** | **Dates** | **Engineer** | **Sheet** |
| | 337649.9 E 228972 N | 13/09/2008-16/09/2008 | | 1/2 |

| Depth (m) | Sample / Tests | Casing Depth (m) | Water Depth (m) | Field Records | Level (mCD) | Depth (m) (Thickness) | Description | Legend | Water |
|---|---|---|---|---|---|---|---|---|---|
| 0.00-0.45<br>0.00 | SPT N=7<br>B | | | 1,2/1,2,2,2 | | | Loose grey silty fine to medium SAND with a trace of fine gravel and occasional shells | | |
| 1.00-1.45<br>1.00 | SPT N=8<br>B | | | 2,2/2,2,2,2 | | | | | |
| | | | | | | (3.00) | | | |
| 2.00-2.45<br>2.00 | SPT N=8<br>B | | | 1,2/1,2,3,2 | | | | | |
| | | | | | -7.50 | 3.00 | | | |
| 3.00-3.45<br>3.00 | SPT N=43<br>B | | | 5,6/9,10,12,12 | | | Dense grey silty fine to coarse SAND with a trace of fine to medium gravel and occasional shells | | |
| 4.00-4.45<br>4.00 | SPT N=37<br>B | | | 6,7/8,9,10,10 | | | | | |
| 5.00-5.45<br>5.00 | SPT N=45<br>B | | | 5,7/9,10,13,13 | | | | | |
| 6.00-6.45<br>6.00 | SPT N=43<br>B | | | 4,7/9,9,12,13 | | | | | |
| | | | | | | (7.00) | | | |
| 7.00-7.45<br>7.00 | SPT N=38<br>B | | | 6,8/8,9,10,11 | | | | | |
| 8.00-8.45<br>8.00 | SPT N=36<br>B | | | 5,6/8,9,10,9 | | | | | |
| 9.00-9.45<br>9.00 | SPT N=33<br>B | | | 4,8/8,9,7,9 | | | | | |
| 10.00-10.45 | SPT N=36 | | | 5,6/7,8,10,11 | -14.50 | 10.00 | | | |

| Remarks | Scale (approx) | Logged By |
|---|---|---|
| | 1:50 | dc/kl |
| | **Figure No.** 08-0585.BH01 | |

# Glover Site Investigations Ltd

| Site | Borehole Number |
|---|---|
| Proposed Windfarm Kish & Bray Banks off Co Dublin and Co Wicklow | BH01 |

| Boring Method | Casing Diameter | Ground Level (mCD) | Client | Job Number |
|---|---|---|---|---|
| Cable Percussion | 200mm cased to 20.00m | -4.50 | Saorgus Energy Ltd | 08-0585 |
| | **Location** | **Dates** | **Engineer** | **Sheet** |
| | 337649.9 E 228972 N | 13/09/2008-16/09/2008 | | 2/2 |

| Depth (m) | Sample / Tests | Casing Depth (m) | Water Depth (m) | Field Records | Level (mCD) | Depth (m) (Thickness) | Description | Legend | Water |
|---|---|---|---|---|---|---|---|---|---|
| 10.00 | B | | | | | | Dense grey slightly silty fine to medium SAND with occasional shells | | |
| 11.00-11.45<br>11.00 | SPT N=42<br>B | | | 5,7/8,10,11,13 | | | | | |
| 12.00-12.45<br>12.00 | SPT N=37<br>B | | | 3,6/8,8,9,12 | | (5.00) | | | |
| 13.50-13.95<br>13.50 | SPT N=37<br>B | | | 5,7/8,9,10,10 | | | | | |
| 15.00-15.45<br>15.00 | SPT N=62<br>D | | | 7,10/12,15,17,18 | -19.50 | 15.00 | Very dense grey slightly silty fine to medium SAND with occasional shells | | |
| 16.50-16.95<br>16.50 | SPT N=65<br>D | | | 8,11/12,16,18,19 | | (5.00) | | | |
| 18.00-18.45<br>18.00 | SPT N=56<br>D | | | 7,10/12,13,15,16 | | | | | |
| 19.50-19.95<br>19.50 | SPT N=51<br>D | | | 8,9/10,13,14,14 | | | Complete at 20.00m | | |
| | | | | | -24.50 | 20.00 | | | |

| Remarks | Scale (approx) | Logged By |
|---|---|---|
| | 1:50 | dc/kl |
| | **Figure No.** 08-0585.BH01 | |

# Glover Site Investigations Ltd

| Site | Borehole Number |
|---|---|
| Proposed Windfarm Kish & Bray Banks off Co Dublin and Co Wicklow | BH02 |

| Boring Method | Casing Diameter | Ground Level (mCD) | Client | Job Number |
|---|---|---|---|---|
| Cable Percussion | 200mm cased to 19.10m | -13.10 | Saorgus Energy Ltd | 08-0585 |
| | **Location** | **Dates** | **Engineer** | **Sheet** |
| | 338022.6 E 225316.9 N | 21/09/2008-26/09/2008 | | 1/2 |

| Depth (m) | Sample / Tests | Casing Depth (m) | Water Depth (m) | Field Records | Level (mCD) | Depth (m) (Thickness) | Description | Legend | Water |
|---|---|---|---|---|---|---|---|---|---|
| 0.00-0.45<br>0.00 | SPT N=14<br>B | | | 1,2/3,3,3,5 | | | Medium dense grey slightly silty fine to medium SAND with occasional cobbles | | |
| 1.00-1.45<br>1.00 | SPT N=13<br>B | | | 2,2/3,2,4,4 | | | | | |
| | | | | | | (3.20) | | | |
| 2.00-2.45<br>2.00 | SPT N=17<br>B | | | 3,4/3,5,4,5 | | | | | |
| 3.00-3.45<br>3.00 | SPT N=51<br>B | | | 5,7/9,11,14,17 | -16.30 | 3.20 | Dense grey slightly silty fine to medium SAND with a trace of fine gravel and occasional shells | | |
| 4.00-4.45<br>4.00 | SPT N=42<br>B | | | 4,7/8,10,12,12 | | | | | |
| 5.00-5.45<br>5.00 | SPT N=41<br>B | | | 5,6/8,10,11,12 | | | | | |
| 6.00-6.45<br>6.00 | SPT N=67<br>B | | | 7,8/11,15,18,23 | | | | | |
| | | | | | | (6.80) | | | |
| 7.00-7.45<br>7.00 | SPT N=48<br>B | | | 6,8/10,12,12,14 | | | | | |
| 8.00-8.45<br>8.00 | SPT N=47<br>B | | | 7,9/10,12,13,12 | | | | | |
| 9.00-9.45<br>9.00 | SPT N=47<br>B | | | 6,8/10,13,12,12 | | | | | |
| 10.00-10.45 | SPT N=44 | | | 6,7/10,11,12,11 | -23.10 | 10.00 | | | |

**Remarks**

| Scale (approx) | Logged By |
|---|---|
| 1:50 | DC/KL |

**Figure No.**
08-0585.BH02

# Glover Site Investigations Ltd

| Site | Borehole Number |
|---|---|
| Proposed Windfarm Kish & Bray Banks off Co Dublin and Co Wicklow | BH02 |

| Boring Method | Casing Diameter | Ground Level (mCD) | Client | Job Number |
|---|---|---|---|---|
| Cable Percussion | 200mm cased to 19.10m | -13.10 | Saorgus Energy Ltd | 08-0585 |
| | **Location** | **Dates** | **Engineer** | **Sheet** |
| | 338022.6 E 225316.9 N | 21/09/2008-26/09/2008 | | 2/2 |

| Depth (m) | Sample / Tests | Casing Depth (m) | Water Depth (m) | Field Records | Level (mCD) | Depth (m) (Thickness) | Description | Legend | Water |
|---|---|---|---|---|---|---|---|---|---|
| 10.00 | B | | | | | | Dense grey slightly silty fine to medium SAND with occasional shells | | |
| 11.00-11.45<br>11.00 | SPT N=40<br>B | | | 7,8/9,9,10,12 | | (2.00) | | | |
| 12.00-12.45<br>12.00 | SPT N=60<br>B | | | 8,10/13,15,16,16 | -25.10 | 12.00 | Very dense grey slightly silty fine to medium SAND with occasional shells | | |
| 13.50-13.95<br>13.50 | SPT N=61<br>B | | | 10,13/14,15,16,16 | | | | | |
| 15.00-15.45<br>15.00 | SPT N=56<br>B | | | 8,11/12,12,16,16 | | (7.10) | | | |
| 16.50-16.95<br>16.50 | SPT N=62<br>B | | | 7,10/13,15,16,18 | | | | | |
| 18.00-18.45<br>18.00 | SPT N=57<br>B | | | 9,11/12,14,15,16 | | | | | |
| | | | | | -32.20 | 19.10 | Complete at 19.10m | | |

| Remarks | Scale (approx) | Logged By |
|---|---|---|
| | 1:50 | DC/KL |
| | **Figure No.** | |
| | 08-0585.BH02 | |

# Glover Site Investigations Ltd

| | | | | |
|---|---|---|---|---|
| **Site** | Proposed Windfarm Kish & Bray Banks off Co Dublin and Co Wicklow | | | **Borehole Number** BH03 |
| **Boring Method** Cable Percussion | **Casing Diameter** 200mm cased to 20.00m | **Ground Level (mCD)** -7.30 | **Client** Saorgus Energy Ltd | **Job Number** 08-0585 |
| | **Location** 338954.6 E 225303.1 N | **Dates** 17/09/2008-19/09/2008 | **Engineer** | **Sheet** 1/2 |

| Depth (m) | Sample / Tests | Casing Depth (m) | Water Depth (m) | Field Records | Level (mCD) | Depth (m) (Thickness) | Description | Legend | Water |
|---|---|---|---|---|---|---|---|---|---|
| 0.00-0.45<br>0.00 | SPT N=17<br>B | | | 2,3/4,5,4,4 | | | Medium dense grey silty fine to medium SAND with occasional shells | | |
| 1.00-1.45<br>1.00 | SPT N=15<br>B | | | 3,3/3,4,5,3 | | | | | |
| 2.00-2.45<br>2.00 | SPT N=14<br>B | | | 2,3/3,3,4,4 | | | | | |
| 3.00-3.45<br>3.00 | SPT N=14<br>B | | | 2,2/3,4,3,4 | | (6.00) | | | |
| 4.00-4.45<br>4.00 | SPT N=15<br>B | | | 3,3/3,4,4,4 | | | | | |
| 5.00-5.45<br>5.00 | SPT N=16<br>B | | | 3,4/3,4,4,5 | | | | | |
| 6.00-6.45<br>6.00 | SPT N=68<br>B | | | 7,12/13,16,18,21 | -13.30 | 6.00 | Very dense grey slightly silty fine to medium SAND with occasional shells | | |
| 7.00-7.45<br>7.00 | SPT N=54<br>B | | | 8,10/11,13,15,15 | | | | | |
| 8.00-8.45<br>8.00 | SPT N=53<br>B | | | 9,10/11,13,13,16 | | (4.00) | | | |
| 9.00-9.45<br>9.00 | SPT N=51<br>B | | | 8,11/10,10,13,18 | | | | | |
| 10.00-10.45 | SPT N=43 | | | 7,8/9,10,12,12 | -17.30 | 10.00 | | | |

| | | |
|---|---|---|
| **Remarks** | **Scale (approx)** 1:50 | **Logged By** DC/KL |
| | **Figure No.** 08-0585.BH03 | |

# Glover Site Investigations Ltd

| Site | Borehole Number |
|---|---|
| Proposed Windfarm Kish & Bray Banks off Co Dublin and Co Wicklow | BH03 |

| Boring Method | Casing Diameter | Ground Level (mCD) | Client | Job Number |
|---|---|---|---|---|
| Cable Percussion | 200mm cased to 20.00m | -7.30 | Saorgus Energy Ltd | 08-0585 |
| | **Location** | **Dates** | **Engineer** | **Sheet** |
| | 338954.6 E 225303.1 N | 17/09/2008-19/09/2008 | | 2/2 |

| Depth (m) | Sample / Tests | Casing Depth (m) | Water Depth (m) | Field Records | Level (mCD) | Depth (m) (Thickness) | Description | Legend | Water |
|---|---|---|---|---|---|---|---|---|---|
| 10.00 | B | | | | | | Dense grey slightly silty fine to medium SAND with occasional shells | | |
| 11.00-11.45<br>11.00 | SPT N=42<br>B | | | 6,7/9,10,11,12 | | (2.30) | | | |
| 12.00-12.45<br>12.00 | SPT N=54<br>B | | | 3,4/5,15,16,18 | | | | | |
| | | | | | -19.60 | 12.30 | Very dense grey slightly silty fine to medium SAND with occasional shells | | |
| 13.50-13.95<br>13.50 | SPT N=55<br>B | | | 8,9/12,13,14,16 | | | | | |
| 15.00-15.45<br>15.00 | SPT N=65<br>B | | | 9,11/13,16,18,18 | | | | | |
| | | | | | | (7.70) | | | |
| 16.50-16.95<br>16.50 | SPT N=57<br>D | | | 7,10/12,15,14,16 | | | | | |
| 18.00-18.45<br>18.00 | SPT N=58<br>D | | | 10,11/13,14,16,15 | | | | | |
| 19.50-19.95<br>19.50 | SPT N=66<br>D | | | 10,14/15,17,16,18 | | | | | |
| | | | | | -27.30 | 20.00 | Complete at 20.00m | | |

| Remarks | Scale (approx) | Logged By |
|---|---|---|
| | 1:50 | DC/KL |
| | **Figure No.** | |
| | 08-0585.BH03 | |

# Appendix D

## Laboratory test results

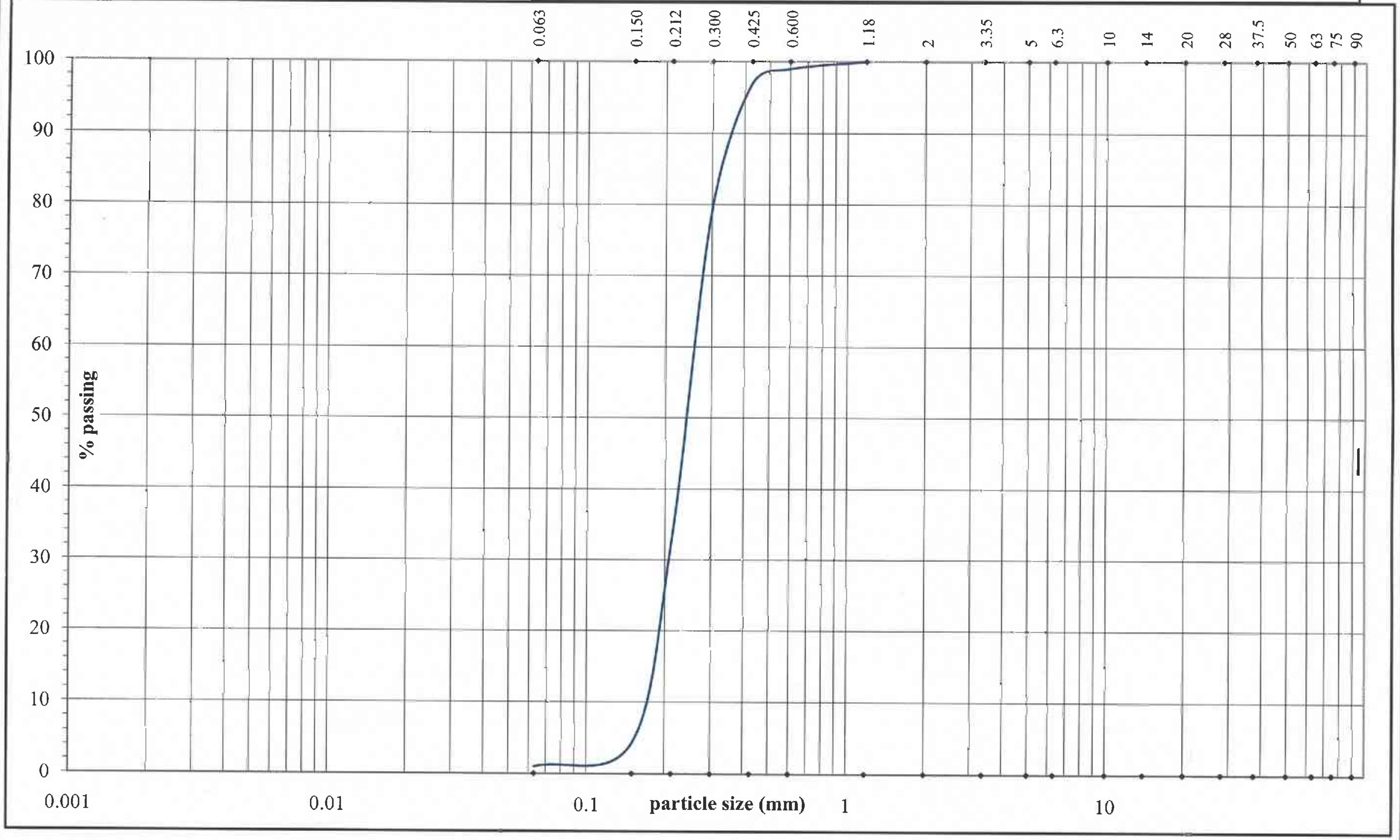
GLOVER SITE INVESTIGATIONS LIMITED

Glover Site Investigations Ltd

# Particle Size Distribution

*BS1377:1990 Part 2 Clause 9.2 and 9.5*

| Particle size (mm) | % passing |
|---|---|
| 125 | 100 |
| 90 | 100 |
| 75 | 100 |
| 63 | 100 |
| 50 | 100 |
| 37.5 | 100 |
| 28 | 100 |
| 20 | 100 |
| 14 | 100 |
| 10 | 100 |
| 6.3 | 100 |
| 5 | 100 |
| 3.35 | 100 |
| 2 | 100 |
| 1.18 | 100 |
| 0.600 | 99.0 |
| 0.425 | 96.8 |
| 0.300 | 79.1 |
| 0.212 | 32.7 |
| 0.150 | 4.3 |
| 0.063 | 1.0 |




| Fines 1% | Sand 99% | | | Gravel 0% | | | Cobbles 0% |
|---|---|---|---|---|---|---|---|
| | fine | medium | coarse | fine | medium | coarse | |

Sample natural moisture content (%) = 21

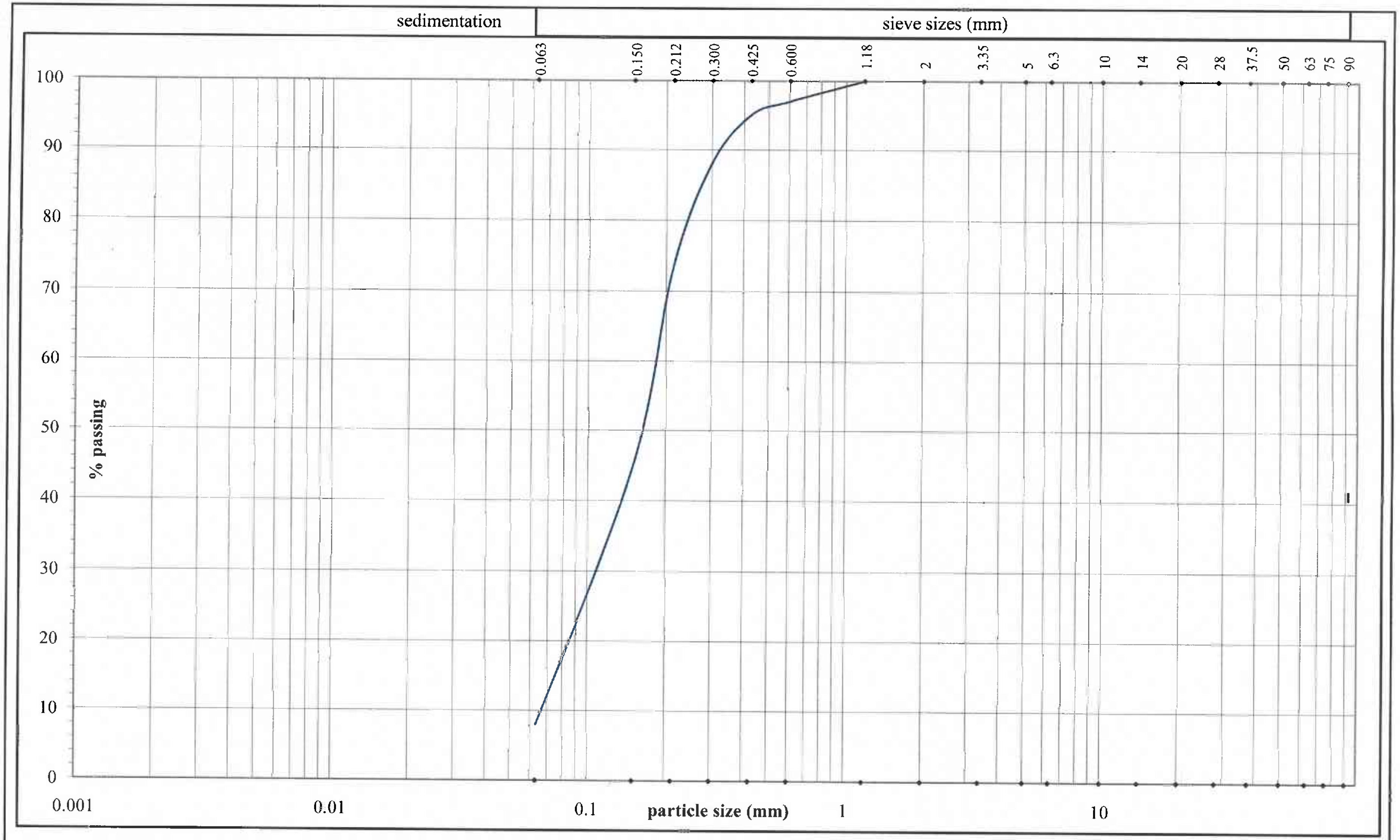
| Project: | Kish & Bray Banks | Exploratory Hole No.: | BH01 | Sample Type | Sample No. | Sample at (m) | Sample to (m) | Sample description: |
|---|---|---|---|---|---|---|---|---|
| Job No.: | 08-0585 | | | B | 1 | 0.00 | | |

Glover Site Investigations Ltd

# Particle Size Distribution

*BS1377:1990 Part 2 Clause 9.2 and 9.5*

| Particle size (mm) | % passing |
|---|---|
| 125 | 100 |
| 90 | 100 |
| 75 | 100 |
| 63 | 100 |
| 50 | 100 |
| 37.5 | 100 |
| 28 | 100 |
| 20 | 100 |
| 14 | 100 |
| 10 | 100 |
| 6.3 | 100 |
| 5 | 100 |
| 3.35 | 100 |
| 2 | 100 |
| 1.18 | 100 |
| 0.6 | 97 |
| 0.425 | 95 |
| 0.3 | 88 |
| 0.212 | 73 |
| 0.15 | 45 |
| 0.063 | 8 |




| | fine | medium | coarse | fine | medium | coarse | Cobbles |
|---|---|---|---|---|---|---|---|
| Fines 8% | Sand 92% | | | Gravel 0% | | | 0% |

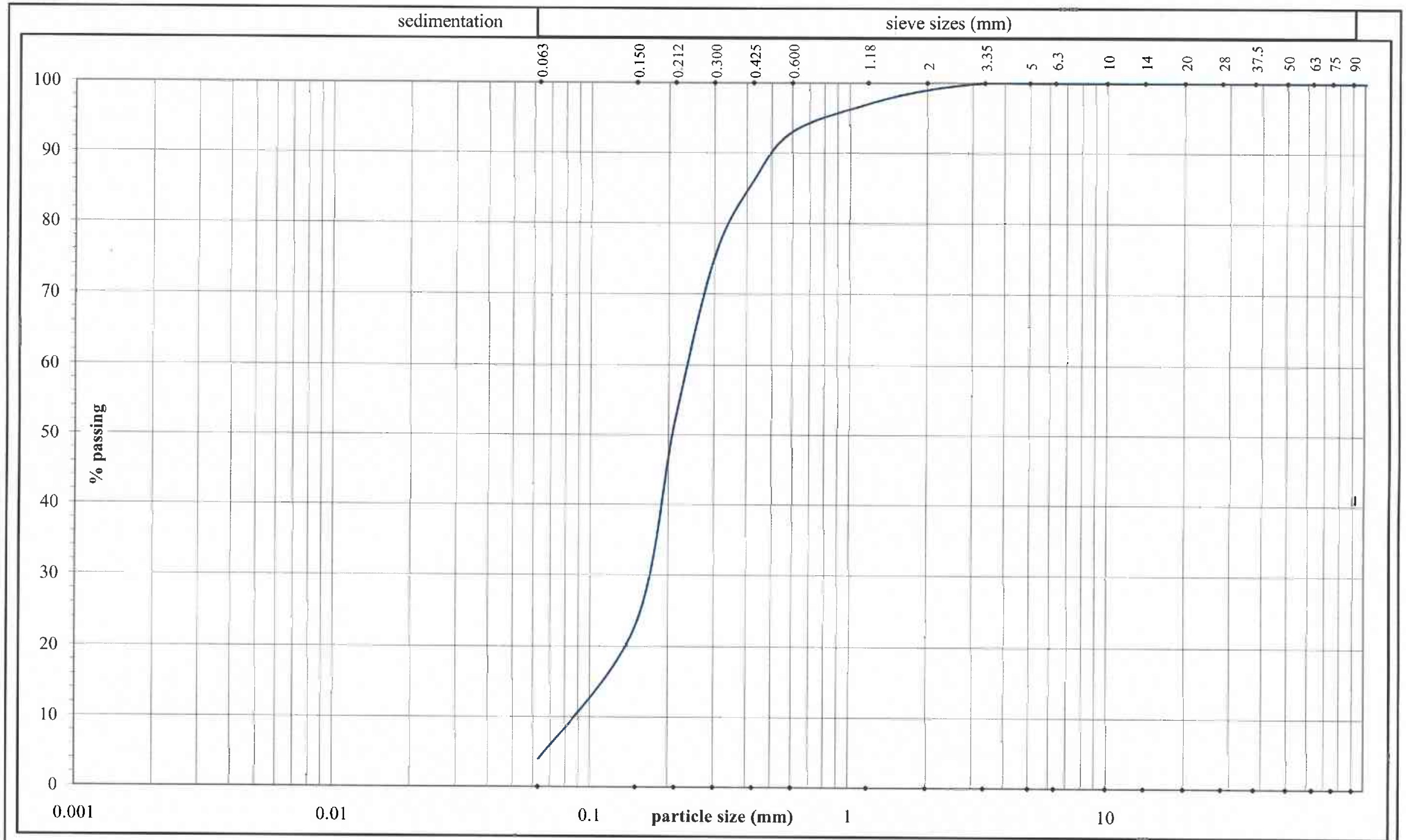
| Project: | Kish & Bray Banks | Exploratory Hole No.: | BH01 | Sample Type | Sample No. | at (m) | to (m) | Sample description: |
|---|---|---|---|---|---|---|---|---|
| Job No.: | 08-0585 | | | B | 2 | 1.00 | | |

Glover Site Investigations Ltd

# Particle Size Distribution

*BS1377:1990 Part 2 Clause 9.2 and 9.5*

| Particle size (mm) | % passing |
|---|---|
| 125 | 100 |
| 90 | 100 |
| 75 | 100 |
| 63 | 100 |
| 50 | 100 |
| 37.5 | 100 |
| 28 | 100 |
| 20 | 100 |
| 14 | 100 |
| 10 | 100 |
| 6.3 | 100 |
| 5 | 100 |
| 3.35 | 100 |
| 2 | 99 |
| 1.18 | 97 |
| 0.6 | 93 |
| 0.425 | 86 |
| 0.3 | 75 |
| 0.212 | 52 |
| 0.15 | 23 |
| 0.063 | 4 |




| | Fines 4% | fine | medium | coarse | fine | medium | coarse | Cobbles |
|---|---|---|---|---|---|---|---|---|
| | | Sand 95% | | | Gravel 1% | | | 0% |

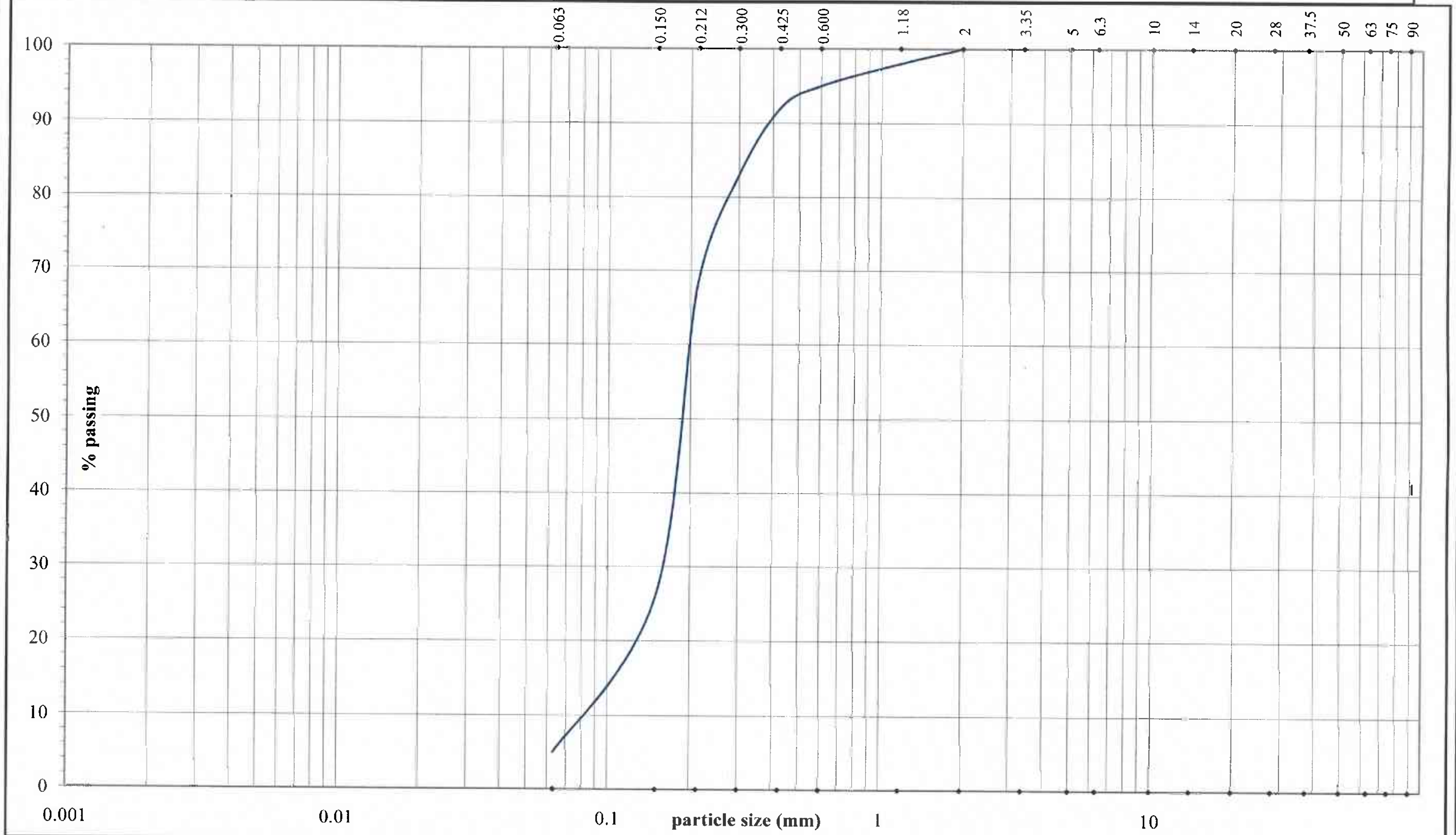
| Project: | Kish & Bray Banks | Exploratory Hole No.: | BH01 | Sample Type | No. | at (m) | to (m) | Sample description: |
|---|---|---|---|---|---|---|---|---|
| Job No.: | 08-0585 | | | B | 3 | 2.00 | | |

Glover Site Investigations Ltd

# Particle Size Distribution

*BS1377:1990 Part 2 Clause 9.2 and 9.5*

| Particle size (mm) | % passing |
|---|---|
| 125 | 100 |
| 90 | 100 |
| 75 | 100 |
| 63 | 100 |
| 50 | 100 |
| 37.5 | 100 |
| 28 | 100 |
| 20 | 100 |
| 14 | 100 |
| 10 | 100 |
| 6.3 | 100 |
| 5 | 100 |
| 3.35 | 100 |
| 2 | 100 |
| 1.18 | 98 |
| 0.6 | 95 |
| 0.425 | 92 |
| 0.3 | 83 |
| 0.212 | 68 |
| 0.15 | 26 |
| 0.063 | 5 |




| | Fines | Sand | | | Gravel | | | Cobbles |
|---|---|---|---|---|---|---|---|---|
| | | fine | medium | coarse | fine | medium | coarse | |
| | Fines 5% | Sand 95% | | | Gravel 0% | | | 0% |

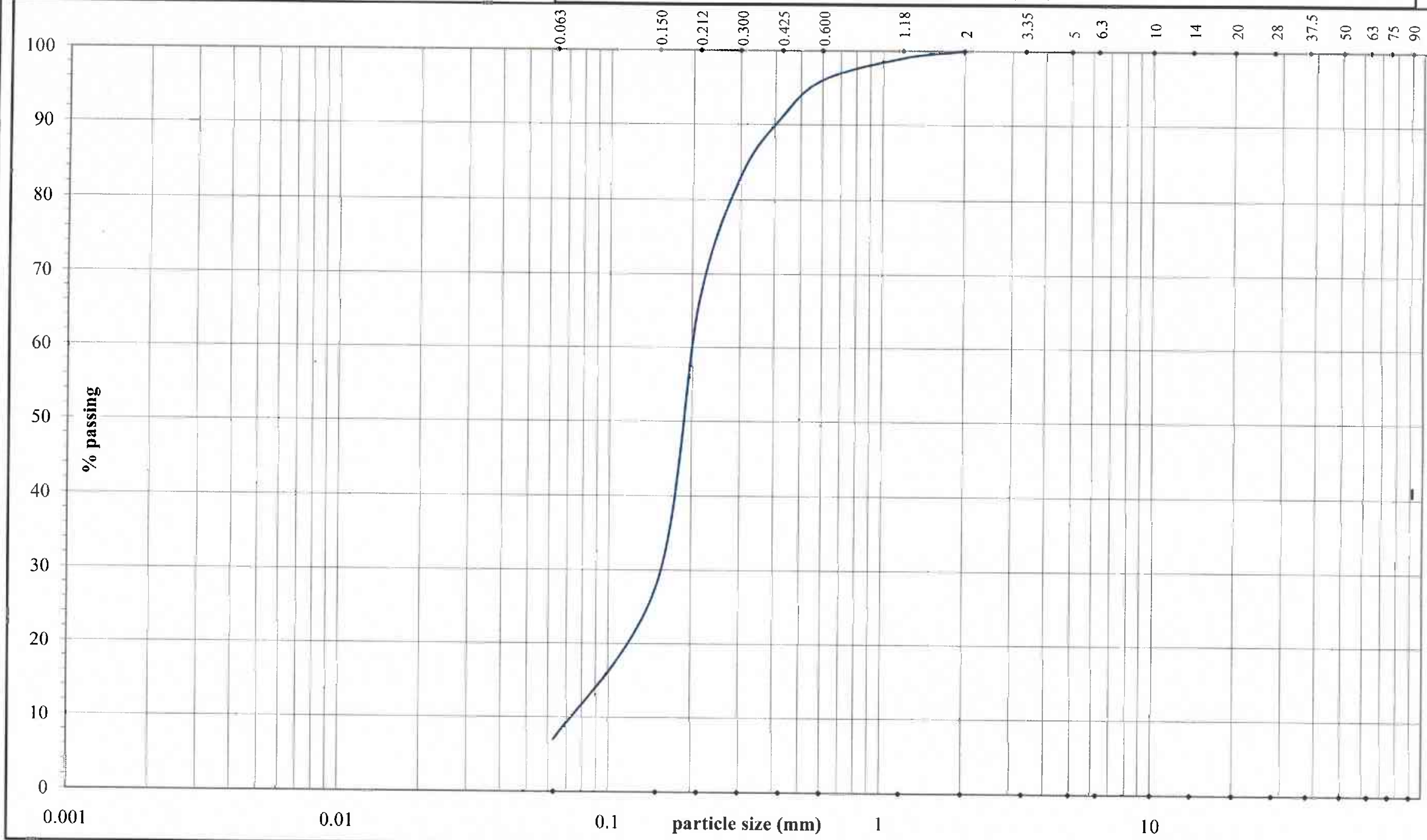
| Project: | Kish and Bray Banks | Exploratory Hole No.: | BH01 | Sample Type | No. | at (m) | to (m) | Sample description: |
|---|---|---|---|---|---|---|---|---|
| Job No.: | 08-0585 | | | B | 4 | 3.00 | | |

*Glover Site Investigations Ltd*

# Particle Size Distribution

***BS1377:1990 Part 2 Clause 9.2 and 9.5***

| Particle size (mm) | % passing |
|---|---|
| 125 | 100 |
| 90 | 100 |
| 75 | 100 |
| 63 | 100 |
| 50 | 100 |
| 37.5 | 100 |
| 28 | 100 |
| 20 | 100 |
| 14 | 100 |
| 10 | 100 |
| 6.3 | 100 |
| 5 | 100 |
| 3.35 | 100 |
| 2 | 100 |
| 1.18 | 99 |
| 0.6 | 96 |
| 0.425 | 91 |
| 0.3 | 83 |
| 0.212 | 66 |
| 0.15 | 28 |
| 0.063 | 7 |




| | fine | medium | coarse | fine | medium | coarse | Cobbles |
|---|---|---|---|---|---|---|---|
| Fines 7% | Sand 93% | | | Gravel 0% | | | 0% |

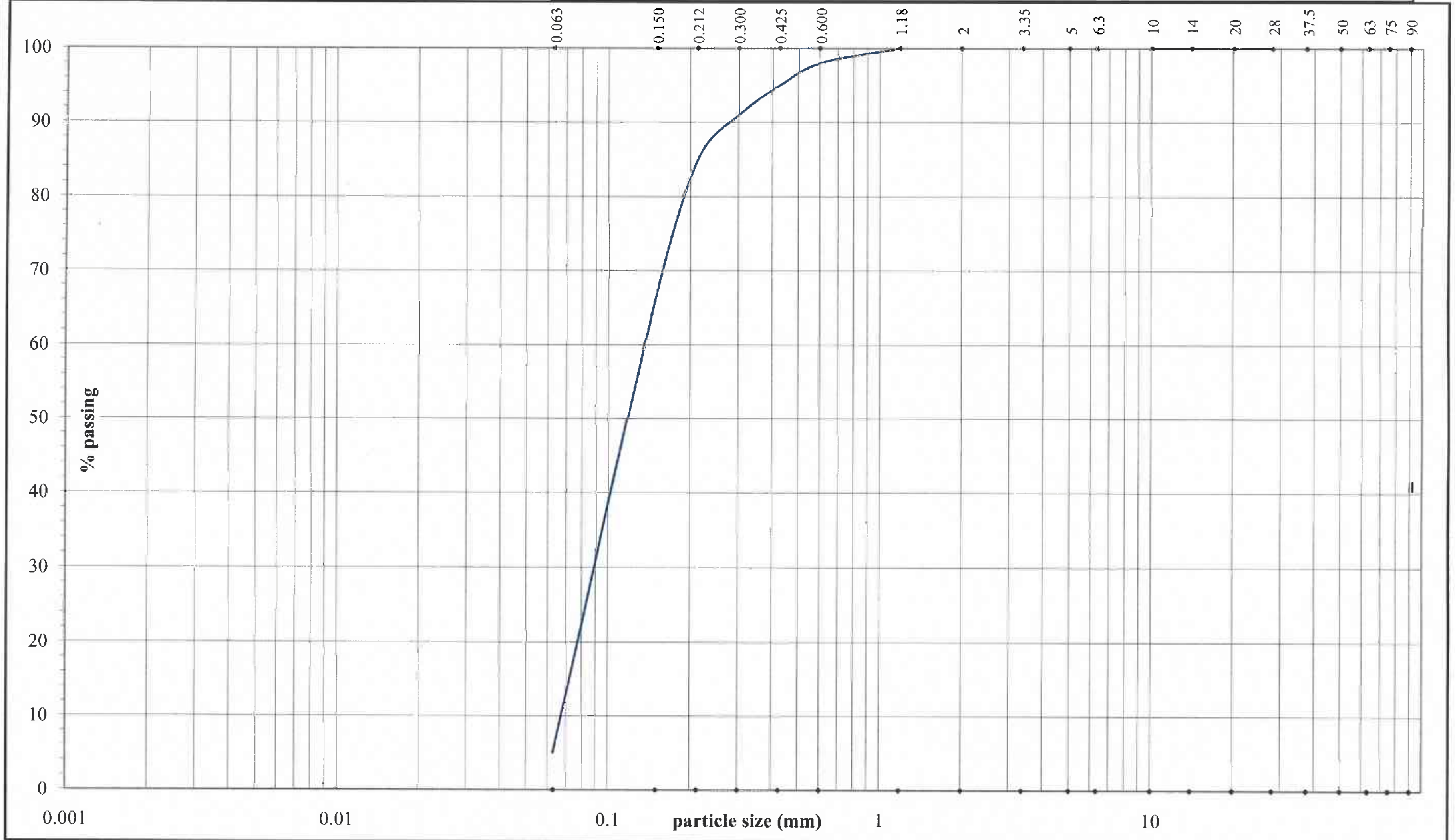
| Project: | Kish and Bray Banks | Exploratory Hole No.: | BH01 | Sample Type | Sample No. | at (m) | to (m) | Sample description: |
|---|---|---|---|---|---|---|---|---|
| Job No.: | 08-0585 | | | B | 5 | 4.00 | | |

*Glover Site Investigations Ltd*

# Particle Size Distribution

***BS1377:1990 Part 2 Clause 9.2 and 9.5***

| Particle size (mm) | % passing |
|---|---|
| 125 | 100 |
| 90 | 100 |
| 75 | 100 |
| 63 | 100 |
| 50 | 100 |
| 37.5 | 100 |
| 28 | 100 |
| 20 | 100 |
| 14 | 100 |
| 10 | 100 |
| 6.3 | 100 |
| 5 | 100 |
| 3.35 | 100 |
| 2 | 100 |
| 1.18 | 100 |
| 0.6 | 98 |
| 0.425 | 95 |
| 0.3 | 91 |
| 0.212 | 85 |
| 0.15 | 67 |
| 0.063 | 5 |




| | Fines 5% | fine | medium | coarse | fine | medium | coarse | Cobbles |
|---|---|---|---|---|---|---|---|---|
| | | Sand 95% | | | Gravel 0% | | | 0% |

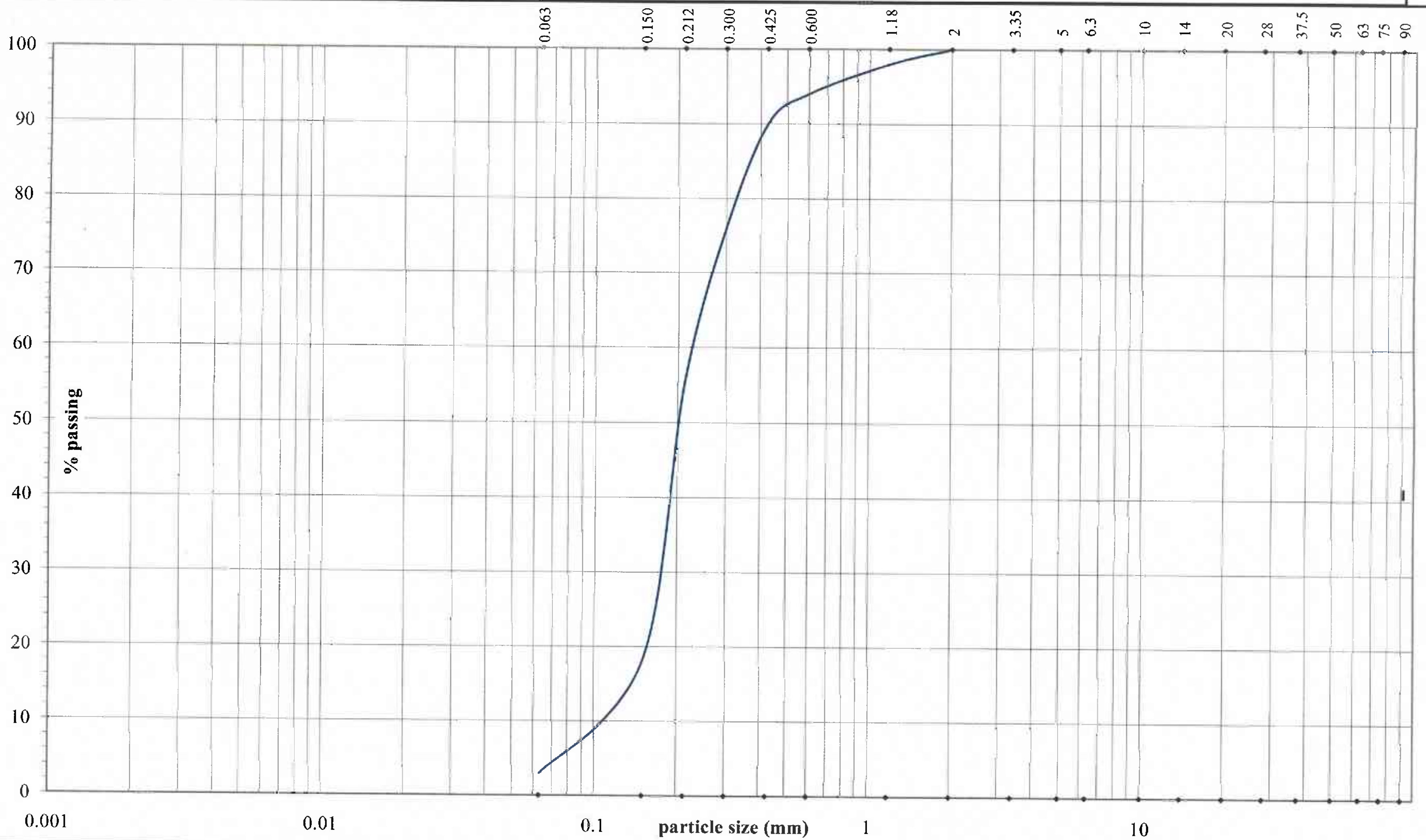
| Project: | Kish and Bray Banks | Exploratory Hole No.: | BH01 | Sample | | | | Sample description: | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Type | No. | at (m) | to (m) | | |
| Job No.: | 08-0585 | | | B | 6 | 5.00 | | | |

Glover Site Investigations Ltd

# Particle Size Distribution

*BS1377:1990 Part 2 Clause 9.2 and 9.5*

| Particle size (mm) | % passing |
|---|---|
| 125 | 100 |
| 90 | 100 |
| 75 | 100 |
| 63 | 100 |
| 50 | 100 |
| 37.5 | 100 |
| 28 | 100 |
| 20 | 100 |
| 14 | 100 |
| 10 | 100 |
| 6.3 | 100 |
| 5 | 100 |
| 3.35 | 100 |
| 2 | 100 |
| 1.18 | 98 |
| 0.6 | 94 |
| 0.425 | 90 |
| 0.3 | 76 |
| 0.212 | 55 |
| 0.15 | 18 |
| 0.063 | 3 |




| | Fines 3% | fine | medium | coarse | fine | medium | coarse | Cobbles |
|---|---|---|---|---|---|---|---|---|
| | | Sand 97% | | | Gravel 0% | | | 0% |

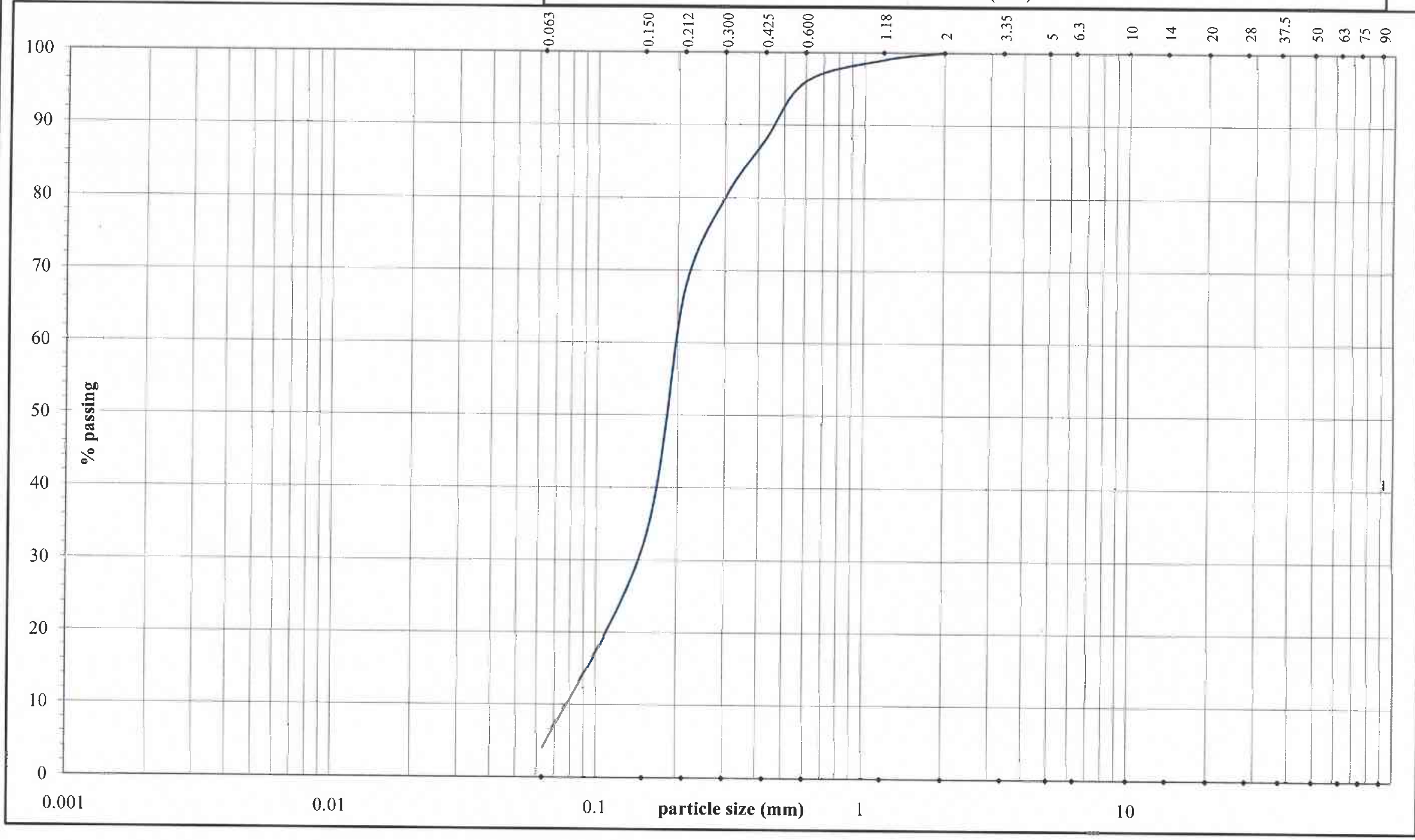
| Project: | Kish and Bray Banks | Exploratory Hole No.: | BH01 | Sample Type | No. | at (m) | to (m) | Sample description: |
|---|---|---|---|---|---|---|---|---|
| Job No.: | 08-0585 | | | B | 7 | 6.00 | | |

*Glover Site Investigations Ltd*

# Particle Size Distribution

*BS1377:1990 Part 2 Clause 9.2 and 9.5*

| Particle size (mm) | % passing |
|---|---|
| 125 | 100 |
| 90 | 100 |
| 75 | 100 |
| 63 | 100 |
| 50 | 100 |
| 37.5 | 100 |
| 28 | 100 |
| 20 | 100 |
| 14 | 100 |
| 10 | 100 |
| 6.3 | 100 |
| 5 | 100 |
| 3.35 | 100 |
| 2 | 100 |
| 1.18 | 99 |
| 0.6 | 96 |
| 0.425 | 88 |
| 0.3 | 80 |
| 0.212 | 67 |
| 0.15 | 32 |
| 0.063 | 4 |




| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Fines 4% | fine | medium | coarse | fine | medium | coarse | Cobbles 0% |
| | Sand 96% | | | Gravel 0% | | | |

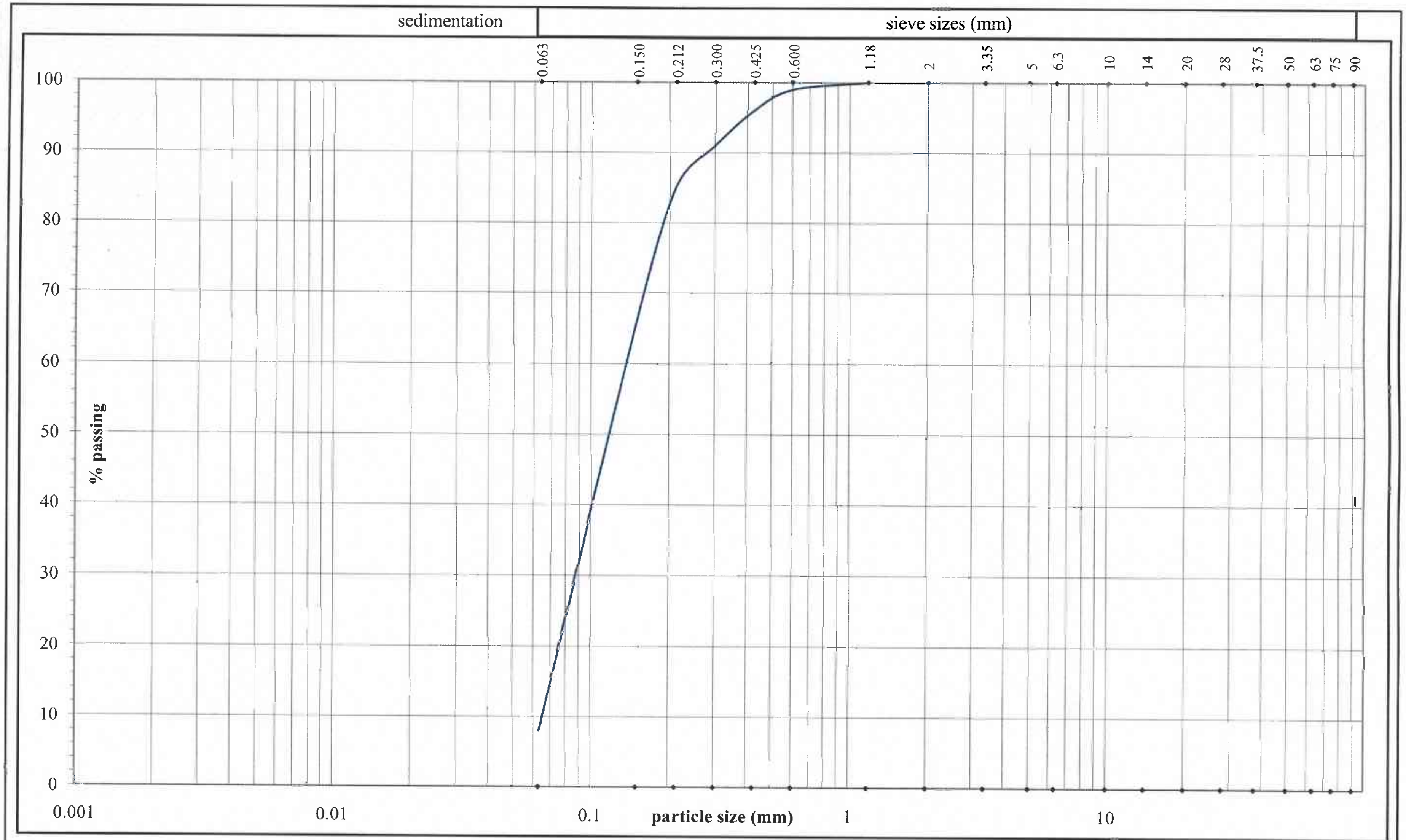
| Project: | Kish and Bray Banks | Exploratory Hole No.: | BH01 | Sample Type | Sample No. | Sample at (m) | Sample to (m) | Sample description: |
|---|---|---|---|---|---|---|---|---|
| Job No.: | 08-0585 | | | B | 8 | 7.00 | | |

**Glover Site Investigations Ltd**

# Particle Size Distribution

***BS1377:1990 Part 2 Clause 9.2 and 9.5***

| Particle size (mm) | % passing |
|---|---|
| 125 | 100 |
| 90 | 100 |
| 75 | 100 |
| 63 | 100 |
| 50 | 100 |
| 37.5 | 100 |
| 28 | 100 |
| 20 | 100 |
| 14 | 100 |
| 10 | 100 |
| 6.3 | 100 |
| 5 | 100 |
| 3.35 | 100 |
| 2 | 100 |
| 1.18 | 100 |
| 0.6 | 99 |
| 0.425 | 96 |
| 0.3 | 91 |
| 0.212 | 85 |
| 0.15 | 66 |
| 0.063 | 8 |




| | fine | medium | coarse | fine | medium | coarse | |
|---|---|---|---|---|---|---|---|
| Fines 8% | Sand 92% | | | Gravel 0% | | | Cobbles 0% |

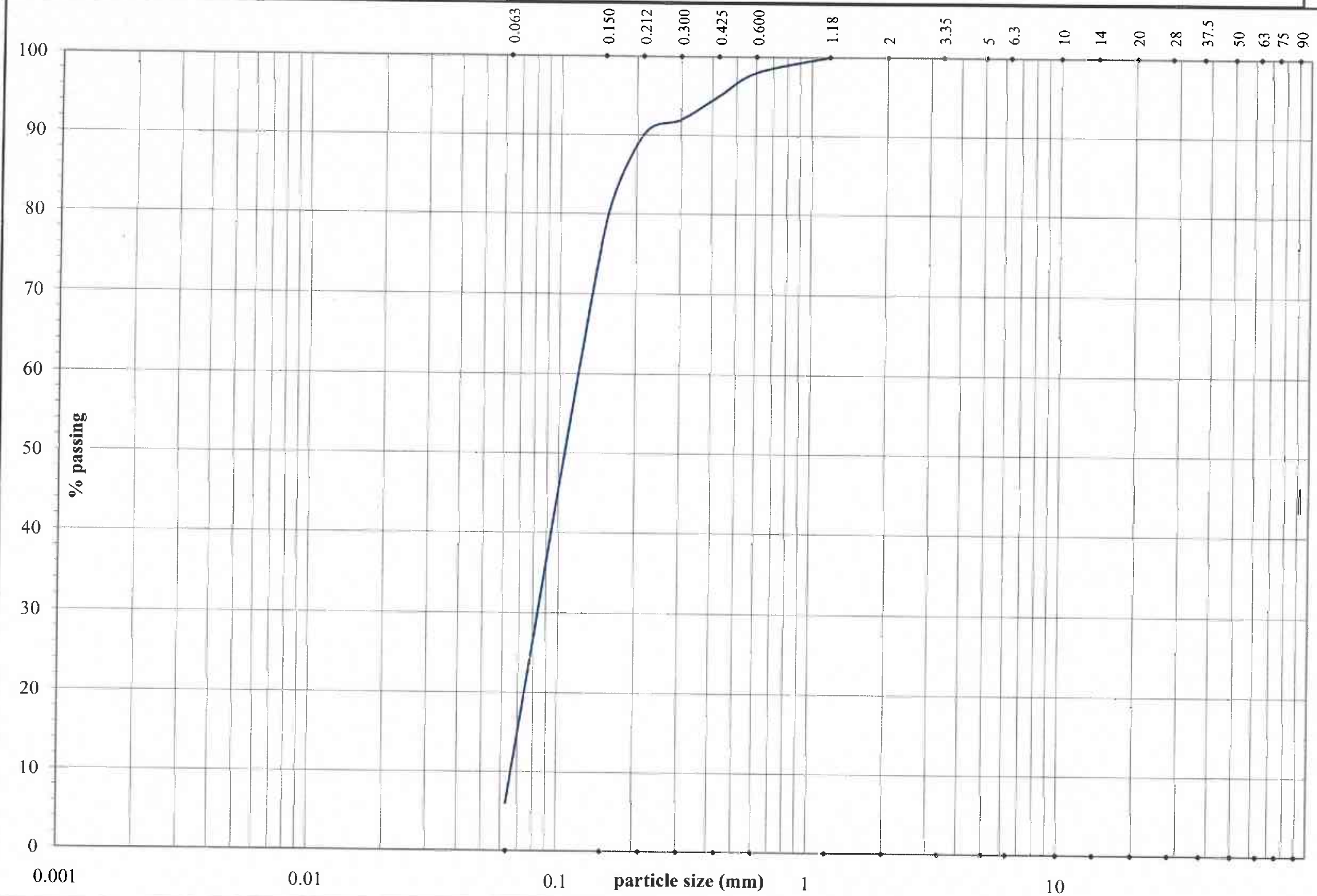
| Project: | Kish and Bray Banks | Exploratory Hole No.: | BH01 | Sample Type | Sample No. | Sample at (m) | Sample to (m) | Sample description: |
|---|---|---|---|---|---|---|---|---|
| Job No.: | 08-0585 | | | B | 9 | 8.00 | | |

Glover Site Investigations Ltd

# Particle Size Distribution

*BS1377:1990 Part 2 Clause 9.2 and 9.5*

| Particle size (mm) | % passing |
|---|---|
| 125 | 100 |
| 90 | 100 |
| 75 | 100 |
| 63 | 100 |
| 50 | 100 |
| 37.5 | 100 |
| 28 | 100 |
| 20 | 100 |
| 14 | 100 |
| 10 | 100 |
| 6.3 | 100 |
| 5 | 100 |
| 3.35 | 100 |
| 2 | 100 |
| 1.18 | 100 |
| 0.6 | 98 |
| 0.425 | 95 |
| 0.3 | 92 |
| 0.212 | 90 |
| 0.15 | 78 |
| 0.063 | 6 |




| | Fines 6% | fine | medium | coarse | fine | medium | coarse | Cobbles 0% |
|---|---|---|---|---|---|---|---|---|
| | | Sand 94% | | | Gravel 0% | | | |

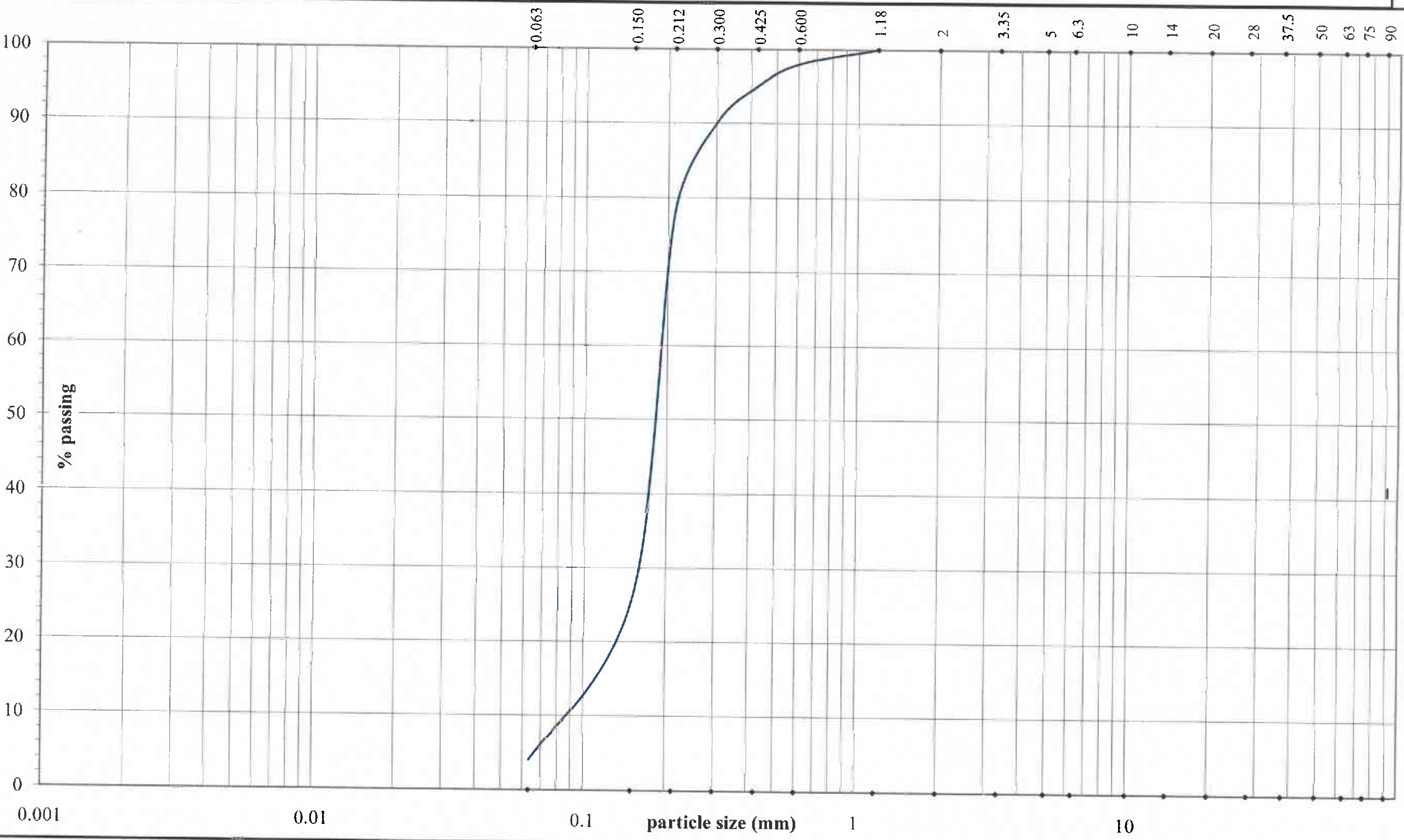
| Project: | Kish and Bray Banks | Exploratory Hole No.: | BH01 | Sample Type | Sample No. | Sample at (m) | Sample to (m) | Sample description: |
|---|---|---|---|---|---|---|---|---|
| Job No.: | 08-0585 | | | B | 10 | 9.00 | | |

*Glover Site Investigations Ltd*

# Particle Size Distribution

*BS1377:1990 Part 2 Clause 9.2 and 9.5*

| Particle size (mm) | % passing |
|---|---|
| 125 | 100 |
| 90 | 100 |
| 75 | 100 |
| 63 | 100 |
| 50 | 100 |
| 37.5 | 100 |
| 28 | 100 |
| 20 | 100 |
| 14 | 100 |
| 10 | 100 |
| 6.3 | 100 |
| 5 | 100 |
| 3.35 | 100 |
| 2 | 100 |
| 1.18 | 100 |
| 0.6 | 98 |
| 0.425 | 95 |
| 0.3 | 90 |
| 0.212 | 78 |
| 0.15 | 26 |
| 0.063 | 4 |



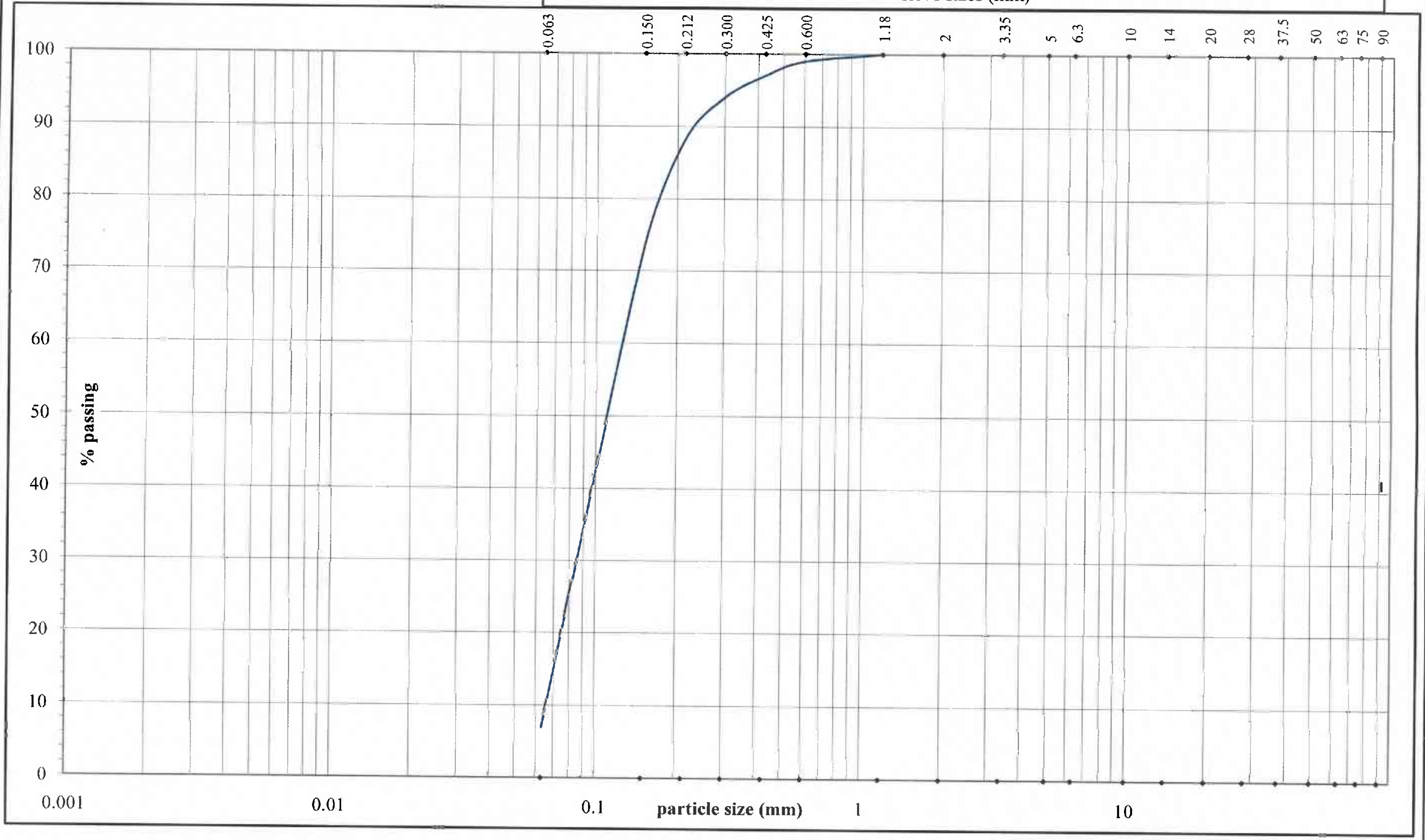

| Fines 4% | Sand 96% | | | Gravel 0% | | | Cobbles 0% |
|---|---|---|---|---|---|---|---|
| | fine | medium | coarse | fine | medium | coarse | |

| Project: | Kish and Bray Banks | Exploratory Hole No.: | BH01 | Sample Type | Sample No. | at (m) | to (m) | Sample description: |
|---|---|---|---|---|---|---|---|---|
| Job No.: | 08-0585 | | | B | 11 | 10.00 | | |

# Particle Size Distribution

*BS1377:1990 Part 2 Clause 9.2 and 9.5*

| Particle size (mm) | % passing |
|---|---|
| 125 | 100 |
| 90 | 100 |
| 75 | 100 |
| 63 | 100 |
| 50 | 100 |
| 37.5 | 100 |
| 28 | 100 |
| 20 | 100 |
| 14 | 100 |
| 10 | 100 |
| 6.3 | 100 |
| 5 | 100 |
| 3.35 | 100 |
| 2 | 100 |
| 1.18 | 100 |
| 0.6 | 99 |
| 0.425 | 97 |
| 0.3 | 94 |
| 0.212 | 88 |
| 0.15 | 73 |
| 0.063 | 7 |




| | Sand | | | Gravel | | | |
|---|---|---|---|---|---|---|---|
| Fines 7% | fine | medium | coarse | fine | medium | coarse | Cobbles |
| | Sand 93% | | | Gravel 0% | | | 0% |

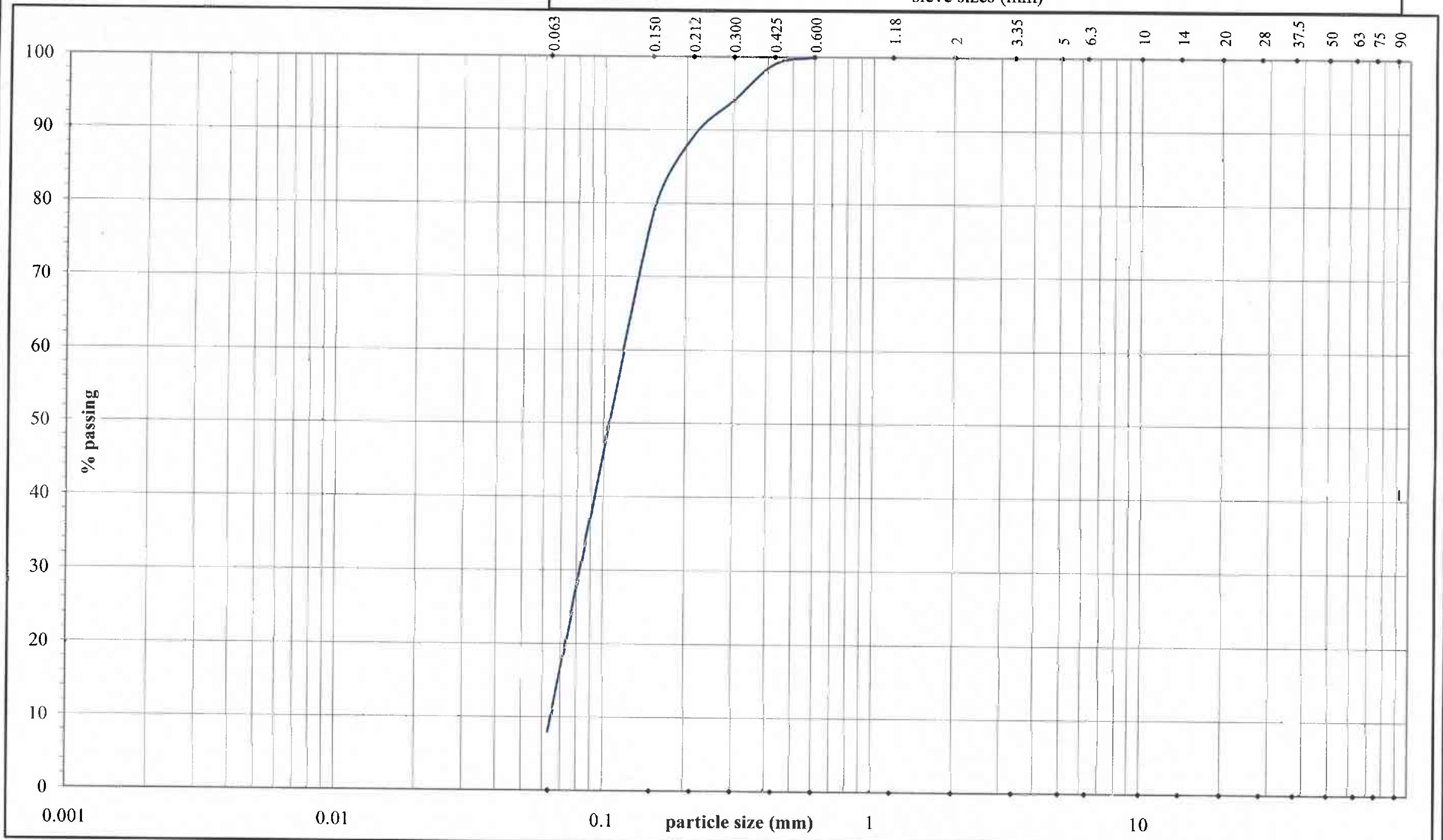
| Project: | Kish and Bray Banks | Exploratory Hole No.: | BH01 | Sample Type | Sample No. | at (m) | to (m) | Sample description: |
|---|---|---|---|---|---|---|---|---|
| Job No.: | 08-0585 | | | B | 12 | 11.00 | | |

Glover Site Investigations Ltd

# Particle Size Distribution

*BS1377:1990 Part 2 Clause 9.2 and 9.5*

| Particle size (mm) | % passing |
|---|---|
| 125 | 100 |
| 90 | 100 |
| 75 | 100 |
| 63 | 100 |
| 50 | 100 |
| 37.5 | 100 |
| 28 | 100 |
| 20 | 100 |
| 14 | 100 |
| 10 | 100 |
| 6.3 | 100 |
| 5 | 100 |
| 3.35 | 100 |
| 2 | 100 |
| 1.18 | 100 |
| 0.6 | 100 |
| 0.425 | 99 |
| 0.3 | 94 |
| 0.212 | 89 |
| 0.15 | 78 |
| 0.063 | 8 |



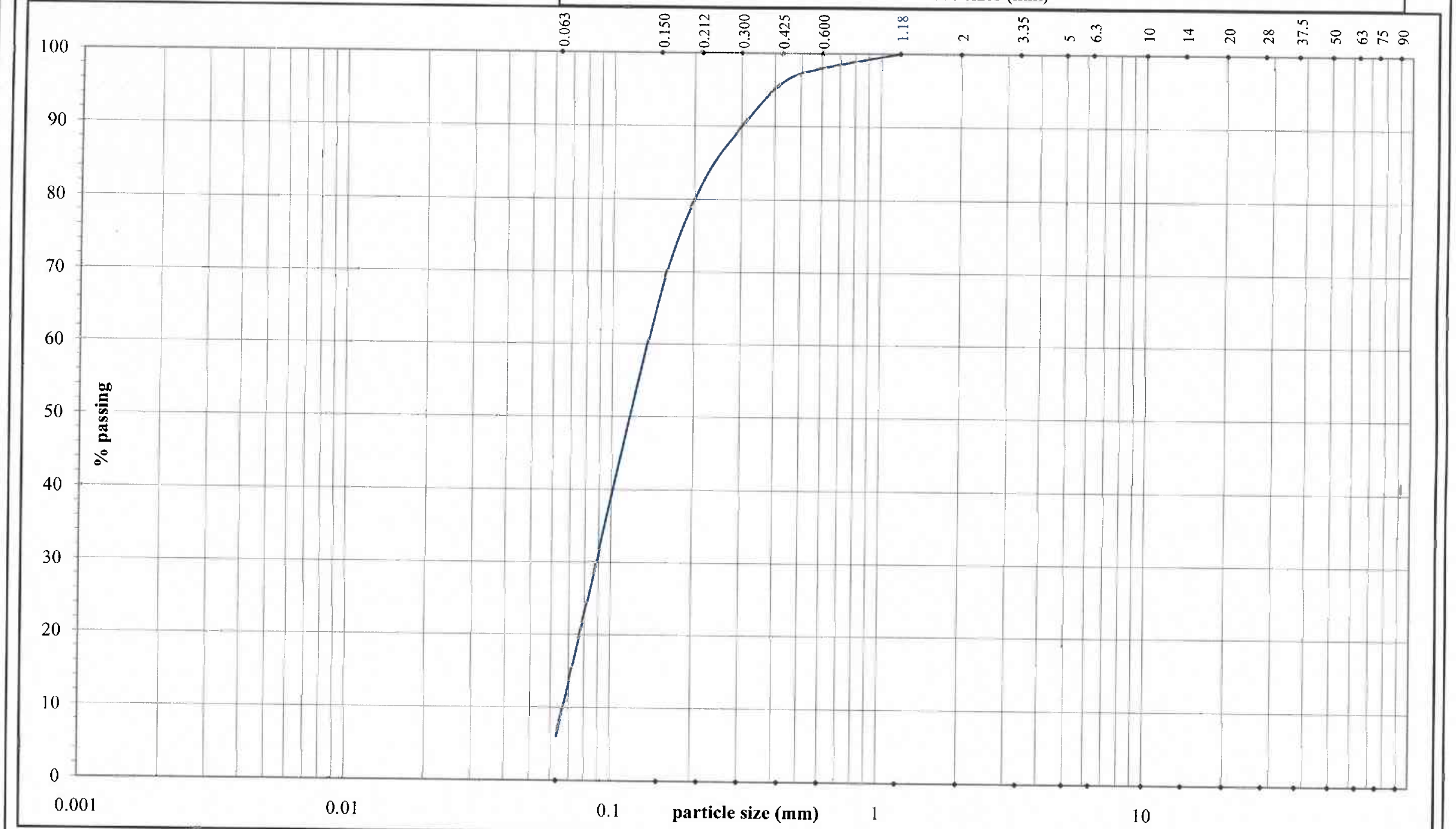

| | fine | medium | coarse | fine | medium | coarse | Cobbles |
|---|---|---|---|---|---|---|---|
| Fines 8% | Sand 92% | | | Gravel 0% | | | 0% |

| Project: | Kish and Bray Banks | Exploratory Hole No.: | BH01 | Sample Type | No. | at (m) | to (m) | Sample description: |
|---|---|---|---|---|---|---|---|---|
| Job No.: | 08-0585 | | | B | 13 | 12.00 | | |

# Particle Size Distribution

*BS1377:1990 Part 2 Clause 9.2 and 9.5*

| Particle size (mm) | % passing |
|---|---|
| 125 | 100 |
| 90 | 100 |
| 75 | 100 |
| 63 | 100 |
| 50 | 100 |
| 37.5 | 100 |
| 28 | 100 |
| 20 | 100 |
| 14 | 100 |
| 10 | 100 |
| 6.3 | 100 |
| 5 | 100 |
| 3.35 | 100 |
| 2 | 100 |
| 1.18 | 100 |
| 0.6 | 98 |
| 0.425 | 96 |
| 0.3 | 90 |
| 0.212 | 82 |
| 0.15 | 67 |
| 0.063 | 6 |




| | fine | medium | coarse | fine | medium | coarse | Cobbles |
|---|---|---|---|---|---|---|---|
| Fines 6% | Sand 94% | | | Gravel 0% | | | 0% |

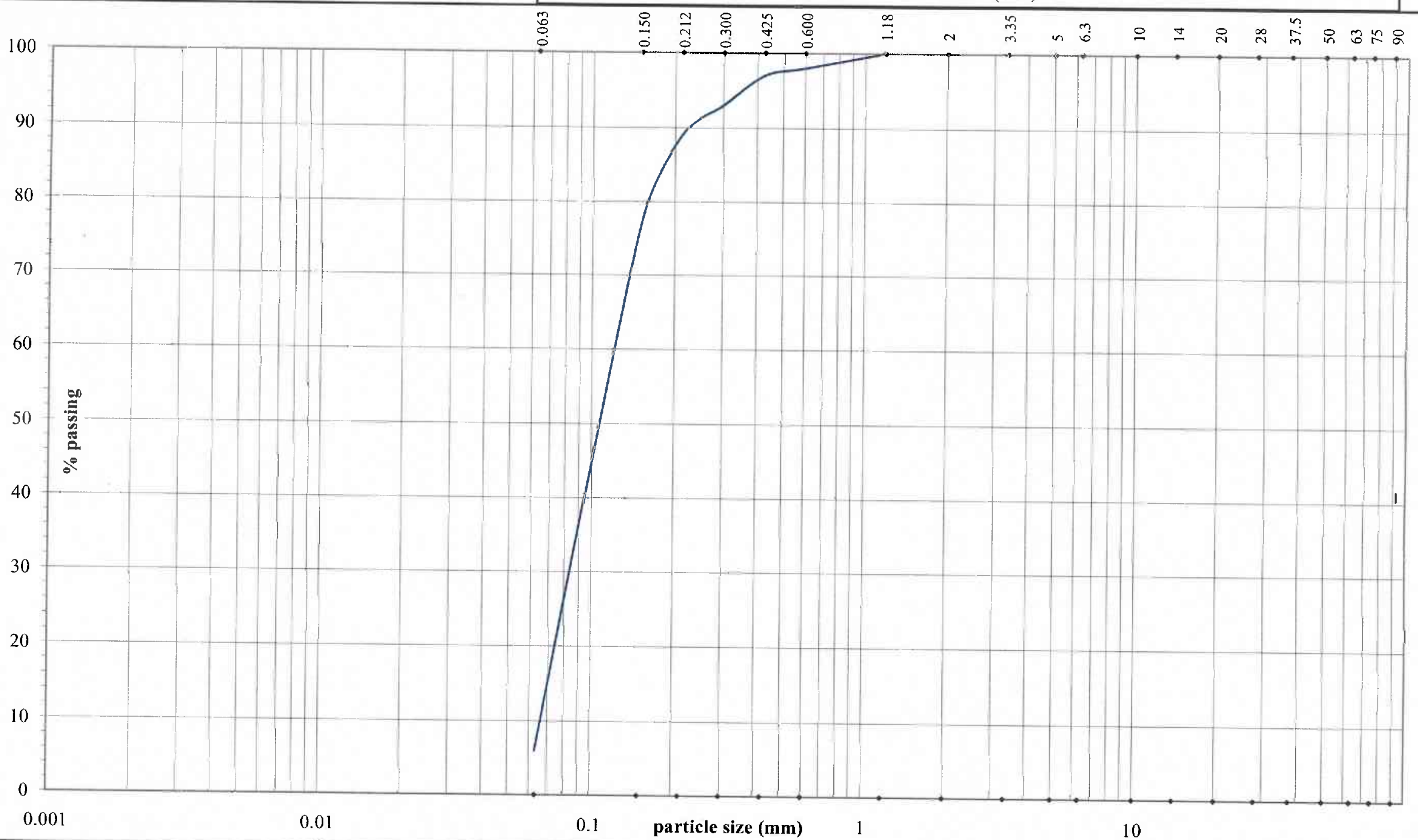
| Project: | Kish and Bray Banks | Exploratory Hole No.: | BH01 | Sample Type | Sample No. | Sample at (m) | Sample to (m) | Sample description: |
|---|---|---|---|---|---|---|---|---|
| Job No.: | 08-0585 | | | B | 14 | 13.50 | | |

Glover Site Investigations Ltd

# Particle Size Distribution

*BS1377:1990 Part 2 Clause 9.2 and 9.5*

| Particle size (mm) | % passing |
|---|---|
| 125 | 100 |
| 90 | 100 |
| 75 | 100 |
| 63 | 100 |
| 50 | 100 |
| 37.5 | 100 |
| 28 | 100 |
| 20 | 100 |
| 14 | 100 |
| 10 | 100 |
| 6.3 | 100 |
| 5 | 100 |
| 3.35 | 100 |
| 2 | 100 |
| 1.18 | 100 |
| 0.6 | 98 |
| 0.425 | 97 |
| 0.3 | 93 |
| 0.212 | 89 |
| 0.15 | 77 |
| 0.063 | 6 |




| | fine | medium | coarse | fine | medium | coarse | |
|---|---|---|---|---|---|---|---|
| Fines 6% | Sand 94% | | | Gravel 0% | | | Cobbles 0% |

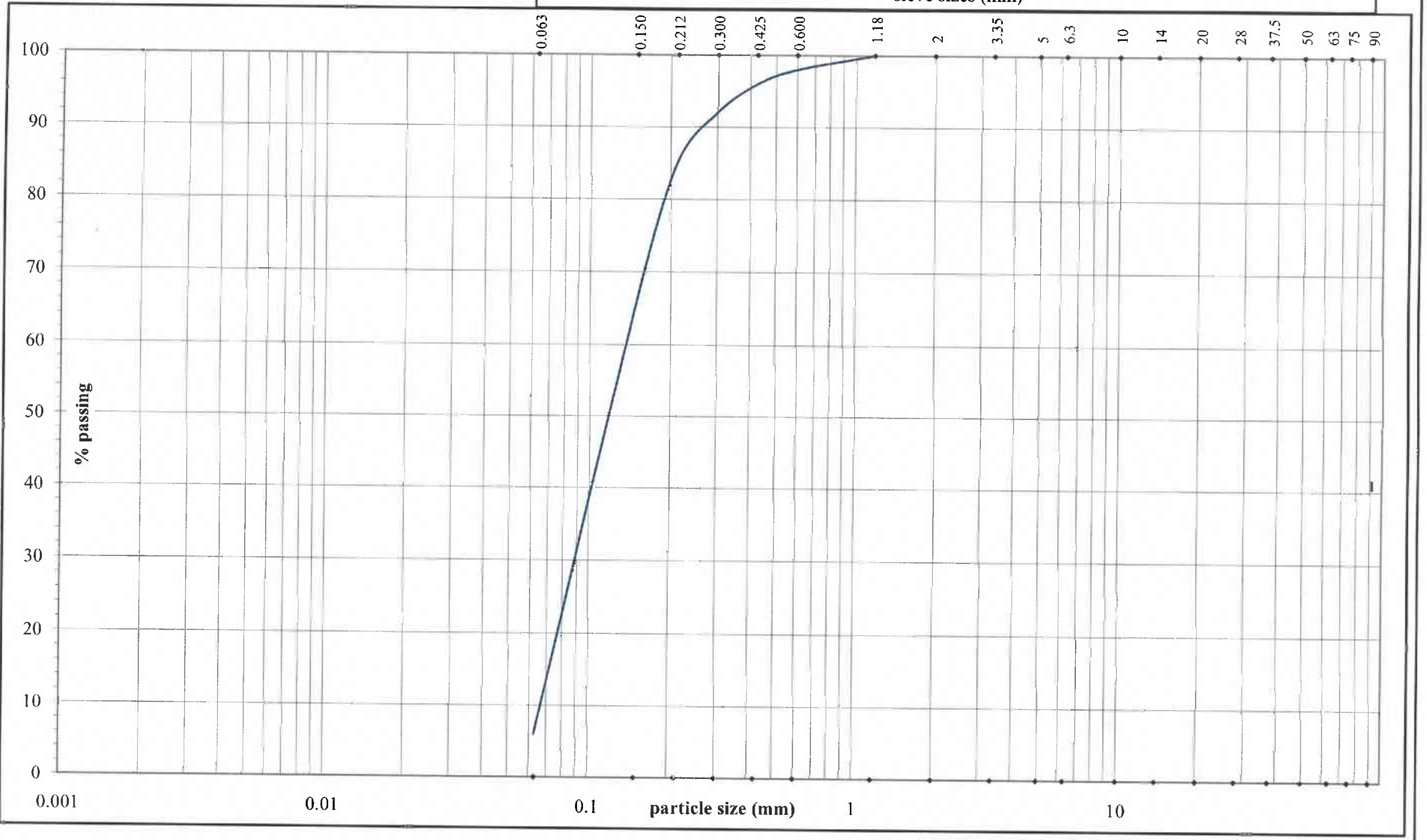
| Project: | Kish and Bray Banks | Exploratory Hole No.: | BH01 | Sample | | | | Sample description: |
|---|---|---|---|---|---|---|---|---|
| | | | | Type | No. | at (m) | to (m) | |
| Job No.: | 08-0585 | | | D | 4 | 19.50 | | |

*Glover Site Investigations Ltd*

# Particle Size Distribution

***BS1377:1990 Part 2 Clause 9.2 and 9.5***

| Particle size (mm) | % passing |
|---|---|
| 125 | 100 |
| 90 | 100 |
| 75 | 100 |
| 63 | 100 |
| 50 | 100 |
| 37.5 | 100 |
| 28 | 100 |
| 20 | 100 |
| 14 | 100 |
| 10 | 100 |
| 6.3 | 100 |
| 5 | 100 |
| 3.35 | 100 |
| 2 | 100 |
| 1.18 | 100 |
| 0.6 | 98 |
| 0.425 | 96 |
| 0.3 | 92 |
| 0.212 | 85 |
| 0.15 | 66 |
| 0.063 | 6 |




| | fine | medium | coarse | fine | medium | coarse | Cobbles |
|---|---|---|---|---|---|---|---|
| Fines 6% | Sand 94% | | | Gravel 0% | | | 0% |

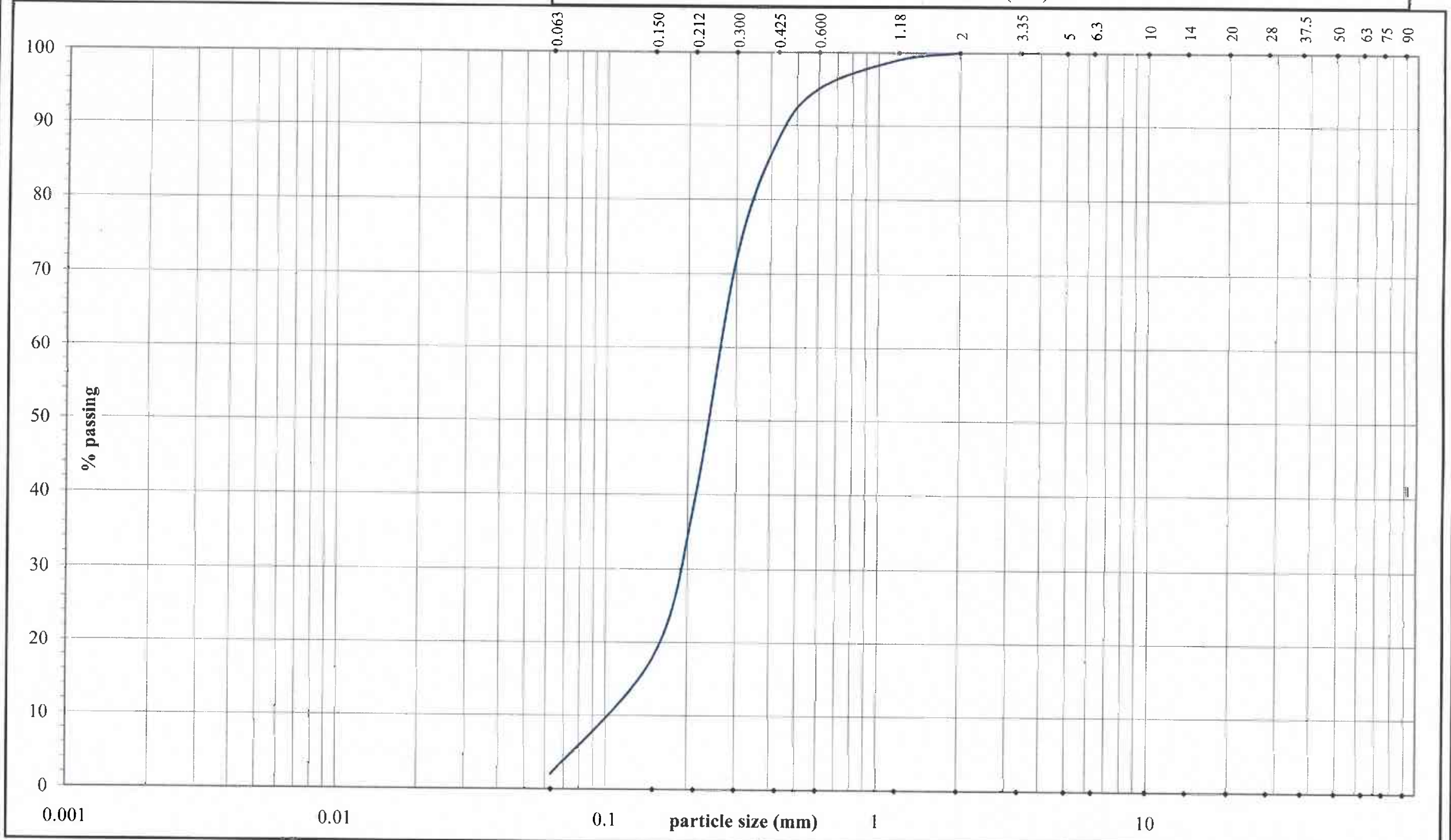
| Project: | Kish and Bray Banks | Exploratory Hole No.: | BH02 | Sample Type | Sample No. | Sample at (m) | Sample to (m) | Sample description: |
|---|---|---|---|---|---|---|---|---|
| Job No.: | 08-0585 | | | B | 1 | 0.00 | | |

*Glover Site Investigations Ltd*

# Particle Size Distribution

***BS1377:1990 Part 2 Clause 9.2 and 9.5***

| Particle size (mm) | % passing |
|---|---|
| 125 | 100 |
| 90 | 100 |
| 75 | 100 |
| 63 | 100 |
| 50 | 100 |
| 37.5 | 100 |
| 28 | 100 |
| 20 | 100 |
| 14 | 100 |
| 10 | 100 |
| 6.3 | 100 |
| 5 | 100 |
| 3.35 | 100 |
| 2 | 100 |
| 1.18 | 99 |
| 0.6 | 95 |
| 0.425 | 88 |
| 0.3 | 72 |
| 0.212 | 39 |
| 0.15 | 18 |
| 0.063 | 2 |




| | Fines 2% | fine | medium | coarse | fine | medium | coarse | Cobbles |
|---|---|---|---|---|---|---|---|---|
| | | Sand 98% | | | Gravel 0% | | | 0% |

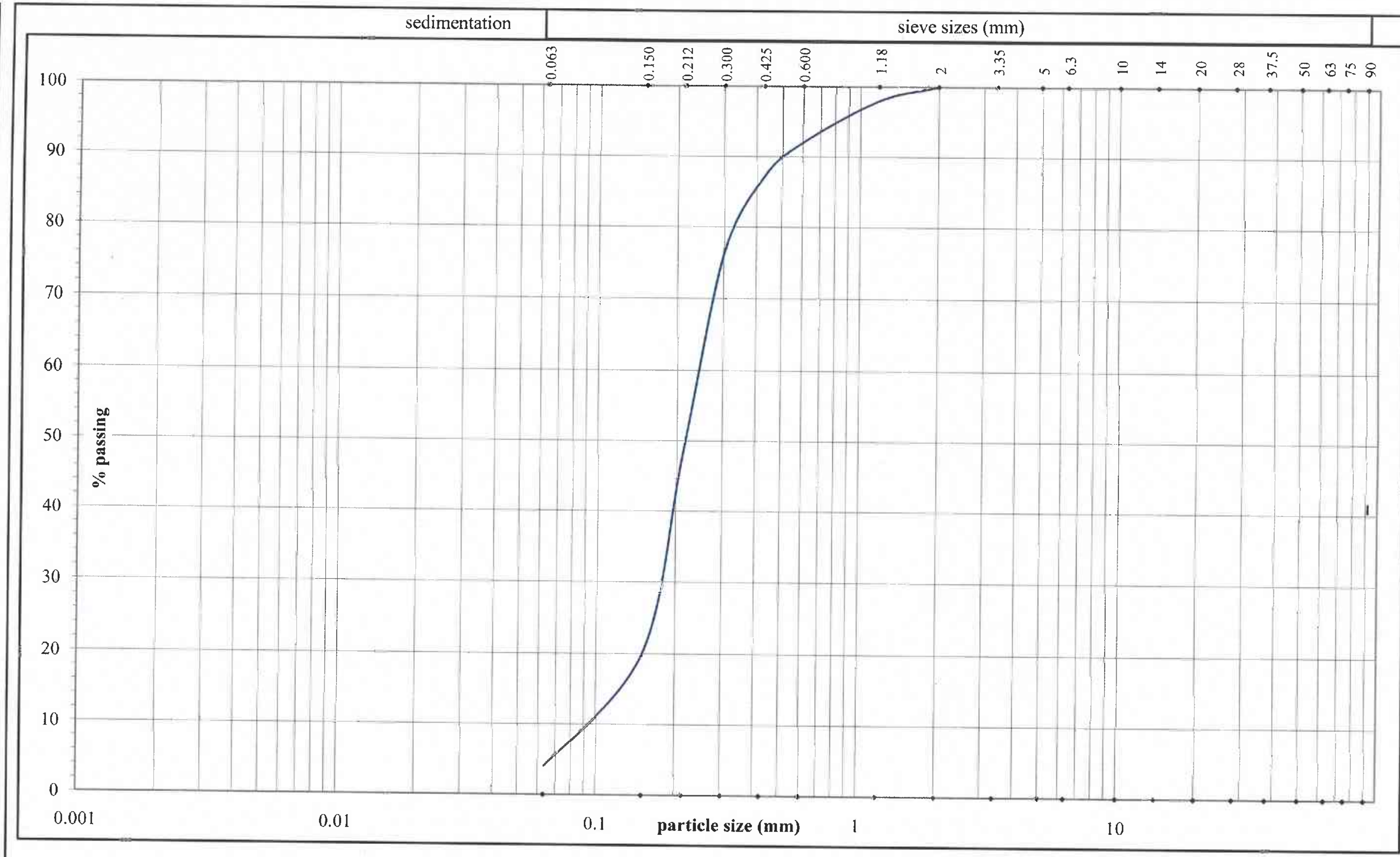
| Project: | Kish and Bray Banks | Exploratory Hole No.: | BH02 | Sample | | | | Sample description: | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Type | No. | at (m) | to (m) | | |
| Job No.: | 08-0585 | | | B | 2 | 1.00 | | | |

Glover Site Investigations Ltd

# Particle Size Distribution

*BS1377:1990 Part 2 Clause 9.2 and 9.5*

| Particle size (mm) | % passing |
|---|---|
| 125 | 100 |
| 90 | 100 |
| 75 | 100 |
| 63 | 100 |
| 50 | 100 |
| 37.5 | 100 |
| 28 | 100 |
| 20 | 100 |
| 14 | 100 |
| 10 | 100 |
| 6.3 | 100 |
| 5 | 100 |
| 3.35 | 100 |
| 2 | 100 |
| 1.18 | 98 |
| 0.6 | 92 |
| 0.425 | 87 |
| 0.3 | 76 |
| 0.212 | 48 |
| 0.15 | 20 |
| 0.063 | 4 |




| Fines 4% | Sand: fine | Sand: medium | Sand: coarse | Gravel: fine | Gravel: medium | Gravel: coarse | Cobbles |
|---|---|---|---|---|---|---|---|
| | Sand 96% | | | Gravel 0% | | | 0% |

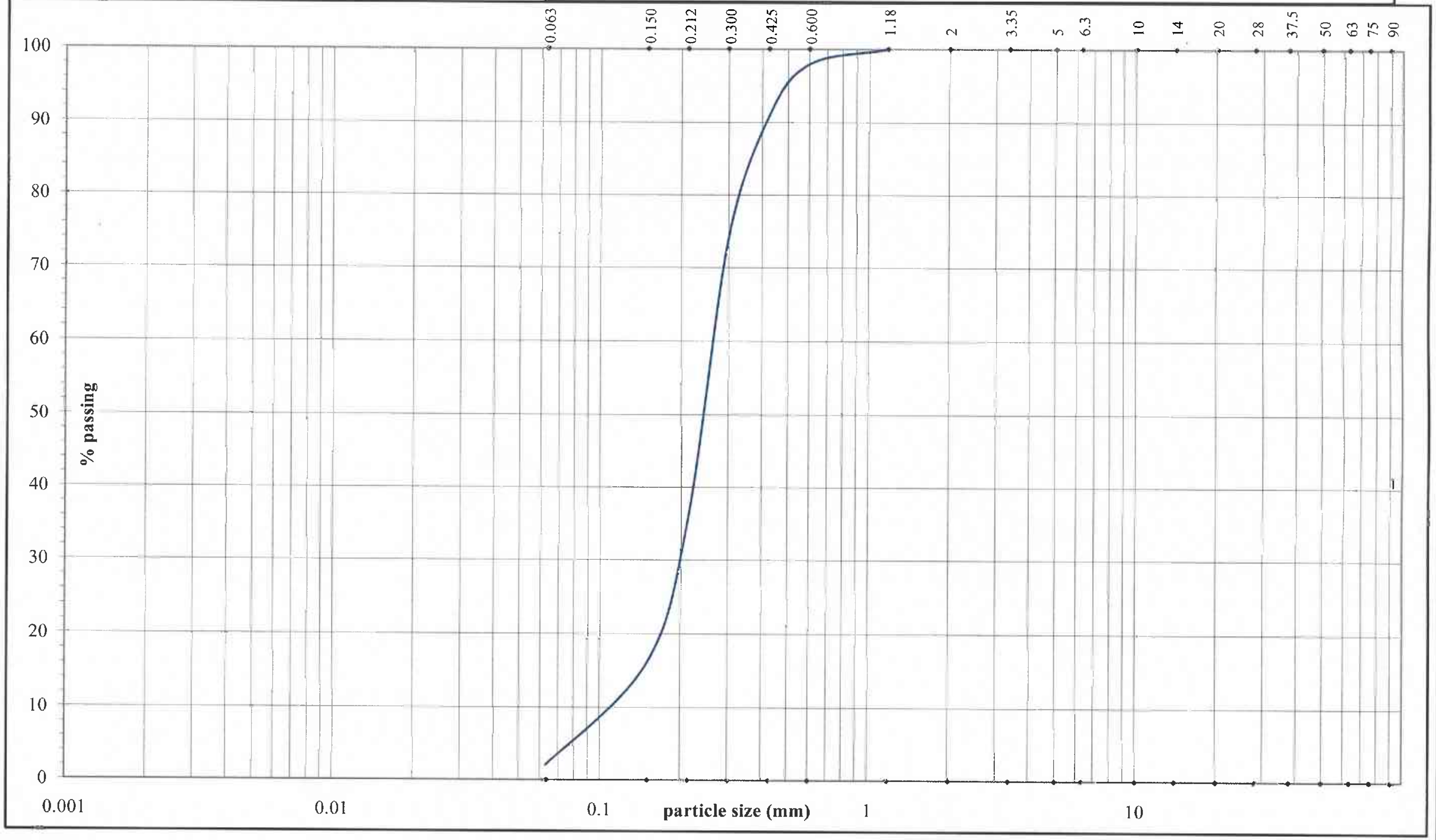
| Project: | Kish and Bray Banks | Exploratory Hole No.: | BH02 | Sample Type | Sample No. | Sample at (m) | Sample to (m) | Sample description: |
|---|---|---|---|---|---|---|---|---|
| Job No.: | 08-0585 | | | B | 3 | 2.00 | | |

Glover Site Investigations Ltd

# Particle Size Distribution

*BS1377:1990 Part 2 Clause 9.2 and 9.5*

| Particle size (mm) | % passing |
|---|---|
| 125 | 100 |
| 90 | 100 |
| 75 | 100 |
| 63 | 100 |
| 50 | 100 |
| 37.5 | 100 |
| 28 | 100 |
| 20 | 100 |
| 14 | 100 |
| 10 | 100 |
| 6.3 | 100 |
| 5 | 100 |
| 3.35 | 100 |
| 2 | 100 |
| 1.18 | 100 |
| 0.6 | 98 |
| 0.425 | 91 |
| 0.3 | 74 |
| 0.212 | 35 |
| 0.15 | 16 |
| 0.063 | 2 |




| Fines 2% | fine | medium | coarse | fine | medium | coarse | Cobbles |
|---|---|---|---|---|---|---|---|
| | Sand 98% | | | Gravel 0% | | | 0% |

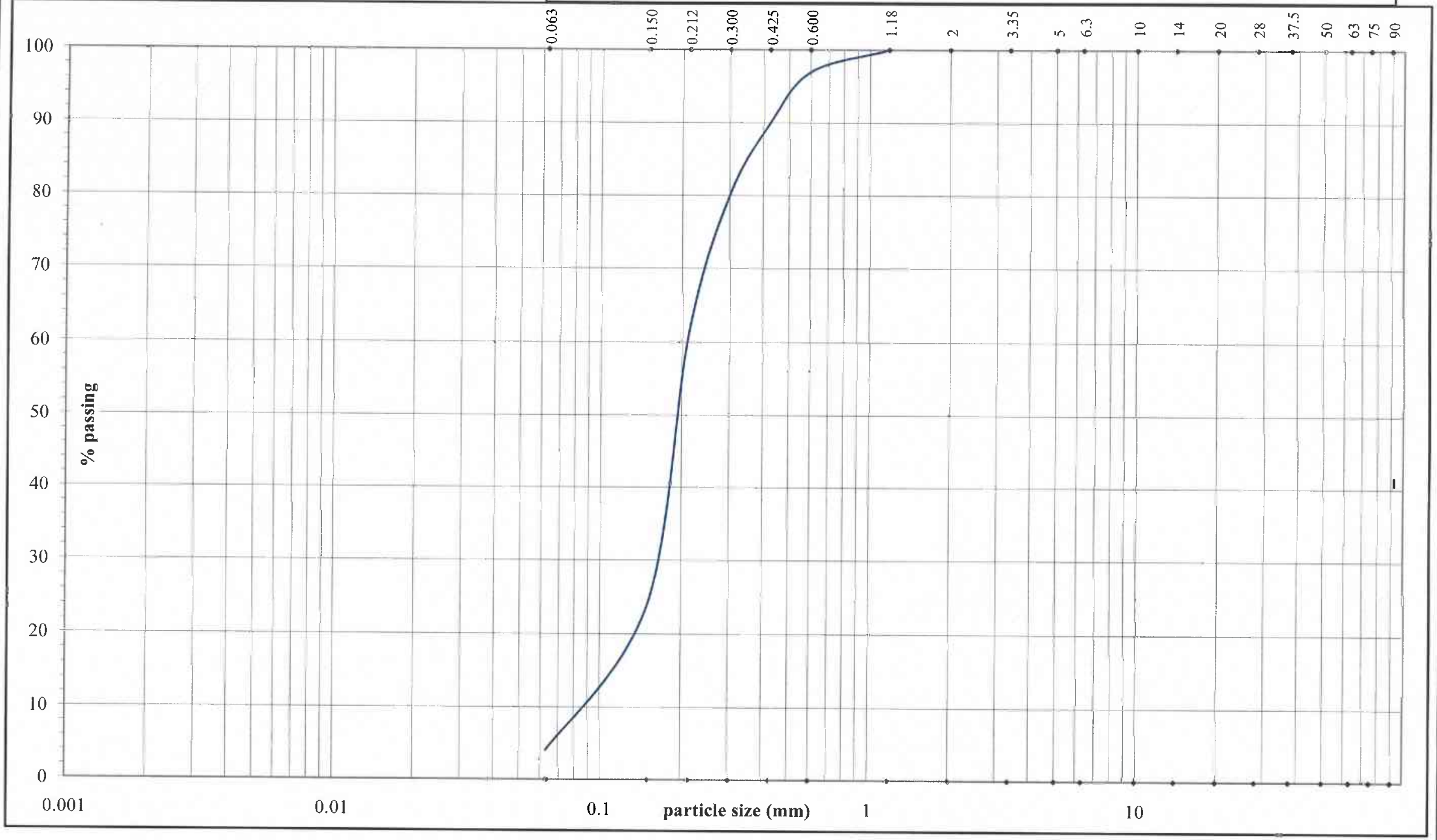
| Project: | Kish and Bray Banks | Exploratory Hole No.: | BH02 | Sample Type | No. | at (m) | to (m) | Sample description: |
|---|---|---|---|---|---|---|---|---|
| Job No.: | 08-0585 | | | B | 4 | 3.00 | | |

Glover Site Investigations Ltd

# Particle Size Distribution

*BS1377:1990 Part 2 Clause 9.2 and 9.5*

| Particle size (mm) | % passing |
|---|---|
| 125 | 100 |
| 90 | 100 |
| 75 | 100 |
| 63 | 100 |
| 50 | 100 |
| 37.5 | 100 |
| 28 | 100 |
| 20 | 100 |
| 14 | 100 |
| 10 | 100 |
| 6.3 | 100 |
| 5 | 100 |
| 3.35 | 100 |
| 2 | 100 |
| 1.18 | 100 |
| 0.6 | 97 |
| 0.425 | 90 |
| 0.3 | 80 |
| 0.212 | 61 |
| 0.15 | 24 |
| 0.063 | 4 |




| | Fines | Sand: fine | Sand: medium | Sand: coarse | Gravel: fine | Gravel: medium | Gravel: coarse | Cobbles |
|---|---|---|---|---|---|---|---|---|
| | Fines 4% | Sand 96% | | | Gravel 0% | | | 0% |

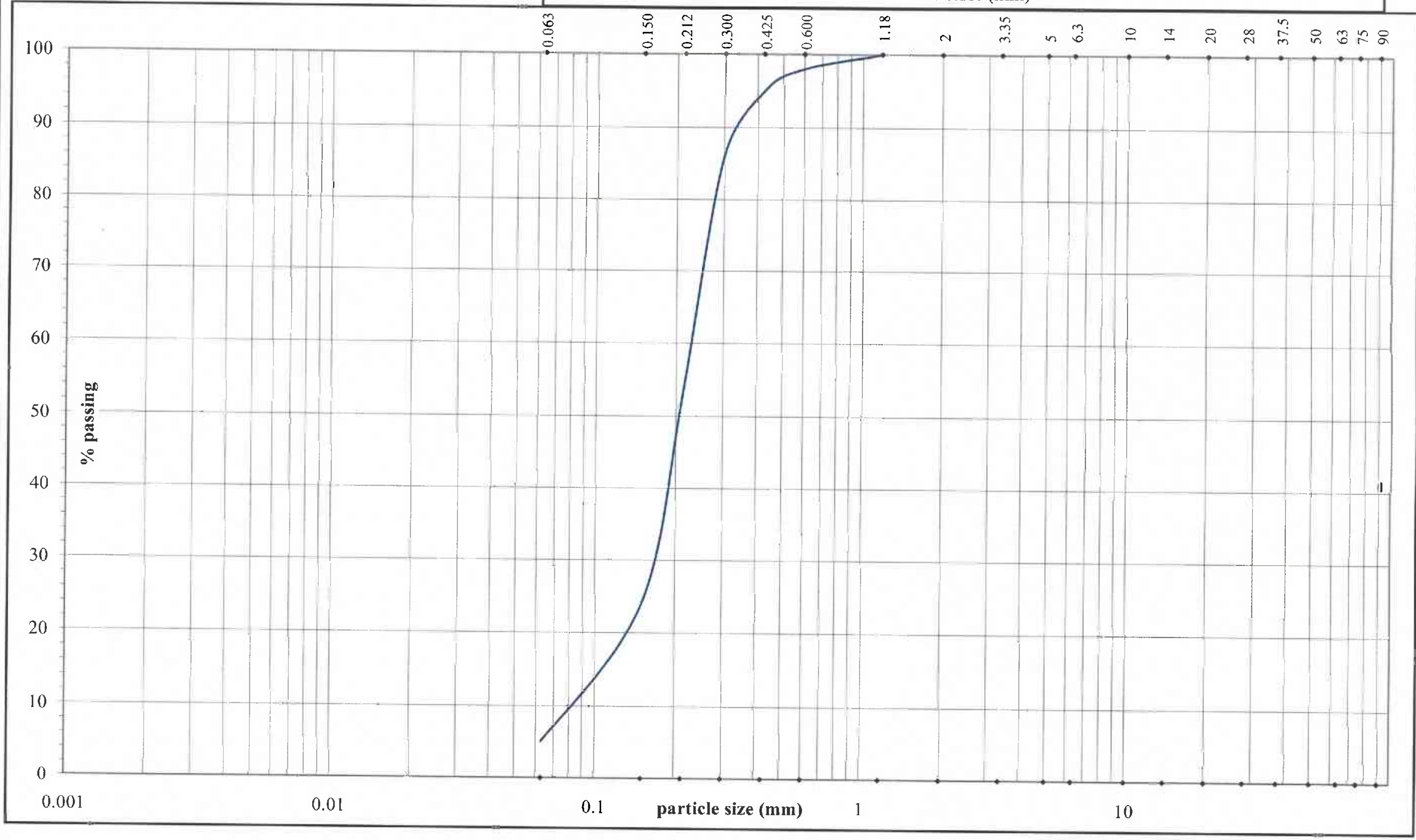
| Project: | Kish and Bray Banks | Exploratory Hole No.: | BH02 | Sample Type | Sample No. | Sample at (m) | Sample to (m) | Sample description: | |
|---|---|---|---|---|---|---|---|---|---|
| Job No.: | 08-0585 | | | B | 5 | 4.00 | | | |

*Glover Site Investigations Ltd*

# Particle Size Distribution

***BS1377:1990 Part 2 Clause 9.2 and 9.5***

| Particle size (mm) | % passing |
|---|---|
| 125 | 100 |
| 90 | 100 |
| 75 | 100 |
| 63 | 100 |
| 50 | 100 |
| 37.5 | 100 |
| 28 | 100 |
| 20 | 100 |
| 14 | 100 |
| 10 | 100 |
| 6.3 | 100 |
| 5 | 100 |
| 3.35 | 100 |
| 2 | 100 |
| 1.18 | 100 |
| 0.6 | 98 |
| 0.425 | 95 |
| 0.3 | 86 |
| 0.212 | 53 |
| 0.15 | 24 |
| 0.063 | 5 |




| Fines 5% | Sand: fine | Sand: medium | Sand: coarse | Gravel: fine | Gravel: medium | Gravel: coarse | Cobbles |
|---|---|---|---|---|---|---|---|
| Fines 5% | Sand 95% | | | Gravel 0% | | | 0% |

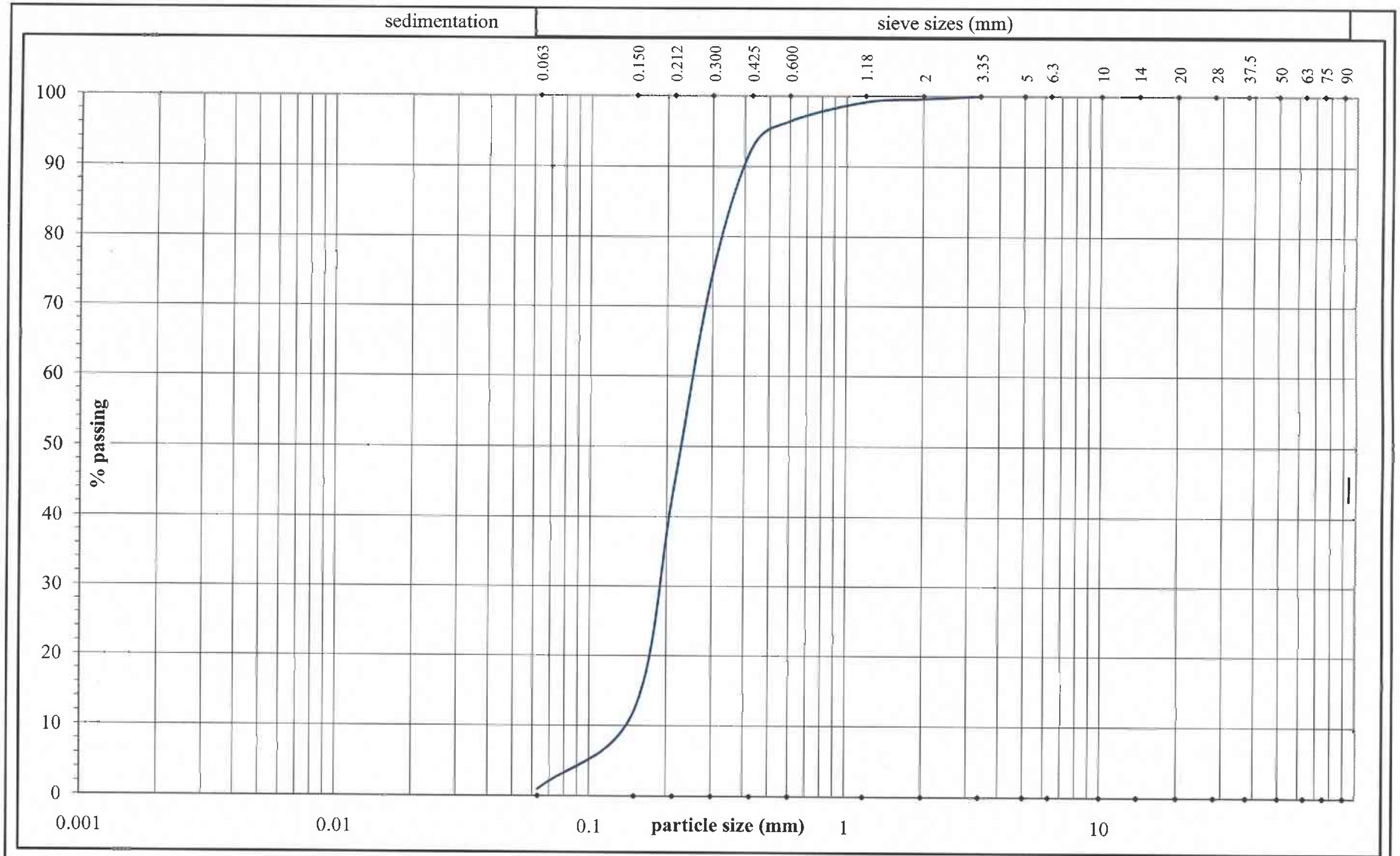
| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Project: | Kish and Bray Banks | Exploratory Hole No.: | BH02 | Sample | | | Sample description: |
| | | | | Type | No. | at (m) | to (m) |
| Job No.: | 08-0585 | | | B | 6 | 5.00 | |

Glover Site Investigations Ltd

# Particle Size Distribution

*BS1377:1990 Part 2 Clause 9.2 and 9.5*

| Particle size (mm) | % passing |
|---|---|
| 125 | 100 |
| 90 | 100 |
| 75 | 100 |
| 63 | 100 |
| 50 | 100 |
| 37.5 | 100 |
| 28 | 100 |
| 20 | 100 |
| 14 | 100 |
| 10 | 100 |
| 6.3 | 100 |
| 5 | 100 |
| 3.35 | 100 |
| 2 | 99.6 |
| 1.18 | 99.1 |
| 0.600 | 96.4 |
| 0.425 | 92.6 |
| 0.300 | 74.8 |
| 0.212 | 43.7 |
| 0.150 | 12.1 |
| 0.063 | 0.9 |




| | fine | medium | coarse | fine | medium | coarse | Cobbles |
|---|---|---|---|---|---|---|---|
| Fines 1% | Sand 99% | | | Gravel 0% | | | 0% |

Sample natural moisture content (%) = 22

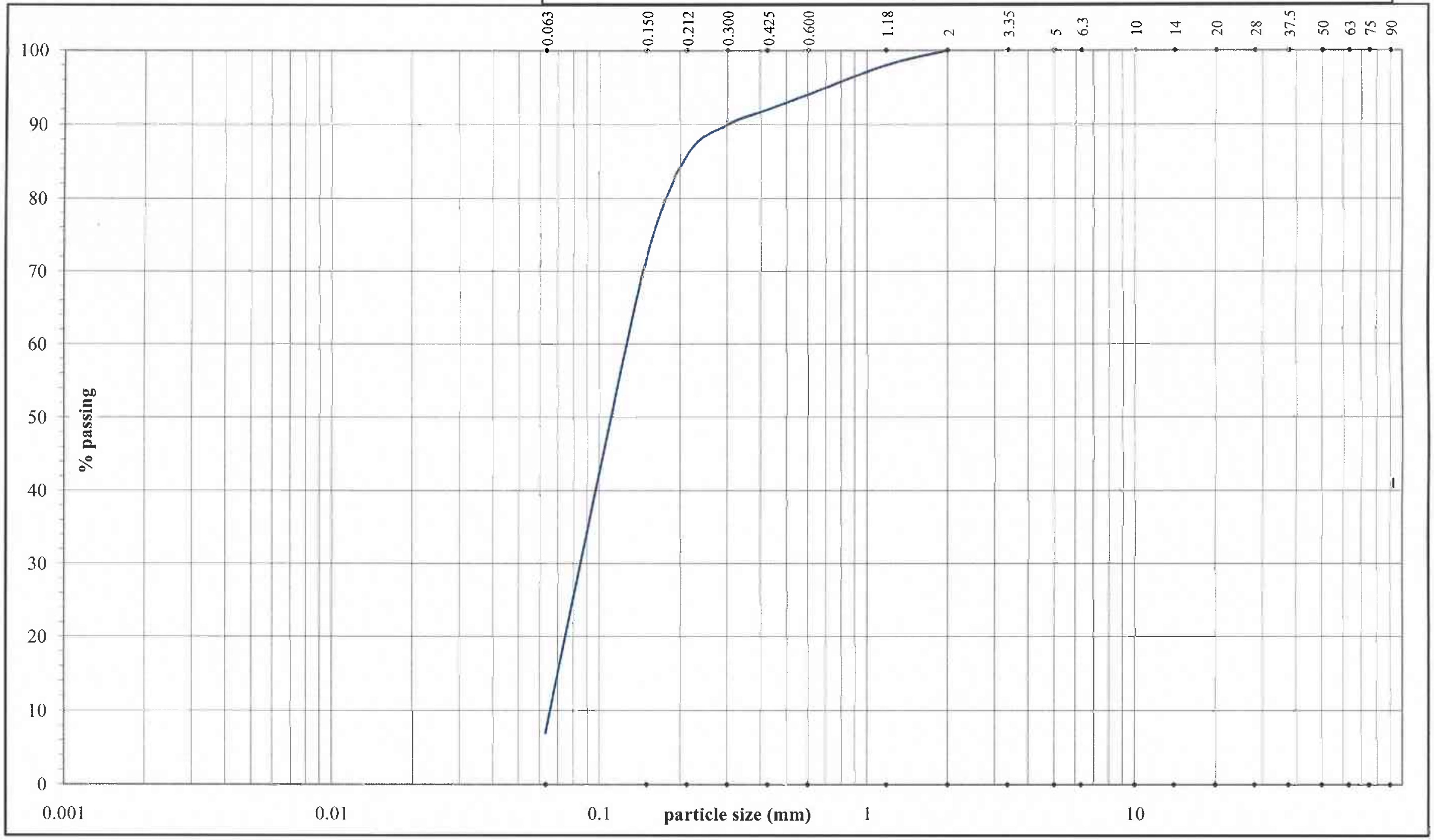
| Project: | Kish and Bray Banks | Exploratory Hole No.: | BH02 | Sample Type | Sample No. | Sample at (m) | Sample to (m) | Sample description: |
|---|---|---|---|---|---|---|---|---|
| Job No.: | 08-0585 | | | B | 7 | 6.00 | | |

Glover Site Investigations Ltd

# Particle Size Distribution

*BS1377:1990 Part 2 Clause 9.2 and 9.5*

| Particle size (mm) | % passing |
|---|---|
| 125 | 100 |
| 90 | 100 |
| 75 | 100 |
| 63 | 100 |
| 50 | 100 |
| 37.5 | 100 |
| 28 | 100 |
| 20 | 100 |
| 14 | 100 |
| 10 | 100 |
| 6.3 | 100 |
| 5 | 100 |
| 3.35 | 100 |
| 2 | 100 |
| 1.18 | 98 |
| 0.6 | 94 |
| 0.425 | 92 |
| 0.3 | 90 |
| 0.212 | 86 |
| 0.15 | 72 |
| 0.063 | 7 |




| | fine | medium | coarse | fine | medium | coarse | |
|---|---|---|---|---|---|---|---|
| Fines 7% | Sand 93% | | | Gravel 0% | | | Cobbles 0% |

| Project: | Kish and Bray Banks | Exploratory Hole No.: | BH02 | Sample Type | Sample No. | Sample at (m) | Sample to (m) | Sample description: |
|---|---|---|---|---|---|---|---|---|
| Job No.: | 08-0585 | | | B | 9 | 8.00 | | |

Glover Site Investigations Ltd

# Particle Size Distribution

*BS1377:1990 Part 2 Clause 9.2 and 9.5*

| Particle size (mm) | % passing |
|---|---|
| 125 | 100 |
| 90 | 100 |
| 75 | 100 |
| 63 | 100 |
| 50 | 100 |
| 37.5 | 100 |
| 28 | 100 |
| 20 | 100 |
| 14 | 100 |
| 10 | 100 |
| 6.3 | 100 |
| 5 | 100 |
| 3.35 | 100 |
| 2 | 100 |
| 1.18 | 99 |
| 0.6 | 96 |
| 0.425 | 90 |
| 0.3 | 82 |
| 0.212 | 53 |
| 0.15 | 32 |
| 0.063 | 5 |


| Fines 5% | fine | medium | coarse | fine | medium | coarse | Cobbles 0% |
|---|---|---|---|---|---|---|---|
| | Sand 95% | | | Gravel 0% | | | |

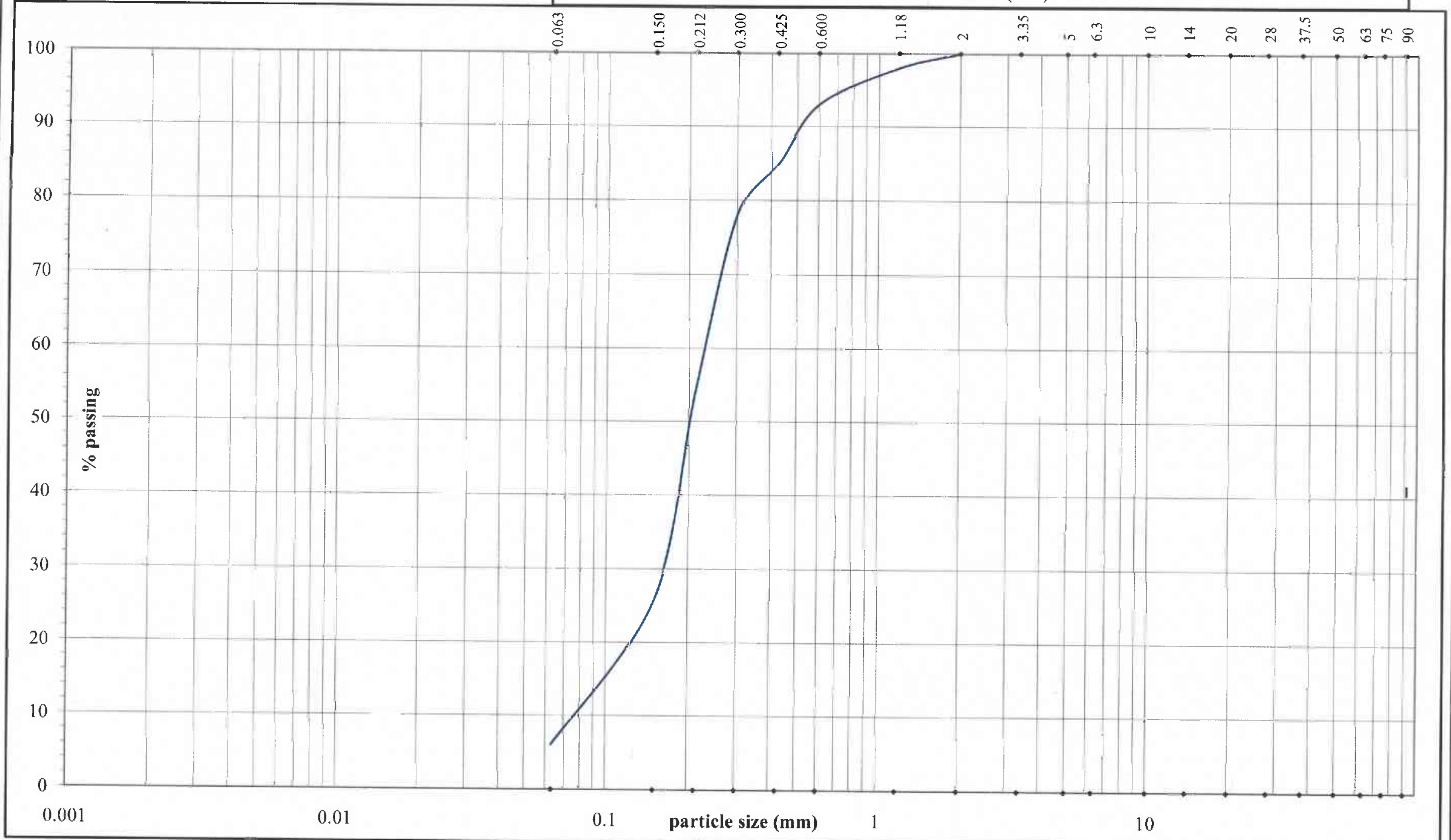
| Project: | Kish and Bray Banks | Exploratory Hole No.: | BH02 | Sample Type | No. | at (m) | to (m) | Sample description: |
|---|---|---|---|---|---|---|---|---|
| Job No.: | 08-0585 | | | B | 11 | 10.00 | | |

Glover Site Investigations Ltd

# Particle Size Distribution

*BS1377:1990 Part 2 Clause 9.2 and 9.5*

| Particle size (mm) | % passing |
|---|---|
| 125 | 100 |
| 90 | 100 |
| 75 | 100 |
| 63 | 100 |
| 50 | 100 |
| 37.5 | 100 |
| 28 | 100 |
| 20 | 100 |
| 14 | 100 |
| 10 | 100 |
| 6.3 | 100 |
| 5 | 100 |
| 3.35 | 100 |
| 2 | 100 |
| 1.18 | 98 |
| 0.6 | 93 |
| 0.425 | 85 |
| 0.3 | 78 |
| 0.212 | 54 |
| 0.15 | 26 |
| 0.063 | 6 |




| | Sand | | | Gravel | | | Cobbles |
|---|---|---|---|---|---|---|---|
| Fines 6% | fine | medium | coarse | fine | medium | coarse | 0% |
| | Sand 94% | | | Gravel 0% | | | |

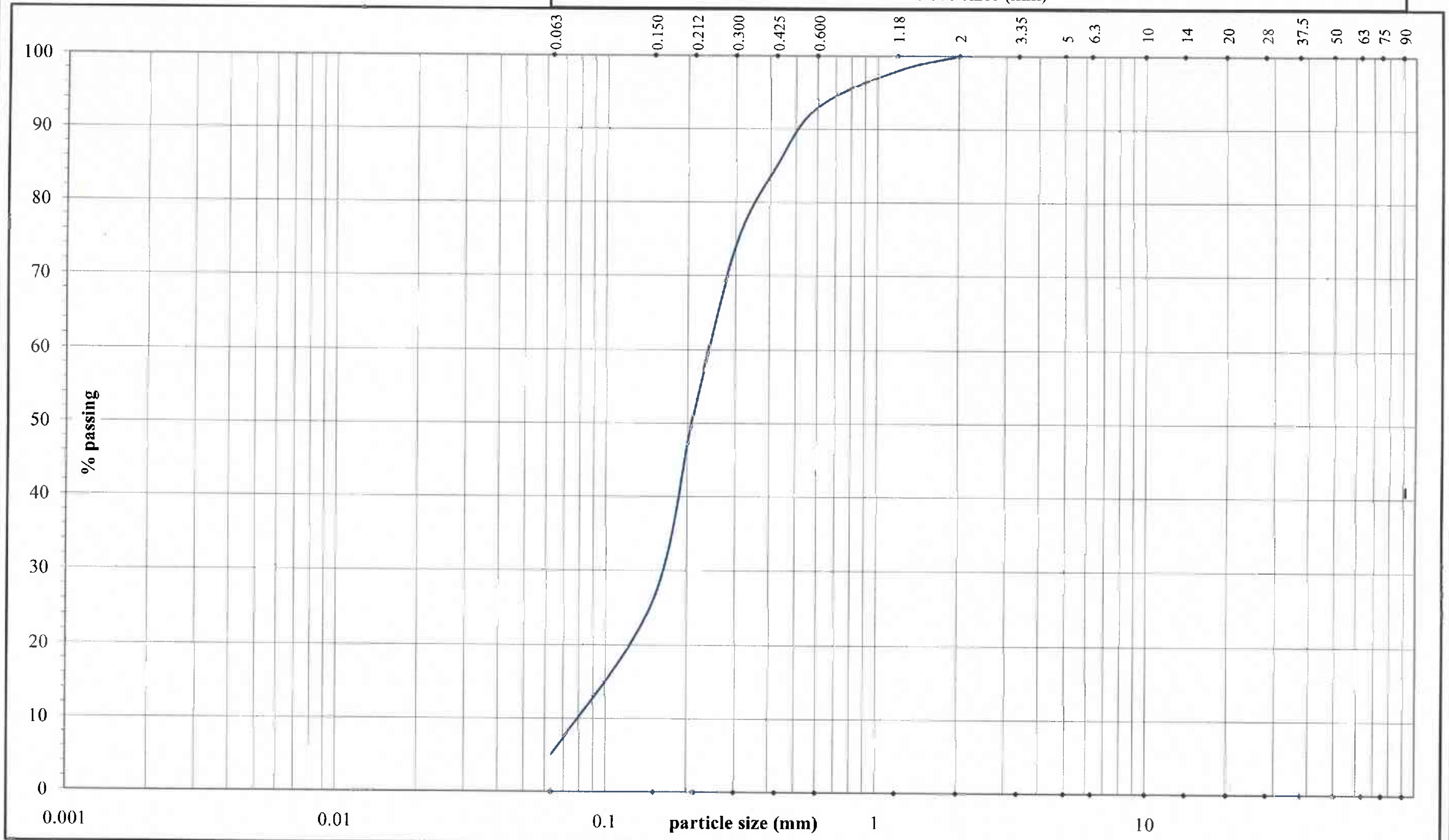
| Project: | Kish and Bray Banks | Exploratory Hole No.: | BH02 | Sample Type | Sample No. | Sample at (m) | Sample to (m) | Sample description: |
|---|---|---|---|---|---|---|---|---|
| Job No.: | 08-0585 | | | B | 13 | 12.00 | | |

Glover Site Investigations Ltd

# Particle Size Distribution

*BS1377:1990 Part 2 Clause 9.2 and 9.5*

| Particle size (mm) | % passing |
|---|---|
| 125 | 100 |
| 90 | 100 |
| 75 | 100 |
| 63 | 100 |
| 50 | 100 |
| 37.5 | 100 |
| 28 | 100 |
| 20 | 100 |
| 14 | 100 |
| 10 | 100 |
| 6.3 | 100 |
| 5 | 100 |
| 3.35 | 100 |
| 2 | 100 |
| 1.18 | 98 |
| 0.6 | 93 |
| 0.425 | 85 |
| 0.3 | 74 |
| 0.212 | 52 |
| 0.15 | 26 |
| 0.063 | 5 |




| | Sand | | | Gravel | | | |
|---|---|---|---|---|---|---|---|
| Fines 5% | fine | medium | coarse | fine | medium | coarse | Cobbles |
| | Sand 95% | | | Gravel 0% | | | 0% |

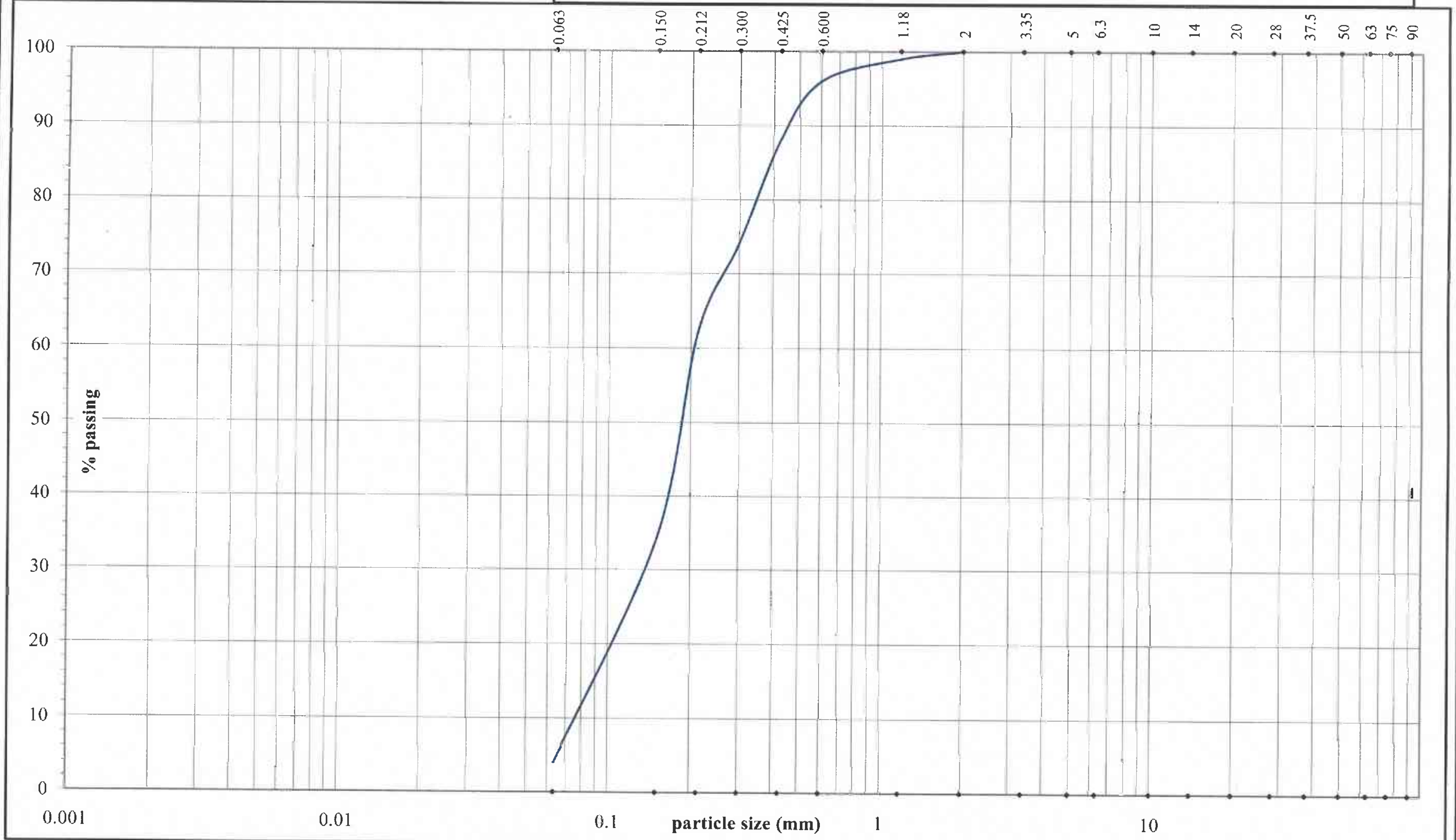
| Project: | Kish and Bray Banks | Exploratory Hole No.: | BH02 | Sample Type | Sample No. | at (m) | to (m) | Sample description: |
|---|---|---|---|---|---|---|---|---|
| Job No.: | 08-0585 | | | B | 15 | 15.00 | | |

Glover Site Investigations Ltd

# Particle Size Distribution

*BS1377:1990 Part 2 Clause 9.2 and 9.5*

| Particle size (mm) | % passing |
|---|---|
| 125 | 100 |
| 90 | 100 |
| 75 | 100 |
| 63 | 100 |
| 50 | 100 |
| 37.5 | 100 |
| 28 | 100 |
| 20 | 100 |
| 14 | 100 |
| 10 | 100 |
| 6.3 | 100 |
| 5 | 100 |
| 3.35 | 100 |
| 2 | 100 |
| 1.18 | 99 |
| 0.6 | 96 |
| 0.425 | 88 |
| 0.3 | 74 |
| 0.212 | 62 |
| 0.15 | 34 |
| 0.063 | 4 |




| | fine | medium | coarse | fine | medium | coarse | Cobbles |
|---|---|---|---|---|---|---|---|
| Fines 4% | Sand 96% | | | Gravel 0% | | | 0% |

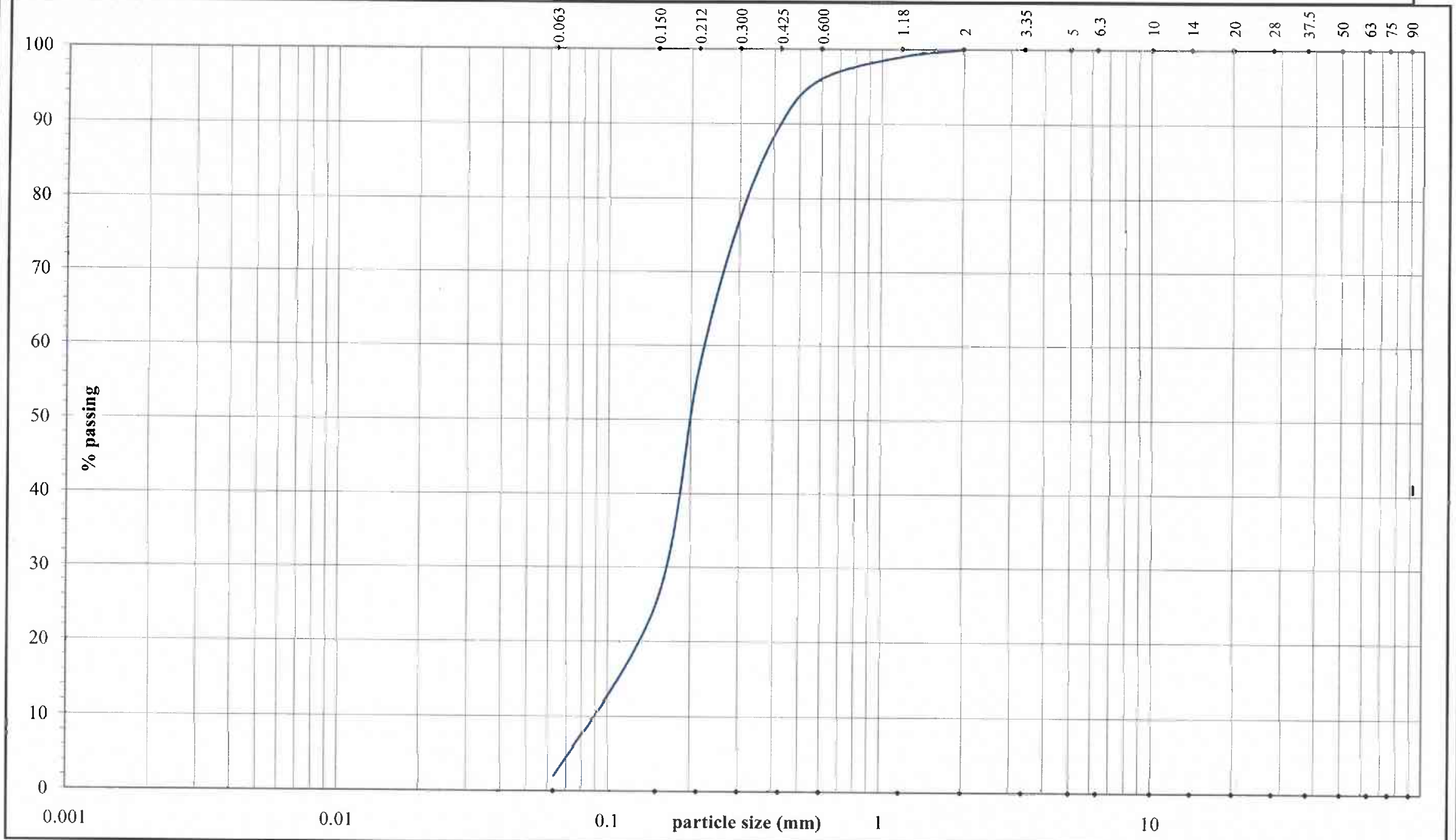
| Project: | Kish and Bray Banks | Exploratory Hole No.: | BH02 | Sample Type | Sample No. | Sample at (m) | Sample to (m) | Sample description: |
|---|---|---|---|---|---|---|---|---|
| Job No.: | 08-0585 | | | B | 17 | 18.00 | | |

Glover Site Investigations Ltd

# Particle Size Distribution

BS1377:1990 Part 2 Clause 9.2 and 9.5

| Particle size (mm) | % passing |
|---|---|
| 125 | 100 |
| 90 | 100 |
| 75 | 100 |
| 63 | 100 |
| 50 | 100 |
| 37.5 | 100 |
| 28 | 100 |
| 20 | 100 |
| 14 | 100 |
| 10 | 100 |
| 6.3 | 100 |
| 5 | 100 |
| 3.35 | 100 |
| 2 | 100 |
| 1.18 | 99 |
| 0.6 | 96 |
| 0.425 | 90 |
| 0.3 | 77 |
| 0.212 | 56 |
| 0.15 | 25 |
| 0.063 | 2 |




| | fine | medium | coarse | fine | medium | coarse | Cobbles |
|---|---|---|---|---|---|---|---|
| Fines 2% | Sand 98% | | | Gravel 0% | | | 0% |

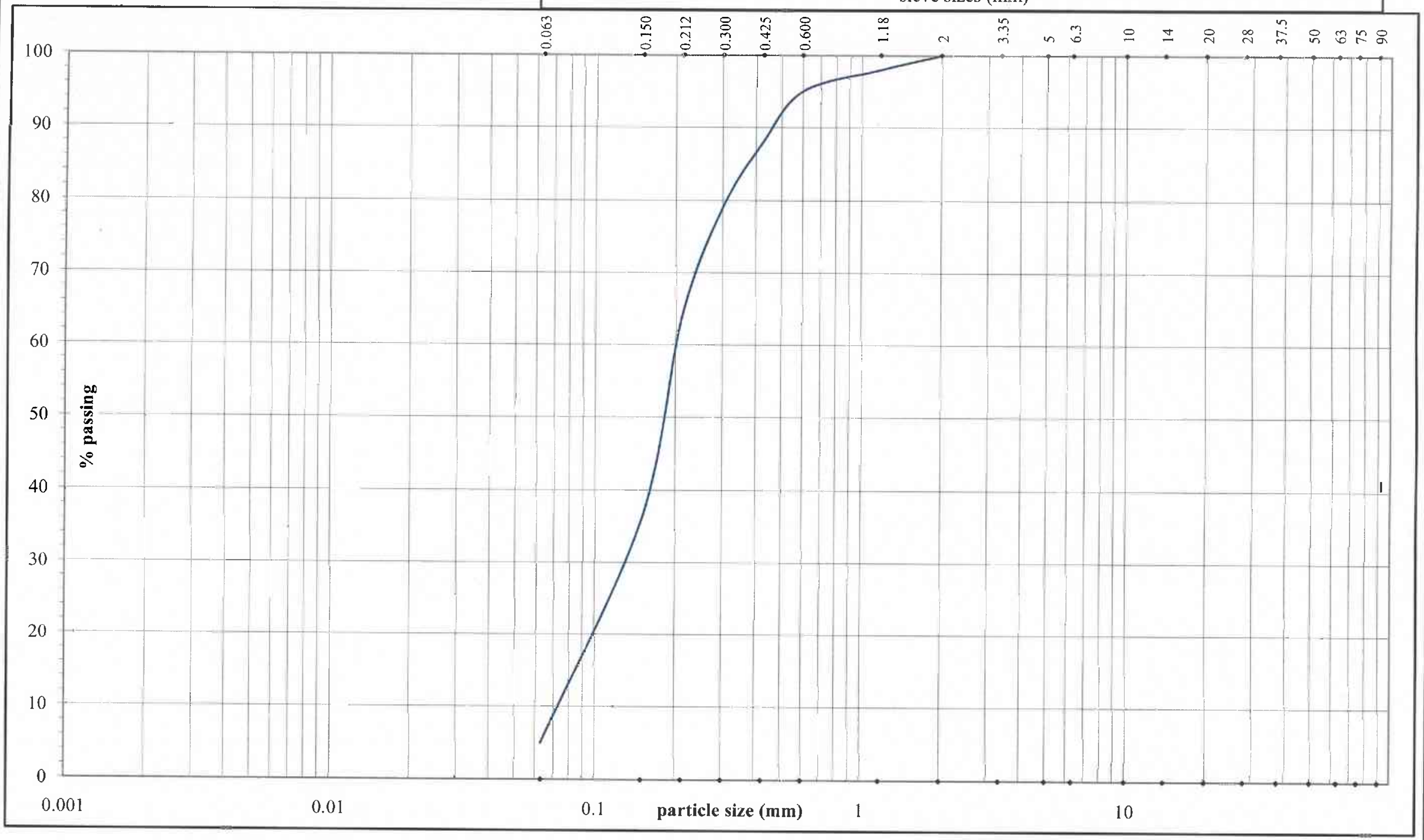
| Project: | Kish and Bray Banks | Exploratory Hole No.: | BH03 | Sample Type | Sample No. | Sample at (m) | Sample to (m) | Sample description: |
|---|---|---|---|---|---|---|---|---|
| Job No.: | 08-0585 | | | B | 1 | 0.00 | | |

*Glover Site Investigations Ltd*

# Particle Size Distribution

***BS1377:1990 Part 2 Clause 9.2 and 9.5***

| Particle size (mm) | % passing |
|---|---|
| 125 | 100 |
| 90 | 100 |
| 75 | 100 |
| 63 | 100 |
| 50 | 100 |
| 37.5 | 100 |
| 28 | 100 |
| 20 | 100 |
| 14 | 100 |
| 10 | 100 |
| 6.3 | 100 |
| 5 | 100 |
| 3.35 | 100 |
| 2 | 100 |
| 1.18 | 98 |
| 0.6 | 95 |
| 0.425 | 88 |
| 0.3 | 79 |
| 0.212 | 64 |
| 0.15 | 36 |
| 0.063 | 5 |




| | fine | medium | coarse | fine | medium | coarse | Cobbles |
|---|---|---|---|---|---|---|---|
| Fines 5% | Sand 95% | | | Gravel 0% | | | 0% |

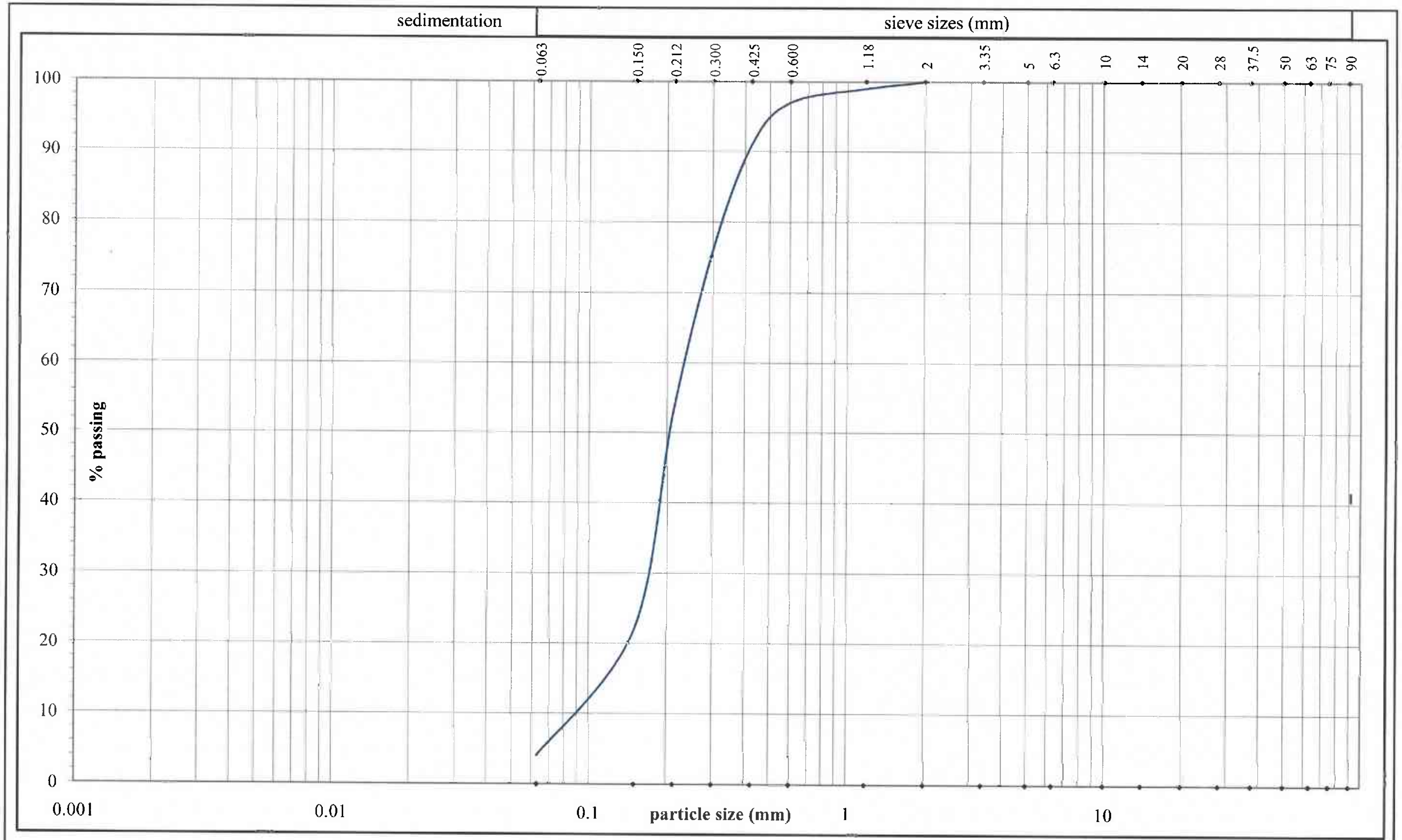
| Project: | Kish and Bray Banks | Exploratory Hole No.: | BH03 | Sample | | | | Sample description: | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Type | No. | at (m) | to (m) | | |
| Job No.: | 08-0585 | | | B | 2 | 1.00 | | | |

Glover Site Investigations Ltd

# Particle Size Distribution

*BS1377:1990 Part 2 Clause 9.2 and 9.5*

| Particle size (mm) | % passing |
|---|---|
| 125 | 100 |
| 90 | 100 |
| 75 | 100 |
| 63 | 100 |
| 50 | 100 |
| 37.5 | 100 |
| 28 | 100 |
| 20 | 100 |
| 14 | 100 |
| 10 | 100 |
| 6.3 | 100 |
| 5 | 100 |
| 3.35 | 100 |
| 2 | 100 |
| 1.18 | 99 |
| 0.6 | 97 |
| 0.425 | 91 |
| 0.3 | 76 |
| 0.212 | 53 |
| 0.15 | 22 |
| 0.063 | 4 |




| | Sand | | | Gravel | | | |
|---|---|---|---|---|---|---|---|
| Fines 4% | fine | medium | coarse | fine | medium | coarse | Cobbles 0% |
| | Sand 96% | | | Gravel 0% | | | |

| Project: | Kish and Bray Banks | Exploratory Hole No.: | BH03 | Sample Type | No. | at (m) | to (m) | Sample description: |
|---|---|---|---|---|---|---|---|---|
| Job No.: | 08-0585 | | | B | 3 | 2.00 | | |

Glover Site Investigations Ltd

# Particle Size Distribution

BS1377:1990 Part 2 Clause 9.2 and 9.5

| Particle size (mm) | % passing |
|---|---|
| 125 | 100 |
| 90 | 100 |
| 75 | 100 |
| 63 | 100 |
| 50 | 100 |
| 37.5 | 100 |
| 28 | 100 |
| 20 | 100 |
| 14 | 100 |
| 10 | 100 |
| 6.3 | 100 |
| 5 | 100 |
| 3.35 | 100 |
| 2 | 100 |
| 1.18 | 100 |
| 0.6 | 98 |
| 0.425 | 95 |
| 0.3 | 88 |
| 0.212 | 71 |
| 0.15 | 32 |
| 0.063 | 7 |


| | Fines 7% | Sand 93% | | | Gravel 0% | | | Cobbles 0% |
|---|---|---|---|---|---|---|---|---|
| | | fine | medium | coarse | fine | medium | coarse | |

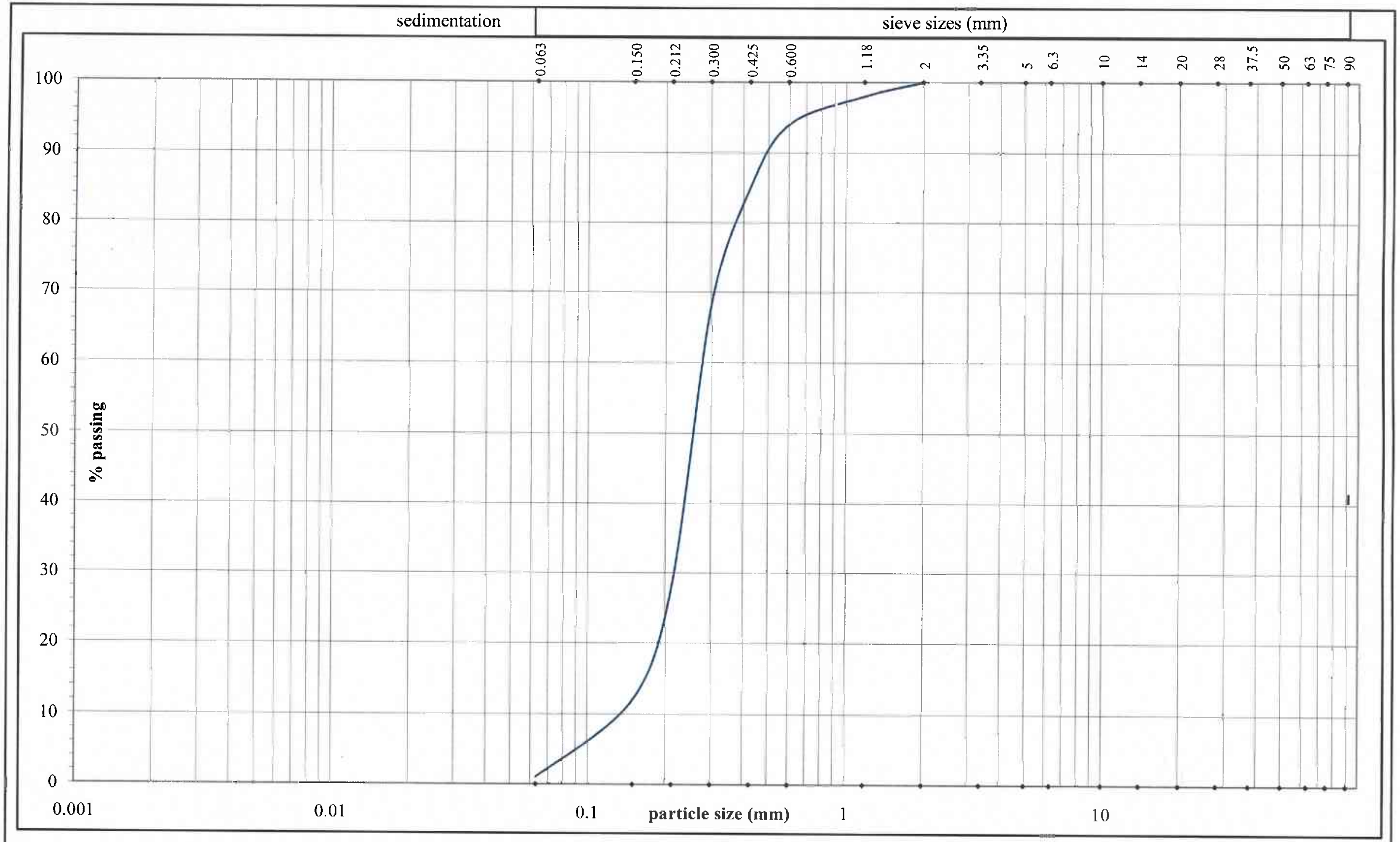
| Project: | Kish and Bray Banks | Exploratory Hole No.: | BH03 | Sample Type | Sample No. | Sample at (m) | Sample to (m) | Sample description: |
|---|---|---|---|---|---|---|---|---|
| Job No.: | 08-0585 | | | B | 4 | 3.00 | | |

Glover Site Investigations Ltd

# Particle Size Distribution

*BS1377:1990 Part 2 Clause 9.2 and 9.5*

| Particle size (mm) | % passing |
|---|---|
| 125 | 100 |
| 90 | 100 |
| 75 | 100 |
| 63 | 100 |
| 50 | 100 |
| 37.5 | 100 |
| 28 | 100 |
| 20 | 100 |
| 14 | 100 |
| 10 | 100 |
| 6.3 | 100 |
| 5 | 100 |
| 3.35 | 100 |
| 2 | 100 |
| 1.18 | 98 |
| 0.6 | 94 |
| 0.425 | 85 |
| 0.3 | 68 |
| 0.212 | 28 |
| 0.15 | 12 |
| 0.063 | 1 |




| Fines 1% | fine | medium | coarse | fine | medium | coarse | Cobbles |
|---|---|---|---|---|---|---|---|
| | Sand 99% | | | Gravel 0% | | | 0% |

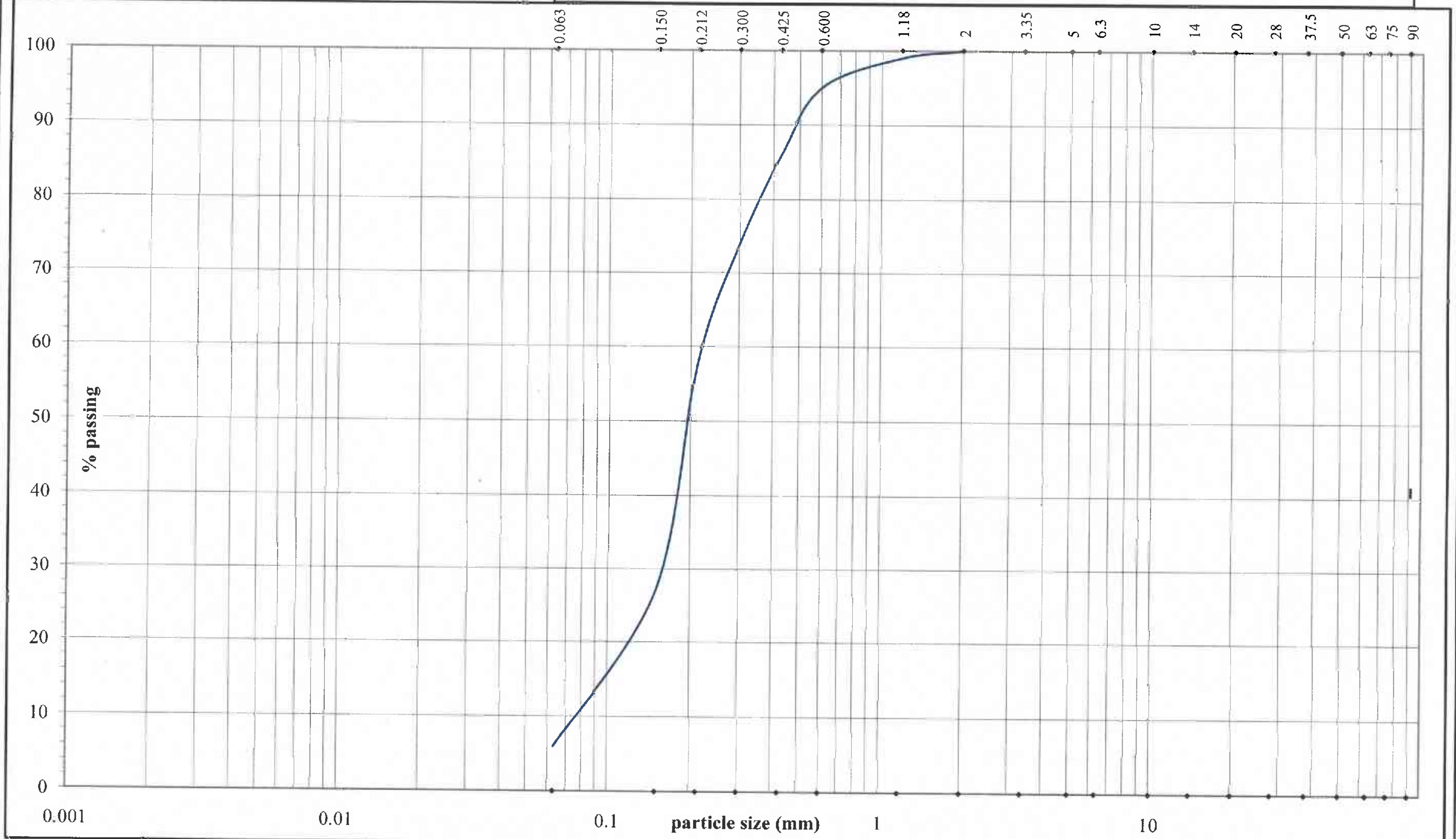
| Project: | Kish and Bray Banks | Exploratory Hole No.: | BH03 | Sample Type | No. | at (m) | to (m) | Sample description: | |
|---|---|---|---|---|---|---|---|---|---|
| Job No.: | 08-0585 | | | B | 5 | 4.00 | | | |

*Glover Site Investigations Ltd*

# Particle Size Distribution

***BS1377:1990 Part 2 Clause 9.2 and 9.5***

| Particle size (mm) | % passing |
|---|---|
| 125 | 100 |
| 90 | 100 |
| 75 | 100 |
| 63 | 100 |
| 50 | 100 |
| 37.5 | 100 |
| 28 | 100 |
| 20 | 100 |
| 14 | 100 |
| 10 | 100 |
| 6.3 | 100 |
| 5 | 100 |
| 3.35 | 100 |
| 2 | 100 |
| 1.18 | 99 |
| 0.6 | 95 |
| 0.425 | 86 |
| 0.3 | 74 |
| 0.212 | 58 |
| 0.15 | 27 |
| 0.063 | 6 |




| | Fines 6% | fine | medium | coarse | fine | medium | coarse | Cobbles |
|---|---|---|---|---|---|---|---|---|
| | | Sand 94% | | | Gravel 0% | | | 0% |

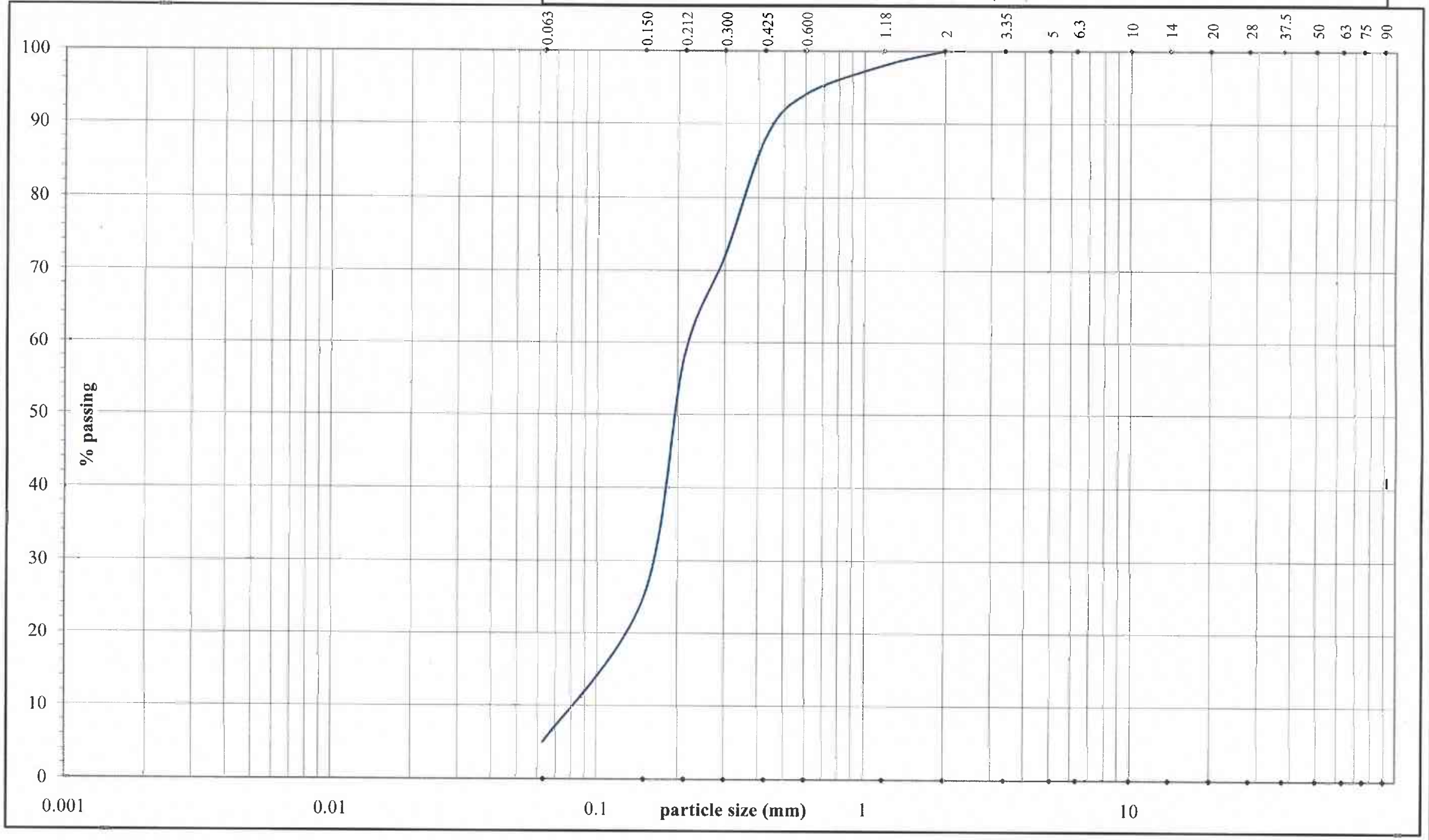
| Project: | Kish and Bray Banks | Exploratory Hole No.: | BH03 | Sample Type | No. | at (m) | to (m) | Sample description: |
|---|---|---|---|---|---|---|---|---|
| Job No.: | 08-0585 | | | B | 6 | 5.00 | | |

*Glover Site Investigations Ltd*

# Particle Size Distribution

***BS1377:1990 Part 2 Clause 9.2 and 9.5***

| Particle size (mm) | % passing |
|---|---|
| 125 | 100 |
| 90 | 100 |
| 75 | 100 |
| 63 | 100 |
| 50 | 100 |
| 37.5 | 100 |
| 28 | 100 |
| 20 | 100 |
| 14 | 100 |
| 10 | 100 |
| 6.3 | 100 |
| 5 | 100 |
| 3.35 | 100 |
| 2 | 100 |
| 1.18 | 98 |
| 0.6 | 94 |
| 0.425 | 88 |
| 0.3 | 72 |
| 0.212 | 58 |
| 0.15 | 25 |
| 0.063 | 5 |




| | Sand 95% | | | Gravel 0% | | | Cobbles |
|---|---|---|---|---|---|---|---|
| Fines 5% | fine | medium | coarse | fine | medium | coarse | 0% |

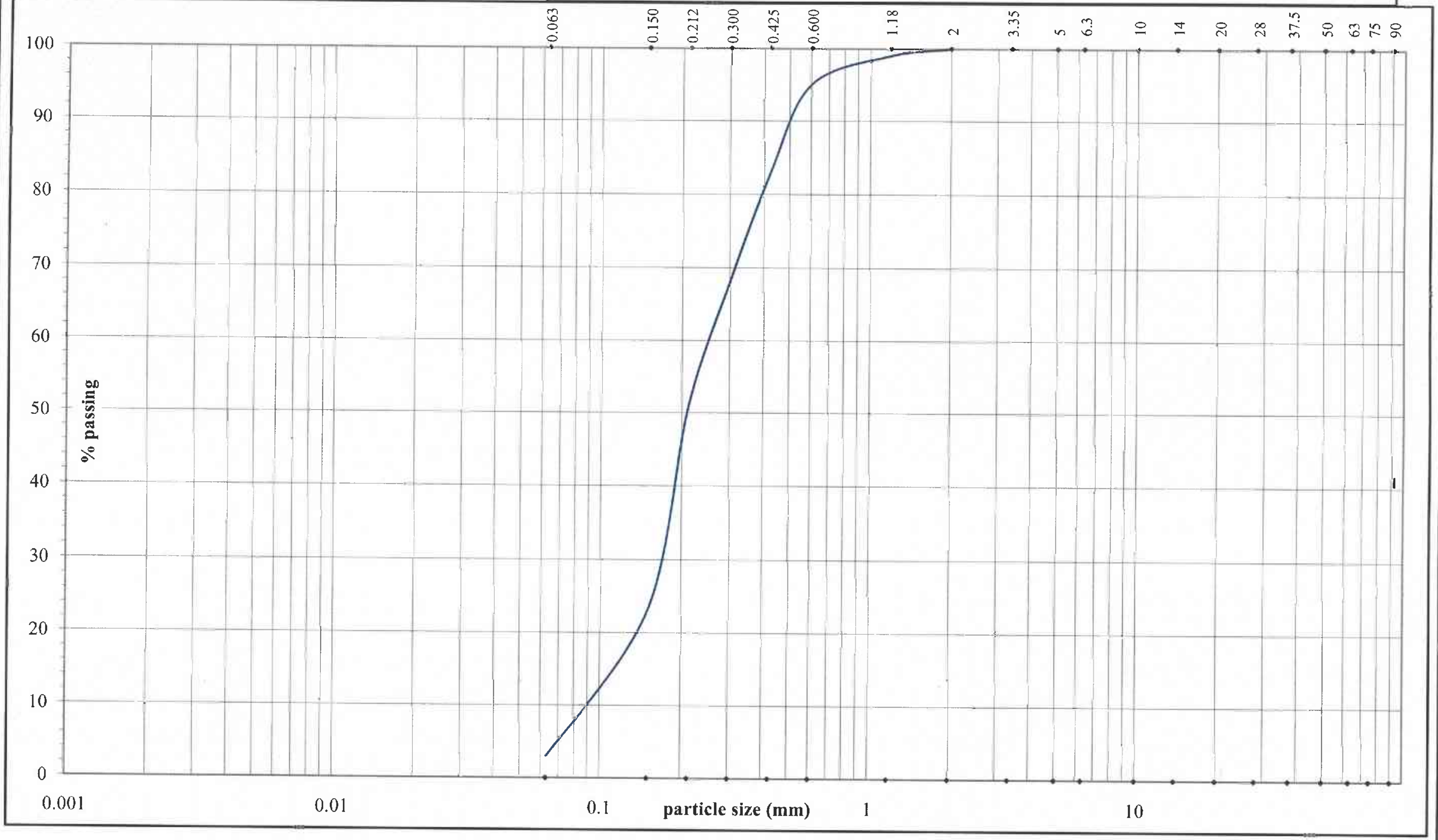
| Project: | Kish and Bray Banks | Exploratory Hole No.: | BH03 | Sample Type | Sample No. | Sample at (m) | Sample to (m) | Sample description: | |
|---|---|---|---|---|---|---|---|---|---|
| Job No.: | 08-0585 | | | B | 7 | 6.00 | | | |

Glover Site Investigations Ltd

# Particle Size Distribution

*BS1377:1990 Part 2 Clause 9.2 and 9.5*

| Particle size (mm) | % passing |
|---|---|
| 125 | 100 |
| 90 | 100 |
| 75 | 100 |
| 63 | 100 |
| 50 | 100 |
| 37.5 | 100 |
| 28 | 100 |
| 20 | 100 |
| 14 | 100 |
| 10 | 100 |
| 6.3 | 100 |
| 5 | 100 |
| 3.35 | 100 |
| 2 | 100 |
| 1.18 | 99 |
| 0.6 | 95 |
| 0.425 | 83 |
| 0.3 | 68 |
| 0.212 | 51 |
| 0.15 | 23 |
| 0.063 | 3 |




| | fine | medium | coarse | fine | medium | coarse | |
|---|---|---|---|---|---|---|---|
| Fines 3% | Sand 97% | | | Gravel 0% | | | Cobbles 0% |

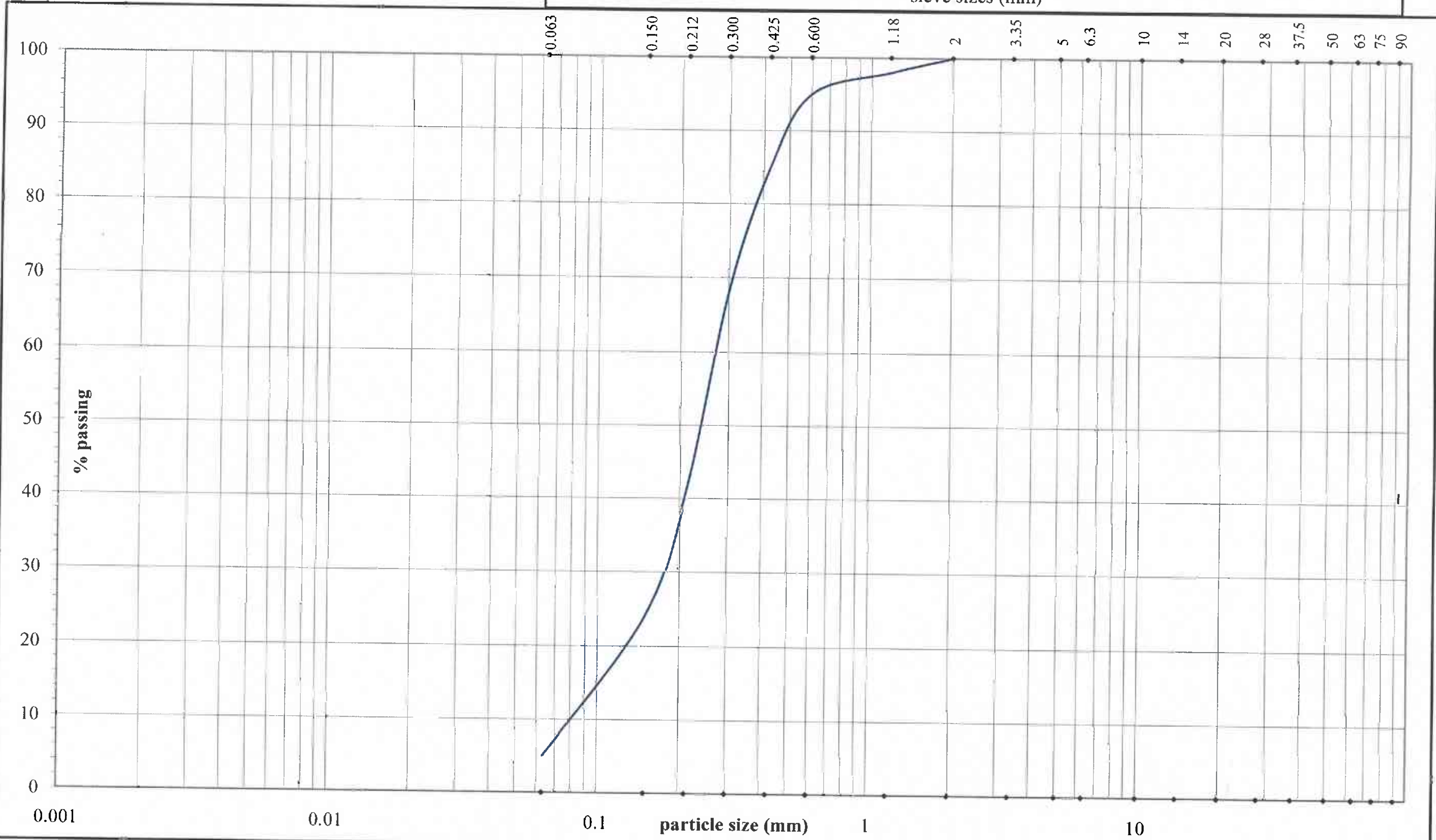
| Project: | Kish and Bray Banks | Exploratory Hole No.: | BH03 | Sample Type | No. | at (m) | to (m) | Sample description: |
|---|---|---|---|---|---|---|---|---|
| Job No.: | 08-0585 | | | B | 8 | 7.00 | | |

*Glover Site Investigations Ltd*

# Particle Size Distribution

***BS1377:1990 Part 2 Clause 9.2 and 9.5***

| Particle size (mm) | % passing |
|---|---|
| 125 | 100 |
| 90 | 100 |
| 75 | 100 |
| 63 | 100 |
| 50 | 100 |
| 37.5 | 100 |
| 28 | 100 |
| 20 | 100 |
| 14 | 100 |
| 10 | 100 |
| 6.3 | 100 |
| 5 | 100 |
| 3.35 | 100 |
| 2 | 100 |
| 1.18 | 98 |
| 0.6 | 95 |
| 0.425 | 85 |
| 0.3 | 68 |
| 0.212 | 41 |
| 0.15 | 24 |
| 0.063 | 5 |




| Fines 5% | Sand 95% | | | Gravel 0% | | | Cobbles 0% |
|---|---|---|---|---|---|---|---|
| | fine | medium | coarse | fine | medium | coarse | |

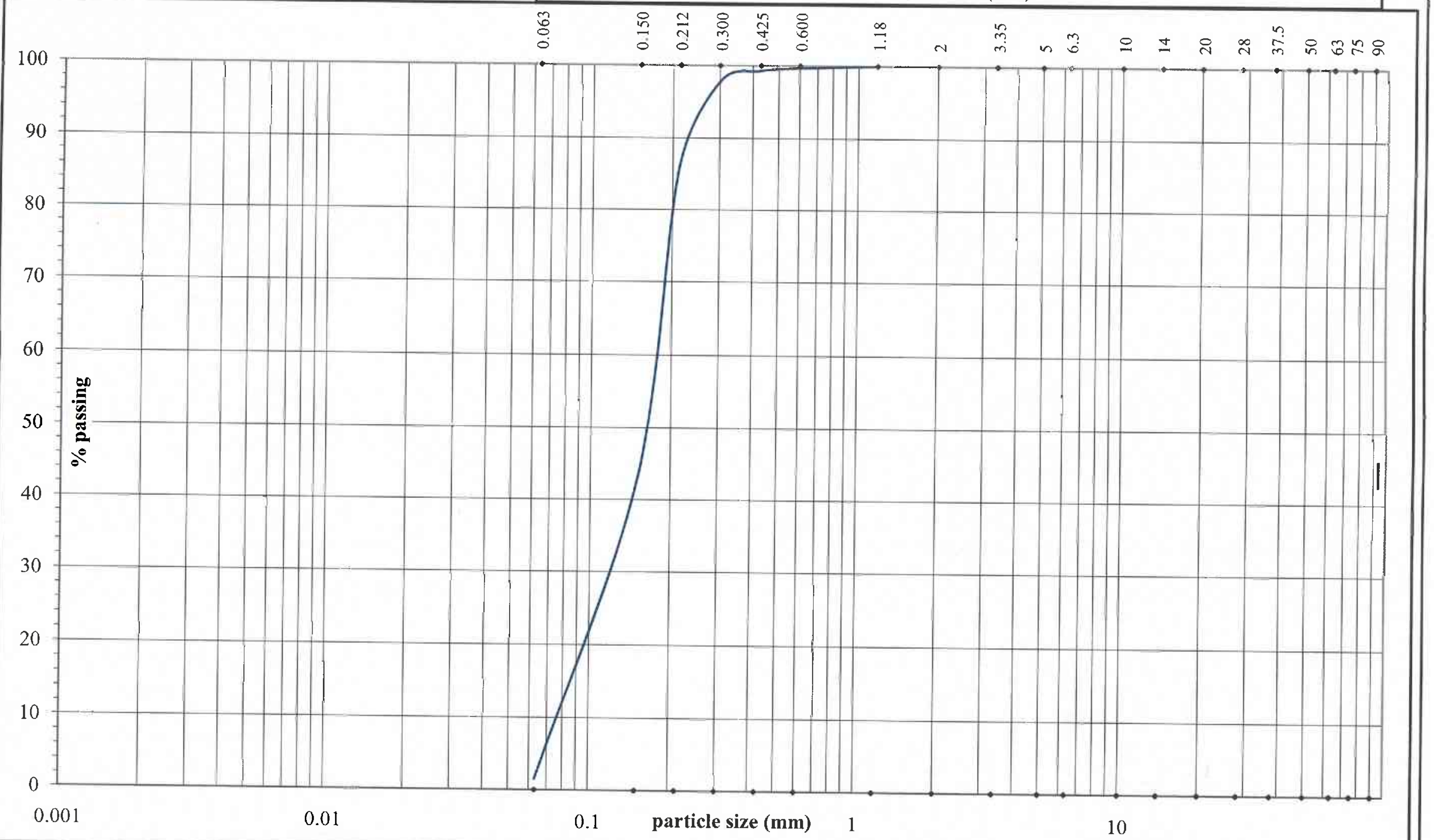
| Project: | Kish and Bray Banks | Exploratory Hole No.: | BH03 | Sample Type | Sample No. | Sample at (m) | Sample to (m) | Sample description: |
|---|---|---|---|---|---|---|---|---|
| Job No.: | 08-0585 | | | B | 9 | 8.00 | | |

Glover Site Investigations Ltd

# Particle Size Distribution

*BS1377:1990 Part 2 Clause 9.2 and 9.5*

| Particle size (mm) | % passing |
|---|---|
| 125 | 100 |
| 90 | 100 |
| 75 | 100 |
| 63 | 100 |
| 50 | 100 |
| 37.5 | 100 |
| 28 | 100 |
| 20 | 100 |
| 14 | 100 |
| 10 | 100 |
| 6.3 | 100 |
| 5 | 100 |
| 3.35 | 100 |
| 2 | 100 |
| 1.18 | 100 |
| 0.600 | 99.7 |
| 0.425 | 99.3 |
| 0.300 | 97.8 |
| 0.212 | 85.9 |
| 0.150 | 42.7 |
| 0.063 | 1.5 |




| | Fines 1% | fine | medium | coarse | fine | medium | coarse | Cobbles |
|---|---|---|---|---|---|---|---|---|
| | | Sand 99% | | | Gravel 0% | | | 0% |

Sample natural moisture content (%) = 26

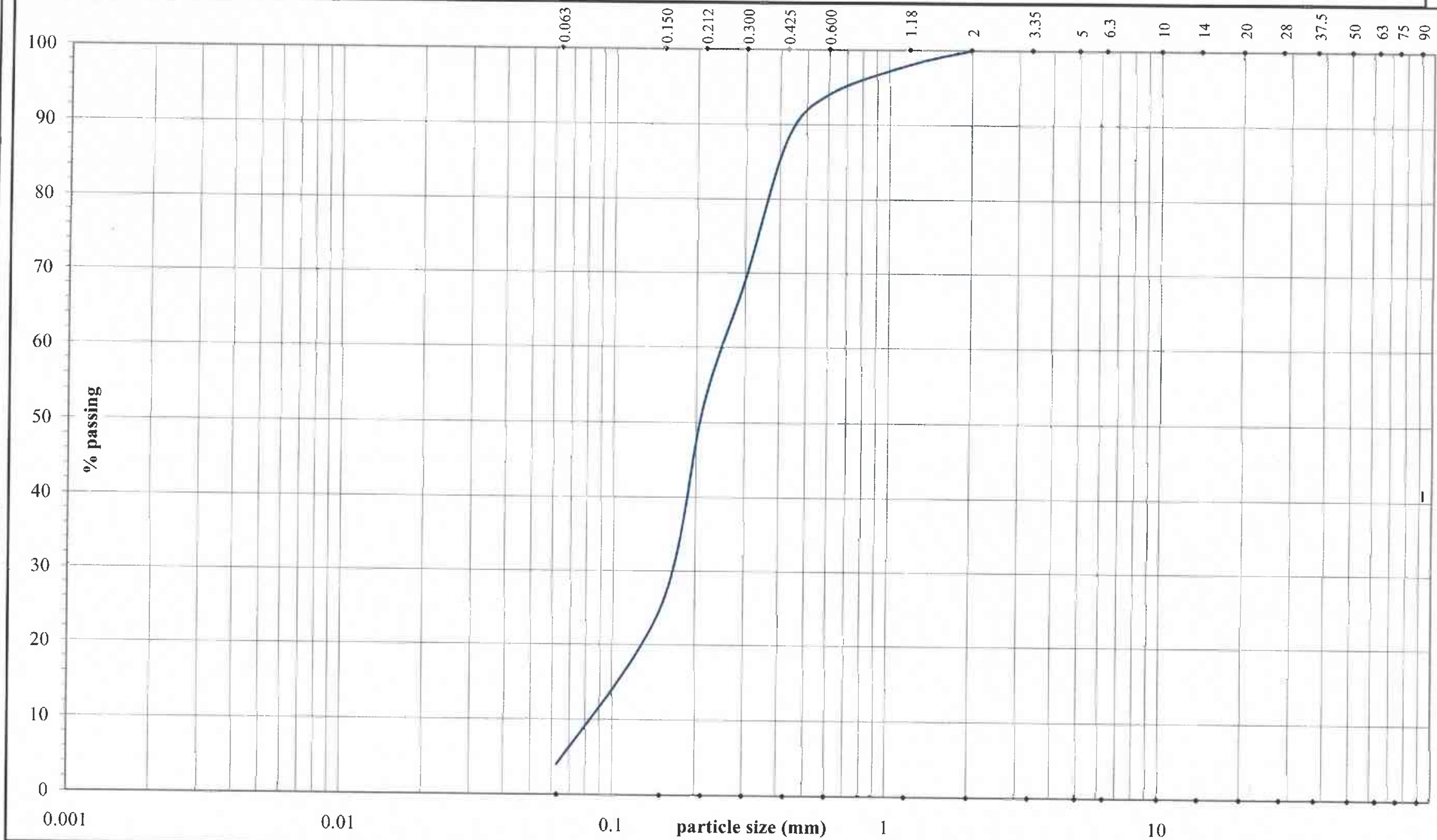
| Project: | Kish and Bray Banks | Exploratory Hole No.: | BH03 | Sample Type | No. | at (m) | to (m) | Sample description: |
|---|---|---|---|---|---|---|---|---|
| Job No.: | 08-0585 | | | B | 10 | 9.00 | | |

*Glover Site Investigations Ltd*

# Particle Size Distribution

***BS1377:1990 Part 2 Clause 9.2 and 9.5***

| Particle size (mm) | % passing |
|---|---|
| 125 | 100 |
| 90 | 100 |
| 75 | 100 |
| 63 | 100 |
| 50 | 100 |
| 37.5 | 100 |
| 28 | 100 |
| 20 | 100 |
| 14 | 100 |
| 10 | 100 |
| 6.3 | 100 |
| 5 | 100 |
| 3.35 | 100 |
| 2 | 100 |
| 1.18 | 98 |
| 0.6 | 94 |
| 0.425 | 88 |
| 0.3 | 69 |
| 0.212 | 52 |
| 0.15 | 25 |
| 0.063 | 4 |




| | Fines 4% | fine | medium | coarse | fine | medium | coarse | Cobbles 0% |
|---|---|---|---|---|---|---|---|---|
| | | | Sand 96% | | | Gravel 0% | | |

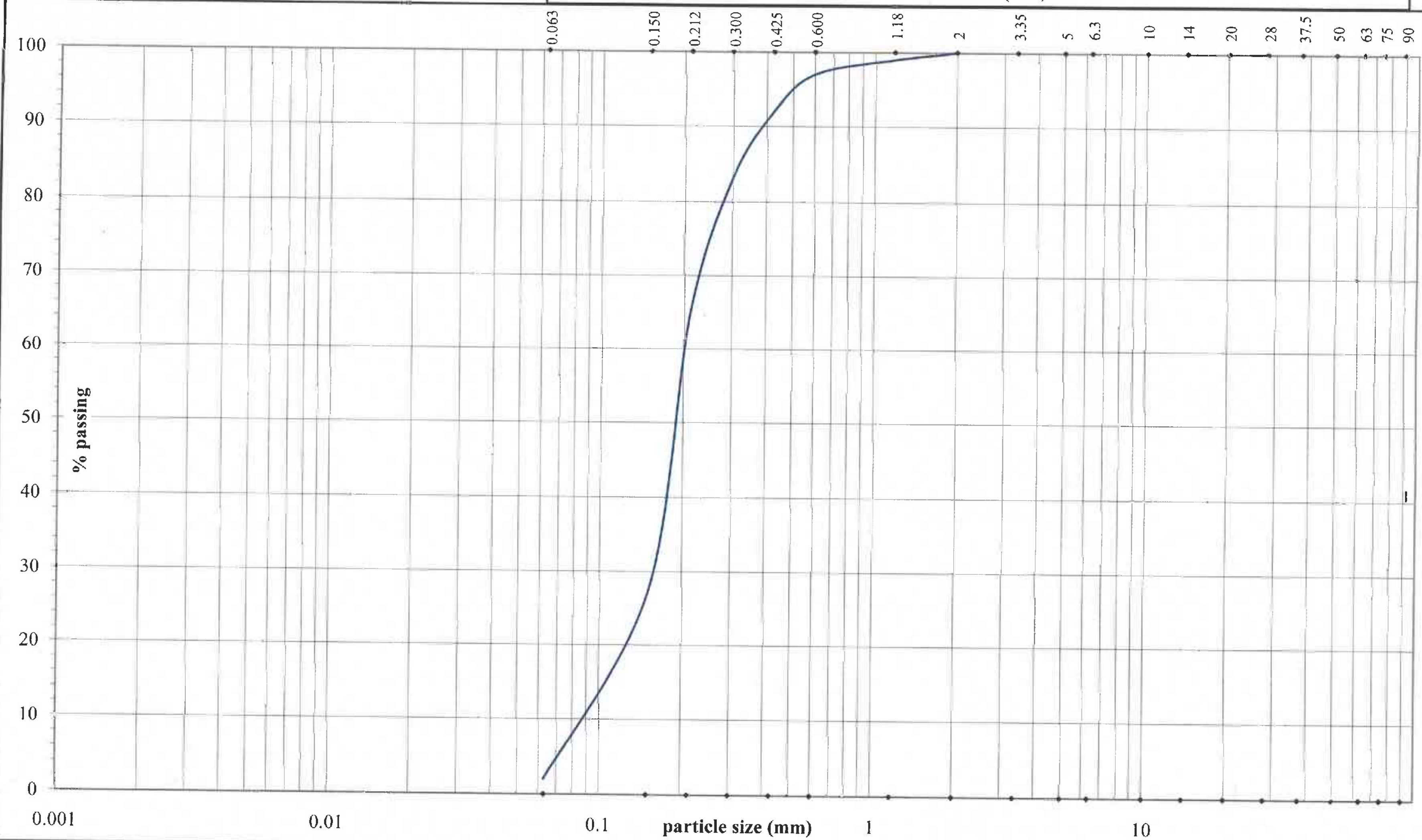
| Project: | Kish and Bray Banks | Exploratory Hole No.: | BH03 | Sample Type | Sample No. | Sample at (m) | Sample to (m) | Sample description: | |
|---|---|---|---|---|---|---|---|---|---|
| Job No.: | 08-0585 | | | B | 11 | 10.00 | | | |

Glover Site Investigations Ltd

# Particle Size Distribution

*BS1377:1990 Part 2 Clause 9.2 and 9.5*

| Particle size (mm) | % passing |
|---|---|
| 125 | 100 |
| 90 | 100 |
| 75 | 100 |
| 63 | 100 |
| 50 | 100 |
| 37.5 | 100 |
| 28 | 100 |
| 20 | 100 |
| 14 | 100 |
| 10 | 100 |
| 6.3 | 100 |
| 5 | 100 |
| 3.35 | 100 |
| 2 | 100 |
| 1.18 | 99 |
| 0.6 | 97 |
| 0.425 | 92 |
| 0.3 | 83 |
| 0.212 | 65 |
| 0.15 | 27 |
| 0.063 | 2 |




| | Fines 2% | Sand 98% | | | Gravel 0% | | | Cobbles 0% |
|---|---|---|---|---|---|---|---|---|
| | | fine | medium | coarse | fine | medium | coarse | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Project: | Kish and Bray Banks | Exploratory Hole No.: | BH03 | Sample | | | | Sample description: |
| | | | | Type | No. | at (m) | to (m) | |
| Job No.: | 08-0585 | | | B | 13 | 12.00 | | |

Glover Site Investigations Ltd

# Particle Size Distribution

*BS1377:1990 Part 2 Clause 9.2 and 9.5*

| Particle size (mm) | % passing |
|---|---|
| 125 | 100 |
| 90 | 100 |
| 75 | 100 |
| 63 | 100 |
| 50 | 100 |
| 37.5 | 100 |
| 28 | 100 |
| 20 | 100 |
| 14 | 100 |
| 10 | 100 |
| 6.3 | 100 |
| 5 | 100 |
| 3.35 | 100 |
| 2 | 100 |
| 1.18 | 98 |
| 0.6 | 94 |
| 0.425 | 83 |
| 0.3 | 68 |
| 0.212 | 47 |
| 0.15 | 24 |
| 0.063 | 2 |


| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Fines 2% | fine | medium | coarse | fine | medium | coarse | Cobbles 0% |
| | Sand 98% | | | Gravel 0% | | | |

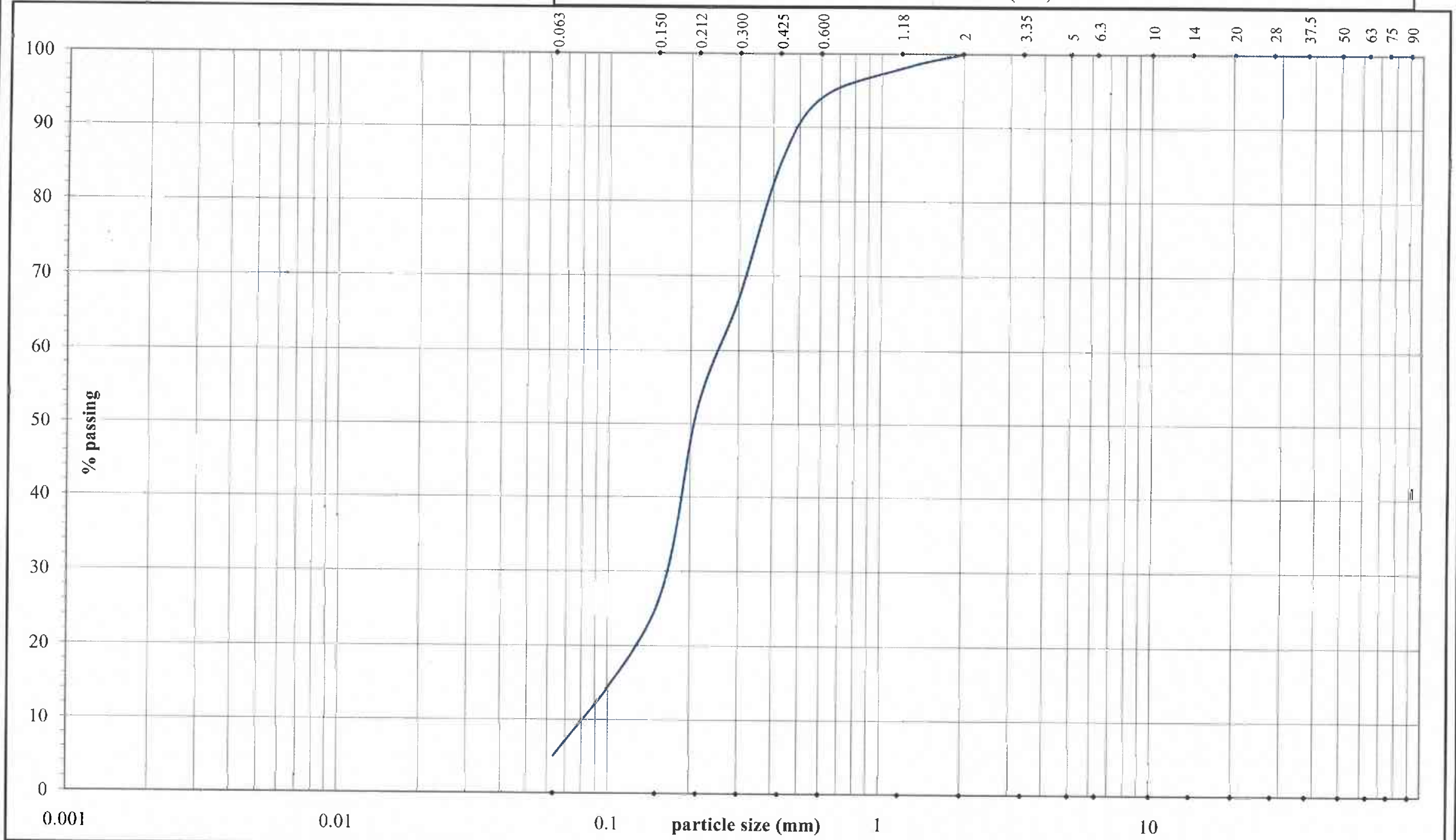
| Project: | Kish and Bray Banks | Exploratory Hole No.: | BH03 | Sample Type | Sample No. | at (m) | to (m) | Sample description: |
|---|---|---|---|---|---|---|---|---|
| Job No.: | 08-0585 | | | B | 14 | 13.50 | | |

*Glover Site Investigations Ltd*

# Particle Size Distribution

***BS1377:1990 Part 2 Clause 9.2 and 9.5***

| Particle size (mm) | % passing |
|---|---|
| 125 | 100 |
| 90 | 100 |
| 75 | 100 |
| 63 | 100 |
| 50 | 100 |
| 37.5 | 100 |
| 28 | 100 |
| 20 | 100 |
| 14 | 100 |
| 10 | 100 |
| 6.3 | 100 |
| 5 | 100 |
| 3.35 | 100 |
| 2 | 100 |
| 1.18 | 98 |
| 0.6 | 94 |
| 0.425 | 85 |
| 0.3 | 67 |
| 0.212 | 52 |
| 0.15 | 25 |
| 0.063 | 5 |




| | fine | medium | coarse | fine | medium | coarse | Cobbles |
|---|---|---|---|---|---|---|---|
| Fines 5% | Sand 95% | | | Gravel 0% | | | 0% |

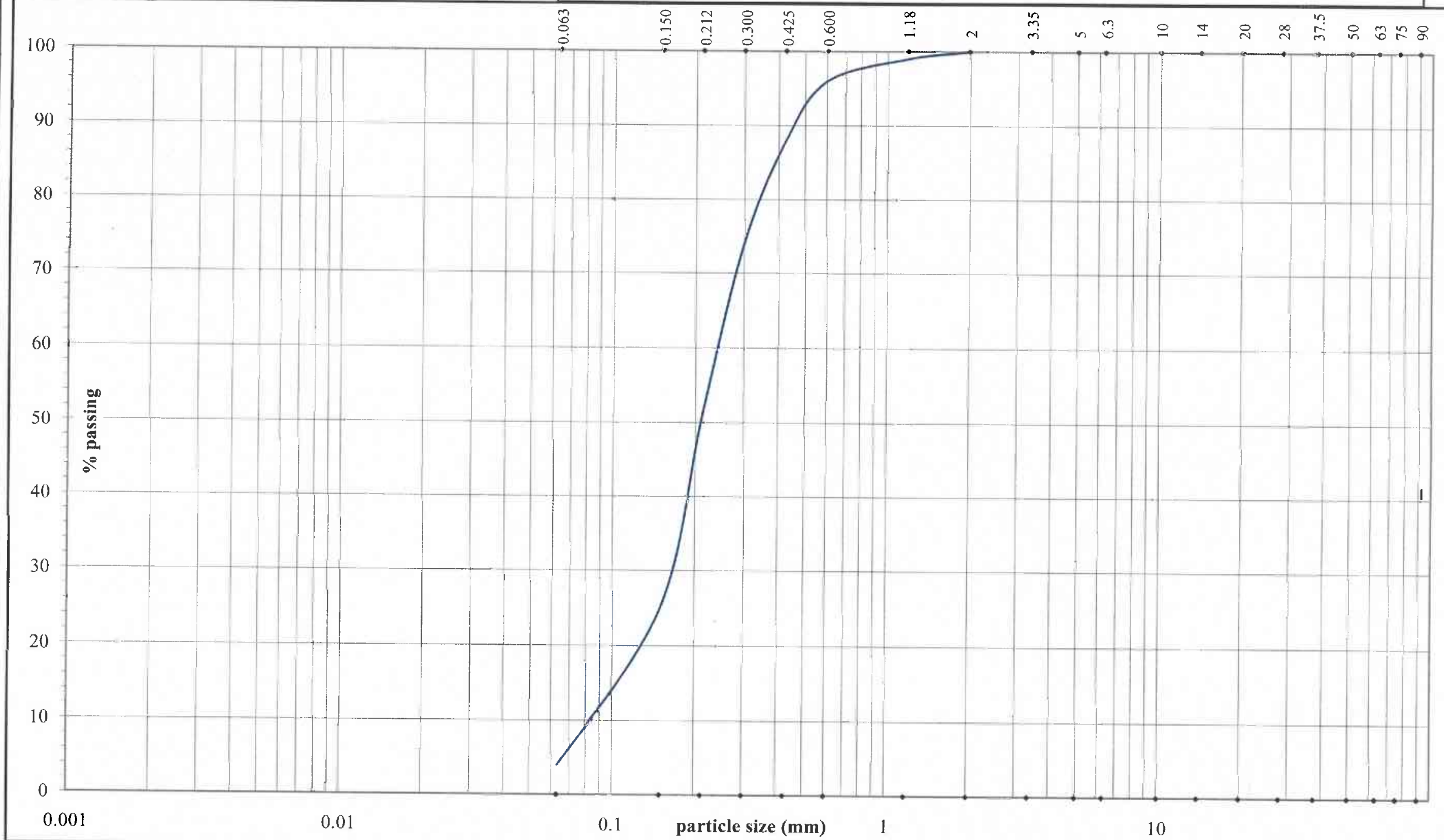
| Project: | Kish and Bray Banks | Exploratory Hole No.: | BH03 | Sample Type | Sample No. | Sample at (m) | Sample to (m) | Sample description: |
|---|---|---|---|---|---|---|---|---|
| Job No.: | 08-0585 | | | B | 15 | 15.00 | | |

**Glover Site Investigations Ltd**

# Particle Size Distribution

*BS1377:1990 Part 2 Clause 9.2 and 9.5*

| Particle size (mm) | % passing |
|---|---|
| 125 | 100 |
| 90 | 100 |
| 75 | 100 |
| 63 | 100 |
| 50 | 100 |
| 37.5 | 100 |
| 28 | 100 |
| 20 | 100 |
| 14 | 100 |
| 10 | 100 |
| 6.3 | 100 |
| 5 | 100 |
| 3.35 | 100 |
| 2 | 100 |
| 1.18 | 99 |
| 0.6 | 96 |
| 0.425 | 88 |
| 0.3 | 74 |
| 0.212 | 51 |
| 0.15 | 25 |
| 0.063 | 4 |




| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Fines 4% | fine | medium | coarse | fine | medium | coarse | Cobbles 0% |
| | Sand 96% | | | Gravel 0% | | | |

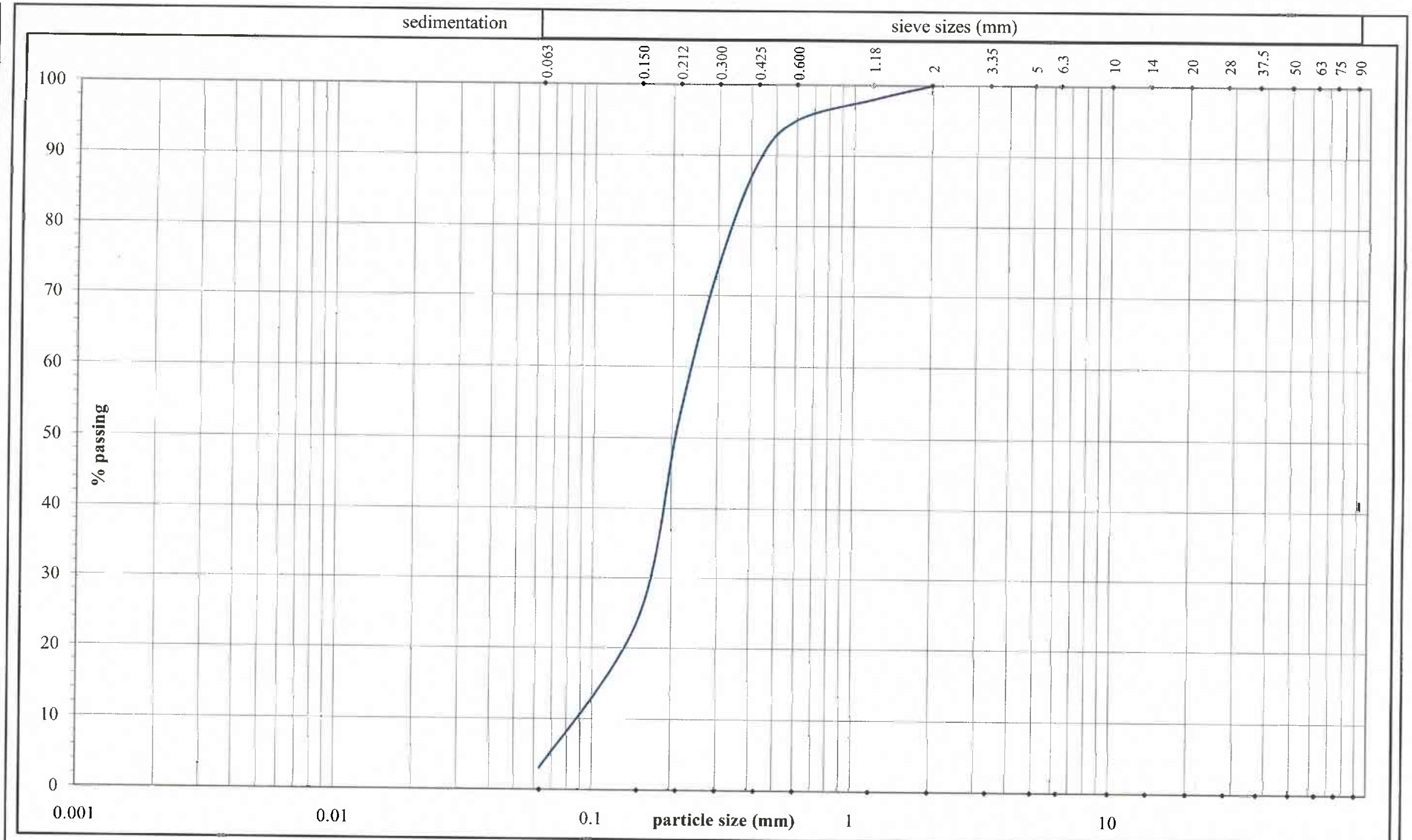
| Project: | Kish and Bray Banks | Exploratory Hole No.: | BH03 | Sample Type | No. | at (m) | to (m) | Sample description: |
|---|---|---|---|---|---|---|---|---|
| Job No.: | 08-0585 | | | B | 16 | 16.50 | | |

**Glover Site Investigations Ltd**

# Particle Size Distribution

**BS1377:1990 Part 2 Clause 9.2 and 9.5**

| Particle size (mm) | % passing |
|---|---|
| 125 | 100 |
| 90 | 100 |
| 75 | 100 |
| 63 | 100 |
| 50 | 100 |
| 37.5 | 100 |
| 28 | 100 |
| 20 | 100 |
| 14 | 100 |
| 10 | 100 |
| 6.3 | 100 |
| 5 | 100 |
| 3.35 | 100 |
| 2 | 100 |
| 1.18 | 98 |
| 0.6 | 95 |
| 0.425 | 89 |
| 0.3 | 74 |
| 0.212 | 52 |
| 0.15 | 24 |
| 0.063 | 3 |




| | Fines 3% | Sand 97% | | | Gravel 0% | | | Cobbles 0% |
|---|---|---|---|---|---|---|---|---|
| | | fine | medium | coarse | fine | medium | coarse | |

| Project: | Kish and Bray Banks | Exploratory Hole No.: | BH03 | Sample Type | No. | at (m) | to (m) | Sample description: |
|---|---|---|---|---|---|---|---|---|
| Job No.: | 08-0585 | | | D | 3 | 19.50 | | |

**Job No.:** 08-0585

**Contract:** Kish and Bray Banks

*Glover Site Investigations Ltd*

## CHEMICAL TESTS

**Tests 3, 4, 5 & 9 of BS 1377 : Part 3 : 1990**



| EH No. | Sample | | Sample Depth | | Passing 2mm Sieve (%) | Organic Matter Content * (%) | Mass Loss on Ignition # (%) | Sulphate Content $SO_4$ | | pH Value @ |
|---|---|---|---|---|---|---|---|---|---|---|
| | Type | No. | at (m) | to (m) | | | | Soil/water extract $ (mg/l) | Groundwater (mg/l) | |
| BH01 | B | 2 | 1.00 | | | 100 | | 63 | | 7.5 |
| BH01 | B | 9 | 8.00 | | | 100 | | 41 | | 7.5 |
| BH01 | D | 4 | 19.50 | | | 100 | | 35 | | 7 |
| BH02 | B | 3 | 2.00 | | | 100 | | 44 | | 7.5 |
| BH02 | B | 7 | 6.00 | | | 100 | | 28 | | 7 |
| BH02 | B | 9 | 8.00 | | | 100 | | 36 | | 7.5 |
| BH03 | B | 3 | 2.00 | | | 100 | | 39 | | 7.5 |
| BH03 | B | 10 | 9.00 | | | 100 | | 41 | | 7.5 |
| BH03 | D | 3 | 19.50 | | | 100 | | 35 | | 7.5 |

* Walkley and Black's dichromate method –Clause 3

# Average of 3 specimens - Clause 4

$ Water soluble $SO_4$ from 2:1 water - soil extract - Clause 5.5

@ Average of 2/3 specimens - Clause 9.5

Clause Nos. of BS 1377 : Part 3 : 1990

Appendix E

Photographs of Jack-up platform

GLOVER SITE INVESTIGATIONS LIMITED


Fastnet Shipping Ltd
Fastnet Shipping Ltd


JAKUP
PANAMA

# Kish and Bray Banks

## Proposed Turbine Location Feasibility Study

## Hydrographic and Geophysical Report of Survey

## Volume 1

## June – September 2008

**PN 18/08**

**Prepared For:**

Saorgus Energy Ltd
Enterprise House
Kerry Technology Park
Listowel Road
Tralee
Co. Kerry

**Prepared By:**

Hydrographic Surveys Ltd
The Cobbles
Crosshaven
Co. Cork

**Contents**

**Drawings**

| | |
|---|---|
| **HS 59-1/08 Bathymetric Survey** | **Scale 1:5000** |
| **HS 59-2/08 Bathymetric Survey** | **Scale 1:5000** |
| **HS 59-3/08 Bathymetric Survey** | **Scale 1:5000** |
| **HS 59-4/08 Bathymetric Survey** | **Scale 1:5000** |
| **HS 59-5/08 Bathymetric Survey** | **Scale 1:5000** |
| **HS 59D-1/08 Subbottom Cross-Sections** | **Horizontal Scale 1:5000**<br>**Vertical Scale 1:500** |
| **HS 59D-2/08 Subbottom Cross-Sections** | **Horizontal Scale 1:5000**<br>**Vertical Scale 1:500** |

## 1. Introduction

A bathymetric and geophysical survey was carried out on the Kish and Bray Banks as part of a Hydrographic and geophysical project commissioned by Saorgus Energy Ltd to determine locations for a total of 145 wind turbines.

Mobilisation for the bathymetric survey took place on the $13^{th}$ June 2008. This element was finally completed on $18^{th}$ September 2008 with demobilisation from site taking place on the $19^{th}$ September.
The geophysical survey was carried out between the $11^{th}$ and $15^{th}$ September 2008. The following report outlines the methodologies employed during the survey and describes the results achieved.

# 2. Methodology

## 2.1 Horizontal Control and Grid

Horizontal control was provided by DGPS using satellite broadcast corrections. The navigation unit used was the Trimble AgDGPS 132 unit which provides sub-metre accuracy.

The DGPS position was interfaced and logged to Hypack Survey software to provide real-time line guidance and a continuous record of position. On-line transformation of WGS'84 latitude and longitude to Irish National Grid took place within the survey programme.

## 2.2 Bathymetric Survey

The ODOM Hydrotrac digital echosounder was used to record the seabed levels within the survey area. This echosounder has a resolution of .01meters. It also has an "all-in-one" recorder/digitizer providing data in both analogue and digital format.

The sounder was also interfaced into the Hypack 2008 survey software thereby providing a digital record with related position fixes.

The bar-check method was used both at the start and end of each day's survey for calibration of the echosounder.

Survey lines were planned at 150m centres in an East-west direction covering the total length of the Kish and Bray banks. A total of 115 bathymetric survey lines were run.

## 2.3 Vertical Datum

Tides were measured in Dun Laoghaire Harbour using a Valeport 740 model vented tide gauge. This was installed onto the pier at Dun Laoghaire and recorded tidal height every 5 minutes for the duration of the survey. The tidal height results were reduced to Chart datum, as requested by the clients, using a TBM of

+5.39m CD.

### 2.4 Geophysical Survey

The C-boom Low Voltage boomer was employed for recording the subsurface profiles over the banks.

The seismic parameters were set to allow for a penetration of approximately 90m below the seabed.
The C-boom system was towed astern. Layback from the antenna position was recorded and applied to all the results relating to the subbottom survey.

All the data was recorded in digital format. Navigation was interfaced into this system from the Trimble unit thereby providing a continuous record of position. Processing of all profiles was carried out using the Coda Octopus subbottom processing toolkit. A total of 12 east-west lines were run over the length of the banks.

## 3. Results

### 3.1 Bathymetric Survey Results

The results of the bathymetric survey are presented in the following charts:

**HS:59-1/08** to **HS:59-5/08** Depths have been reduced to Chart Datum and contours are given at 5m intervals.
The general characteristics of the bathymetry within the survey area can be summarised as follows:

**HS:59-1/08:** At the Western limit contours are more closely spaced together than on the eastern side. This indicates that the bank has a steep west slope and slightly gentler eastern aspect. Least depths recorded over the top of the bank range from between 2.8m to 4.0m CD.
Sandwaves are a prominent feature over the bank. Progressing southwards the top of the bank would appear to be characterised by two prominent peaks.

The sandwaves seem to fade out towards the Eastern limit.

**Table One**

**Depths at Proposed Turbine Locations**

| Turbine Number | Depth m CD | Turbine Number | Depth m CD |
|---|---|---|---|
| **T1** | 17.7 | **T16** | 20.0 |
| **T2** | 3.7 | **T17** | 7.0 |
| **T3** | 12.6 | **T18** | 5.5 |
| **T4** | 17.4 | **T19** | 14.6 |
| **T5** | 26.7 | **T20** | 25.8 |
| **T6** | 17.6 | **T21** | 20.0 |
| **T7** | 5.0 | **T22** | 8.0 |

| | | | |
|---|---|---|---|
| **T8** | 12.1 | **T23** | 5.8 |
| **T9** | 17.0 | **T24** | 15.3 |
| **T10** | 26.0 | **T25** | 26.1 |
| **T11** | 19.1 | **T26** | 20.0 |
| **T12** | 4.7 | **T27** | 8.0 |
| **T13** | 9.9 | **T28** | 6.2 |
| **T14** | 16.5 | **T29** | 16.6 |
| **T15** | 25.6 | **T30** | 26.5 |

**HS:59-2/08:** The eastern side of the bank is starting to display a very steep incline from the top of the bank. The western slope is gradually becoming more gentle.

The shallowest depths recorded over the top of the bank range from 3.9m to 4.9m. Heights of sandwaves vary between 0.5 to 1.3m.

**Table two**

**Depths at Proposed Turbine Locations**

| Turbine Number | Depth m CD | Turbine Number | Depth m CD |
|---|---|---|---|
| **T31** | 20.2 | **T48** | 11.2 |
| **T32** | 9.7 | **T49** | 8.1 |
| **T33** | 6.0 | **T50** | 14.4 |
| **T34** | 13.7 | **T51** | 20.8 |
| **T35** | 25.8 | **T52** | 14.5 |
| **T36** | 23.0 | **T53** | 10.0 |
| **T37** | 10.0 | **T54** | 7.5 |
| **T38** | 7.0 | **T55** | 26.5 |
| **T39** | 11.0 | **T56** | 22.0 |
| **T40** | 25.4 | **T57** | 16.5 |
| **T41** | 21.0 | **T58** | 11.0 |
| **T42** | 12.0 | **T59** | 8.0 |
| **T43** | 7.8 | **T60** | 26.0 |

| | | | |
|---|---|---|---|
| **T44** | 6.2 | **T61** | 21.3 |
| **T45** | 26.2 | **T62** | 17.0 |
| **T46** | 25.4 | **T63** | 11.0 |
| **T47** | 15.7 | **T64** | 8.8 |
| | | **T65** | 22.0 |

**HS:59-3/08:** towards the southern limits of HS:59-3/08 the bathymetric depths become quite shallow with depths of 1.5m recorded in places. The bank is still characterised by a gently sloping western slope with a steep eastern slope.

**Table Three**

**Depths at Proposed Turbine Locations**

| Turbine Number | Depth m CD | Turbine Number | Depth m CD |
|---|---|---|---|
| **T66** | >20.0 | **T81** | 15.0 |
| **T67** | 17.0 | **T82** | 8.0 |
| **T68** | 11.0 | **T83** | 10.4 |
| **T69** | 9.0 | **T84** | 21.9 |
| **T70** | 23.1 | **T85** | 14.0 |
| **T71** | >21.0 | **T86** | 7.0 |
| **T72** | 17.3 | **T87** | 16.0 |
| **T73** | 13.3 | **T88** | 23.3 |
| **T74** | 7.9 | **T89** | 14.0 |
| **T75** | 24.6 | **T90** | 7.5 |
| **T76** | >20.0 | **T91** | 16.8 |
| **T77** | 16.1 | **T92** | 21.3 |
| **T78** | 11.2 | **T93** | 12.5 |
| **T79** | 4.8 | **T94** | 2.0 |
| **T80** | 21.0 | **T95** | 23.6 |

**HS:59-4/08:** Least depths over the bank range from 1.4m to 3.0m, south to Northing 217200N. South of 217200N there is a deepening ranging from 4.3m to 6m on average on the bank.

The asymmetrical nature of the bank seems to be tapering off slightly. From the spread of the contours the bank seems to be more symmetrical.

Sandwaves are still a feature, however the heights are not as prominent.

**Table Four**

**Depths at Proposed Turbine Locations**

| Turbine Number | Depth m CD | Turbine Number | Depth m CD |
|---|---|---|---|
| **T96** | 21.0 | **T112** | 8.3 |
| **T97** | 12.5 | **T113** | 23.5 |
| **T98** | 2.0 | **T114** | 23.7 |
| **T99** | 22.4 | **T115** | 19.0 |
| **T100** | 23.6 | **T116** | 5.0 |
| **T101** | 16.5 | **T117** | 14.0 |
| **T102** | 3.6 | **T118** | 28.7 |
| **T103** | 13.4 | **T119** | 24.3 |
| **T104** | 27.8 | **T120** | 11.8 |
| **T105** | 27.1 | **T121** | 5.8 |
| **T106** | 20.8 | **T122** | 23.2 |
| **T107** | 8.5 | **T123** | 23.4 |
| **T108** | 8.8 | **T124** | 12.0 |
| **T109** | 23.6 | **T125** | 8.4 |
| **T110** | 22.1 | **T126** | 26.4 |
| **T111** | 7.0 | | |

**HS:59-5/08**: Depths recorded on top of the bank can be as shallow as 2.6-2.8m, this averages out to between 3-4m towards the southern extent of the survey area. The asymmetrical nature of the bank that was such a prominent feature at the northern limits does not appear to be as evident at this end of the Kish and Bray banks.

**Table Five**

**Depths at Proposed Turbine Locations**

| Turbine Number | Depth m CD | Turbine Number | Depth m CD |
|---|---|---|---|
| **T127** | 23.1 | **T136** | 20.0 |
| **T128** | 18.2 | **T137** | 17.5 |
| **T129** | 5.6 | **T138** | 3.0 |
| **T130** | 23.8 | **T139** | 18.7 |
| **T131** | 21.3 | **T140** | 18.5 |
| **T132** | 17.8 | **T141** | 19.3 |
| **T133** | 7.4 | **T142** | 17.3 |
| **T134** | 20.8 | **T143** | 9.5 |
| **T135** | 20.5 | **T144** | 17.5 |
| | | **T145** | 18.1 |

## 3.2 Geophysical Survey Results

### 3.2.1 Background Information

The Kish and Bray banks are described as the largest sand bank found off the east coast of Ireland. It measures approximately 18km in length. The surface seabed sediments are largely composed of sand of medium to low acoustic reflectivity (Jackson, et al. 1995, Anglesey Sheet 1:250,000 series Seabed Sediments BGS and GSI).

The sequence of Quaternary sediments found covering the Kish and Bray banks can be classified under the Prograded facies of the Western Irish Sea Formation (Jackson et al 1995, Anglesey Sheet 1:250,000 Quaternary Sediments BGS and GSI The Geology of the Irish Sea). The main characteristics of the facies are largely composed of sand. Over the Kish and Bray banks this facies is typically overlain by the Surface Sands formation which is characterised by sands, slightly gravelly sands and some muddier sands.

According to Wheeler et al. (2001) a simple stratigraphy of the Kish and Bray banks consists of :

*Unit A:* an upper layer of sand with weak internal reflectors suggesting minimal density contrasts.

*Unit B:* Thin unit underlying Unit A with a strong acoustic response. This unit may contain clay, gravel layers and mud and silt. This in turn overlies Unit C.

*Unit C:* A poorly imaged unit with few internal reflectors which occasionally contains thin beds comparable with Unit B.

Wheeler et al. (2001) also indicate that over the Kish Bank the thickness of Unit A to Unit B can be over 38m and on the Bray Bank can be over 37m.

### 3.2.2 Subbottom Profiles

The results of the subbottom profiling survey carried out by HSL are presented as a series of 12 east-west orientated cross sections that run the length of the Kish and Bray banks. These are displayed on charts **HS:59D-1/08 and HS:59D-2/08**

Three boreholes were drilled on the Kish Bank by Glover Site Investigations under contract to Saorgus Energy. The results of BH1, BH2 and BH3 have been incorporated onto the appropriate sections.

The interpretations presented for this element of the survey are based on correlations between characteristics displayed on subbottom profiles, geotechnical information where available, background data and the authors experience. These are subject to change pending further ground-truthing.

Two main horizons were identified within the seismic profiles. These were represented by a planar, almost continuous character.

From the existing borehole information and the background data it would appear most likely that these horizons are indicative of changes in the subsurface sediment texture and density. The principal composition of this sediment would be sand with densities ranging from medium to very dense with gravel layers and silt. There may also be a clay component.

The horizons that have been identified as possible rock/glacial till would seem to correlate with Unit C from Wheeler et al. 2001 who describe this unit as a poorly imaged strata that occasionally contains other thin beds comparable with those described above. Given the lack of information, if it is required to identify/clarify this unit, further ground-truthing would be advisable.

In lieu of any further information, at present based on the data resolved from the subbottom profiles it would appear that within the sections the range of material thickness can be summarised as follows.

| **Subbottom Section** | **Interpreted Material thickness** |
|---|---|
| Section 1 | 5-33m |
| Section 2 | 24-42m |
| Section 3 | 15-38m |
| Section 4 | 10-20m |
| Section 5 | greater than 27m |
| Section 6 | greater than 20m |
| Section 7 | greater than 20m |
| Section 8 | 10-30m |
| Section 9 | at least 20m |
| Section 10 | 15-20m |
| Section 11 | up to 22m |
| Section 12 | at least 20m |

## Bibliography

Jackson, et al. 1995. United Kingdom Offshore regional report: The Geology of the Irish Sea. *London: HMSO for the British Geological Survey*.

Wheeler, et al. 2001. Seabed Mapping and Seafloor Processes in the Kish, Burford, Bray and Fraser Banks Area, South-Western Irish Sea. *Irish Geography, Volume 34(2), 194-211*

## Maps

Anglesey Sheet 53$^o$N – 06$^o$W including part of Dublin 53$^o$N – 08$^o$W, British Geological Survey and Geological Survey Of Ireland, 1:250,000 **Seabed Sediments**

Anglesey Sheet 53$^o$N – 06$^o$W including part of Dublin 53$^o$N – 08$^o$W, British Geological Survey and Geological Survey Of Ireland, 1:250,000 **Quaternary Geology**

**Appendix One**

**Equipment List**

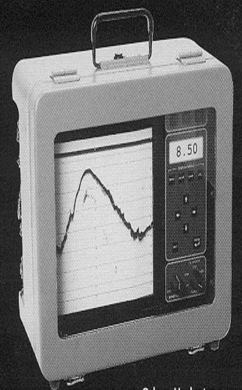
## Appendix One

## Equipment List and Technical Specifications

**Navigation:** Trimble AgDGPS 132 Receiver This navigation unit provides sub-metre differential position accuracy in differential mode.

**Bathymetry** ODOM Hydrotrac digital echosounder
Hypack 2008 survey software.
The navigation can be interfaced into this software package to provide real-time line guidance and continuous logging of position in both Latitude and Longitude and Irish National Grid.

The ODOM Hydrotrac digital echosounder recorder set up onboard during survey.




Odom Hydrotrac
featuring full waterproof cover.

odom

**Hydrotrac**™ WAS SPECIFICALLY DESIGNED TO WORK ON SMALL SURVEY BOATS AND INFLATABLE WATER CRAFT IN RUGGED CONDITIONS SUCH AS SURF ZONES. WHILE BEING COMPACT AND PORTABLE, IT IS FULLY WATERPROOF DURING OPERATION. HYDROTRAC INCORPORATES THE THERMAL PRINTER AND ADVANCED FEATURES OF ODOM'S ESTABLISHED ECHOTRAC LINE OF ECHO SOUNDERS AND IS COMPETITIVELY PRICED.

### SPECIFICATIONS

Frequency
- 200 kHz *(standard)*
- 40 & 33 kHz *(optional)*

Output Power
- 500 Watts

Power Requirement
- 9-18 VDC *(standard)*
- 18-36 VDC or 110/220
- VAC *(optional)*

Ports
- 2 *(RS232 or RS422)*
- Resolution 0.1 feet or .01 meters *(selectable)*

### CONTROLS

- Sensitivity
- Chart On/Off & Advance
- Event Mark
- Transmit Power *(High/Med/Low)*

### TOUCH PAD SETTINGS

- Draft, Velocity & Tide Inputs
- Time & Date
- Scale Width & Center
- Blanking
- Calibration Gate
- Alarm Filter
- Fix Interval

**Specifications for the ODOM Hydrotrac digital echosounder**

**Subbottom Profiling:** C-boom low voltage subbottom profiling system

Coda Octopus Subbottom Processing Toolkit software.

The subbottom system was deployed astern. The technical specifications for the C Boom system are discussed below.

Towed catamaran with seismic source for C-boom subbottom profiling system

# C-Boom

## Technical Specifications

**Model** C-Boom LVB

### C-Boom Catamaran

Comprising Frame, Plate and Electronics module
Dimensions 950 x 1010 x 370mm
Weight in Air 30Kg
Energy discharge per pulse 100J
Acoustic output (re 1uPa @ 1m) -200dB
Dominant frequency 1760Hz
Resolution better than 300mm
Firing rate 6 per second max
Working voltage 400 – 600 Volts DC
Transducer diameter 370mm
Power supply & trigger connector 6 pin Impulse
(Via combined power & tow cable)
Transducer Connection 4 Pin LVB Connector
Tow frame 19mm Stainless 316 tube
Tow Depth: 0 – 1000mm continuous

### C-Boom Power Supply

Dimensions (Inc 19" mounting) 485 x 430 x 85mm
Weight 18Kg
Supply voltage 110 / 220 Volts ac, 50/60 Hz
(Operator selected)
Output voltage 400 – 600Volts dc
(Operator adjustable)
Connections Mains - IEC
Catamaran - 12 Pin Cannon
Trigger - BNC 50Ω
Power consumption 800W
Power source 1.5 KVA generator
Resolution 30cm or better
Environmental Safe portable equipment
Electrical isolation Fully isolated from mains input
and trigger circuits

# C-Boom

## Technical Specifications

**Model** C-Boom LVB

### C-Boom Light Weight Tow Cable

Standard length 60m
(Other lengths available on request)
Weight in air 13Kg
Weight in water 4Kg
Diameter 14mm
Composition Double polyurethane jacket
Double screened
Kevlar reinforced
Cable breaking strain 700Kg
Cable termination Termination shell is bonded on to the
Aramide strain member with potting

## Appendix Two

## Table of Proposed Turbine Locations

| Turbine ID | Easting | Northing | Latitude (Modified Airy) | Longitude (Modified Airy) |
|---|---|---|---|---|
| T1 | 336839.3 | 229934.4 | 53 18 7.287 N | 005 56 49.6296 W |
| T2 | 337375 | 229885.3 | 53 18 5.2009 N | 005 56 20.7947 W |
| T3 | 337964.3 | 229885.3 | 53 18 4.65 N | 005 55 48.9911 W |
| T4 | 338500 | 229885.3 | 53 18 4.1472 N | 005 55 20.0805 W |
| T5 | 339035.7 | 229885.3 | 53 18 3.6424 N | 005 54 51.1701 W |
| T6 | 336839.3 | 229344.3 | 53 17 48.2093 N | 005 56 50.5449 W |
| T7 | 337375 | 229344.3 | 53 17 47.7108 N | 005 56 21.6369 W |
| T8 | 337964.3 | 229344.3 | 53 17 47.16 N | 005 55 49.837 W |
| T9 | 338446.4 | 229344.3 | 53 17 46.7076 N | 005 55 23.822 W |
| T10 | 339035.7 | 229344.3 | 53 17 46.1525 N | 005 54 52.0225 W |
| T11 | 336839.3 | 228852.5 | 53 17 32.3096 N | 005 56 51.3073 W |
| T12 | 337437.5 | 228861.6 | 53 17 31.3651 N | 005 55 56.6381 W |
| T13 | 337964.3 | 228852.5 | 53 17 31.2605 N | 005 55 50.6014 W |
| T14 | 338500 | 228852.5 | 53 17 30.7578 N | 005 55 21.7013 W |
| T15 | 339035.7 | 228852.5 | 53 17 30.2532 N | 005 54 52.7972 W |
| T16 | 336785.7 | 228311.5 | 53 17 14.8692 N | 005 56 55.0376 W |
| T17 | 337375 | 228311.5 | 53 17 14.3209 N | 005 56 23.2442 W |
| T18 | 337910.8 | 228311.5 | 53 17 13.8204 N | 005 55 54.3375 W |
| T19 | 338446.4 | 228360.7 | 53 17 14.9087 N | 005 55 25.3646 W |
| T20 | 338982.2 | 228311.5 | 53 17 12.8138 N | 005 54 56.5354 W |
| T21 | 336892.9 | 227819.7 | 53 16 58.87 N | 005 56 50.0164 W |
| T22 | 337428.6 | 227819.7 | 53 16 58.3714 N | 005 56 21.1179 W |
| T23 | 337964.3 | 227819.7 | 53 16 57.8709 N | 005 55 52.2195 W |
| T24 | 338553.6 | 227819.7 | 53 16 57.3179 N | 005 55 20.4299 W |
| T25 | 339089.3 | 227819.7 | 53 16 56.8134 N | 005 54 51.532 W |
| T26 | 337053.6 | 227278.7 | 53 16 41.2303 N | 005 56 42.1868 W |
| T27 | 337589.3 | 227278.7 | 53 16 40.7312 N | 005 56 13.2915 W |
| T28 | 338125 | 227278.7 | 53 16 40.2302 N | 005 55 44.3965 W |
| T29 | 338714.3 | 227278.7 | 53 16 39.6769 N | 005 55 12.6055 W |
| T30 | 339250 | 227278.7 | 53 16 39.1718 N | 005 54 43.7161 W |
| T31 | 337107.2 | 226737.7 | 53 16 23.6902 N | 005 56 40.1351 W |
| T32 | 337696.4 | 226737.7 | 53 16 23.141 N | 005 56 8.3577 W |
| T33 | 338232.2 | 226737.7 | 53 16 22.6396 N | 005 55 39.4606 W |
| T34 | 338767.9 | 226737.7 | 53 16 22.1364 N | 005 55 10.5691 W |
| T35 | 339303.6 | 226737.7 | 53 16 21.6312 N | 005 54 41.6779 W |
| T36 | 337160.7 | 226196.7 | 53 16 6.1501 N | 005 56 38.0892 W |
| T37 | 337750 | 226196.7 | 53 16 5.6008 N | 005 56 6.31 W |
| T38 | 338339.3 | 226196.7 | 53 16 5.049 N | 005 55 34.5312 W |
| T39 | 338875 | 226196.7 | 53 16 4.5456 N | 005 55 5.643 W |
| T40 | 339410.7 | 226196.7 | 53 16 4.0399 N | 005 54 36.7551 W |
| T41 | 337231.4 | 225655.7 | 53 15 48.5941 N | 005 56 35.1162 W |
| T42 | 337857.1 | 225655.7 | 53 15 48.0105 N | 005 56 1.378 W |
| T43 | 338446.4 | 225655.7 | 53 15 47.4585 N | 005 55 29.6026 W |
| T44 | 338982.1 | 225655.7 | 53 15 46.9547 N | 005 55 0.7181 W |
| T45 | 339517.9 | 225655.7 | 53 15 46.4487 N | 005 54 31.828 W |
| T46 | 337214.3 | 225114.8 | 53 15 31.1229 N | 005 56 36.8775 W |
| T47 | 337750 | 225114.8 | 53 15 30.6236 N | 005 56 7.9954 W |
| T48 | 338285.7 | 225114.8 | 53 15 30.1224 N | 005 55 39.1136 W |
| T49 | 338821.4 | 225114.8 | 53 15 29.6192 N | 005 55 10.2319 W |

| Turbine ID | Easting | Northing | Latitude (Modified Airy) | Longitude (Modified Airy) |
|---|---|---|---|---|
| T50 | 339357.1 | 225114.8 | 53 15 29.114 N | 005 54 41.3506 W |
| T51 | 337589.3 | 224573.8 | 53 15 13.2833 N | 005 56 17.5009 W |
| T52 | 338125 | 224573.8 | 53 15 12.7828 N | 005 55 48.6223 W |
| T53 | 338660.7 | 224573.8 | 53 15 12.2801 N | 005 55 19.7439 W |
| T54 | 339196.4 | 224573.8 | 53 15 11.7757 N | 005 54 50.8656 W |
| T55 | 339785.7 | 224573.8 | 53 15 11.2185 N | 005 54 19.0982 W |
| T56 | 337642.9 | 224032.8 | 53 14 55.7431 N | 005 56 15.453 W |
| T57 | 338178.6 | 224032.8 | 53 14 55.2423 N | 005 55 46.5776 W |
| T58 | 338767.9 | 223983.6 | 53 14 53.0987 N | 005 55 14.8905 W |
| T59 | 339303.6 | 223983.6 | 53 14 52.594 N | 005 54 46.0159 W |
| T60 | 339892.9 | 223983.6 | 53 14 52.0364 N | 005 54 14.2525 W |
| T61 | 337803.6 | 223491.8 | 53 14 38.1028 N | 005 56 7.6331 W |
| T62 | 338339.3 | 223491.8 | 53 14 37.6015 N | 005 55 38.761 W |
| T63 | 338928.6 | 223491.8 | 53 14 37.0479 N | 005 55 7 W |
| T64 | 339464.3 | 223491.8 | 53 14 36.5427 N | 005 54 38.1289 W |
| T65 | 339946.4 | 223491.8 | 53 14 36.0863 N | 005 54 12.1464 W |
| T66 | 338107 | 222902 | 53 14 18.7513 N | 005 55 52.2011 W |
| T67 | 338607 | 222902 | 53 14 18.2826 N | 005 55 25.2565 W |
| T68 | 339107 | 222902 | 53 14 17.8123 N | 005 54 58.3122 W |
| T69 | 339607 | 222902 | 53 14 17.3403 N | 005 54 31.3681 W |
| T70 | 340107.1 | 222852.5 | 53 14 15.2661 N | 005 54 4.4972 W |
| T71 | 338143 | 222386 | 53 14 02.0356 N | 005 55 51.0659 W |
| T72 | 338642 | 222360 | 53 14 00.7273 N | 005 55 24.2188 W |
| T73 | 339142.9 | 222360.7 | 53 14 0.2787 N | 005 54 57.228 W |
| T74 | 339678.6 | 222360.7 | 53 13 59.7727 N | 005 54 28.3633 W |
| T75 | 340214.3 | 222360.7 | 53 13 59.265 N | 005 53 59.499 W |
| T76 | 338375 | 221770 | 53 13 41.9034 N | 005 55 39.5271 W |
| T77 | 338875 | 221819.7 | 53 13 43.0407 N | 005 55 39.5271 W |
| T78 | 339410.7 | 221770.5 | 53 13 40.9453 N | 005 54 43.727 W |
| T79 | 339946.4 | 221770.5 | 53 13 40.4386 N | 005 54 14.8661 W |
| T80 | 338446.4 | 221377.1 | 53 13 29.1341 N | 005 55 36.2941 W |
| T81 | 339035.7 | 221327.9 | 53 13 26.99 N | 005 55 4.6248 W |
| T82 | 339517.9 | 221377.1 | 53 13 28.1258 N | 005 54 38.5709 W |
| T83 | 340107.1 | 221377.1 | 53 13 27.5681 N | 005 54 6.8303 W |
| T84 | 338553.6 | 220737.7 | 53 13 8.3622 N | 005 55 31.5185 W |
| T85 | 339089.3 | 220737.7 | 53 13 7.8587 N | 005 55 2.6633 W |
| T86 | 339625 | 220737.7 | 53 13 7.3533 N | 005 54 33.8085 W |
| T87 | 340160.7 | 220737.7 | 53 13 6.8461 N | 005 54 4.9539 W |
| T88 | 338500 | 220245.9 | 53 12 52.5128 N | 005 55 35.1737 W |
| T89 | 339089.3 | 220196.7 | 53 12 50.3686 N | 005 55 3.512 W |
| T90 | 339624.9 | 220196.7 | 53 12 49.8634 N | 005 54 34.6657 W |
| T91 | 340160.7 | 220245.9 | 53 12 50.9467 N | 005 54 5.7312 W |
| T92 | 338660.7 | 219606.6 | 53 12 31.6939 N | 005 55 27.5181 W |
| T93 | 339196.4 | 219606.6 | 53 12 31.1902 N | 005 54 58.6698 W |
| T94 | 339785.7 | 219606.6 | 53 12 30.6339 N | 005 54 26.9354 W |
| T95 | 340321.4 | 219606.6 | 53 12 30.1262 N | 005 53 58.0877 W |
| T96 | 338660.7 | 219065.6 | 53 12 14.2036 N | 005 55 28.3635 W |
| T97 | 339250 | 219065.6 | 53 12 13.6495 N | 005 54 56.6324 W |
| T98 | 339785.7 | 219065.6 | 53 12 13.1438 N | 005 54 27.7878 W |
| T99 | 340321.4 | 219065.6 | 53 12 12.6361 N | 005 53 58.9433 W |

| Turbine ID | Easting | Northing | Latitude (Modified Airy) | Longitude (Modified Airy) |
|---|---|---|---|---|
| T100 | 338500 | 218475.4 | 53 11 55.2734 N | 005 55 37.9375 W |
| T101 | 339035.7 | 218524.6 | 53 11 56.3611 N | 005 55 9.0189 W |
| T102 | 339571.4 | 218524.6 | 53 11 55.8563 N | 005 54 40.1775 W |
| T103 | 340107.1 | 218524.6 | 53 11 55.3495 N | 005 54 11.3361 W |
| T104 | 340696.4 | 218524.6 | 53 11 54.7897 N | 005 53 39.6093 W |
| T105 | 338232.1 | 218032.8 | 53 11 41.2149 N | 005 55 53.0502 W |
| T106 | 338821.4 | 218032.8 | 53 11 40.6628 N | 005 55 21.3258 W |
| T107 | 339357.1 | 218032.8 | 53 11 40.1589 N | 005 54 52.4871 W |
| T108 | 339946.4 | 218032.8 | 53 11 39.6022 N | 005 54 20.7632 W |
| T109 | 340428.6 | 218032.8 | 53 11 39.145 N | 005 53 54.8051 W |
| T110 | 338821.4 | 217491.8 | 53 11 23.1725 N | 005 55 22.1715 W |
| T111 | 339357.1 | 217491.8 | 53 11 22.6687 N | 005 54 53.3361 W |
| T112 | 339946.4 | 217442.6 | 53 11 20.5215 N | 005 54 21.6933 W |
| T113 | 340482.1 | 217491.8 | 53 11 21.6042 N | 005 53 52.7809 W |
| T114 | 338553.6 | 216901.7 | 53 11 4.3459 N | 005 55 37.5071 W |
| T115 | 339089.3 | 216901.7 | 53 11 3.843 N | 005 55 8.6751 W |
| T116 | 339625 | 216901.7 | 53 11 3.3383 N | 005 54 39.8433 W |
| T117 | 340214.3 | 216901.7 | 53 11 2.781 N | 005 54 8.1271 W |
| T118 | 340750 | 216901.7 | 53 11 2.272 N | 005 53 39.2958 W |
| T119 | 338821.4 | 216360.7 | 53 10 46.6046 N | 005 55 23.9389 W |
| T120 | 339357.1 | 216409.8 | 53 10 47.6882 N | 005 54 55.0333 W |
| T121 | 339892.9 | 216409.8 | 53 10 47.1825 N | 005 54 26.1993 W |
| T122 | 340482.1 | 216360.7 | 53 10 45.0367 N | 005 53 54.5694 W |
| T123 | 338982.1 | 215868.9 | 53 10 30.5538 N | 005 55 16.06 W |
| T124 | 339517.9 | 215868.9 | 53 10 30.0495 N | 005 54 47.2289 W |
| T125 | 340053.6 | 215868.9 | 53 10 29.5434 N | 005 54 18.4036 W |
| T126 | 340589.3 | 215868.9 | 53 10 29.0354 N | 005 53 49.5784 W |
| T127 | 338875 | 215327.9 | 53 10 13.1641 N | 005 55 22.668 W |
| T128 | 339410.7 | 215327.9 | 53 10 12.6604 N | 005 54 53.8457 W |
| T129 | 340000 | 215327.9 | 53 10 12.1041 N | 005 54 22.1397 W |
| T130 | 340535.7 | 215327.9 | 53 10 11.5963 N | 005 53 53.3177 W |
| T131 | 338982.1 | 214737.7 | 53 09 53.9826 N | 005 55 17.8281 W |
| T132 | 339517.9 | 214737.7 | 53 09 53.4785 N | 005 54 49 W |
| T133 | 340107.1 | 214737.7 | 53 09 52.922 N | 005 54 17.3072 W |
| T134 | 340642.9 | 214737.7 | 53 09 52.4138 N | 005 53 48.4835 W |
| T135 | 341178.6 | 214737.7 | 53 09 51.9037 N | 005 53 19.6655 W |
| T136 | 339035.7 | 214196.7 | 53 09 36.4419 N | 005 55 15.7901 W |
| T137 | 339571.4 | 214196.7 | 53 09 35.9377 N | 005 54 46.9745 W |
| T138 | 340107.1 | 214196.7 | 53 09 35.4317 N | 005 54 18.1593 W |
| T139 | 340642.9 | 214196.7 | 53 09 34.9237 N | 005 53 49.3389 W |
| T140 | 341232.1 | 214196.7 | 53 09 34.3628 N | 005 53 17.6464 W |
| T141 | 339035.7 | 213606.6 | 53 09 17.3641 N | 005 55 16.7121 W |
| T142 | 339625 | 213606.6 | 53 09 16.8096 N | 005 54 45.0174 W |
| T143 | 340160.7 | 213606.6 | 53 09 16.3035 N | 005 54 16.2056 W |
| T144 | 340696.4 | 213606.6 | 53 09 15.7954 N | 005 53 47.3942 W |
| T145 | 341285.7 | 213606.6 | 53 09 15.2342 N | 005 53 15.7002 W |

**Survey Personnel**

**Project Manager:** Mike Haberlin

**Field Surveyors:** Colin Johnston
Joanna Andrewsksa

**Geophysicist:** Claire M$^{c}$Carthy

**Autocad Technician:** Gary Curtin

**Report Compiled By:**

**____________________________________________Date:_________________**

**Report Approved for Issue By:**

**____________________________________________Date:_________________**

**Hydrographic Surveys Ltd.,**
**The Cobbles,**
**Crosshaven,**
**Co. Cork.**
**Tel: +353 21 4831184    Fax: +353 21 4831193**
**www.info@hydrosurvey.com**

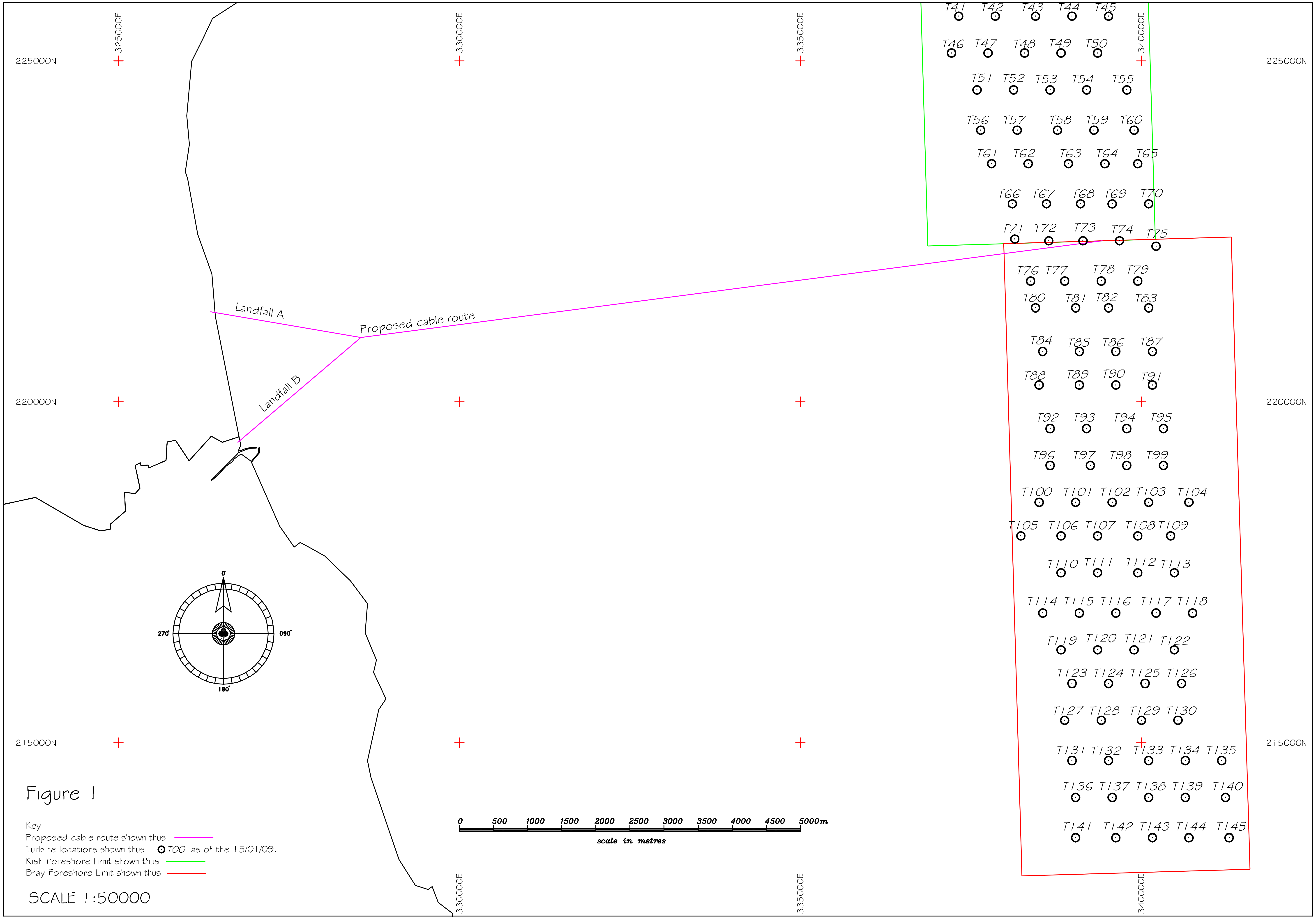
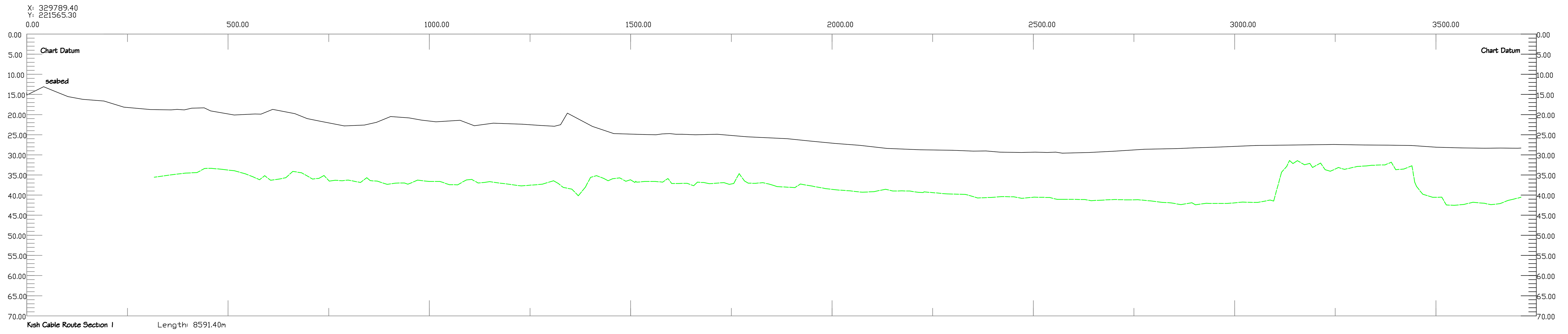
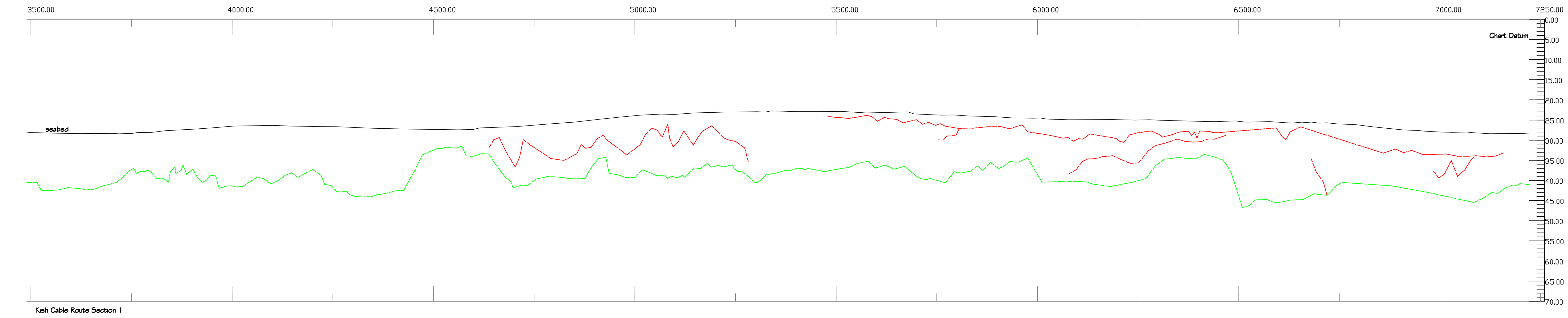


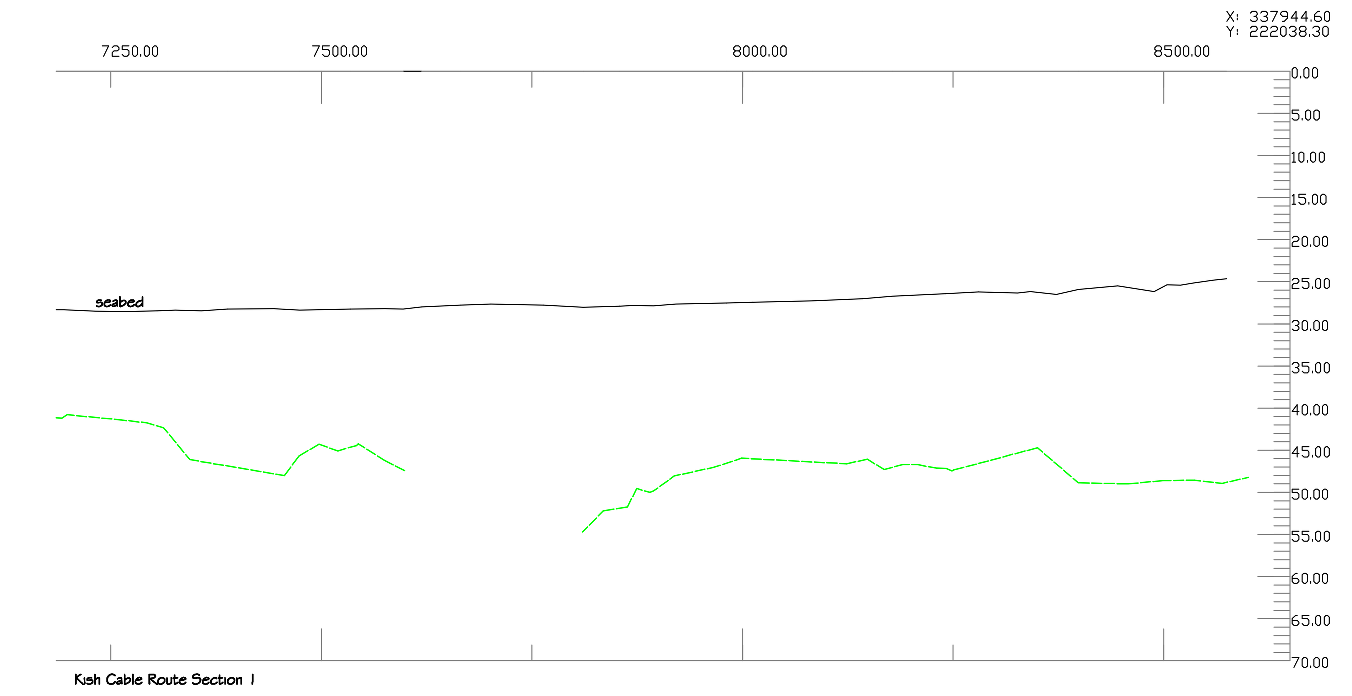

Figure 1

Key
Proposed cable route shown thus
Turbine locations shown thus T00 as of the 15/01/09.
Kish Foreshore Limit shown thus
Bray Foreshore Limit shown thus

SCALE 1:50000




Title: Proposed Cable Route
Geophysical Cross Sections
Site: Kish & Bray Banks
Location: East Coast of Ireland

Client: Saorgus Energy Ltd. Tralee, Co. Kerry.
Surveyed by: Hydrographic Surveys Ltd.
The Cobbles, Crosshaven, Co. Cork. Ireland.

Drwg. No. HS59D-3/08
Project No. 18/08
Date June/Sept 08
Scale Horz. 1:500
Vert. 1:500
Sheet 1 of 1.

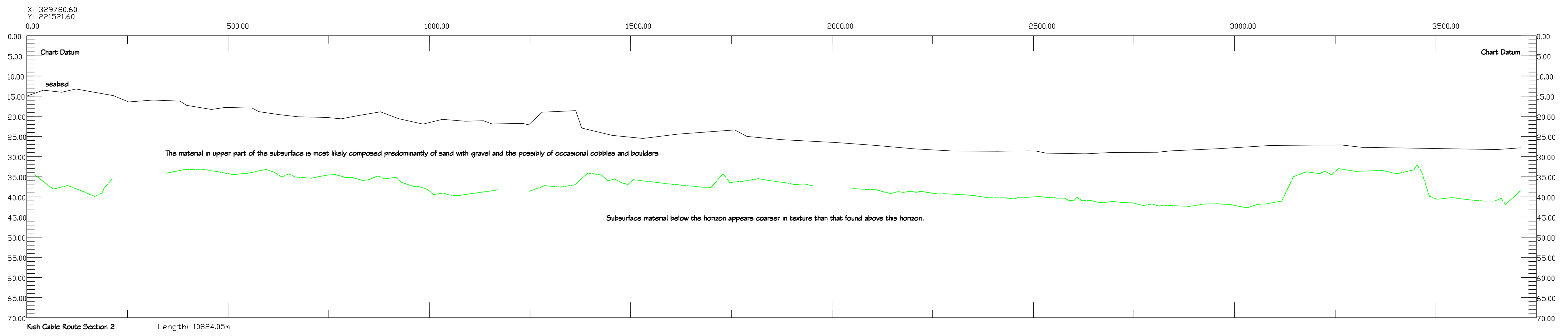
Memoir
1. Constructed on Irish Grid.
2. Horizontal control by D.G.P.S.
3. All levels related to Chart Datum.

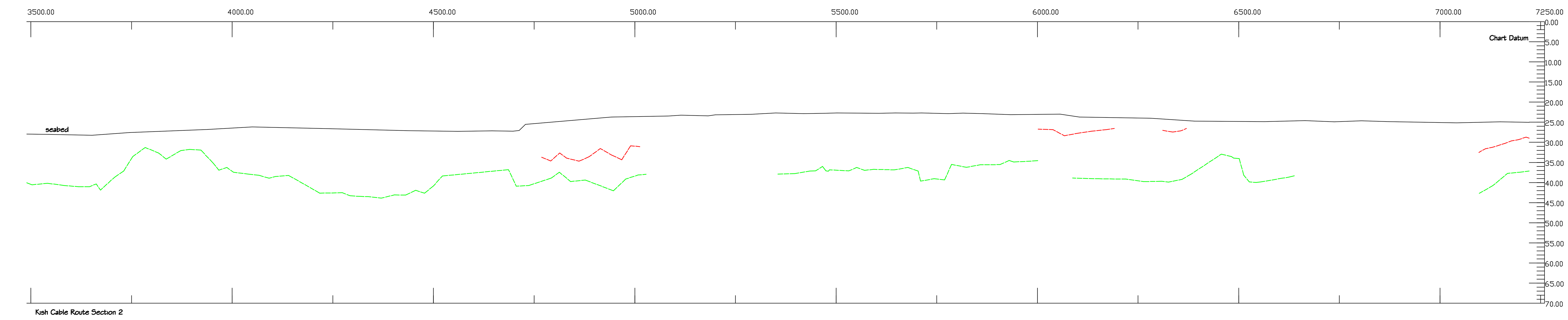
Key
———— Seabed in Chart Datum
- - - - (red) Horizons indicating a change within the upper sediment unit. This unit correlates with the undivided surface sands formation and the prograded facies unit of the western Irish sea formation. The horizon most likely represents internal sorting within the unit.
- - - - (green) Horizons indicating change in sediment texture above this horizon the sediment is most likely composed predominantly of sand with gravel and the possibility of occasional cobbles and boulders. Below this horizon the subsurface material appears coarser in texture and would seem to correlate with the upper till facies of the Cardigan Bay Formation.

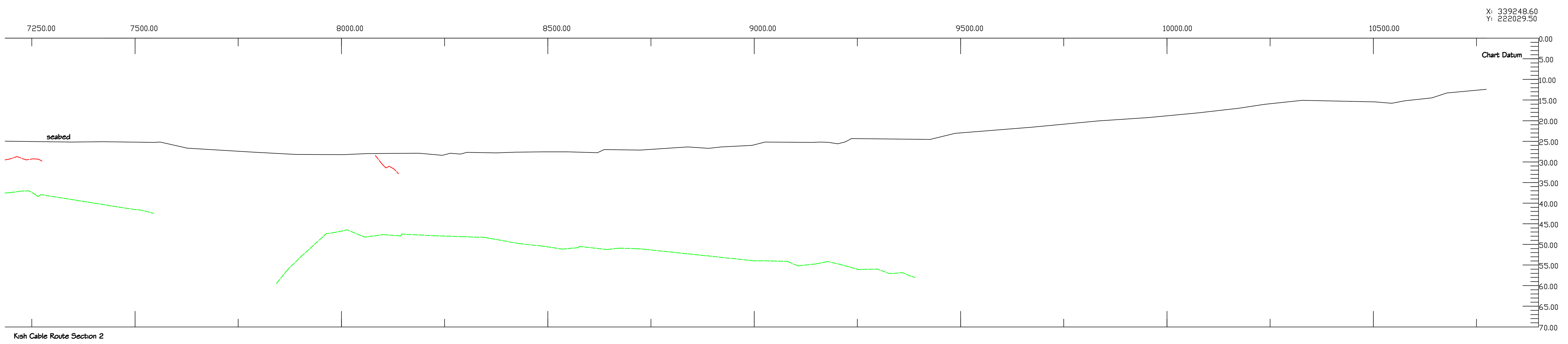
Note
The interpretations presented on the cross sections are based on characteristics displayed on the subbottom profiles,any available ground-truth information and on the authors experience.
The interpretations are subject to change pending further ground truthing.

Drawn by G.C.
Checked by M.J.H.
Approved by M.J.H.

Tel. 00 353 21 4831184 e-mail info@hydrosurvey.com



| | |
|---|---|
| Title | Thickness of Sediment |
| Site | Kish & Bray Banks,<br>Proposed Cable Route |
| Location | East Coast of Ireland |
| Survey | Seismic Survey |

Client
Saorgus Energy Ltd. Tralee, Co. Kerry.

Surveyed by
Hydrographic Surveys Ltd.
The Cobbles, Crosshaven, Co. Cork. Ireland.

Memoir

1. Constructed on Irish Grid.
2. Horizontal control by D.G.P.S.
3. Depth below seabed where change occurs in subsurface sediment composition shown thus 4.5

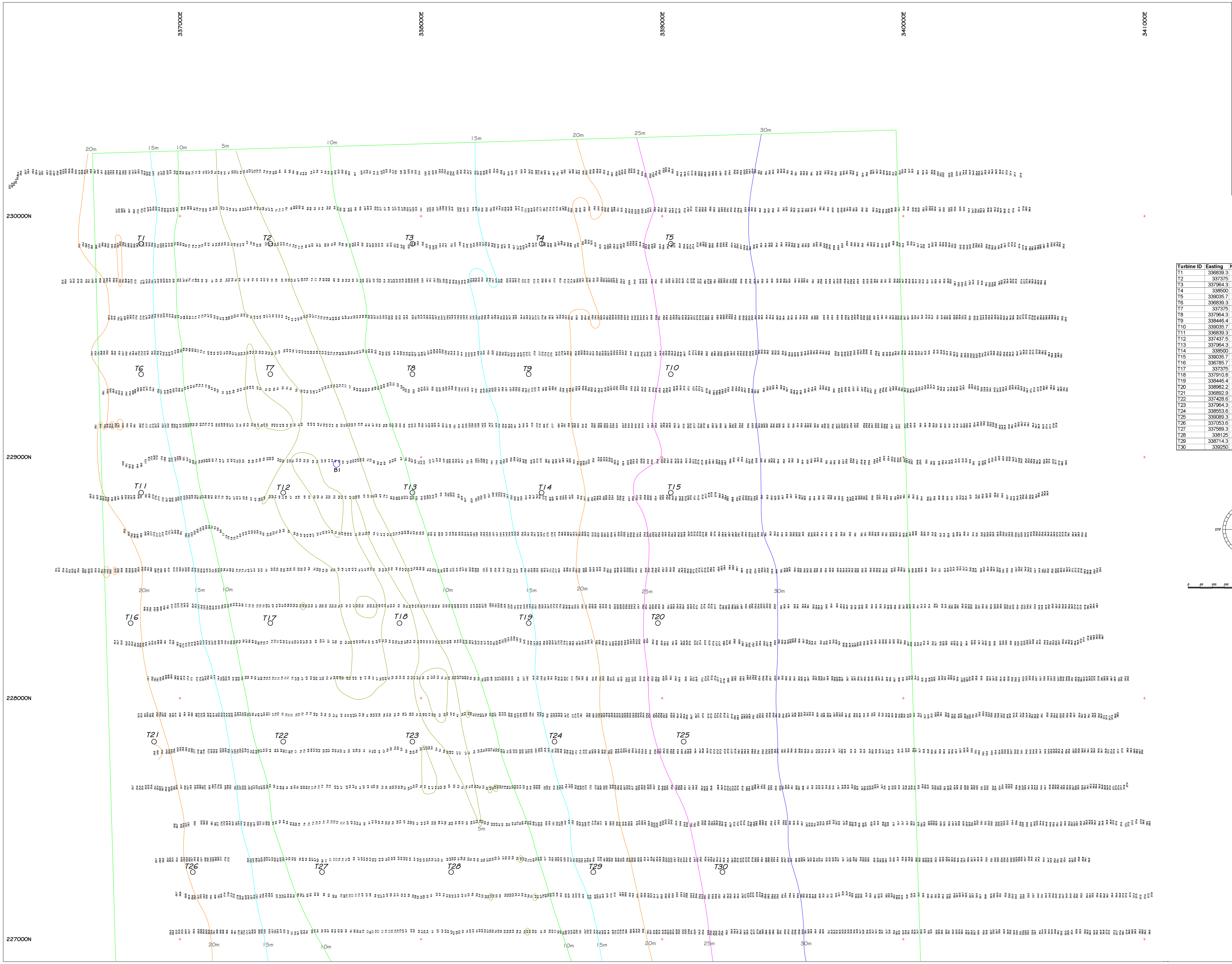
Key

Proposed route shown thus

| | | | |
|---|---|---|---|
| Drwg. No. | HS 59E-6/08 | Drawn by | G.C. |
| Project | No. 18/08 | Checked by | R.B. |
| Date | June/Sept 08 | Approved by | M.J.H. |
| Scale | 1:5000 | | |

Sheet 1 of 1.

Tel. 00 353 21 4831184 e-mail info@hydrosurvey.com




| | |
|---|---|
| Title | Proposed Turbine Locations |
| Site | Kish & Bray Banks |
| Location | East Coast of Ireland |
| Survey | Bathymetric Survey |

Client
Saorgus Energy Ltd. Tralee, Co. Kerry.

Surveyed by
Hydrographic Surveys Ltd.
The Cobbles, Crosshaven, Co. Cork. Ireland.

Memoir
1. Constructed on Irish Grid.
2. Horizontal control by D.G.P.S.
3. Soundings in metres and decimetres reduced to Chart Datum.

Key
Proposed turbine locations shown thus ⊙T68
Kish Foreshore Limit shown thus
Bray Foreshore Limit shown thus
Borehole locations shown thus ○

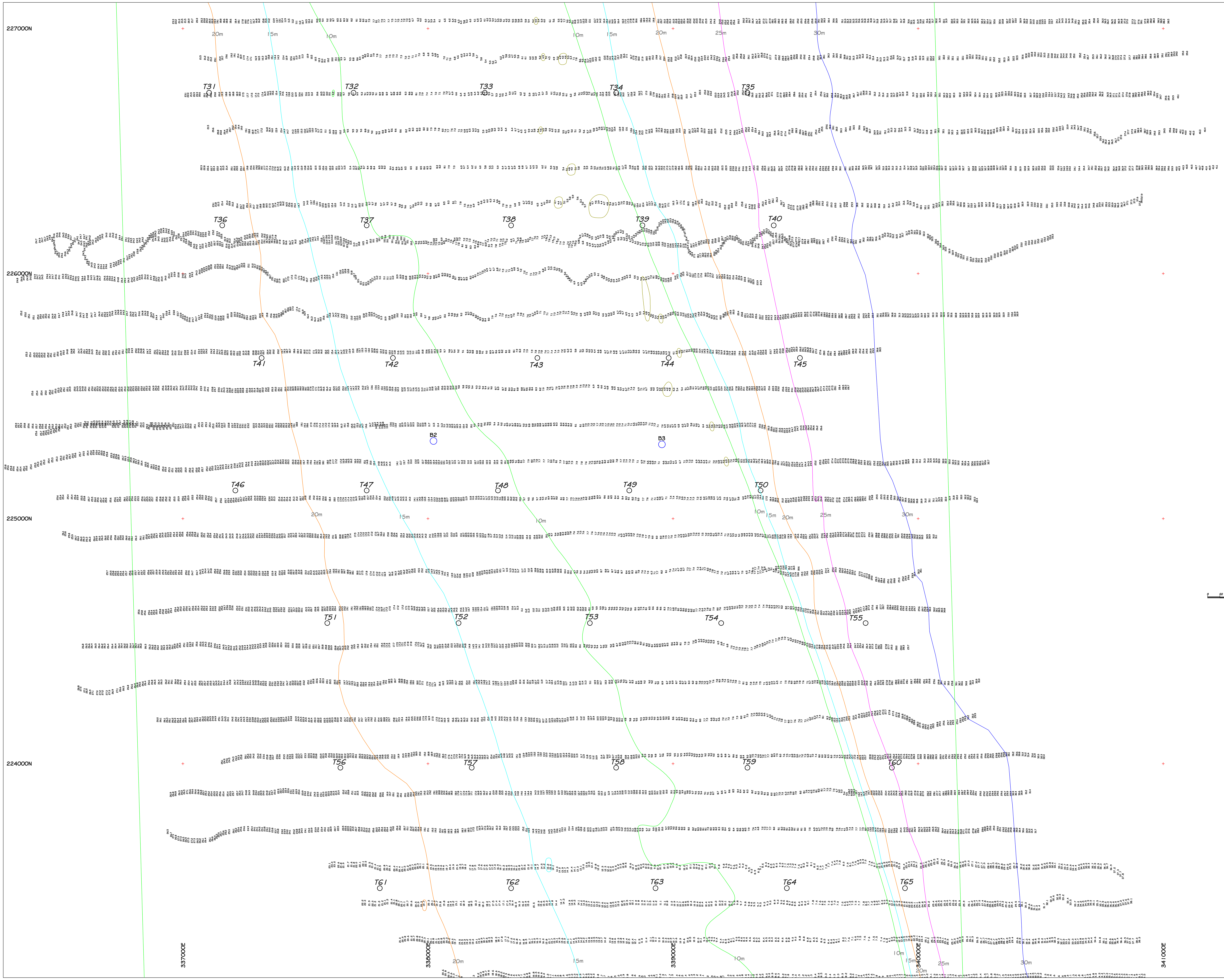
| | | | |
|---|---|---|---|
| Drwg. No. | HS 59-1/08 | Drawn by | G.C. |
| Project | No. 18/08 | Checked by | C.McC. |
| Date | June/Sept 08 | Approved by | M.J.H. |
| Scale | 1:5000 | | |

Sheet 1 of 5.

Tel. 00 353 21 4831184 e-mail info@hydrosurvey.com

Modified Airy

| Turbine ID | Easting | Northing | Latitude | Longitude |
|---|---|---|---|---|
| T1 | 336839.3 | 229934.4 | 53 18 7.287 N | 005 56 49.6296 W |
| T2 | 337375 | 229885.3 | 53 18 5.2009 N | 005 56 20.7947 W |
| T3 | 337964.3 | 229885.3 | 53 18 4.65 N | 005 55 48.9911 W |
| T4 | 338500 | 229885.3 | 53 18 4.1472 N | 005 55 20.0805 W |
| T5 | 339035.7 | 229885.3 | 53 18 3.6424 N | 005 54 51.1701 W |
| T6 | 336839.3 | 229344.3 | 53 17 48.2093 N | 005 56 50.5449 W |
| T7 | 337375 | 229344.3 | 53 17 47.7108 N | 005 56 21.6369 W |
| T8 | 337964.3 | 229344.3 | 53 17 47.16 N | 005 55 49.837 W |
| T9 | 338446.4 | 229344.3 | 53 17 46.7076 N | 005 55 23.822 W |
| T10 | 339035.7 | 229344.3 | 53 17 46.1525 N | 005 54 52.0225 W |
| T11 | 336839.3 | 228852.5 | 53 17 32.3096 N | 005 56 51.3073 W |
| T12 | 337437.5 | 228861.6 | 53 17 31.3651 N | 005 55 56.6381 W |
| T13 | 337964.3 | 228852.5 | 53 17 31.2605 N | 005 55 50.6014 W |
| T14 | 338500 | 228852.5 | 53 17 30.7578 N | 005 55 21.7013 W |
| T15 | 339035.7 | 228852.5 | 53 17 30.2532 N | 005 54 52.7972 W |
| T16 | 336785.7 | 228311.5 | 53 17 14.8692 N | 005 56 55.0376 W |
| T17 | 337375 | 228311.5 | 53 17 14.3209 N | 005 56 23.2442 W |
| T18 | 337910.8 | 228311.5 | 53 17 13.8204 N | 005 55 54.3375 W |
| T19 | 338446.4 | 228360.7 | 53 17 14.9087 N | 005 55 25.3646 W |
| T20 | 338982.2 | 228311.5 | 53 17 12.8138 N | 005 54 56.5354 W |
| T21 | 336892.9 | 227819.7 | 53 16 58.87 N | 005 56 50.0164 W |
| T22 | 337428.6 | 227819.7 | 53 16 58.3714 N | 005 56 21.1179 W |
| T23 | 337964.3 | 227819.7 | 53 16 57.8709 N | 005 55 52.2195 W |
| T24 | 338553.6 | 227819.7 | 53 16 57.3179 N | 005 55 20.4299 W |
| T25 | 339089.3 | 227819.7 | 53 16 56.8134 N | 005 54 51.532 W |
| T26 | 337053.6 | 227278.7 | 53 16 41.2303 N | 005 56 42.1868 W |
| T27 | 337589.3 | 227278.7 | 53 16 40.7312 N | 005 56 13.2915 W |
| T28 | 338125 | 227278.7 | 53 16 40.2302 N | 005 55 44.3965 W |
| T29 | 338714.3 | 227278.7 | 53 16 39.6769 N | 005 55 12.6055 W |
| T30 | 339250 | 227278.7 | 53 16 39.1718 N | 005 54 43.7161 W |




| | |
|---|---|
| Title | Proposed Turbine Locations |
| Site | Kish & Bray Banks |
| Location | East Coast of Ireland |
| Survey | Bathymetric Survey |

Client
Saorgus Energy Ltd. Tralee, Co. Kerry.

Surveyed by
Hydrographic Surveys Ltd.
The Cobbles, Crosshaven, Co. Cork. Ireland.

Memoir
1. Constructed on Irish Grid.
2. Horizontal control by D.G.P.S.
3. Soundings in metres and decimetres reduced to Chart Datum.

Key
Proposed turbine locations shown thus ⊙T68
Kish Foreshore Limit shown thus
Bray Foreshore Limit shown thus
Borehole locations shown thus ○

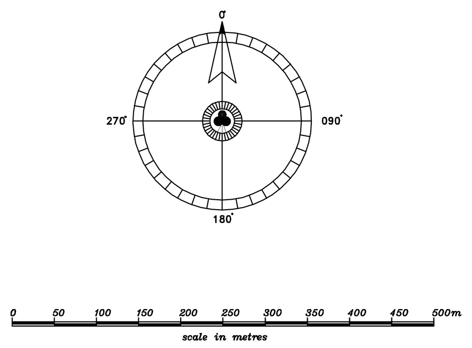
| | |
|---|---|
| Drwg. No. | HS 59-2/08 |
| Project | No. 18/08 |
| Date | June/Sept 08 |
| Scale | 1:5000 |

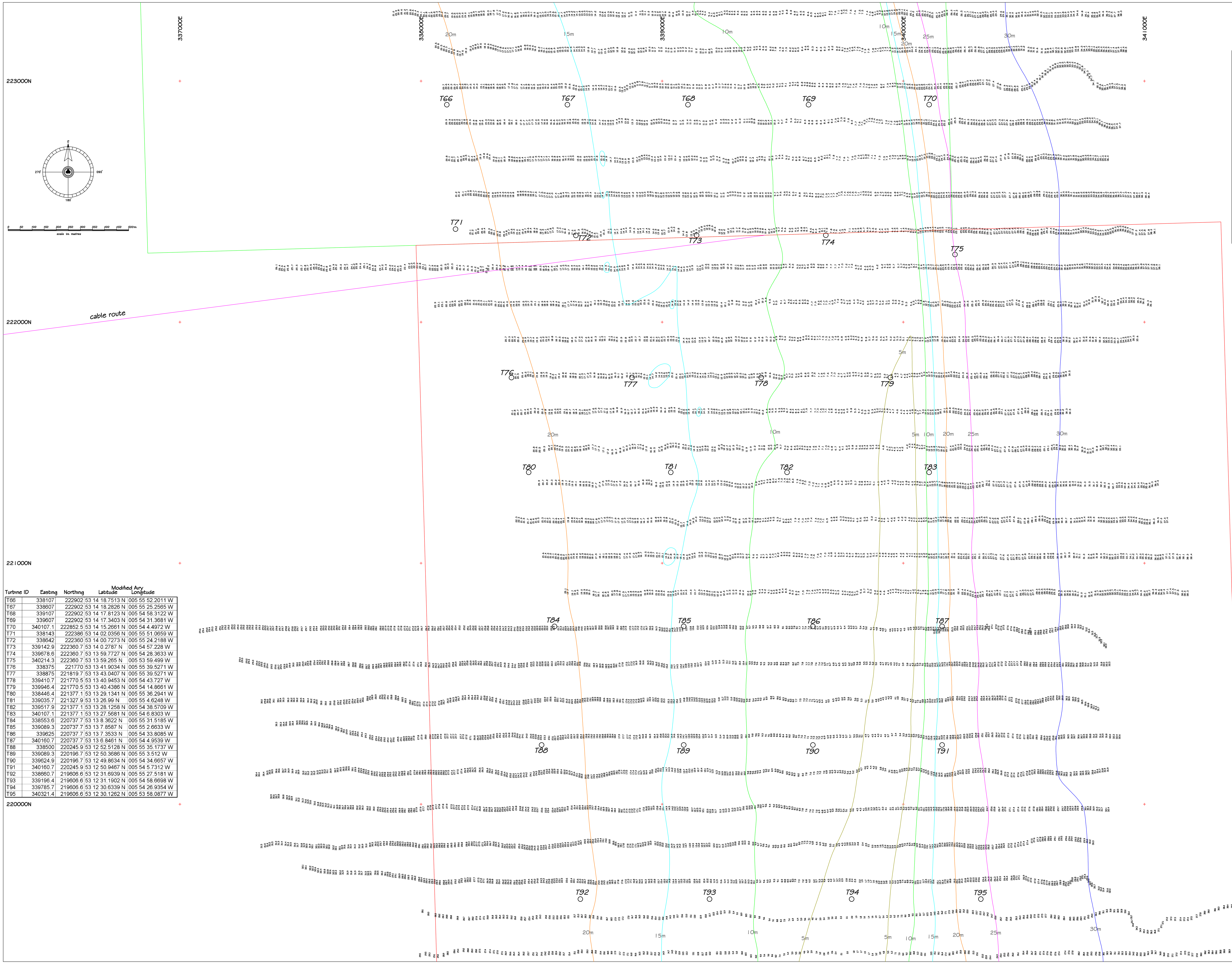
Drawn by G.C.
Checked by C.McC.
Approved by M.J.H.

Sheet 2 of 5.

Tel. 00 353 21 4831184 e-mail info@hydrosurvey.com

| Turbine ID | Easting | Northing | Latitude | Longitude |
|---|---|---|---|---|
| T31 | 337107.2 | 226737.7 | 53 16 23.6902 N | 005 56 40.1351 W |
| T32 | 337696.4 | 226737.7 | 53 16 23.141 N | 005 56 8.3577 W |
| T33 | 338232.2 | 226737.7 | 53 16 22.6396 N | 005 55 39.4606 W |
| T34 | 338767.9 | 226737.7 | 53 16 22.1364 N | 005 55 10.5691 W |
| T35 | 339303.6 | 226737.7 | 53 16 21.6312 N | 005 54 41.6779 W |
| T36 | 337160.7 | 226196.7 | 53 16 6.1501 N | 005 56 38.0892 W |
| T37 | 337750 | 226196.7 | 53 16 5.6008 N | 005 56 6.31 W |
| T38 | 338339.3 | 226196.7 | 53 16 5.049 N | 005 55 34.5312 W |
| T39 | 338875 | 226196.7 | 53 16 4.5456 N | 005 55 5.643 W |
| T40 | 339410.7 | 226196.7 | 53 16 4.0399 N | 005 54 36.7551 W |
| T41 | 337231.4 | 225655.7 | 53 15 48.5941 N | 005 56 35.1162 W |
| T42 | 337857.1 | 225655.7 | 53 15 48.0105 N | 005 56 1.378 W |
| T43 | 338446.4 | 225655.7 | 53 15 47.4585 N | 005 55 29.6026 W |
| T44 | 338982.1 | 225655.7 | 53 15 46.9547 N | 005 55 0.7181 W |
| T45 | 339517.9 | 225655.7 | 53 15 46.4487 N | 005 54 31.828 W |
| T46 | 337214.3 | 225114.8 | 53 15 31.1229 N | 005 56 36.8775 W |
| T47 | 337750 | 225114.8 | 53 15 30.6236 N | 005 56 7.9954 W |
| T48 | 338285.7 | 225114.8 | 53 15 30.1224 N | 005 55 39.1136 W |
| T49 | 338821.4 | 225114.8 | 53 15 29.6192 N | 005 55 10.2319 W |
| T50 | 339357.1 | 225114.8 | 53 15 29.114 N | 005 54 41.3506 W |
| T51 | 337589.3 | 224573.8 | 53 15 13.2833 N | 005 56 17.5009 W |
| T52 | 338125 | 224573.8 | 53 15 12.7828 N | 005 55 48.6223 W |
| T53 | 338660.7 | 224573.8 | 53 15 12.2801 N | 005 55 19.7439 W |
| T54 | 339196.4 | 224573.8 | 53 15 11.7757 N | 005 54 50.8656 W |
| T55 | 339785.7 | 224573.8 | 53 15 11.2185 N | 005 54 19.0982 W |
| T56 | 337642.9 | 224032.8 | 53 14 55.7431 N | 005 56 15.453 W |
| T57 | 338178.6 | 224032.8 | 53 14 55.2423 N | 005 55 46.5776 W |
| T58 | 338767.9 | 223983.6 | 53 14 53.0987 N | 005 55 14.8905 W |
| T59 | 339303.6 | 223983.6 | 53 14 52.594 N | 005 54 46.0159 W |
| T60 | 339892.9 | 223983.6 | 53 14 52.0364 N | 005 54 14.2525 W |
| T61 | 337803.6 | 223491.8 | 53 14 38.1028 N | 005 56 7.6331 W |
| T62 | 338339.3 | 223491.8 | 53 14 37.6015 N | 005 55 38.761 W |
| T63 | 338928.6 | 223491.8 | 53 14 37.0479 N | 005 55 7 W |
| T64 | 339464.3 | 223491.8 | 53 14 36.5427 N | 005 54 38.1289 W |
| T65 | 339946.4 | 223491.8 | 53 14 36.0863 N | 005 54 12.1464 W |






| Turbine ID | Easting | Northing | Modified Airy Latitude | Modified Airy Longitude |
|---|---|---|---|---|
| T66 | 338107 | 222902 | 53 14 18.7513 N | 005 55 52.2011 W |
| T67 | 338607 | 222902 | 53 14 18.2826 N | 005 55 25.2565 W |
| T68 | 339107 | 222902 | 53 14 17.8123 N | 005 54 58.3122 W |
| T69 | 339607 | 222902 | 53 14 17.3403 N | 005 54 31.3681 W |
| T70 | 340107.1 | 222852.5 | 53 14 15.2661 N | 005 54 4.4972 W |
| T71 | 338143 | 222386 | 53 14 02.0356 N | 005 55 51.0659 W |
| T72 | 338642 | 222360 | 53 14 00.7273 N | 005 55 24.2188 W |
| T73 | 339142.9 | 222360.7 | 53 14 0.2787 N | 005 54 57.228 W |
| T74 | 339678.6 | 222360.7 | 53 13 59.7727 N | 005 54 28.3633 W |
| T75 | 340214.3 | 222360.7 | 53 13 59.265 N | 005 53 59.499 W |
| T76 | 338375 | 221770 | 53 13 41.9034 N | 005 55 39.5271 W |
| T77 | 338875 | 221819.7 | 53 13 43.0407 N | 005 55 39.5271 W |
| T78 | 339410.7 | 221770.5 | 53 13 40.9453 N | 005 54 43.727 W |
| T79 | 339946.4 | 221770.5 | 53 13 40.4386 N | 005 54 14.8661 W |
| T80 | 338446.4 | 221377.1 | 53 13 29.1341 N | 005 55 36.2941 W |
| T81 | 339035.7 | 221327.9 | 53 13 26.99 N | 005 55 4.6248 W |
| T82 | 339517.9 | 221377.1 | 53 13 28.1258 N | 005 54 38.5709 W |
| T83 | 340107.1 | 221377.1 | 53 13 27.5681 N | 005 54 6.8303 W |
| T84 | 338553.6 | 220737.7 | 53 13 8.3622 N | 005 55 31.5185 W |
| T85 | 339089.3 | 220737.7 | 53 13 7.8587 N | 005 55 2.6633 W |
| T86 | 339625 | 220737.7 | 53 13 7.3533 N | 005 54 33.8085 W |
| T87 | 340160.7 | 220737.7 | 53 13 6.8461 N | 005 54 4.9539 W |
| T88 | 338500 | 220245.9 | 53 12 52.5128 N | 005 55 35.1737 W |
| T89 | 339089.3 | 220196.7 | 53 12 50.3686 N | 005 55 3.512 W |
| T90 | 339624.9 | 220196.7 | 53 12 49.8634 N | 005 54 34.6657 W |
| T91 | 340160.7 | 220245.9 | 53 12 50.9467 N | 005 54 5.7312 W |
| T92 | 338660.7 | 219606.6 | 53 12 31.6939 N | 005 55 27.5181 W |
| T93 | 339196.4 | 219606.6 | 53 12 31.1902 N | 005 54 58.6698 W |
| T94 | 339785.7 | 219606.6 | 53 12 30.6339 N | 005 54 26.9354 W |
| T95 | 340321.4 | 219606.6 | 53 12 30.1262 N | 005 53 58.0877 W |

Title: Proposed Turbine Locations
Site: Kish & Bray Banks
Location: East Coast of Ireland
Survey: Bathymetric Survey

Client
Saorgus Energy Ltd. Tralee, Co. Kerry.

Surveyed by
Hydrographic Surveys Ltd.
The Cobbles, Crosshaven, Co. Cork. Ireland.

Memoir
1. Constructed on Irish Grid.
2. Horizontal control by D.G.P.S.
3. Soundings in metres and decimetres reduced to Chart Datum.

Key
Proposed turbine locations shown thus OT68
Kish Foreshore Limit shown thus
Bray Foreshore Limit shown thus

Drwg. No. HS 59-3/08
Project No. 18/08
Date June/Sept 08
Scale 1:5000

Drawn by G.C.
Checked by C.McC.
Approved by M.J.H.

Sheet 3 of 5.

Tel. 00 353 21 4831184 e-mail info@hydrosurvey.com

| | |
|---|---|
| Title | Proposed Turbine Locations |
| Site | Kish & Bray Banks |
| Location | East Coast of Ireland |
| Survey | Bathymetric Survey |

Client
Saorgus Energy Ltd. Tralee, Co. Kerry.

Surveyed by
Hydrographic Surveys Ltd.
The Cobbles, Crosshaven, Co. Cork. Ireland.

Memoir
1. Constructed on Irish Grid.
2. Horizontal control by D.G.P.S.
3. Soundings in metres and decimetres reduced to Chart Datum.

Key
Proposed turbine locations shown thus ⊙T68
Kish Foreshore Limit shown thus (green line)
Bray Foreshore Limit shown thus (red line)

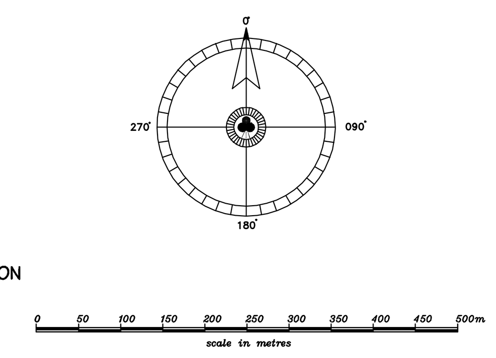
Drwg. No. HS 59-4/08
Project No. 18/08
Date June/Sept 08
Scale 1:5000

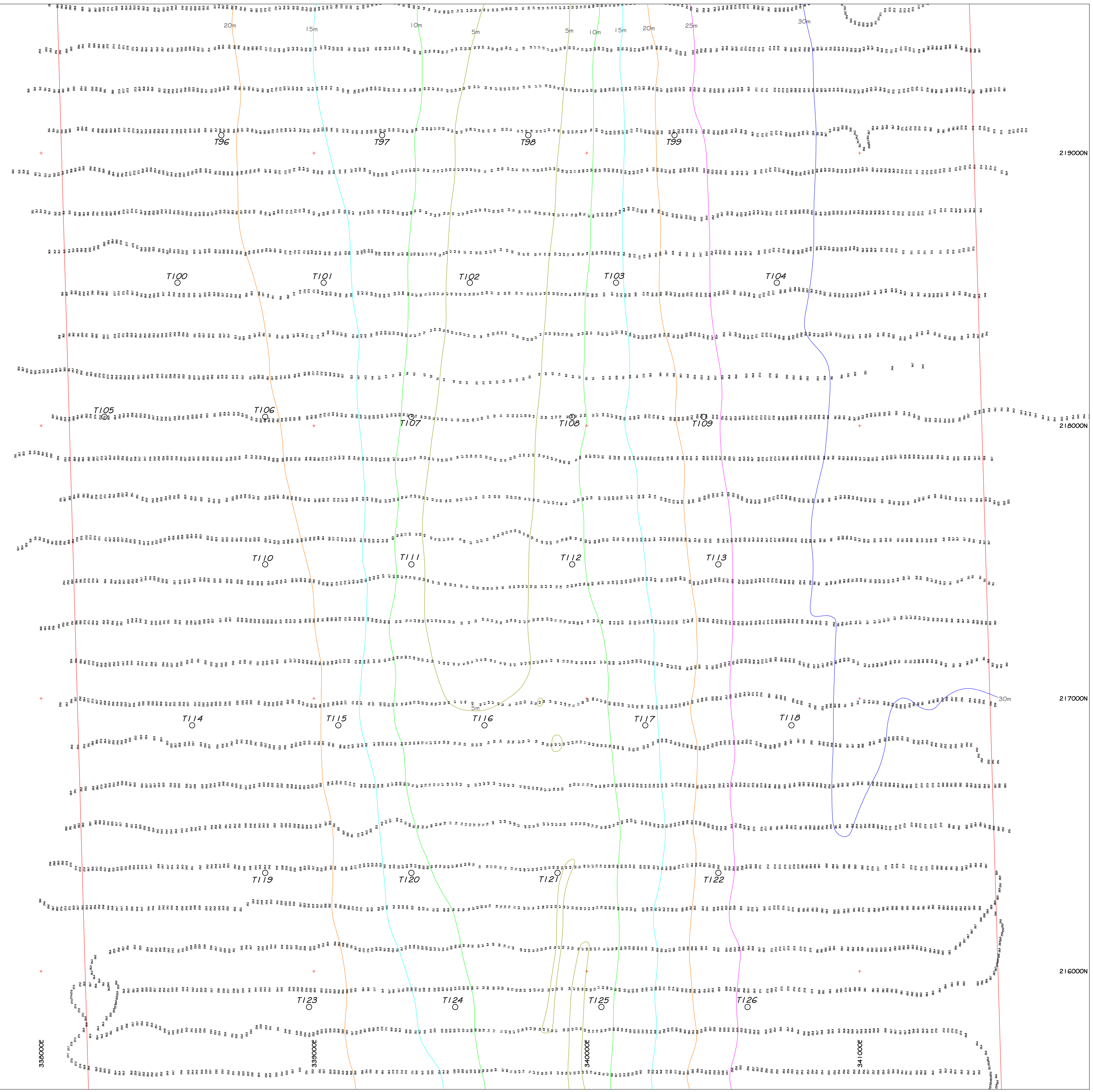
Drawn by G.C.
Checked by C.McC.
Approved by M.J.H.

Sheet 4 of 5.

Tel. 00 353 21 4831184 e-mail info@hydrosurvey.com

| Turbine ID | Easting | Northing | Modified Airy Latitude | Modified Airy Longitude |
|---|---|---|---|---|
| T96 | 338660.7 | 219065.6 | 53 12 14.2036 N | 005 55 28.3635 W |
| T97 | 339250 | 219065.6 | 53 12 13.6495 N | 005 54 56.6324 W |
| T98 | 339785.7 | 219065.6 | 53 12 13.1438 N | 005 54 27.7878 W |
| T99 | 340321.4 | 219065.6 | 53 12 12.6361 N | 005 53 58.9433 W |
| T100 | 338500 | 218475.4 | 53 11 55.2734 N | 005 55 37.9375 W |
| T101 | 339035.7 | 218524.6 | 53 11 56.3611 N | 005 55 9.0189 W |
| T102 | 339571.4 | 218524.6 | 53 11 55.8563 N | 005 54 40.1775 W |
| T103 | 340107.1 | 218524.6 | 53 11 55.3495 N | 005 54 11.3361 W |
| T104 | 340696.4 | 218524.6 | 53 11 54.7897 N | 005 53 39.6093 W |
| T105 | 338232.1 | 218032.8 | 53 11 41.2149 N | 005 55 53.0502 W |
| T106 | 338821.4 | 218032.8 | 53 11 40.6628 N | 005 55 21.3258 W |
| T107 | 339357.1 | 218032.8 | 53 11 40.1589 N | 005 54 52.4871 W |
| T108 | 339946.4 | 218032.8 | 53 11 39.6022 N | 005 54 20.7632 W |
| T109 | 340428.6 | 218032.8 | 53 11 39.145 N | 005 53 54.8051 W |
| T110 | 338821.4 | 217491.8 | 53 11 23.1725 N | 005 55 22.1715 W |
| T111 | 339357.1 | 217491.8 | 53 11 22.6687 N | 005 54 53.3361 W |
| T112 | 339946.4 | 217442.6 | 53 11 20.5215 N | 005 54 21.6933 W |
| T113 | 340482.1 | 217491.8 | 53 11 21.6042 N | 005 53 52.7809 W |
| T114 | 338553.6 | 216901.7 | 53 11 4.3459 N | 005 55 37.5071 W |
| T115 | 339089.3 | 216901.7 | 53 11 3.843 N | 005 55 8.6751 W |
| T116 | 339625 | 216901.7 | 53 11 3.3383 N | 005 54 39.8433 W |
| T117 | 340214.3 | 216901.7 | 53 11 2.781 N | 005 54 8.1271 W |
| T118 | 340750 | 216901.7 | 53 11 2.272 N | 005 53 39.2958 W |
| T119 | 338821.4 | 216360.7 | 53 10 46.6046 N | 005 55 23.9389 W |
| T120 | 339357.1 | 216409.8 | 53 10 47.6882 N | 005 54 55.0333 W |
| T121 | 339892.9 | 216409.8 | 53 10 47.1825 N | 005 54 26.1993 W |
| T122 | 340482.1 | 216360.7 | 53 10 45.0367 N | 005 53 54.5694 W |
| T123 | 338982.1 | 215868.9 | 53 10 30.5538 N | 005 55 16.06 W |
| T124 | 339517.9 | 215868.9 | 53 10 30.0495 N | 005 54 47.2289 W |
| T125 | 340053.6 | 215868.9 | 53 10 29.5434 N | 005 54 18.4036 W |
| T126 | 340589.3 | 215868.9 | 53 10 29.0354 N | 005 53 49.5784 W |





Title: Proposed Turbine Locations
Site: Kish & Bray Banks
Location: East Coast of Ireland
Survey: Bathymetric Survey

Client
Saorgus Energy Ltd. Tralee, Co. Kerry.

Surveyed by
Hydrographic Surveys Ltd.
The Cobbles, Crosshaven, Co. Cork. Ireland.

Memoir
1. Constructed on Irish Grid.
2. Horizontal control by D.G.P.S.
3. Soundings in metres and decimetres reduced to Chart Datum.

Key
Proposed turbine locations shown thus ⊙T68
Kish Foreshore Limit shown thus
Bray Foreshore Limit shown thus

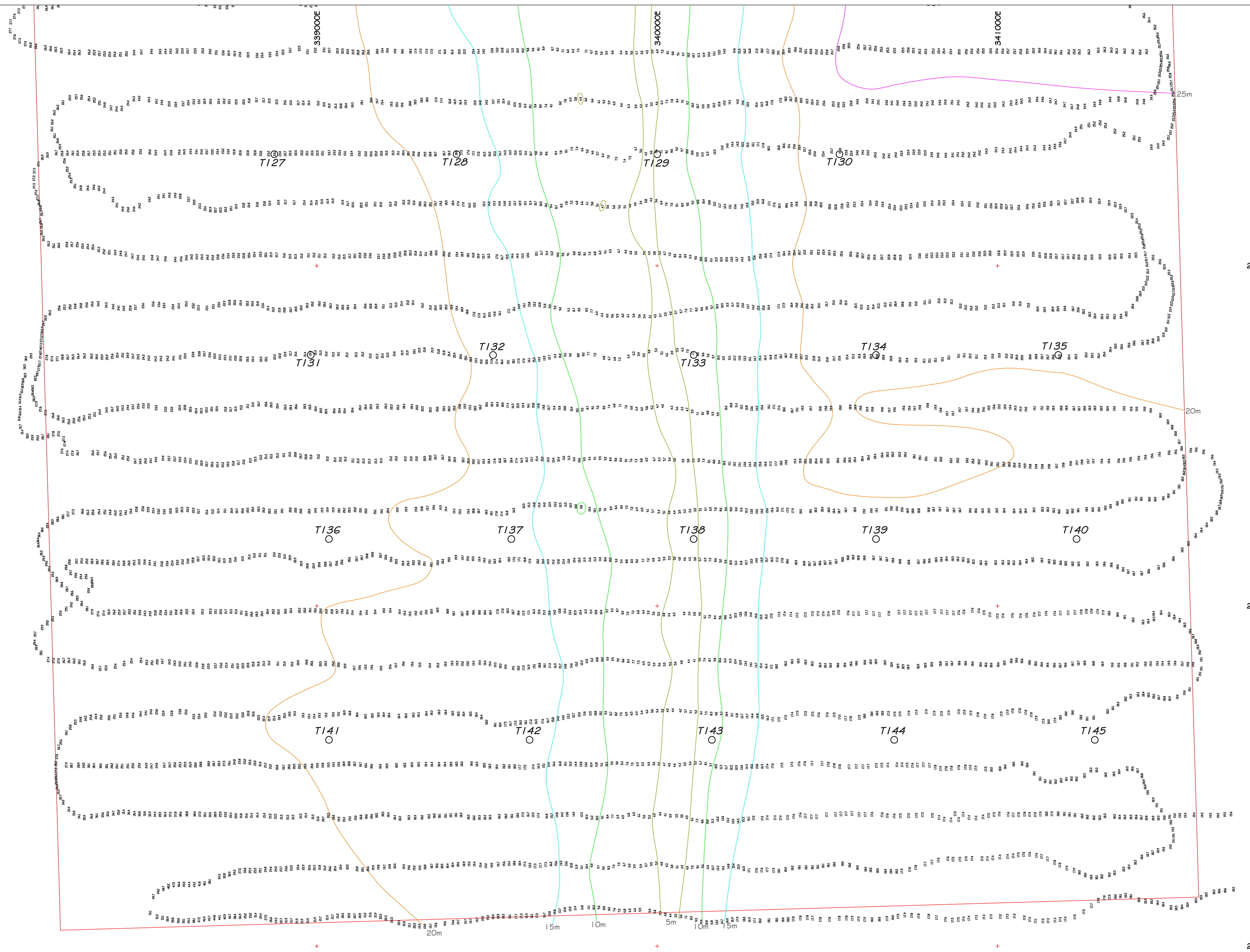
Drwg. No. HS 59-5/08
Project No. 18/08
Date June/Sept 08
Scale 1:5000

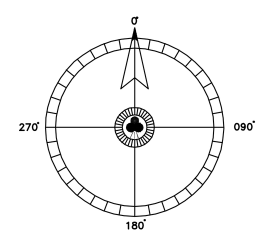
Drawn by G.C.
Checked by C.McC.
Approved by M.J.H.

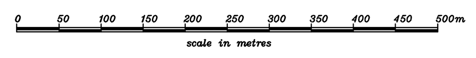
Sheet 5 of 5.

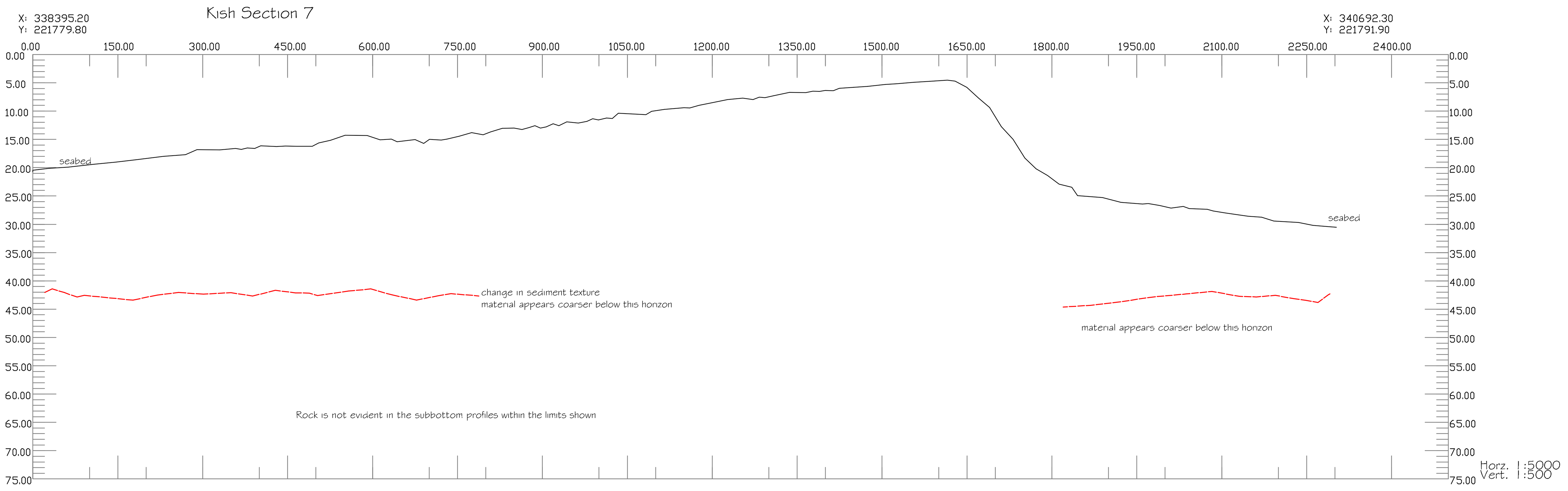
Tel. 00 353 21 4831184 e-mail info@hydrosurvey.com

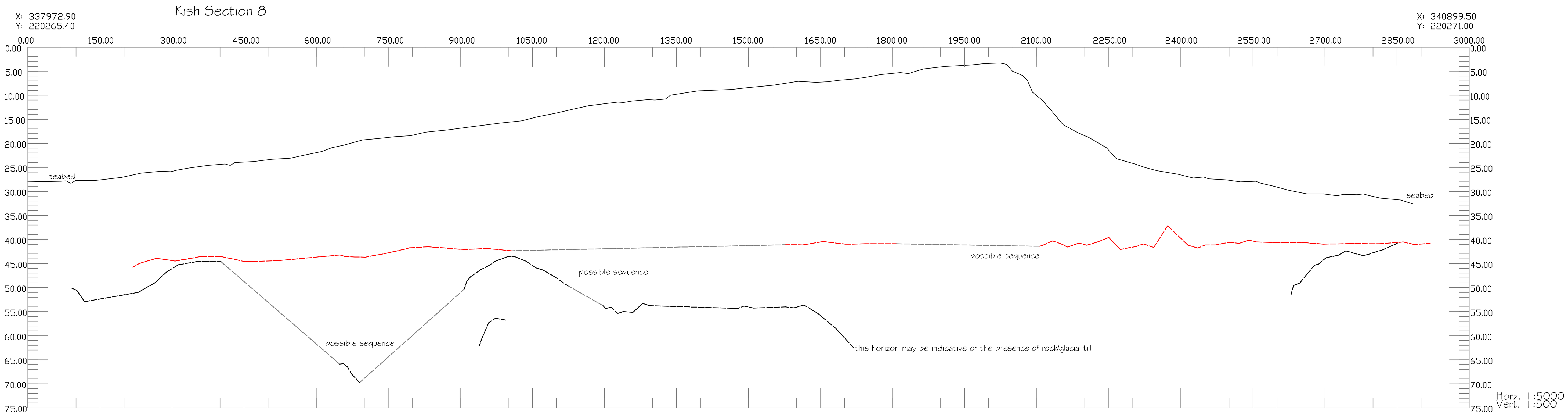
| Turbine ID | Easting | Northing | Modified Airy Latitude | Modified Airy Longitude |
|---|---|---|---|---|
| T127 | 338875 | 215327.9 | 53 10 13.1641 N | 005 55 22.668 W |
| T128 | 339410.7 | 215327.9 | 53 10 12.6604 N | 005 54 53.8457 W |
| T129 | 340000 | 215327.9 | 53 10 12.1041 N | 005 54 22.1397 W |
| T130 | 340535.7 | 215327.9 | 53 10 11.5963 N | 005 53 53.3177 W |
| T131 | 338982.1 | 214737.7 | 53 09 53.9826 N | 005 55 17.8281 W |
| T132 | 339517.9 | 214737.7 | 53 09 53.4785 N | 005 54 49 W |
| T133 | 340107.1 | 214737.7 | 53 09 52.922 N | 005 54 17.3072 W |
| T134 | 340642.9 | 214737.7 | 53 09 52.4138 N | 005 53 48.4835 W |
| T135 | 341178.6 | 214737.7 | 53 09 51.9037 N | 005 53 19.6655 W |
| T136 | 339035.7 | 214196.7 | 53 09 36.4419 N | 005 55 15.7901 W |
| T137 | 339571.4 | 214196.7 | 53 09 35.9377 N | 005 54 46.9745 W |
| T138 | 340107.1 | 214196.7 | 53 09 35.4317 N | 005 54 18.1593 W |
| T139 | 340642.9 | 214196.7 | 53 09 34.9237 N | 005 53 49.3389 W |
| T140 | 341232.1 | 214196.7 | 53 09 34.3628 N | 005 53 17.6464 W |
| T141 | 339035.7 | 213606.6 | 53 09 17.3641 N | 005 55 16.7121 W |
| T142 | 339625 | 213606.6 | 53 09 16.8096 N | 005 54 45.0174 W |
| T143 | 340160.7 | 213606.6 | 53 09 16.3035 N | 005 54 16.2056 W |
| T144 | 340696.4 | 213606.6 | 53 09 15.7954 N | 005 53 47.3942 W |
| T145 | 341285.7 | 213606.6 | 53 09 15.2342 N | 005 53 15.7002 W |

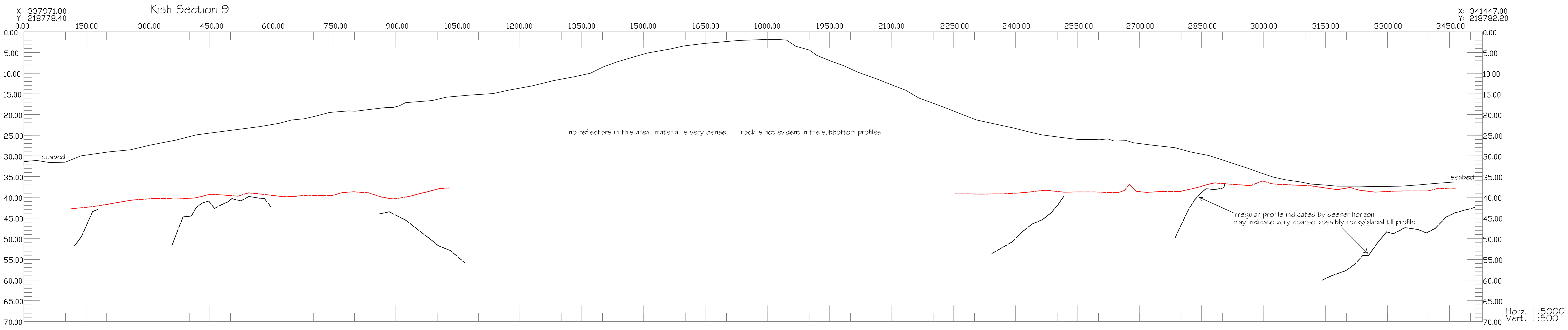


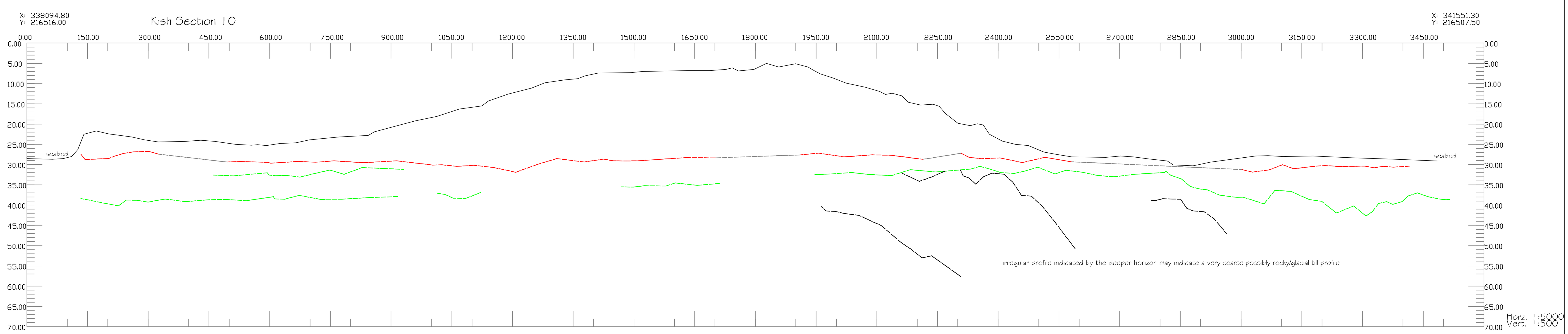



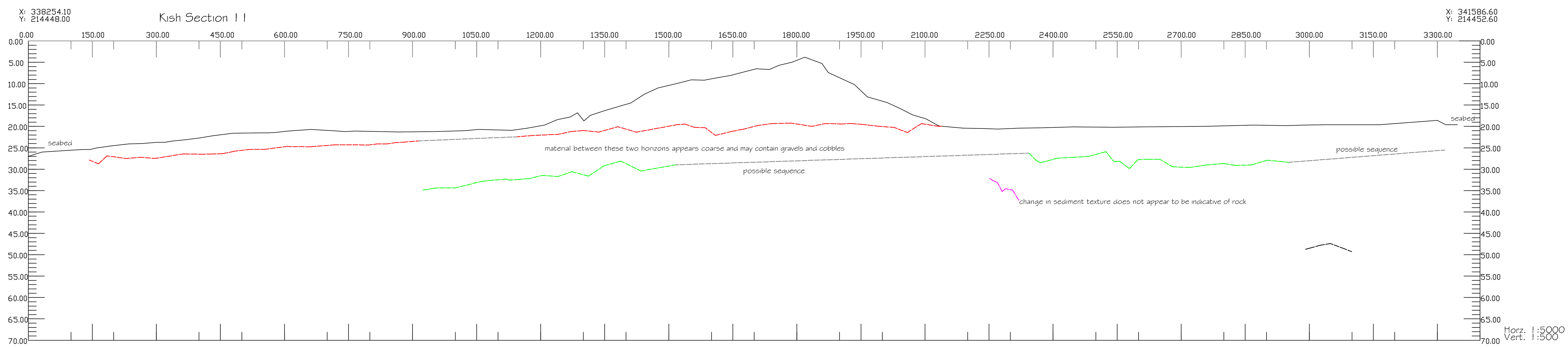


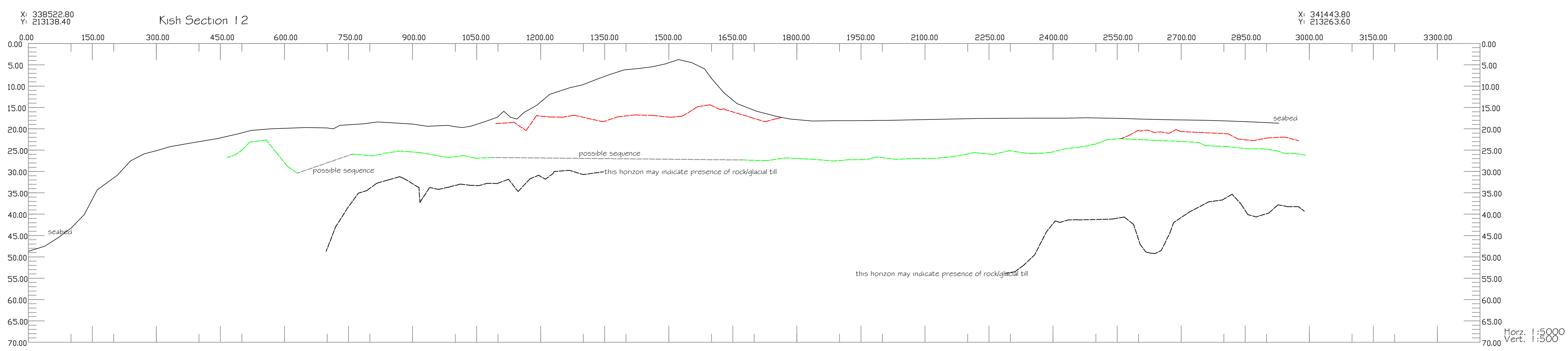



Site: Proposed Turbine Locations
Kish & Bray Banks
Location: East Coast of Ireland
Survey: Subbottom Cross Sections

Client
Saorgus Energy Ltd. Tralee, Co. Kerry.
Surveyed by
Hydrographic Surveys Ltd.
The Cobbles, Crosshaven, Co. Cork. Ireland.

Memoir
1. Constructed on Irish Grid.
2. Horizontal control by D.G.P.S.
3. All levels related to Chart Datum.

Key
Seabed in Chart Datum
Horizons indicating changes in sediment texture.
Horizons indicating changes in sediment texture.
Deeper horizon, may be indicative of presence of rock/glacial till.
Possible sequence
The horizons represented on each section are indicative of the thickness of material within the subsurface.

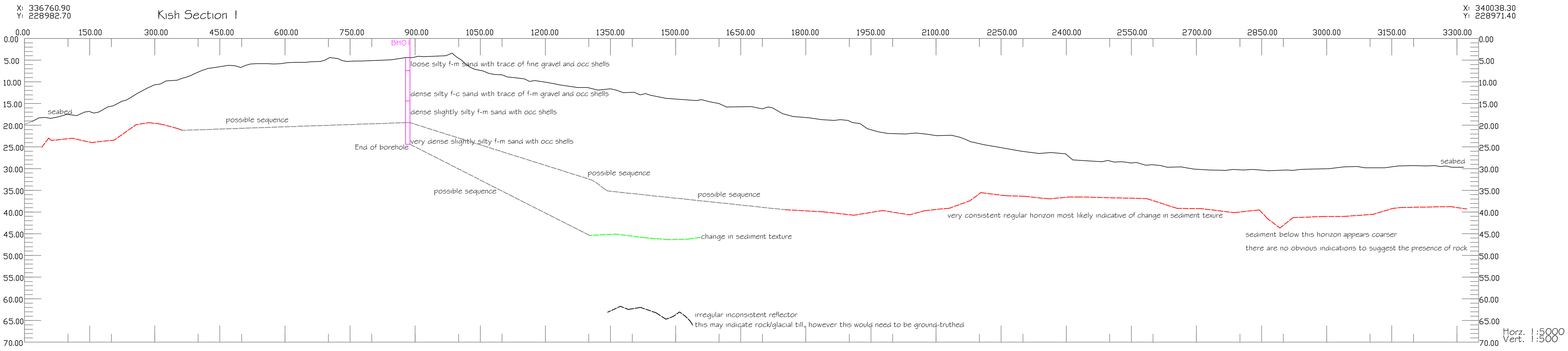
Note
The interpretations presented on the cross sections are based on characteristics displayed on the subbottom profiles,any available ground-truth information and on the authors experience.
The interpretations are subject to change pending further ground truthing.

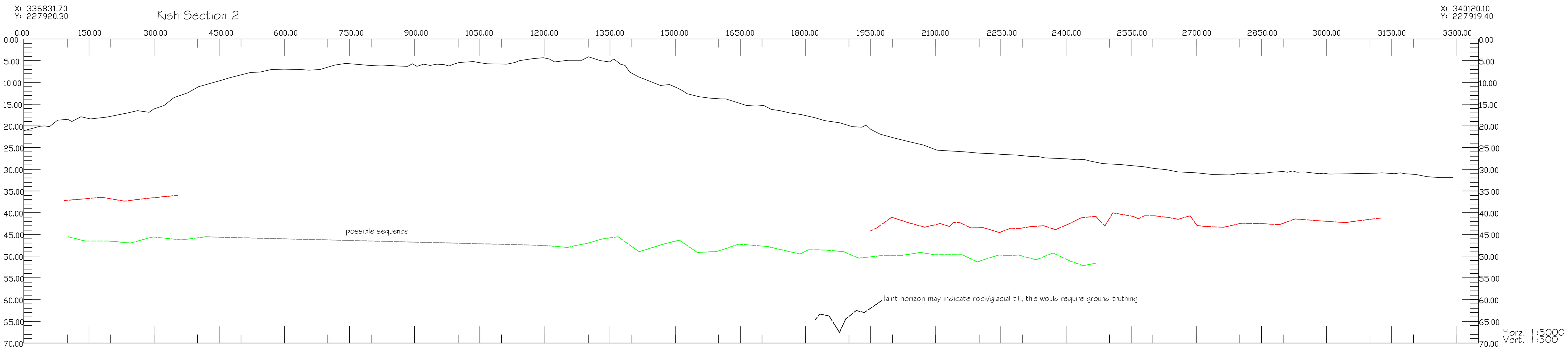
Drwg. No. HS59D-2/08
Project No. 18/08
Date June/Sept 08
Scale Horz. 1:5000
Vert. 1:500

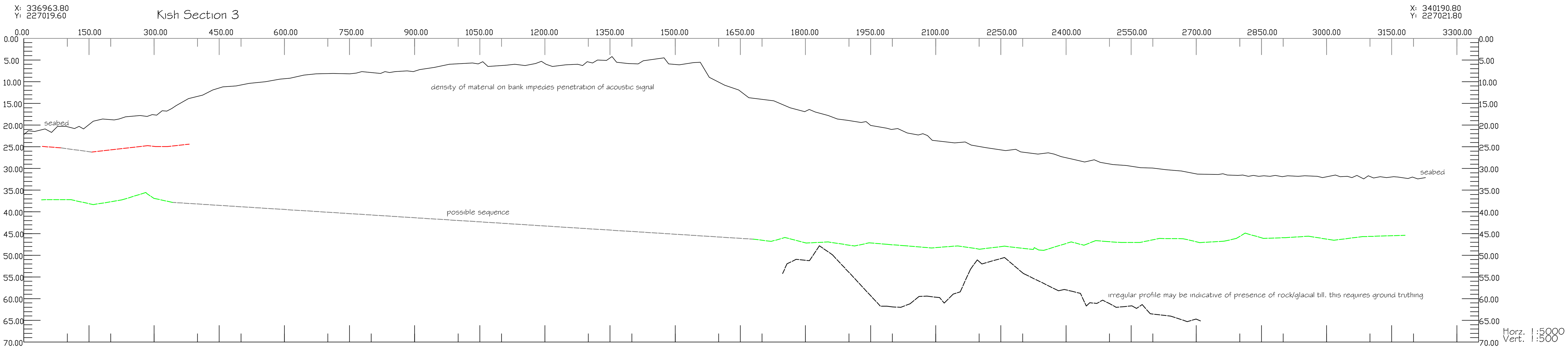
Sheet 2 of 2.

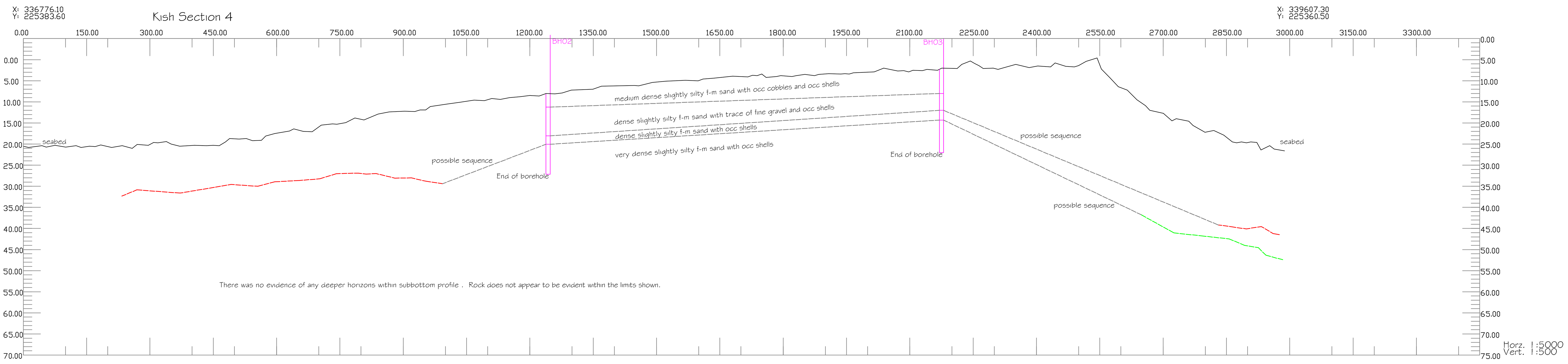
Drawn by G.C.
Checked by C.McC.
Approved by M.J.H.

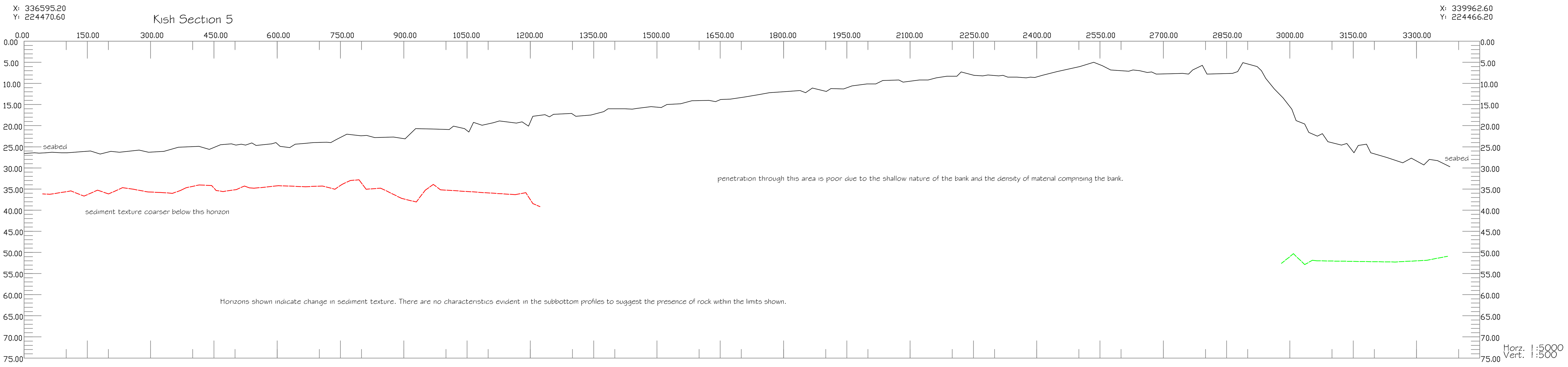
Tel. 00 353 21 4831184 e-mail info@hydrosurvey.com

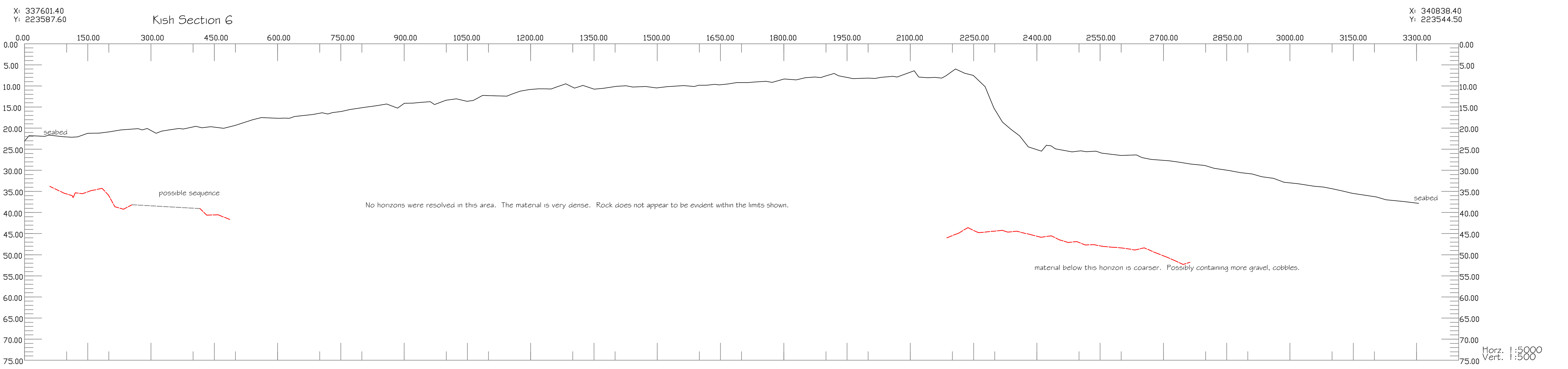



| | |
|---|---|
| Site | Proposed Turbine Locations |
| | Kish & Bray Banks |
| Location | East Coast of Ireland |
| Survey | Subbottom Cross Sections |

Client
Saorgus Energy Ltd. Tralee, Co. Kerry.
Surveyed by
Hydrographic Surveys Ltd.
The Cobbles, Crosshaven, Co. Cork. Ireland.

Memoir
1. Constructed on Irish Grid.
2. Horizontal control by D.G.P.S.
3. All levels related to Chart Datum.

Key
- Seabed in Chart Datum
- Horizons indicating changes in sediment texture and density.
- Horizons indicating changes in sediment texture and density.
- Deeper horizon, may be indicative of presence of rock.
- Possible sequence

The horizons represented on each section are indicative of the thickness of material within the subsurface.

Note
The interpretations presented on the cross sections are based on characteristics displayed on the subbottom profiles,any available ground-truth information and on the authors experience.
The interpretations are subject to change pending further ground truthing.

Revisions
1. 19/12/08 borehole data repositioned.

| | |
|---|---|
| Drwg. No. | HS59D-1/08 |
| Project | No. 18/08 |
| Date | June/Sept 08 |
| Scale | Horz. 1:5000<br>Vert. 1:500 |

Sheet 1 of 2.

| | |
|---|---|
| Drawn by | G.C. |
| Checked by | C.McC. |
| Approved by | M.J.H. |

Tel. 00 353 21 4831184 e-mail info@hydrosurvey.com