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Argyll and Bute Council

Iona & Fionnphort Marine Access Improvements

Feasibility Study

Report No. CM1052-MA-R1801

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Revision 01

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Contents

1 Introduction

1.1 Report Objectives

The objective of this report is to provide a feasibility study of proposed coastal protection structures in the Sound of Iona on behalf of Argyll and Bute Council, and to report on the outcome of the studies required by the project scope.

1.2 Design Team

The design team comprised the following:

- Adam Cronin, Director;
- Shane McCarthy, Associate;
- Paul Murphy, Project Engineer;
- Steven Gregan, Coastal Modelling Team Lead;
- Elsa Simoes, Senior Engineer [Part];
- McLaughlin & Harvey Contractors.

1.3 Project Scope

The project scope is defined as follows:

1.3.1 *Provide a numerical wave modelling study to determine the wave height to enable the design of the structures at both the Iona and Fionnphort locations;*

1.3.2 *Provide a sedimentation analysis to determine the requirements of any future maintenance at both locations (commentary on the engineering properties of the sampled materials in relation to material volumes, dredging techniques and potential contamination);*

1.3.3 *Prepare specification and tender documentation for a geotechnical survey at both locations. (The client will invite tenders). Provide analysis of results;*

1.3.4 *Provide/comment on the feasibility of details submitted by The Sound of Iona Harbours Group being incorporated into the scheme;*

1.3.5 *Update cost estimates for both schemes from the results obtained from the above.*

1.4 Study Area

The study area comprises two separate locations in the Sound of Iona and is described further in Section 2.

1.5 Review of Existing Information

The following information was provided to ByrneLooby:

1.5.1 *Iona Slipway Repair Design Statement, George Leslie Ltd/Macleod Consulting;*

This document comprises a design statement for the 2015 repairs to the slipway at Iona. It is not relevant for the purposes of this report.

1.5.2 *The Future for the Sound of Iona Harbours, Sound of Iona Harbours Committee;*

This report was prepared by the Sound of Iona Harbours Committee to demonstrate the reasons why investment in landing and berthing facilities at Fionnphort and Iona is required. It identifies the risks of landing at Fionnphort, and particularly Iona for the Loch Buie ferry. It also highlights how the Loch Buie is the only vessel in the CalMac fleet requiring dinghy access. The report discusses the difficulties which CalMac have in accessing the ferry from the dinghy when sheltered in Bull Hole

1.5.3 *Iona/Fionnphort Overnight Berth Feasibility Study, Arch Henderson;*

Argyll and Bute Council appointed Arch Henderson to carry out a feasibility study for an overnight berth at either Iona or Fionnphort for the ferry. Arch Henderson presented 10 separate options for the development, which comprised cofferdam structures, sheet piled walls, suspended decks, and rock armour revetments/breakwaters. The report recommends that the most cost effective solution is a cofferdam option at either Iona or Fionnphort.

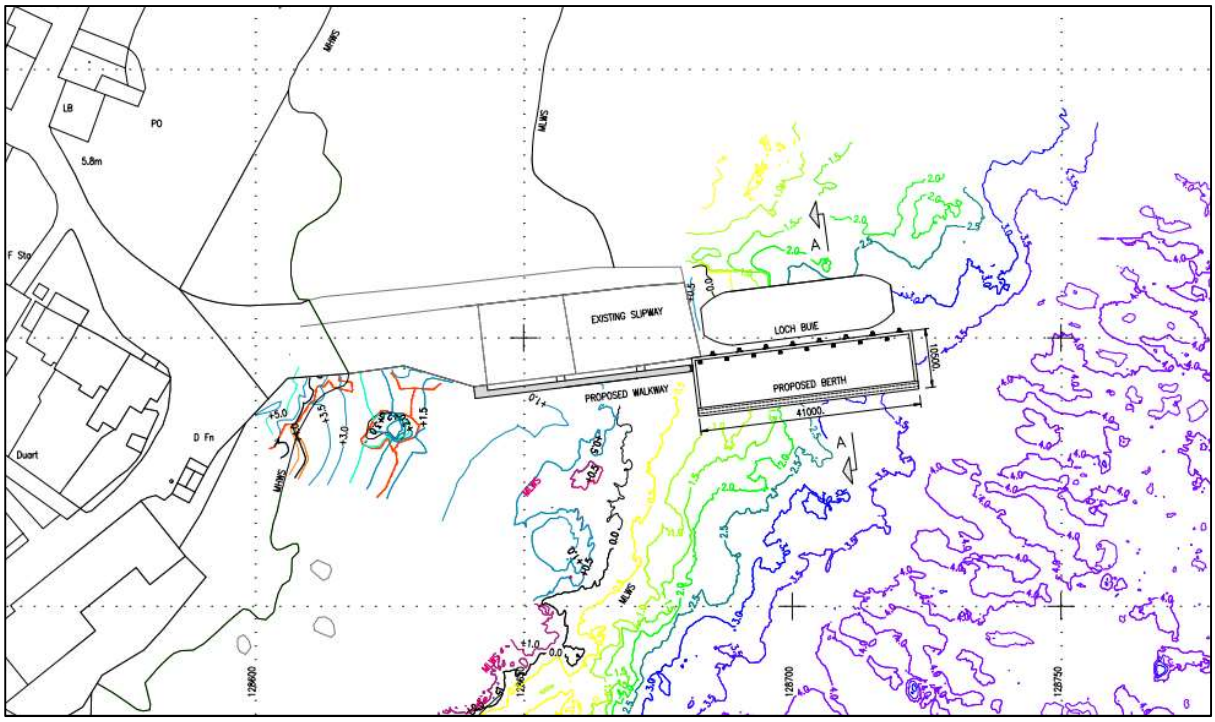


Figure 1-1 Feasibility Study Option 1 - Fionnphort (Arch Henderson)

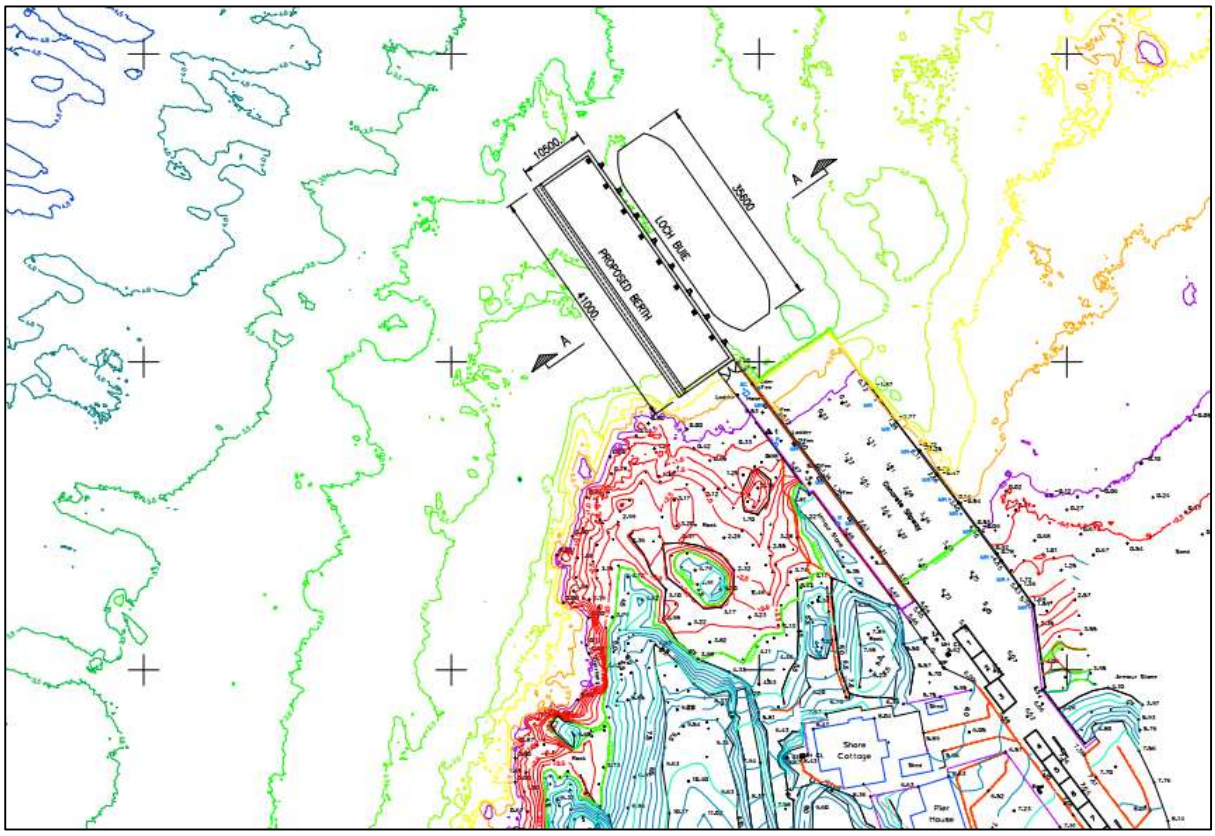


Figure 1-2 Feasibility Study Option 4 - Fionnphort (Arch Henderson)

In the opinion of ByrneLooby, neither of these layouts proposed provide sufficient protection for the overnight berthing of the ferry. The structure length does not provide adequate protection from the prevailing south to south westerly waves, and the overnight berths are fully exposed to the north.

1.5.4 *Piers and Harbours Group Meeting Minutes, South West Mull and Iona Development;*

The minutes of this meeting provide a commentary from the Piers and Harbours Group in relation to the Arch Henderson Report (refer to Section 1.5.3). The comments in relation to the Arch Henderson Report were as follows:

[Iona]

*"**Option 1-3**: Over-night berthing on Iona. This is not considered a serious option and has been ruled out previously."*

[Fionnphort]

*"**Option 4**: This option is favoured by A&BC on the basis of cost. Ferry operators/skippers argue that this proposal will not enable the boat to berth at Fionnphort Pier in anything approaching storm conditions. There is insufficient*

protection for the Pier against the height of the swell and inadequate provision for absorbing wave energy.

***Option 5**: This option is in the wrong place. It is too far south so it is not able to act as a breakwater and access is difficult. The position makes no sense.*

***Options 6 & 7**: The shape and design of these options could work if the structure were to be moved north. It could then act as a breakwater for Fionnphort pier. The shape could break the swell and could also give overnight berthing for other vessels."*

The Group did not discuss Options 8,9,10.

The general opinion was that further consultation with local groups is required as the project progresses, and that modelling of proposed structures should be used to determine wave parameters and therefore optimal protection layouts.

1.5.5 *Sound of Iona Harbours Project Brief;*

The Sound of Iona Harbour Project Brief was prepared by the Sound of Iona Harbours Group which is a subcommittee of South West Mull and Iona Development. This report discusses the current problems with infrastructure at Iona and Fionnphort and advises the primary objectives as:

- *"Protection to the exposed landing slip at Iona such that the Cal-Mac Ferry can safely and consistently expect to be able to berth without fear of service disruption, significant passenger discomfort, or threat to safety of passenger and vehicular traffic in anything other than extreme weather.*
- *An overnight berthing facility for the Cal-Mac ferry which is walk on accessible for the crew, safe to work and secure for the vessel in all conditions, and which by its construction creates protection for the exposed landing slip at Fionnphort and enables additional alongside berthing to be created at the underdeveloped and overused existing facility."*

The report also suggests design criteria:

"Better definition of the height of the proposed structures, before the brief is submitted to consultants, should be included. References should include the previous JONSWAP wave data produced by Arch Henderson and any previous proposals for a breakwater on Iona.

1. *A return period of 1 year (1m) could be applied to Iona, where overnight berthing is not required, making the breakwater height 1.2 m. above MHWS*
2. *A return period of 10 years (1.4m.) on the Fionnphort North breakwater, so define this 1.5m. above MHWS*

3. *A return period of 200 years (1.7m.) South of Fionnphort will require a breakwater at least 2.5m above MHWS. Arch Henderson have defined this height as 10.5m above Chart datum, which is 6m above MHWS. It may be possible to reduce this height if the 2.5:1 slope is reduced but costs incurred by the quantity of rock armour should be considered."*

1.5.6 *Wave Energy Breakwater Proposal for the Sound of Iona;*

A brief proposal was prepared by The Sound of Iona Harbour Committee for the potential inclusion or allowance for a wave energy generation device as part of any proposed breakwater structures. Reference was made to a large wave energy scheme at Mutriku in the Basque region of Spain.

An outline sketch of a basic vertical wave energy device constructed within a solid concrete breakwater structure was also provided.

A number of work elements within the proposal, such as, funding options, are outside the scope of this feasibility study.

1.5.7 *Bathymetric and Topographic Surveys*

Bathymetric and topographic surveys were carried out by Aspect Land and Hydrographic Surveys in May 2015. This information was used to determine the existing deck levels.

Updated bathymetric surveys were undertaken by Aspect Land and Hydrographic Surveys in 2017 and was used as the basis for bed levels in this report.

1.5.8 *Sound of Iona Masterplan, Sinclair Knight Merz*

The Sound of Iona Masterplan was prepared by Sinclair Knight Merz in 2013. The objectives of the masterplan were split into five principles:

- *"Creating safer landing facilities for tourists, fishermen and Cal Mac staff who currently require to use jetties at either side (which provide only the most primitive forms of landing and no berthing facilities)*
- *developing the marine heritage of the Sound in order to support higher forms of tourism activity*
- *improving the local economy by providing a wider range of facilities which build on the existing maritime activities*
- *increasing the attractiveness of the pier areas for visitors and local users*
- *contributing towards the longer term growth in population within the settlements"*

The following concept development projects were identified as part of the Masterplan:

- Fionnphort
    - Development of north and/or south breakwaters;
    - Extend the existing mole;
    - Development of a Visitor Reception Facility Ticket/ Toilet / Viewing Deck / Shops.
    - Design and Build Queue shelter and segregated queuing area at to facilitate passenger management;
    - Provide new carparking;
    - Provide a new fishermen's slipway and laydown area.
- Iona
    - Construct a new breakwater;
    - Repairs to existing slipway;
    - Extension or re-configuration to main pier at Iona, providing a mole wall as part of southern side buttress to the pier;
    - Design and Build a passenger shelter and segregated queuing area to facilitate passenger management;
    - Provide new and improved pier-side services (toilets, showers etc).

2 Existing Sites

The sites are located on the Inner Hebrides on the west coast of Scotland.

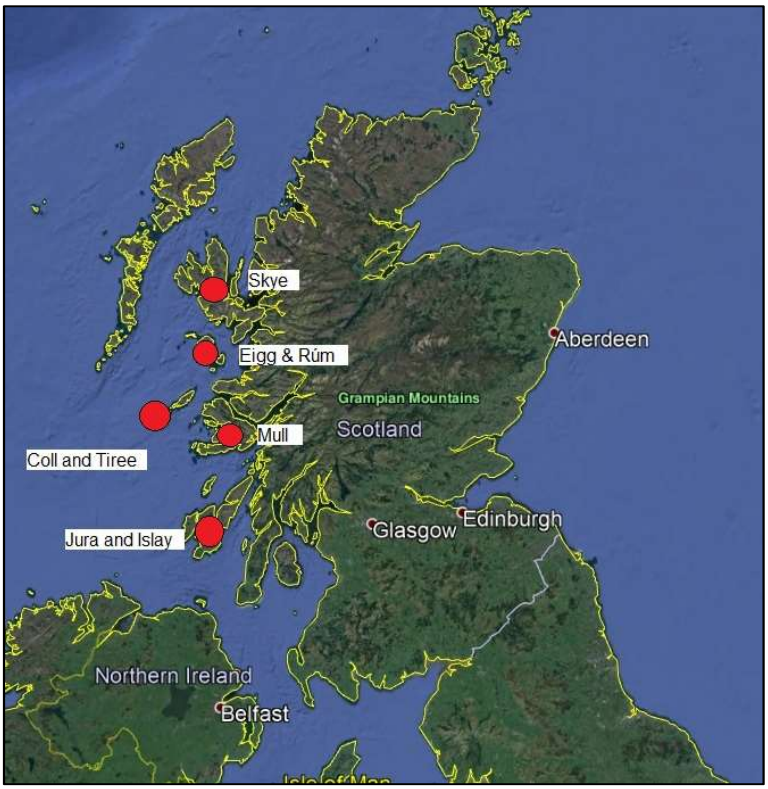


Figure 2-1 Location of Inner Hebrides *Source: Google Maps*

Figure 2-2 Isle of Mull Source: Google Maps

Figure 2-3 Sound of Iona Source: Google Maps

2.1 Fionnphort

2.1.1 Site Location

Fionnphort is a small village located on the South West corner of the Isle of Mull. It is located approximately 35 miles west of Craignure, which is the main ferry port on the Isle of Mull. Ferries operate between Oban, on the mainland, and Craignure on a daily basis. Fionnphort is normally accessed via car from Craignure on a single lane road.

The site of the proposed development is located on the foreshore adjacent to Fionnphort village.

2.1.2 Site Description

The existing site comprises the following elements:

- 55m long x 4m wide concrete quay wall;
- 16m wide reinforced concrete slipway;
- Sandy beach with rocky outcrops;
- Swing mooring field.

The site lies on the eastern edge of the Sound of Iona and is exposed to northerly and southerly swell waves, and locally generated westerly waves.

2.1.3 Existing Facilities

The following facilities are provided at the site:

- Reinforced concrete slipway;
- Reinforced concrete quay wall;
- Public parking spaces;
- Ferry queuing car spaces;
- Pier Equipment:
    - Fenders;
    - Mooring rings;
    - Handrails;
    - Lamp standards;
    - Mooring bollards;
    - Life rings;
    - Toe rails;
    - Water supply;
    - Access ladders;

The facilities are used primarily by the Caledonian MacBrayne ferry services between Fionnphort and Iona, but is also used by local fisherman, tour operators and local boat owners.

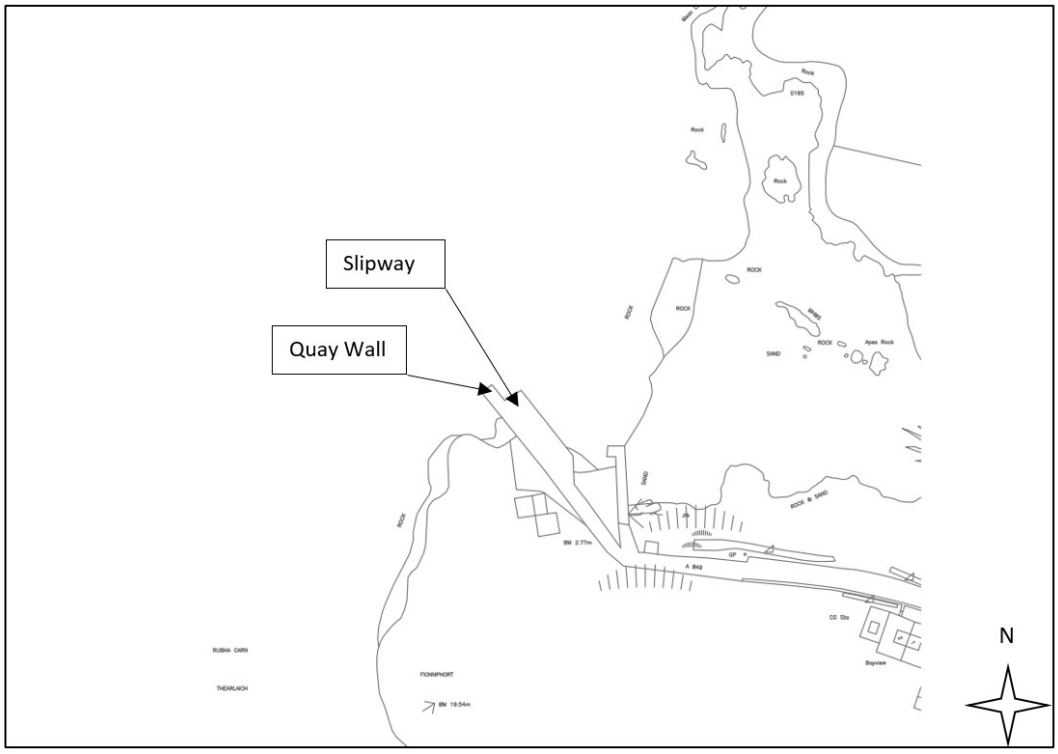


Figure 2-4 Fionnphort Existing Layout

Figure 2-5 Fionnphort Pier and Slipway

2.2 Iona

2.2.1 Site Location

Iona is a small island located west of the Isle of Mull. The location of the proposed development is at Baile Mór, which is the most populated area on the island. The island is a popular destination due to Iona Abbey which is located adjacent to Baile Mór.

2.2.2 Site Description

The site comprises a higher level and lower level slipway. The higher level slipway is approximately 15m wide, with the lower level slipway being approximately 4.5m wide, though these dimensions vary. The length of the entire structure is approximately 90m above and below mean low water.

The higher level slipway is predominantly used by the Caledonian MacBrayne ferry service and the lower level slipway is predominantly used by local boat operators, fishermen and the marine leisure industry.

2.2.3 Existing Facilities

The following facilities are provided at the site:

- Reinforced concrete higher level slipway;
- Reinforced concrete lower level slipway;
- Ferry queuing car spaces;
- Slipway Equipment:
    - Mooring rings;
    - Lamp standards;
    - Mooring bollards;
    - Life rings;
    - Information board;
    - Handrails;
    - Access ladder to foreshore;

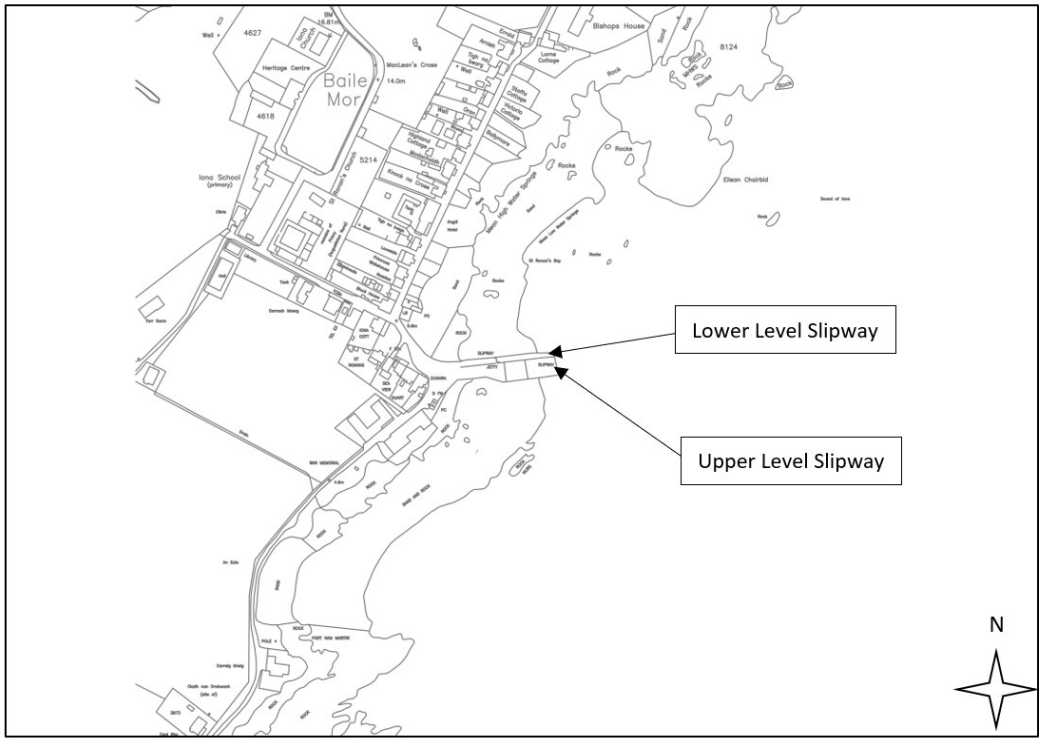


Figure 2-6 Iona - Existing Layout

Figure 2-7 Lower and Higher Level Slipway Iona

2.3 Operators and Vessels

The following parties operate between Fionnphort and Iona:

- Caledonian MacBrayne;

- Crab/fishing vessel operators;
- Leisure boat operators;
- Private boat owners;

Caledonian MacBrayne operate the MV Loch Buie between Fionnphort and Iona. This is a 30m long vessel with a draught of 1.6m. It is likely that they will increase the size of the ferry to a 43.5m long vessel (MV Lochinvar) which will have a draft of 1.73m. A typical daily track plot of the MV Loch Buie is indicated in Figure 2-8 and has been used as the basis of the assumption of the existing navigation channel.

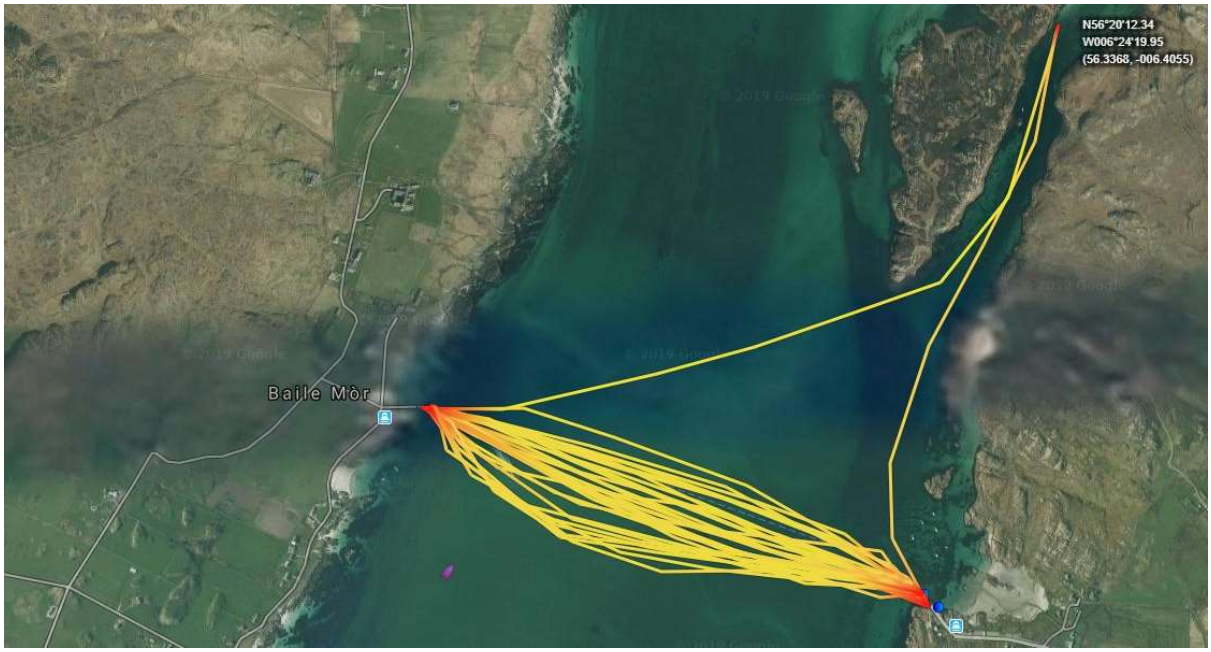


Figure 2-8 Loch Buie Track Plot (30th July 2019) Source: www.marinetraffic.com

2.4 Problems with the Sites

Based on a literary review, consultation with local stakeholders and site visits carried out by ByrneLooby staff, the following sub-sections identify the constraints, risks and difficulties associated at each site.

2.4.1 Fionnphort

- No overnight berthing available. Ferry operators are required to berth the vessel at Bull Hole, which requires access via dinghy at the start and end of operations each day. There are safety risks associated with accessing the ferry via dinghy, particularly during winter months.
- Limited protection from southerly and westerly wave action. This reduces the time available for safe landing of the ferry vessel at the pier. It can also result in excessive

movement of the vessel at the berth, making landing and holding of the vessel in position difficult.

- Restricted berthing length at the existing pier causing the ferry to overhang.
- Pier congestion.
- Parking issues/ferry queuing.
- Conflict between mixed use of fishing and tourism industries.

2.4.2 Iona

- The slipway is very vulnerable to waves from north, east and south. This impacts upon all slipway users. The ferry holds its position at Iona using the weight of the ramp and the friction between the ramp and the slipway deck. The ferry is particularly vulnerable to waves at the slipway, resulting in the ramp of the ferry rising and falling from the deck of the slipway. This makes holding the ferry in position very difficult and is also a risk to foot passengers and vehicles.
- The lack of a berthing structure also makes the holding of the ferry in place difficult.
- Swell and waves affecting crossings
- Pier congestion.
- Conflict between mixed use of fishing and tourism industries.

2.5 Improvement Objectives

The primary objective of this feasibility study is to identify potential infrastructure improvements at both Fionnphort and Iona to address landing and berthing problems and risks identified in Section 2.4. Based on these objectives, concept layouts were prepared and are presented in Section 3. The recommended option for each site is then presented in Section 7.

3 Concept Layouts

Preliminary concepts as detailed in this section were developed to aid consultations with all stakeholders and Argyll and Bute Council. A number of these concept layouts were then advanced to the modelling stage in order to ascertain their suitability and performance.

3.1 Fionnphort

3.1.1 Fionnphort Layout 1

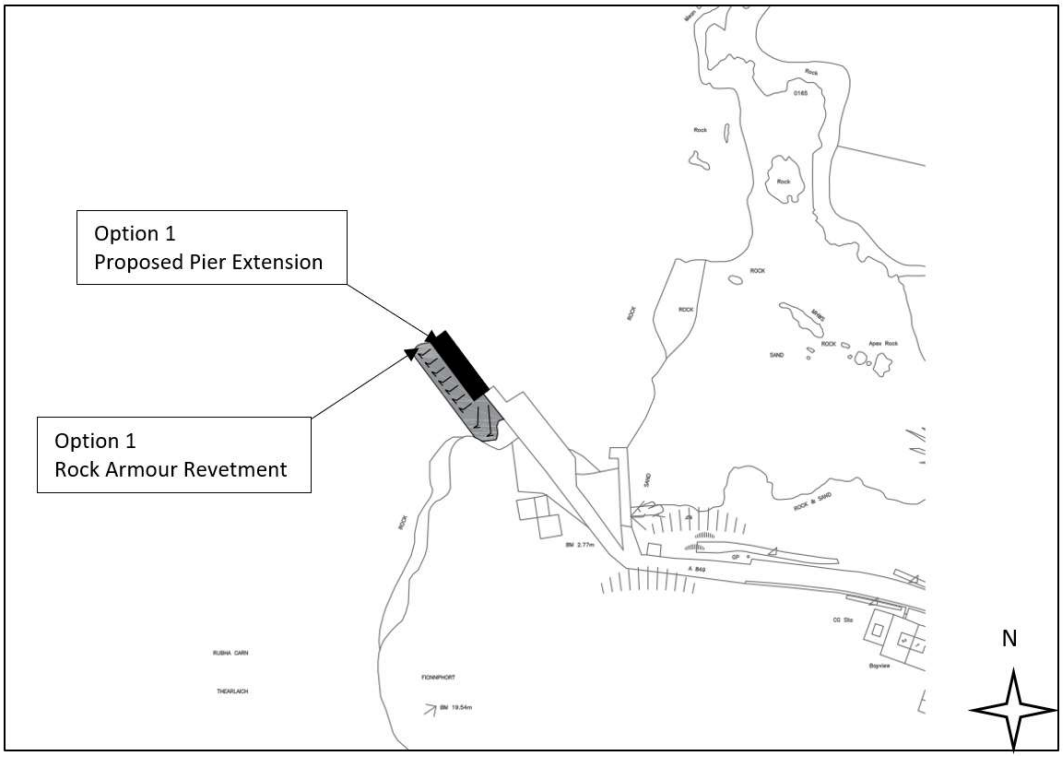


Figure 3-1 Fionnphort Layout 1

Fionnphort Layout 1 comprises a circa 40m extension to the existing pier at Fionnphort, and the development of a circa 70m rock armour revetment on the seaward side of the pier. The pier extension would provide a more secure berthing face and overnight berth, with the revetment reducing the impact of waves reflecting from the pier structure. This structure is similar in nature to the Arch Henderson Layout Option 4.

This layout provides an overnight berth for the existing Loch Buie vessel and also provides some wave protection. It is ByrneLooby's opinion that the berth remains vulnerable to direct waves from the south-west and west, and there is also a risk of waves refracting around the revetment. The limitations of this layout were also raised during the consultations with local stakeholders. A decision was therefore made by ByrneLooby not to carry out hydrodynamic modelling of this layout.

3.1.2 Fionnphort Layout 2

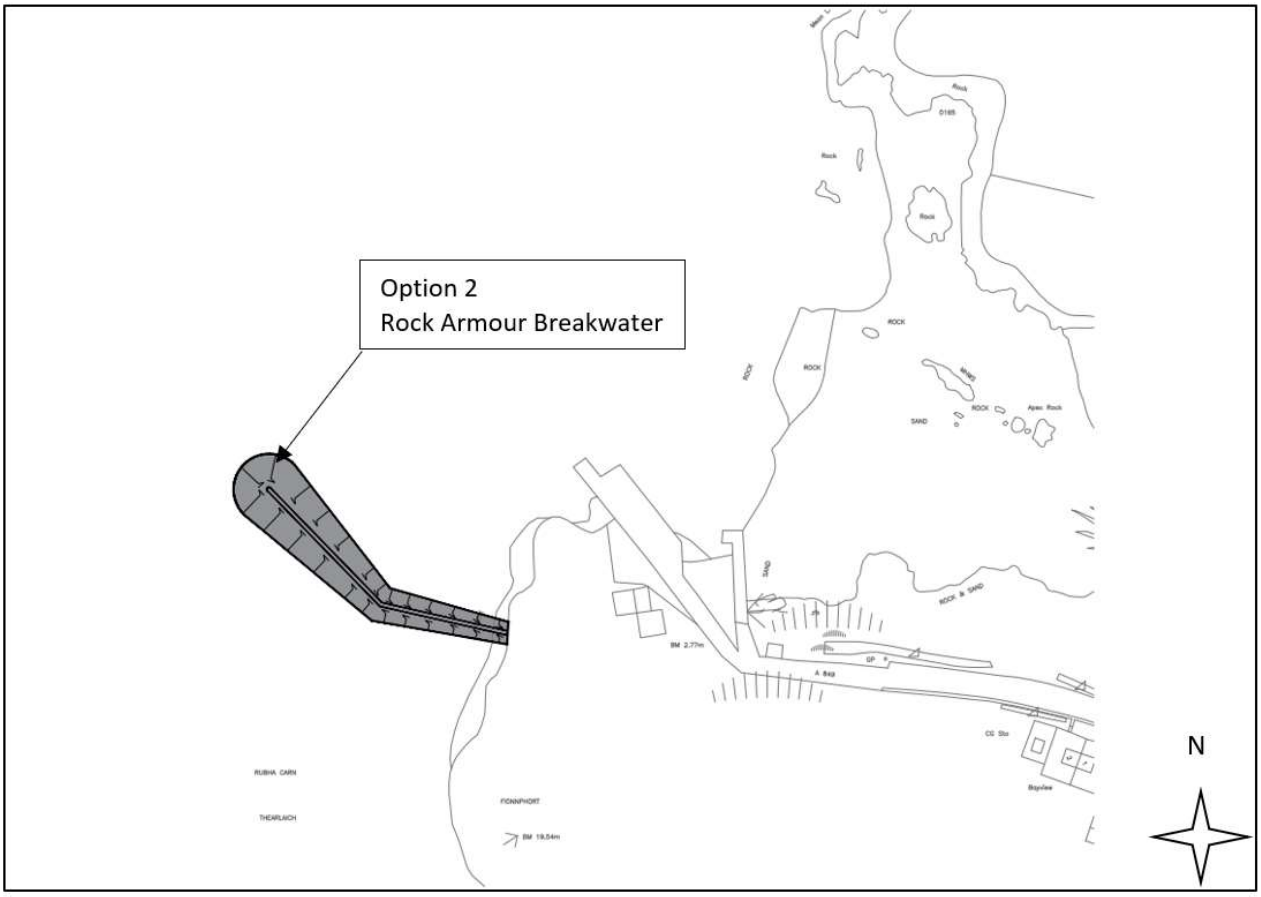


Figure 3-2 Fionnphort Layout 2

Fionnphort Layout 2 Comprises a Rock Armour Breakwater with a crest length of circa 140m. The breakwater is located approximately 125m south west of the existing slipway at Fionnphort. The function of the structure is primarily to provide defence from waves propagating from a southerly direction. It would be possible to provide an overnight berth in the lee of the breakwater.

This layout was deemed to be too remote from the existing pier and slipway and would not provide sufficient protection from the likely wave regime at the site. A decision was therefore made by ByrneLooby not to carry out hydrodynamic modelling of this layout.

3.1.3 Fionnphort Layout 3

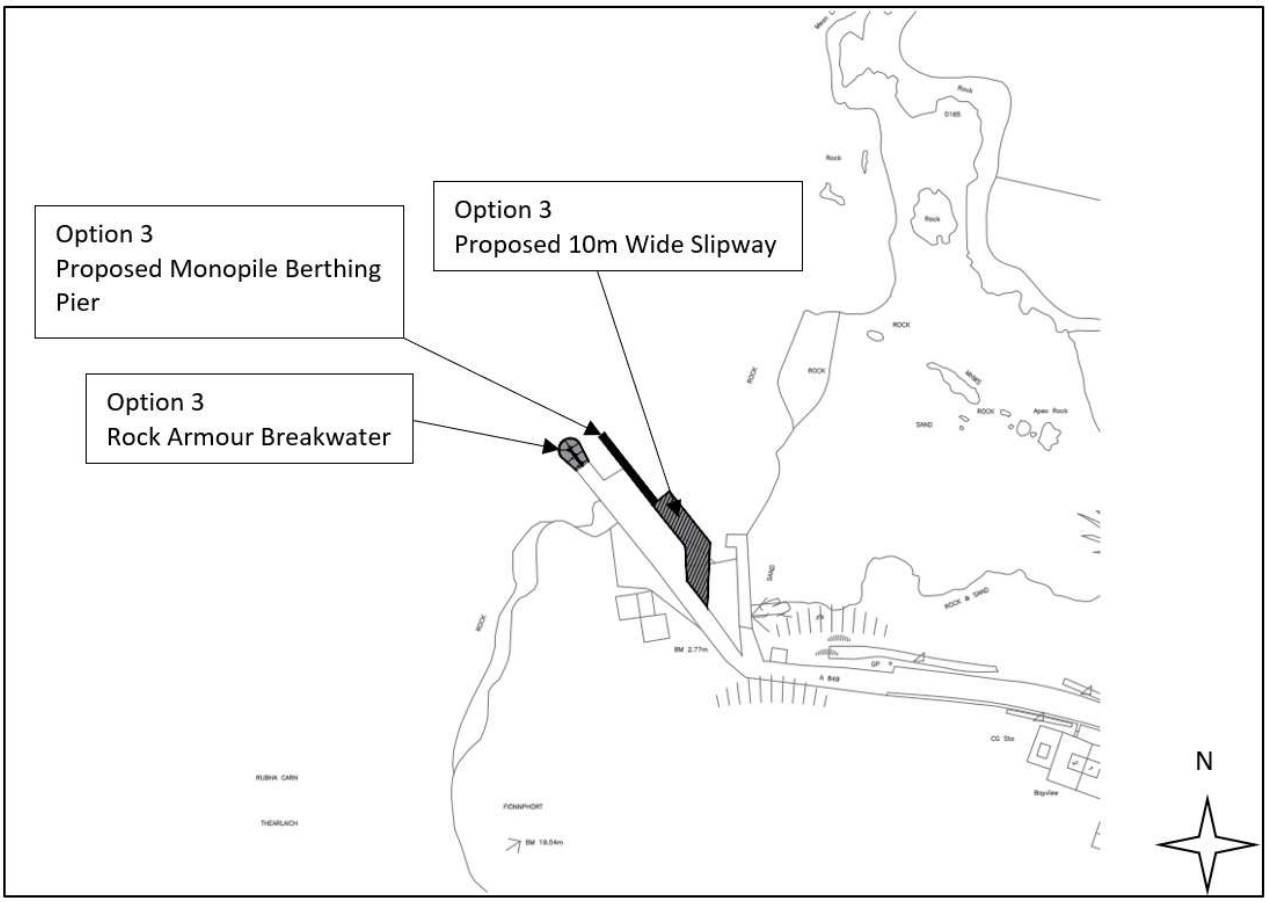


Figure 3-3 Fionnphort Layout 3

Fionnphort Layout 3 comprises a new breakwater which extends circa 10m in a north westerly direction from the head of the existing pier. A monopile berthing pier, 40m in length would be installed immediately north east of the existing slipway to facilitate the overnight berthing of the ferry. A new 10m wide reinforced concrete slipway, circa 62m in length, would be constructed to the east of the existing slipway. The new slipway would act as a dedicated slipway for ferry berthing, which would alleviate any conflicts of uses and congestion.

Again, this option does not provide adequate protection from the wave climate expected. A decision was therefore made by ByrneLooby not to carry out hydrodynamic modelling of this layout.

3.1.4 Fionnphort Layout 4

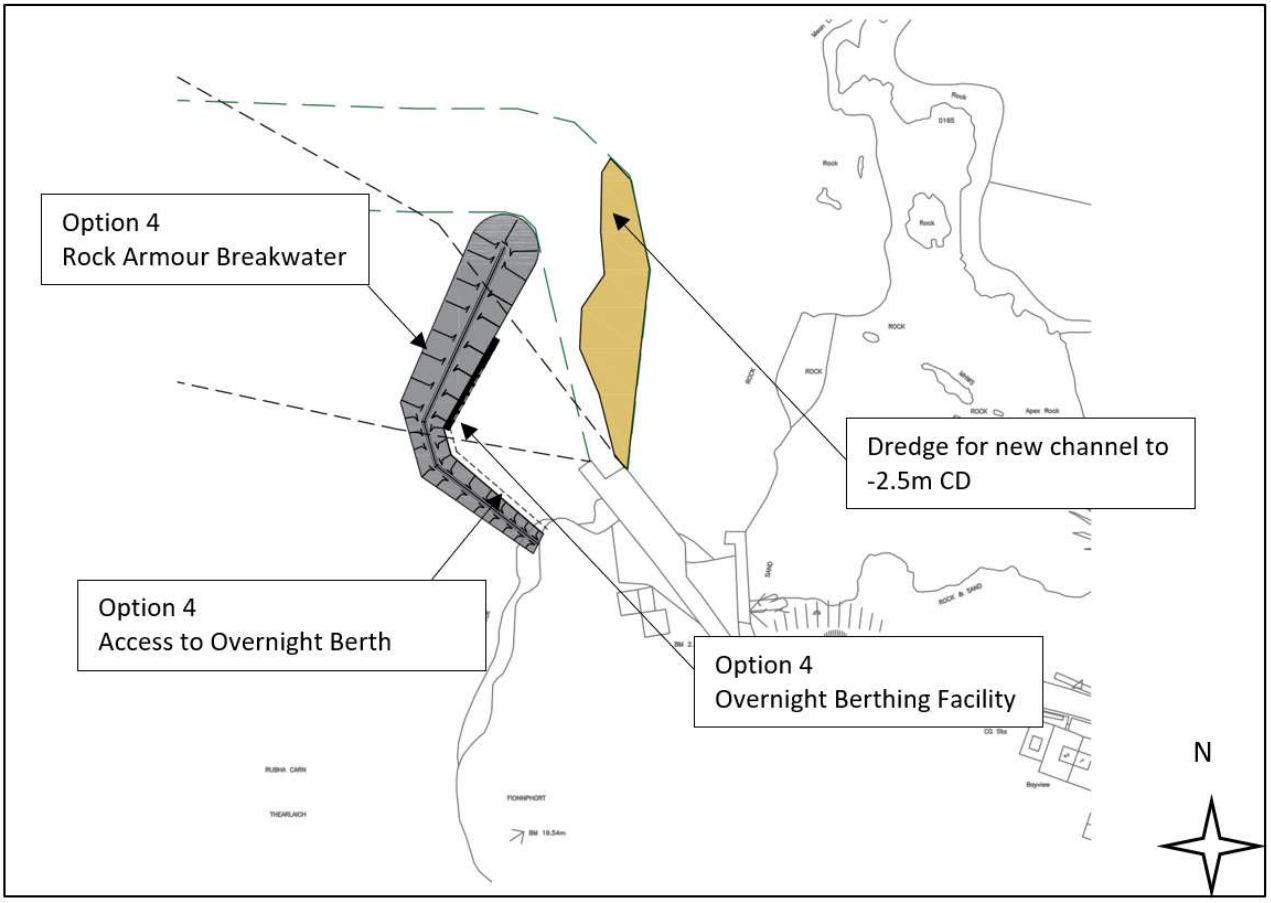


Figure 3-4 Fionnphort Layout 4

Fionnphort Layout 4 comprises a rock armour breakwater with an overall crest length of circa 175m. The breakwater comprises a rock armour structure with a proposed slope of 1 in 1.5. It extends in a north westerly direction from the existing rock outcrop, then turning north and north east over three legs. The function of the structure is primarily to provide defence from waves propagating from a southerly direction, however a high level of protection is also provided from westerly and northerly waves.

A 50m long overnight berthing structure is indicated in the lee of the outer arm of the breakwater. Access to this berth would be via a dedicated pedestrian (CalMac staff only) walkway running parallel to the lee of the breakwater, supported on an array of tubular piles.

This layout will require an alteration to the navigation channel to Fionnphort. The existing bed levels on the navigation channel vary between -5.0m CD to -2.5m CD. A new navigation channel will be required to the north and east of the proposed breakwater, extending to the slipway. Subject to detailed design, it is likely that the new navigation channel would encroach upon the -2.0m CD Contour. MV Loch Buie has a draught of 1.6m, and a potential larger vessel (MV Lochinvar) has a draught of 1.73m. At LAT, there is a risk of contact between the hull of the vessel and the seabed, so minor dredging works may be required.

ByrneLooby opine that the volume of dredge material may be in the order of 1,500m^3 and dredged to a maximum depth of 500mm (in order to achieve -2.5m CD). This material is likely to comprise coarse sand which should be re-used within the breakwater structure where possible.

3.1.5 Fionnphort Layout 5

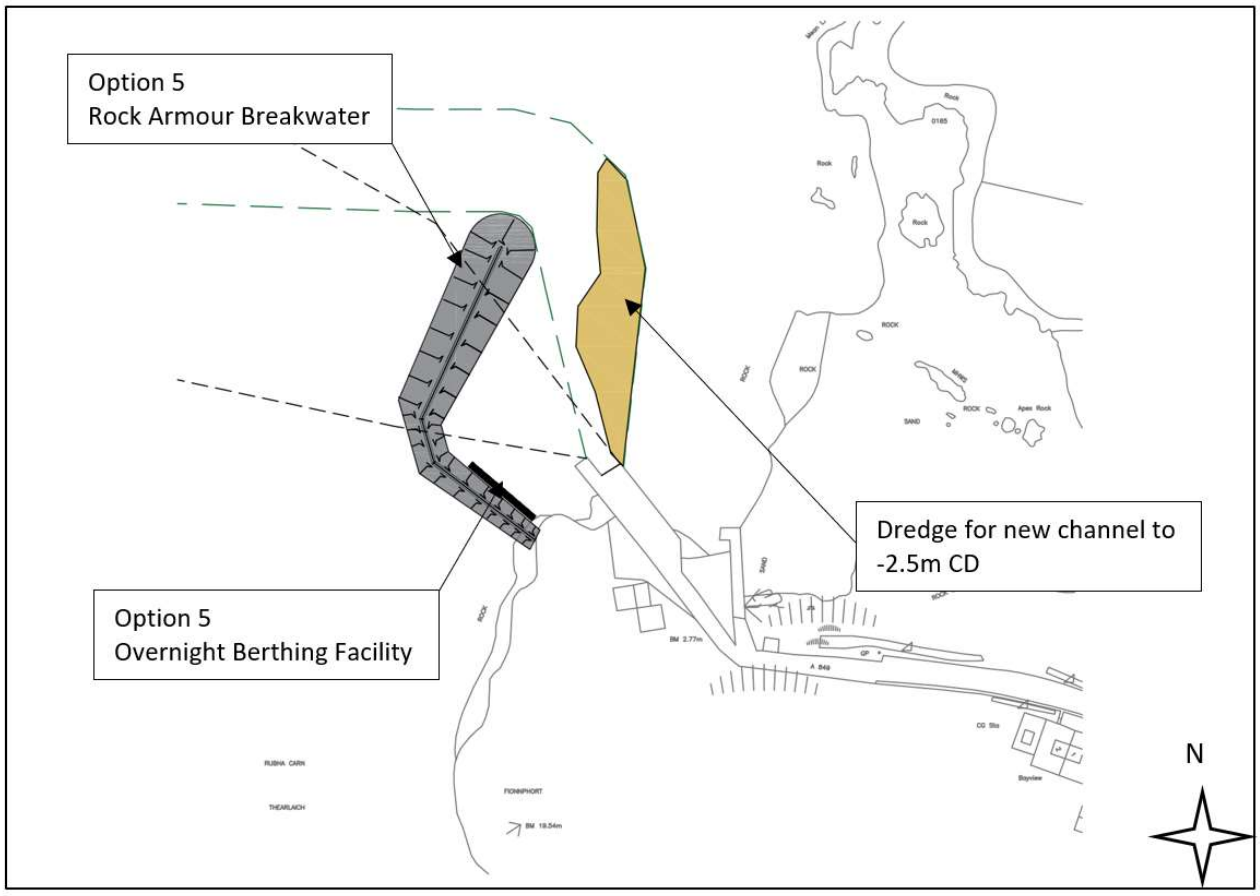


Figure 3-5 Fionnphort Layout 5

Fionnphort Layout 5 is a variation on Layout 4, the variation being that the overnight berth is directly connected to the existing rock outcrop in the lee of the first leg of the breakwater.

3.2 Iona

3.2.1 Iona Layout 1A

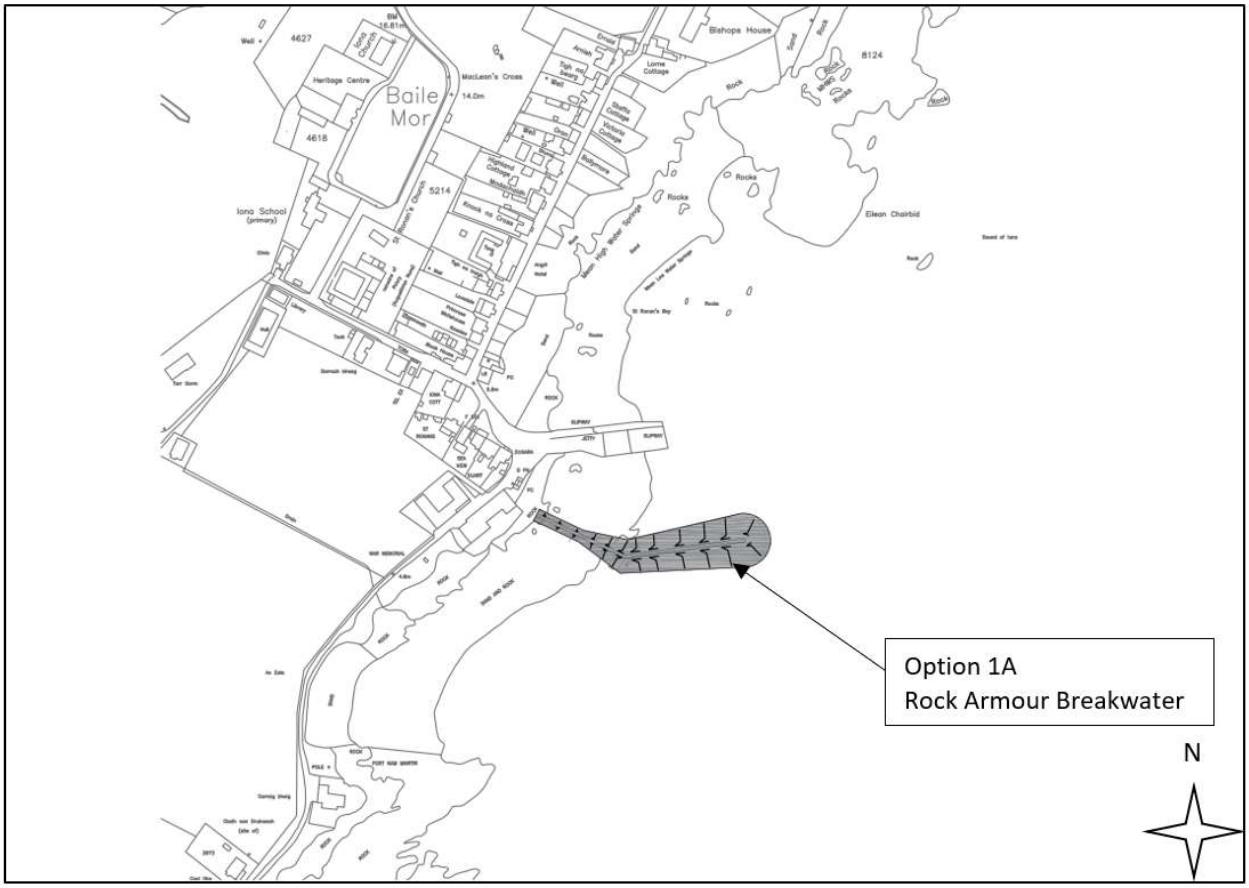


Figure 3-6 Iona Layout 1A

Option 1A comprises a breakwater development approximately 70m south of the existing slipway in Iona. The overall length of the breakwater crest is 140m. The breakwater comprises a rock armour structure with a proposed slope of 1 in 1.5. The function of the structure is primarily to provide defence from waves propagating from a southerly direction.

This layout has been subject of hydrodynamic modelling and is discussed in Section 6.3.4.

3.2.2 Iona Layout 1B

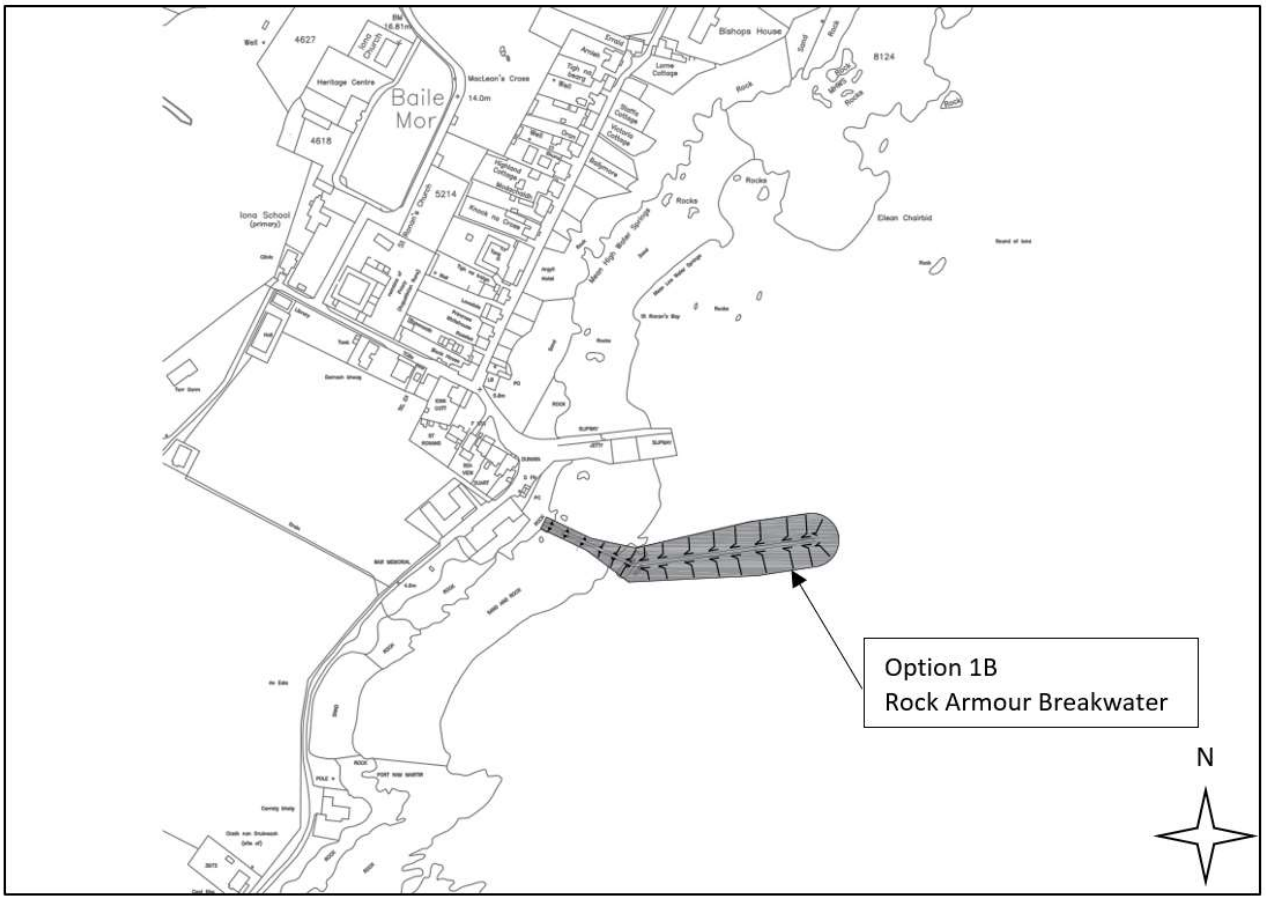


Figure 3-7 Iona Layout 1B

Option 1B comprises an extension of the Option 1A layout and has an overall crest length of 177m. It is located approximately 70m south of the existing slipway in Iona. The breakwater comprises a rock armour structure with a proposed slope of 1 in 1.5. The function of the structure is primarily to provide defence from waves propagating from a southerly direction but is anticipated to provide greater protection than Layout 1A and it also provides protection for future longer ferry vessels.

This layout has been the subject of hydrodynamic modelling and is discussed in Section 6.3.5.

The structure is likely to have a negative impact on the typical track of the ferry; however, it is understood that the vessel operator will alter their course in a more northerly trajectory when approaching the slipway.

3.2.3 Iona Layout 2A

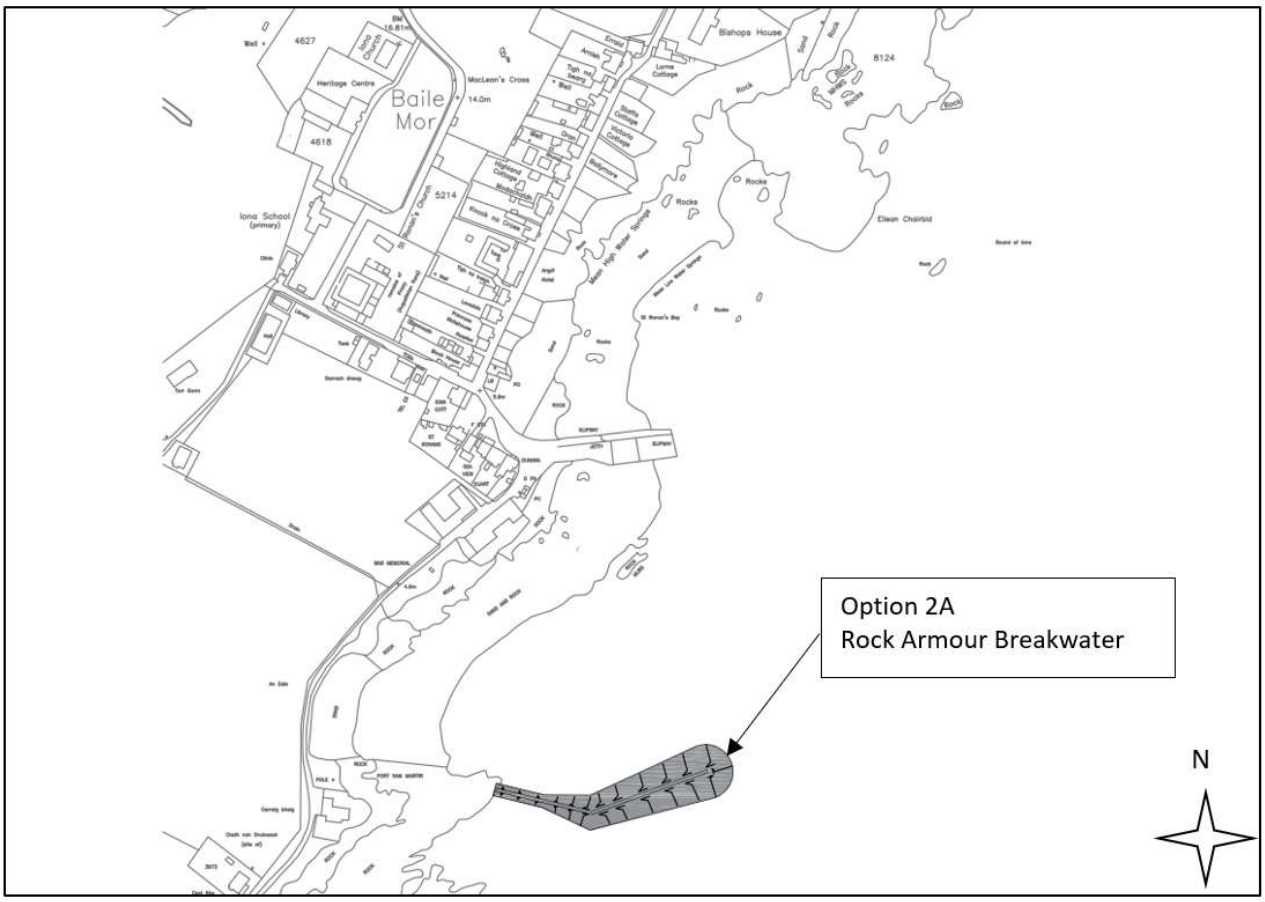


Figure 3-8 Iona Layout 2A

Layout 2A comprises a breakwater with an approximate crest length of 140m located approximately 210m south of the slipway at Iona. The breakwater comprises a rock armour structure with a proposed slope of 1 in 1.5. The function of the structure is primarily to provide defence from waves propagating from a southerly direction. It extends from an existing natural rock outcrop which provides some natural protection to the slipway and comprises two legs; leg 1 extends approximately west to east, and leg 2 extends in an east-north-east direction.

This layout has been the subject of hydrodynamic modelling and is discussed in Section 6.3.6.

3.2.4 Iona Layout 2B

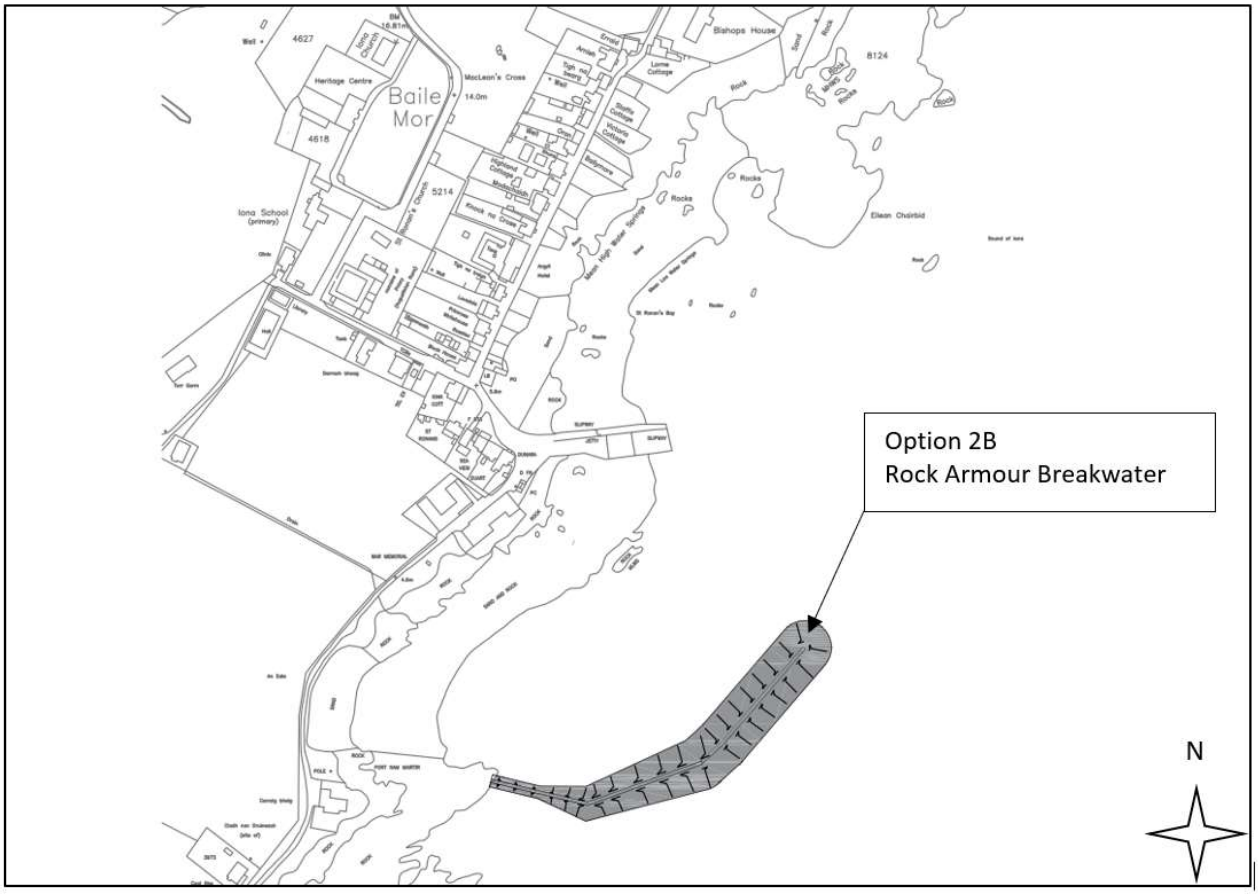


Figure 3-9 Iona Layout 2B

Option 2B comprises an extension of the Option 2A Layout and has an overall crest length of 235m. It comprises the first two legs of Option 2A Layout, with a third leg extending in a north-easterly direction. The breakwater comprises a rock armour structure with a proposed slope of 1 in 1.5. The function of the structure is primarily to provide defence from waves propagating from a southerly direction but anticipated to provide greater protection than Layout 2A.

This layout was not modelled as it was opined that there would be marginal wave reduction despite a considerably high capital development cost.

3.2.5 Iona Layout 3

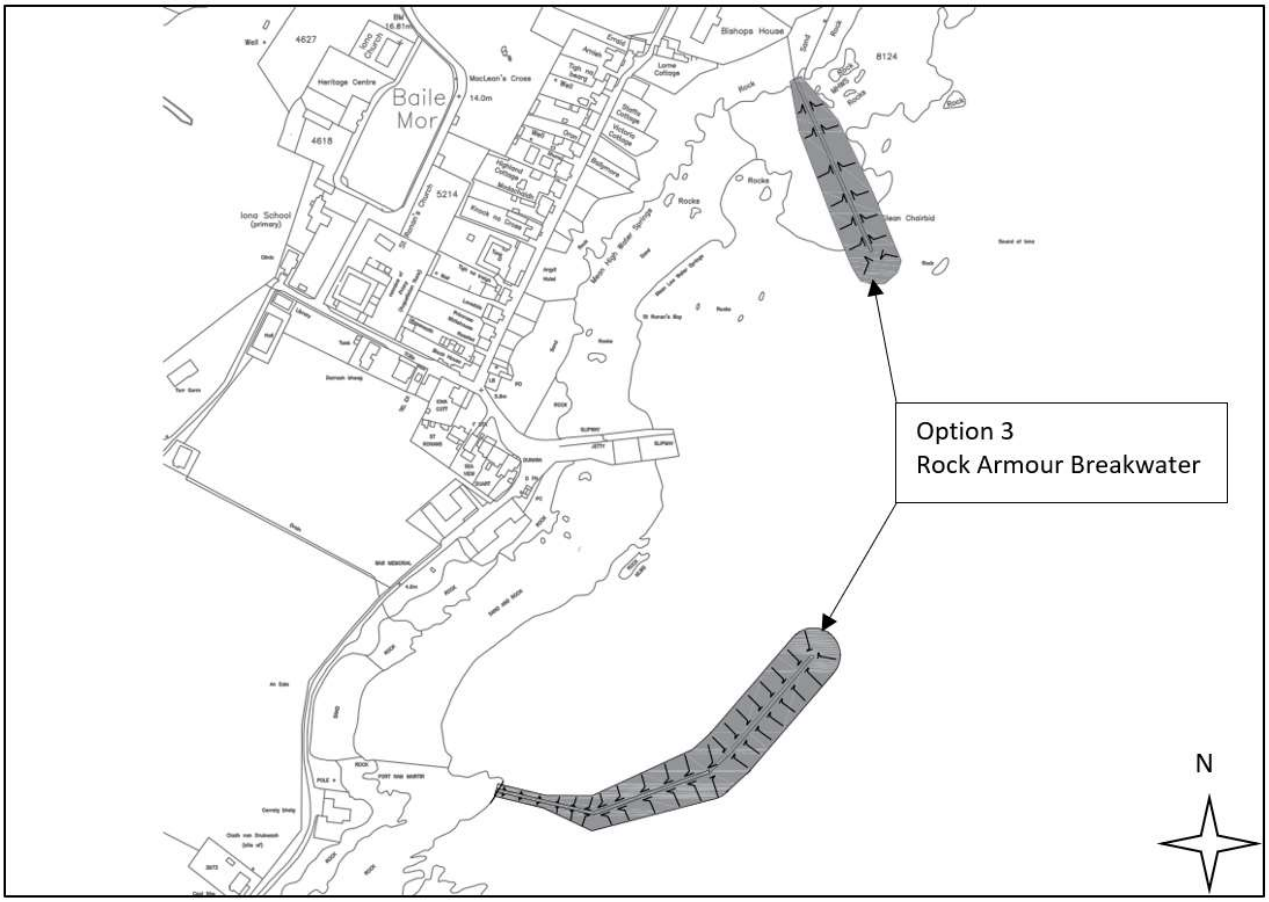


Figure 3-10 Iona Layout 3

Iona Layout Option 3 comprises the Option 2B layout to the south with an additional breakwater to the north. The purpose of the northern breakwater is to provide additional protection from waves incident from the north. The northern breakwater comprises a rock armour structure with a crest length of 118m. The southern end of the north breakwater is approximately 170m from the slipway.

This option was not modelled as it was opined that the capital development cost would be prohibitive, and there was strong local opposition to the development due to proximity to Iona Abbey.

4 Consultations

The Concept Layouts discussed in Section 3 were presented to members of the South West Mull and Iona Development group in August 2017. In general, the attendees were receptive to Iona Layouts 1A,1B,2A,2B. Discussions were held regarding a breakwater to the north (i.e. Iona Layout 3), however it was felt that the required length of this breakwater would be cost prohibitive. There was some support for the development of layouts 2A/B in order to develop a mooring bay between the breakwater and slipway. Though the development of layouts 2A/B would provide a more sheltered bay in front of the existing strand, it is outside the remit of this study.

The general consensus was that Fionnphort Layouts 1, 2 and 3 would not provide sufficient shelter to the existing and proposed infrastructure, so would not allow the development of an overnight berth.

Further consultation and public drop-in sessions were held at both Iona and Fionnphort in March 2019. ByrneLooby presented Fionnphort Option 5 and Iona Option 1A/1B. These were proffered by ByrneLooby as the most viable layouts for each site, taking into account wave attenuation performance, capital costs and potential environmental impacts.

Additional outputs/queries from these consultations included:

- Berthing piles requirement to the south of Iona slipway;
- Extension of berthing face at Fionnphort slipway to allow for larger vessels;
- Provision of a second overnight/emergency berth at Fionnphort;
- Clarification on height of proposed breakwater structures.

5 Surveys and Investigations

5.1 Licensing

Licenses are required for the carrying out of certain activities in Scottish Seas. The Marine Scotland Licensing Operations Team are responsible for the permitting of the activities under Part 4 of the Marine (Scotland) Act 2010.

On behalf of Argyll and Bute Council, ByrneLooby applied to Marine Scotland for a licence to carry out Ground Investigation works in the Sound of Iona. A licence was granted under Licence Number 06660/18/0.

The extraction of grab samples for sediment analysis were exempt from marine licensing.

5.2 Ground Investigation

Ground Investigation works were carried out by *Causeway Geotech* in August 2018. The works comprised marine boreholes, soil sampling, in-situ and laboratory testing, and marine geophysical surveying. It comprised 13 marine boreholes with rotary coring. The works were carried out via a modular jack-up barge, with the geophysical survey carried out using bathymetric and sub-bottom profilers. Laboratory testing was carried out offsite.

The ground investigation is summaries as follows:

- Marine sands and gravel deposits were encountered at all boreholes to a maximum depth of 5m;
- Stiff to very stiff sandy gravelly clay was encountered in varying thicknesses at three locations (two at Iona, one at Fionnphort);
- Bedrock underling the overburden material was found to be schist at Iona and felsic granite at Fionnphort.

The geotechnical interpretative report provided by *Causeway Geotech* indicates the suitability of gravity type rock armour breakwaters, and rock socketed pile solutions. They recommend the appointment of specialists for the detailed design stage of the development.

Some dredging of overburden may be required at Fionnphort to facilitate the new navigation channel. In order to be cost effective, this dredging should be limited to the overburden material which comprises sand, with clays and gravels at greater depths (Borehole 12). The sand may be reused in the core of the breakwater structure if the engineering properties suit the design. A backhoe dredger would be suitable for this application as it is the most basic dredging plant for the limited dredging required. It is suitable for working in discrete locations.

5.3 Sediment Sampling and Analysis

Sediment analysis works were carried out by *Projects 46* at the site in August 2017. 12No. 7kg samples were extracted from the foreshore by divers using hand tools. 6No. samples were extracted at Iona and 6 No. at Fionnphort. The results of the analysis are enclosed in Appendix A – Sediment Analysis Results.

Samples were analysed for their engineering properties and grading classification. All samples generally comprised sands, with some areas of gravels. The results of the grab sampling are consistent with the borehole site investigation.

Sand is a dynamic material and subject to sediment transport along the shoreline. The construction of new structures may impact upon the coastal regime and sediment transport patterns, resulting in areas of erosion and accretion.

6 Hydrodynamic Modelling

6.1 Introduction

In order to prove the performance of breakwater layouts for Iona and Fionnphort, ByrneLooby carried out hydrodynamic modelling. The initial modelling comprised Fionnphort Layout 4/5 and Iona Layout 1A/2A. By agreement with Argyll and Bute Council the existing layout at Iona, and an additional option 1B at Iona was modelled. This full report is found in Appendix D – Wave Modelling.

Danish Hydraulic Institute's (DHI) MIKE21 Spectral Wave (SW) Model has been utilised for the local wave modelling and subsequently to describe the wave climate at the project site. MIKE21 SW is a third-generation spectral phase-averaged wind-wave model for computing random, short- and long crested waves in coastal areas, lakes and estuaries from given wind, bottom and current conditions. MIKE21 SW is capable of simulating a range of wave physics such as wave generation by wind, shoaling, diffraction, refraction, wave dissipation due to white capping, bottom friction and depth induced breaking.

A local, high resolution model has been setup for the Sound of Iona covering the project locations at Iona and Fionnphort. The wave modelling has been conducted using DHI's MIKE21 SW (Flexible Mesh) (DHI, 2019).

The boundary conditions for the spectral wave modelling has been obtained from DHI's metocean portal based on DHI's MIKE21 Spectral Wave Model for Northern Europe (Regional Model). The regional wave model has been set up with the fully spectral, in-stationary formulation suitable for wave studies involving time-dependent wave events and rapidly-varying wind conditions in space and time and forced by CFSR wind fields. Detailed sensitivity studies of wind forcing, momentum transfer, white-capping, air-sea interaction, etc, has been conducted and the results were validated against a large number of in-situ observation across northern Europe as well as satellite altimeter data.

Long term wind and wave data covering 39 and 20 years respectively (boundary conditions for the local model), have been extracted at locations at the site.

A Peak Over Threshold method (with wind storms selected such that they do not occur within 72 hours of each other) was applied to the long term dataset to estimate the extreme offshore wind and wave data at the boundary of the local model. The extreme wind speeds and wave heights were estimated by fitting a three-parameter Weibull Probability Function to the data series.

Using the local wave models, the extreme wave conditions have been simulated and provide inputs for the wave penetration model.

6.2 Boundary Conditions

Three environmental forcing parameters have been included in the local wave modelling: winds, wave and water levels.

- Wave parameters from the DHI Metocean Database has been extracted at the local wave model boundaries based on the model domain.
- The extreme wind speeds for the various directional sectors were based on CFSR data sources for the region.
- The design water levels have been estimated based on the extreme water level analysis and sea level rise estimated over a period of 50 years (design life).

The 1 in 1, 1 in 50 and 1 in 100 year Annual Return Interval extreme wave conditions for the western, northern, eastern and southern directional sectors have been obtained by conducting an extreme analysis on the full wave climate and applied at the local model boundary.

6.3 Layouts and Cases

12 separate cases (variations of return period and wave directions) were modelled for both Iona and Fionnphort for the following layouts:

The following layouts were modelled:

- Existing Layout at Iona (Figure 2-6)
- Iona Layout 1A (Figure 3-6)
- Iona Layout 1B (Figure 3-7)
- Iona Layout 2A (Figure 3-8)
- Fionnphort Layout 4/5 (Figure 3-4/Figure 3-5)

Note, the wave rose shown on the figures indicate the input wave parameters. Waves incident on the structures travel perpendicular to the wave contours.

6.3.1 Existing Layout at Fionnphort (Figure 2-4)

The existing layout at Fionnphort is vulnerable to waves incident from all sectors. The topography of the area allows for a breakwater configuration which will provide a greater degree of protection however.

The model indicates that a 1 in 1 year significant wave height of 2.28m and, and a 1 in 50 year significant wave height of 2.67m is incident south of the proposed breakwater location (boundary condition). Some loss of energy is likely between this point and the existing pier

and slipway location; however, it is clear that these are unacceptable wave heights at a ferry landing location.

6.3.2 Fionnphort Layout 4/5 (Figure 3-4/Figure 3-5)

The proposed breakwater development in Fionnphort will result in a considerable reduction in wave heights at the slipway and proposed overnight berth.

For the prevailing wind conditions, the 1 in 1 year wave heights at the overnight berth will be reduced to 0.63m at the slipway (Case 6) and 0.34m at the overnight berth (Case 6). Refer to Figure 6-1.

Similarly, the 1 in 50 year wave height will be reduced to 0.79m at the slipway (Case 12) and 0.41m at the overnight berth (Case 12). Refer to Figure 6-2.

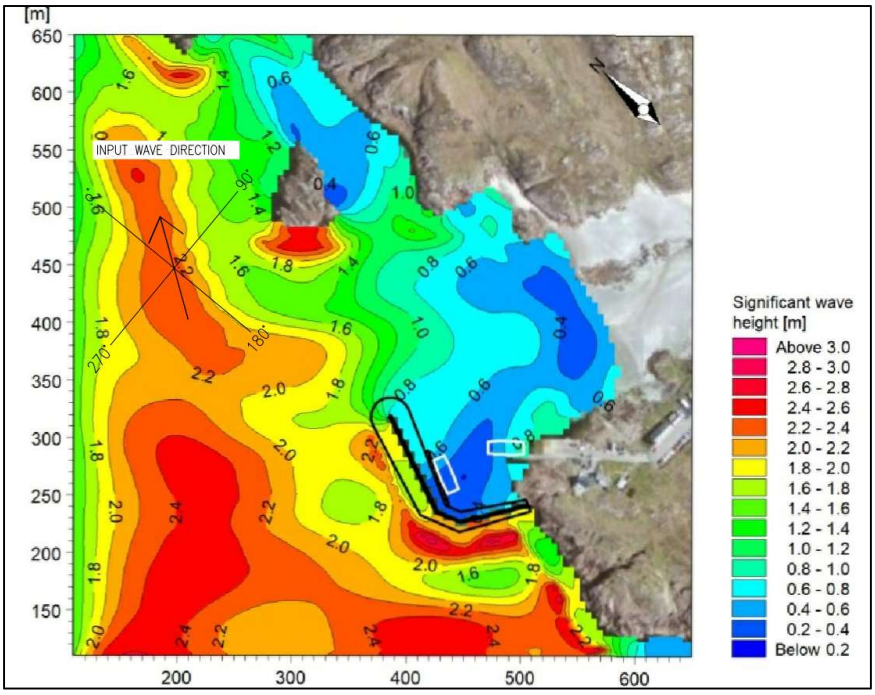


Figure 6-1 1 in 1 year South Westerly Wave Direction (Case 6)

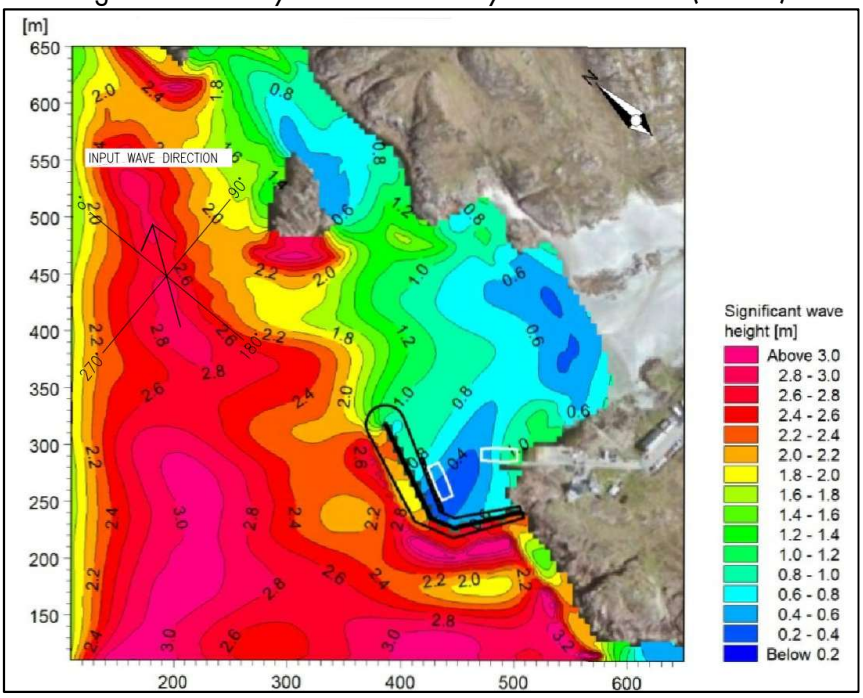


Figure 6-2 1 in 50 year South Westerly Wave Direction (Case 12)

6.3.3 Existing Layout at Iona (Figure 2-6)

The existing layout at Iona is vulnerable to waves incident from all sectors. It is acknowledged that protection to the slipway cannot be provided from all wave directions, so protection from prevailing waves (south/south westerly) is considered critical. The critical case determined in the modelling is south westerly generated waves. The model indicates that a 1 in 1 year significant wave height of 1.5m and, and a 1 in 50 year significant wave height of 1.69m is incident at the slipway. Refer to Figure 6-3 and Figure 6-4 respectively.

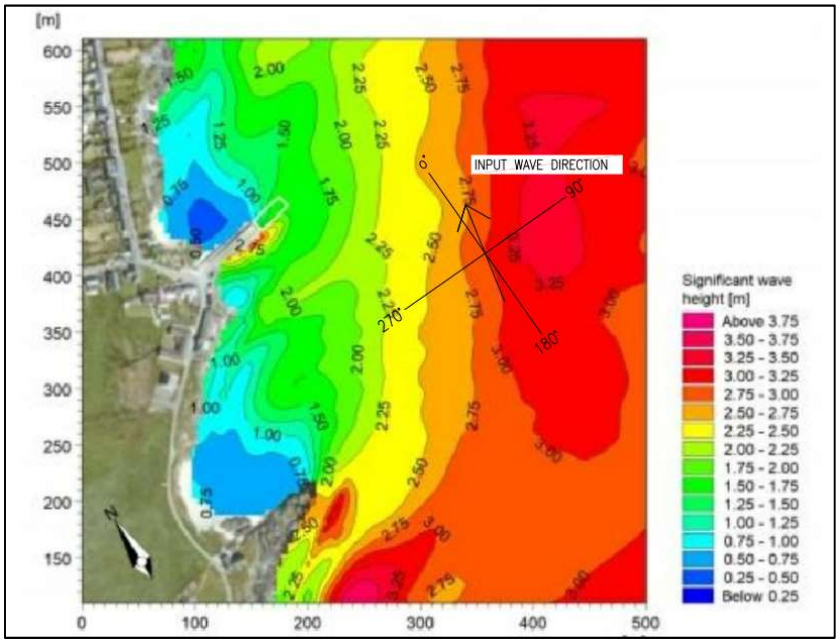


Figure 6-3 Iona Existing - 1 in 1 Year Southerly Wave Direction (Case 5)

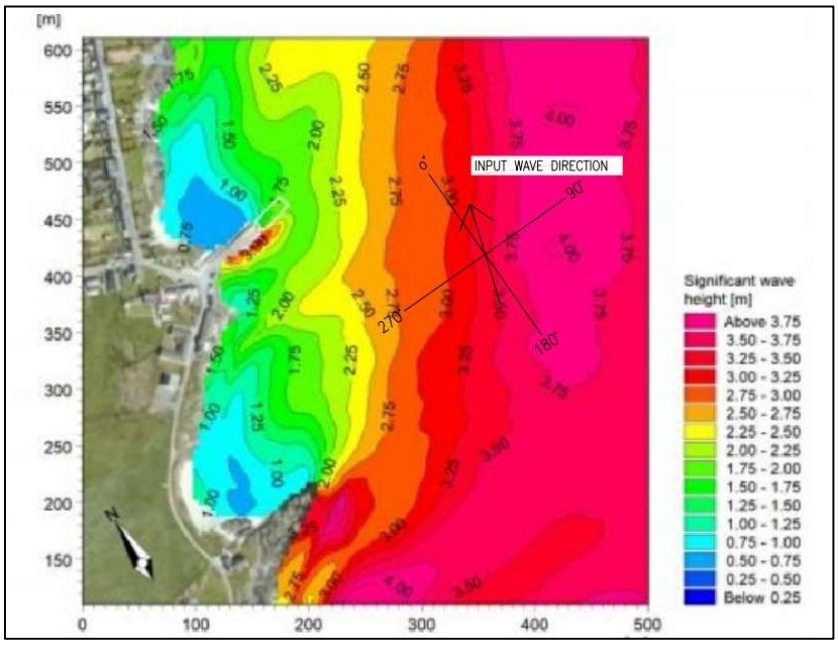


Figure 6-4 Iona Existing - 1 in 50 Year Southerly Wave Direction (Case 11)

6.3.4 Iona Layout 1A (Figure 3-6)

The model indicates that the introduction of the breakwater Layout 1A at Iona results in a reduction of the 1 in 1 year significant wave height to 0.6m and the 1 in 50 year significant wave height to 0.64m. This represents a reduction in wave height of approximately 60%. Refer to Figure 6-5 and Figure 6-6 respectively

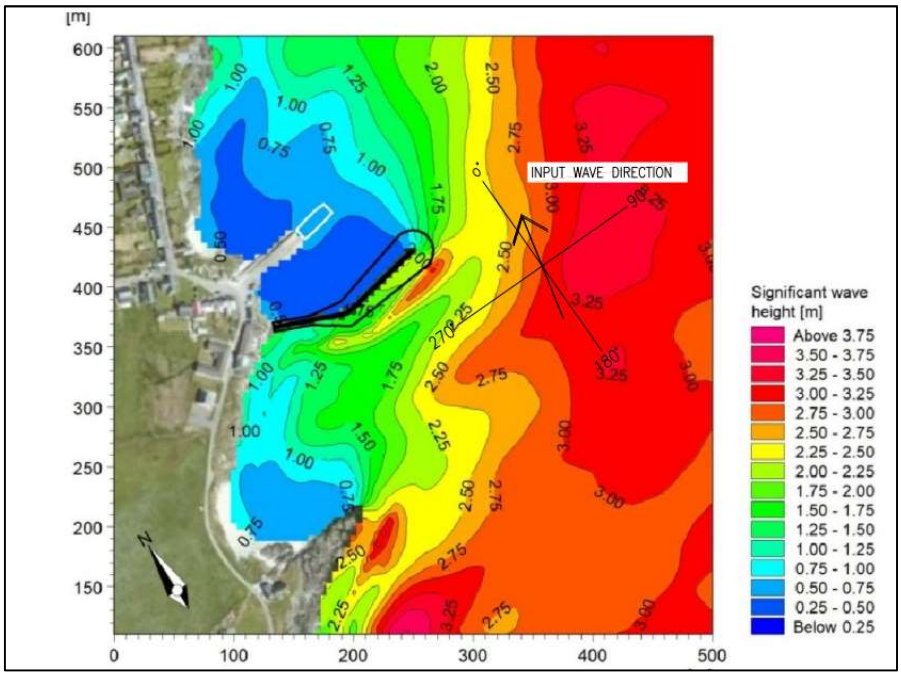


Figure 6-5 Iona Layout 1A - 1 in 1 Year Southerly Wave Direction (Case 5)

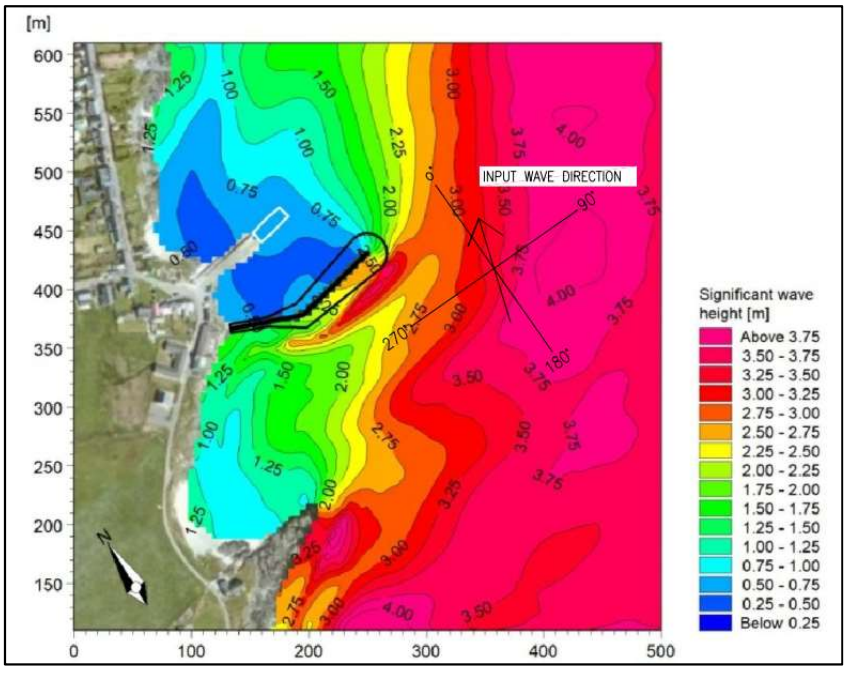


Figure 6-6 Iona Layout 1A - 1 in 50 Year Southerly Wave Direction (Case 11)

6.3.5 Iona Layout 1B (Figure 3-7)

Layout 1B comprises a breakwater approximately 37m longer than Layout 1A. The 37m extension yielded a 1 in 1 year significant wave height of 0.54m with a 1 in 50 year significant wave height of 0.59m. (Note, Figure 6-7 and Figure 6-8 indicate a 50m long extension. Results were interpolated for the 37m long extension.

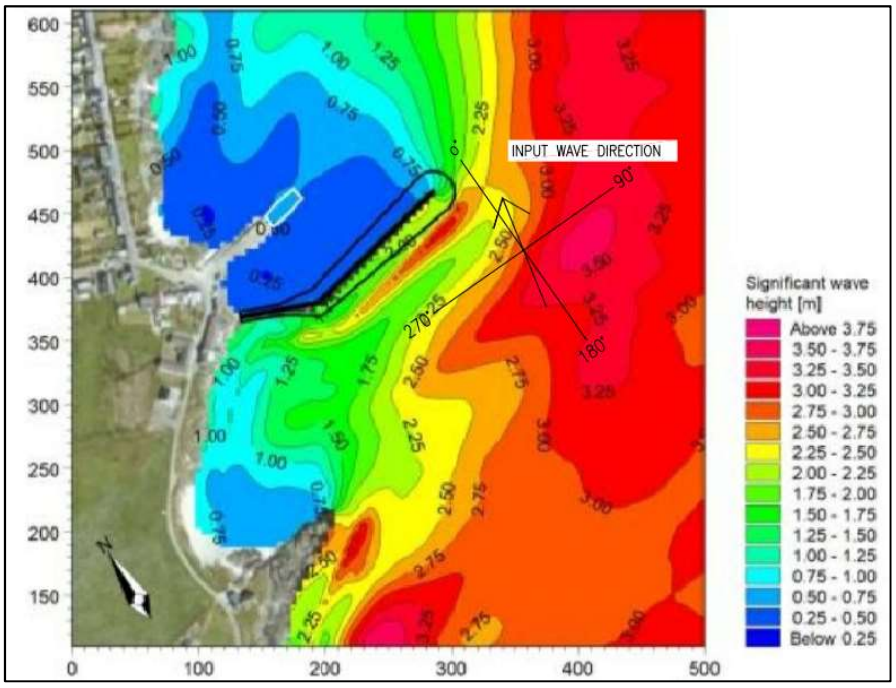


Figure 6-7 Iona Layout 1B - 1 in 1 Year Southerly Wave Direction (Case 5)

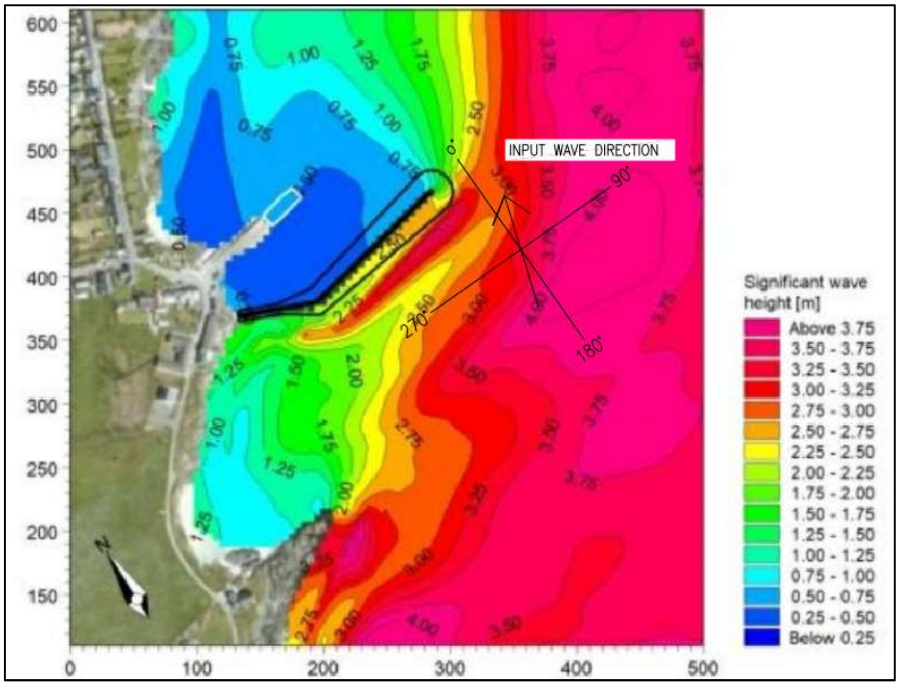


Figure 6-8 Iona Layout 1B - 1 in 50 Year Southerly Wave Direction (Case 11)

6.3.6 Iona Layout 2A (Figure 3-8)

The model indicates that the introduction of the breakwater Layout 2A at Iona results in a reduction of the 1 in 1 year significant wave height to 0.75m and the 1 in 50 year significant wave height to 1.0m. This represents a reduction in wave height of approximately 50%.

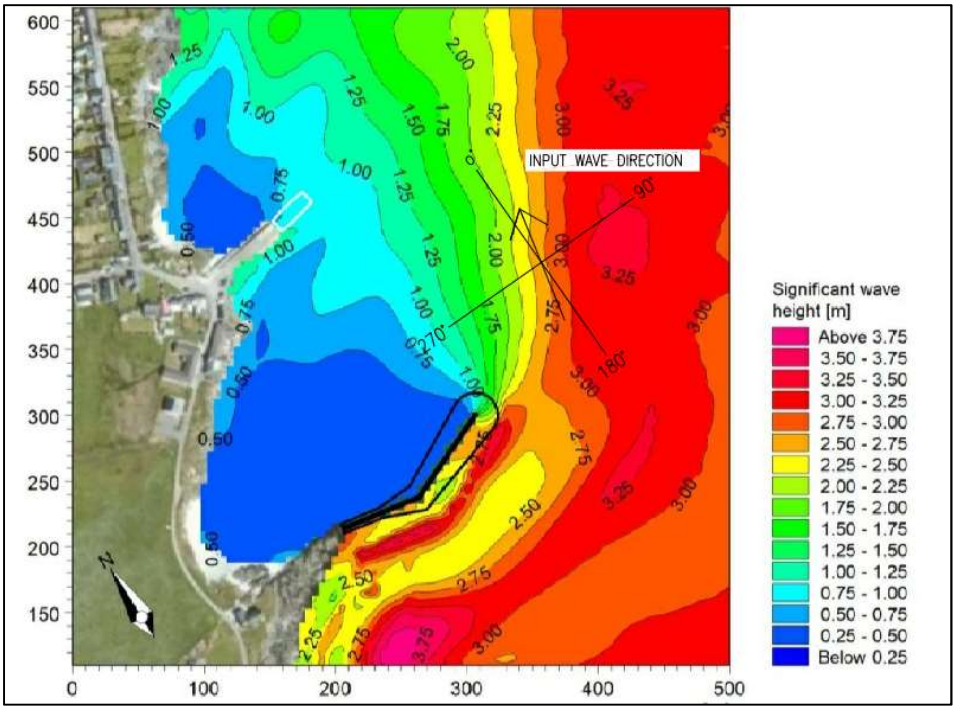


Figure 6-9 Iona Layout 2A - 1 in 1 Year Southerly Wave Direction (Case 5)

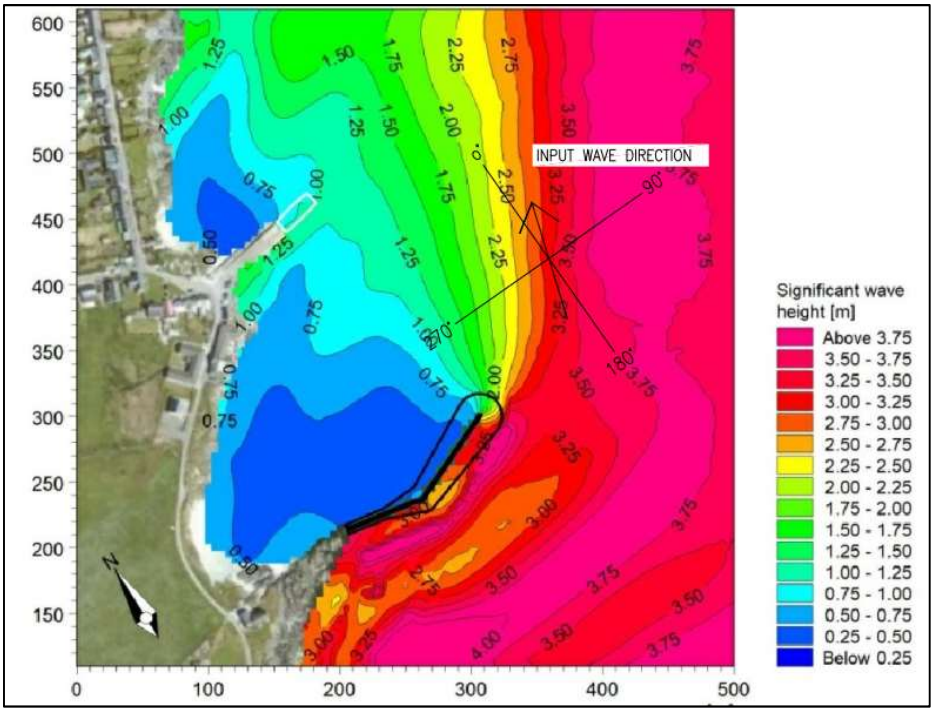


Figure 6-10 Iona Layout 2A - 1 in 50 Year Southerly Wave Direction (Case 11)

6.4 Discussion

6.4.1 Fionnphort

The construction of the proposed breakwater at Fionnphort will significantly reduce wave heights from all directions. It will allow the development of an overnight berth which will be subject to a 0.41m wave height in a 1 in 50 year event. The slipway will be subject to a wave height of 0.79m in a 1 in 50 year event. This wave height will mean that the slipway will not be usable in such an event, but this will be a rare event, when the ferry will not be crossing and will be berthed at the overnight berth.

[Insert Comment from CalMac]

6.4.2 Iona

Table 6-1 presents the reduction in wave heights for the various layouts for the waves incident from a southerly direction. Layout 1B provides the greatest protection. ByrneLooby are of the opinion that the development of option 2B would not significantly reduce wave heights as waves will refract around the structure.

Layout	Case 5 (1 in 1 year) (H_{m0} m)	Case 11 (1 in 50yr) (H_{m0} m)
Existing	1.5m	1.69m
1A	0.6m	0.64m
1B	0.54m	0.59m
2A	0.75m	1.0m

Table 6-1 - Iona Layout Comparison

It must be noted, that none of the layouts proposed for Iona will significantly reduce waves incident from the east or north. Figure 6-11 indicates a 1 in 50 year northerly wave resulting in a 1.3m have height at the proposed slipway, despite the introduction of the breakwater. It is acknowledged that these events do occur, and the breakwater shall be designed to accommodate same, but landing of the ferry, or indeed ferry crossings will not be possible. The breakwater will create calm waters to the south of the structure during northerly events.

[Insert Comment from CalMac]

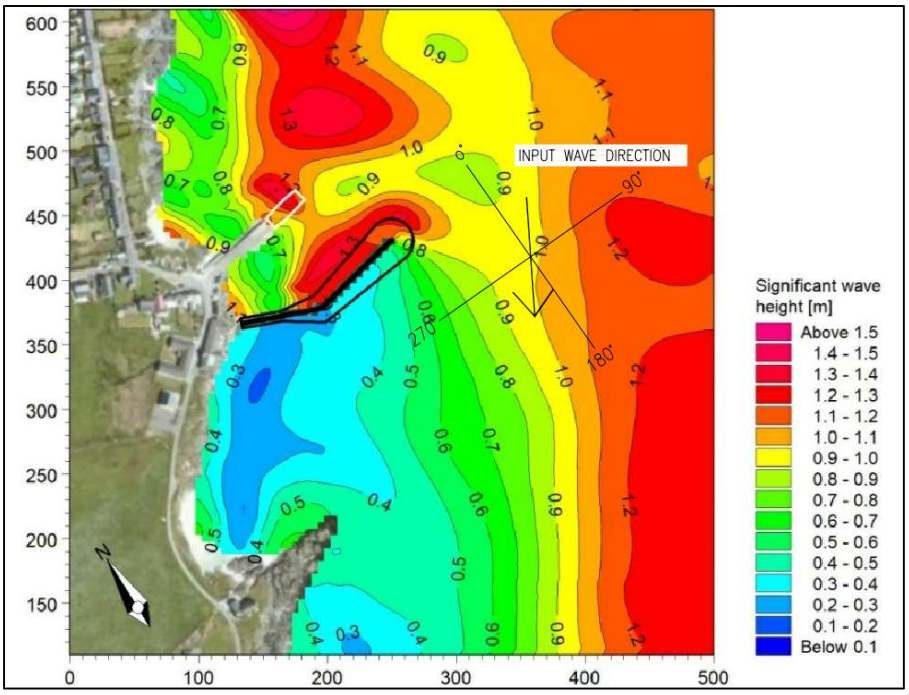


Figure 6-11 Iona Layout 1a - 1 in 50 Year Northerly Wave Direction (Case 8)

7 Preferred Options

7.1 Fionnphort

The preferred option at Fionnphort is Layout 5. It comprises a rock armour breakwater with an overall crest length of circa 175m. The breakwater comprises a rock armour structure with a proposed slope of 1 in 1.5. It extends in a north westerly direction from the existing rock outcrop, then turning north and north east over three legs. The function of the structure is primarily to provide defence from waves propagating from a southerly direction, however a high level or protection is also provided from westerly and northerly waves. There is a significant reduction in wave heights incident from a southerly direction.

An overnight berth is positioned in the lee of the breakwater, immediately north of the first leg. This berth will comprise a piled structure with a steel deck. It will allow the ferry to be berthed at Fionnphort overnight and avoid the need to berth the vessel at Bull Hole. This will result in a considerable reduction in safety risks to the ferry operators who currently access Bull Hole via dinghy. Access from the structure to the ferry will be via ladder. The structure will be connected to the existing rock outcrop.

It is proposed to install a single pile, offset from the end of the existing pier to provide additional berthing length for ferry vessels.

In order to accommodate the new navigation channel requirements, some dredging works will be required, however these will be minor in nature and comprise overburden dredging only.

There is scope for an additional emergency berth on the outer leg of the breakwater in the future. This may be utilised in the case of a ferry breakdown.

The layout of the preferred option is presented in Appendix E – Preferred Layouts.

7.2 Iona

The preferred option at Iona is Layout 1B. The option comprises a rock armour breakwater with an overall crest length of 177m. It is located approximately 70m south of the existing slipway in Iona. The breakwater comprises a rock armour structure with a proposed slope of 1 in 1.5. The function of the structure is primarily to provide defence from waves propagating from a southerly direction but anticipated to provide greater protection than Layout 1A and it also provides protection for future longer ferry vessels. The structure will not provide protection from the waves propagating from northerly or easterly directions.

The breakwater will result in an overall reduction of wave heights at the structure. This will significantly reduce the risks to ferry operators and passengers and vehicles boarding and disembarking the ferry. The reduction in wave height provides a greater grip between the ferry ramp and the slipway deck.

In order to further secure the ferry to the slipway, it is proposed to install a series of berthing piles. The ferry operator may secure the ferry to these piles by means of a mooring line or propelling the stern of the vessel towards the piles while using the vessel ramp on the slipway as a pivot point. Typical slipway berthing piles are indicated in Figure 7-1.

Figure 7-1 Typical Slipway Berthing Piles

8 Preliminary Cross Section Design

8.1 Design Working Life

BS6349-1-1:2013 provides indicative design working life categories for maritime works. For the purposes of this project, a design working life of 50 years is applicable.

BRITISH STANDARD **BS 6349-1-1:2013**

Table 1 **Indicative design working life categories for maritime works**

Design working life category	Indicative design working life (years)	Examples
1	10	Temporary structures [A)]
2	10 to 25	Structural parts designed to be replaceable within a structure or facility of longer design working life
3	15 to 30	Structures dedicated to non-renewable natural resources, petrochemicals or similar industrial or commercial applications (such as open-piled jetties, mooring and berthing dolphins, Ro-Ro linkspans)
4	50	Common port infrastructure for commercial and industrial ports including reclamation, shore protection, breakwaters, quay walls
5	100	Common port infrastructure including breakwaters for ports of nationally-significant strategic or economic value. Infrastructure for regional flood defence or coastal management infrastructure

[A)] Structures or parts of structures that can be dismantled with a view to being re-used should not be considered as temporary.

Figure 8-1 Design Working Life (Extracted from Table 1 of BS 6349-1-1:2013).

8.2 Tide Levels

Tidal information for the site has been obtained with respect to Oban from Table V, of the UK and Ireland Tide Tables (NP201-11) and is reproduced in Table 8-1 – Tide Levels

Name	Level Chart Datum (m)
MHWS	+4.0
MHWN	+2.9
MLWN	+1.8
MLWS	+0.7

Table 8-1 – Tide Levels

8.3 Design Still Water Level

The design water level has been estimated as the sum of the extreme water level and sea level rise estimated over the design life considered (50 years) as 0.56m.

Return Period (Years)	Design Water Level (m MSL)	Design Water Level (m CD)
1 in 1	+3.36	+5.76
1 in 50	+3.85	+6.25
1 in 100	+3.93	+6.33

Table 8-2 – Design Still Water Level

It must be noted that these design water levels exceed the existing level of the existing pier in Fionnphort (circa +5.5m CD) and top of slipway at Iona (circa +5.5m CD), so consideration will be needed into raising these structures in the future.

8.4 Design Wave Height and Crest Level

Detailed design of the cross section of the breakwaters will be required to determine the proposed crest level of the structure. The main design criteria in breakwater design is the allowable wave overtopping discharge. Overtopping is caused by waves running up the structure and is measured in litres per second per metre. The discharge is a function of the wave height, slope, structure roughness and structure height. The allowable discharge must be considered in relation to the impact on property and persons behind the structure. For this project, the allowable discharge at Iona will be greater than that at Fionnphort, as there will not be sensitive property or persons immediately behind the structure, however the overnight berth and ferry operators will be located immediately behind the structure in Fionnphort.

A design wave height of 2.3m for the 1 in 50 year return period may be selected for the preliminary calculation of the crest level. For the purpose of this feasibility study, the crest level has been determined as follows:

Level / Height	Level
Design Still Water Level:	+6.25mCD
Design Wave	2.3m/2
Wave Runup	1.25m (estimate)
Freeboard	1.0m
Sum	**+9.65m CD**

Table 8-3 Preliminary Crest Level Design

This design level is circa 4m above the existing pier in Fionnphort and is very likely to be a controversial issue during the planning application process. Note, Arch Henderson indicated a crest level of +10.5mCD in their feasibility study, and although appearing high, the breakwater crest is likely to be in the order of this level. It may be possible for the crest level of the breakwater to be designed at a lower level. This will depend on the wave runup calculated, the acceptable overtopping volumes (to be determined by Argyll and Bute Council), and other design parameters.

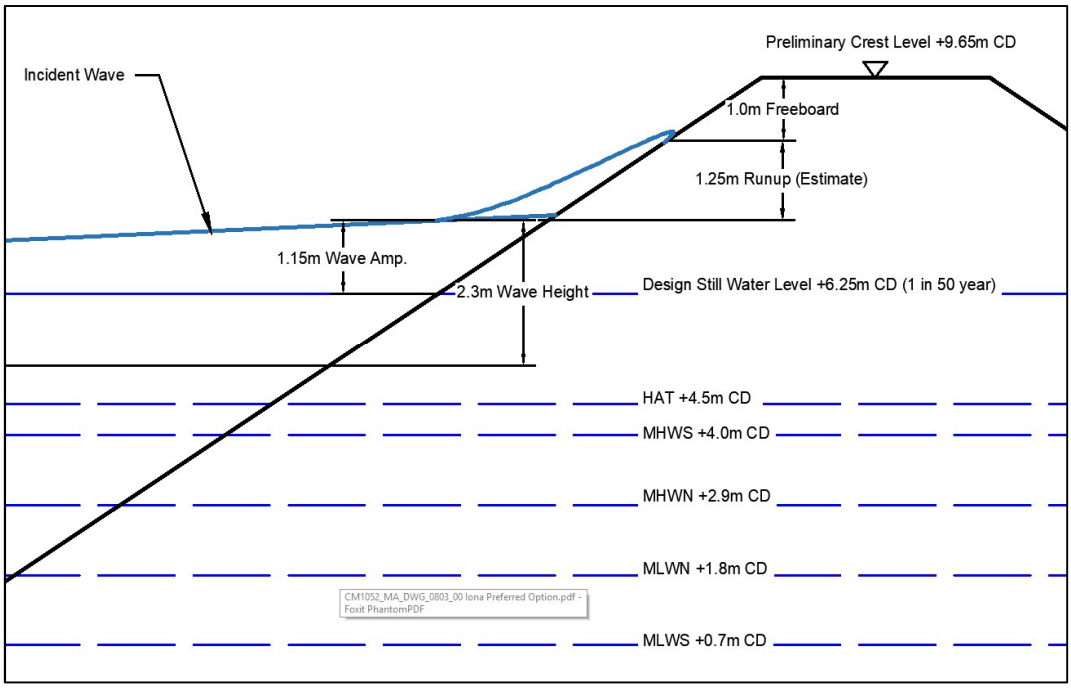


Figure 8-2 Crest Level Design

8.5 Rock Armour Sizing

Using the Hudson Equation, the primary rock armour sizing has been determined to be in the order of 4.7tonnes (mean). The size of the rock armour can be curtailed and reduced in areas through the detailed design (such as areas not subject to southerly waves and the lee of the breakwater). These rock armour units will have a mean diameter of 1.2m.

This size of rock armour is available in the quarry discussed in Section 9.4.

8.6 Crest Width

The breakwater crests will be in the order 3.6m in order to accommodate 3 No. rock armour units on the crest.

8.7 Breakwater Slope

In order to reduce the volume of rock armour to be imported, the slope of the breakwaters has been set to the maximum standard steepness of 1 in 1.5. A steeper slope increases the size of rock armour required, for example, in this case a slope of 1 in 2 would reduce the rock armour size to 3.5tonnes (mean) however the quantity of materials would significantly increase. This would also result in greater land take and encroach further on existing structures.

8.8 Detailed Design

It is recommended that the following failure modes are assessed in the detailed design of the breakwater cross sections:

- Wave overtopping;
- Wave venting;
- Erosion/breakage of armour;
- Armour slip failure;
- Global slip failure;
- Toe erosion/scour;
- Global overturning/sliding stability;
- Core settlement;
- Armour settlement;
- Subsoil settlement.

ByrneLooby recommend that Argyll and Bute Council prepare a functional requirements document for agreement with stakeholders in order to agree acceptable overtopping volumes and other critical design parameters.

9 Resources, Materials and Constructability

ByrneLooby collaborated with Mclaughlin and Harvey in relation to the constructability of the preferred options. McLaughlin and Harvey have previous experience of marine civil engineering on the west coast of Scotland and Inner Hebrides.

9.1 Construction Plant

The following plant will be necessary at Iona and Fionnphort:

- Safety Boat
- Work Boat
- Split Barge
- Spud Leg Barge
- Jack Up Barge
- Piling/Coring Rig
- Excavators
- Long Reach Excavators
- Dumpers

9.2 Form of Construction & Methodology

Site compounds will be developed on both Iona and Fionnphort for the installation of welfare facilities, offices, and general storage. The site of the compound locations will require agreement with Argyll and Bute Council and be sufficient in size for the proposed material storage and construction plant.

The breakwaters will be formed using quarried rock. The rock (comprising core material and rock armour) will be transferred by sea to the site and stockpiled on the foreshore (sea bed and directly into the works). The stockpiling of rock will require a licence from Marine Scotland and can form part of the main Marine Licence application. The main purpose for shipping the rock armour is to quickly transfer large quantities of materials, without impacting upon the road and ferry networks. This will ultimately reduce costs and result in a shorter construction programme. The material will be placed into the split hopper barge at the quarry, and towed to site, where the split barge will open and deposit the rock armour directly onto the seabed and onto the works, Once the material has been deposited to a level just below low Tide, the excavator on a spud leg barge will then transfer the material from the split barge to the breakwater revetment or to a temporary stockpile on the foreshore, the material will be

transferred around the site from the stockpiles using dump trucks and the excavator will complete the final profiling and filling of the breakwater.

The Ground Investigation Interpretative Report indicates that some settlement of the breakwater structures will occur, so the breakwaters shall be designed to accommodate this.

Working from the shore outwards, core material will be placed on the sea bed and used as a platform for the construction plant. Care will be required to ensure that the core material is sufficient large enough not to suffer from washout from waves during the temporary stage. A geotextile membrane will be placed on the seabed prior to the installation of the core material. When the inner core material is sufficiently sized, long reach excavators will be used to place the rock armour units. It is likely that the works will be constructed to +4.5m CD as quickly as possible, to ensure that plant may operate independent of tidal cycles.

The overnight berth at Fionnphort will be constructed from a jack up barge. A coring/piling rig will be placed upon the jack-up barge, and core through the bedrock to form a rock socket for the piles. The superstructure of the overnight berth may arrive prefabricated and fitted to the top of the piles. It is likely that the piles, superstructure and furniture will be transferred to site by land and ferries. A suitable storage facility will need to be identified at Fionnphort for the temporary storage of the piles and platform.

9.3 Phasing

McLaughlin and Harvey have indicated that the preferred construction phasing would comprise:

1. Fionnphort Breakwater and Dredging;
2. Fionnphort Overnight Berth and Berthing Pile;
3. Iona Breakwater;
4. Iona Berthing Piles.

An indicative project programme is included in Appendix F – Outline Programme.

9.4 Materials Sources

It is likely that local sources of rock armour will not be suitable. McLaughlin and Harvey have identified Glensada Quarry (Aggregate Industries) as a quarry which will be capable of producing rock armour material to a grading sufficient for the application at Iona and Fionnphort. The quarry is equipped with marine loading facilities. It is estimated that one split barge load may be transferred from Glensada Quarry to Iona/Fionnphort per day.

9.5 Human Resources

It is likely that specialist contractors will be required to carry out most of the works, but local human resources may also be used if suitable.

10 Sound of Iona Harbours Group

Once the functional design of the proposed breakwaters was completed and the preferred options for modelling were agreed, ByrneLooby reviewed the options for incorporating a wave energy device within the proposed structures.

The primary wave energy device types that are accepted as being viable are as follows:

- Point Absorber
- Surface Attenuator
- Overtopping Device
- Oscillating Water Column
- Oscillating Wave Surge Converter
- Submerged Pressure Device

The device proposed by the Sound of Iona Harbour Committee appears to be a Oscillating Water Column Device. This type of device utilises wave action, via an inlet, to compress air and drive an air turbine, thus creating electricity. The Mutriku wave energy plant uses this exact form of wave energy to electricity.

This type of wave energy structure requires rigid, concrete foundations and caisson type chamber structures to house the necessary devices. Given that the developed preferred options for Iona and Fionnphort breakwaters are rubble-mound type structures, they are not suitable to house oscillating water column energy devices. The rubble mound breakwaters were chosen as they provide excellent wave attenuation properties, are cost effective to develop and are constructed from naturally quarried rock, thus minimising the environmental impact of the materials supply.

Our suggestion at this preliminary design stage is that a wave or tidal energy device could be constructed at the outer end of each breakwater structures. Point Absorber buoys could be located on the seabed at the outer end of the breakwater structures. These would mark the outer end of the breakwaters, thus acting as a navigation buoy while also generating electricity. The development of these devices would not require significant civil infrastructure and the optimal location of these devices could be designed independently of the breakwater structures. Point Absorber devices take up a minimum foreshore footprint and have minimal environmental impact as they are fabricated offsite and deployed in a similar manner to any other buoy. The hydrodynamic assessment carried out as part of this will provide wave data to allow a preliminary assessment of a Point Absorber device at Iona and Fionnphort. Mooring piles could also be installed as part of the breakwater developments, as piling plant will be on both sites.

We also recommend that consideration be given to the installation of tidal turbines at the outer end of each breakwater. The support structures could be provided by steel piles, installed as part of the harbour protection works or be tethered to the seabed to mooring piles.

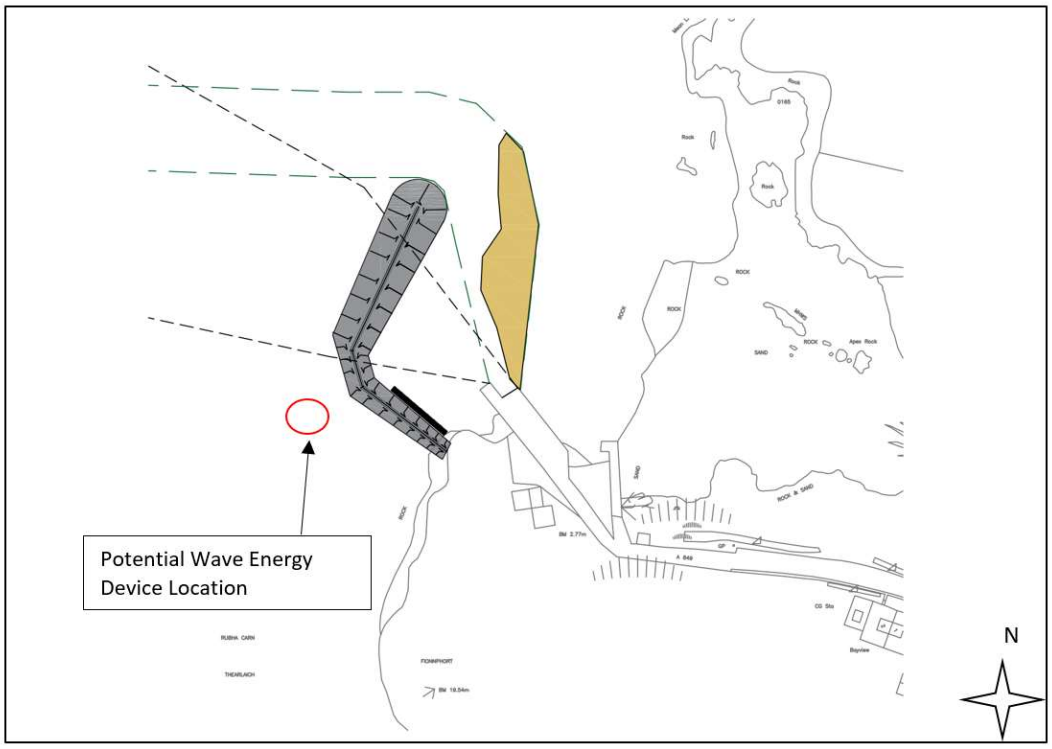


Figure 10-1 Potential Wave Energy Device – Fionnphort

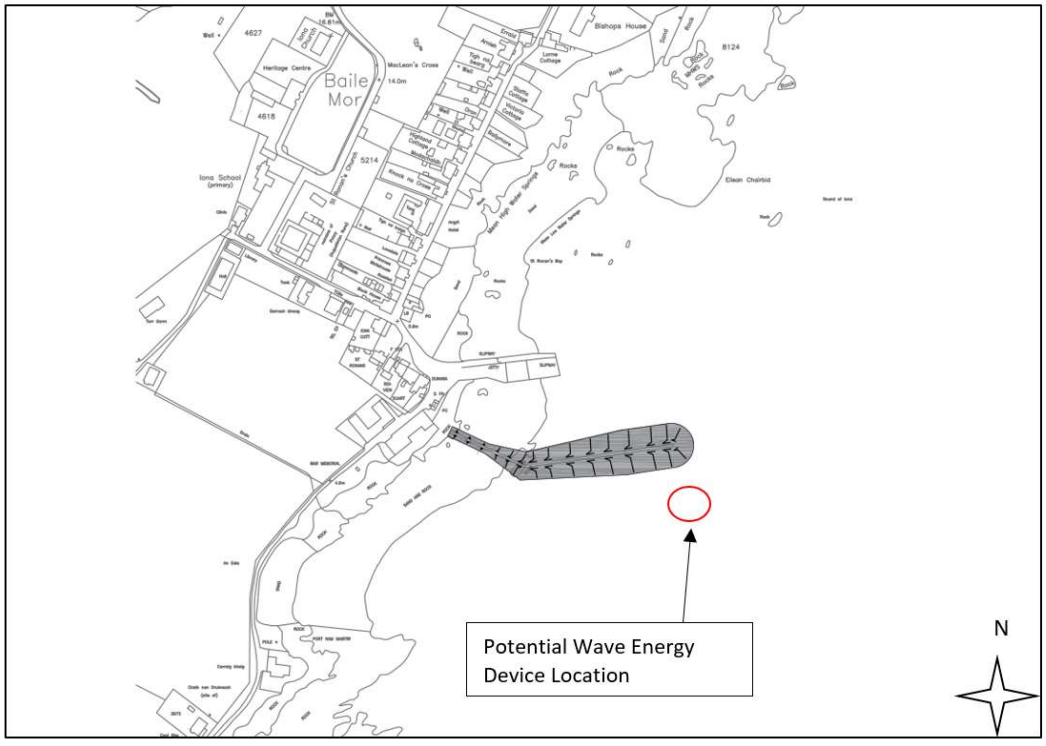


Figure 10-2 Potential Wave Energy Device - Iona

11 Cost Estimates

Using market rates provided by McLaughlin and Harvey, the following cost estimates have been developed:

Layout	Iona 1A	Iona 1B	Iona 2A	Iona 2B	Fionnphort 5
Preliminaries	£1.106m	£1.370m	£1.120m	£1.720m	£1.340m
Mobilisation / Demobilisation	£1.036m	£1.035m	£1.036m	£1.036m	£1.133m
Breakwater	£5.709m	£7.072m	£5.785m	£8.877m	£4.572m
Weather Risk	£0.264m	£0.327m	£0.268m	£0.411m	£0.411m
Berthing Piles	£0.160m	£0.160m	£0.160m	£0.160m	£0.060m
Overnight Berth	-	-	-	-	£0.820m
Total	**£8.275m**	**£9.965m**	**£8.370m**	**£12.200m**	**£8.336m**

Table 11-1 Cost Estimates

The above table does not include for other contingencies, VAT, design fees etc. The cost of tidal or wave energy generation equipment is not included.

Value engineering may be provided for awarding contracts jointly.

12 Preferred Options Development

The following additional stages will be necessary to develop the preferred options:

12.1 Environmental Impact Assessment

Schedule 2 of the 2017 EIA Regulations would appear to indicate that an EIA is required under Item 10(m) – "*Coastal work to combat erosion and maritime works capable of altering the coast through the construction, for example, of dykes, moles, jetties and other sea defence works, excluding the maintenance and reconstruction of such works*".

An EIA screening should be sought from Argyll and Bute Planning Department and Marine Scotland. It is likely that an assessment of impact on coastal processes, landscape and visual, and protected sites (SACs, SPAs) will need to be addressed.

12.2 Planning Permission

Argyll and Bute Council will be required to directly apply for planning permission for the proposed development.

12.3 Marine Scotland Licensing

Consent will be required from Marine Scotland for the construction and permanent works on the foreshore as the works will be below Mean Low Water Springs. A pre application consultation may be required from Marine Scotland as part of the process. Argyll and Bute Council will be required to write to Marine Scotland to determine if a pre application consultation is required.

12.4 Crown Estate Lease

A lease will be required from Crown Estate (Scotland) in order to permit Argyll and Bute Council occupation of the foreshore.

12.5 Detailed Design

ByrneLooby recommends that designers are appointed to carry out detailed design of the structures. A number of the design parameters are identified in this report. It is recommended that detailed design is carried out at an early stage to ensure that suitable designs and drawings are issued for the permitting (Planning and Marine Scotland licensing) process. For example, the design may yield a breakwater crest at a greater level than indicated in this report. The crest level will be an important factor in the consenting process.

12.6 Procurement

Argyll and Bute's procurement and commissioning team will be responsible for the procurement of suitable designers and contractors. It is recommended that contractors are

appointed on the basis of the most economically advantageous tender (as opposed to lowest price) due to the specialist nature of the marine civil engineer works required.

13 Conclusions and Recommendations

- The existing marine infrastructure between Fionnphort and Iona is in urgent need of investment. The primary investment required is the installation of coastal protection structures in order to reduce wave heights at both berthing locations. This will reduce safety risks to passengers and operators.
- Concept layouts of proposed coastal protection structures were prepared by ByrneLooby. These layouts were discussed with stakeholders at a number of consultations.
- One option at Fionnphort and three options at Iona were modelled using Mike21 Hydrodynamic Modelling software. The model showed that the proposed layout at Fionnphort results in a significant reduction of wave heights. The length of the structures and proximity to the slipway were the governing factors in the Iona models.
- Option 1B was selected by ByrneLooby as the preferred option at Iona. This layout is generally accepted by the stakeholders, provides a good degree of protection to the slipway and is a medium cost solution. It is noted however that this structure will not provide protection from waves incident from the north or east. The estimated cost of this development is £9.9m.
- Option 5 was selected by ByrneLooby as the preferred option at Fionnphort. The estimated cost of this development is £8.3m.
- The proposed development at Iona will comprise the breakwater and berthing piles. These works will significantly reduce risks to passengers and operators.
- The proposed development at Fionnphort will comprise a breakwater development, overnight berth, berthing monopile, and minor dredging works. Risks to passengers will be reduced and the risks to ferry operators will be significantly reduced as dinghy access to Bull Hole will no longer be required.
- It will be necessary for Argyll and Bute Council to carry out an Environmental Impact Screening and prepare a Planning Application and Marine Scotland Licence Application.
- Sediment Analysis and Ground Investigations were carried out on behalf of Argyll and Bute Council and managed by ByrneLooby as part of this commission. These are included in the appendices to this report.
- ByrneLooby recommends that designers are appointed to carry out detailed design of the structures. A number of the design parameters are identified in this report. It is recommended that detailed design is carried out at an early stage to ensure that

suitable designs and drawings are issued for the permitting (Planning and Marine Scotland licensing) process.

Appendix A – Sediment Analysis Results

Iona & Fionnphort

Sediment Sampling

Results Report

Client	Argyll & Bute Council
Job Number	P46_2017_0037
Report Number	P46-2017-0031-001
Revision	1
Report Issue Date	19 Sept 2017

Revision History				
Revision	**Status**	**Compiled By**	**Approved By**	**Date Issued**
0	First issue for review.	James Holt	Steven Lloyd	12 Sept 2017
1	Final	James Holt	Steven Lloyd	19 Sept 2017
2				

CONTENTS

LIST OF FIGURES

1 INTRODUCTION

This report provides results from seabed sediment sampling and subsequent laboratory analysis conducted at 12 locations specified in client drawing CM1052-108 Rev 00.

At each location a sample of approximately 7kg was removed from the seabed using hand tools. Water depth was recorded at each sample location and subsequenlty reduced to LAT for presentation. Representative images of the seabed were also obtained at each location for refernece.

2 LOCATION DATA

2.1 Sample Location 01

Date and Time : 25/08/17, 13:20hrs BST Depth : 0.3m

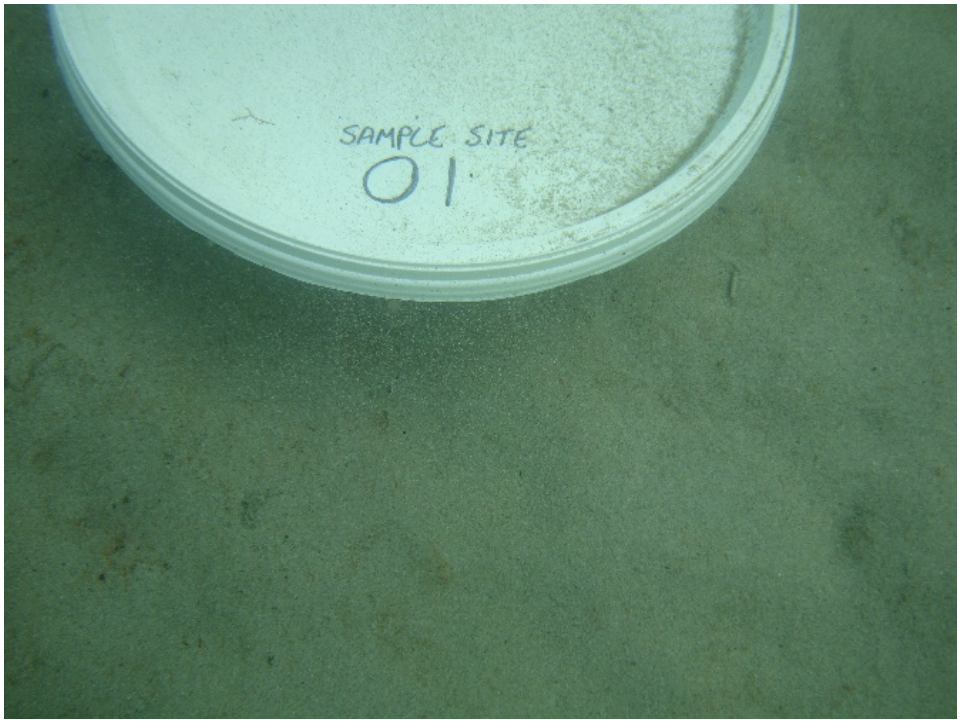


Figure **2**-**1** Location 01 – Sampling Location Image 1

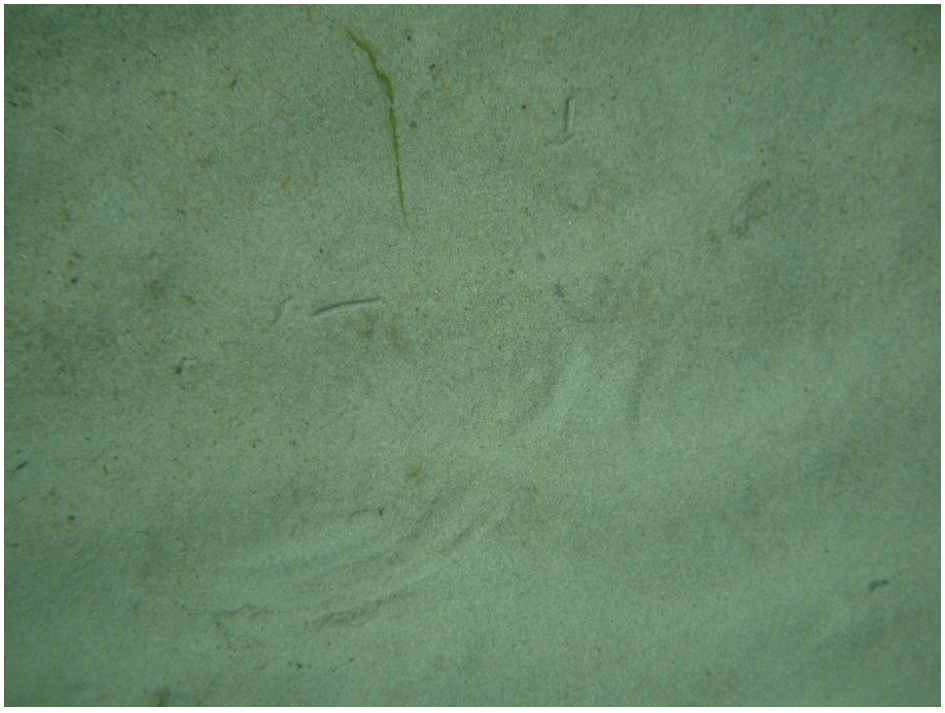


Figure **2**-**2** Location 01 – Sampling Location Image 2

2.2 Sample Location 02

Date and Time : 25/08/17, 14:10hrs BST Depth : 4.1m

Figure **2**-**3** Location 02 – Sampling Location Image 1

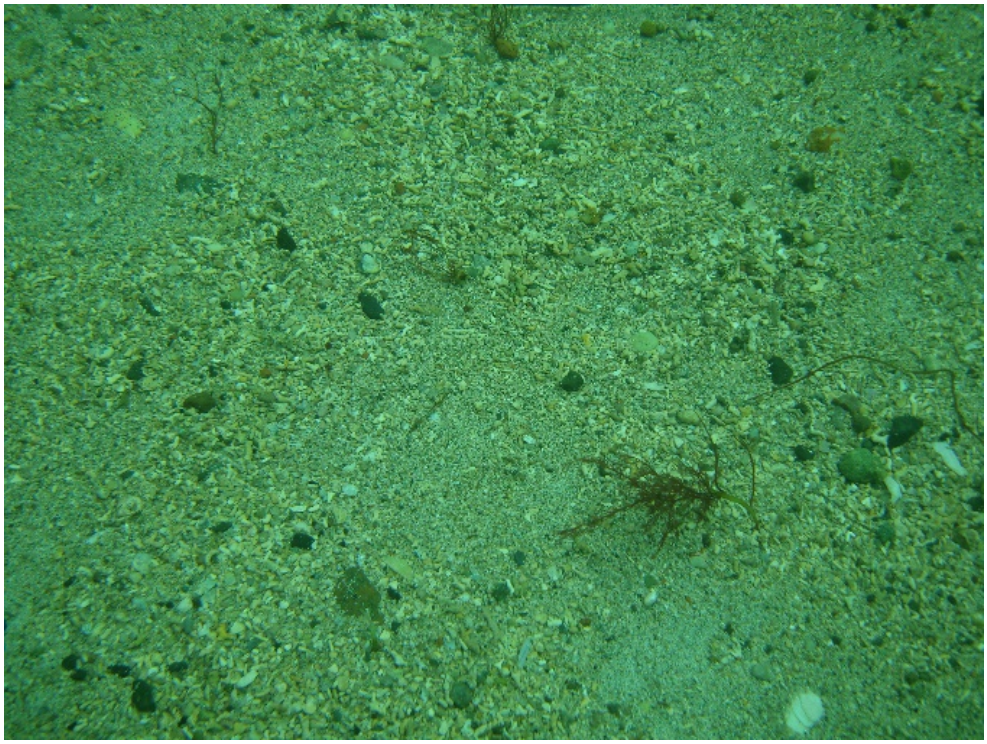


Figure **2**-**4** Location 02 – Sampling Location Image 2

2.3 Sample Location 03

Date and Time : 25/08/17, 16:10hrs BST Depth : -0.1m (Drying)

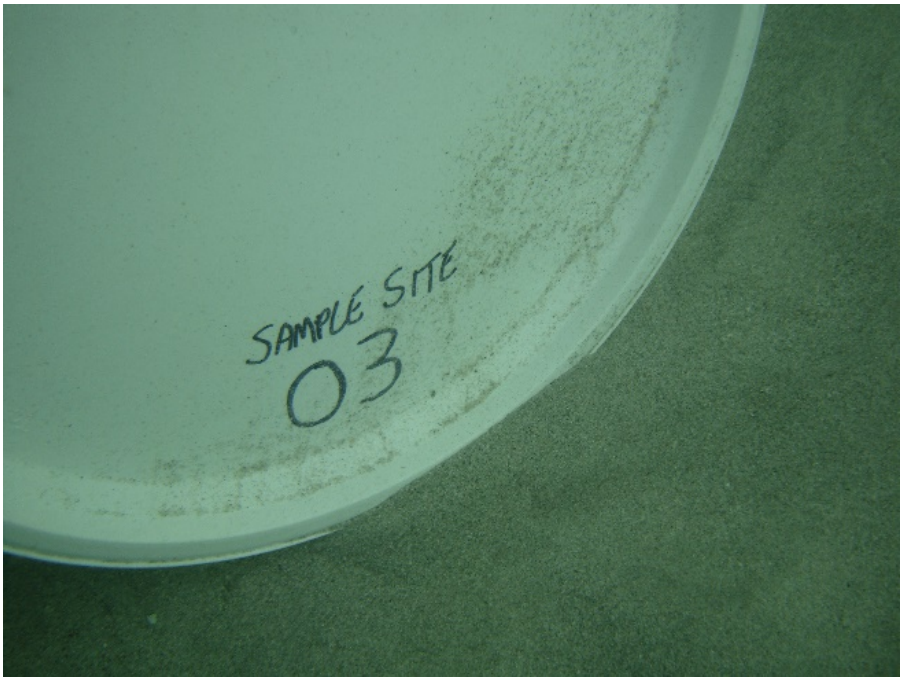


Figure **2**-**5** Location 03 – Sampling Location Image 1

Figure **2**-**6** Location 03 – Sampling Location Image 2

2.4 Sample Location 04

Date and Time : 25/08/17, 15:40hrs BST Depth : 3.9m

Figure **2-7** Location 04 –Sampling Location Image 1

Figure **2-8** Location 04 –Sampling Location Image 2

Figure **2**-**9** Location 04 – General Surrounding Seabed

2.5 Sample Location 05

Date and Time : 25/08/17, 15:20hrs BST Depth : 2.1m

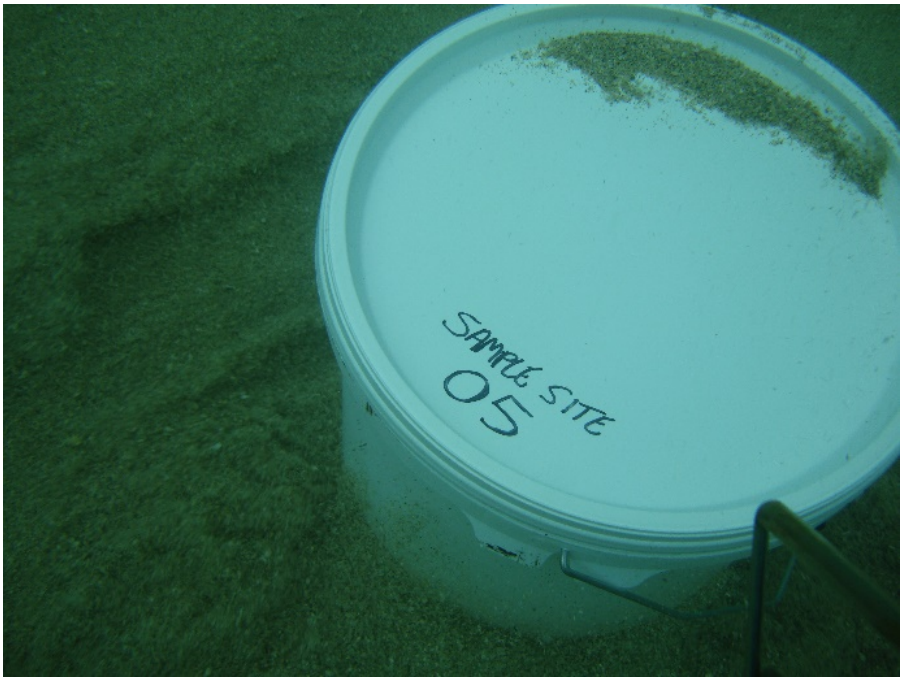


Figure **2**-**10** Location 05 –Sampling Location Image 1

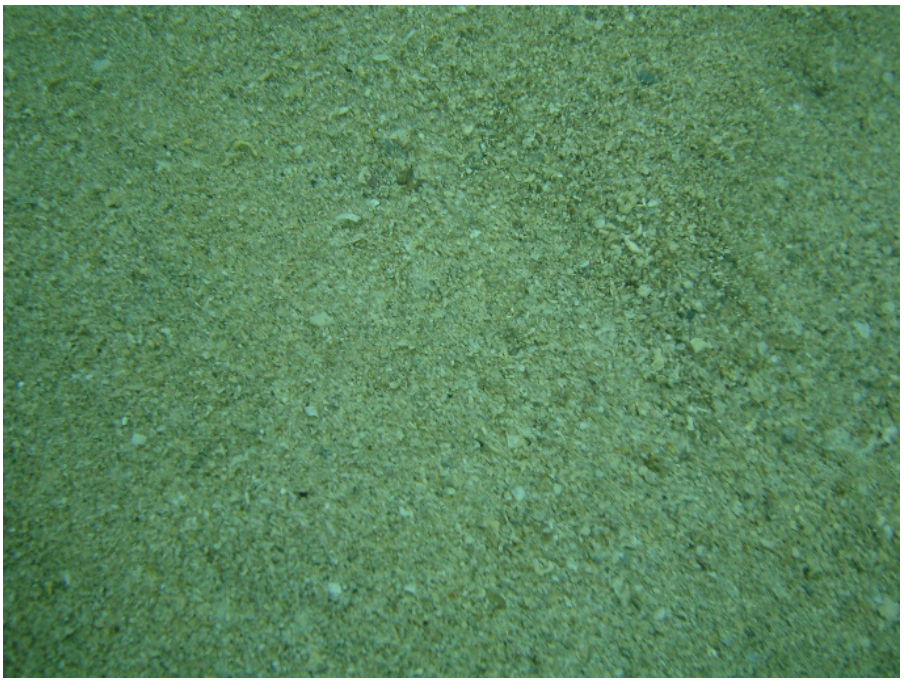


Figure **2**-**11** Location 05 –Sampling Location Image 2

Figure **2**-**12** Location 05 – General Surrounding Seabed

2.6 Sample Location 06

Date and Time : 25/08/17, 14:30hrs BST Depth : 3.5m

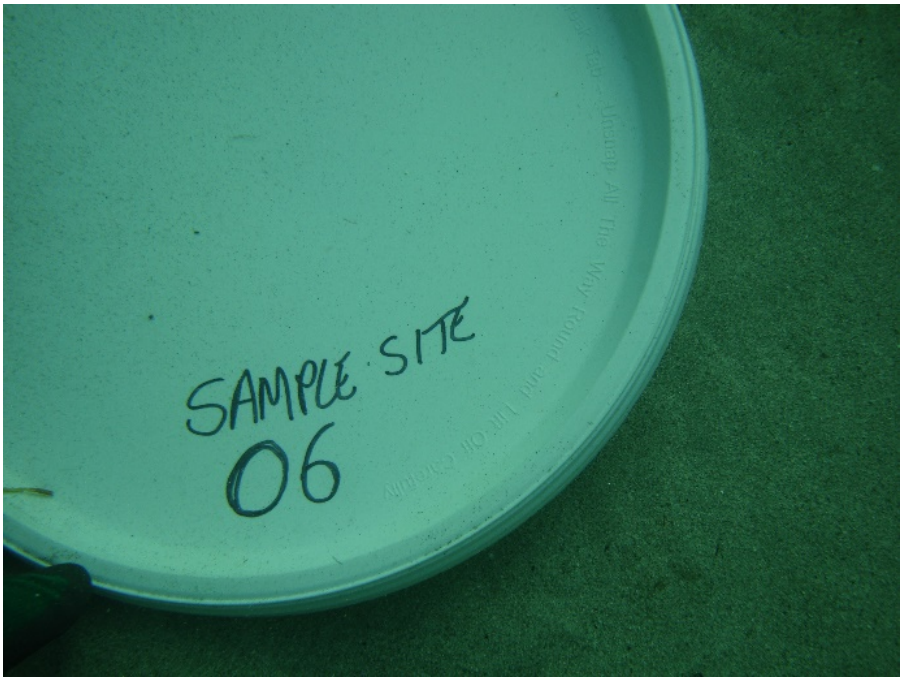


Figure **2**-**13** Location 06 –Sampling Location Image 1

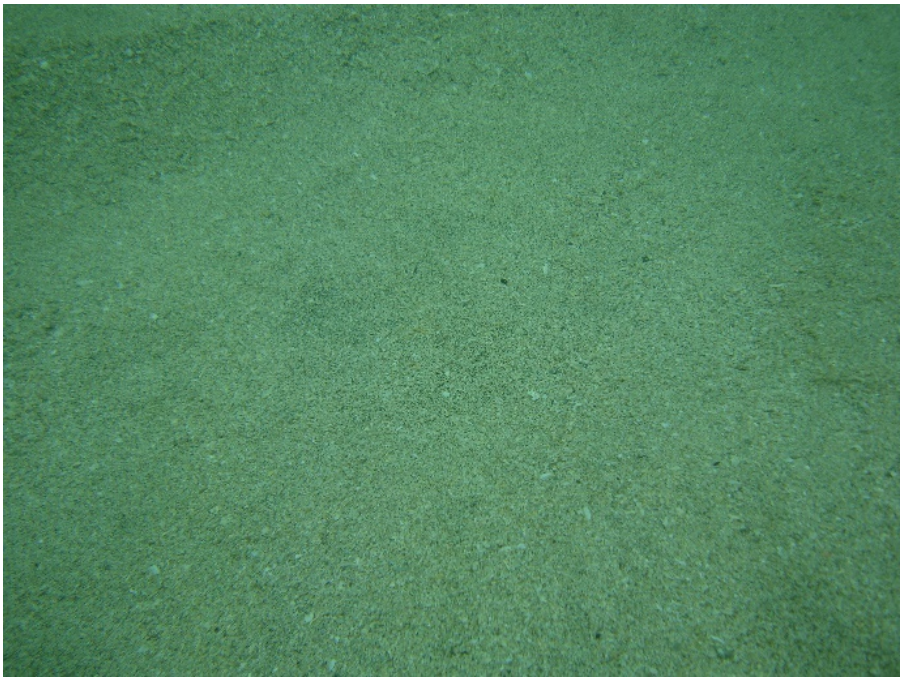


Figure **2**-**14** Location 06 –Sampling Location Image 2

2.7 Sample Location 07

Date and Time : 26/08/17, 11:15hrs BST Depth = 4.9m

Figure **2**-**15** Location 07 –Sampling Location Image 1

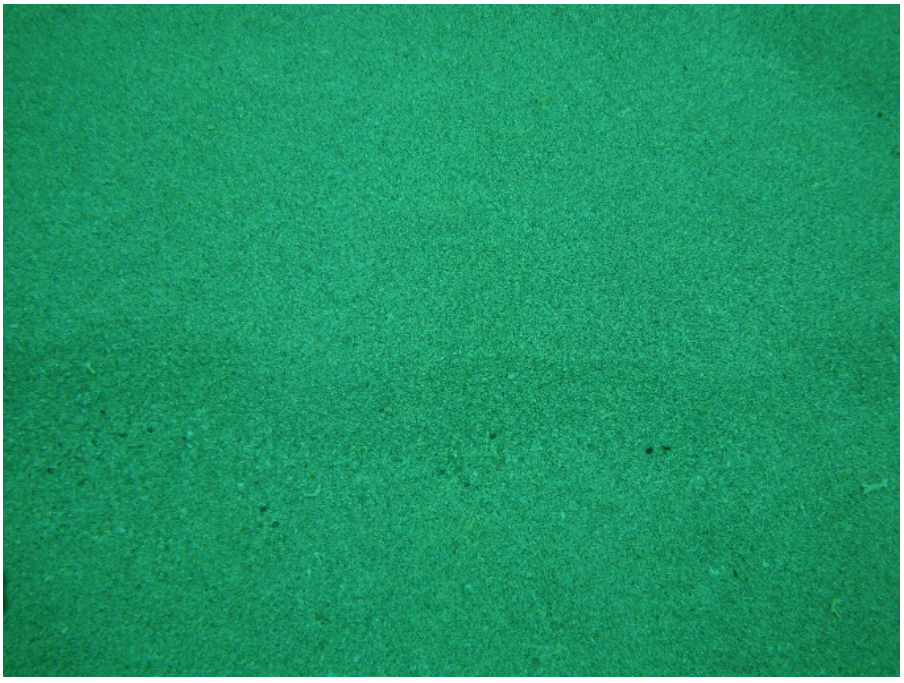


Figure **2**-**16** Location 07 –Sampling Location Image 2

Figure **2**-**17** Location 07 –General Surrounding Seabed

2.8 Sample Location 08

Date and Time : 26/08/17, 11:27hrs BST Depth = 5.6m

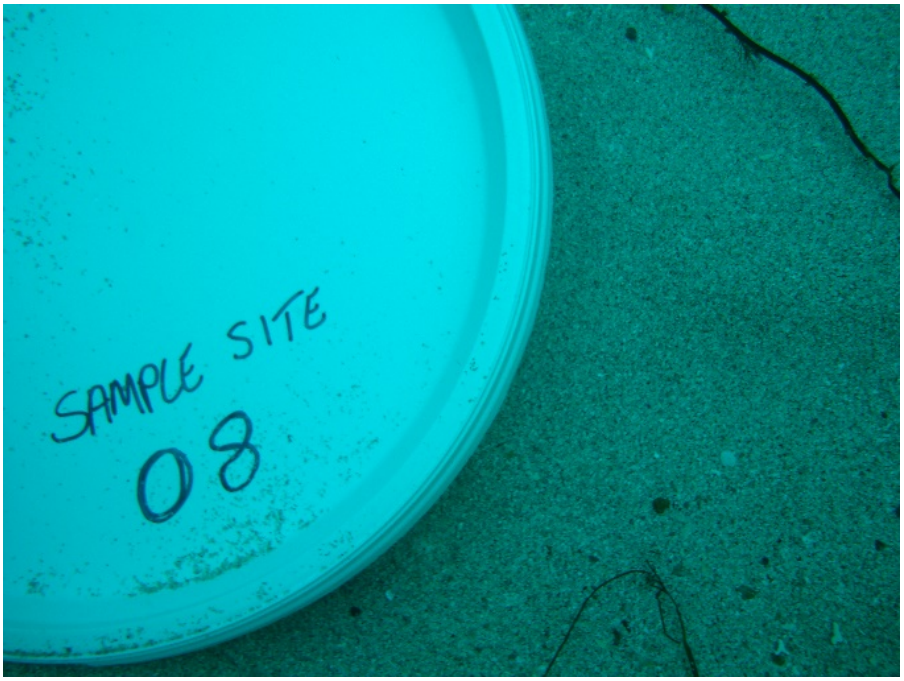


Figure **2-18** Location 08 –Sampling Location Image 1

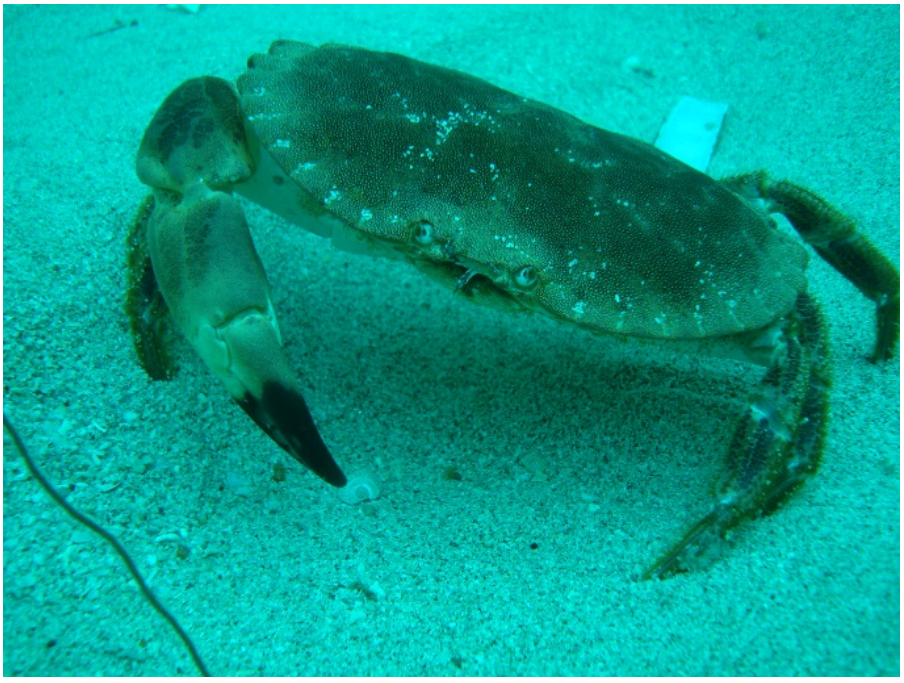


Figure **2-19** Location 08 –Sampling Location Image 2

Figure **2**-**20** Location 08 –General Surrounding Seabed

2.9 Sample Location 09

Date and Time : 26/08/17, 10:27hrs BST Depth = 5.4m

Figure **2-21** Location 09 –Sampling Location Image 1

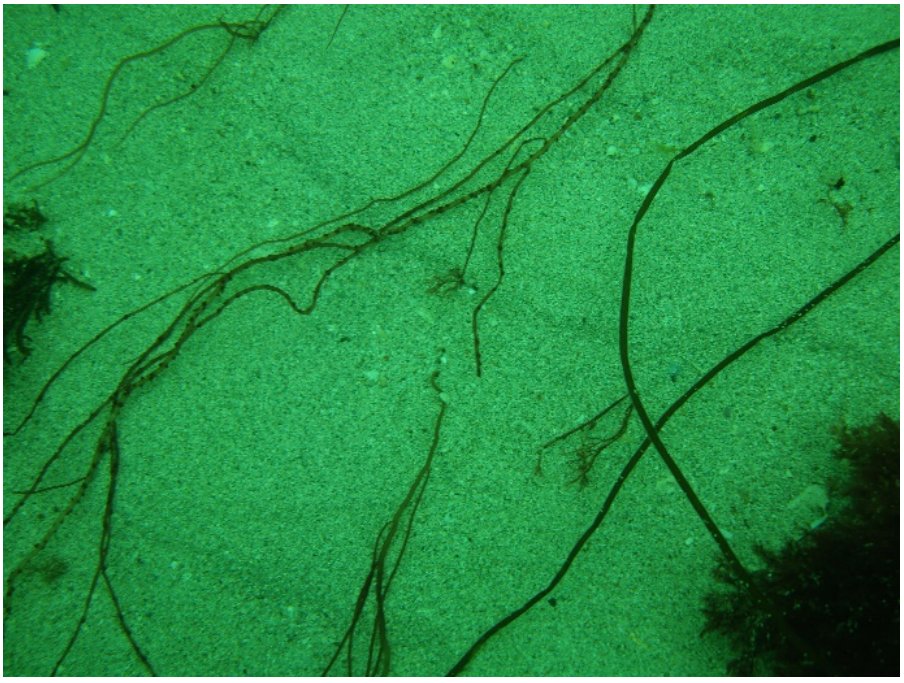


Figure **2-22** Location 09 –Sampling Location Image 2

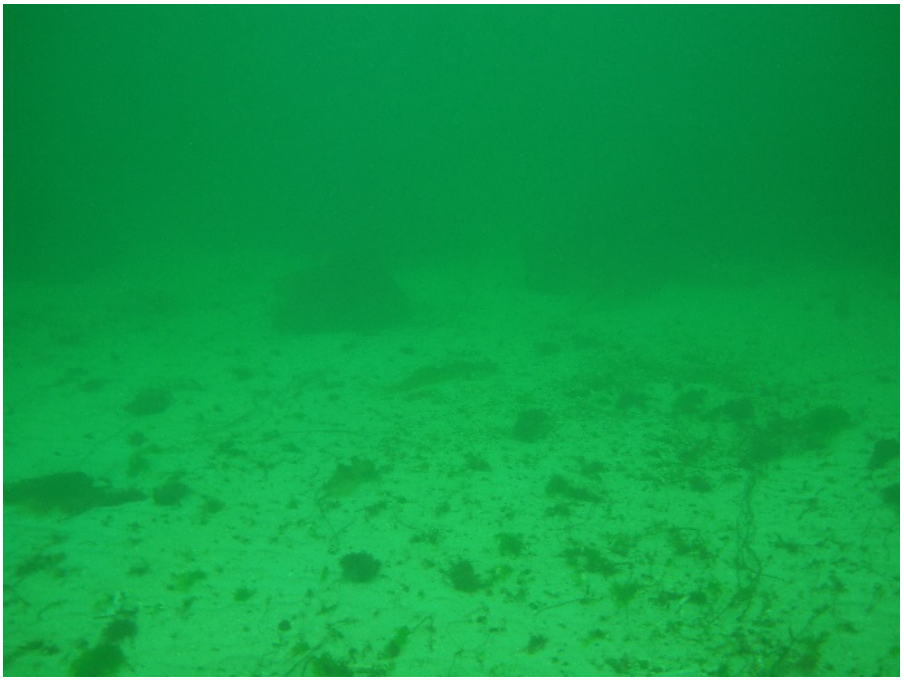


Figure **2**-**23** Location 09 –General Surrounding Seabed

2.10 Sample Location 10

Date and Time : 26/08/17, 10:46hrs BST Depth = 2.8m

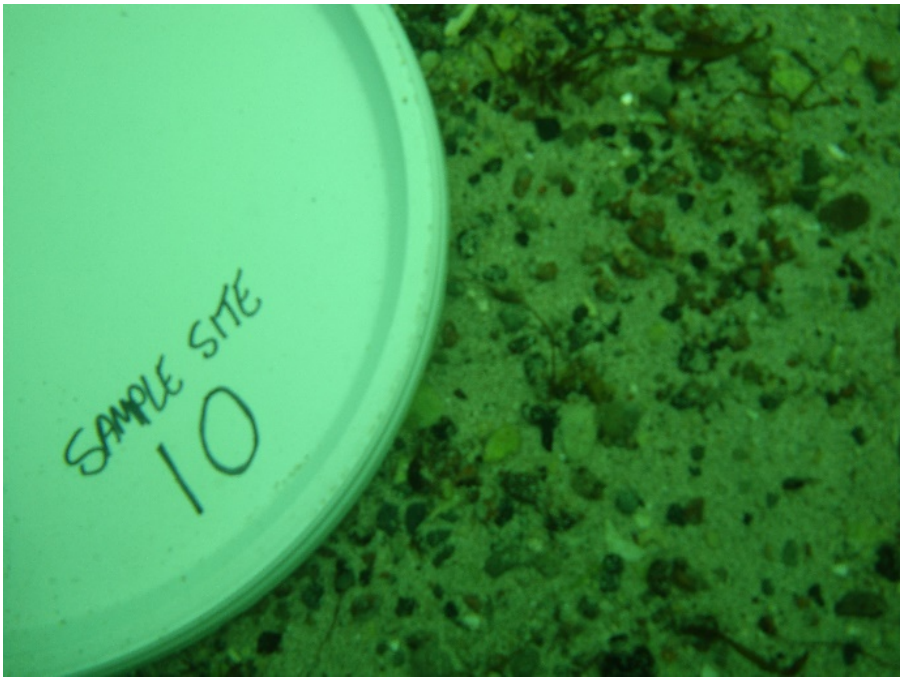


Figure **2-24** Location 10 –Sampling Location Image 1

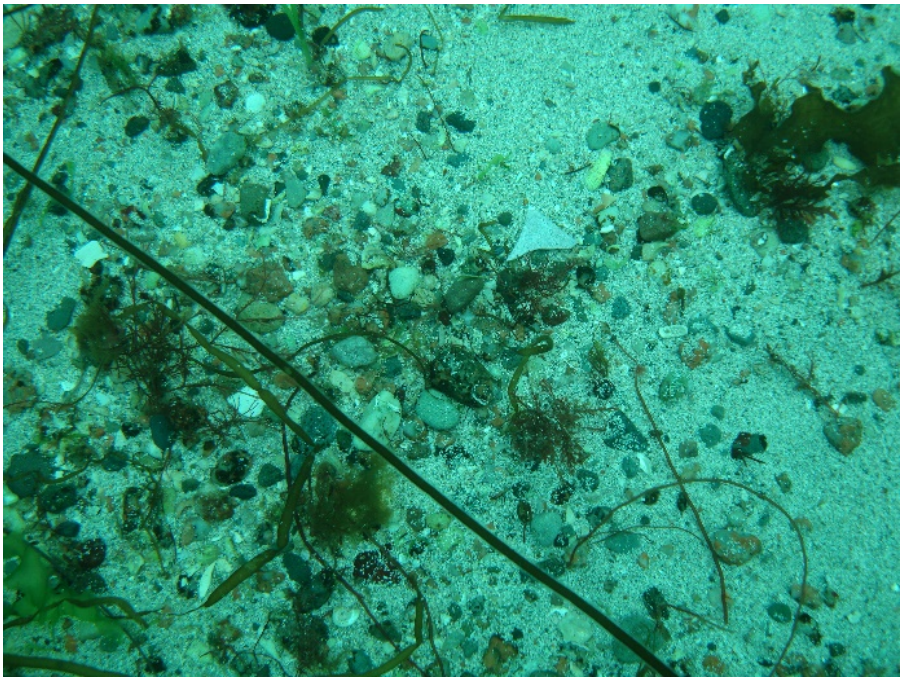


Figure **2-25** Location 10 –Sampling Location Image 2

Figure **2**-**26** Location 10 –General Surrounding Seabed

2.11 Sample Location 11

Date and Time : 26/08/17, 10:58hrs BST Depth 3.6m

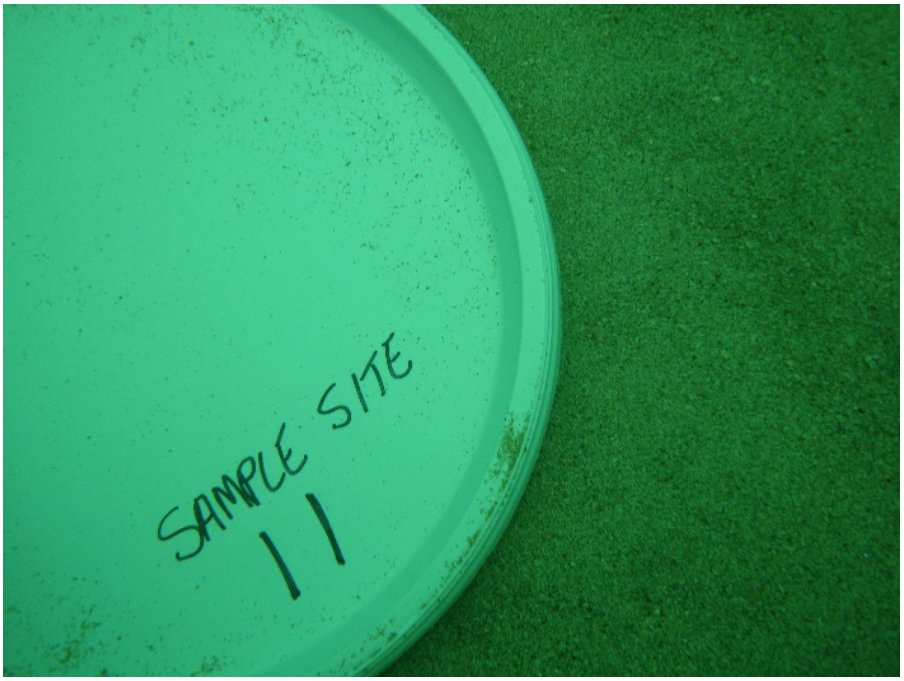


Figure **2**-**27** Location 11 – Sampling Location Image 1

Figure **2**-**28** Location 11 –Sampling Location Image 2

Figure **2**-**29** Location 11 –General Surrounding Seabed

2.12 Sample Location 12

Date and Time : 25/08/17, 17:05hrs BST Depth = 0.4m

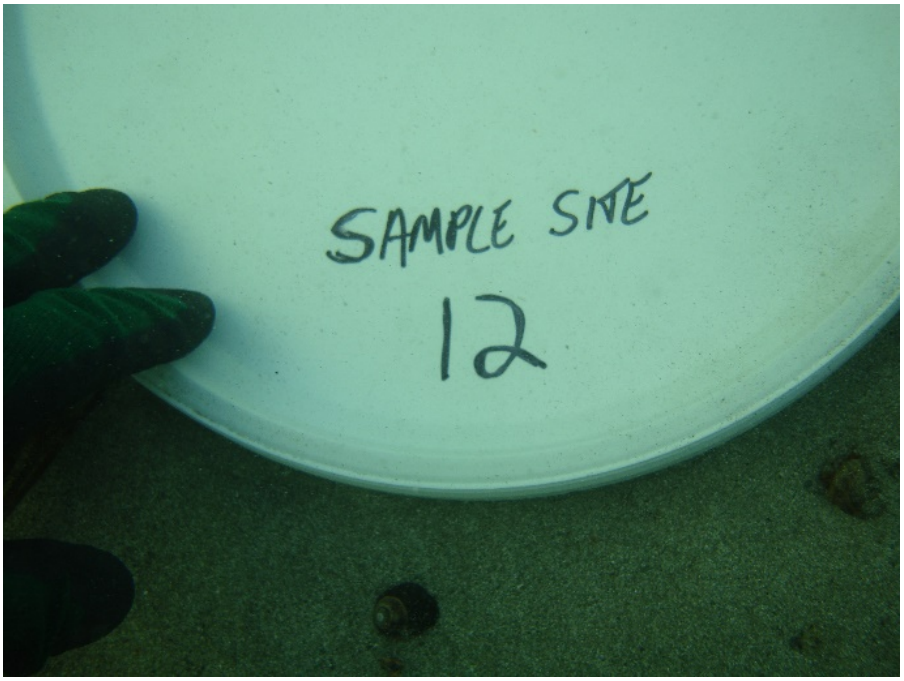


Figure **2**-**30** Location 12 –Sampling Location Image 1

Figure **2**-**31** Location 12 –Sampling Location Image 2

Figure **2**-**32** Location 12 –General Surrounding Seabed

3 LABORATORY ANALYSIS RESULTS

LABORATORY TEST CERTIFICATE

MATtest Limited
materials testing & consultancy

10 Queenslie Point
Queenslie Industrial Estate
120 Stepps Road
Glasgow
G33 3NQ

Tel: 0141 774 4032
Fax: 0141 774 3552

email: info@mattest.org
Website: www.mattest.org

Certificate No : **17/1006 - 01**

To : **Steven Lloyd**

Client : **Projects 46**
The Power House
Earsham Hall
Hall Road
Earsham
Bungay

Dear Sirs,

LABORATORY TESTING OF SOIL

Introduction

We refer to samples taken from Iona & Fionnphort - Sediment Sampling and delivered to our laboratory on 30th August 2017.

Material & Source

Sample Reference	:	See Report Plates
Sampled By	:	Client
Sampling Certificate	:	Not Supplied
Location	:	See Report Plates
Description	:	See Page 2
Date Sampled	:	Not Supplied
Date Tested	:	30th August 2017 Onwards
Source	:	Iona & Fionnphort - Sediment Sampling

Test Results;

As Detailed On Page 2 to Page 17 inclusive

Comments;

Opinions and interpretations expressed herein are outside the scope of UKAS accreditation
This report should not be reproduced except in full without the written approval of the laboratory
All remaining samples for this project will be disposed of 28 days after issue of this test certificate

Remarks;

Approved for Issue

T McLelland (Director)

Date 06/09/2017

UKAS TESTING
2643

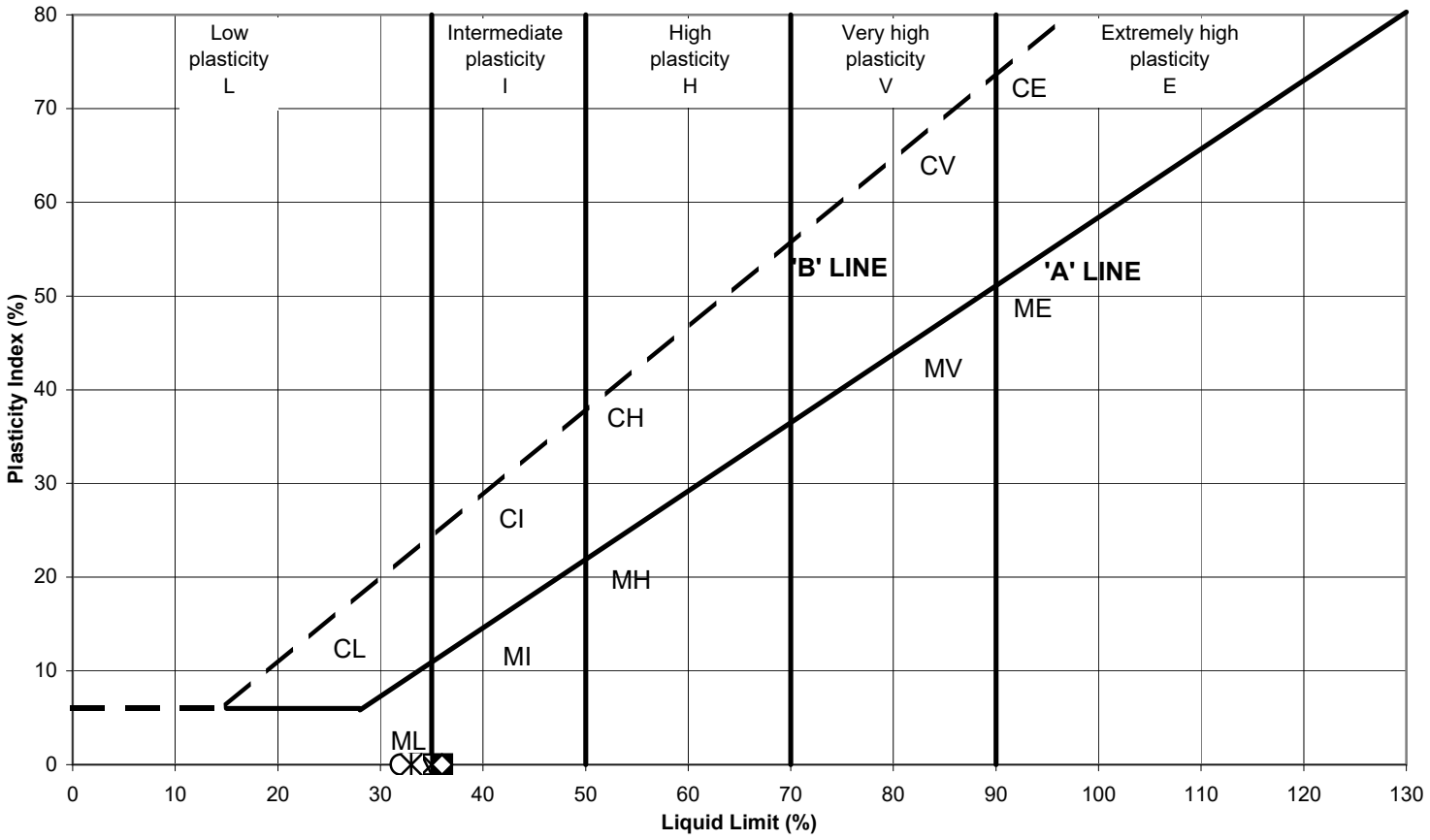
BOREHOLE	SAMPLE	DEPTH (m)	SAMPLE DESCRIPTION
-	1	-	Grey fine to medium SAND with pockets of seaweed and shell fragments.
-	2	-	Grey fine to coarse SAND and GRAVEL with pockets of seaweed and shell fragments.
-	3	-	Grey fine to coarse SAND with pockets of seaweed and shell fragments.
-	4	-	Grey very gravelly fine to coarse SAND with pockets of seaweed and shell fragments. Gravel is fine to medium.
-	5	-	Brown slightly gravelly fine to coarse SAND with pockets of seaweed and shell fragments. Gravel is fine.
-	6	-	Grey slightly gravelly fine to coarse SAND with pockets of seaweed and shell fragments. Gravel is fine.
-	7	-	Brown slightly gravelly fine to coarse SAND with pockets of seaweed and shell fragments. Gravel is fine.
-	8	-	Brown gravelly fine to coarse SAND with pockets of seaweed and shell fragments. Gravel is fine to medium.
-	9	-	Grey slightly gravelly fine to coarse SAND with pockets of seaweed and shell fragments. Gravel is fine to coarse.
-	10	-	Brown fine to coarse SAND and GRAVEL with pockets of seaweed and shell fragments.
-	11	-	Brown fine to coarse SAND with pockets of seaweed and shell fragments.
-	12	-	Grey gravelly fine to coarse SAND with pockets of seaweed and shell fragments. Gravel is fine to medium.

SUMMARY OF SAMPLE DESCRIPTIONS

BOREHOLE	SAMPLE	DEPTH (m)	MOISTURE CONTENT (%)
-	1	-	42
-	2	-	24
-	3	-	33
-	4	-	30
-	5	-	41
-	6	-	35
-	7	-	39
-	8	-	37
-	9	-	39
-	10	-	23
-	11	-	44
-	12	-	25

Tested in accordance with BS 1377: Part 2: 1990: Clause 3

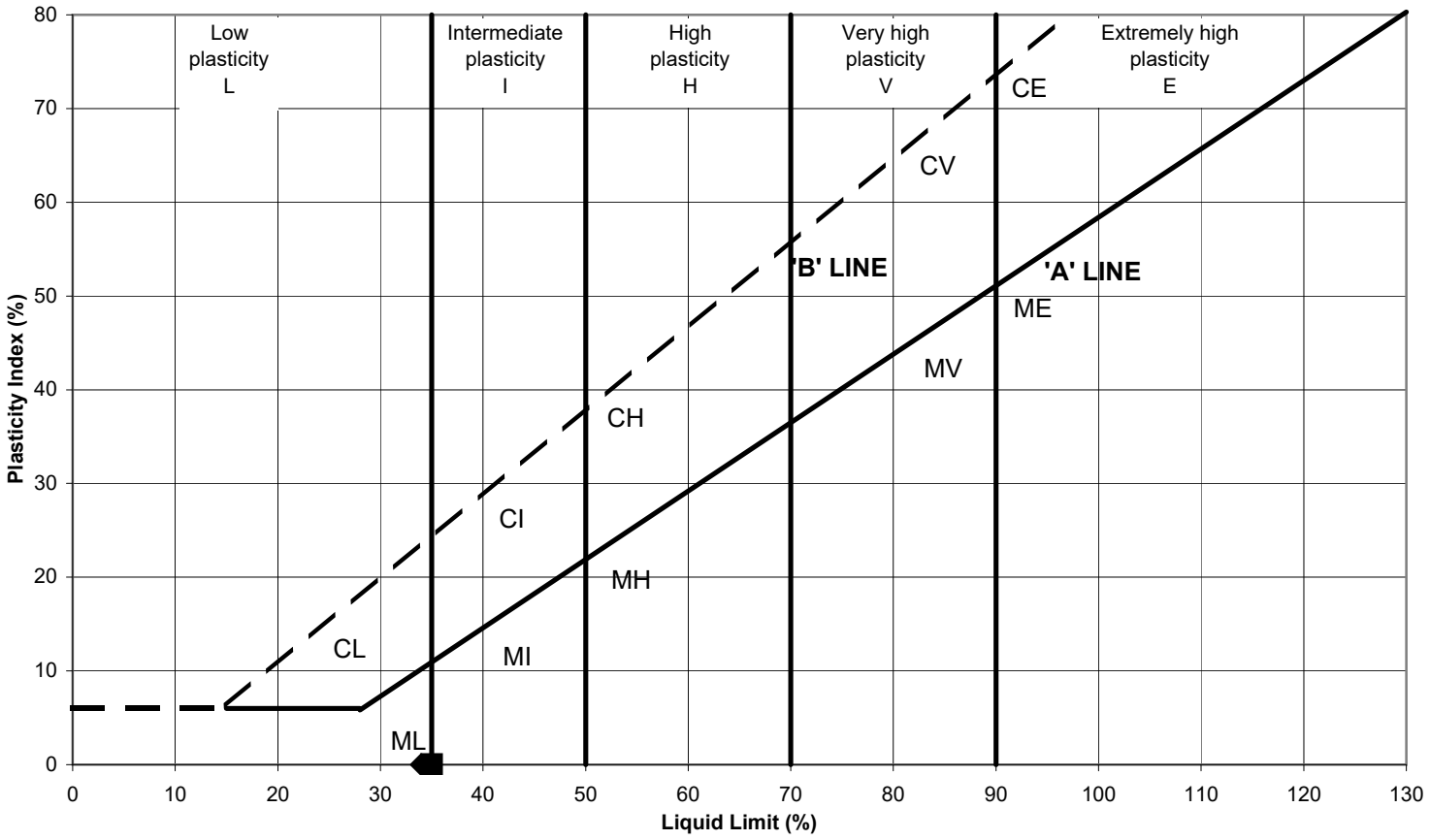
SUMMARY OF MOISTURE CONTENT TEST RESULTS



Symbol	Borehole	Sample	Depth	Moisture Content (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	% Passing 0.425mm Sieve	Remarks
■	-	1	-	42	36	Non Plastic	Non Plastic	99	
◆	-	2	-	24	34	Non Plastic	Non Plastic	21	
▲	-	3	-	33	33	Non Plastic	Non Plastic	98	
●	-	4	-	30	33	Non Plastic	Non Plastic	26	
□	-	5	-	41	34	Non Plastic	Non Plastic	26	
◇	-	6	-	35	36	Non Plastic	Non Plastic	93	
△	-	7	-	39	34	Non Plastic	Non Plastic	42	
○	-	8	-	37	32	Non Plastic	Non Plastic	37	
×	-	9	-	39	35	Non Plastic	Non Plastic	56	
✳	-	10	-	23	33	Non Plastic	Non Plastic	25	

All samples were tested in accordance with BS 1377 : Part 2 : 1990 Clause 4.3, 5.3 and 5.4.
All samples were washed on a 0.425mm test sieve prior to test.

SUMMARY OF ATTERBERG LIMITS TEST RESULTS



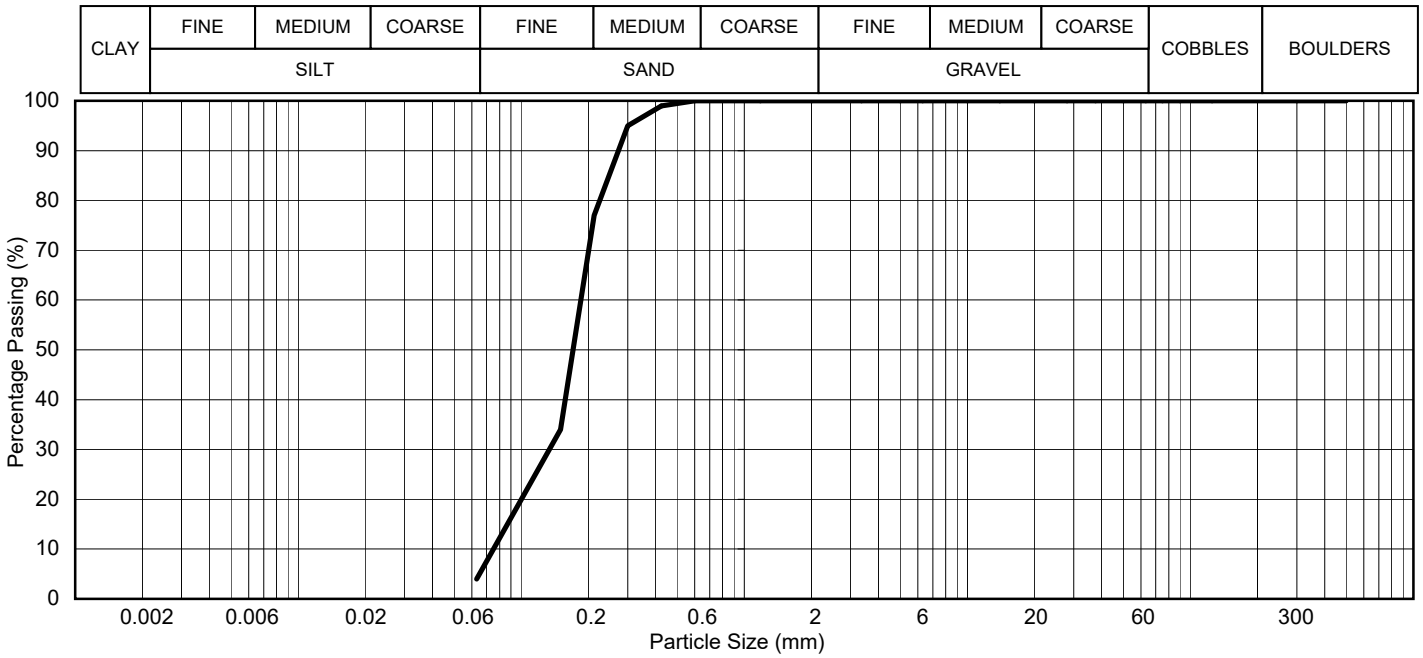
Symbol	Borehole	Sample	Depth	Moisture Content (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	% Passing 0.425mm Sieve	Remarks
■	-	11	-	44	35	Non Plastic	Non Plastic	61	
◆	-	12	-	25	34	Non Plastic	Non Plastic	72	
▲									
●									
□									
◇									
△									
○									
×									
✳									

All samples were tested in accordance with BS 1377 : Part 2 : 1990 Clause 4.3, 5.3 and 5.4.
All samples were washed on a 0.425mm test sieve prior to test.

SUMMARY OF ATTERBERG LIMITS TEST RESULTS

MATtest Limited
materials testing & consultancy

Borehole	-
Sample	1
Depth (m)	-



SIEVING				SEDIMENTATION	
Sieve Size (mm)	Percentage Passing (%)	Specification Not Applicable		Particle Size (mm)	Percentage Passing (%)
		Lower %	Upper %		
500.0	100	-	-	0.020	
300.0	100	-	-	0.006	
125.0	100	-	-	0.002	
90.0	100	-	-		
75.0	100	-	-	**GRADING CLASSIFICATION (SHW TABLE 6/2)**	
63.0	100	-	-	-	
50.0	100	-	-		
37.5	100	-	-	Grading classification proves the material has met the relevant grading requirements only. Further testing may be required to assess compliance with SHW.	
28.0	100	-	-		
20.0	100	-	-		
14.0	100	-	-		
10.0	100	-	-	**PERCENTAGE SOIL TYPES**	
6.30	100	-	-		
5.00	100	-	-		
3.35	100	-	-		
2.00	100	-	-		
1.18	100	-	-	**UNIFORMITY COEFFICIENT (SHW TABLE 6/1 NOTE 5)**	
0.600	100	-	-		
0.425	99	-	-		
0.300	95	-	-		
0.212	77	-	-		
0.150	34	-	-		
0.063	4	-	-		

CLAY	SILT ₸	SAND	GRAVEL	COBBLES
/	4	96	0	0

D10	D60	Specification
-	-	
UNIFORMITY COEFFICIENT	-	-

Remarks

₸ Where a sedimentation test was not carried out, this figure represents total fines, i.e., particles of diameter less than 63 microns

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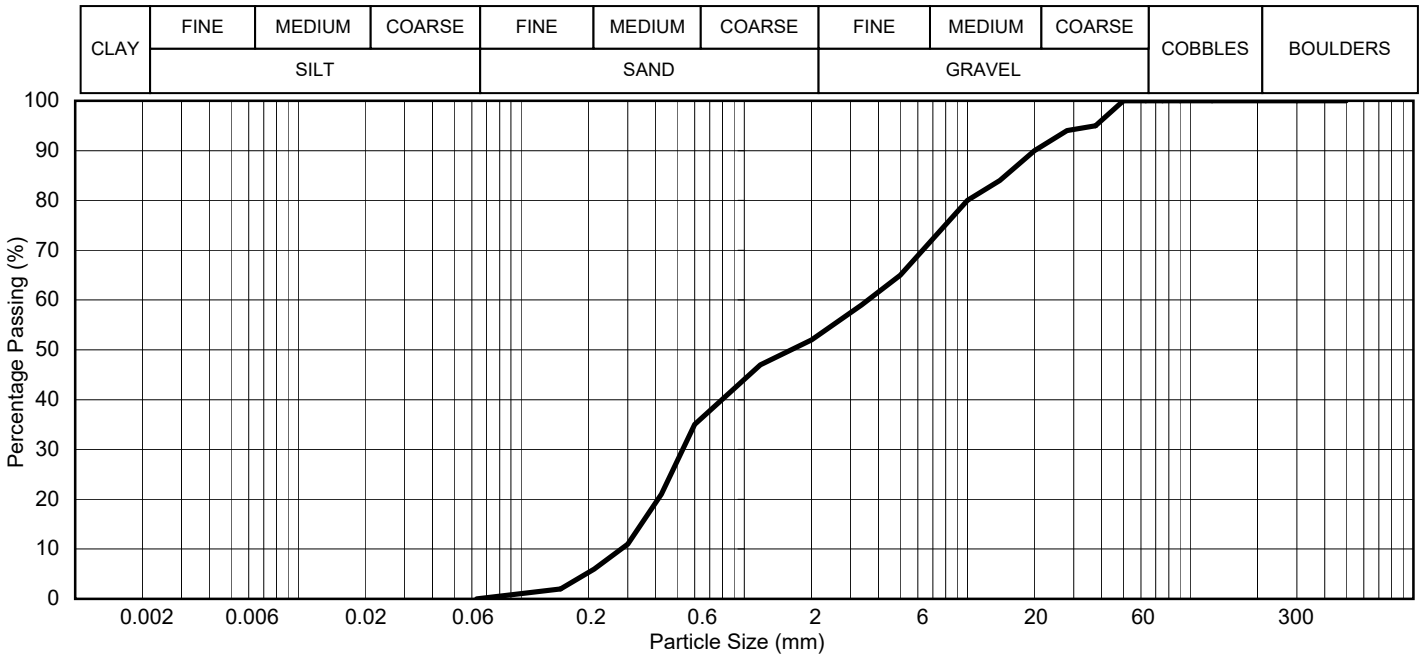
Borehole	-
Sample	2
Depth (m)	-



SIEVING				SEDIMENTATION	
Sieve Size (mm)	Percentage Passing (%)	Specification Not Applicable		Particle Size (mm)	Percentage Passing (%)
		Lower %	Upper %		
500.0	100	-	-	0.020	
300.0	100	-	-	0.006	
125.0	100	-	-	0.002	
90.0	100	-	-		
75.0	100	-	-	**GRADING CLASSIFICATION (SHW TABLE 6/2)**	
63.0	100	-	-	-	
50.0	100	-	-		
37.5	95	-	-	Grading classification proves the material has met the relevant grading requirements only. Further testing may be required to assess compliance with SHW.	
28.0	94	-	-		
20.0	90	-	-		
14.0	84	-	-		
10.0	80	-	-	**PERCENTAGE SOIL TYPES**	
6.30	70	-	-		
5.00	65	-	-		
3.35	59	-	-		
2.00	52	-	-		
1.18	47	-	-	**UNIFORMITY COEFFICIENT (SHW TABLE 6/1 NOTE 5)**	
0.600	35	-	-		
0.425	21	-	-		
0.300	11	-	-		
0.212	6	-	-		
0.150	2	-	-		
0.063	0	-	-		

CLAY	SILT Ŧ	SAND	GRAVEL	COBBLES
/	0	52	48	0

D10	D60	Specification
-	-	
UNIFORMITY COEFFICIENT	-	-

Remarks

Ŧ Where a sedimentation test was not carried out, this figure represents total fines, i.e., particles of diameter less than 63 microns

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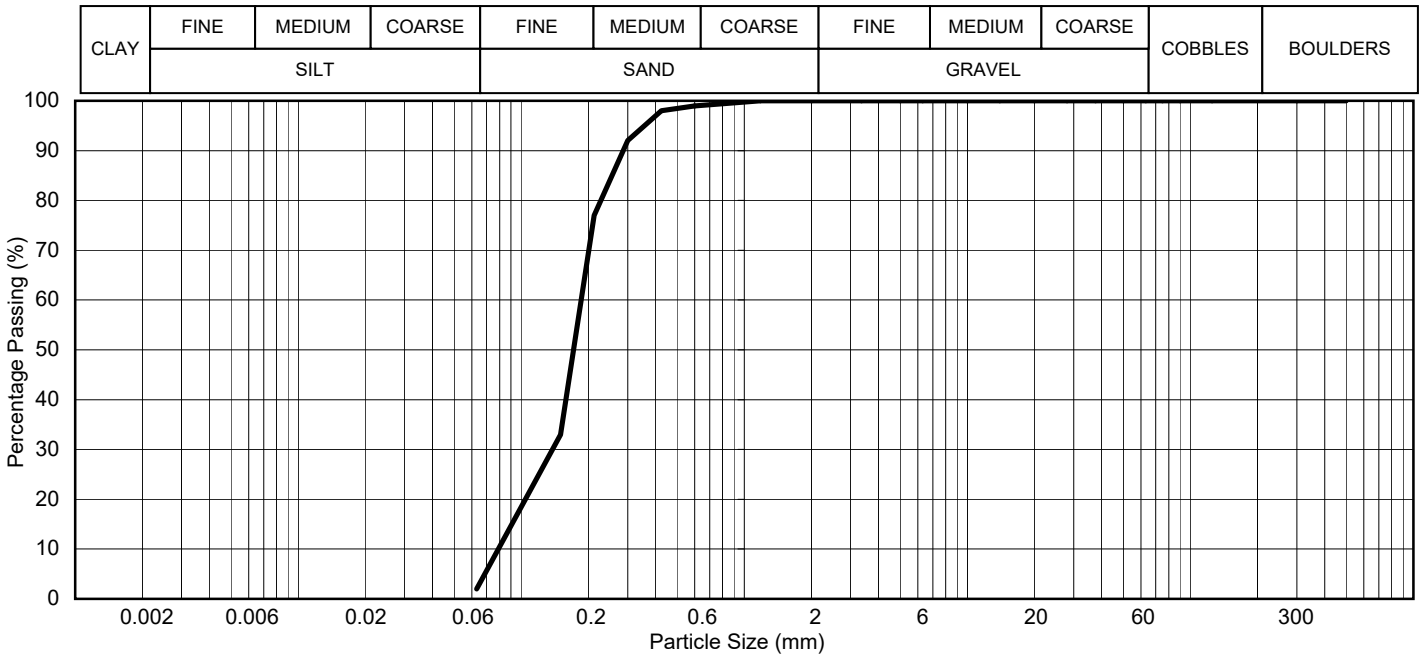
Borehole	-
Sample	3
Depth (m)	-



SIEVING				SEDIMENTATION	
Sieve Size (mm)	Percentage Passing (%)	Specification Not Applicable		Particle Size (mm)	Percentage Passing (%)
		Lower %	Upper %		
500.0	100	-	-	0.020	
300.0	100	-	-	0.006	
125.0	100	-	-	0.002	
90.0	100	-	-		
75.0	100	-	-	**GRADING CLASSIFICATION (SHW TABLE 6/2)**	
63.0	100	-	-	-	
50.0	100	-	-		
37.5	100	-	-	Grading classification proves the material has met the relevant grading requirements only. Further testing may be required to assess compliance with SHW.	
28.0	100	-	-		
20.0	100	-	-		
14.0	100	-	-		
10.0	100	-	-	**PERCENTAGE SOIL TYPES**	
6.30	100	-	-		
5.00	100	-	-		
3.35	100	-	-		
2.00	100	-	-		
1.18	100	-	-	**UNIFORMITY COEFFICIENT (SHW TABLE 6/1 NOTE 5)**	
0.600	99	-	-		
0.425	98	-	-		
0.300	92	-	-		
0.212	77	-	-		
0.150	33	-	-		
0.063	2	-	-		

CLAY	SILT ₸	SAND	GRAVEL	COBBLES
/	2	98	0	0

D10	D60	Specification
-	-	
UNIFORMITY COEFFICIENT	-	-

Remarks

₸ Where a sedimentation test was not carried out, this figure represents total fines, i.e., particles of diameter less than 63 microns

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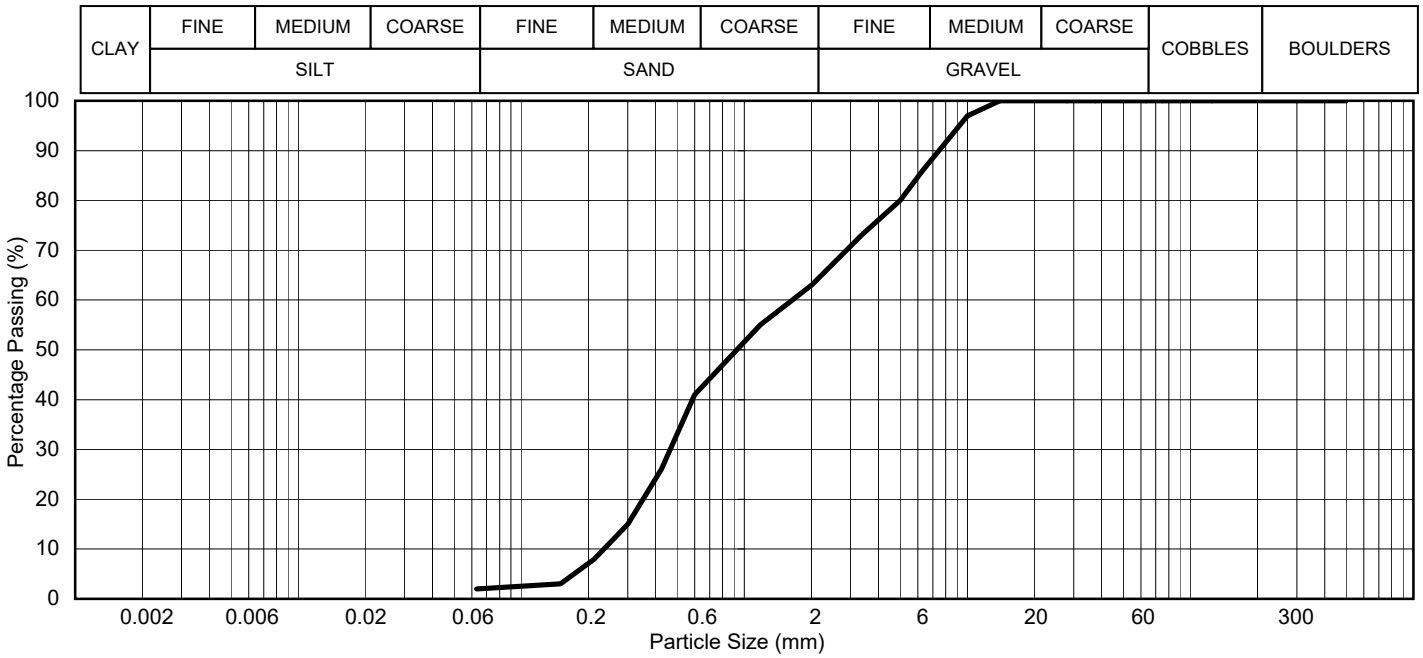
Borehole	-
Sample	4
Depth (m)	-



SIEVING				SEDIMENTATION	
Sieve Size (mm)	Percentage Passing (%)	Specification Not Applicable		Particle Size (mm)	Percentage Passing (%)
		Lower %	Upper %		
500.0	100	-	-	0.020	
300.0	100	-	-	0.006	
125.0	100	-	-	0.002	
90.0	100	-	-		
75.0	100	-	-	**GRADING CLASSIFICATION (SHW TABLE 6/2)**	
63.0	100	-	-	-	
50.0	100	-	-		
37.5	100	-	-	Grading classification proves the material has met the relevant grading requirements only. Further testing may be required to assess compliance with SHW.	
28.0	100	-	-		
20.0	100	-	-		
14.0	100	-	-		
10.0	97	-	-	**PERCENTAGE SOIL TYPES**	
6.30	86	-	-		
5.00	80	-	-		
3.35	73	-	-		
2.00	63	-	-		
1.18	55	-	-	**UNIFORMITY COEFFICIENT (SHW TABLE 6/1 NOTE 5)**	
0.600	41	-	-		
0.425	26	-	-		
0.300	15	-	-		
0.212	8	-	-		
0.150	3	-	-		
0.063	2	-	-		

CLAY	SILT ₸	SAND	GRAVEL	COBBLES
/	2	61	37	0

D10	D60	Specification
-	-	
UNIFORMITY COEFFICIENT	-	-

Remarks

₸ Where a sedimentation test was not carried out, this figure represents total fines, i.e., particles of diameter less than 63 microns

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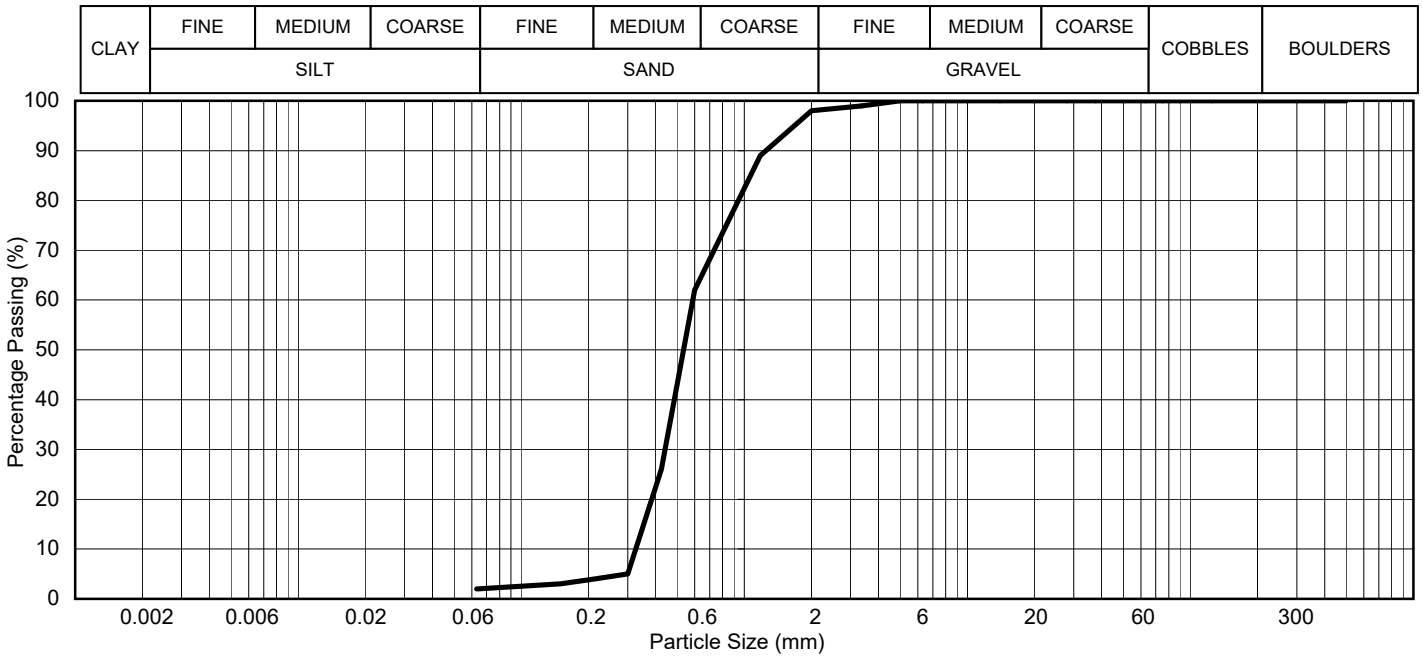
Borehole	-
Sample	5
Depth (m)	-



SIEVING				SEDIMENTATION	
Sieve Size (mm)	Percentage Passing (%)	Specification Not Applicable		Particle Size (mm)	Percentage Passing (%)
		Lower %	Upper %		
500.0	100	-	-	0.020	
300.0	100	-	-	0.006	
125.0	100	-	-	0.002	
90.0	100	-	-		
75.0	100	-	-	**GRADING CLASSIFICATION (SHW TABLE 6/2)**	
63.0	100	-	-	-	
50.0	100	-	-		
37.5	100	-	-	Grading classification proves the material has met the relevant grading requirements only. Further testing may be required to assess compliance with SHW.	
28.0	100	-	-		
20.0	100	-	-		
14.0	100	-	-		
10.0	100	-	-	**PERCENTAGE SOIL TYPES**	
6.30	100	-	-		
5.00	100	-	-		
3.35	99	-	-		
2.00	98	-	-		
1.18	89	-	-	**UNIFORMITY COEFFICIENT (SHW TABLE 6/1 NOTE 5)**	
0.600	62	-	-		
0.425	26	-	-		
0.300	5	-	-		
0.212	4	-	-		
0.150	3	-	-		
0.063	2	-	-		

CLAY	SILT ₸	SAND	GRAVEL	COBBLES
/	2	96	2	0

D10	D60	Specification
-	-	
UNIFORMITY COEFFICIENT	-	-

Remarks

₸ Where a sedimentation test was not carried out, this figure represents total fines, i.e., particles of diameter less than 63 microns

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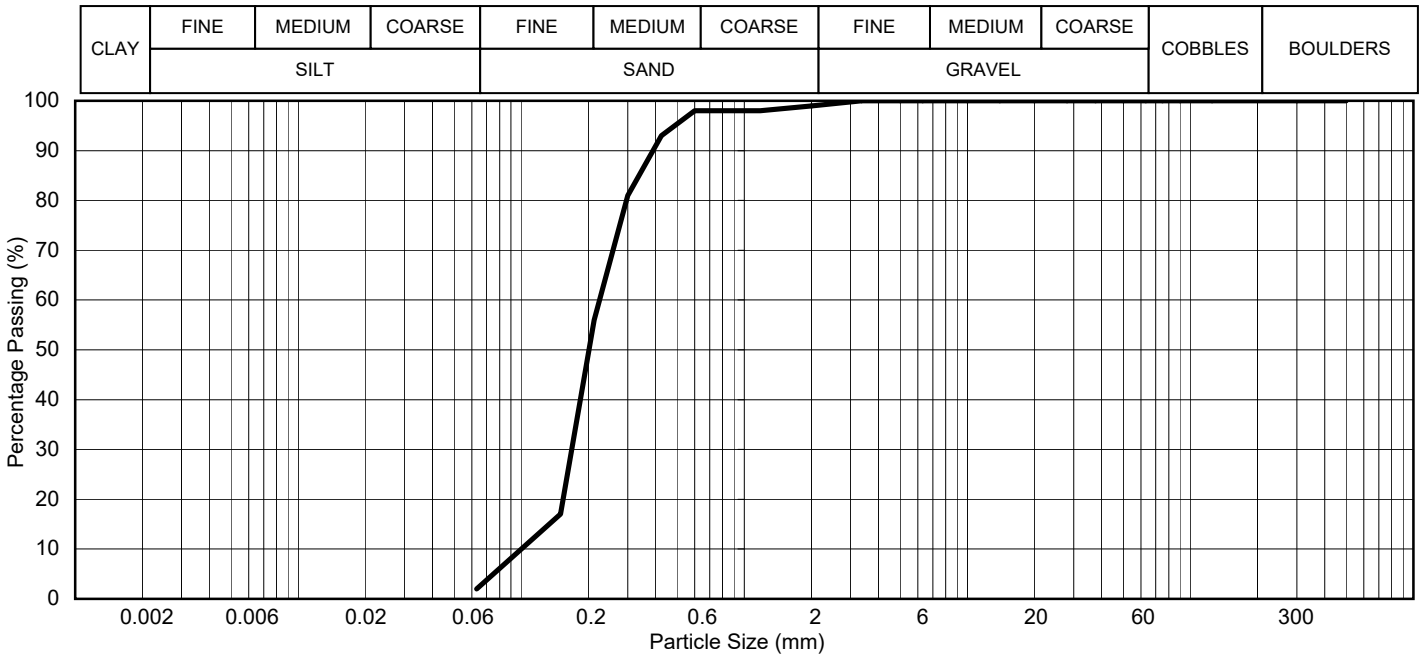
Borehole	-
Sample	6
Depth (m)	-



SIEVING				SEDIMENTATION	
Sieve Size (mm)	Percentage Passing (%)	Specification Not Applicable		Particle Size (mm)	Percentage Passing (%)
		Lower %	Upper %		
500.0	100	-	-	0.020	
300.0	100	-	-	0.006	
125.0	100	-	-	0.002	
90.0	100	-	-		
75.0	100	-	-	**GRADING CLASSIFICATION (SHW TABLE 6/2)**	
63.0	100	-	-	-	
50.0	100	-	-		
37.5	100	-	-	Grading classification proves the material has met the relevant grading requirements only. Further testing may be required to assess compliance with SHW.	
28.0	100	-	-		
20.0	100	-	-		
14.0	100	-	-		
10.0	100	-	-	**PERCENTAGE SOIL TYPES**	
6.30	100	-	-		
5.00	100	-	-		
3.35	100	-	-		
2.00	99	-	-		
1.18	98	-	-	**UNIFORMITY COEFFICIENT (SHW TABLE 6/1 NOTE 5)**	
0.600	98	-	-		
0.425	93	-	-		
0.300	81	-	-		
0.212	56	-	-		
0.150	17	-	-		
0.063	2	-	-		

CLAY	SILT ₸	SAND	GRAVEL	COBBLES
/	2	97	1	0

D10	D60	Specification
-	-	
UNIFORMITY COEFFICIENT	-	-

Remarks

₸ Where a sedimentation test was not carried out, this figure represents total fines, i.e., particles of diameter less than 63 microns

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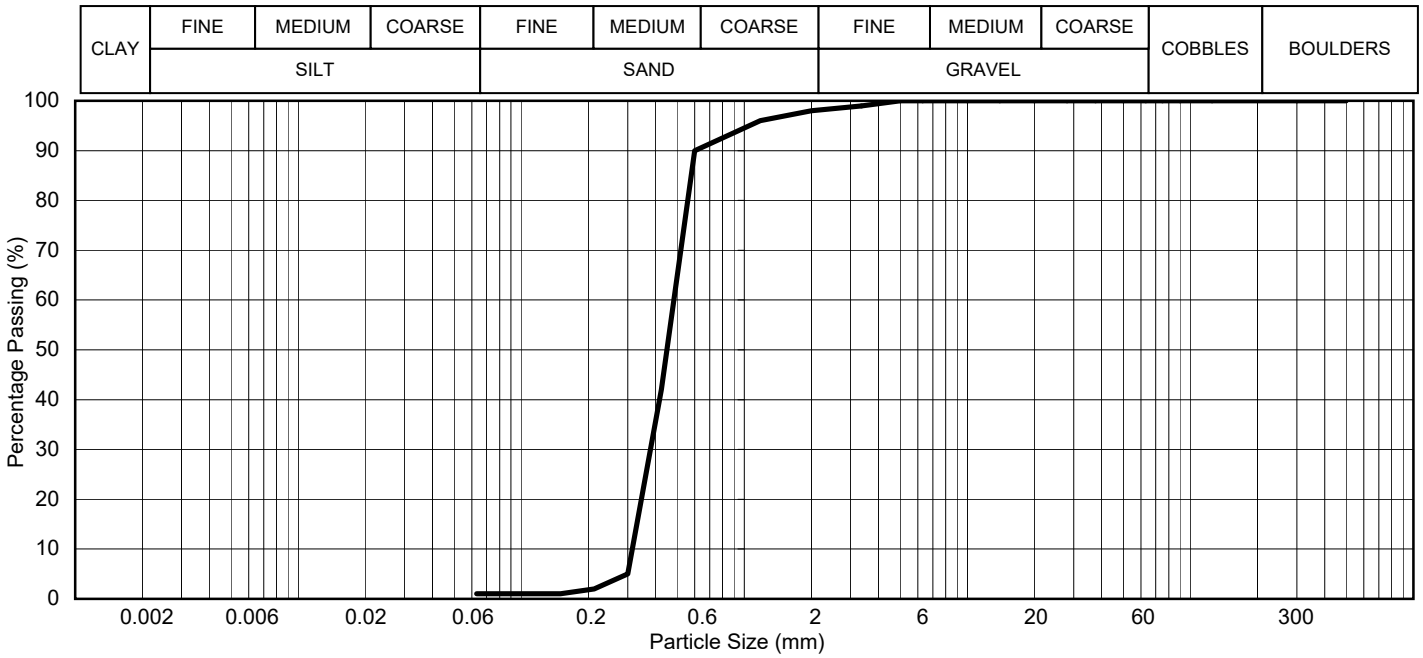
Borehole	-
Sample	7
Depth (m)	-



SIEVING				SEDIMENTATION	
Sieve Size (mm)	Percentage Passing (%)	Specification Not Applicable		Particle Size (mm)	Percentage Passing (%)
		Lower %	Upper %		
500.0	100	-	-	0.020	
300.0	100	-	-	0.006	
125.0	100	-	-	0.002	
90.0	100	-	-		
75.0	100	-	-	**GRADING CLASSIFICATION (SHW TABLE 6/2)**	
63.0	100	-	-	-	
50.0	100	-	-		
37.5	100	-	-	Grading classification proves the material has met the relevant grading requirements only. Further testing may be required to assess compliance with SHW.	
28.0	100	-	-		
20.0	100	-	-		
14.0	100	-	-		
10.0	100	-	-	**PERCENTAGE SOIL TYPES**	
6.30	100	-	-	**CLAY** / **SILT Ŧ** / **SAND** / **GRAVEL** / **COBBLES**	
5.00	100	-	-		
3.35	99	-	-	/ 1 97 2 0	
2.00	98	-	-		
1.18	96	-	-	**UNIFORMITY COEFFICIENT (SHW TABLE 6/1 NOTE 5)**	
0.600	90	-	-	**D10** / **D60** / **Specification**	
0.425	42	-	-		
0.300	5	-	-	- -	
0.212	2	-	-	**UNIFORMITY COEFFICIENT** - -	
0.150	1	-	-		
0.063	1	-	-		

Remarks

Ŧ Where a sedimentation test was not carried out, this figure represents total fines, i.e., particles of diameter less than 63 microns

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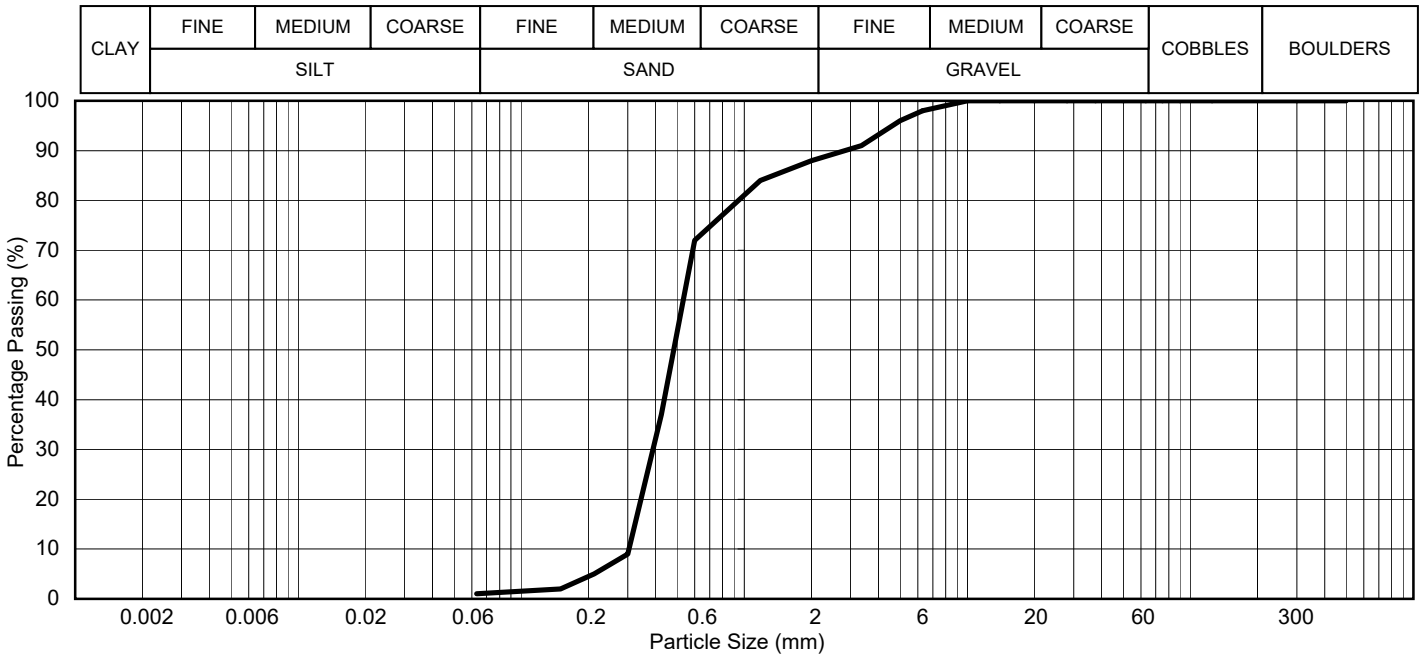
Borehole	-
Sample	8
Depth (m)	-



SIEVING				SEDIMENTATION	
Sieve Size (mm)	Percentage Passing (%)	Specification Not Applicable		Particle Size (mm)	Percentage Passing (%)
		Lower %	Upper %		
500.0	100	-	-	0.020	
300.0	100	-	-	0.006	
125.0	100	-	-	0.002	
90.0	100	-	-		
75.0	100	-	-	**GRADING CLASSIFICATION (SHW TABLE 6/2)**	
63.0	100	-	-	-	
50.0	100	-	-		
37.5	100	-	-	Grading classification proves the material has met the relevant grading requirements only. Further testing may be required to assess compliance with SHW.	
28.0	100	-	-		
20.0	100	-	-		
14.0	100	-	-		
10.0	100	-	-	**PERCENTAGE SOIL TYPES**	
6.30	98	-	-		
5.00	96	-	-		
3.35	91	-	-		
2.00	88	-	-		
1.18	84	-	-	**UNIFORMITY COEFFICIENT (SHW TABLE 6/1 NOTE 5)**	
0.600	72	-	-		
0.425	37	-	-		
0.300	9	-	-		
0.212	5	-	-		
0.150	2	-	-		
0.063	1	-	-		

CLAY	SILT ₸	SAND	GRAVEL	COBBLES
/	1	87	12	0

D10	D60	Specification
-	-	
UNIFORMITY COEFFICIENT	-	-

Remarks

₸ Where a sedimentation test was not carried out, this figure represents total fines, i.e., particles of diameter less than 63 microns

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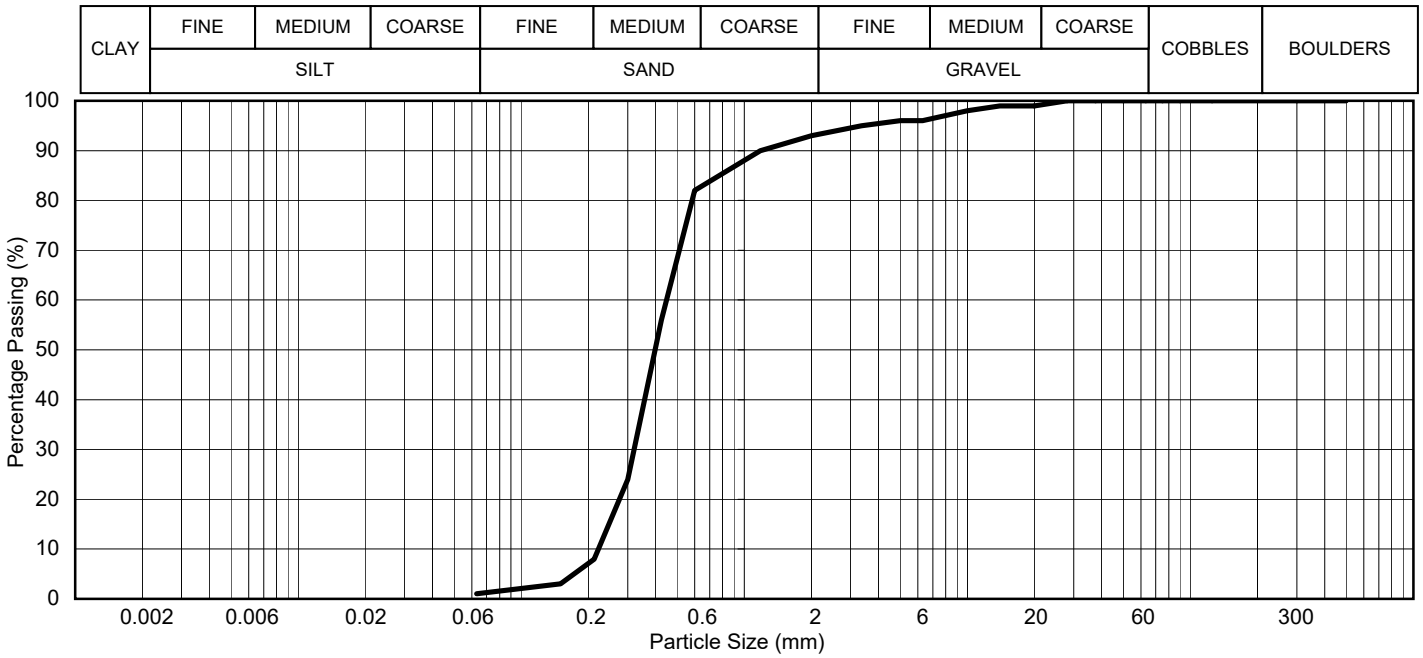
Borehole	-
Sample	9
Depth (m)	-



SIEVING				SEDIMENTATION	
Sieve Size (mm)	Percentage Passing (%)	Specification Not Applicable		Particle Size (mm)	Percentage Passing (%)
		Lower %	Upper %		
500.0	100	-	-	0.020	
300.0	100	-	-	0.006	
125.0	100	-	-	0.002	
90.0	100	-	-		
75.0	100	-	-	**GRADING CLASSIFICATION (SHW TABLE 6/2)**	
63.0	100	-	-	-	
50.0	100	-	-		
37.5	100	-	-	Grading classification proves the material has met the relevant grading requirements only. Further testing may be required to assess compliance with SHW.	
28.0	100	-	-		
20.0	99	-	-		
14.0	99	-	-		
10.0	98	-	-	**PERCENTAGE SOIL TYPES**	
6.30	96	-	-	**CLAY** / **SILT Ŧ** / **SAND** / **GRAVEL** / **COBBLES**	
5.00	96	-	-		
3.35	95	-	-	/ 1 92 7 0	
2.00	93	-	-		
1.18	90	-	-	**UNIFORMITY COEFFICIENT (SHW TABLE 6/1 NOTE 5)**	
0.600	82	-	-	**D10** / **D60** / **Specification**	
0.425	56	-	-		
0.300	24	-	-	- / -	
0.212	8	-	-	**UNIFORMITY COEFFICIENT** - / -	
0.150	3	-	-		
0.063	1	-	-		

Remarks

Ŧ Where a sedimentation test was not carried out, this figure represents total fines, i.e., particles of diameter less than 63 microns

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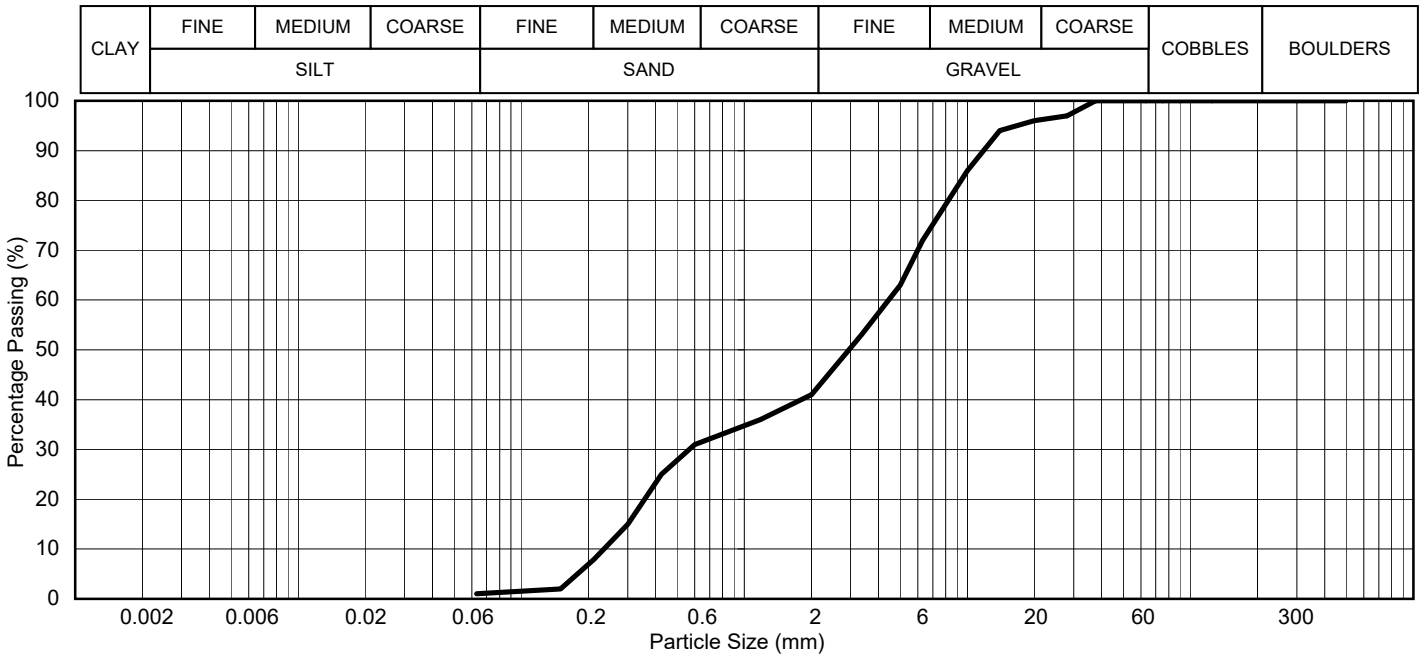
Borehole	-
Sample	10
Depth (m)	-



SIEVING				SEDIMENTATION	
Sieve Size (mm)	Percentage Passing (%)	Specification Not Applicable		Particle Size (mm)	Percentage Passing (%)
		Lower %	Upper %		
500.0	100	-	-	0.020	
300.0	100	-	-	0.006	
125.0	100	-	-	0.002	
90.0	100	-	-		
75.0	100	-	-	**GRADING CLASSIFICATION (SHW TABLE 6/2)**	
63.0	100	-	-	-	
50.0	100	-	-		
37.5	100	-	-	Grading classification proves the material has met the relevant grading requirements only. Further testing may be required to assess compliance with SHW.	
28.0	97	-	-		
20.0	96	-	-		
14.0	94	-	-		
10.0	86	-	-	**PERCENTAGE SOIL TYPES**	
6.30	72	-	-		
5.00	63	-	-		
3.35	53	-	-		
2.00	41	-	-		
1.18	36	-	-	**UNIFORMITY COEFFICIENT (SHW TABLE 6/1 NOTE 5)**	
0.600	31	-	-		
0.425	25	-	-		
0.300	15	-	-		
0.212	8	-	-		
0.150	2	-	-		
0.063	1	-	-		

CLAY	SILT ₸	SAND	GRAVEL	COBBLES
/	1	40	59	0

D10	D60	Specification
-	-	
UNIFORMITY COEFFICIENT	-	-

Remarks

₸ Where a sedimentation test was not carried out, this figure represents total fines, i.e., particles of diameter less than 63 microns

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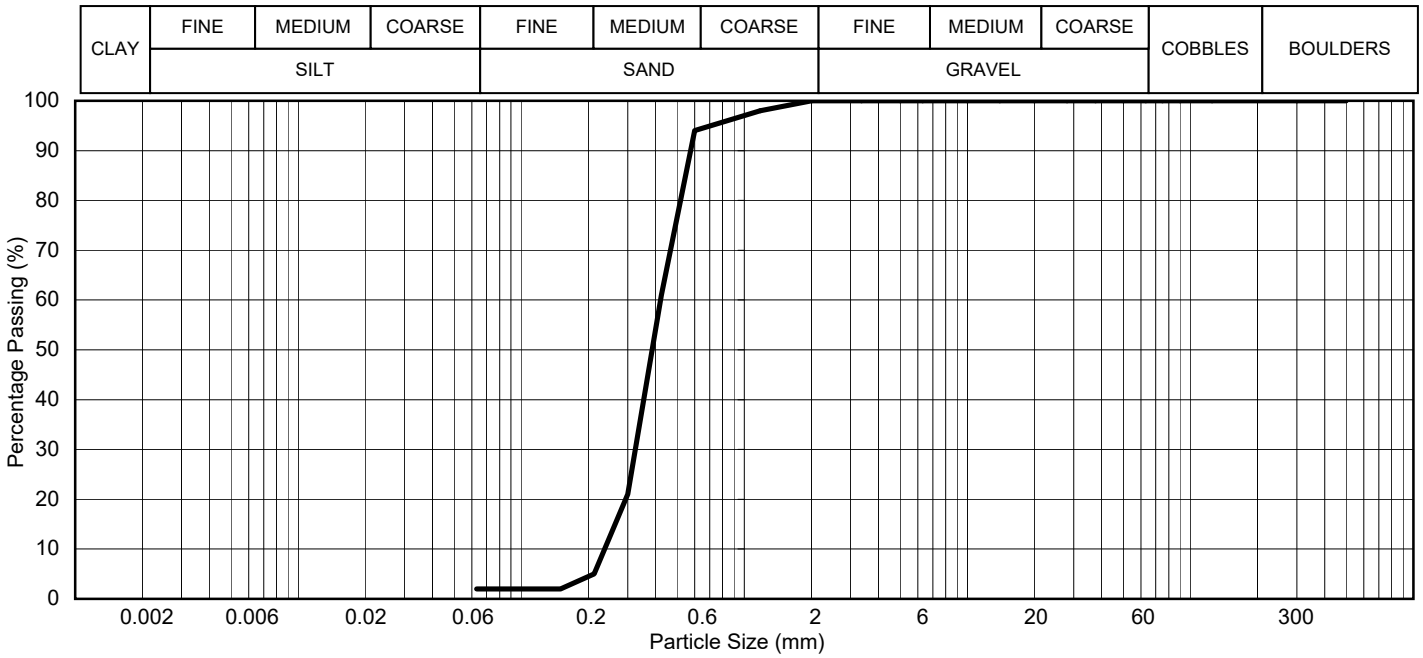
Borehole	-
Sample	11
Depth (m)	-



SIEVING				SEDIMENTATION	
Sieve Size (mm)	Percentage Passing (%)	Specification Not Applicable		Particle Size (mm)	Percentage Passing (%)
		Lower %	Upper %		
500.0	100	-	-	0.020	
300.0	100	-	-	0.006	
125.0	100	-	-	0.002	
90.0	100	-	-		
75.0	100	-	-	**GRADING CLASSIFICATION (SHW TABLE 6/2)**	
63.0	100	-	-	-	
50.0	100	-	-		
37.5	100	-	-	Grading classification proves the material has met the relevant grading requirements only. Further testing may be required to assess compliance with SHW.	
28.0	100	-	-		
20.0	100	-	-		
14.0	100	-	-		
10.0	100	-	-	**PERCENTAGE SOIL TYPES**	
6.30	100	-	-		
5.00	100	-	-		
3.35	100	-	-		
2.00	100	-	-		
1.18	98	-	-	**UNIFORMITY COEFFICIENT (SHW TABLE 6/1 NOTE 5)**	
0.600	94	-	-		
0.425	61	-	-		
0.300	21	-	-		
0.212	5	-	-		
0.150	2	-	-		
0.063	2	-	-		

CLAY	SILT ₸	SAND	GRAVEL	COBBLES
/	2	98	0	0

D10	D60	Specification
-	-	
UNIFORMITY COEFFICIENT	-	-

Remarks

₸ Where a sedimentation test was not carried out, this figure represents total fines, i.e., particles of diameter less than 63 microns

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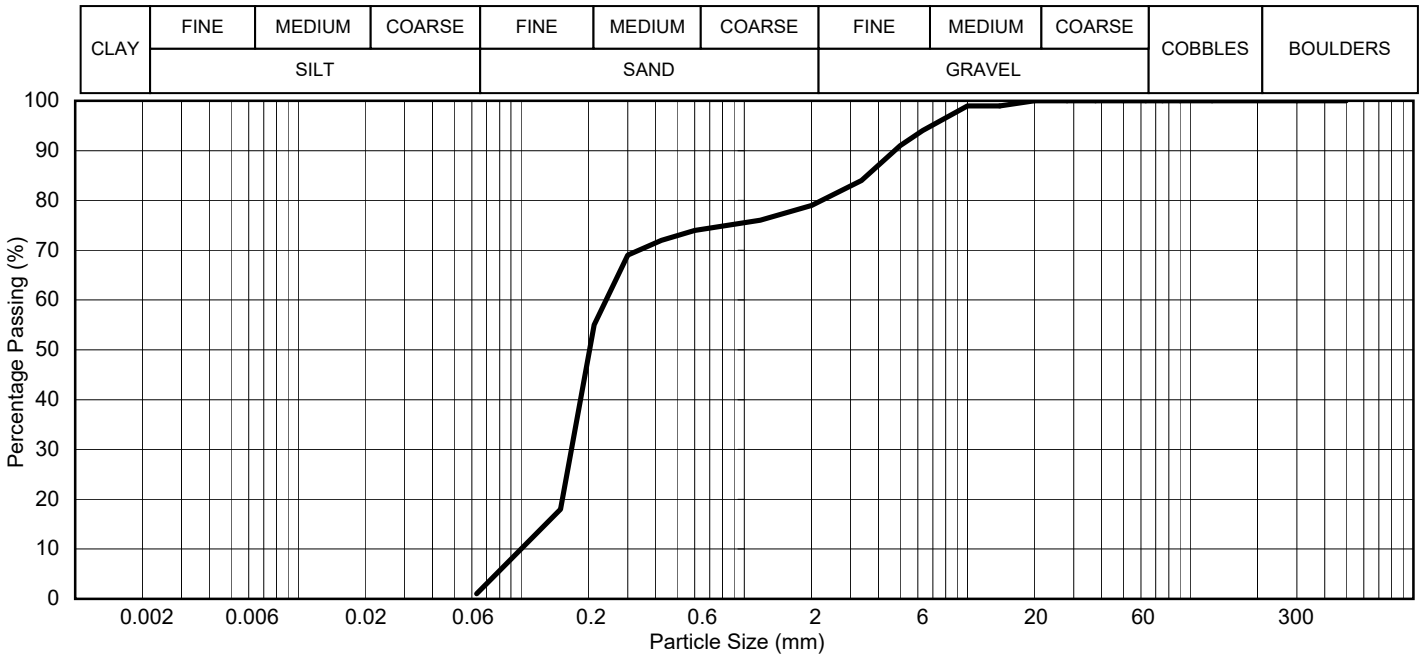
Borehole	-
Sample	12
Depth (m)	-



SIEVING				SEDIMENTATION	
Sieve Size (mm)	Percentage Passing (%)	Specification Not Applicable		Particle Size (mm)	Percentage Passing (%)
		Lower %	Upper %		
500.0	100	-	-	0.020	
300.0	100	-	-	0.006	
125.0	100	-	-	0.002	
90.0	100	-	-		
75.0	100	-	-	**GRADING CLASSIFICATION (SHW TABLE 6/2)**	
63.0	100	-	-	-	
50.0	100	-	-		
37.5	100	-	-	Grading classification proves the material has met the relevant grading requirements only. Further testing may be required to assess compliance with SHW.	
28.0	100	-	-		
20.0	100	-	-		
14.0	99	-	-		
10.0	99	-	-	**PERCENTAGE SOIL TYPES**	
6.30	94	-	-		
5.00	91	-	-		
3.35	84	-	-		
2.00	79	-	-		
1.18	76	-	-	**UNIFORMITY COEFFICIENT (SHW TABLE 6/1 NOTE 5)**	
0.600	74	-	-		
0.425	72	-	-		
0.300	69	-	-		
0.212	55	-	-		
0.150	18	-	-		
0.063	1	-	-		

CLAY	SILT ₸	SAND	GRAVEL	COBBLES
/	1	78	21	0

D10	D60	Specification
-	-	
UNIFORMITY COEFFICIENT	-	-

Remarks

₸ Where a sedimentation test was not carried out, this figure represents total fines, i.e., particles of diameter less than 63 microns

Appendix B – Ground Investigation Results

Fionnphort and Iona – Ground Investigation

INTERPRETATIVE REPORT

Client:	Argyll and Bute Council
Client's Representative:	Cronin Millar (BLP)
Report No.:	18-0144 Interpretative
Date:	12 November 2018
Status:	Final for Issue

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Approved: ISO 9001 • ISO 14001 • OHSAS 18001

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APPENDICES

Appendix A	Site and exploratory hole location plans
Appendix B	Borehole logs
Appendix C	Core photographs
Appendix D	Geotechnical laboratory test results
Appendix E	Marine geophysical survey results (Aspect Surveys)
Appendix F	Geological long sections
Appendix G	SPT hammer energy measurement report

Document Control Sheet

Report No.:		18-0144			
Project Title:		Fionnphort and Iona – Ground Investigation INTERPRETATIVE REPORT			
Client:		Argyll and Bute Council			
Client's Representative:		Cronin Millar (BLP)			
Revision:	A00	**Status:**	Final for Issue	**Issue Date:**	12 November 2018
Prepared by:		**Reviewed by:**		**Approved by:**	
[redacted]					

The works were conducted in accordance with:

UK Specification for Ground Investigation 2nd Edition, published by ICE Publishing (2012)

British Standards Institute (2015) BS 5930:2015, Code of practice for site investigations.

Laboratory testing was conducted in accordance with:

British Standards Institute BS 1377-2:1990, BS EN ISO 17892-1:2014, and BS EN ISO 17892-2:2014

METHODS OF DESCRIBING SOILS AND ROCKS

Soil and rock descriptions are based on the guidance in BS5930:2015, The Code of Practice for Site Investigation.

Abbreviations used on exploratory hole logs	
U	Nominal 100mm diameter undisturbed open tube sample (thick walled sampler)
UT	Nominal 100mm diameter undisturbed open tube sample (thin walled sampler)
P	Nominal 100mm diameter undisturbed piston sample
B	Bulk disturbed sample
LB	Large bulk disturbed sample
D	Small disturbed sample
C	Core sub-sample (displayed in the Field Records column on the logs)
L	Liner sample from dynamic sampled borehole
W	Water sample
ES / EW	Soil sample for environmental testing / Water sample for environmental testing
SPT (s)	Standard penetration test using a split spoon sampler (small disturbed sample obtained)
SPT (c)	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. The length achieved is stated (mm) for any test increment less than 75mm
N=X	SPT blow count 'N' given by the summation of the blows 'X' required to drive the full test length (300mm)
N=X/Z	Incomplete standard penetration test where the full test length was not achieved. The blows 'X' represent the total blows for the given test length 'Z' (mm)
V VR	Shear vane test (borehole) Hand vane test (trial pit) Shear strength stated in kPa V: undisturbed vane shear strength VR: remoulded vane shear strength
dd/mm/yy: 1.0 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: 2015	
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.
AZCL	Assessed zone of core loss: The estimated depth range where core was not recovered.
DIF	Drilling induced fracture: A fracture of non-geological origin brought about by the rock coring.

Fionnphort and Iona

1 AUTHORITY

On the instructions of Cronin Millar (BLP) Consulting Engineers, ("the Client's Representative"), acting on the behalf of Argyll and Bute Council ("the Client"), a ground investigation was undertaken at the above location to provide geotechnical information to support the design and construction of new sea protection measures at Fionnphort and Iona, and an overnight berth/pier structure at Fionnphort, on the Isle of Mull.

This report details the work carried out both on site and in the geotechnical testing laboratories; it contains a description of the site and the works undertaken, the exploratory hole logs and the laboratory test results. A discussion on the recommendations for construction is also provided.

All information given in this report is based upon the ground conditions encountered during the site investigation works, and on the results of the laboratory and field tests performed. However, there may be conditions at the site that have not been taken into account, such as unpredictable soil strata, contaminant concentrations, and water conditions between or below exploratory holes. It should be noted that groundwater levels usually vary due to seasonal and/or other effects and may at times differ to those recorded during the investigation. No responsibility can be taken for conditions not encountered through the scope of work commissioned, for example between exploratory hole points, or beneath the termination depths achieved.

This report was prepared by Causeway Geotech Ltd for the use of the Client and the Client's Representative in response to a particular set of instructions. Any other parties using the information contained in this report do so at their own risk and any duty of care to those parties is excluded.

2 SCOPE

The extent of the investigation, as instructed by the Client's Representative, included marine boreholes, soil sampling, in-situ and laboratory testing, marine geophysical surveys, and the preparation of a report on the findings including recommendations for construction.

3 DESCRIPTION OF SITE

As shown on the site location plans in Appendix A, the works were conducted around the location of the existing Caledonian MacBrayne ferry terminals/slipways in Fionnphort and Iona.

The boreholes were put down at given locations within the Sound of Iona adjacent to the ferry terminals/slipways and associated piers.

4 SITE OPERATIONS

4.1 Summary of site works

Site operations, which were conducted between 2nd and 30th August 2018 comprised:

- Thirteen marine boreholes with rotary follow-on
- Soil and rock core sampling
- In-situ testing of soils
- Geotechnical laboratory testing
- Geophysical Surveys (multi-beam bathymetry and sub bottom profiling)

The exploratory holes and in-situ tests were located as instructed by the Client's Representative, as shown on the exploratory hole location plans in Appendix A.

4.2 Marine Plant

The OCM50 jack-up barge was deployed for the duration of the site works. OCM50 is a Combi-float C5 modular jack-up barge in an eight-pontoon configuration joined and secured with a simple pinning system. The jack-up barge sits on four 18m spudded legs with associated hydraulic rams and can be operated in both spudded (floating) or jack-up modes.

The barge was contracted and operated through Ocean Crest Marine for the duration of the site works. Boreholes were sunk through an integral moonpool through one of the pontoons which make up the main deck of the jack-up barge.

Ocean Crest Marine also provided the marine support vessels OCM Supporter to assist with crew transfers and barge movement.

4.3 Boreholes

4.3.1 Boreholes by combined percussion boring and rotary follow-on drilling

Thirteen boreholes (BH01-BH09, BH09A, and BH10-BH12) were put down by a combination of light cable percussion boring and rotary follow-on drilling techniques with core recovery in bedrock. Where the cable percussion borehole had not been advanced onto bedrock, rotary percussion and coring methods were employed to advance the borehole to completion/bedrock.

Standard penetration tests were carried out in accordance with EC7 at standard depth intervals throughout the overburden using the split spoon sampler ($SPT_{(s)}$) or solid cone attachment ($SPT_{(c)}$). The penetrations are stated for those tests for which the full 150mm seating drive or 300mm test drive was not possible. The N-values provided on the borehole logs are uncorrected and no allowance has been made for energy ratio corrections. The SPT hammer energy measurement report is provided in Appendix G.

The core was extracted in up to 1.5m lengths using a SK6L GeoborS core barrel, which produced core of nominal 103mm diameter, and was placed in single channel wooden core boxes. On occasion where coring proved to be difficult, a conventional T2-101 core barrel was used, which produced a core of nominal 83mm diameter, and was placed in single channel wooden core boxes.

The core was subsequently photographed and examined by a qualified and experienced Engineering Geologist, thus enabling the production of an engineering log in accordance with *BS 5930: 2015: Code of practice for ground investigations*.

Appendix B presents the borehole logs, with core photographs presented in Appendix C.

4.4 Marine Geophysical Surveys

Aspect Land & Hydrographic Surveys Ltd. were contracted to carry out both multibeam bathymetric and sub-bottom profiler surveys at areas adjacent to the existing pier and slipway structures at Iona and Fionnphort on the Isle of Mull.

A copy of the Report and the resulting layouts are presented in Appendix E.

4.5 Surveying

The as-built exploratory hole positions were surveyed throughout the project by the Site Engineer from Causeway Geotech. Surveying was carried out using a Trimble R8S GPS system employing VRS and real time kinetic (RTK) techniques.

The plan coordinates (UK National Grid) and ground elevation (mCD) at each location are recorded on the individual exploratory hole logs. The exploratory hole plan presented in Appendix A shows these as-built positions.

5 LABORATORY WORK

Upon their receipt in the laboratory, all disturbed samples were carefully examined and accurately described, and their descriptions incorporated into the borehole logs.

5.1 Geotechnical laboratory testing of soils

Laboratory testing of soils comprised:

- **soil classification:** moisture content measurement, Atterberg Limit tests, bulk density tests, and particle size distribution analysis.
- **soil chemistry:** pH and water-soluble sulphate content

Laboratory testing of soils samples was carried out in accordance with British Standards Institute (1990) *BS 1377:1990, Methods of test for soils for civil engineering purposes. Parts 1 to 9.*

The test results are presented in Appendix D.

5.2 Geotechnical laboratory testing of rock

Laboratory testing of rock sub-samples comprised:

- point load index
- unconfined compressive strength (UCS) tests

Test	Test carried out in accordance with
Point load index	ISRM Suggested Methods (1985) Suggested method for determining point-load strength. Int. J. Rock Mech. Min. Sci. Geomech. Abstr. 22, pp. 53–60
Uniaxial compression strength tests	ISRM Suggested Methods (1981) Suggested method for determining deformability of rock materials in uniaxial compression, Part 2 and ISRM (2007) Ulusay R, Hudson JA (eds) The complete ISRM suggested methods for rock characterization, testing and monitoring, 2007

The test results are presented in Appendix D.

6 GROUND CONDITIONS

6.1 General geology of the area

Published geological mapping indicate the superficial deposits underlying the site comprise marine beach deposits consisting of sands and gravels with occasional clay and silt horizons. These deposits are underlain by Neoproterozoic era schists/metasediments of the Iona Group (BH01-BH06) and monzogranites of the Silurian derived Ross of Mull Pluton (BH07-BH12).

6.2 Ground types encountered during investigation of the site

A summary of the ground types encountered in the exploratory holes is listed below, in approximate stratigraphic order:

- **Marine sands and gravel deposits:** typically dense to very dense sands and gravels with low cobble content. Found in all exploratory holes at the seabed surface, extending to a maximum depth of 5.00mbgl (-9.40mCD) in BH05.

- **Cohesive marine deposits:** stiff to very stiff sandy gravelly clay was found in BH03, BH06 and BH12. In BH03 the deposit was 0.50m thick and encountered between 3.10mbgl (-7.37mCD) and 3.60mbgl (-7.87mCD), directly overlying the schist bedrock. In BH06 the deposit was 2.40m thick and encountered between 1.40mbgl (-5.43mCD) and 3.80mbgl (-7.83mCD), again directly overlying the schist bedrock. The deposit in BH12 was 200mm thick, encountered between 1.20mbgl (-4.88mCD) to 1.40mbgl (-5.08mCD), occurring as a thin bed within the marine sands and gravel strata.

- **Bedrock Iona (schist):** Rockhead at the Iona locations was in the form of schist/metasediment; encountered at depths ranging from 0.60mbgl (-1.16mCD/-3.53mCD) in BH01/BH02, to a depth of 5.00mbgl (-9.40mCD) in borehole BH05. The schist bedrock was found to a maximum depth of 10.50mbgl (-14.53mbgl) in BH06 where the borehole terminated.

- **Bedrock Fionnphort (felsic granite):** Rockhead at the Fionnphort locations was in the form of felsic granite; encountered at depths ranging from 0.20mbgl (-2.66mCD) in BH11, to a maximum depth of 2.50mbgl (-6.18mCD) in borehole BH12. The granite bedrock was found to a maximum depth of 10.00mbgl (-12.26mbgl) in BH08 where the borehole terminated.

Representative geological long sections, showing the marine sediment accumulations overlying the rockhead profile at the sites of the investigation works, are provided in Appendix F.

6.3 Groundwater

Groundwater was not noted during drilling at any of the borehole locations. However, it should be noted that the casing used in supporting the borehole walls during drilling may have sealed out any groundwater strikes encountered and the possibility of encountering groundwater during excavation works should not be ruled out. Seasonal variation in groundwater levels should also be factored into design considerations.

It should be noted that any groundwater strikes within bedrock may have been masked by the fluid used as the drilling flush medium.

7 DISCUSSION

7.1 Proposed construction

It is proposed to upgrade the existing Ferry Terminals at both Fionnphort and Iona.

The upgrade works for the Ferry Terminals will include:

- Sea protection/breakwater at Iona
- Sea protection/breakwater at Fionnphort
- Overnight berth/pier structure at Fionnphort

Limited information has been provided at this stage and any designs based on the recommendations or conclusions within this report should be completed in accordance with the current design codes, taking into account the variation and the specific details contained within the exploratory holes. Causeway Geotech were commissioned to provide a geotechnical report, and it is outwith our remit to advise on structure design.

7.2 Bearing resistance

The undrained bearing resistance as displayed in Annex D of EN 1997-1 gives the following equation:

$$\frac{R}{A'} = (\pi + 2)c_u b_c s_c i_c + q$$

Where:

c_u = the soil's undrained shear strength
q = the total overburden pressure at the foundation base
R = design resistance
A' = area of foundation (unknown at this stage)
b = base inclination factor
s = shape factor
i = load inclination factor

The drained bearing resistance of a spread foundation q_{ult} is shown in the following equation:

$$q_{ult} = c'N_c + q'N_q + \frac{\gamma'BN_\gamma}{2}$$

Where:

c' = the soil's effective cohesion
q' = the effective overburden pressure at the foundation base
γ = the effective weight density of the soil below the foundation
N_c, N_q, N_γ = bearing capacity factors

This table does not take into account the variations in soil composition, and the effects of differential movement within a particular structure. Calculation of the design bearing resistance over the entire structure will entail a knowledge of the magnitude and distribution of the structural actions.

In the UK the Eurocodes are applied using Design Approach 1, of which there are two combinations. In Design Approach 1, Combination 1, partial factors are applied to actions alone. In Design Approach 1, Combination 2 the partial factors are mainly applied to the material factors.

7.3 Soil strength parameters

When estimating the shear strength of cohesive soils (silt/clay), reference is made to the results of Standard Penetration Tests (SPT's) carried out within the boreholes. The undrained shear strength of cohesive soils can be estimated using the correlation developed by Stroud & Butler:

$$C_u = f_1 \times N$$

where f_1 is typically in the range 4 to 6. A median f_1 value of 5 is adopted for this report.

For granular soils (sand/gravel), a graphical relationship between SPT "N" value and angle of shearing resistance, φ, has been developed by Peck, Hanson and Thorburn. This is published in *Foundation Design and Construction* (Tomlinson, 2001) and is referenced in this report when deriving angles of shearing resistance for the granular soils.

7.4 Rock strength parameters

When estimating the design resistance values for the rock where only point load (Is50) results are available, a conversion factor of 20 has been used. This is based on common industry best practice. The relationship between UCS and the point load strength could be therefore be expressed as:

$$UCS = (K)\ Is50 = (20)\ Is50$$

Where K is the conversion factor; 20 used for the purposes of this report.

7.5 Recommendations for construction

7.5.1 Proposed New Sea Protection/Rock Armour Breakwater - Iona

7.5.1.1 Rock armour foundations

The ground conditions at the locations of the proposed new sea protection measures at Iona are reasonably uniform; dense to very dense granular marine deposits with pockets of stiff to very stiff cohesive deposits directly overlying a gently offshore-sloping rockhead. The rockhead at Iona is composed exclusively of dark grey schist at relatively shallow levels. Based on the known ground conditions, shallow foundation design can be considered; the current proposals are to lay a rock armour structure directly onto the sea bed.

There are two options being investigated at the time of writing:

- Option 1/1a – breakwater structure running from shoreline through BH02 to BH03 and beyond
- Option 2/2a – breakwater structure running from shoreline through BH04, BH05 out to BH06

7.5.1.1.1 Potential founding strata – Iona Option 1/1a

Potential founding strata are as follows; this will be confirmed by a specialist contractor:

- BH02: Strong Schist found at 0.80mbgl (-3.73mCD).
- BH03: Medium dense sandy gravels with cobbles encountered at 1.00mbgl (-5.27mCD). Weak to medium strong Schist encountered at 3.60mbgl (-7.87mCD).

Table 1: Ground parameters for bearing strata derived from in-situ testing and laboratory results

Location	Depth (mbgl)	Strata Description	Design Resistance Values (kN/m²) DA1-1/DA1-2	Angle of Shearing Resistance Φ (Degrees)
BH02	0.80	Weathered SCHIST	1770/683	42.00
	1.50	Strong SCHIST	50200/35857	-
	1.95	Strong SCHIST	66000/47142	-
BH03	1.00	Med. Dense GRAVEL	519/261	33.00
	2.00	Dense SAND	683/335	35.00
	3.25	Very Stiff CLAY	875/625	-
	3.60	Weathered SCHIST	1770/683	42.00
	7.90	Weak SCHIST	8000/5714	-

The current proposal is to infill this area with imported primary armour stone, laid down in a layer over the seabed. The area would then be brought up to approximately +4mCD through compacted imported engineering grade rockfill; proposed slope of breakwater currently 1:1.5.

The primary armour stone could be placed directly onto the weathered bedrock in BH02, and onto the medium dense to dense sands and gravels which directly overlie the bedrock in BH03. Specialist contractors would need to be approached to confirm the allowable bearing pressures of the primary armour stone and imported engineering grade rockfill; this would normally be through plate load testing of the imported fill following compaction.

7.5.1.1.2 Potential founding strata – Iona Option 2/2a

Potential founding strata are as follows; this will be confirmed by the specialist contractor:

- BH04: Medium dense sandy Gravel with cobbles encountered at 0.90mbgl (-4.84mCD). Weak to medium strong Schist found at 2.20mbgl (-6.14mCD).
- BH05: Medium dense sandy Gavel with cobbles encountered at 1.00mbgl (-5.40mCD). Weak to medium strong Schist found at 5.20mbgl (-9.60mCD).
- BH06: Medium dense sandy Gravel with cobbles encountered at 0.50mbgl (-4.53mCD). Medium strong Schist found at 6.00mbgl (-10.03mCD).

Table 2: Ground parameters for bearing strata derived from in-situ testing and laboratory results

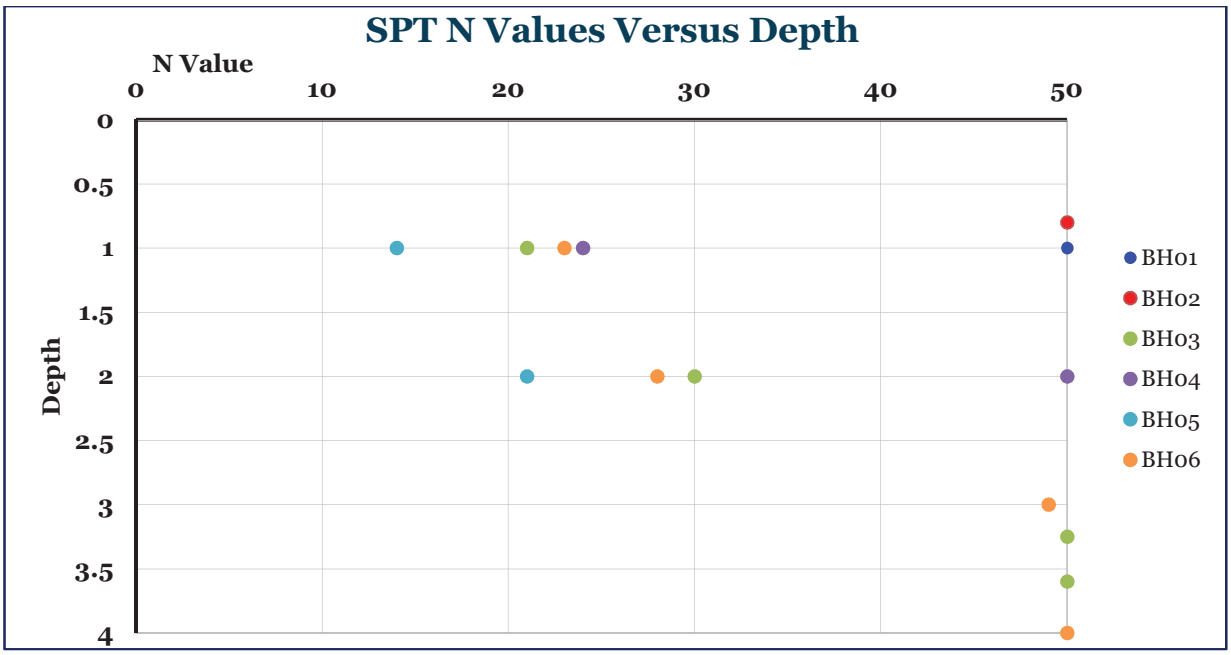
Location	Depth (mbgl)	Strata Description	Design Resistance Values (kN/m²) DA1-1/DA1-2	Angle of Shearing Resistance Φ (Degrees)
BH04	1.00	Med. Dense GRAVEL	568/284	34.00
	2.00	Weathered SCHIST	1770/683	42.00
	3.05	Weak SCHIST	20000/14285	-
	3.80	Very Strong SCHIST	148000/105714	-
BH05	1.00	Med. Dense GRAVEL	421/216	31.00
	2.00	Med. Dense SAND	519/261	33.00
	3.00	Dense GRAVEL	701/343	36.00
	4.00	Dense GRAVEL	924/430	38.00
	5.00	Weathered SCHIST	1770/683	42.00
	6.00	Med. Strong SCHIST	34000/24285	-
	7.90	Med. Strong SCHIST	34000/24285	-
BH06	1.00	Med. Dense GRAVEL	551/276	34.00
	2.00	Stiff CLAY	490/350	-
	3.00	Very Stiff CLAY	857.5/612.5	-
	4.00	Weathered SCHIST	1770/683	42.00
	6.90	Med. strong SCHIST	46000/32857	-

The current proposal is to infill this area with imported primary armour stone, laid down in a layer over the seabed. The area would then be brought up to approximately +4mCD through compacted imported engineering grade rockfill; proposed slope of breakwater currently 1:1.5.

The primary armour stone could be placed directly onto the medium dense sandy gravel with cobbles in BH04, BH05, and BH06. Specialist contractors would need to be approached to confirm the allowable bearing pressures of the primary armour stone and imported engineering grade rockfill; this would normally be through plate load testing of the imported fill following compaction.

A summary of standard penetration test results against depth for the Iona works area is presented in the graph below.

Graph 1: Summary of SPT *N* Values across the areas investigated – Sea Protection Iona works area



7.5.2 Proposed New Sea Protection/Rock Armour Breakwater - Fionnphort

7.5.2.1 Rock armour foundations

The ground conditions at the locations of the proposed new sea protection measures at Fionnphort are reasonably uniform; dense to very dense granular marine deposits with pockets of stiff to very stiff cohesive deposits overlying a gently offshore-sloping rockhead. The rockhead at Fionnphort is composed exclusively of pinkish red and grey felsic granite at relatively shallow levels. Based on the known ground conditions, shallow foundation design can be considered; the current proposals are to lay a rock armour structure directly onto the sea bed.

There is a single option being investigated at the time of writing:

- Option 1 – breakwater structure running from shoreline through BH11, BH10, BH09A and beyond

7.5.2.1.1 Potential founding strata - Fionnphort

Potential founding strata at Fionnphort are as follows; this will be confirmed by the specialist contractor:

- BH09A: Very dense sandy Gravel encountered at 0.00mbgl (-2.52mCD). Medium strong to strong Granite encountered at 1.40mbgl (-3.92mCD).
- BH10: Strong to very strong Granite found at 1.00mbgl (-4.70mCD).
- BH11: Medium strong to strong Granite found at 0.30mbgl (-2.76mCD).

Table 3: Ground parameters for bearing strata derived from in-situ testing and laboratory results

Location	Depth (mbgl)	Strata Description	Design Resistance Values (kN/m²) DA1-1/DA1-2	Angle of Shearing Resistance Φ (Degrees)
BH09A	1.00	Very Dense GRAVEL	1770/683	42.00
	4.50	Very Strong GRANITE	186000/132857	-
	4.80	Very Strong GRANITE	196000/140000	-
	5.10	Med. Strong GRANITE	44100/31500	-
	5.10	Very Strong GRANITE	200000/142857	-
BH10	1.00	Weathered GRANITE	1770/683	42.00
	1.30	Very Strong GRANITE	182000/130000	-
	1.70	Very Strong GRANITE	160000/114285	-
BH11	0.55	Very Strong GRANITE	146000/104285	-
	2.60	Med. Strong GRANITE	36300/25928	-

The ground conditions at BH12 were investigated at the request of the local community in the event a breakwater could potentially be constructed here in the future to create an enclosed harbour. The rock armour would run from BH12 eastwards to the shoreline.

Potential founding strata at BH12 are as follows; this will be confirmed by the specialist contractor:

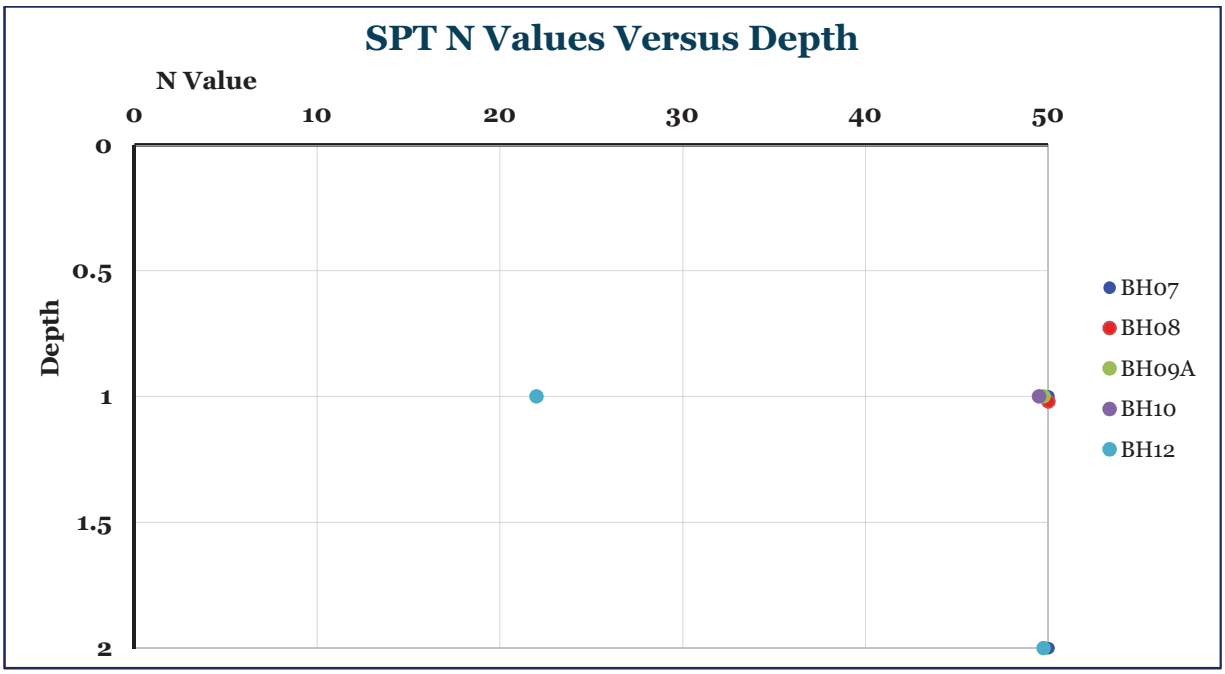
- BH12: Medium dense gravelly Sand encountered at 1.00mbgl (-4.68mCD). Strong to very strong Granite found at 2.70mbgl (-6.38mCD).

Table 4: Ground parameters for bearing strata derived from in-situ testing and laboratory results

Location	Depth (mbgl)	Strata Description	Design Resistance Values (kN/m²) DA1-1/DA1-2	Angle of Shearing Resistance Φ (Degrees)
BH12	1.00	Med. Dense GRAVEL	534/268	33.00
	2.00	Very Dense GRAVEL	1770/683	42.00
	3.00	Very Strong GRANITE	148000/105714	-
	5.50	Strong GRANITE	74400/53142	-

A summary of standard penetration test results against depth for the Fionnphort works area is presented in the graph below.

Graph 2: Summary of SPT *N* Values across the areas investigated – Sea Protection Fionnphort works area



7.5.3 Proposed New Overnight Berth/Pier Structure - Fionnphort

7.5.3.1 Piled pier foundations

The ground conditions at the locations of the proposed new overnight berth and pier structure consist of very dense sandy gravel marine deposits overlying a medium strong to strong granite rockhead. The rockhead is composed exclusively of pinkish red and grey felsic granite at relatively shallow levels. Based on the known ground conditions and on the proposals, it follows that a piled solution may be used to transfer the loadings to depth within the bedrock.

7.5.3.1.1 Potential founding strata - Fionnphort

Potential founding strata at Fionnphort are as follows; this will be confirmed by the specialist piling contractor:

- BH09A: Very dense sandy Gravel encountered at 0.00mbgl (-2.52mCD). Medium strong to strong Granite encountered at 1.40mbgl (-3.92mCD).

Table 5: Ground parameters for bearing piles derived from in-situ testing and laboratory results

Location	Depth (mbgl)	Strata Description	Design Resistance Values (kN/m²) DA1-1/DA1-2	Angle of Shearing Resistance Φ (Degrees)
BH09A	1.00	Very Dense GRAVEL	1770/683	42.00
	4.50	Very Strong GRANITE	186000/132857	-
	4.80	Very Strong GRANITE	196000/140000	-
	5.10	Med. Strong GRANITE	44100/31500	-
	5.10	Very Strong GRANITE	200000/142857	-

Due to the thin layers of overburden at the proposed location for the new overnight berth/pier structure, the specialist piling contractor will most likely propose drilled piles into the underlying granite bedrock.

In all instances above, it is recommended that the advice of specialist contractors is sought out at an early stage to ensure the correct methods and pile specifications are selected with regard to the site-specific ground conditions. Piling contractors will be able to advise on pile drivability based on ground conditions as presented in this Report.

Pile driving conditions will vary across the site through local variations in ground conditions, further accentuated by the presence of cobbles and/or boulders. The ultimate load capacity of the piles should be determined by the execution of in-situ dynamic load tests.

In terms of design properties for the rockhead in this area of the pier we have assumed the piles are taken to the top of the rockhead only. Based on the laboratory test results the weakest rockhead design resistance value of 31500 kN/m² should be used in this scenario. The likely advancement and socketing of the piles deeper into the rockhead would penetrate beyond the weaker layers of granite and would increase the design resistance value up to a maximum figure of 142857 kN/m².

7.5.4 Soil aggressivity

An assessment of the Aggressive Chemical Environment for Concrete (ACEC) was undertaken through reference to the Building Research Establishment (BRE) Special Digest 1 (2005).

As noted by BRE Special Digest 1, sulphates in the soil and groundwater are the chemical agents most likely to attack concrete. The extent to which sulphates affect concrete is linked to their concentrations, the type of ground, the presence of groundwater, the type of concrete and the form of construction in which concrete is used.

BRE Special Digest 1 identifies four different categories of site which require specific procedures for investigation for aggressive ground conditions:

- Sites not subjected to previous development and not perceived as containing pyrite;
- Sites not subjected to previous development and perceived as containing pyrite;

- Brownfield sites not perceived as containing pyrite;
- Brownfield sites perceived as containing pyrite.

For the purposes of this report the site was classified as not having been subject to previous development and not perceived as containing pyrite.

The results of chemical tests (pH and water-soluble sulphate contents) on soil samples from both Iona and Fionnphort sites indicate a Design Sulphate Class DS-1 and ACEC Class AC-1^{s} – reference Table C1 of BRE Special Digest 1 (Building Research Establishment, 2005).

The Special Digest does not require measures to protect underground concrete elements; reference should be made to the *Building Research Establishment (2005) BRE Special Digest 1, Concrete in aggressive ground* documentation by the nominated Geotechnical Design Engineer.

8 REFERENCES

BS 1377: 1990: Methods of test for soils for civil engineering purposes. British Standards Institution.

BS 5930: 2015: Code of practice for ground investigations. British Standards Institution.

BS EN 1997-2: 2007: Eurocode 7 - Geotechnical design - Part 2 Ground investigation and testing. British Standards Institution.

Construction Industry Research and Information Association (CIRIA). 1993. Research Project 369. The Standard Penetration Test (SPT): Methods and Use. CIRIA. London.

BS EN ISO 14688-1: 2002: Geotechnical investigation and testing - Identification and classification of soil - Part 1 Identification and description. British Standards Institution.

Building Research Establishment (2005) BRE Special Digest 1, Concrete in aggressive ground.

CAUSEWAY GEOTECH

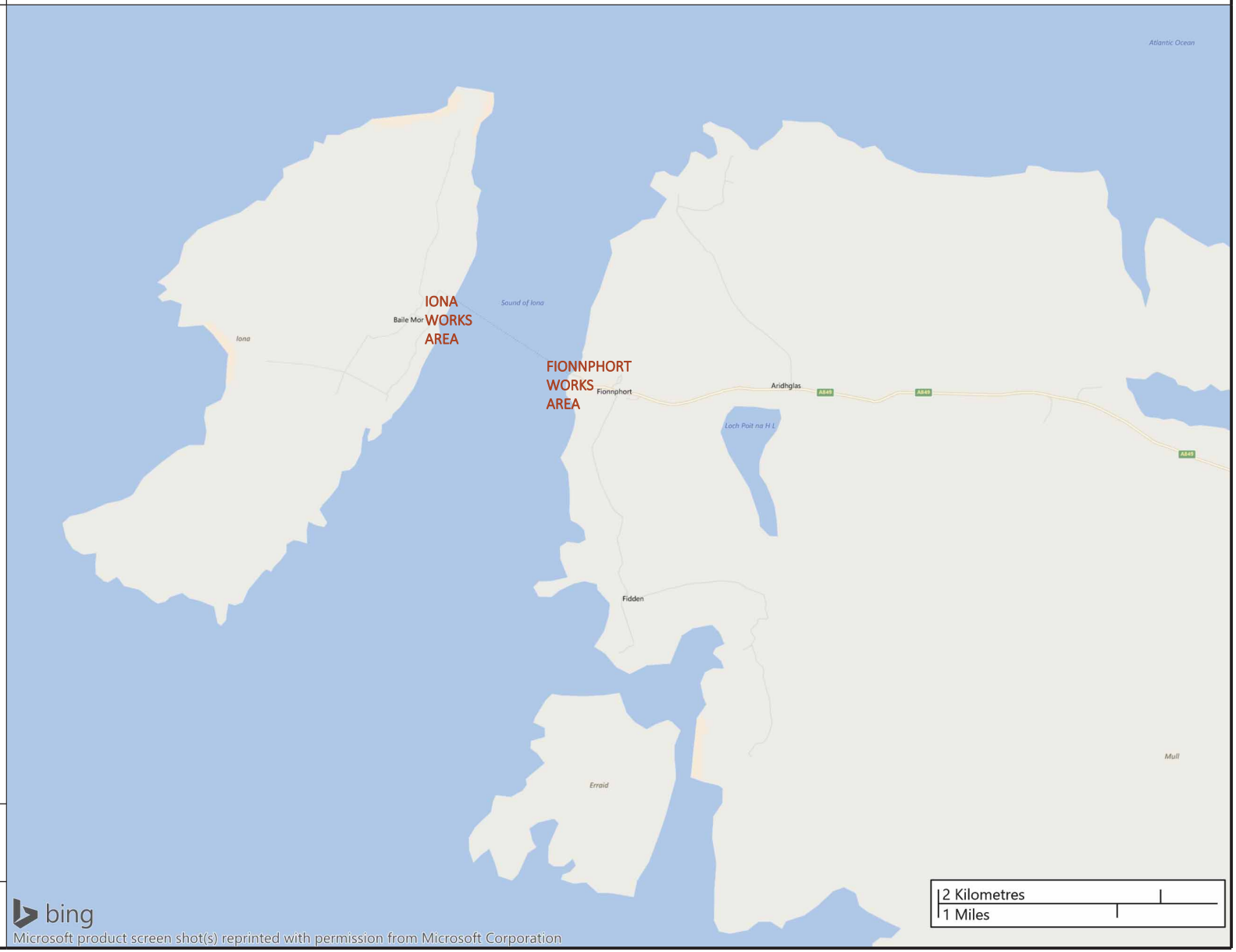
APPENDIX A

Exploratory hole location plan

CAUSEWAY GEOTECH

Project No.:	18-0144	**Client:**	Argyll and Bute Council
Project Name:	Fionnphort and Iona Ground Investigation	**Client's Representative:**	Byrne Looby Partners

Legend Key



Title:
Site Location Plan

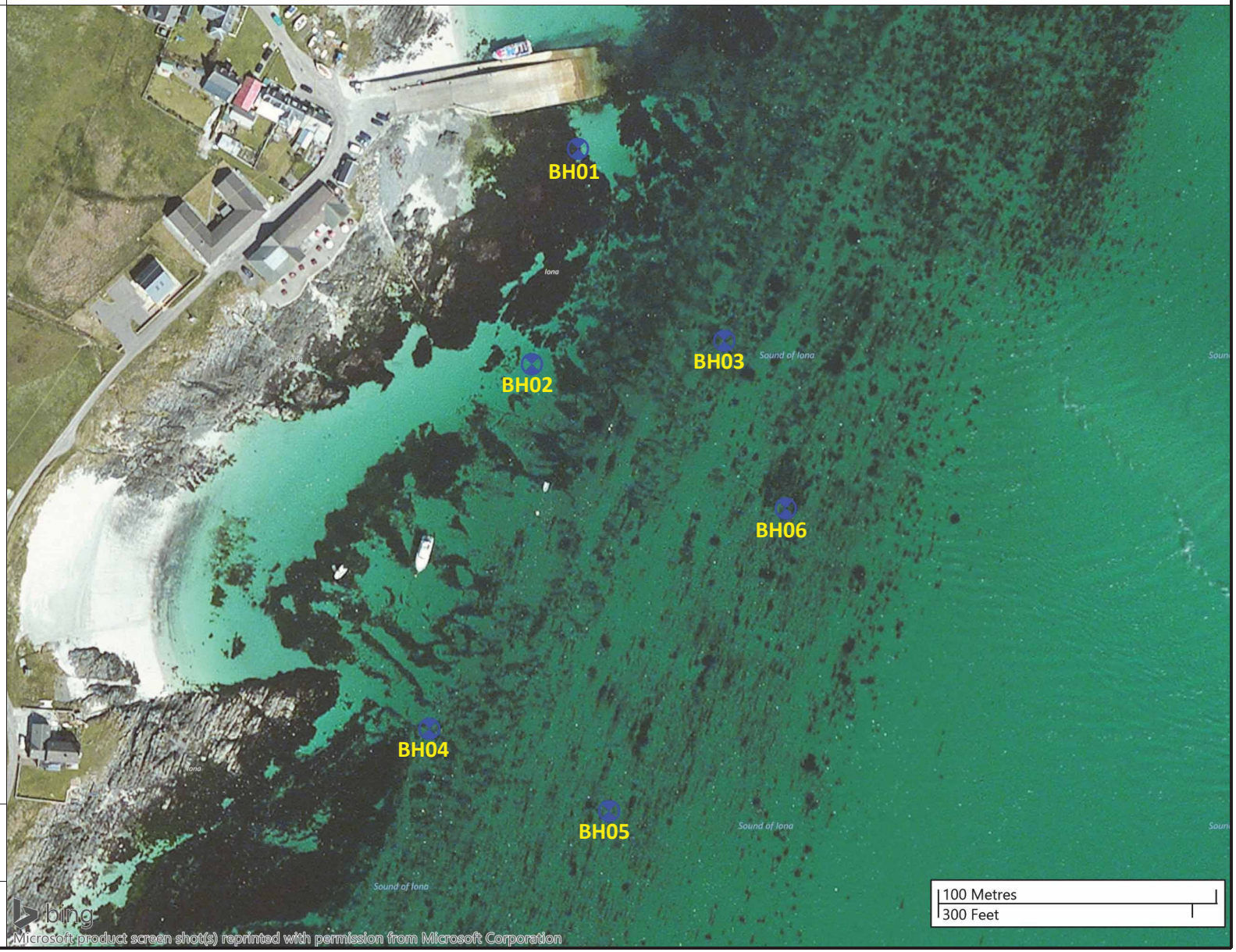
Last Revised:	**Scale:**
09/11/2018	1:50000

CAUSEWAY GEOTECH

Project No.:	18-0144	**Client:**	Argyll and Bute Council
Project Name:	Fionnphort and Iona Ground Investigation	**Client's Representative:**	Byrne Looby Partners

Legend Key

- Percussion/Rotary Coring - CP+RC



Title:

Site Location Plan

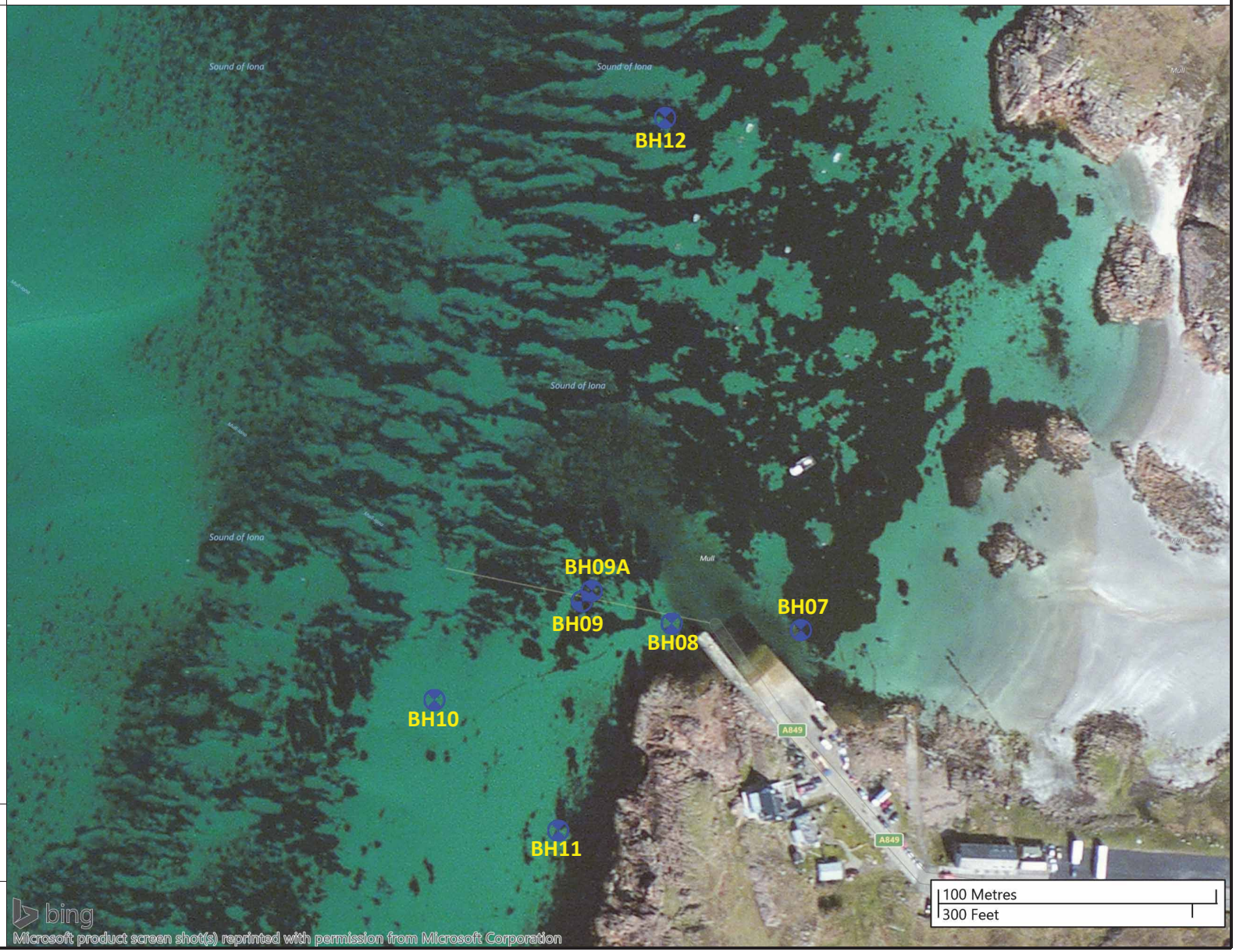
Last Revised:	**Scale:**
09/11/2018	1:2000

CAUSEWAY GEOTECH

Project No.:	18-0144	**Client:**	Argyll and Bute Council
Project Name:	Fionnphort and Iona Ground Investigation	**Client's Representative:**	Byrne Looby Partners

Legend Key

- Cable Percussion - CP Cable
- Percussion/Rotary Coring - CP+RC



Title:

Site Location Plan

Last Revised:	**Scale:**
09/11/2018	1:2000

CAUSEWAY GEOTECH

APPENDIX B

Borehole Logs

CAUSEWAY GEOTECH

Method	Plant Used	Top	Base
Cable Percussion	Dando 3000	0.00	1.00
Rotary Coring	Comacchio 405	1.00	7.00

Project No.: 18-0144

Project Name: Fionnphort and Iona Ground Investigation

Borehole No.: BH01

Coordinates: 128674.26 E, 723974.81 N

Client: Argyll and Bute Council

Sheet 1 of 1

Client's Representative: Byrne Looby Partners

Scale: 1:50

Driller: CC+TA

Ground Level: -0.56 mCD

Dates: 22/08/2018

Logger: NH+LN

Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mCD)	Depth (m) (Thickness)	Legend	Description	Water	Backfill
0.00 - 0.60	B1					(0.60)		Grey slightly silty slightly gravelly fine to coarse SAND. Gravel is subangular fine.		
					-1.16	0.60				
1.00 - 1.02	SPT (C) 0	1.00		N=50 (25 for 10mm/50 for 15mm)		(0.70)		Weathered SCHIST recovered as dark grey angular coarse GRAVEL.		
1.30	100 47 33		20 6 20		-1.86	1.30		Strong to very strong thinly foliated dark grey SCHIST with white veining. Partially weathered with some staining on fracture surfaces Discontinuities: 1. 50-80 degree foliation fractures, closely spaced, (10/100/300), planar, smooth, closed with patchy white mineral growth and occasional brown and grey staining 2. Sub-vertical joints throughout, probably closely spaced, planar, smooth, with patchy white mineral growth and occasional brown and grey staining		
2.50	100 33 23		5 NI							
4.00	80 31 31					(5.70)				
5.50	87 80 53		8							
7.00					-7.56	7.00		End of Borehole at 7.00m		
	TCR	SCR	RQD	FI						

Remarks
Deck to Bed = 6.40m

Terminated on recovery of 6.00m core

Core Barrel	Water Strikes				Chiselling Details		
	Struck at (m)	Casing to (m)	Time (min)	Rose to (m)	From (m)	To (m)	Time (hh:mm)
SK6L/T2-101					0.60	1.00	02:00

Flush Type	Water Added		Casing Details	
	From (m)	To (m)	To (m)	Diam (mm)
Polymer			1.00	200

CAUSEWAY GEOTECH

Method	Plant Used	Top	Base
Cable Percussion	Dando 3000	0.00	0.80
Rotary Coring	Comacchio 405	0.80	6.80

Project No.: 18-0144

Project Name: Fionnphort and Iona Ground Investigation

Borehole No.: BH02

Coordinates: 128652.63 E, 723898.14 N

Client: Argyll and Bute Council

Sheet 1 of 1

Client's Representative: Byrne Looby Partners

Scale: 1:50

Driller: AH+SJ

Ground Level: -2.93 mCD

Dates: 23/08/2018

Logger: NH+LN

Depth (m)	Sample / Tests	TCR	SCR	RQD	Casing Depth (m)	Water Depth (m)	FI	Field Records	Level (mCD)	Depth (m) (Thickness)	Legend	Description	Water	Backfill
0.00 - 0.50	B1									(0.60)		Grey very sandy slightly silty subrounded fine to coarse GRAVEL with low cobble content and fragments of shell. Sand is fine to coarse. Cobbles are subangular.		
									-3.53	0.60				
0.80 - 0.86	SPT (C)							N=50 (25 for 30mm/50 for 25mm)		(0.20)		Weathered SCHIST recovered as dark grey angular coarse GRAVEL.		
0.80 - 0.86								N=50 (25 for 30mm/50 for 25mm)	-3.73	0.80		Strong thickly foliated dark grey SCHIST with occasional off white mineral veins. Largely unweathered. Discontinuities: 1. 10 to 40 degree joints, medium spaced (40/250/400) planar , smooth, closed. 2. 80 to 90 degree joints, typically planar occasionally undulating, smooth, closed with patchy blueish grey staining.		
		100	98	86										
2.20						4								
		100	89	73										
3.80										(6.00)				
		100	63	32										
						20								
5.30														
		100	89	73		4								
6.80									-9.73	6.80		End of Borehole at 6.80m		

Remarks
Deck to Bed = 9.80m

Terminated on recovery of 6.00m core

Core Barrel: SK6L

Flush Type:

Water Strikes			
Struck at (m)	Casing to (m)	Time (min)	Rose to (m)

Water Added	
From (m)	To (m)

Casing Details	
To (m)	Diam (mm)
0.80	200

Chiselling Details		
From (m)	To (m)	Time (hh:mm)
0.60	0.80	02:00

CAUSEWAY GEOTECH

Method	Plant Used	Top	Base
Cable Percussion	Dando 3000	0.00	3.60
Rotary Coring	Comacchio 404	3.60	9.60

Project No.: 18-0144

Project Name: Fionnphort and Iona Ground Investigation

Borehole No.: BH03

Coordinates: 128722.78 E, 723902.15 N

Client: Argyll and Bute Council

Sheet 1 of 1

Client's Representative: Byrne Looby Partners

Scale: 1:50

Ground Level: -4.27 mCD

Dates: 20/08/2018

Driller: CC+TA

Logger: NH+LN

Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mCD)	Depth (m) (Thickness)	Legend	Description	Water	Backfill
0.30 - 0.70	B1					(0.75)		Grey gravelly fine to medium SAND with fragments of shell. Gravel is subangular to subrounded fine to coarse.		
0.70 - 0.80	B2				-5.02	0.75				
0.80 - 2.10	B3							Medium dense grey sandy slightly silty subangular to subrounded fine to coarse GRAVEL with high cobble content. Sand is fine to coarse. Cobbles are angular.		
1.00 - 1.45	SPT (S) N=21	1.00		N=21 (2,4/4,6,5,6)		(1.25)				
2.00 - 2.45	SPT (S) N=30	2.00		N=30 (1,4/6,6,7,11)	-6.27	2.00		Dense brownish grey silty very gravelly fine to coarse SAND. Gravel is subangular to subrounded fine to coarse.		
2.10 - 3.20	B4					(1.10)				
3.20 - 3.50	B5				-7.37	3.10		Stiff to very stiff grey sandy slightly gravelly silty CLAY. Sand is fine to coarse. Gravel is subangular to subrounded fine to coarse. Occasional pocket-sized deposits of grey fine to medium sand.		
3.25 - 3.46	SPT (S)	3.25		N=50 (25 for 85mm/50 for 125mm)		(0.50)				
3.60 - 3.66				N=50 (25 for 25mm/50 for 35mm)	-7.87	3.60		Weak to medium strong thinly foliated highly fractured black SCHIST largely recovered as angular fine to coarse gravel. Partially weathered with slightly reduced strength Discontinuities: 1. 0-30 degree joints, very closely spaced (10/40/400), planar, smooth 2. Sub-vertial joints, probably closely spaced, planar, smooth		
3.50 - 3.60	B6									
3.60 - 3.66	SPT (C)	3.60		N=50 (25 for 25mm/50 for 35mm)						
5.10	87 0 0		NI							
6.60	100 0 0					(6.00)				
7.20	86 46 0		20+							
8.10	100 33 33		5							
9.60	100 30 13		20+		-13.87	9.60		End of Borehole at 9.60m		
	TCR SCR RQD		FI							

Remarks
Deck to Bed = 8.90m

Terminated on recovery of 6.00m core

Core Barrel: SK6L

Flush Type: Polymer

Water Strikes			
Struck at (m)	Casing to (m)	Time (min)	Rose to (m)

Water Added		Casing Details	
From (m)	To (m)	To (m)	Diam (mm)
		3.60	200

Chiselling Details		
From (m)	To (m)	Time (hh:mm)
3.40	3.60	01:00

CAUSEWAY GEOTECH

Method	Plant Used	Top	Base
Cable Percussion	Dando 3000	0.00	2.20
Rotary Coring	Comacchio 405	2.20	5.20

Project No.: 18-0144

Project Name: Fionnphort and Iona Ground Investigation

Borehole No.: BH04

Coordinates: 128607.10 E, 723768.94 N

Client: Argyll and Bute Council

Sheet 1 of 1

Client's Representative: Byrne Looby Partners

Scale: 1:50

Ground Level: -3.94 mCD

Dates: 24/08/2018

Driller: AH+SJ

Logger: SG+LN

Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mCD)	Depth (m) (Thickness)	Legend	Description	Water	Backfill
0.00 - 0.90	B2					(0.90)		Grey very sandy slightly silty subrounded fine to coarse GRAVEL with low cobble content and fragments of shell. Sand is fine to coarse. Cobbles are subangular.		
0.90 - 2.00	B3				-4.84	0.90		Medium dense brownish grey sandy slightly silty subangular to subrounded fine to coarse GRAVEL predominately of schist and granite with low cobble content and fragments of shell. Sand is fine to coarse. Cobbles are subrounded predominately schist and granite.		
1.00	D1									
1.00 - 1.45	SPT (S) N=24	1.00		N=24 (4,5/5,6,6,7)		(1.10)				
2.00 - 2.02	SPT (C)	2.00		N=50 (25 for 10mm/50 for 5mm)	-5.94	2.00 (0.20)		Weathered SCHIST recovered as dark grey angular coarse GRAVEL.		
					-6.14	2.20		Weak to medium strong thickly foliated dark grey SCHIST with occasional off white mineral veins. Largely unweathered. Discontinuities: 1. 10 to 35 degree joints, medium spaced (35/240/380) planar , smooth, closed. 2. 75 to 85 degree joints, typically planar, smooth, closed with blueish grey staining.		
	100 92	79				(1.50)				
3.70			5		-7.64	3.70		Strong to very strong thickly foliated dark grey SCHIST with occasional off white mineral veins. Largely unweathered. Discontinuities: 1. 10 to 35 degree joints, medium spaced (35/240/380) planar , smooth, closed. 2. 75 to 85 degree joints, typically planar, smooth, closed with blueish grey staining.		
	100 83	71				(1.50)				
5.20					-9.14	5.20		End of Borehole at 5.20m		

TCR	SCR	RQD	FI

Remarks
Deck to Bed = 7.90m

Terminated on recovery of 3.00m core

Core Barrel: SK6L

Flush Type:

Water Strikes

Struck at (m)	Casing to (m)	Time (min)	Rose to (m)

Water Added

From (m)	To (m)

Casing Details

To (m)	Diam (mm)
2.20	200

Chiselling Details

From (m)	To (m)	Time (hh:mm)
2.00	2.20	01:00

CAUSEWAY GEOTECH

Method	Plant Used	Top	Base
Cable Percussion	Dando 3000	0.00	5.20
Rotary Coring	Comacchio 405	5.20	8.20

Project No.: 18-0144

Project Name: Fionnphort and Iona Ground Investigation

Borehole No.: BH05

Coordinates: 128670.19 E, 723735.13 N

Client: Argyll and Bute Council

Sheet 1 of 1

Client's Representative: Byrne Looby Partners

Scale: 1:50

Driller: AH+SJ

Ground Level: -4.40 mCD

Dates: 25/08/2018

Logger: CH+LN

Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mCD)	Depth (m) (Thickness)	Legend	Description	Water	Backfill
0.00 - 1.00	B1							Medium dense brownish grey very sandy slightly silty subangular to subrounded fine to coarse GRAVEL predominately of schist and granite with low cobble content and fragments of shell. Sand is fine to coarse. Cobbles are subrounded predominately schist and granite.		
1.00	D2					(2.00)				
1.00 - 2.00	B3									
1.00 - 1.45	SPT (S) N=14	1.00		N=14 (2,3/3,3,4,4)						
2.00	D5				-6.40	2.00		Medium dense brownish grey very gravelly slightly silty fine to coarse SAND with low cobble content and fragments of shell. Gravel is subangular to subrounded fine to coarse predominately of schist and granite. Cobbles are subrounded predominately schist and granite.		
2.00 - 2.80	B4									
2.00 - 2.45	SPT (S) N=21	2.00		N=21 (4,4/5,6,5,5)		(0.80)				
					-7.20	2.80		Dense brown very gravelly slightly silty fine to coarse SAND with low cobble content. Gravel is subrounded fine to coarse predominately of schist and granite. Cobbles are subrounded predominately of schist and granite.		
3.00 - 5.00	B6									
3.00 - 3.45	SPT (S) N=31	3.00		N=31 (5,6/7,7,8,9)						
4.00 - 4.45	SPT (S) N=41	4.00		N=41 (8,8/9,10,10,12)		(2.20)				
5.00 - 5.20	SPT (S)	5.00		N=50 (25 for 100mm/50 for 100mm)	-9.40	5.00 (0.20)		Weathered SCHIST recovered as dark grey angular coarse GRAVEL.		
	100 0	0	NI		-9.60	5.20 (1.40)		Weak to medium strong (locally very weak), narrowly foliated black SCHIST (largely recovered as angular gravel). Distinctly weathered: reduced strength, much closer fracture spacing Discontinuities: very closely spaced joints at various angles, planar, smooth		
6.70			20+		-11.00	6.60		Medium strong indistinctly narrowly foliated dark grey SCHIST with off white mineral veining. Discontinuities: 1. 10-40 degree joints, probably closely spaced (20/100/300), undulating, rough, with patchy orange staining		
	100 75	50	5			(1.60)				
			9							
8.20					-12.60	8.20		End of Borehole at 8.20m		
	TCR SCR	RQD	FI							

Remarks
Deck to Bed = 7.80m

Terminated on recovery of 3.00m core

Core Barrel: SK6L

Flush Type: Polymer

Water Strikes

Struck at (m)	Casing to (m)	Time (min)	Rose to (m)

Water Added

From (m)	To (m)

Casing Details

To (m)	Diam (mm)
5.20	200

Chiselling Details

From (m)	To (m)	Time (hh:mm)
5.00	5.20	01:00

CAUSEWAY GEOTECH

Method	Plant Used	Top	Base
Cable Percussion	Dando 3000	0.00	4.50
Rotary Coring	Comacchio 405	4.50	7.50
Rotary Coring	Comacchio 405	7.50	10.50

Project No.: 18-0144

Project Name: Fionnphort and Iona Ground Investigation

Borehole No.: BH06

Coordinates: 128741.26 E, 723840.24 N

Client: Argyll and Bute Council

Sheet 1 of 2

Client's Representative: Byrne Looby Partners

Scale: 1:50

Ground Level: -4.03 mCD

Dates: 21/08/2018

Driller: CC+TA

Logger: NH+LN

Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mCD)	Depth (m) (Thickness)	Legend	Description	Water	Backfill
0.00 - 0.50	B1					(0.50)		Grey very sandy subrounded fine to coarse GRAVEL predominately of schist and granite with low cobble content. Sand is fine to coarse. Cobbles are subangular predominately of schist and granite.		
0.50 - 1.50	B2				-4.53	0.50		Medium dense grey sandy slightly silty subrounded to rounded fine to coarse GRAVEL predominately of schist and granite with low cobble content. Sand is fine to coarse. Cobbles are angular predominately of schist and granite.		
1.00	D6					(0.90)				
1.00 - 1.45	SPT (S) N=23	1.00		N=23 (4,5/5,6,5,7)						
					-5.43	1.40		Stiff to very stiff brown slightly sandy slightly gravelly CLAY. Sand is fine to coarse. Gravel is subangular to subrounded fine predominately of schist and granite.		
1.50 - 2.50	B3									
2.00	D7									
2.00 - 2.45	SPT (S) N=28	2.00		N=28 (6,10/7,7,8,6)						
2.50 - 3.50	B4					(2.40)				
3.00	D8									
3.00 - 3.45	SPT (S) N=49	3.00		N=49 (5,8/11,12,12,14)						
					-7.83	3.80				
4.00	B5							Weathered SCHIST recovered as dark grey angular coarse GRAVEL.		
4.00 - 4.08	SPT (C)	4.00		N=50 (25 for 30mm/50 for 50mm)		(0.70)				
					-8.53	4.50		Weak (locally very weak), narrowly foliated black SCHIST (largely recovered as angular gravel). Distinctly weathered: reduced strength, much closer fracture spacing Discontinuities: very closely spaced joints at various angles, planar, smooth		
	100 0	0	NI			(1.50)				
			20+							
6.00					-10.03	6.00		Medium strong indistinctly narrowly foliated dark grey SCHIST with off white mineral veining. Discontinuities: 1. 10-40 degree joints, probably closely spaced (20/100/300), undulating, rough, with patchy orange staining 2. 70-90 degree joints, probably closely spaced, undulating, rough, with patchy orange staining		
	100 80	53	4							
			8							
7.50										
	73 17	17	NI			(4.50)				
9.00										
	80 53	27	20+							
	TCR SCR	RQD	FI							

Remarks
Deck to Bed = 10.20m

Terminated on recovery of 6.00m core

Core Barrel
SK6L/T2-101

Flush Type
Polymer

Water Strikes

Struck at (m)	Casing to (m)	Time (min)	Rose to (m)

Water Added

From (m)	To (m)
0.00	4.50

Casing Details

To (m)	Diam (mm)
4.50	200

Chiselling Details

From (m)	To (m)	Time (hh:mm)
4.20	4.50	01:00

CAUSEWAY GEOTECH

Method	Plant Used	Top	Base
Cable Percussion	Dando 3000	0.00	4.50
Rotary Coring	Comacchio 405	4.50	7.50
Rotary Coring	Comacchio 405	7.50	10.50

Project No.: 18-0144

Project Name: Fionnphort and Iona Ground Investigation

Borehole No.: BH06

Coordinates: 128741.26 E, 723840.24 N

Client: Argyll and Bute Council

Sheet 2 of 2

Client's Representative: Byrne Looby Partners

Scale: 1:50

Driller: CC+TA

Ground Level: -4.03 mCD

Dates: 21/08/2018

Logger: NH+LN

Depth (m)	TCR	SCR	RQD	FI	Field Records	Level (mCD)	Depth (m) (Thickness)	Legend	Description	Water	Backfill
10.50						-14.53	10.50		Medium strong indistinctly narrowly foliated dark grey SCHIST with off white mineral veining. Discontinuities: 1. 10-40 degree joints, probably closely spaced (20/100/300), undulating, rough, with patchy orange staining 2. 70-90 degree joints, probably closely spaced, undulating, rough, with patchy orange staining End of Borehole at 10.50m		

TCR	SCR	RQD	FI

Remarks
Deck to Bed = 10.20m

Terminated on recovery of 6.00m core

Core Barrel: SK6L/T2-101

Flush Type: Polymer

Water Strikes

Struck at (m)	Casing to (m)	Time (min)	Rose to (m)

Water Added

From (m)	To (m)

Casing Details

To (m)	Diam (mm)

Chiselling Details

From (m)	To (m)	Time (hh:mm)
4.20	4.50	01:00

CAUSEWAY GEOTECH

Method	Plant Used	Top	Base
Cable Percussion	Dando 3000	0.00	2.00
Rotary Coring	Comacchio 405	2.00	8.00

Project No.: 18-0144

Project Name: Fionnphort and Iona Ground Investigation

Borehole No.: BH07

Coordinates: 129935.26 E, 723445.79 N

Client: Argyll and Bute Council

Sheet 1 of 1

Client's Representative: Byrne Looby Partners

Scale: 1:50

Driller: CC+TA

Ground Level: -0.96 mCD

Dates: 02/08/2018 - 03/08/2018

Logger: NH+LN

Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mCD)	Depth (m) (Thickness)	Legend	Description	Water	Backfill
0.00 - 1.00	B2					(0.90)		Grey sandy slightly silty subangular to subrounded fine to coarse GRAVEL predominantly of felsic granite with low cobble content and fragments of shell. Sand is fine to coarse. Cobbles are subangular to subrounded predominantly of felsic granite.		
					-1.86	0.90				
1.00 - 2.00	B1									
1.00 - 1.15	SPT (S)	1.00		N=50 (28 for 114mm/50 for 38mm)		(0.90)		Very dense grey sandy slightly silty subangular to subrounded fine to coarse GRAVEL predominantly of felsic granite with low cobble content and fragments of shell. Sand is fine to coarse. Cobbles are subangular to subrounded predominantly of felsic granite.		
					-2.76	1.80				
2.00 - 2.05	SPT (S)	2.00		N=50 (25 for 25mm/50 for 25mm)		(0.20)		Weathered GRANITE recovered as pink and grey angular coarse GRAVEL.		
2.00 - 2.05				N=50 (25 for 25mm/50 for 25mm)	-2.96	2.00		Medium strong to strong massive pinkish red and grey speckled GRANITE. Largely unweathered Discontinuities: 1. 10-30 degree joints, typically medium spaced (50/200/350), planar, rough 2. Sub-vertical joints, undulating, rough, patchy grey staining		
	100 97 90									
3.50										
	100 100 93		4							
5.00						(6.00)				
	100 80 79									
			NI							
6.50										
	80 53 47		5							
			NI							
8.00					-8.96	8.00		End of Borehole at 8.00m		
	TCR SCR RQD		FI							

Remarks
Deck to Bed = 5.70m

Terminated on recovery of 6.00m core

Core Barrel: SK6L

Flush Type:

Water Strikes

Struck at (m)	Casing to (m)	Time (min)	Rose to (m)

Water Added

From (m)	To (m)

Casing Details

To (m)	Diam (mm)
2.00	200

Chiselling Details

From (m)	To (m)	Time (hh:mm)
1.80	2.00	01:00

CAUSEWAY GEOTECH

Method	Plant Used	Top	Base
Cable Percussion	Dando 3000	0.00	1.40
Rotary Coring	Comacchio 405	1.40	10.00

Project No.: 18-0144

Project Name: Fionnphort and Iona Ground Investigation

Borehole No.: BH08

Coordinates: 129888.57 E, 723451.09 N

Client: Argyll and Bute Council

Sheet 1 of 1

Client's Representative: Byrne Looby Partners

Scale: 1:50

Driller: CC+TA

Ground Level: -2.26 mCD

Dates: 04/08/2018

Logger: NH+LN

Depth (m)	Sample / Tests		Casing Depth (m)	Water Depth (m)	Field Records	Level (mCD)	Depth (m) (Thickness)	Legend	Description	Water	Backfill
0.00 - 0.50	B1						(0.50)		Light grey very gravelly slightly silty fine to coarse SAND with fragments of shell. Gravel is subangular to subrounded fine to coarse		
0.50 - 1.10	B2					-2.76	0.50		Dense reddish grey very sandy slightly silty subangular fine to coarse GRAVEL predominantly of felsic granite with low cobble content and fragments of shell. Sand is fine to coarse. Cobbles are subangular predominantly of felsic granite.		
1.00 - 1.11	SPT (C)		1.00		N=50 (25 for 30mm/50 for 80mm)		(0.60)				
						-3.36	1.10		Very dense red sandy slightly silty subangular to subrounded fine to coarse		
1.10 - 1.40	B3					-3.66	(0.30) 1.40		GRAVEL predominantly of felsic granite with low cobble content. Sand is fine to coarse. Cobbles are subangular predominantly of felsic granite.		
	100	19	0						Medium strong to strong (locally very strong) highly fractured pinkish red and grey speckled GRANITE. Partially weathered with slightly reduced strength and closer fracture spacing		
2.90				20+					Discontinuities:		
	100	7	0						1. 10-30 degree joints, closely spaced (10/30/170), undulating, rough		
4.40									2. 70-90 degree joints, probably closely spaced, undulating, rough		
	100	21	10	NI			(8.60)				
5.80				20+							
	100	30	30								
6.80				NI							
	83	0	0								
7.40											
	100	29	0								
8.60				20							
	100	43	26								
				NI							
10.00						-12.26	10.00		End of Borehole at 10.00m		
	TCR	SCR	RQD	FI							

Remarks
Deck to Bed = 7.60m

Terminated on recovery of 8.60m core

Core Barrel: SK6L

Flush Type:

Water Strikes

Struck at (m)	Casing to (m)	Time (min)	Rose to (m)

Water Added

From (m)	To (m)

Casing Details

To (m)	Diam (mm)
1.40	200

Chiselling Details

From (m)	To (m)	Time (hh:mm)
1.20	1.40	01:00

CAUSEWAY GEOTECH

Method	Plant Used	Top	Base
Cable Percussion	Dando 3000	0.00	0.10

Project No.: 18-0144	**Project Name:** Fionnphort and Iona Ground Investigation
Coordinates: 129856.55 E 723461.21 N	**Client:** Argyll and Bute Council
	Client's Representative: Byrne Looby Partners
Ground Level: -2.46 mCD	**Dates:** 06/08/2018

Borehole No.: BH09

Sheet 1 of 1

Scale: 1:50

Driller: CC

Logger: NH

Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mCD)	Depth (m) (Thickness)	Legend	Description	Water	Backfill
					-2.56	(0.10) 0.10		BOULDER or Possible ROCK End of Borehole at 0.10m		

Remarks
Deck to Bed = 7.90m

Terminated on large boulder, moved to BH09A

Water Strikes

Struck at (m)	Casing to (m)	Time (min)	Rose to (m)

Water Added

From (m)	To (m)

Casing Details

To (m)	Diam (mm)
0.10	200

Chiselling Details

From (m)	To (m)	Time (hh:mm)
0.00	0.10	01:00

CAUSEWAY GEOTECH

Method	Plant Used	Top	Base
Cable Percussion	Dando 3000	0.00	1.40
Rotary Coring	Comacchio 405	1.40	8.20

Project No.: 18-0144

Project Name: Fionnphort and Iona Ground Investigation

Borehole No.: BH09A

Coordinates: 129860.41 E, 723464.75 N

Client: Argyll and Bute Council

Sheet 1 of 1

Client's Representative: Byrne Looby Partners

Scale: 1:50

Driller: CC+TA

Ground Level: -2.52 mCD

Dates: 08/08/2018 - 09/08/2018

Logger: NH

Depth (m)	Sample / Tests	TCR	SCR	RQD	Casing Depth (m)	Water Depth (m)	FI	Field Records	Level (mCD)	Depth (m) (Thickness)	Legend	Description	Water	Backfill
0.00 - 1.00	B1									(1.20)		Very dense very sandy slightly silty subangular to subrounded fine to coarse GRAVEL predominantly of felsic granite with fragments of shell. Sand is fine to coarse.		
1.00 - 1.12	SPT (C)				1.00			N=50 (25 for 85mm/50 for 30mm)	-3.72	1.20 (0.20)		Weathered GRANITE recovered as pink and grey angular coarse GRAVEL.		
		100	0	0		NI			-3.92	1.40		Medium strong to strong (locally very strong) massive pinkish red and grey speckled GRANITE. Partially weathered with slightly closer fracture spacing. Discontinuities: 1. 0 to 30 degree joints, closely spaced (20/100/400) planar, rough 2. 70 to 90 degree joints, closely spaced, undulating, rough		
2.30		100	9	9		20+								
3.90		100	92	23		11				(6.80)				
5.10		100	65	65		NI								
						2								
6.65		96	89	67		8								
						4								
8.20									-10.72	8.20		End of Borehole at 8.20m		

Remarks
Deck to Bed = 8.00m

Terminated on recovery of 6.80m core

Core Barrel: SK6L

Flush Type:

Water Strikes

Struck at (m)	Casing to (m)	Time (min)	Rose to (m)

Water Added

From (m)	To (m)

Casing Details

To (m)	Diam (mm)
1.40	200

Chiselling Details

From (m)	To (m)	Time (hh:mm)
1.20	1.40	01:00

CAUSEWAY GEOTECH

Method	Plant Used	Top	Base
Cable Percussion	Dando 3000	0.00	1.00
Rotary Coring	Comacchio 405	1.00	6.10
Rotary Coring	Commachio 405	6.10	7.00

Project No.: 18-0144

Project Name: Fionnphort and Iona Ground Investigation

Borehole No.: BH10

Coordinates: 129801.13 E, 723429.01 N

Client: Argyll and Bute Council

Sheet 1 of 1

Client's Representative: Byrne Looby Partners

Scale: 1:50

Driller: CC+TA

Ground Level: -3.71 mCD

Dates: 15/08/2018

Logger: NH+LN

Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mCD)	Depth (m) (Thickness)	Legend	Description	Water	Backfill
0.00 - 0.70	B1					(0.70)		Grey very sandy slightly silty subangular to subrounded fine to coarse GRAVEL predominantly of felsic granite with fragments of shell. Sand is fine to coarse.		
0.70 - 1.00	B2				-4.40	0.70 (0.30)		Weathered GRANITE recovered as pink and grey angular coarse GRAVEL.		
1.00 - 1.06	SPT (C)			N=50 (25 for 30mm/50 for 30mm)	-4.70	1.00		Strong to very strong massive pinkish red and grey speckled GRANITE. Largely unweathered. Discontinuities: 1. 10 to 30 degree joints, typically medium spaced (20/200/350) planar, rough, closed, occasionally with front orange staining. 2. 60 to 80 degree joints from 1.0m to 3.70m, planar, rough, closed with patchy greyish orange staining.		
1.00 - 2.20	100 67	47	8							
2.20 - 3.70	100 73	62				(6.00)				
3.70 - 4.50	100 100	100								
4.50 - 5.20	100 100	100								
5.20 - 5.50	100 80	80	3							
5.50 - 6.00	100 100	90								
6.00 - 6.10	100 0	0								
6.10 - 7.00	89 89	80			-10.70	7.00		End of Borehole at 7.00m		
	TCR SCR	RQD	FI							

Remarks
Deck to Bed = 10.40m

Terminated on recovery of 6.00m core

Core Barrel: SK6L/T2-101

Flush Type:

Water Strikes

Struck at (m)	Casing to (m)	Time (min)	Rose to (m)

Water Added

From (m)	To (m)

Casing Details

To (m)	Diam (mm)
1.00	200

Chiselling Details

From (m)	To (m)	Time (hh:mm)
0.80	1.00	01:00

CAUSEWAY GEOTECH

Method	Plant Used	Top	Base
Cable Percussion	Dando 2000	0.00	0.30
Rotary Coring	Comacchio 405	0.30	1.80
Rotary Coring	Comacchio 405	1.80	3.30

Project No.: 18-0144

Project Name: Fionnphort and Iona Ground Investigation

Borehole No.: BH11

Coordinates: 129842.85 E, 723379.02 N

Client: Argyll and Bute Council

Sheet 1 of 1

Client's Representative: Byrne Looby Partners

Scale: 1:50

Driller: CC+TA

Ground Level: -2.46 mCD

Dates: 30/08/2018

Logger: SG+LN

Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mCD)	Depth (m) (Thickness)	Legend	Description	Water	Backfill
0.00 - 0.20	B1				-2.66	(0.20) 0.20		Grey very sandy slightly silty subangular to subrounded fine to coarse GRAVEL predominantly of felsic granite. Sand is fine to coarse.		
					-2.76	(0.10) 0.30		Weathered GRANITE recovered as pink and grey angular coarse GRAVEL.		
	100 80 31		9 4 20					Medium strong to strong (locally very strong) massive pinkish red and grey speckled GRANITE. Partially weathered with orange staining on fracture surfaces. Discontinuities: 1. 0 to 10 degree joints typically closely spaced becoming medium spaced below 1.80m, (40/70/470) undulating, tough, closed with orange staining. 2. Subvertical joints from 0.30m to 2.50m, planar, rough, closed with orange staining.		
1.80	86 80 70		3			(3.00)				
2.50	67 67 67									
3.30					-5.76	3.30		End of Borehole at 3.30m		

TCR	SCR	RQD	FI

Remarks
Deck to Bed = 8.30m

Terminated on recovery of 3.00m core

Core Barrel: SK6L/T2-101

Flush Type:

Water Strikes

Struck at (m)	Casing to (m)	Time (min)	Rose to (m)

Water Added

From (m)	To (m)

Casing Details

To (m)	Diam (mm)
0.30	200

Chiselling Details

From (m)	To (m)	Time (hh:mm)
0.20	0.30	01:00

CAUSEWAY GEOTECH

Method	Plant Used	Top	Base
Cable Percussion	Dando 3000	0.00	2.70
Rotary Coring	Comacchio 405	2.70	4.00
Rotary Coring	Comacchio 405	4.00	8.80

Project No.: 18-0144

Project Name: Fionnphort and Iona Ground Investigation

Borehole No.: BH12

Coordinates: 129897.78 E, 723633.80 N

Client: Argyll and Bute Council

Sheet 1 of 1

Client's Representative: Byrne Looby Partners

Scale: 1:50

Driller: AH+SJ

Ground Level: -3.68 mCD

Dates: 26/08/2018 - 29/08/2018

Logger: SG+LN

Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mCD)	Depth (m) (Thickness)	Legend	Description	Water	Backfill
0.00 - 1.00	B1					(1.20)		Medium dense grey slightly gravelly slightly silty fine to coarse SAND with fragments of shell. Gravel is subrounded fine predominantly of felsic granite.		
1.00	D4									
1.00 - 1.45	SPT (S) N=22	1.00		N=22 (4,4/5,5,6,6)	-4.88	1.20 (0.20)		Stiff brown slightly gravelly sandy CLAY. Sand is fine to coarse. Gravel is subangular to subrounded fine to medium predominantly of felsic granite.		
1.20 - 1.40	B3				-5.08	1.40		Very dense greyish red very sandy slightly silty subangular to subrounded fine to coarse GRAVEL predominantly of felsic granite. Sand is fine to coarse.		
1.50 - 2.50	B2					(1.10)				
2.00	D5									
2.00 - 2.02	SPT (S)	2.00		N=50 (25 for 20mm/50 for 0mm)						
2.50 - 2.70	B6				-6.18	2.50 (0.20)		Weathered GRANITE recovered as pink and grey angular coarse GRAVEL.		
			8		-6.38	2.70		Strong to very strong massive pinkish red and grey speckled GRANITE. Partially weathered with patchy orange staining on fracture surfaces. Discontinuities: 1. 10 to 40 degree joints closely spaced (40/170/800) undulating, rough, with patchy orange staining. 2. Occasional subvertical joints, probably medium spaced, planar, rough, with patchy orange staining.		
	95 82 73		4							
4.00										
	100 87 70		8							
5.50						(6.10)				
	100 100 86		2							
6.80										
	100 100 97									
8.00			7							
	100 88 75									
8.80					-12.48	8.80		End of Borehole at 8.80m		
	TCR SCR RQD FI									

Remarks
Deck to Bed = 11.00m

Terminated on recovery of 6.10m core

Core Barrel: SK6LT2-101

Flush Type:

Water Strikes			
Struck at (m)	Casing to (m)	Time (min)	Rose to (m)

Water Added		Casing Details	
From (m)	To (m)	To (m)	Diam (mm)
		2.70	200

Chiselling Details		
From (m)	To (m)	Time (hh:mm)
2.50	2.70	01:00

CAUSEWAY GEOTECH

APPENDIX C

Core photographs

BH01 1.30m to 2.50m

BH01 2.50m to 4.00m

BH01 4.00m to 5.50m

BH01 5.50m to 7.00m

BH02 0.80m to 2.20m

BH02 2.20m to 3.80m

BH02 3.80m to 5.30m

BH02 5.30m to 6.30m

BH03 3.60m to 5.10m

BH03 5.10m to 6.60m

BH03 6.60m to 7.20m

BH03 7.20m to 8.10m

BH03 8.10m to 9.60m

BH04 2.20m to 3.70m

BH04 3.70m to 5.20m

BH05 5.20m to 6.70m

BH05 6.70m to 8.20m

BH06 4.50m to 6.00m

BH06 6.00m to 7.50m

BH06 7.50m to 9.00m

BH06 9.00m to 10.50m

BH07 2.00m to 3.50m

BH07 3.50m to 5.00m

BH07 5.00m to 6.50m

BH07 6.50m to 8.00m

BH08 1.40m to 2.90m

BH08 2.90m to 4.40m

BH08 4.40m to 5.80m

BH08 5.80m to 6.80m

BH08 6.80m to 7.40m

BH08 7.40m to 8.60m

BH08 8.60m to 10.00m

BH09A 1.40m to 2.30m

BH09A 2.30m to 3.90m

BH09A 3.90m to 5.10m

BH09A 5.10m to 6.65m

BH09A 6.65m to 8.20m

BH10 1.00m to 2.20m

BH10 2.20m to 3.70m

BH10 3.70m to 4.50m

BH10 4.50m to 5.20m

BH10 5.20m to 5.50m

BH10 5.50m to 6.00m

BH10 6.00m to 6.10m

BH10 6.10m to 7.00m

BH11 0.30m to 1.80m

BH11 1.80m to 2.50m

BH11 2.50m to 3.20m

BH12 2.70m to 4.00m

BH12 4.00m to 5.50m

BH12 5.50m to 6.80m

BH12 6.80m to 8.00m

BH12 8.00m to 8.80m

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APPENDIX D

Geotechnical laboratory test results

CAUSEWAY GEOTECH

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SOIL AND ROCK SAMPLE ANALYSIS
LABORATORY TEST REPORT

Project Name:	Fionnphort and Iona Ground Investigation
Project No.:	18-0144
Client:	Argyll and Bute Council
Engineer:	Byrne Looby Partners
Date:	08/10/18

We are pleased to attach the results of laboratory testing carried out for the above project. This memo and its attachments constitute a report of the results of tests as detailed in the Contents page(s).

The attached results complete the testing requested and we would therefore wish to confirm that samples will be retained without charge for a period of 28 days from the above date after which they will be appropriately disposed of unless we receive written instructions to the contrary prior to that date.

We trust our report meets with your approval but if you have any queries or require additional information, please do not hesitate to contact the undersigned.

Approved Signatory

Stephen Watson
Laboratory Manager

Signed for and on behalf of Causeway Geotech Ltd

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Project Name: Fionnphort and Iona Ground Investigation

Report Reference: 18-0144

The table below details the tests carried out, the specifications used, and the number of tests included in this report.

Tests marked with* in this report are not United Kingdom Accreditation Service (UKAS) accredited and are not included in Causeway Geotech Limited's scope of UKAS Accreditation Schedule of Tests. Opinions and interpretations expressed herein are outside the scope of UKAS accreditation.

Material tested	Type of test/Properties measured/Range of measurement	Standard specifications	No. of results included in the report
SOIL	Moisture Content of Soil	BS 1377-2: 1990: Cl 3.2	2
SOIL	Liquid and Plastic Limits of soil-1 point cone penetrometer method	BS 1377-2: 1990: Cl 4.4, 5.3 & 5.4	2
SOIL	Particle size distribution - wet sieving	BS 1377-2: 1990: Cl 9.2	17
SOIL	Particle size distribution - sedimentation hydrometer method	BS 1377-2: 1990: Cl 9.5	1
ROCK	Point load index	ISRM Commission on Testing Methods. Suggested Method for Determining Point Load Strength 1985	17
[redacted] ROCK	Uniaxial Compressive Strength (UCS)*	ISRM Suggested Methods -Rock Characterization Testing and Monitoring, Ed. E T Brown - 1981	8

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SUB-CONTRACTED TESTS

In agreement with Client, the following tests were conducted by an approved sub-contractor. All sub-contracting laboratories used are UKAS accredited.

Material tested	Type of test/Properties measured/Range of measurement	Standard specifications	No. of results included in the report
SOIL – Subcontracted to Chemtest Ltd (UKAS 2183)	pH Value of Soil		8
SOIL – Subcontracted to Chemtest Ltd *(UKAS 2183)*	Sulphate Content water extract		8

[redacted]

CAUSEWAY GEOTECH

Summary of Classification Test Results

Project No.	Project Name
18-0144	Fionnphort and Iona Ground Investigation

Hole No.	Sample				Soil Description	Density bulk / dry Mg/m³		w %	Passing 425µm %	LL %	PL %	PI %	Particle density Mg/m³	Casagrande Classification
	Ref	Top	Base	Type										
BH06	7	2.00		D	Brown slightly sandy gravelly CLAY.			19	95	33 -1pt	14	19		CL
BH12	4	1.00		D	Grey gravelly fine to coarse SAND with fragments of shell.			22	61	32 -1pt	NP			

All tests performed in accordance with BS1377:1990 unless specified otherwise

Key

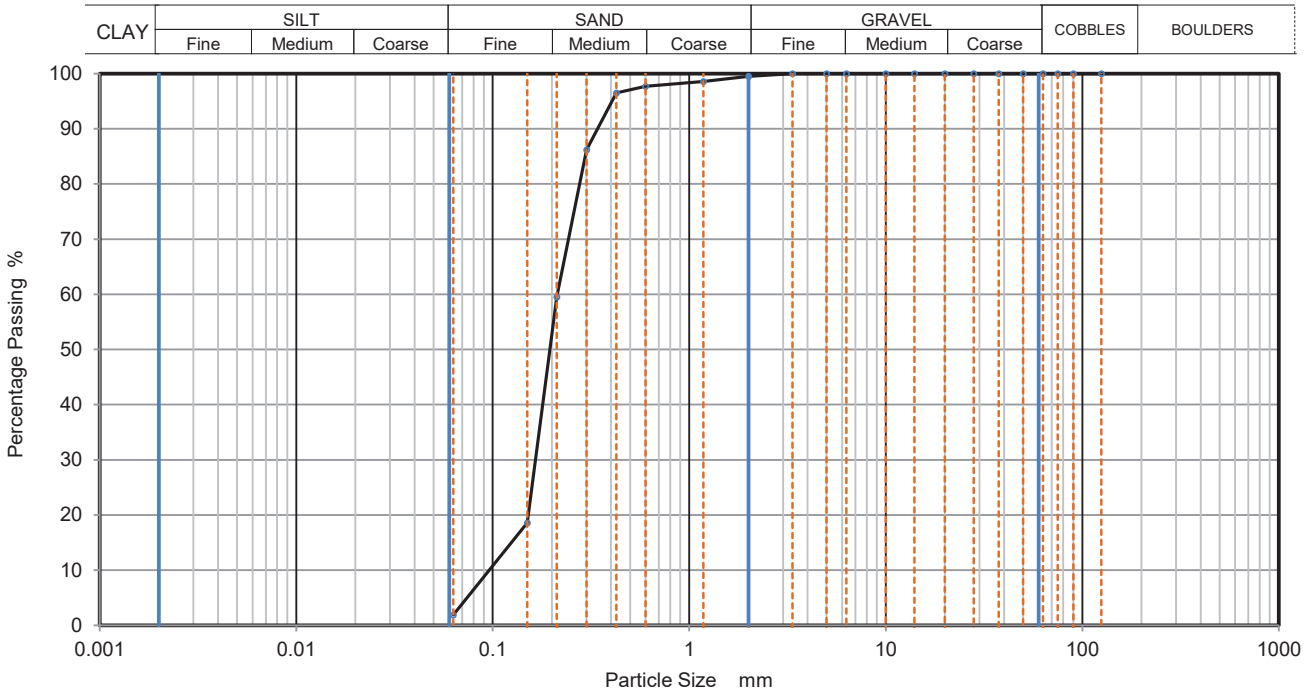
Density test	Liquid Limit	Particle density
Linear measurement unless :	4pt cone unless :	sp - small pyknometer
wd - water displacement	cas - Casagrande method	gj - gas jar
wi - immersion in water	1pt - single point test	

Date Printed: 05/10/2018

Approved By: Stephen.Watson

UKAS TESTING 10122

CAUSEWAY GEOTECH	**PARTICLE SIZE DISTRIBUTION**			Job Ref	**18-0144**
				Borehole/Pit No.	BH01
Site Name	Fionnphort and Iona Ground Investigation			Sample No.	1
Soil Description	Grey fine to medium SAND.			Depth, m	0.00
Specimen Reference	2	Specimen Depth	m	Sample Type	B
Test Method	BS1377:Part 2:1990, clause 9.2			KeyLAB ID	Caus20180929131



Sieving		Sedimentation	
Particle Size mm	% Passing	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	98		
0.425	97		
0.3	86		
0.212	60		
0.15	19		
0.063	2		

Dry Mass of sample, g	248

Sample Proportions	% dry mass
Cobbles	0
Gravel	1
Sand	98
Fines <0.063mm	2

Grading Analysis		
D100	mm	
D60	mm	0.213
D30	mm	0.165
D10	mm	0.096
Uniformity Coefficient		2.2
Curvature Coefficient		1.3

Remarks

Preparation and testing in accordance with BS1377 unless noted below

UKAS TESTING 10122

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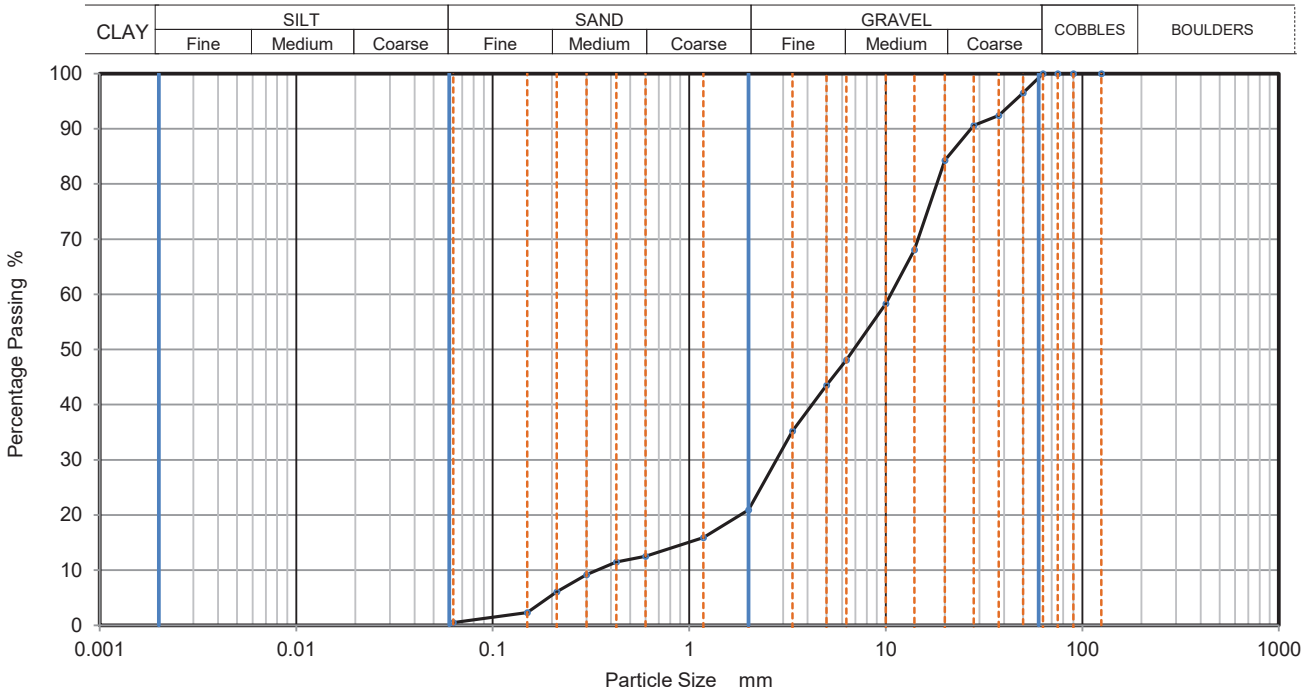
Stephen.Watson	05/10/2018 15:43

CAUSEWAY GEOTECH	**PARTICLE SIZE DISTRIBUTION**			Job Ref	**18-0144**
				Borehole/Pit No.	BH02
Site Name	Fionnphort and Iona Ground Investigation			Sample No.	1
Soil Description	Grey sandy subrounded fine to coarse GRAVEL.			Depth, m	0.00
Specimen Reference	2	Specimen Depth	m	Sample Type	B
Test Method	BS1377:Part 2:1990, clause 9.2			KeyLAB ID	Caus20180929132



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100		
90	100		
75	100		
63	100		
50	97		
37.5	92		
28	91		
20	84		
14	68		
10	58		
6.3	48		
5	44		
3.35	35		
2	21		
1.18	16		
0.6	13		
0.425	12		
0.3	9		
0.212	6		
0.15	2		
0.063	1		

Dry Mass of sample, g	11534

Sample Proportions	% dry mass
Cobbles	0
Gravel	79
Sand	20
Fines <0.063mm	1

Grading Analysis		
D100	mm	
D60	mm	10.6
D30	mm	2.78
D10	mm	0.337
Uniformity Coefficient		31
Curvature Coefficient		2.2

Remarks

Preparation and testing in accordance with BS1377 unless noted below

UKAS TESTING 10122

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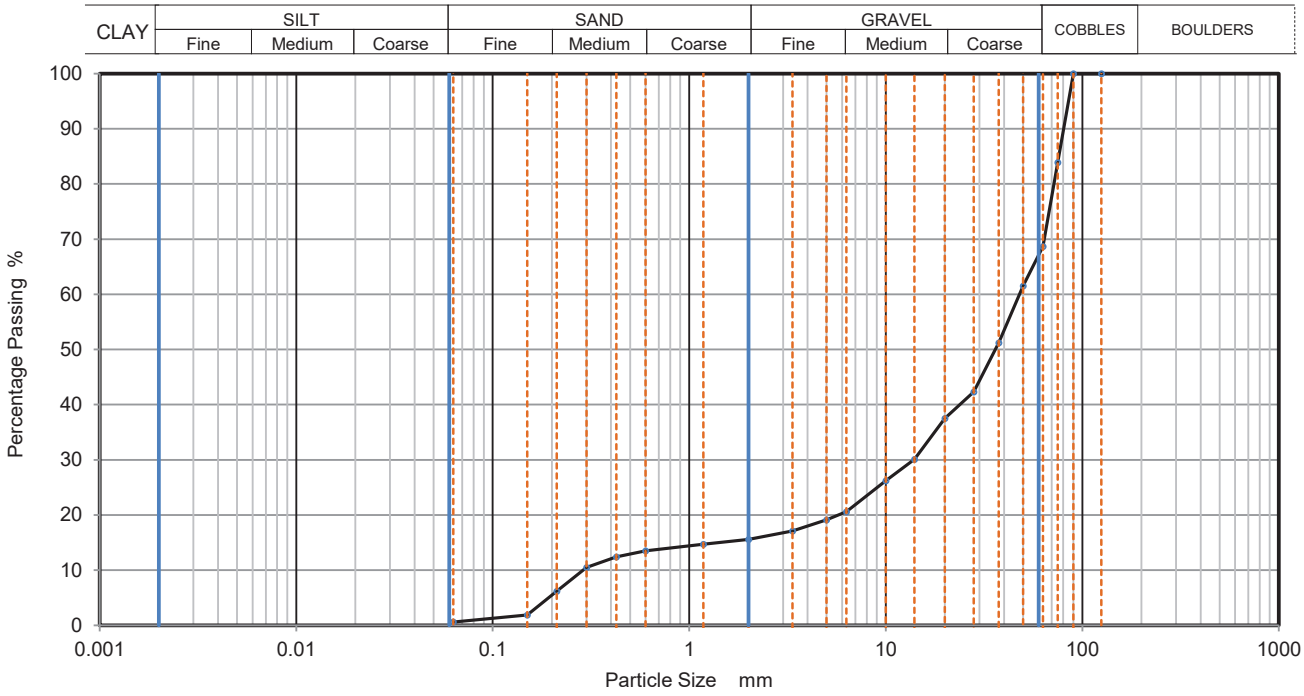
CAUSEWAY GEOTECH	**PARTICLE SIZE DISTRIBUTION**			Job Ref	**18-0144**
				Borehole/Pit No.	BH03
Site Name	Fionnphort and Iona Ground Investigation			Sample No.	3
Soil Description	Grey slightly sandy subangular to subrounded fine to coarse GRAVEL with medium cobble content.			Depth, m	0.80
Specimen Reference	2	Specimen Depth	m	Sample Type	B
Test Method	BS1377:Part 2:1990, clause 9.2			KeyLAB ID	Caus20180929133



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100		
90	100		
75	84		
63	69		
50	62		
37.5	51		
28	42		
20	38		
14	30		
10	26		
6.3	21		
5	19		
3.35	17		
2	16		
1.18	15		
0.6	14		
0.425	12		
0.3	11		
0.212	6		
0.15	2		
0.063	1		

Dry Mass of sample, g	14958

Sample Proportions	% dry mass
Cobbles	31
Gravel	53
Sand	15
Fines <0.063mm	1

Grading Analysis		
D100	mm	
D60	mm	48
D30	mm	13.9
D10	mm	0.289
Uniformity Coefficient		170
Curvature Coefficient		14

Remarks

Preparation and testing in accordance with BS1377 unless noted below

UKAS TESTING 10122

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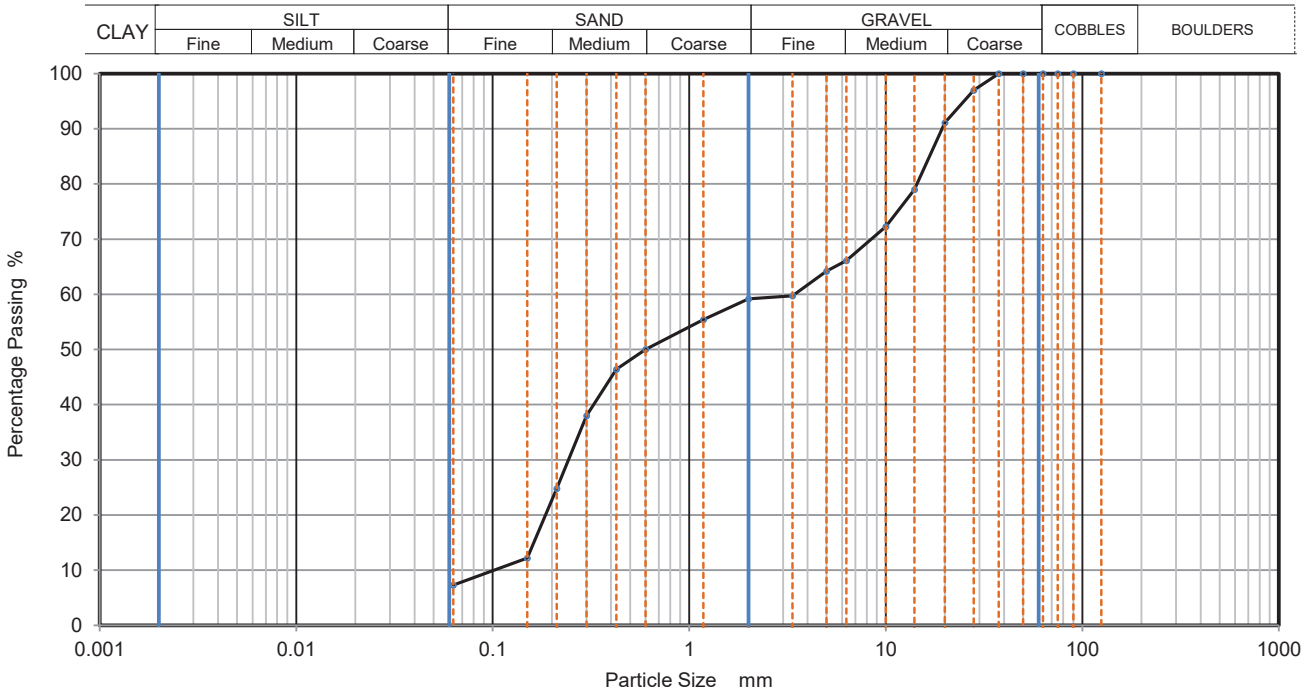
CAUSEWAY GEOTECH	**PARTICLE SIZE DISTRIBUTION**			Job Ref	**18-0144**
				Borehole/Pit No.	BH03
Site Name	Fionnphort and Iona Ground Investigation			Sample No.	4
Soil Description	Brownish grey slightly silty gravelly fine to coarse SAND.			Depth, m	2.10
Specimen Reference	2	Specimen Depth	m	Sample Type	B
Test Method	BS1377:Part 2:1990, clause 9.2			KeyLAB ID	Caus20180929134



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100		
90	100		
75	100		
63	100		
50	100		
37.5	100		
28	97		
20	91		
14	79		
10	72		
6.3	66		
5	64		
3.35	60		
2	59		
1.18	55		
0.6	50		
0.425	46		
0.3	38		
0.212	25		
0.15	12		
0.063	7		

Dry Mass of sample, g	8966

Sample Proportions	% dry mass
Cobbles	0
Gravel	41
Sand	52
Fines <0.063mm	7

Grading Analysis		
D100	mm	
D60	mm	3.44
D30	mm	0.243
D10	mm	0.102
Uniformity Coefficient		34
Curvature Coefficient		0.17

Remarks

Preparation and testing in accordance with BS1377 unless noted below

UKAS TESTING 10122

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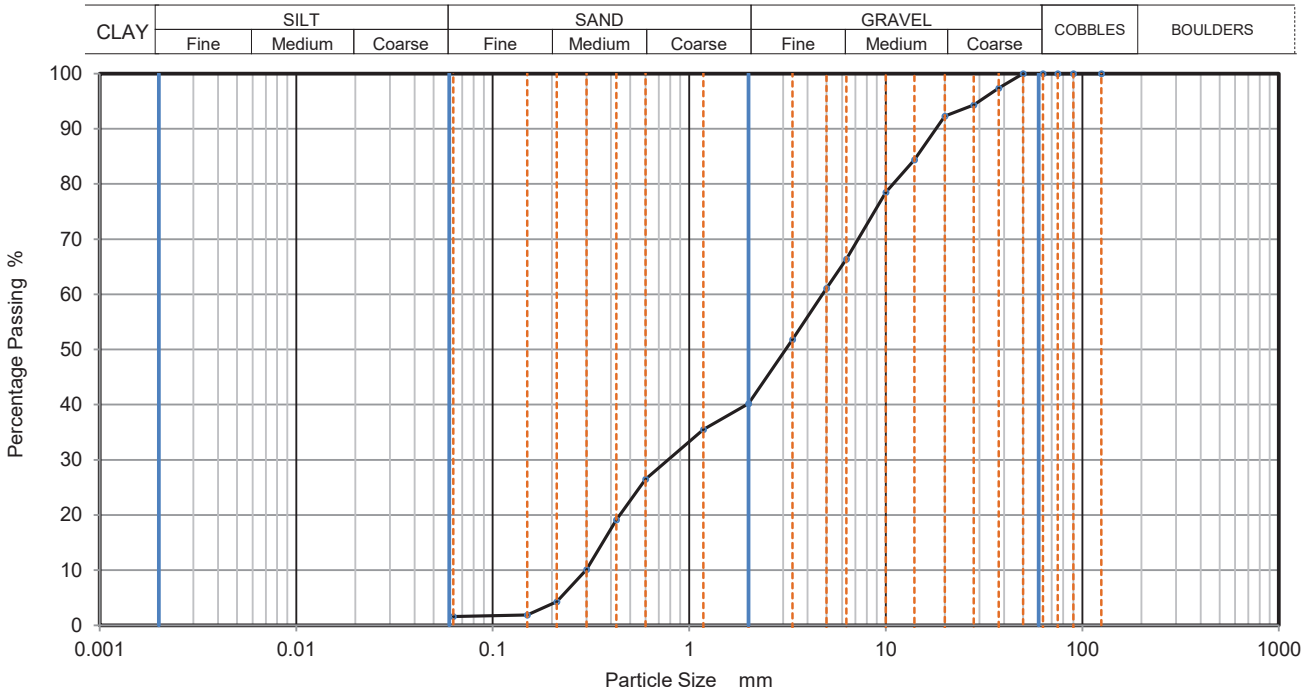
CAUSEWAY GEOTECH	**PARTICLE SIZE DISTRIBUTION**			Job Ref	**18-0144**
				Borehole/Pit No.	BH04
Site Name	Fionnphort and Iona Ground Investigation			Sample No.	2
Soil Description	Grey sandy subrounded fine to coarse GRAVEL.			Depth, m	0.00
Specimen Reference	2	Specimen Depth	m	Sample Type	B
Test Method	BS1377:Part 2:1990, clause 9.2			KeyLAB ID	Caus20180929135



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100		
90	100		
75	100		
63	100		
50	100		
37.5	97		
28	94		
20	92		
14	84		
10	79		
6.3	66		
5	61		
3.35	52		
2	40		
1.18	36		
0.6	27		
0.425	19		
0.3	10		
0.212	4		
0.15	2		
0.063	2		

Dry Mass of sample, g	7614

Sample Proportions	% dry mass
Cobbles	0
Gravel	60
Sand	39
Fines <0.063mm	2

Grading Analysis		
D100	mm	
D60	mm	4.77
D30	mm	0.781
D10	mm	0.299
Uniformity Coefficient		16
Curvature Coefficient		0.43

Remarks

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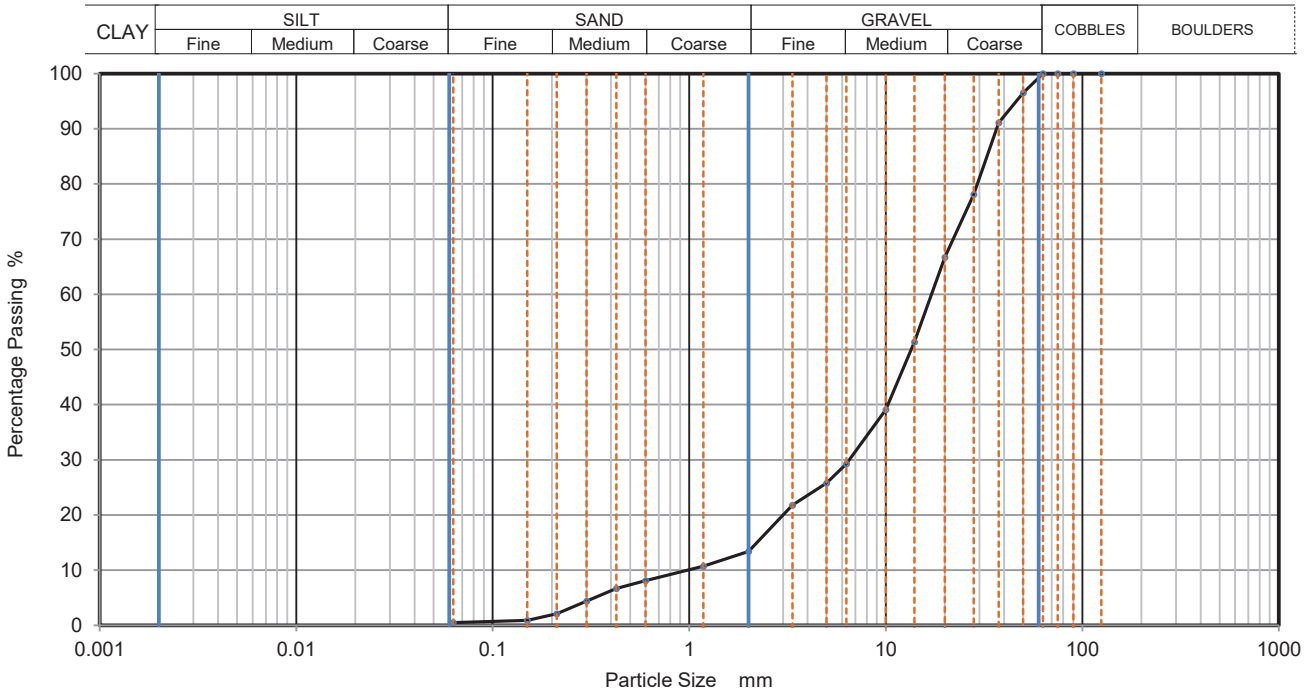
CAUSEWAY GEOTECH	**PARTICLE SIZE DISTRIBUTION**			Job Ref	**18-0144**
				Borehole/Pit No.	BH04
Site Name	Fionnphort and Iona Ground Investigation			Sample No.	3
Soil Description	Brownish grey slightly sandy subangular fine to coarse GRAVEL.			Depth, m	0.90
Specimen Reference	2	Specimen Depth	m	Sample Type	B
Test Method	BS1377:Part 2:1990, clause 9.2			KeyLAB ID	Caus20180929136



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100		
90	100		
75	100		
63	100		
50	97		
37.5	91		
28	78		
20	67		
14	51		
10	39		
6.3	29		
5	26		
3.35	22		
2	13		
1.18	11		
0.6	8		
0.425	7		
0.3	4		
0.212	2		
0.15	1		
0.063	1		

Dry Mass of sample, g	14479

Sample Proportions	% dry mass
Cobbles	0
Gravel	87
Sand	13
Fines <0.063mm	1

Grading Analysis		
D100	mm	
D60	mm	17.1
D30	mm	6.5
D10	mm	0.987
Uniformity Coefficient		17
Curvature Coefficient		2.5

Remarks

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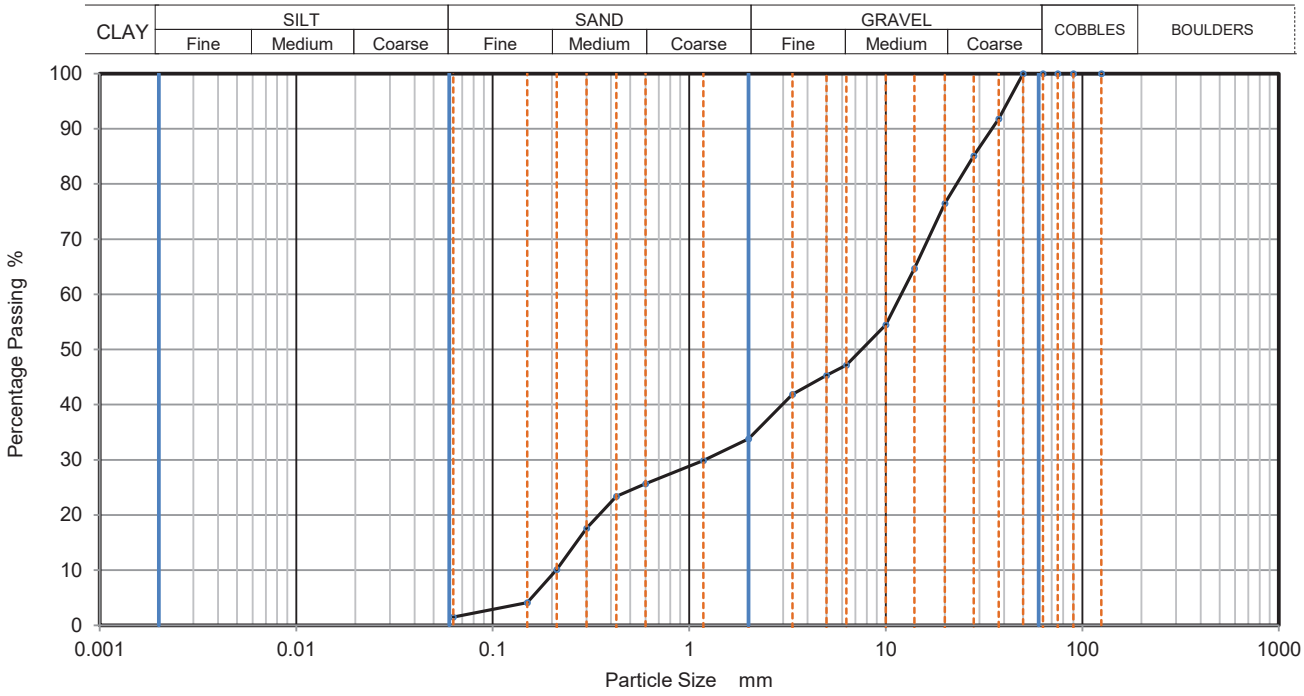
CAUSEWAY GEOTECH	**PARTICLE SIZE DISTRIBUTION**			Job Ref	**18-0144**
				Borehole/Pit No.	BH05
Site Name	Fionnphort and Iona Ground Investigation			Sample No.	3
Soil Description	Brownish grey sandy subangular fine to coarse GRAVEL.			Depth, m	1.00
Specimen Reference	2	Specimen Depth	m	Sample Type	B
Test Method	BS1377:Part 2:1990, clause 9.2			KeyLAB ID	Caus20180929137



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100		
90	100		
75	100		
63	100		
50	100		
37.5	92		
28	85		
20	77		
14	65		
10	55		
6.3	47		
5	45		
3.35	42		
2	34		
1.18	30		
0.6	26		
0.425	23		
0.3	18		
0.212	10		
0.15	4		
0.063	2		

Dry Mass of sample, g	11685

Sample Proportions	% dry mass
Cobbles	0
Gravel	66
Sand	32
Fines <0.063mm	1

Grading Analysis		
D100	mm	
D60	mm	12
D30	mm	1.2
D10	mm	0.211
Uniformity Coefficient		57
Curvature Coefficient		0.57

Remarks

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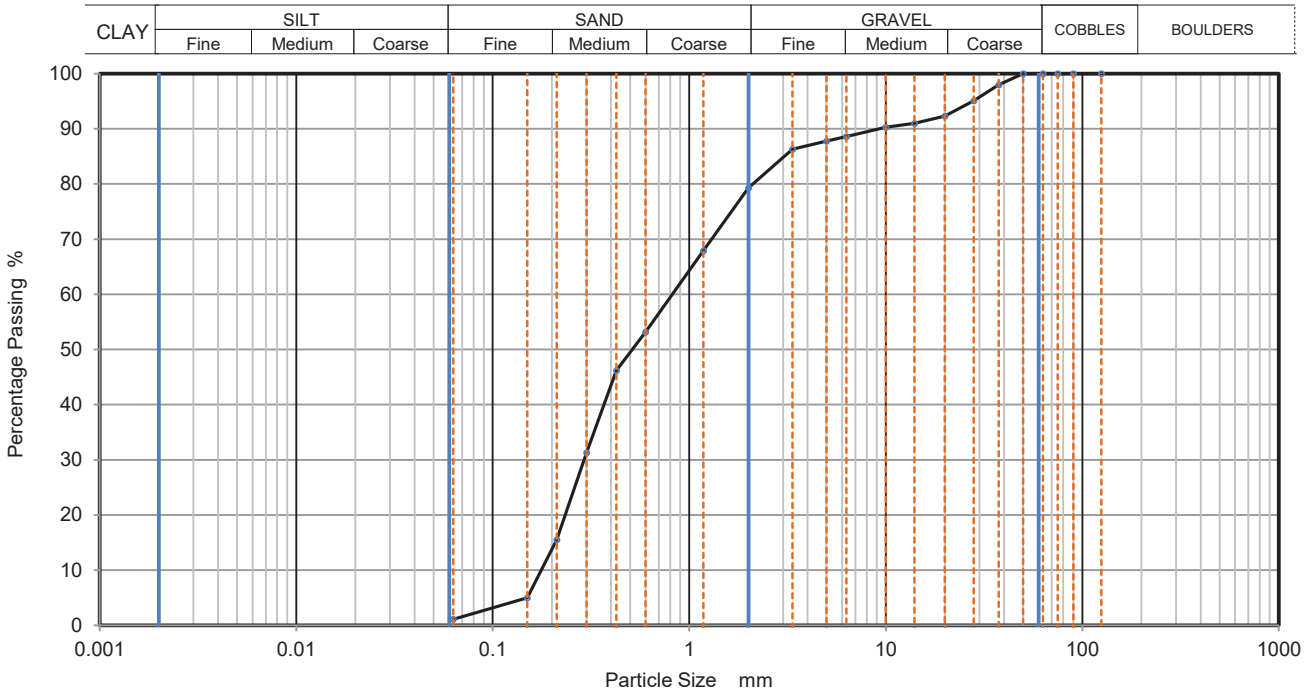
CAUSEWAY GEOTECH	**PARTICLE SIZE DISTRIBUTION**			Job Ref	**18-0144**
				Borehole/Pit No.	BH05
Site Name	Fionnphort and Iona Ground Investigation			Sample No.	4
Soil Description	Brownish grey gravelly fine to coarse SAND.			Depth, m	2.00
Specimen Reference	2	Specimen Depth	m	Sample Type	B
Test Method	BS1377:Part 2:1990, clause 9.2			KeyLAB ID	Caus20180929138



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100		
90	100		
75	100		
63	100		
50	100		
37.5	98		
28	95		
20	92		
14	91		
10	90		
6.3	89		
5	88		
3.35	86		
2	79		
1.18	68		
0.6	53		
0.425	46		
0.3	31		
0.212	16		
0.15	5		
0.063	1		

Dry Mass of sample, g	7198

Sample Proportions	% dry mass
Cobbles	0
Gravel	21
Sand	78
Fines <0.063mm	1

Grading Analysis		
D100	mm	
D60	mm	0.821
D30	mm	0.291
D10	mm	0.177
Uniformity Coefficient		4.6
Curvature Coefficient		0.58

Remarks

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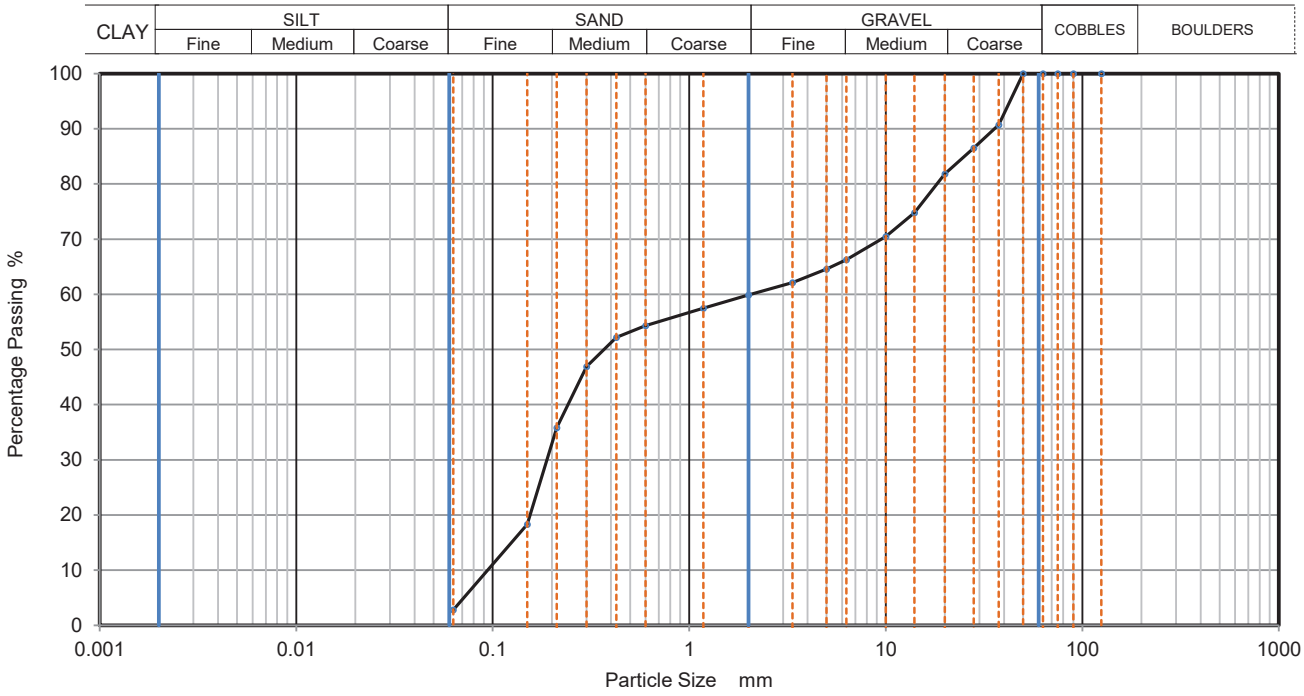
				Borehole/Pit No.	BH05
Site Name	Fionnphort and Iona Ground Investigation			Sample No.	6
Soil Description	Brown gravelly fine to coarse SAND.			Depth, m	3.00
Specimen Reference	2	Specimen Depth	m	Sample Type	B
Test Method	BS1377:Part 2:1990, clause 9.2			KeyLAB ID	Caus20180929139



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100		
90	100		
75	100		
63	100		
50	100		
37.5	91		
28	87		
20	82		
14	75		
10	71		
6.3	66		
5	65		
3.35	62		
2	60		
1.18	58		
0.6	54		
0.425	52		
0.3	47		
0.212	36		
0.15	18		
0.063	3		

Dry Mass of sample, g	7489

Sample Proportions	% dry mass
Cobbles	0
Gravel	40
Sand	57
Fines <0.063mm	3

Grading Analysis		
D100	mm	
D60	mm	2.07
D30	mm	0.189
D10	mm	0.0944
Uniformity Coefficient		22
Curvature Coefficient		0.18

Remarks

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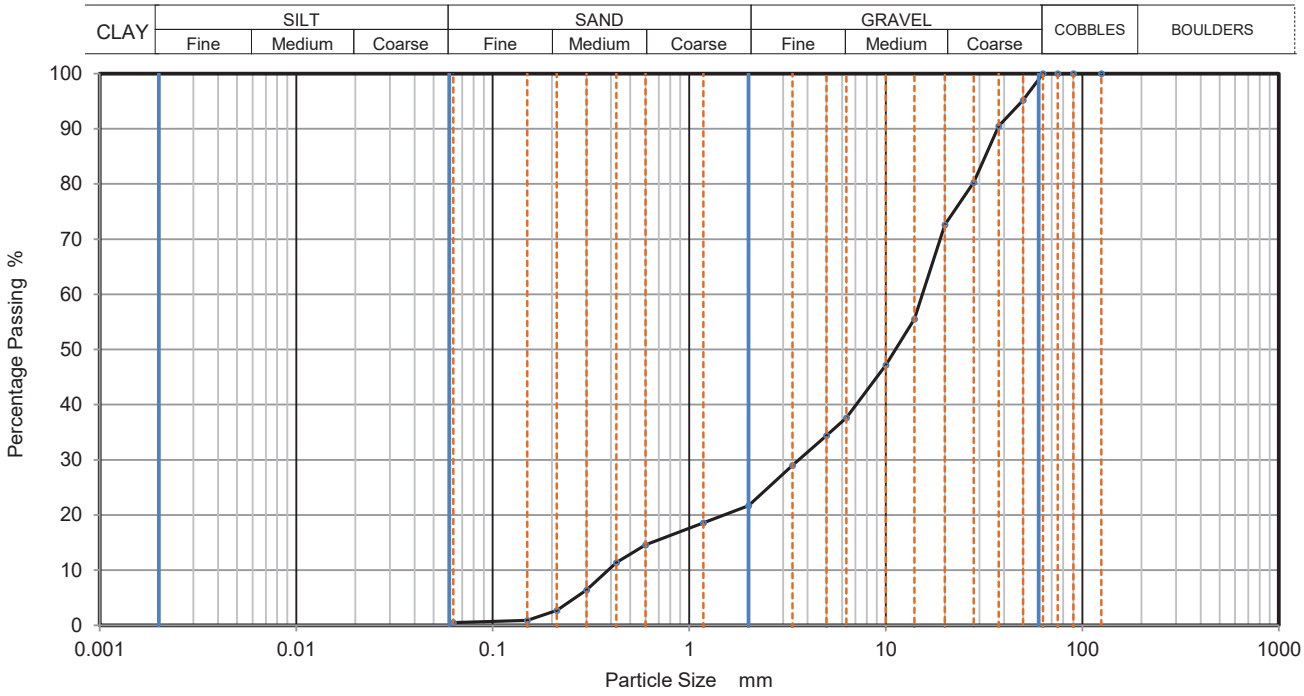
CAUSEWAY GEOTECH	**PARTICLE SIZE DISTRIBUTION**			Job Ref	**18-0144**
				Borehole/Pit No.	BH06
Site Name	Fionnphort and Iona Ground Investigation			Sample No.	1
Soil Description	Grey sandy subrounded fine to coarse GRAVEL.			Depth, m	0.00
Specimen Reference	2	Specimen Depth	m	Sample Type	B
Test Method	BS1377:Part 2:1990, clause 9.2			KeyLAB ID	Caus20180929140



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100		
90	100		
75	100		
63	100		
50	95		
37.5	91		
28	80		
20	73		
14	56		
10	47		
6.3	38		
5	34		
3.35	29		
2	22		
1.18	19		
0.6	15		
0.425	11		
0.3	6		
0.212	3		
0.15	1		
0.063	1		

Dry Mass of sample, g	8467

Sample Proportions	% dry mass
Cobbles	0
Gravel	78
Sand	21
Fines <0.063mm	0

Grading Analysis		
D100	mm	
D60	mm	15.4
D30	mm	3.6
D10	mm	0.386
Uniformity Coefficient		40
Curvature Coefficient		2.2

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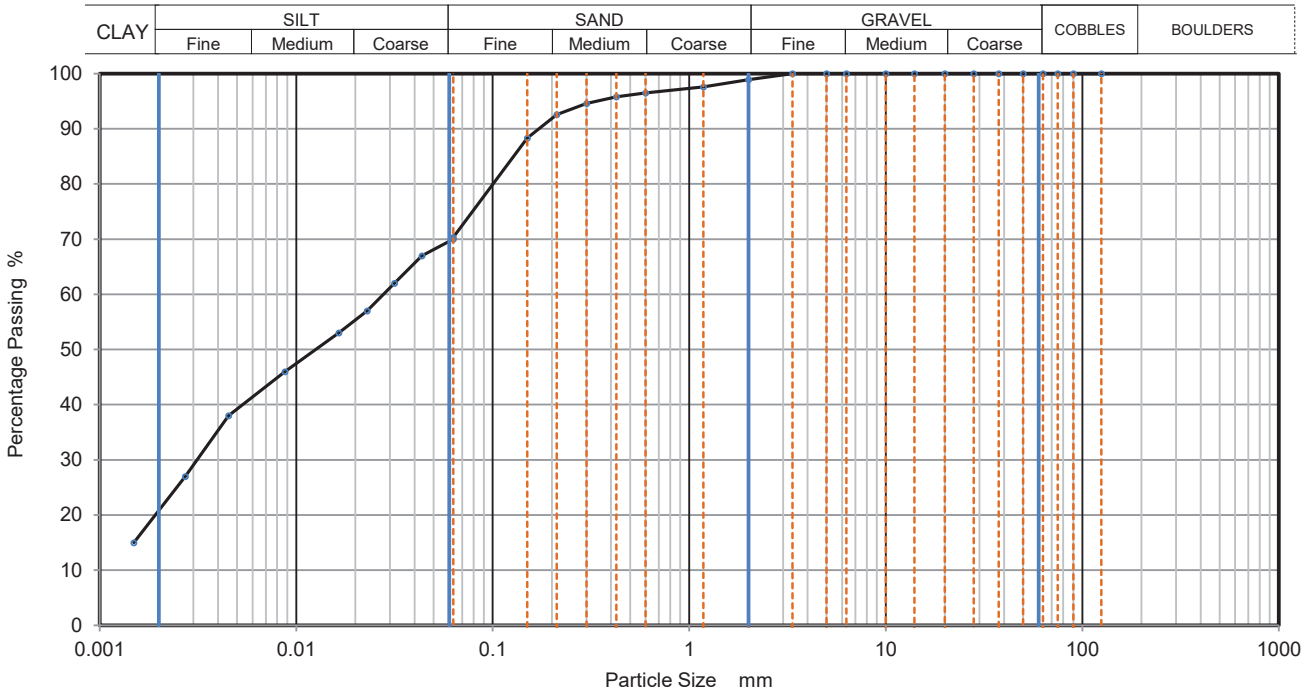
CAUSEWAY GEOTECH	**PARTICLE SIZE DISTRIBUTION**			Job Ref	**18-0144**
				Borehole/Pit No.	BH06
Site Name	Fionnphort and Iona Ground Investigation			Sample No.	4
Soil Description	Brown sandy silty CLAY.			Depth, m	2.50
Specimen Reference	2	Specimen Depth	m	Sample Type	B
Test Method	BS1377:Part 2:1990, clauses 9.2 and 9.5			KeyLAB ID	Caus20180929142



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100	0.0630	70
90	100	0.0436	67
75	100	0.0316	62
63	100	0.0229	57
50	100	0.0165	53
37.5	100	0.0088	46
28	100	0.0045	38
20	100	0.0027	27
14	100	0.0015	15
10	100		
6.3	100		
5	100		
3.35	100		
2	99		
1.18	98		
0.6	97	Particle density	(assumed)
0.425	96	2.65	Mg/m3
0.3	95		
0.212	93		
0.15	88		
0.063	70		

Dry Mass of sample, g	337

Sample Proportions	% dry mass
Cobbles	0
Gravel	1
Sand	29
Silt	49
Clay	21

Grading Analysis		
D100	mm	
D60	mm	0.0284
D30	mm	0.00309
D10	mm	
Uniformity Coefficient		
Curvature Coefficient		

Remarks

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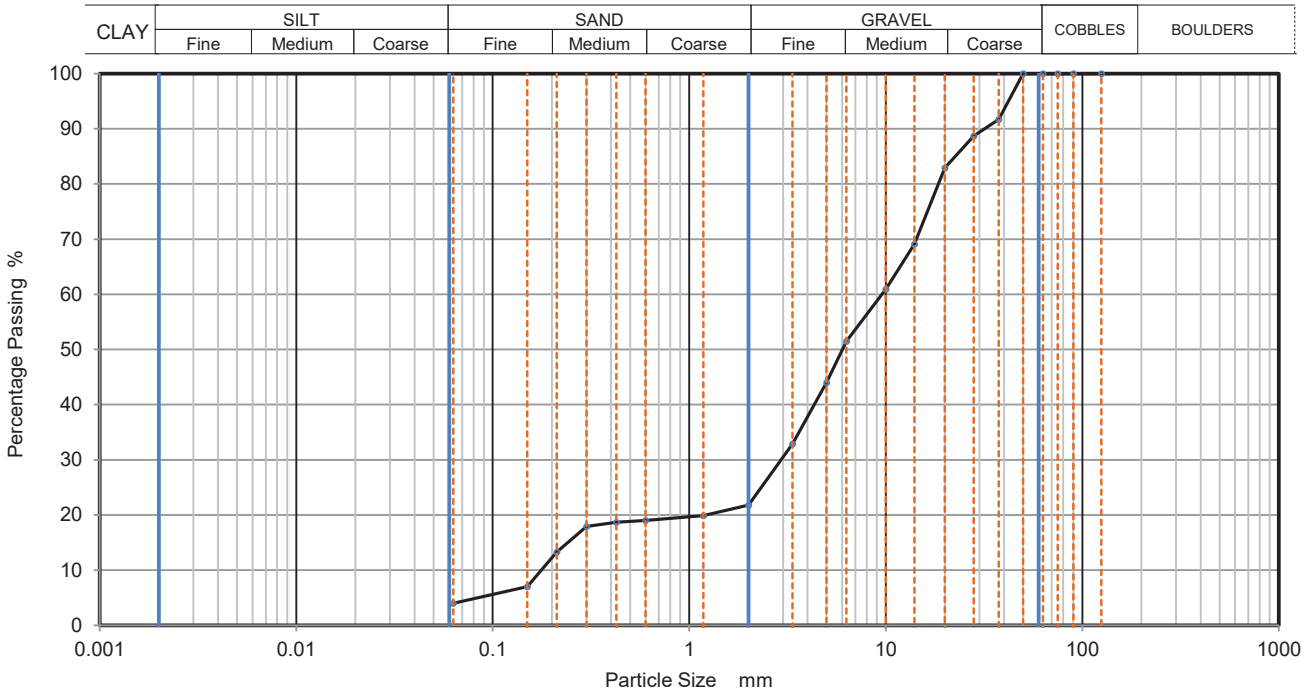
CAUSEWAY GEOTECH	**PARTICLE SIZE DISTRIBUTION**			Job Ref	**18-0144**
				Borehole/Pit No.	BH07
Site Name	Fionnphort and Iona Ground Investigation			Sample No.	2
Soil Description	Grey slightly sandy subangular fine to coarse GRAVEL.			Depth, m	0.00
Specimen Reference	2	Specimen Depth	m	Sample Type	B
Test Method	BS1377:Part 2:1990, clause 9.2			KeyLAB ID	Caus20180929143



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100		
90	100		
75	100		
63	100		
50	100		
37.5	92		
28	89		
20	83		
14	69		
10	61		
6.3	52		
5	44		
3.35	33		
2	22		
1.18	20		
0.6	19		
0.425	19		
0.3	18		
0.212	13		
0.15	7		
0.063	4		

Dry Mass of sample, g	10606

Sample Proportions	% dry mass
Cobbles	0
Gravel	78
Sand	18
Fines <0.063mm	4

Grading Analysis		
D100	mm	
D60	mm	9.56
D30	mm	2.93
D10	mm	0.177
Uniformity Coefficient		54
Curvature Coefficient		5.1

Remarks

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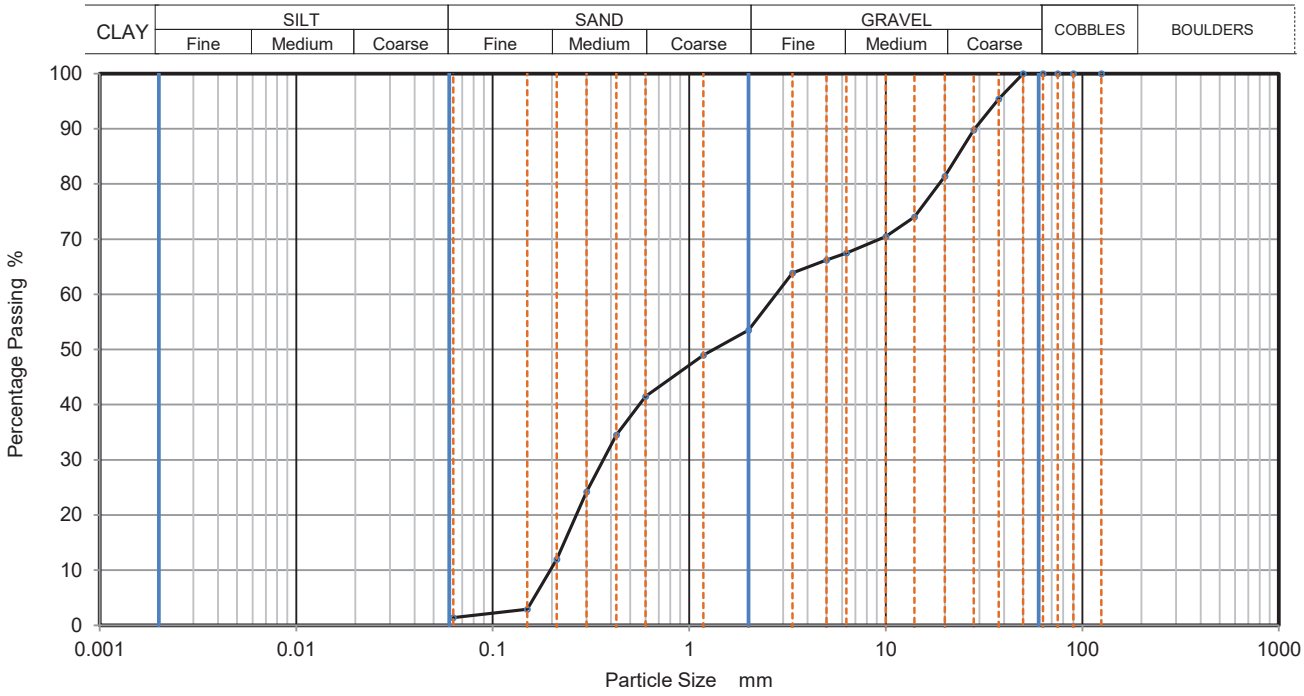
CAUSEWAY GEOTECH	**PARTICLE SIZE DISTRIBUTION**			Job Ref	**18-0144**
				Borehole/Pit No.	BH08
Site Name	Fionnphort and Iona Ground Investigation			Sample No.	1
Soil Description	Light grey gravelly fine to coarse SAND with shell fragments.			Depth, m	0.00
Specimen Reference	2	Specimen Depth	m	Sample Type	B
Test Method	BS1377:Part 2:1990, clause 9.2			KeyLAB ID	Caus20180929144



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100		
90	100		
75	100		
63	100		
50	100		
37.5	95		
28	90		
20	81		
14	74		
10	71		
6.3	68		
5	66		
3.35	64		
2	54		
1.18	49		
0.6	42		
0.425	35		
0.3	24		
0.212	12		
0.15	3		
0.063	1		

Dry Mass of sample, g	8800

Sample Proportions	% dry mass
Cobbles	0
Gravel	47
Sand	52
Fines <0.063mm	1

Grading Analysis		
D100	mm	
D60	mm	2.76
D30	mm	0.365
D10	mm	0.196
Uniformity Coefficient		14
Curvature Coefficient		0.25

Remarks

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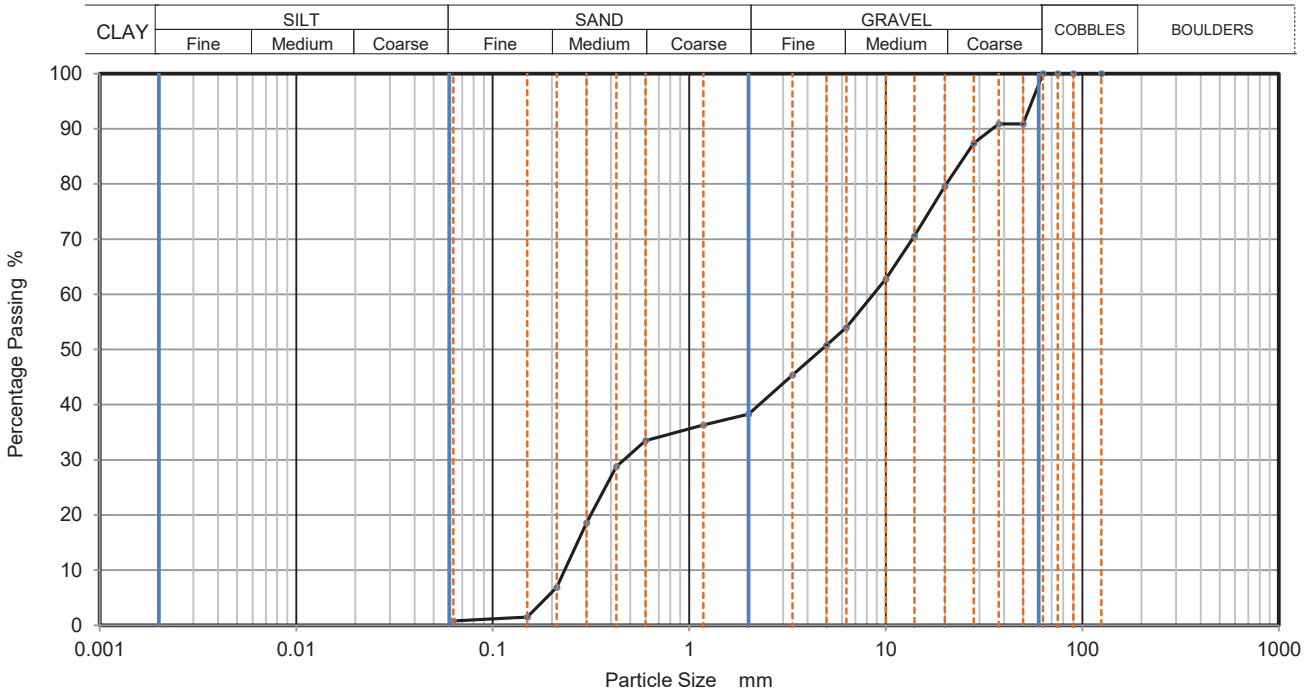
CAUSEWAY GEOTECH	**PARTICLE SIZE DISTRIBUTION**			Job Ref	**18-0144**
				Borehole/Pit No.	BH09A
Site Name	Fionnphort and Iona Ground Investigation			Sample No.	1
Soil Description	Grey sandy subangular fine to coarse GRAVEL with shells and shell fragments.			Depth, m	0.00
Specimen Reference	2	Specimen Depth	m	Sample Type	B
Test Method	BS1377:Part 2:1990, clause 9.2			KeyLAB ID	Caus20180929145



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100		
90	100		
75	100		
63	100		
50	91		
37.5	91		
28	87		
20	80		
14	71		
10	63		
6.3	54		
5	51		
3.35	45		
2	38		
1.18	36		
0.6	34		
0.425	29		
0.3	19		
0.212	7		
0.15	2		
0.063	1		

Dry Mass of sample, g	6621

Sample Proportions	% dry mass
Cobbles	0
Gravel	62
Sand	38
Fines <0.063mm	1

Grading Analysis		
D100	mm	
D60	mm	8.64
D30	mm	0.463
D10	mm	0.232
Uniformity Coefficient		37
Curvature Coefficient		0.11

Remarks

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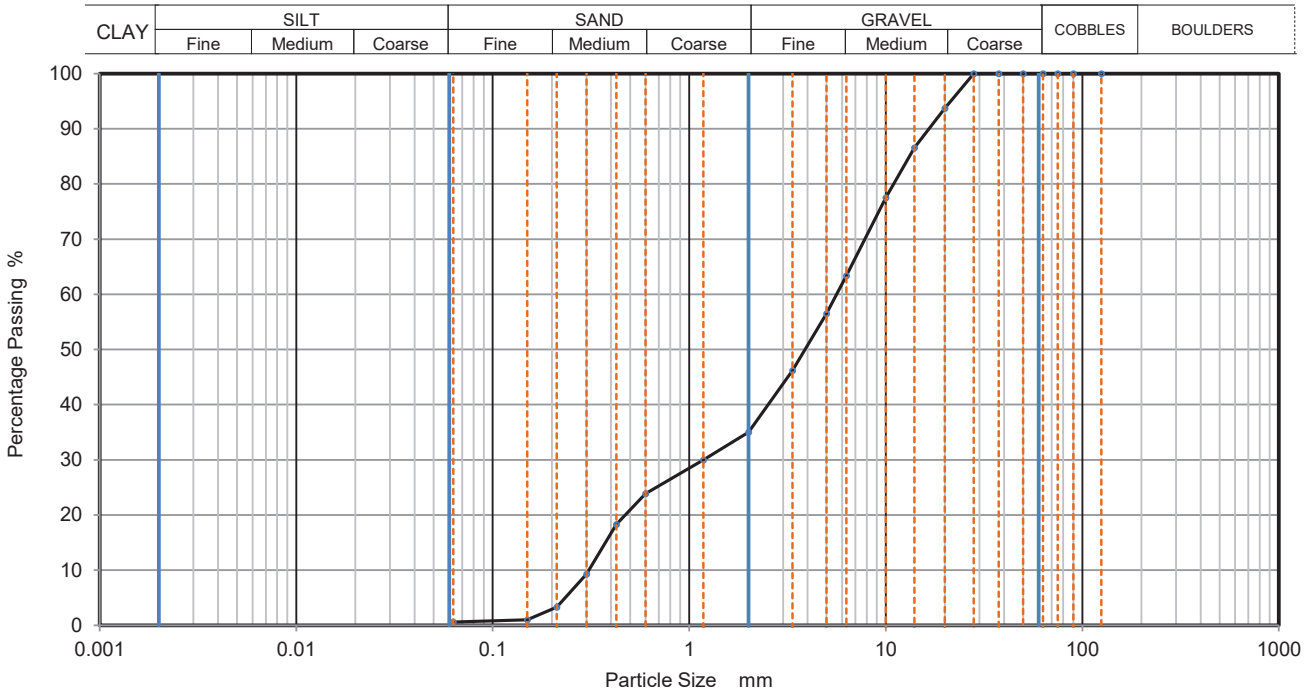
CAUSEWAY GEOTECH	**PARTICLE SIZE DISTRIBUTION**			Job Ref	**18-0144**
				Borehole/Pit No.	BH10
Site Name	Fionnphort and Iona Ground Investigation			Sample No.	1
Soil Description	Grey sandy subangular fine to coarse GRAVEL with shells and sheel fragments.			Depth, m	0.00
Specimen Reference	2	Specimen Depth	m	Sample Type	B
Test Method	BS1377:Part 2:1990, clause 9.2			KeyLAB ID	Caus20180929146



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100		
90	100		
75	100		
63	100		
50	100		
37.5	100		
28	100		
20	94		
14	87		
10	78		
6.3	63		
5	57		
3.35	46		
2	35		
1.18	30		
0.6	24		
0.425	18		
0.3	9		
0.212	3		
0.15	1		
0.063	1		

Dry Mass of sample, g	6631

Sample Proportions	% dry mass
Cobbles	0
Gravel	65
Sand	34
Fines <0.063mm	1

Grading Analysis		
D100	mm	
D60	mm	5.62
D30	mm	1.18
D10	mm	0.309
Uniformity Coefficient		18
Curvature Coefficient		0.81

Remarks

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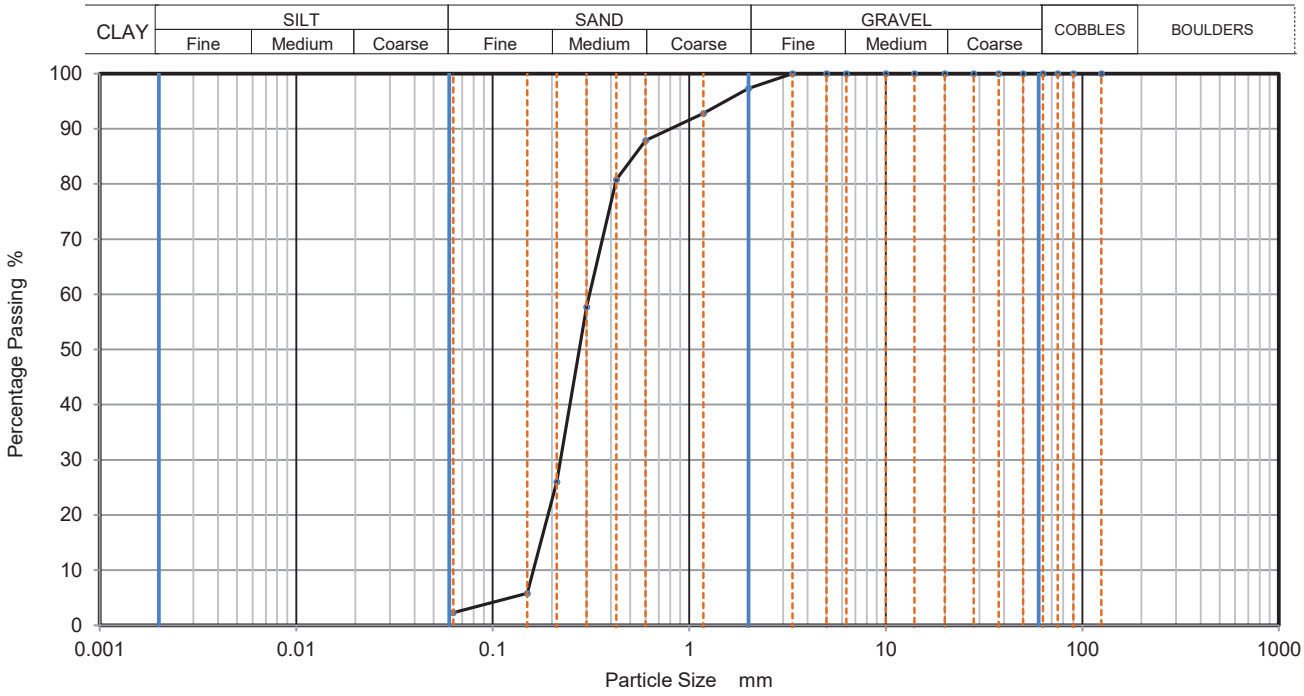
CAUSEWAY GEOTECH	**PARTICLE SIZE DISTRIBUTION**			Job Ref	**18-0144**
				Borehole/Pit No.	BH12
Site Name	Fionnphort and Iona Ground Investigation			Sample No.	1
Soil Description	Grey fine to coarse SAND with shells and shell fragments.			Depth, m	0.00
Specimen Reference	2	Specimen Depth	m	Sample Type	B
Test Method	BS1377:Part 2:1990, clause 9.2			KeyLAB ID	Caus20180929148



Sieving		Sedimentation	
Particle Size mm	% Passing	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	97		
1.18	93		
0.6	88		
0.425	81		
0.3	58		
0.212	26		
0.15	6		
0.063	2		

Dry Mass of sample, g	752

Sample Proportions	% dry mass
Cobbles	0
Gravel	3
Sand	95
Fines <0.063mm	2

Grading Analysis		
D100	mm	
D60	mm	0.31
D30	mm	0.221
D10	mm	0.161
Uniformity Coefficient		1.9
Curvature Coefficient		0.98

Remarks

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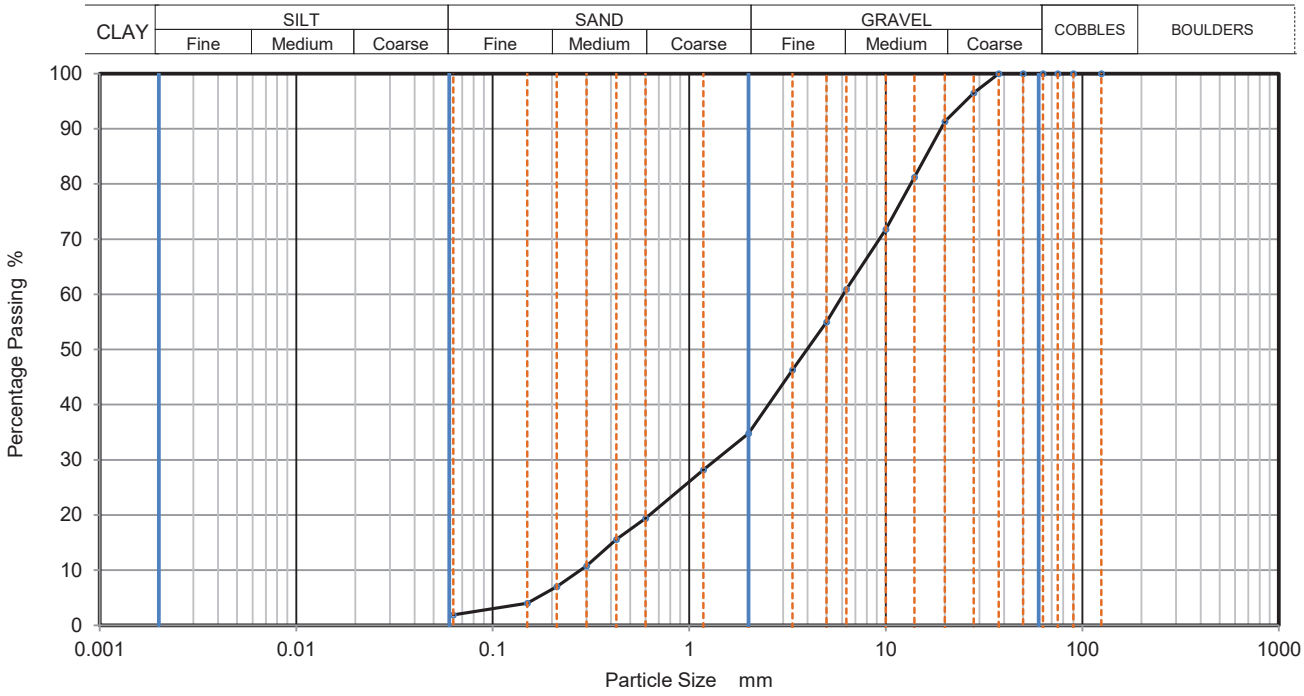
CAUSEWAY GEOTECH	**PARTICLE SIZE DISTRIBUTION**			Job Ref	**18-0144**
				Borehole/Pit No.	BH12
Site Name	Fionnphort and Iona Ground Investigation			Sample No.	2
Soil Description	Greyish red sandy subrounded fine to coarse GRAVEL.			Depth, m	1.50
Specimen Reference	2	Specimen Depth	m	Sample Type	B
Test Method	BS1377:Part 2:1990, clause 9.2			KeyLAB ID	Caus20180929150



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100		
90	100		
75	100		
63	100		
50	100		
37.5	100		
28	97		
20	91		
14	81		
10	72		
6.3	61		
5	55		
3.35	46		
2	35		
1.18	28		
0.6	19		
0.425	16		
0.3	11		
0.212	7		
0.15	4		
0.063	2		

Dry Mass of sample, g	7803

Sample Proportions	% dry mass
Cobbles	0
Gravel	65
Sand	33
Fines <0.063mm	2

Grading Analysis		
D100	mm	
D60	mm	6.09
D30	mm	1.37
D10	mm	0.279
Uniformity Coefficient		22
Curvature Coefficient		1.1

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Final Report

Report No.: 18-29728-1

Initial Date of Issue: 02-Oct-2018

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Neil Haggan
Paul Dunlop
Paul McNamara
Sean Ross
Stephen Franey
Stephen Watson
Stuart Abraham

Project 18-0144 - Iona Ground Investigation

Quotation No.:

Order No.:

No. of Samples: 8

Turnaround (Wkdays): 3

Date Approved: 02-Oct-2018

Approved By:

[redacted]

Details: Martin Dyer, Laboratory Manager

Date Received: 28-Sep-2018

Date Instructed: 28-Sep-2018

Results Due: 02-Oct-2018

Chemtest
The right chemistry to deliver results

Results - Soil

Project: 18-0144 - Iona Ground Investigation

Client: Causeway Geotech Ltd					**Chemtest Job No.:**	18-29728	18-29728	18-29728	18-29728	18-29728	18-29728	18-29728
Quotation No.:					**Chemtest Sample ID.:**	696918	696919	696920	696921	696922	696923	696924	696925
Order No.:					Client Sample Ref.:	1	1	7	2	1	1	1	4
					Sample Location:	BH01	BH02	BH06	BH07	BH08	BH09A	BH10	BH12
					Sample Type:	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL
					Top Depth (m):	0.00	0.00	2.00	0.00	0.00	0.00	0.00	1.00
					Date Sampled:	27-Sep-2018	27-Sep-2018	27-Sep-2018	27-Sep-2018	27-Sep-2018	27-Sep-2018	27-Sep-2018	27-Sep-2018
Determinand	**Accred.**	**SOP**	**Units**	**LOD**									
Moisture	N	2030	%	0.020		21	4.4	13	7.7	15	10	4.0	19
pH	U	2010		N/A		8.7	8.9	9.1	8.8	8.9	9.0	9.7	8.9
Sulphate (2:1 Water Soluble) as SO4	U	2120	g/l	0.010		0.21	0.13	0.17	0.26	0.31	0.21	0.016	0.20

Report Information

Key

U	UKAS accredited
M	MCERTS and UKAS accredited
N	Unaccredited
S	This analysis has been subcontracted to a UKAS accredited laboratory that is accredited for this analysis
SN	This analysis has been subcontracted to a UKAS accredited laboratory that is not accredited for this analysis
T	This analysis has been subcontracted to an unaccredited laboratory
I/S	Insufficient Sample
U/S	Unsuitable Sample
N/E	not evaluated
<	"less than"
>	"greater than"

Comments or interpretations are beyond the scope of UKAS accreditation
The results relate only to the items tested
Uncertainty of measurement for the determinands tested are available upon request
None of the results in this report have been recovery corrected
All results are expressed on a dry weight basis
The following tests were analysed on samples as received and the results subsequently corrected to a dry weight basis TPH, BTEX, VOCs, SVOCs, PCBs, Phenols
For all other tests the samples were dried at < 37°C prior to analysis
All Asbestos testing is performed at the indicated laboratory
Issue numbers are sequential starting with 1 all subsequent reports are incremented by 1

Sample Deviation Codes

A - Date of sampling not supplied
B - Sample age exceeds stability time (sampling to extraction)
C - Sample not received in appropriate containers
D - Broken Container
E - Insufficient Sample (Applies to LOI in Trommel Fines Only)

Sample Retention and Disposal

All soil samples will be retained for a period of 45 days from the date of receipt
All water samples will be retained for 14 days from the date of receipt
Charges may apply to extended sample storage

If you require extended retention of samples, please email your requirements to:
customerservices@chemtest.com

LABORATORY RESTRICTION REPORT

Project Reference	18-0144	To	Neil Haggan
Project Name	Iona Ground Investigation	Position	Project Manager
TR reference	18-0144 /	From	Stephen Watson
		Position	Laboratory Manager

The following sample(s) and test(s) are restricted as detailed below. Could you please complete the "Required Action" column and return the completed form to the laboratory.

Hole Number	Sample			Test Type	Reason for Restriction	Required Action
	Number	Depth (m)	Type			
BH11	1	0.00	B	PSD, pH+S04	Sample damaged in transit	Cancel testing

For electronic reporting a form of electronic signature or printed name is acceptable

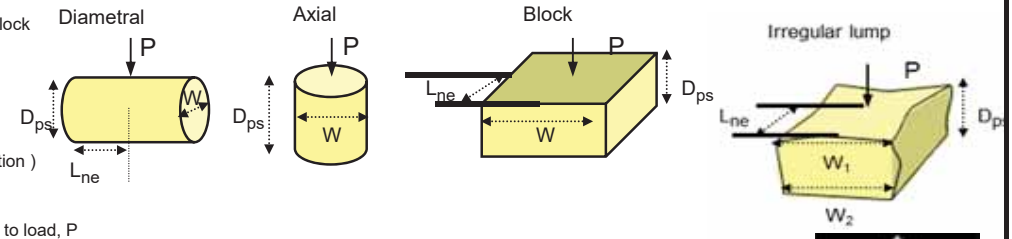
Laboratory Signature Stephen Watson	Project Manager Signature Neil Haggan
Date 27 September 2018	Date 27 September 2018

Point Load Strength Index Tests
Summary of Results

Project No.	Project Name
18-0144	Fionnphort and Iona Ground Investigation

Borehole No.	Sample			Specimen		Rock Type	Test Type see ISRM		Failure Valid (Y/N)	Dimensions				Force P	Equivalent diameter, De	Point Load Strength Index		Remarks (including water content if measured)
	Depth	Ref.	Type	Ref.	Depth		Type (D, A, I, B)	Direction (L, P or U)		Lne	W	Dps	Dps'			I_s	$I_{s(50)}$	
	m				m					mm	mm	mm	mm	kN	mm	MPa	MPa	
BH01	2.50		C	2	2.50	SCHIST	D	U	NO	57.7	83.6	83.6	83.0	50.5	83.3	7.3	9.2	
BH02	1.95		C	2	1.95	SCHIST	D	U	YES	96.0	102.0	102.0	97.0	23.8	99.5	2.4	3.3	
BH03	7.90		C	2	7.90	SCHIST	D	U	YES	51.2	101.8	101.8	97.0	3.0	99.4	0.3	0.4	
BH04	3.05		C	1	3.05	SCHIST	D	U	YES	72.5	102.0	102.0	96.0	7.4	99.0	0.8	1.0	
BH04	3.80		C	1	3.80	SCHIST	D	U	NO	80.8	102.3	102.3	101.0	55.5	101.6	5.4	7.4	
BH05	6.00		C	1	6.00	SCHIST	I	U	NO	63.7	61.9	37.0	34.0	4.4	51.8	1.6	1.7	
BH05	7.90		C	1	7.90	SCHIST	D	U	YES	65.6	101.8	101.8	97.0	12.0	99.4	1.2	1.7	
BH06	6.90		C	2	6.90	SCHIST	D	U	YES	47.2	101.1	101.1	98.0	16.6	99.5	1.7	2.3	
BH07	3.00		C	2	3.00	GRANITE	D	U	NO	73.6	102.2	102.2	98.0	5.9	100.1	0.6	0.8	
BH08	8.60		C	2	8.60	GRANITE	D	U	NO	63.8	102.1	102.1	102.0	45.9	102.0	4.4	6.1	
BH09A	5.10		C	1	5.10	GRANITE	D	U	NO	74.3	101.5	101.5	95.0	71.0	98.2	7.4	10.0	
BH09A	4.50		C	2	4.50	GRANITE	D	U	NO	50.1	101.3	101.3	100.0	69.0	100.6	6.8	9.3	
BH09A	4.80		C	2	4.80	GRANITE	D	U	NO	79.6	102.0	102.0	99.0	72.0	100.5	7.1	9.8	
BH10	1.30		C	2	1.30	GRANITE	D	U	NO	52.6	101.4	101.4	100.0	67.0	100.7	6.6	9.1	
BH10	1.70		C	2	1.70	GRANITE	D	U	NO	68.2	101.5	101.5	99.0	59.0	100.2	5.9	8.0	
BH11	0.55		C	2	0.55	GRANITE	D	U	NO	71.6	102.1	102.1	101.0	55.0	101.5	5.3	7.3	
BH12	3.00		C	2	3.00	GRANITE	D	U	NO	63.8	101.8	101.8	100.0	55.0	100.9	5.4	7.4	

Test Type
D - Diametral, A - Axial, I - Irregular Lump, B - Block
Direction
L - parallel to planes of weakness
P - perpendicular to planes of weakness
U - unknown or random
Dimensions
Dps - Distance between platens (platen separation)
Dps' - at failure (see ISRM note 6)
Lne - Length from platens to nearest free end
W - Width of shortest dimension perpendicular to load, P



Test performed in accordance with ISRM Suggested Methods : 2007, unless noted otherwise

Detailed legend for test and dimensions, based on ISRM, is shown above.

Size factor, F = $(De/50)^{0.45}$ for all tests.

Date Printed: 06/10/2018

Approved By: Stephen.Watson

UKAS TESTING 10122

UNIAXIAL COMPRESSION TEST ON ROCK - SUMMARY OF RESULTS

Project No.	Project Name
18-0144	Fionnphort and Iona Ground Investigation

Hole No.	Sample				Rock Type	Specimen Dimensions2			Bulk Density2	Water Content 1	Uniaxial Compression3			Remarks
	Ref	Top	Base	Type		Dia. mm	Length mm	H/D	Mg/m3	%	Condition	Mode of failure	UCS MPa	
BH01		5.70		C	SCHIST	83.4	220.1	2.6	2.77	0.1	as received	F	91.2	
BH01		5.70		C	SCHIST	101.8	268.3	2.6	2.72	0.1	as received	F	50.2	
BH02		1.50		C	SCHIST	101.8	268.3	2.6	2.72	0.1	as received	F	50.2	
BH07		2.70		C	GRANITE	101.3	223.6	2.2	2.60	0.3	as received	F	74.2	
BH07		4.00		C	GRANITE	101.8	256.7	2.5	2.62	0.3	as received	AC	44.1	
BH09A		5.10		C	GRANITE	101.8	256.7	2.5	2.62	0.3	as received	AC	44.1	
BH11		2.60		C	GRANITE	83.6	178.9	2.1	2.60	0.5	as received	F	36.3	
BH12		5.50		C	GRANITE	82.6	230.9	2.8	2.64	0.2	as received	F	74.4	

Notes

1 ISRM p87 test 1, water content at 105 ± 3 oC, specimen as tested for UCS

2 ISRM p86 clause (vii), Caliper method used for determination of bulk volume and derivation of bulk density

3 ISRM p153 part 1, determination of Uniaxial Compressive Strength (UCS) of Rock Materials

above notes apply unless annotated otherwise in the remarks

Mode of failure :

S - Single shear MS - multiple shear

AC - Axial cleavage F - Fragmented

Test Specification	Date Printed	Approved By	Table
International Society for Rock Mechanics, The complete ISRM suggested methods for Rock Characterization Testing and Monitoring, 2007	10/06/2018 00:00	Stephen.Watson	1 sheet 1

CAUSEWAY GEOTECH

APPENDIX E

Marine geophysical survey report and layouts

Aspect
Land+Hydrographic Surveys
CHARTERED SURVEYORS

TEL: 01294 313 399 • WEB: WWW.ASPECTSURVEYS.COM

MULTIBEAM & GEOPHYSICAL SURVEY

IONA & FIONNPHORT, ISLE OF MULL

SEPTEMBER 2018

PROJECT REF: A6741

REV: 00

Client:

CAUSEWAY GEOTECH
8 DRUMAHISKEY ROAD
BALLYMONEY
COUNTY ANTRIM
R11 4TA

CAUSEWAY GEOTECH

ices Approved Development Partner

Achilles

QAS INTERNATIONAL ISO 9001:2008 REGISTERED FIRM

QAS INTERNATIONAL ISO 14001:2004 REGISTERED FIRM

QAS INTERNATIONAL BS OHSAS 18001:2007 REGISTERED FIRM

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TABLE OF CONTENTS

DOCUMENT ISSUE RECORD

DATE	REVISON	COMPILED	CHECKED	NOTES
21/09/2018	00	ES	CDT	

1. INTRODUCTION

On the instructions of Causeway Geotech, Aspect Land & Hydrographic Surveys Ltd. (herein ALHS) carried out multibeam bathymetric and sub-bottom profiler surveys at areas adjacent to existing pier and slipway structures at Iona and Fionnphort. The program of events was as follows:

Date	Progress
04/09/2018	Vessel, equipment and personnel mobilised to site by ferry and road.
05/09/2018	Vessel launched at Fionnphort ferry slipway. Multibeam bathymetric survey completed. Vessel recovered at slipway overnight.
06/09/2018	Vessel launched at slipway. Sub-bottom profiler survey completed. Vessel recovered at slipway.
07/09/2018	Vessel, equipment and personnel demobilised from site by ferry and road.

2. SCOPE OF WORKS

The surveys aimed to form part of a feasibility study into proposed developments to the site. An overview of the areas surveyed can be seen outlined in red and blue in the image below.

FIGURE 1 - OVERVIEW OF SURVEY AREAS ADJACENT TO IONA AND FIONNPHORT FERRY INFRASTRUCTURE

3. GEODESY & DATUM

The horizontal datum used throughout the data gathering phase of the survey was OSGB36 (OSTN15). Data has been rendered in OSGB36 Datum, British National Grid.

The vertical datum for all bathymetric data is Chart Datum which at Iona is 1.82m below OD. OSTN15 defines OSGB36 National Grid in conjunction with the National GPS Network. In this regard OSTN15 can be considered error free (not including any GPS positional errors).

The accord between OSTN15 and the old triangulation network stations (down to 3rd order) is 0.1m rms.

A Trimble SPS855 RTK GPS base station was used to provide RTK corrections for the survey equipment. The base station used a previously established point, which had been post-processed using OS RINEX data.

This original station was processed to OSTN02. The positional difference was checked between OSTN02 position used in the past and that calculated from data gathered during this observation period.

Transformation	Station Name	Easting (m)	Northing (m)	Level (m CD)
OSTN02	Base 1	129901.543	723438.616	5.518
OSTN15	Base 1	129901.525	723438.628	3.719
Difference		-0.006	0.015	-0.007

The decision was taken to maintain parity with previous surveys to retain the values used previously for the base station (i.e. the OSTN02values above). The differences between the OSTN02 and OSTN15 values as seen in the table above are not significant and within the expected precision of RTK GNSS.

FIGURE 2 - TRIMBLE SPS855 BASE STATION AT BASE 1 LOCATION (FIONNPHORT FERRY PIER)

4. MULTIBEAM BATHYMETRIC SURVEY

A summary of the equipment used in the completion of the multibeam bathymetric survey can be seen in the table below:

Survey Vessel	Coastal Sensor (MCA Cat III)
Positioning System	Trimble Applanix PosMV
GPS Correction Source	Radio Corrections from Base Station
Motion Compensation	Trimble Applanix PosMV
Multibeam Echosounder	R2Sonic 2022

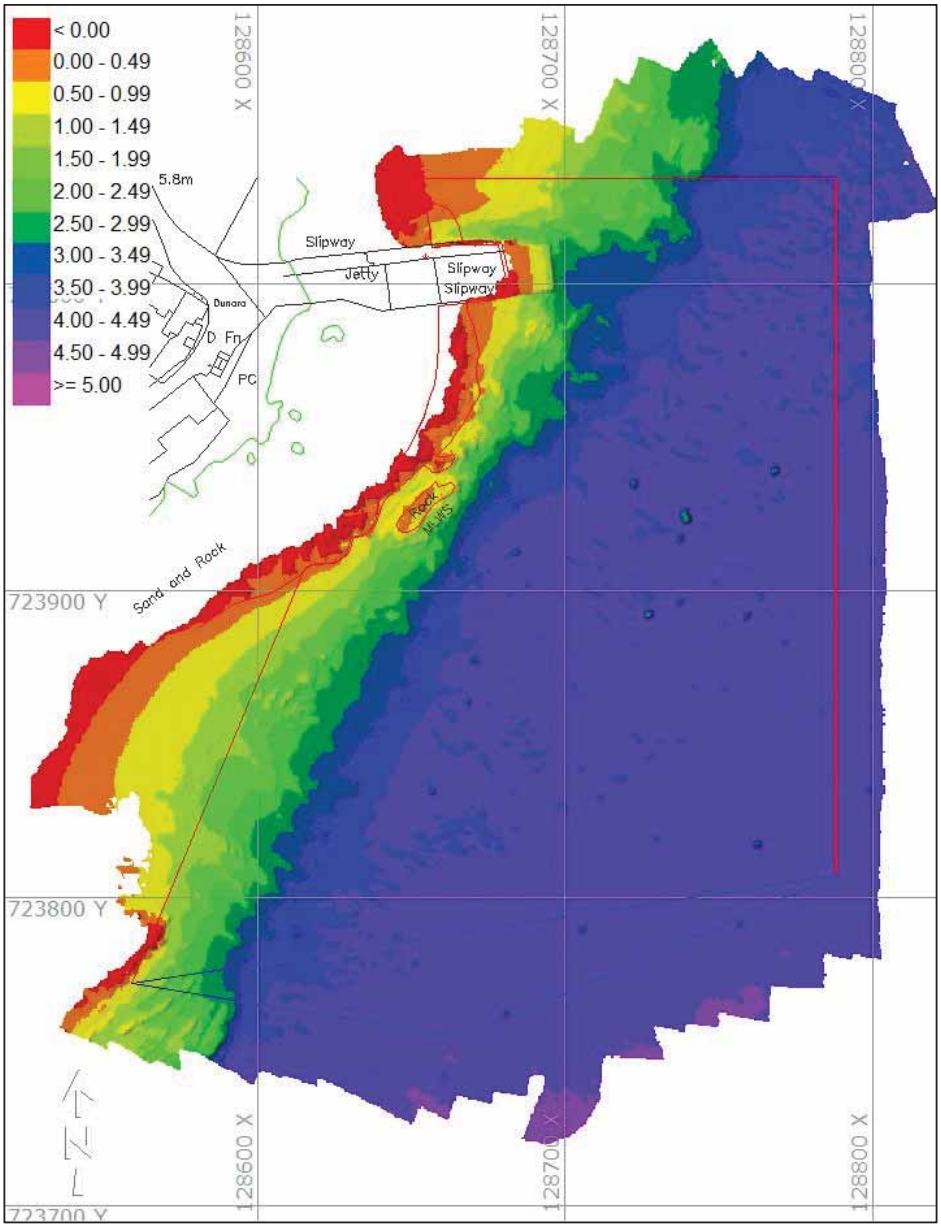


FIGURE 3 - OVERVIEW OF MULTIBEAM BATHYMETRIC DATA COLLECTED AT IONA (DEPTHS RELATIVE TO CD)

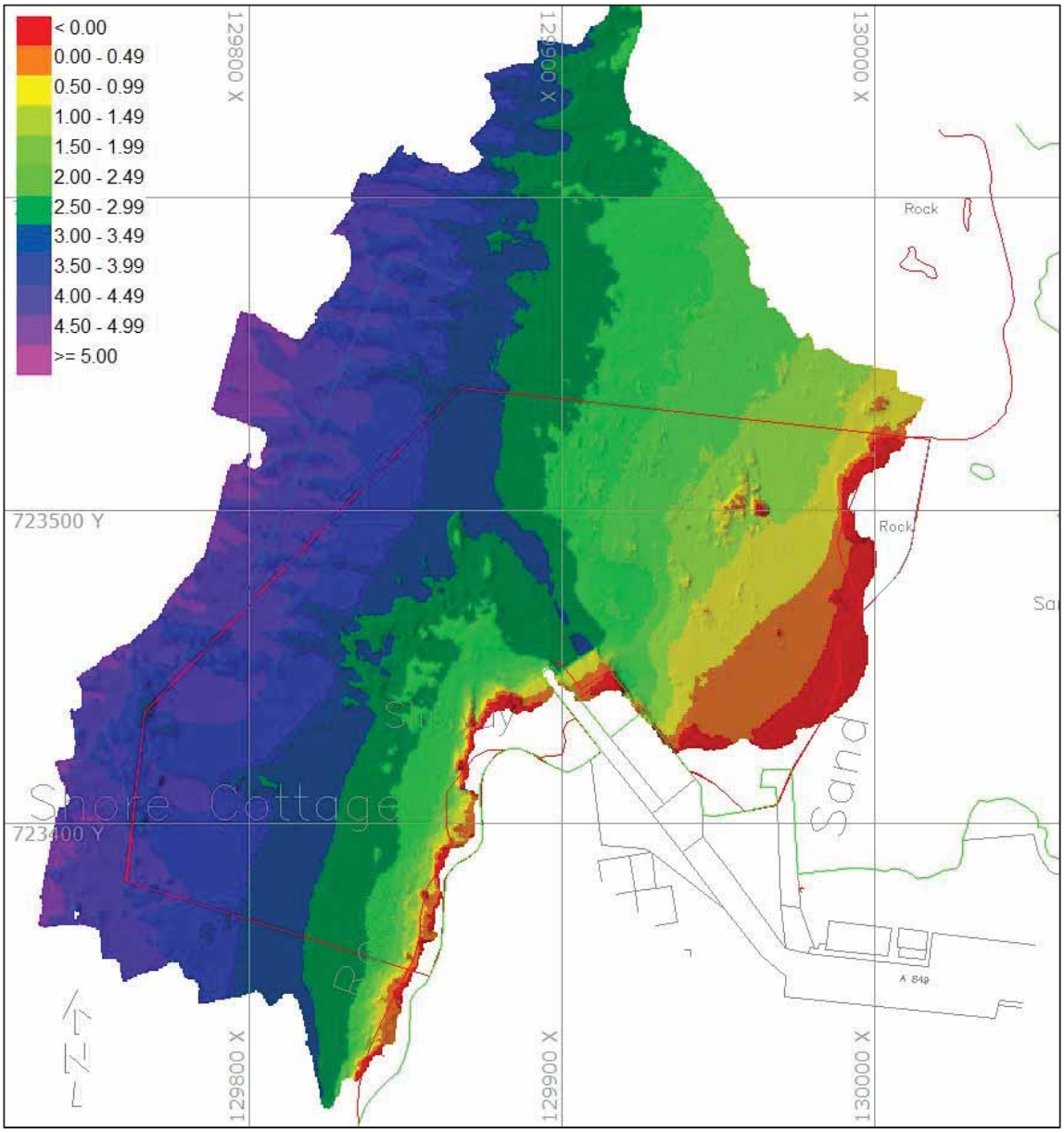


FIGURE 4 - OVERVIEW OF MULTIBEAM BATHYMETRIC DATA COLLECTED AT FIONNPHORT (DEPTHS RELATIVE TO CD)

At the time of the survey, thick weed was encountered in several parts of the survey area which degraded the data quality, despite efforts to mitigate for this. The data and results of the survey are still considered fit for purpose and they meet IHO Special Order.

On the Fionnphort side, numerous boulders or outcrops of rock were seen in the shallows close to the shore. The depth increased slightly moving offshore (to between 3.5 and 4.5m CD) where sand waves were seen, indicating the mobility of the sediment in these areas. These characteristics were also found on the Iona side, with several large obstructions seen in the deeper water.

These are all adequately described in the bathymetric charts and rendered XYZ and GeoTIFF images.

5. GEOPHYSICAL SURVEY

A summary of the equipment used in the completion of the sub-bottom profiler survey can be seen in the table below:

Survey Vessel	Coastal Sensor (MCA Cat III)
Positioning System	Trimble Applanix PosMV
GPS Correction Source	Radio Corrections from Base Station
Sub-Bottom Sound Source	Applied Acoustics AA201 Boomer
Sub-Bottom Power Supply	Applied Acoustics CSP-P 50-350 Joule
Sub-Bottom Receiver	Applied Acoustics 12-element hydrophone

The sub-bottom profiler lines were run at 10m intervals perpendicular to the shore, with 50m cross-lines (minimum interval) for QA purposes. Areas of moorings were present at both sites, with trailing lines and vessels, so some deviations from the planned line spacing were unavoidable.

Two sub-bottom horizons were digitised from the data collected:

Horizon 1 - boundary between stratified surface sediments above and heavier, more consolidated sediments below. The DRAFT geophysical investigations shows that the surface sediments consist of a mixture of SAND and GRAVEL and as such, where this horizon is seen it is likely to represent the top of GRAVEL.

Horizon 2 - top of a hard return and the limit of acoustic penetration. The DRAFT geophysical investigations show that rockhead across the survey areas consists of GRANITE and other METAMORPHIC rock, which ties in with the return digitised as Horizon 2.
Draft Intrusive geophysical investigation results were available at the time of processing and have been integrated with this report.

IONA

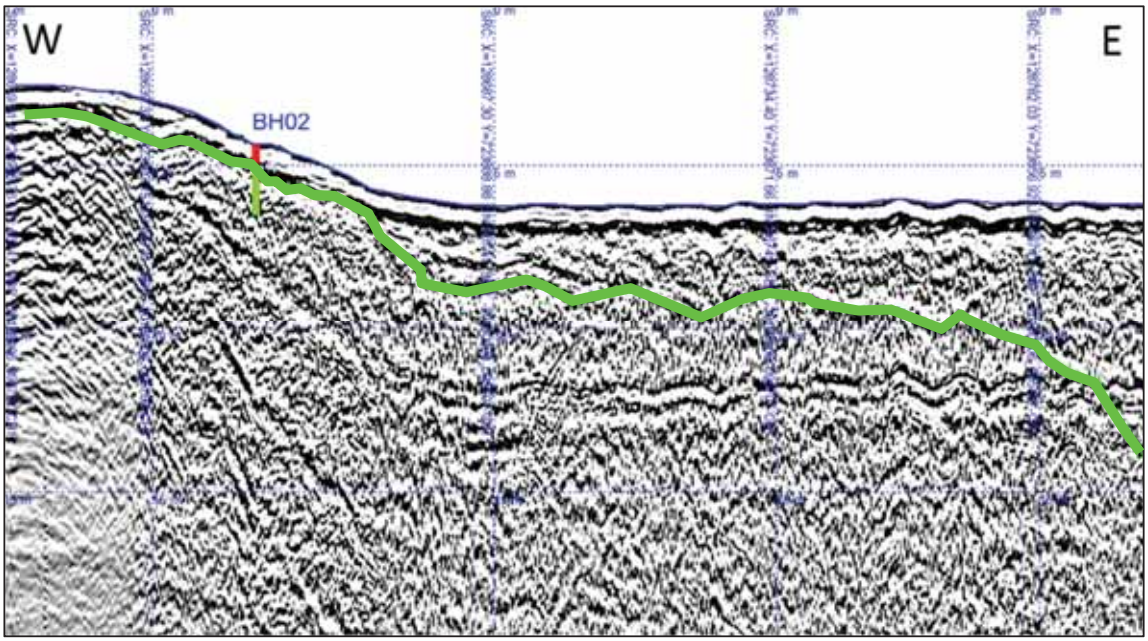


FIGURE 5 - EXTRACT FROM LINE 095707 (RUNNING WEST TO EAST LEFT TO RIGHT ON IONA SIDE) SHOWING DIGITISED HORIZON 2 AND BOREHOLE 2

FIONNPHORT

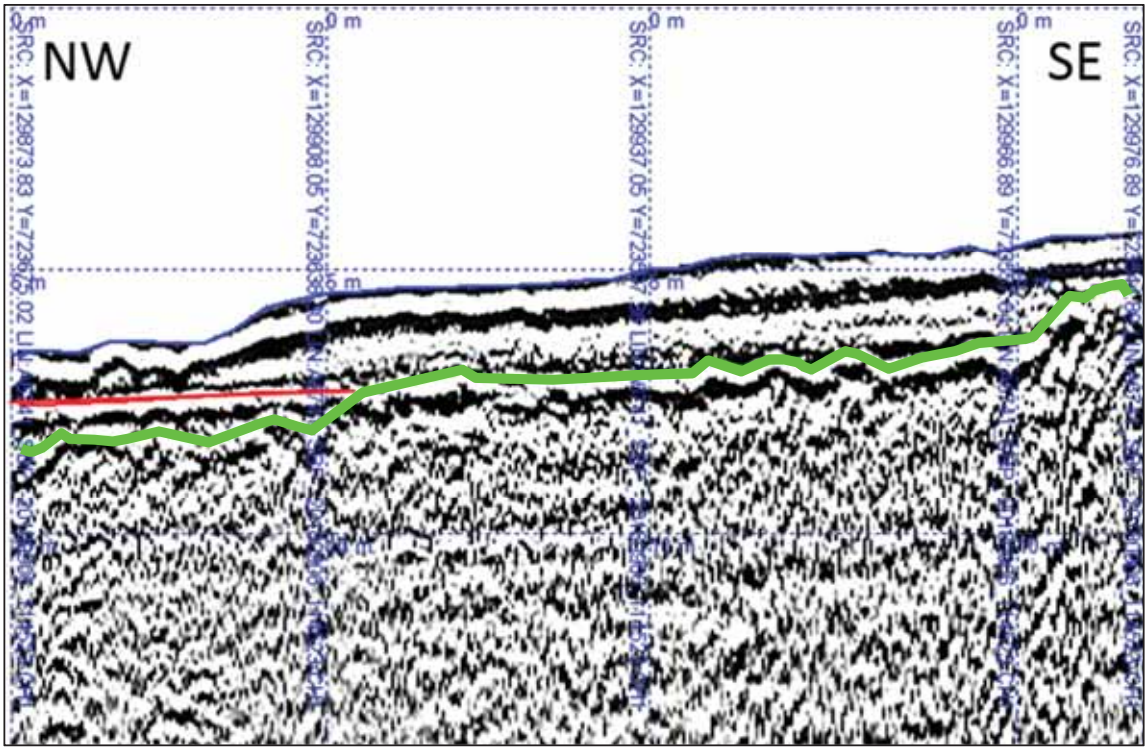


FIGURE 6 - EXTRACT FROM LINE 114523 (RUNNING NORTH-WEST TO SOUTH-EAST LEFT TO RIGHT ON FIONNPHORT SIDE) SHOWING DIGITISED HORIZONS 1 AND 2

At both locations, rock appeared to be quite close to the surface, especially in the shallows. Numerous boulders or rock outcrops were observed on the seabed.

FIGURE 7 - PINK GRANITE OUTCROPPING AT SHORELINE ON FIONNPHORT SIDE (LOOKING SOUTH FROM FERRY PIER)

6. SURVEY VESSEL

ALHS' cabin RIB Coastal Sensor (MCA Cat III) was used for all aspects of the survey. Coastal Sensor has a dedicated side-mount from which the multibeam system can be easily deployed. She also is highly manoeuvrable with twin engines and shallow draught. These features therefore ideally suited the vessel for operating in this rugged and shallow area.

Coastal Sensor was mobilised to site by road and ferry. The vessel was launched and recovered on each day of the survey at the Fionnphort ferry slip in order to minimise transit times to site.

FIGURE 8 - SURVEY VESSEL COASTAL SENSOR EN ROUTE TO SITE

7. SURVEY PERSONNEL

The following people were involved in the completion of this survey.

Name	Position
C. Thomson	QA / Data Release
E. Stacey	Hydrographic Surveyor/Survey Coxswain
K. McElligott	Hydrographic Surveyor

8. SURVEY STANDARDS

The Hydrographic survey is considered complete to International Hydrographic Organisation Special Order standard, with a Full Sea Floor Search being achieved as per IHO publication S44, Table 1. A representation of the section of interest within that document is shown in Table 6:

Order	Examples of Typical Areas	Horizontal Accuracy (95% Confidence Level)	Depth Accuracy for Reduced Depths (95% Confidence Level)	100% Bottom Search	System Detection Capability	Maximum Line Spacing
Special	Harbours, berthing area and associated critical channels with minimum under keel clearances	2m	a = 0.25m b = 0.0075	Compulsory	Cubic features > 1m	Not applicable as 100% search compulsory

TAKEN FROM IHO PUBLICATION S44, TABLE 1, SHOWING REQUIREMENTS OF A SPECIAL ORDER SURVEY

The error limits for depth accuracy are calculated by introducing the values listed in the above table for a and b into the formula $\pm\sqrt{[a^2+(b*d)^2]}$, where:

a constant depth error, i.e. the sum of all constant errors

b*d depth dependent error, i.e. the sum of all depth dependent errors

b factor of depth dependent error

d depth[1]

The multibeam system has shown during this survey to be capable of detecting objects far smaller than the 1m cubic features specified for a Special-Order survey.

[1] *IHO 2005. Publication M-13 'Manual on Hydrography'. Chapter 1, Pages 9-10.*

Annex A
Drawing Register

A6741

Title	Description
A6741_Iona and Fionnphort_MBES.dwg	Bathymetric data rendered as AutoCAD DWG (also rendered as PDF for ease of viewing on non-CAD systems) at Chart Datum
A6741_Iona and Fionnphort_SBP.dwg	Geophysical data rendered as AutoCAD DWG (also rendered as PDF for ease of viewing on non-CAD systems) at Chart Datum
A6741_Fionnphort_MBES_0-5m_CD.xyz	ASCII xyz bathymetric data at 0.5m post-spacing of Fionnphort survey area, at Chart Datum
A6741_Iona_MBES_0-5m_CD.xyz	ASCII xyz bathymetric data at 0.5m post-spacing of Iona survey area, at Chart Datum
A6741_Iona and Fionnphort_Horizon 1_CD.xyz	ASCII xyz geophysical data (digitised horizon 1)
A6741_Iona and Fionnphort_Horizon 2_CD.xyz	ASCII xyz geophysical data (digitised horizon 2)
A6741_Fionnphort_MBES_Imagery.tif/tfw	Georeferenced imagery of bathymetric data at Fionnphort survey area
A6741_Iona_MBES_Imagery.tif/tfw	Georeferenced imagery of bathymetric data at Iona survey area
A6741_Iona and Fionnphort_SBP Web Presentation	Folder containing geophysical data presented as a web-page
A6741_Iona and Fionnphort_SBP_Dig	Folder containing images of geophysical survey lines with digitised horizons and boreholes
A6741_Iona and Fionnphort_Report of Survey_Rev0.pdf	Report of Survey

Annex B
Horizontal & Vertical Positioning System Precision

A6741

Applanix POS MV using RTK corrections.

	HORIZONTAL ACCURACY	VERTICAL ACCURACY
REAL TIME KINEMATIC	±10mm + 1ppm RMS	±20mm + 1ppm RMS

All horizontal positions in the survey are referred to British National Grid.

Multibeam Processing Stages

Sonar Control 2000 software was used to control the MBES system during the data gathering phase.

Data was logged in HYPACK HYSWEEP software.

After data gathering the data was post processed in HYPACK MBMax where the following stages of processing were undertaken:

- Navigation data was processed.
- Motion Sensor data was examined and edited as required.
- Tidal data was examined and edited as required
- Automatic filtering of the data was carried out.
- Individual lines of MBES sounding data were manually edited.
- The data was gridded at an appropriate post spacing for the scale of plot requested by the client. This was exported to AutoCAD for presentation.
- The data was contoured at 0.5m intervals in Hypack and exported to AutoCAD.

Sub-Bottom Profiler Processing Stages

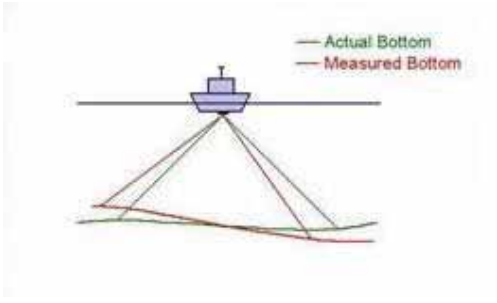
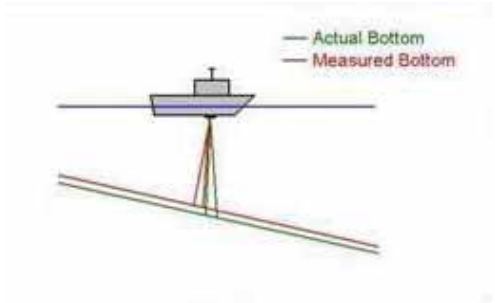
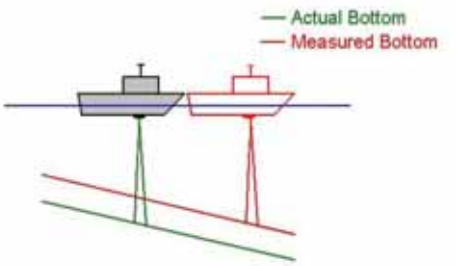
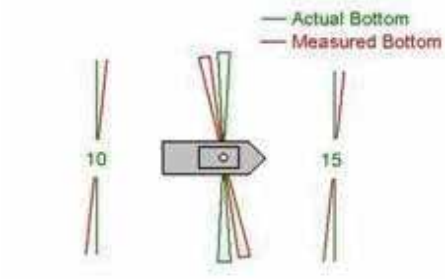
The sub-bottom profiler data was collected and processed using Chesapeake SonarWiz Software.

- SEG-Y data was imported into the software
- Frequency filtering, gain and time-variable gain settings were adjusted to ensure that the best possible picture of the sub-bottom data was available to the user
- Each individual horizon was digitised
- An XYZ of the thickeness between the seabed and each horizon was prepared and exported to McCarthy Taylor System LSS 3D modelling software
- LSS was used to prepare isopach XYZ and to landform this to the seabed data from the multibeam survey
- A drawing file was prepared in AutoCAD to show Chart Datum level of the digitised horizons during the survey

Patch tests are tests which are performed after initial equipment installation, and periodically thereafter as well as if sensors are modified, to quantify any residual biases from the initial system alignment.

During this calibration series, four separate tests must be performed to determine residual alignment biases for:

- Roll offset
- Position Time Delay (Latency)
- Pitch Offset
- Yaw (Heading) Offset

ROLL 	**PITCH** 
▪ *Sonar and Motion Reference Unit (MRU) alignment relative to vertical.* ▪ *Can cause large depth and position errors at outer beams.*	▪ *Sonar and MRU alignment relative to vertical.* ▪ *Can cause depth and position errors across the swath.*
LATENCY 	**YAW (HEADING)** 
▪ *The delay between position and fix transmission.* ▪ *Will cause positional errors.* ▪ *Error is independent of multibeam system.*	▪ *Sonar and MRU alignment relative to vertical* ▪ *Can cause depth and position errors across the swath.*

Annex E
Standard Disclaimer

A6741

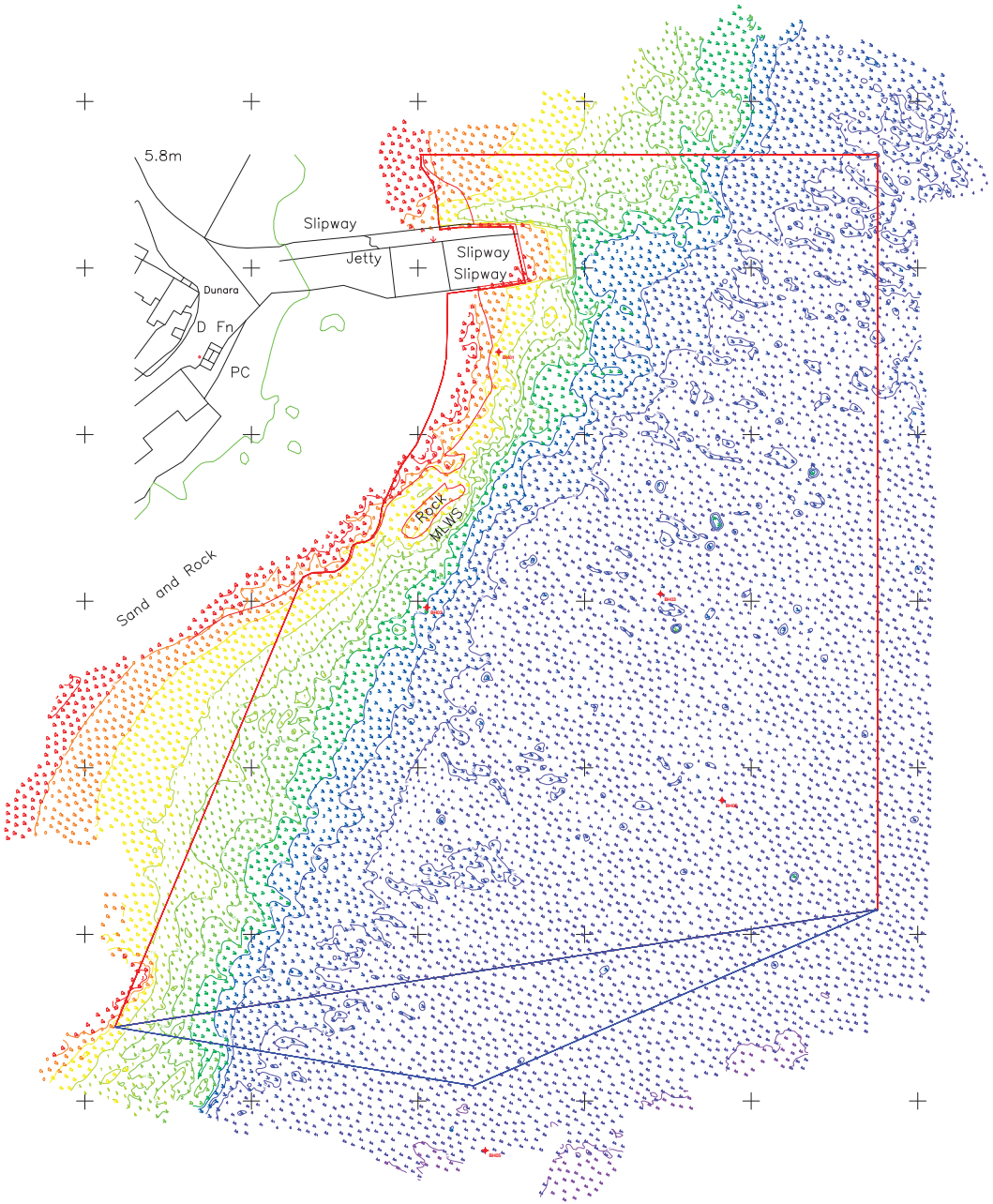
1. All client-supplied data is taken on trust as being accurate and correct, and the sub-contractor cannot be held responsible for the quality and accuracy of that data set.

2. The limits of this survey are defined by the data set; out with the survey limits are not covered at any level by the sub-contractor.

3. The data is accurate at the time of data acquisition, the sub-contractor cannot be held responsible for environmental changes, and the client by accepting this report accepts that the geological environment is subject to continuous change, that items of debris, hard contacts etc. may move, appear, be relocated or removed, thickness of surficial sediment change out with the knowledge of the sub-contractor and they will not be held responsible for such actions at any level.

4. Geophysical interpretation of data is based on an informed opinion of the supplied data, and is subject to inherent errors out with the control of the interpretational geophysicist, which include but are not limited to GPS positioning errors, navigation busts, data quality, assumed speed velocity sediment profiles in the absence of geotechnical data, profile pulse width, and induced scaling errors therein associated with seismic signature.

5. No liability of any kind is accepted by Aspect Land & Hydrographic Surveys Ltd for any error or omission.



Legend

12_8 Depths relative to CHART DATUM.

Sea–bed contour relative to CHART DATUM.

Scale: 1 cm = 5.00 Meters

0 5 10 20 30 40 50

SURVEY IS ROTATED TO GRID NORTH.

Survey Parameters & Equipment

Survey Vessel:	Coastal Sensor (MCA Cat III)
Positioning System:	Trimble Applanix POSMV
GPS Correction Source:	Radio Corrections from Base Station
Echosounder:	R2Sonic 2022 Multibeam System 400kHz
Motion Compensator:	Trimble Applanix POSMV
Positioning System Ephemeral & Datum:	ETRS89
Grid System:	National Grid of Great Britain
Geoid Model:	OSGM15
Transformation Parameters:	OSTN15
Ephemeral:	Airy
Semi-Major Axis:	6377563.396
Flattening (1/f):	299.3249646003
Vertical Datum (Topographic):	Ordnance Datum
Vertical Datum (Hydrographic):	Chart Datum
Distance Unit:	Metre

Chart Datum is 1.82m below Ordnance Datum.

The datum was established using corrected OS Wave data and post-processed using Trimble Business Centre Software.

Coloured Depth Bands:

Notes:

The Bathymetric survey limits are WHITE, data is relative to Chart Datum.

Topographic survey data is relative to Ordnance Datum.

Horizontal and vertical datums were referenced to control stations on site.

Heights in metres above Chart Datum (bmd)

MHWS	MHWN	MLWN	MLWS
4.0	3.0	1.1	0.3

CONTROL STATION COORDINATES (OD)

STN	EASTING	NORTHING	LEVEL
Base 1	129901.543	723438.616	5.518

Aspect
Land + Hydrographic Surveys
CHARTERED SURVEYORS
Thornhouse Business Centre
Ballot Road
Irvine
KA12 0RW
Tel : 01294 313399 Fax : 01294 313389
E-mail: mail@aspectsurveys.com
Web: www.aspectsurveys.com

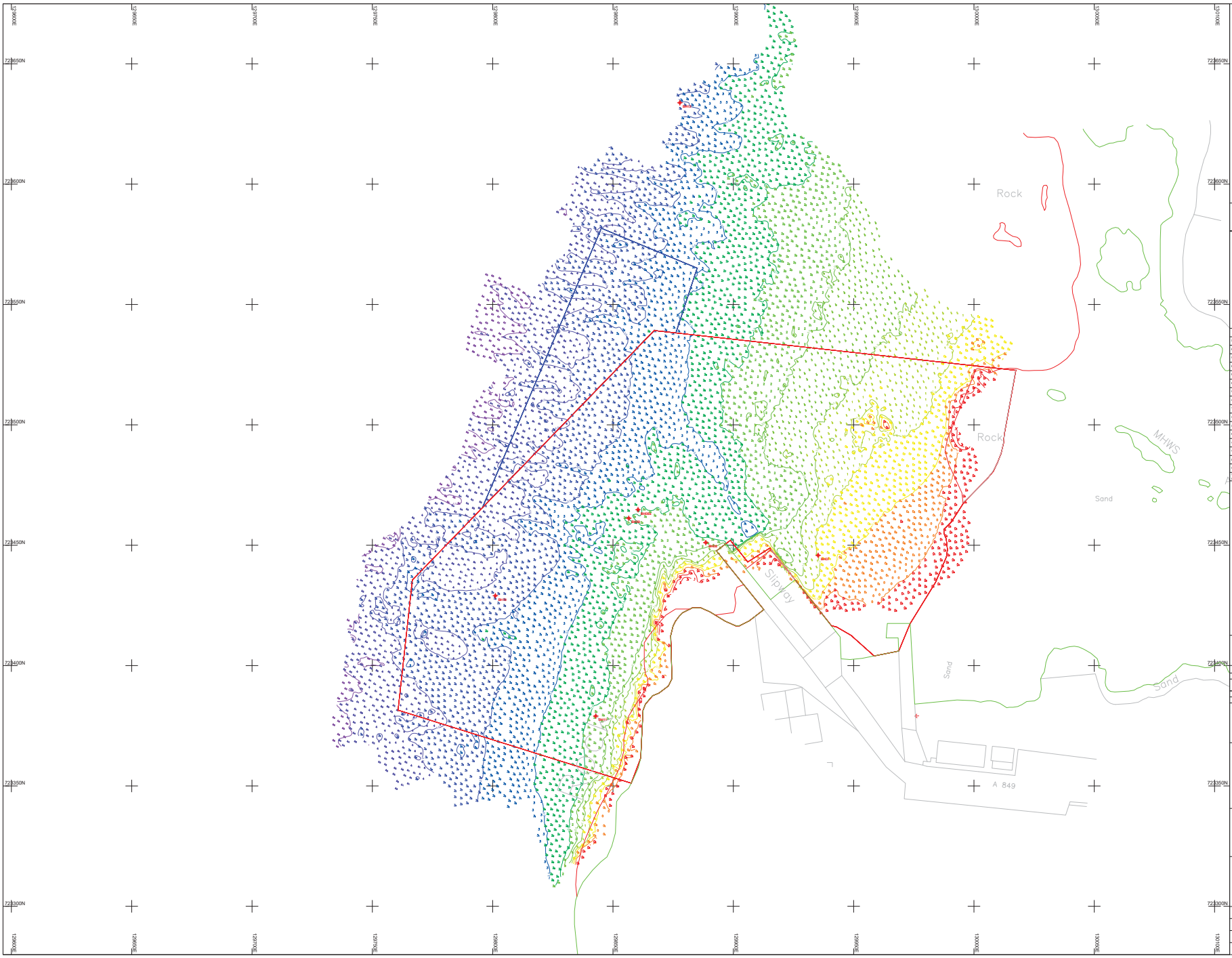
Client :

CAUSEWAY GEOTECH
9 DRUMAHISKEY ROAD
BALLYMONEY
COUNTY ANTRIM
R11 4TA

Project Title :

MULTIBEAM BATHYMETRIC SURVEY
IONA & FIONNPHORT
ISLE OF MULL

Project No: A6741	Scale : 1:500
Surveyed date : 5th September 2018	Issued date : 19th September 2018
Surveyed by : EJS	Checked by : CDT
Sheet No. : 1 of 2	Plot Scale 1:1 @ A0



Legend

Depths relative to CHART DATUM.

Sea–bed contour relative to CHART DATUM.

Scale: 1 cm = 5.00 Meters

5 10 20 30 40 50

SURVEY IS ROTATED TO GRID NORTH.

Survey Parameters & Equipment

Survey Vessel:	Coastal Sensor (MCA Cat III)
Positioning System:	Trimble Applanix POSMV
GPS Correction Source:	Radio Corrections from Base Station
Echosounder:	R2Sonic 2022 Multibeam System 400kHz
Motion Compensator:	Trimble Applanix POSMV
Positioning System Ephemeral & Datum:	ETR89
Grid System:	National Grid of Great Britain
Geoid Model:	OSGM15
Transformation Parameters:	OSTN15
Ephemeral:	Airy
Elem Major Axis:	6377563.396
Flattening (1/f):	299.3249646003
Vertical Datum (Topographic):	Ordnance Datum
Vertical Datum (Hydrographic):	Chart Datum
Distance Unit:	Metre

Chart Datum is 1.82m below Ordnance Datum.

The datum was established using corrected CSI Wales data and post-processed using Trimble Business Centre Software.

Coloured Depth Bands:

0.00
0.00 - 0.49
0.50 - 0.99
1.00 - 1.49
1.50 - 1.99
2.00 - 2.49
2.50 - 2.99
3.00 - 3.49
3.50 - 3.99
4.00 - 4.49
4.50 - 4.99
>= 5.00

Notes:

The Bathymetric survey limits are MHWS, data is relative to Chart Datum.

Topographic survey data is relative to Ordnance Datum.

Horizontal and vertical datums were referenced to control stations on site.

Heights in metres above Chart Datum (tons)

MHWS	MHWN	MLWN	MLWS
4.0	3.0	1.1	0.3

CONTROL STATION COORDINATES (OD)

STN	EASTING	NORTHING	LEVEL
Base 1	129901.543	723418.616	5.518

Aspect
Land + Hydrographic Surveys
CHARTERED SURVEYORS
Thornhouse Business Centre
Ballot Road
Irvine
KA12 0RW
Tel : 01294 313399 Fax : 01294 313389
E-mail: mail@aspectsurveys.com
Web: www.aspectsurveys.com

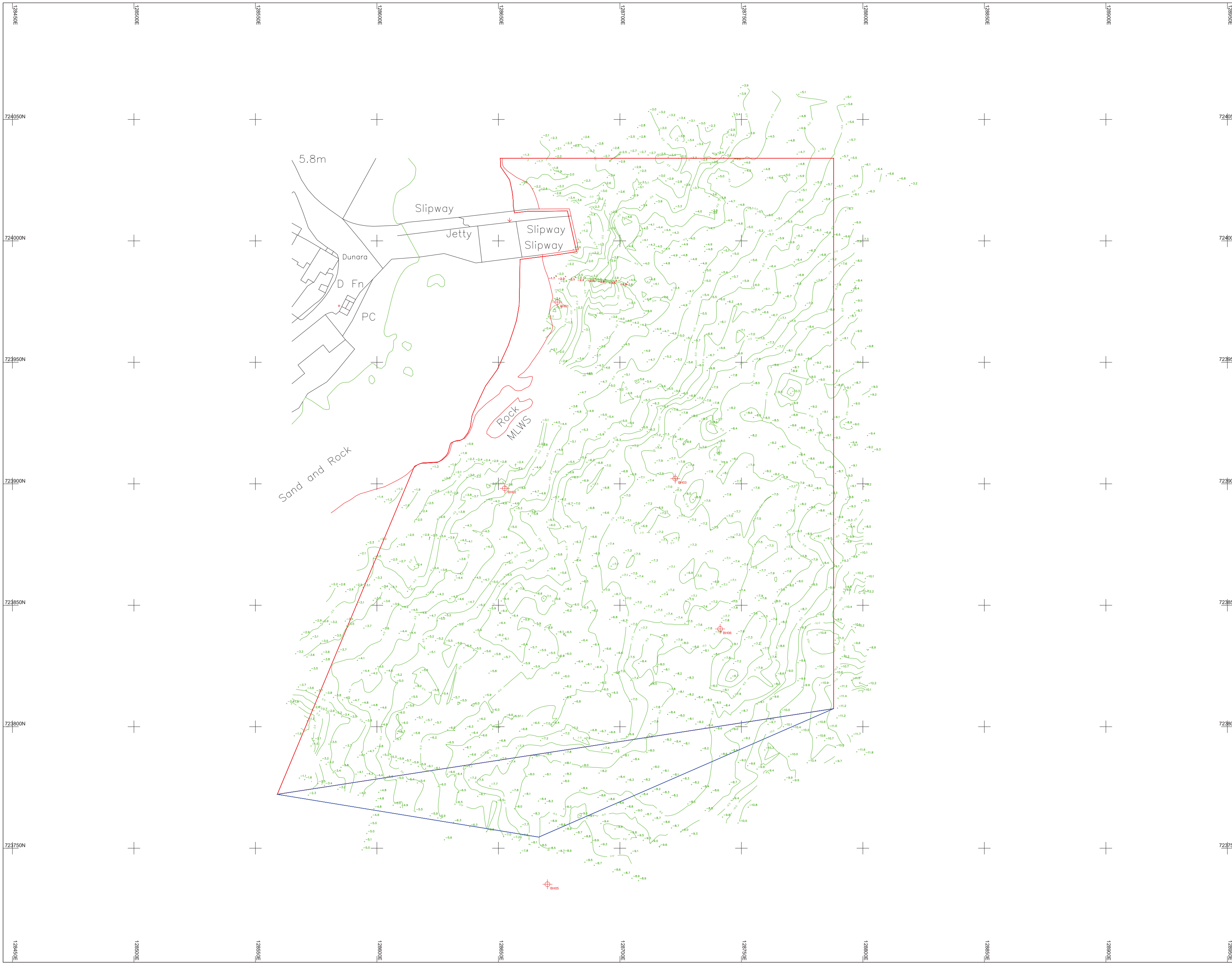
Client :

CAUSEWAY GEOTECH
8 DRUMAHISKEY ROAD
BALLYMONEY
COUNTY ANTRIM
R11 4TA

Project Title :

MULTIBEAM BATHYMETRIC SURVEY
IONA & FIONNPHORT
ISLE OF MULL

Project No: A6741	Scale : 1:500
Surveyed date : 5th September 2018	Issued date : 19th September 2018
Surveyed by : EJS	Checked by : CDT
Sheet No. : 2 of 2	Plot Scale : 1:1 @ A0



Legend

-4.2 (red)	Horizon 1 Level relative to CHART DATUM
(red line)	Horizon 1 Contour relative to CHART DATUM
-4.2 (green)	Horizon 2 Level relative to CHART DATUM
(green line)	Horizon 2 Contour relative to CHART DATUM
BH12	As–drilled borehole position (DRAFT LOGS)

Scale: 1 cm = 5.00 Meters

0 5 10 20 30 40 50

SURVEY IS ROTATED TO GRID NORTH.

Survey Parameters & Equipment	
Survey Vessel:	Coastal Sensor (MCA Cat III)
Positioning System:	Trimble Applanix PosMV
GPS Correction Source:	Radio Corrections from Base Station
Echosounder:	R2Sonic 2022 Multibeam System 400kHz
Motion Compensator:	Trimble Applanix PosMV
Positioning System Spheroid & Datum:	ETRS89
Grid System:	National Grid of Great Britain
Geoid Model:	OSGM15
Transformation Paramaters:	OSTN15
Spheroid:	Airy
Semi Major Axis:	6377563.396
Flattening (1/f):	299.324964600
Vertical Datum (Topographic):	Ordnance Datum
Vertical Datum (Hydrographic):	Chart Datum
Distance Unit:	Metre

Chart Datum is 1.82m below Ordnance Datum.

The datum was established using corrected OS Rinex data and post-processed using Trimble Business Centre Software.

Notes:

Horizon 1 boundary between stratified surface sediments above and heavier, more consolidated sediments below. The DRAFT geophysical investigations shows that the surface sediments consist of a mixture of SAND and GRAVEL and as such, where this horizon is seen it is likely to represent the top of GRAVEL.

Horizon 2 represents the top of a hard return and the limit of acoustic penetration. The DRAFT geophysical investigations show that rockhead across the survey areas consists of GRANITE and other METAMORPHIC rock, which ties in with the return digitised as Horizon 2.

Draft Intrusive geophysical investigation results were available at the time of processing and have been integrated with this report.

Heights in metres above Chart Datum (Iona)			
MHWS	MHWN	MLWN	MLWS
4.0	3.0	1.5	0.5

CONTROL STATION COORDINATES (OD)			
STN	EASTING	NORTHING	LEVEL
Base 1	129901.543	723438.616	5.518

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Land + Hydrographic Surveys
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Ballot Road
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KA12 OHW
Tel : 01294 313399 Fax : 01294 313389
E-mail: mail@aspectsurveys.com
Web: www.aspectsurveys.com

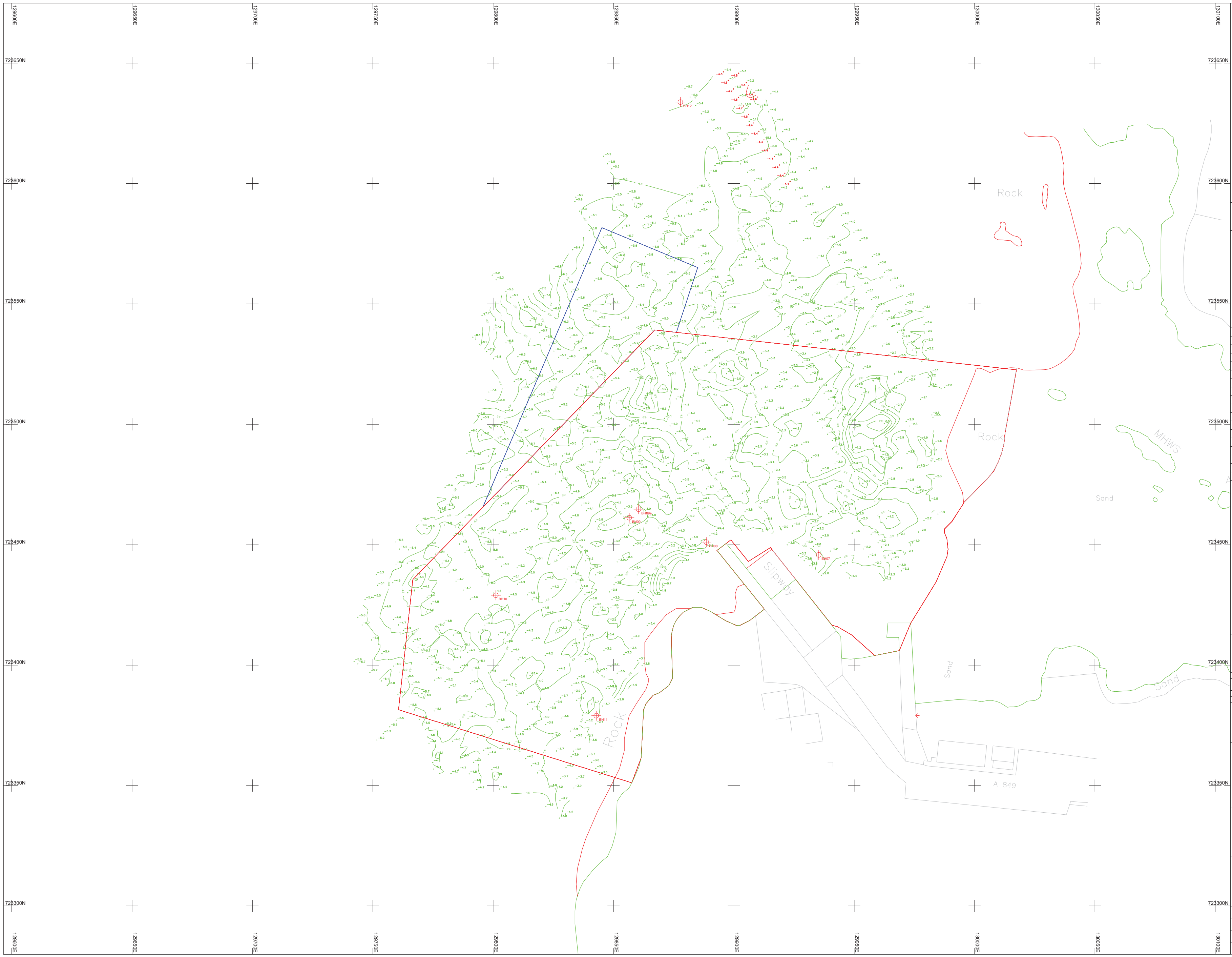
Client :

CAUSEWAY GEOTECH
8 DRUMAHISKEY ROAD
BALLYMONEY
COUNTY ANTRIM
R11 4TA

Project Title :

GEOPHYSICAL SURVEY
IONA & FIONNPHORT
ISLE OF MULL

Project No: A6741	Scale : 1:500
Surveyed date : 5th September 2018	Issued date : 19th September 2018
Surveyed by : EJS	Checked by : CDT
Sheet No. : 1 of 2	Plot Scale: 1:1 @ A0



Legend

−4.2 (red)	Horizon 1 Level relative to CHART DATUM
(red line)	Horizon 1 Contour relative to CHART DATUM
−4.2 (green)	Horizon 2 Level relative to CHART DATUM
(green line)	Horizon 2 Contour relative to CHART DATUM
BH12	As−drilled borehole position (DRAFT LOGS)

Scale: 1 cm = 5.00 Meters

5 10 20 30 40 50

SURVEY IS ROTATED TO GRID NORTH.

Survey Parameters & Equipment	
Survey Vessel:	Coastal Sensor (MCA Cat III)
Positioning System:	Trimble Applanix PosMV
GPS Correction Source:	Radio Corrections from Base Station
Echosounder:	R2Sonic 2022 Multibeam System 400kHz
Motion Compensator:	Trimble Applanix PosMV
Positioning System Spheroid & Datum:	ETRS89
Grid System:	National Grid of Great Britain
Geoid Model:	OSGM15
Transformation Paramaters:	OSTN15
Spheroid:	Airy
Semi Major Axis:	6377563.396
Flattening (1/f):	299.324964600
Vertical Datum (Topographic):	Ordnance Datum
Vertical Datum (Hydrographic):	Chart Datum
Distance Unit:	Metre

Chart Datum is 1.82m below Ordnance Datum.

The datum was established using corrected OS Rinex data and post-processed using Trimble Business Centre Software.

Notes:

Horizon 1 boundary between stratified surface sediments above and heavier, more consolidated sediments below. The DRAFT geophysical investigations shows that the surface sediments consist of a mixture of SAND and GRAVEL and as such, where this horizon is seen it is likely to represent the top of GRAVEL.

Horizon 2 represents the top of a hard return and the limit of acoustic penetration. The DRAFT geophysical investigations show that rockhead across the survey areas consists of GRANITE and other METAMORPHIC rock, which ties in with the return digitised as Horizon 2.

Draft Intrusive geophysical investigation results were available at the time of processing and have been integrated with this report.

Heights in metres above Chart Datum (Iona)			
MHWS	MHWN	MLWN	MLWS
4.0	3.0	1.5	0.5

CONTROL STATION COORDINATES (OD)			
STN	EASTING	NORTHING	LEVEL
Base 1	129901.543	723438.616	5.518

Aspect
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CHARTERED SURVEYORS
Thornhouse Business Centre
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E-mail: mail@aspectsurveys.com
Web: www.aspectsurveys.com

Client :

CAUSEWAY GEOTECH
8 DRUMAHISKEY ROAD
BALLYMONEY
COUNTY ANTRIM
R11 4TA

Project Title :

GEOPHYSICAL SURVEY
IONA & FIONNPHORT
ISLE OF MULL

Project No: A6741	Scale : 1:500
Surveyed date : 5th September 2018	Issued date : 19th September 2018
Surveyed by : EJS	Checked by : CDT
Sheet No. : 2 of 2	Plot Scale: 1:1 @ A0

CAUSEWAY GEOTECH

APPENDIX F

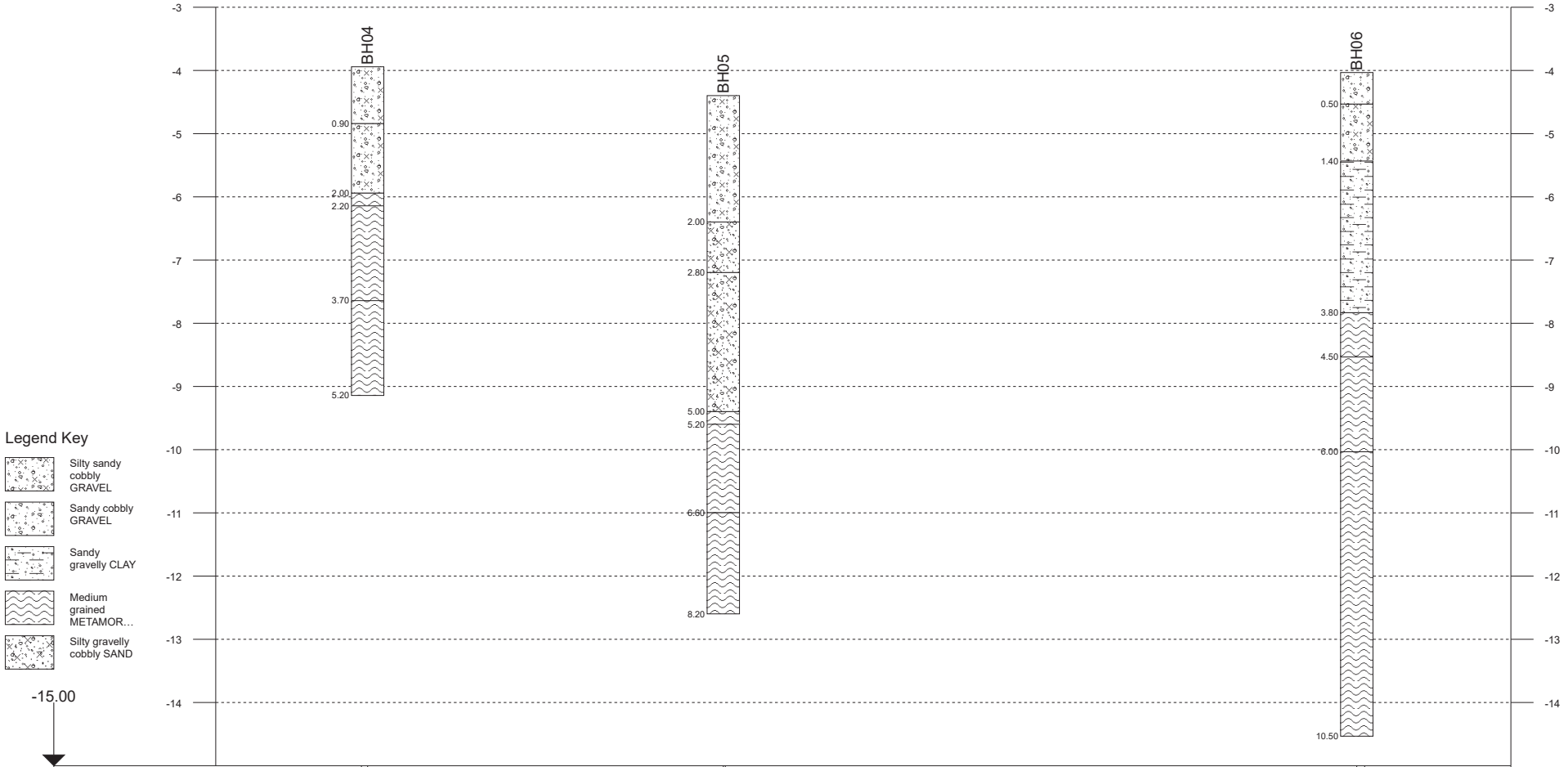
Geological long sections

Project Id: 18-0144	Title: Iona Breakwater - Option 1 / 1a
Project Title: Fionnphort and Iona Ground Investigation	Vertical Scale: 1:92
Location:	Horizontal Scale: 1:419
Client: Argyll and Bute Council	Engineer: Byrne Looby Partners

Project Id: 18-0144
Project Title: Fionnphort and Iona Ground Investigation
Location:
Client: Argyll and Bute Council

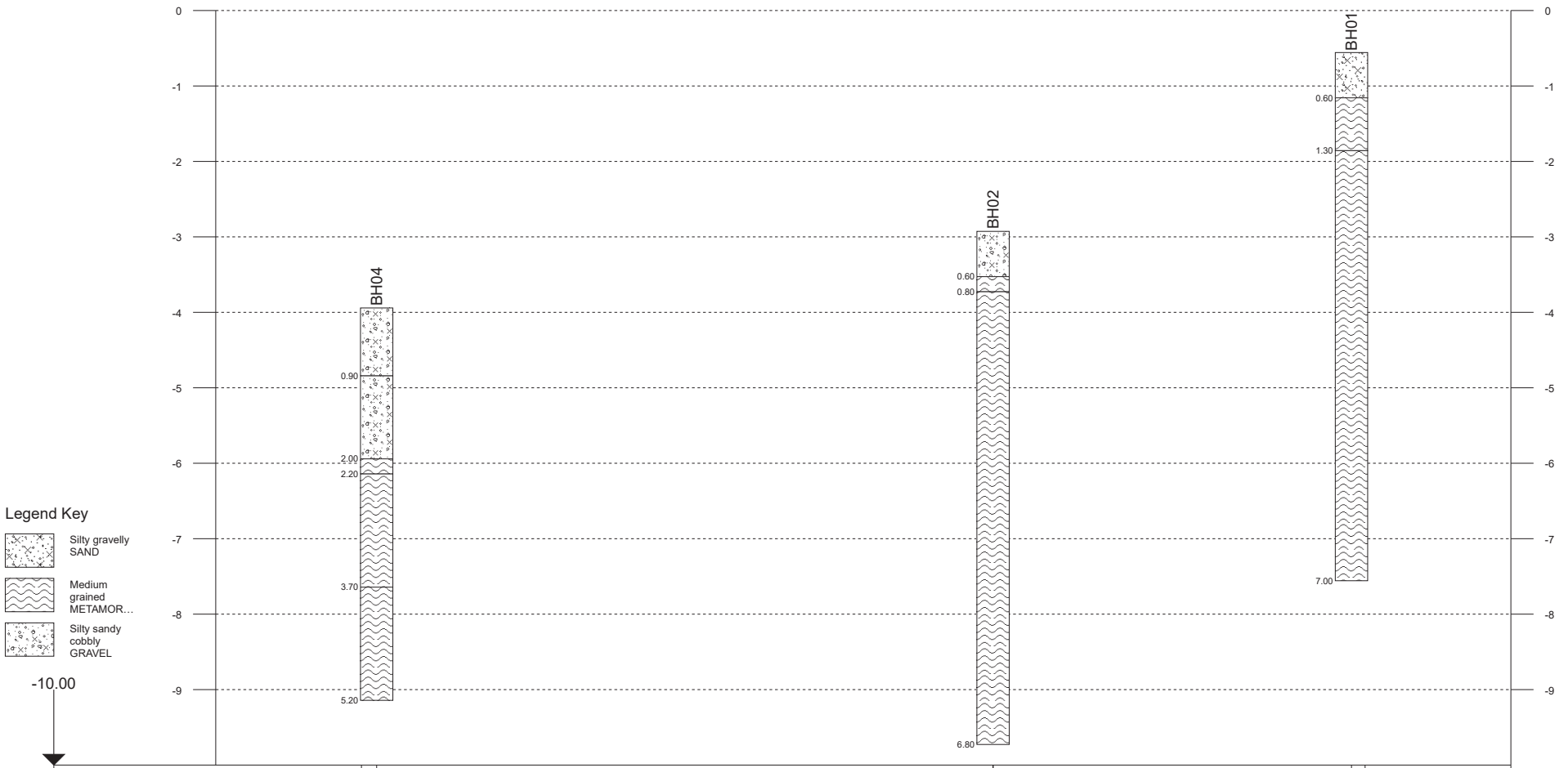
Title: Iona Breakwater - Option 2 / 2a
Vertical Scale: 1:92
Horizontal Scale: 1:1170
Engineer: Byrne Looby Partners

CAUSEWAY GEOTECH

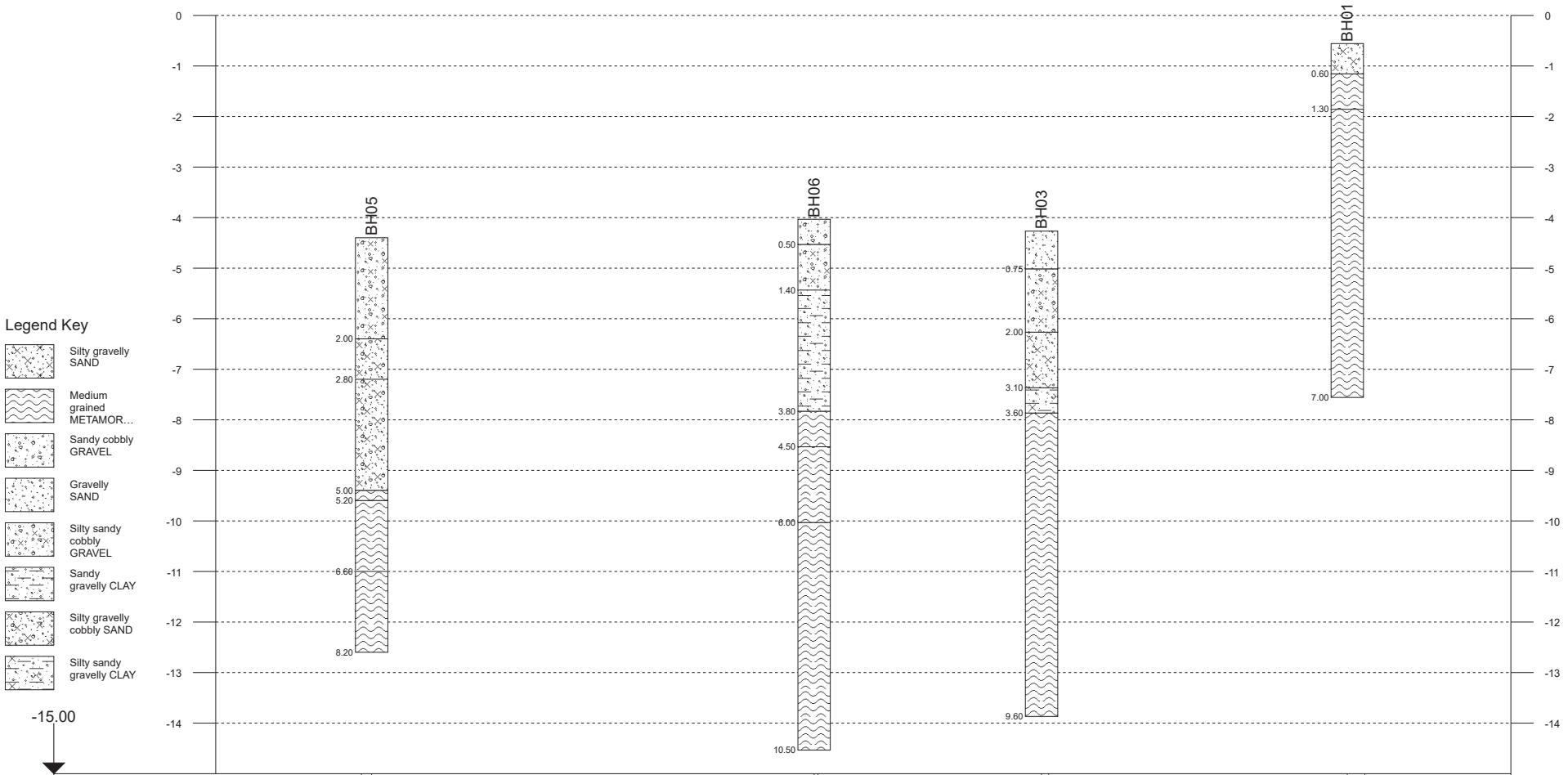


Chainage (m)	0.00	73.03	200.32
Offset (m)	0.52	0.25	0.37
Elevation (mCD)	-3.94	-4.40	-4.03

Project Id: 18-0144	Title: Section BH04-BH02-BH01
Project Title: Fionnphort and Iona Ground Investigation	Vertical Scale: 1:77
Location:	Horizontal Scale: 1:1292
Client: Argyll and Bute Council	Engineer: Byrne Looby Partners



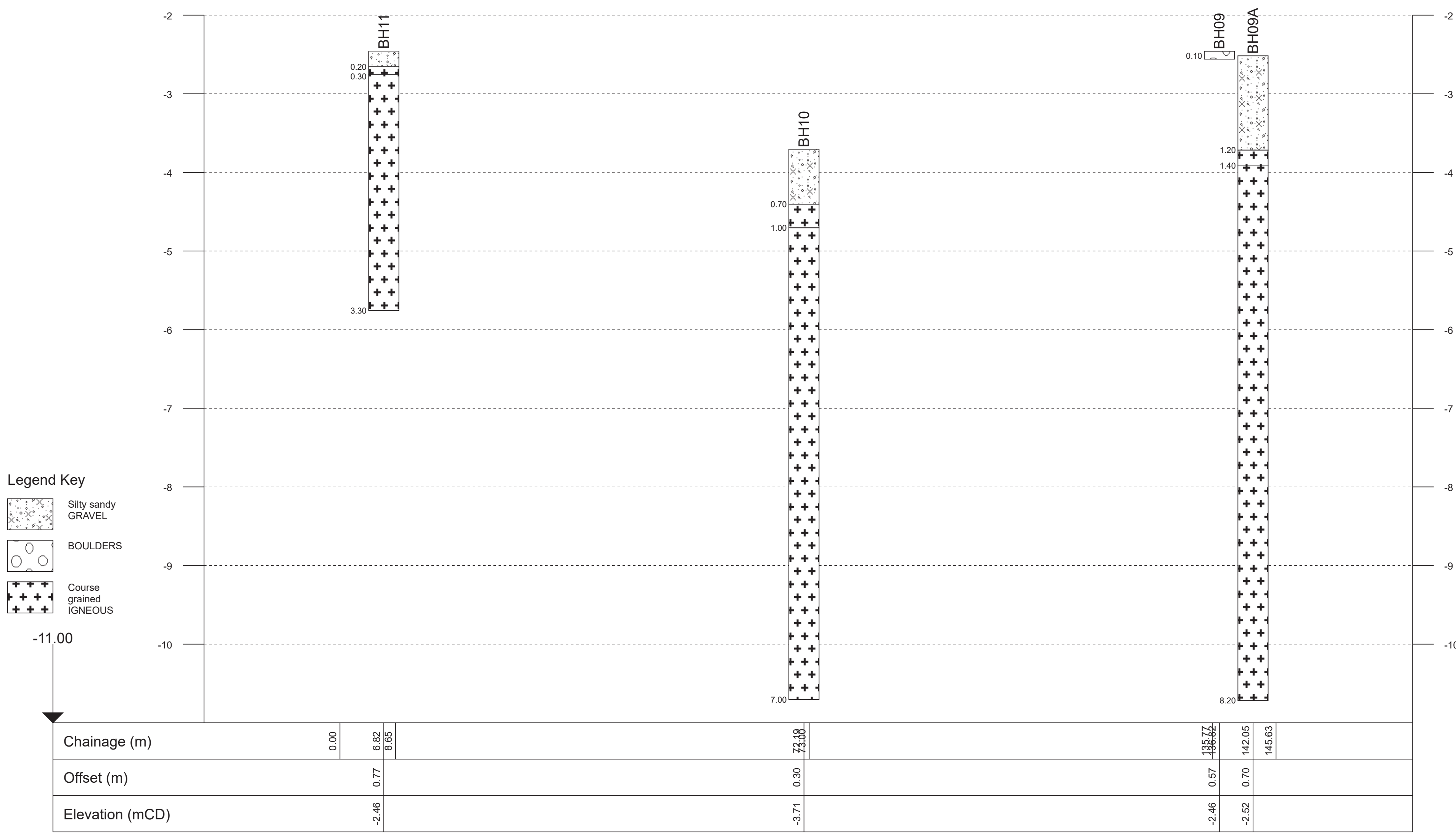
Project Id: 18-0144	Title: Section BH05-BH06-BH03-BH01
Project Title: Fionnphort and Iona Ground Investigation	Vertical Scale: 1:115
Location:	Horizontal Scale: 1:1667
Client: Argyll and Bute Council	Engineer: Byrne Looby Partners



Chainage (m)	0.00 / 2.92	138.80 / 197.07	185.02	282.69 / 287.70
Offset (m)	0.47	0.27	0.69	0.44
Elevation (mCD)	-4.40	-4.03	-4.27	-0.56

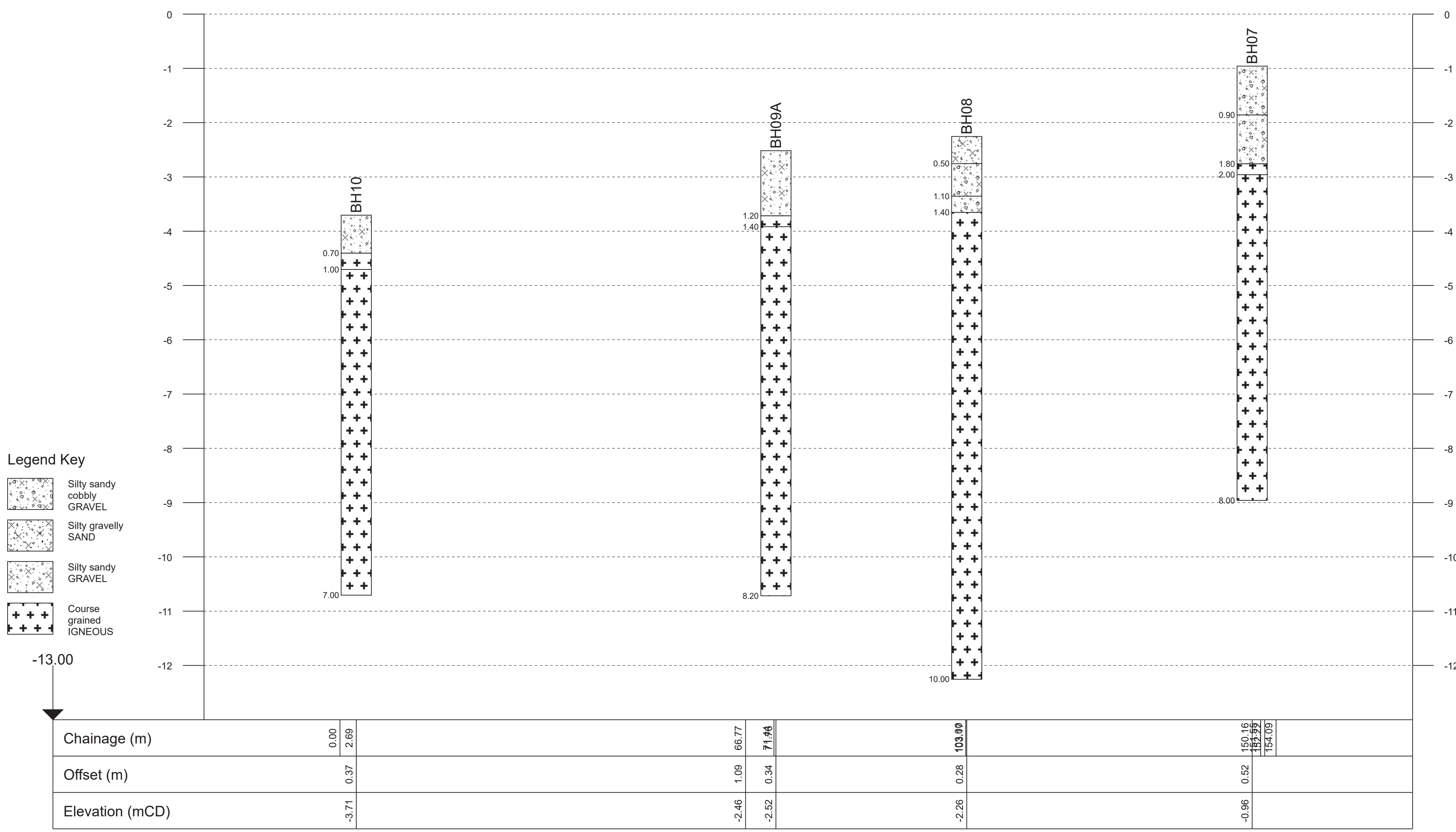
Project Id: 18-0144
Project Title: Fionnphort and Iona Ground Investigation
Location:
Client: Argyll and Bute Council

Title: Fionnphort Breakwater - Option 1
Vertical Scale: 1:69
Horizontal Scale: 1:844
Engineer: Byrne Looby Partners



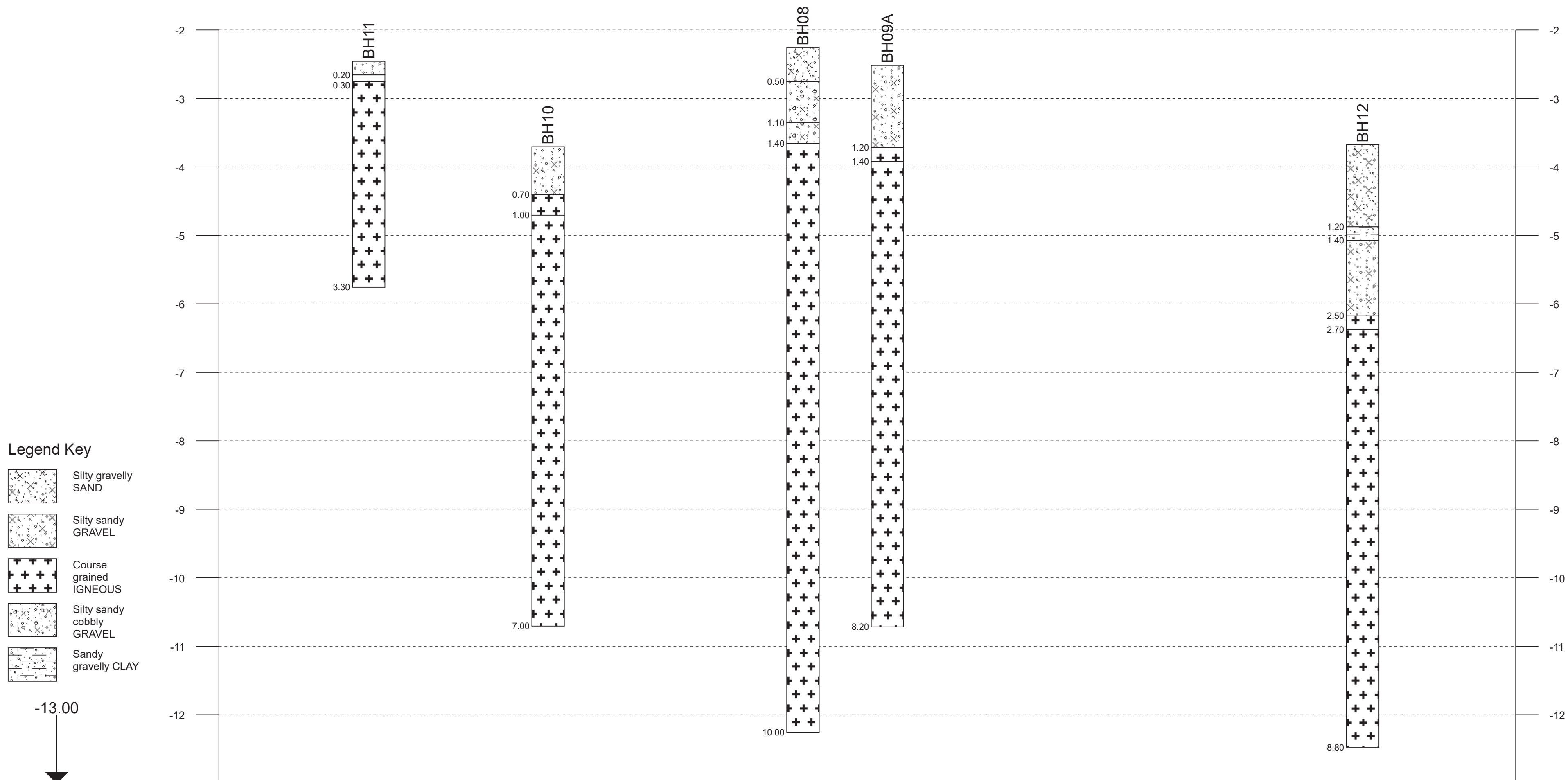
Project Id: 18-0144
Project Title: Fionnphort and Iona Ground Investigation
Location:
Client: Argyll and Bute Council

Title: Section BH10-BH09A-BH08-BH07
Vertical Scale: 1:100
Horizontal Scale: 1:893
Engineer: Byrne Looby Partners



Project Id: 18-0144
Project Title: Fionnphort and Iona Ground Investigation
Location:
Client: Argyll and Bute Council

Title: Section BH11-BH10-BH08-BH09A-BH12
Vertical Scale: 1:85
Horizontal Scale: 1:2113
Engineer: Byrne Looby Partners



	BH11	BH10	BH08	BH09A	BH12
Chainage (m)	0.00 / 1.43	66.54 / 67.57	158.52 / 159.07	189.73	362.26 / 364.73
Offset (m)	0.06	0.07	0.05	1.01	0.53
Elevation (mCD)	-2.46	-3.71	-2.26	-2.52	-3.68

CAUSEWAY GEOTECH

APPENDIX G

SPT hammer energy measurement report

Hammer Energy Test Report

in accordance with BSEN ISO 22476-3:2005

[redacted]

Dynamic sampling uk ltd
5-8 victory parkway
victory road
Derby
DE24 8ZF

Hammer Ref:	D.83
Test Date:	21/03/2018
Report Date:	21/03/2018
File Name:	D.83.spt
Test Operator:	TP

Instrumented Rod Data

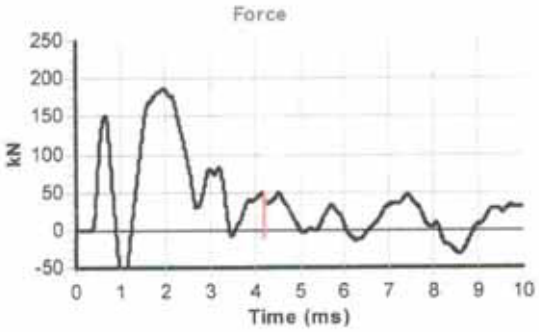
Diameter d_r (mm):	54
Wall Thickness t_r (mm):	6.9
Assumed Modulus E_a (GPa):	208
Accelerometer No.1:	6455
Accelerometer No.2:	6457

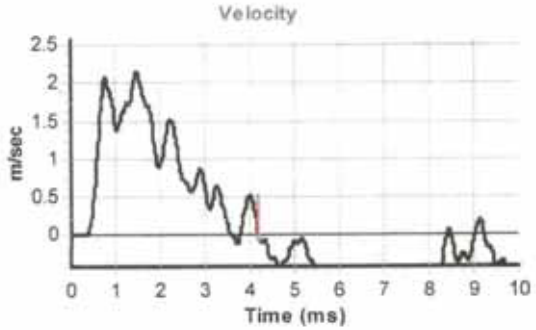
Hammer Information

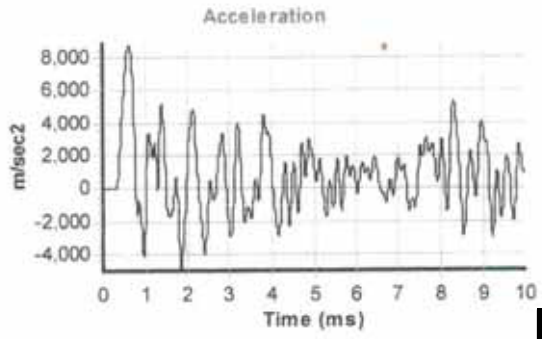
Hammer Mass m (kg):	63.5
Falling Height h (mm):	760
String Length L (m):	15.0

Comments / Location

Drillwell hammer tested at Dynamic samplings yard.







Calculations

Area of Rod A (mm2):	1021
Theoretical Energy E_{theor} (J):	473
Measured Energy E_{meas} (J):	371

Energy Ratio E_r (%): 78

[redacted]

Signed: T.parker.

Title: Associate Director.

The recommended calibration interval is 12 months

Appendix C – Consultation

Note of the Iona and Fionnphort Infrastructure Improvements Drop-in Sessions on Tuesday 26 March from 3pm-5pm at the Public Library on Iona and Wednesday 27 March from 11am-1pm at the Coastguard Hut in Fionnphort.

Present:
Stewart Clark, Marine Operations Manager, ABC – Chair **(SC)**
Allan Finlay, Technical Officer, ABC **(AF)**
Adam Cronin, Director, Byrne Looby **(AC)**

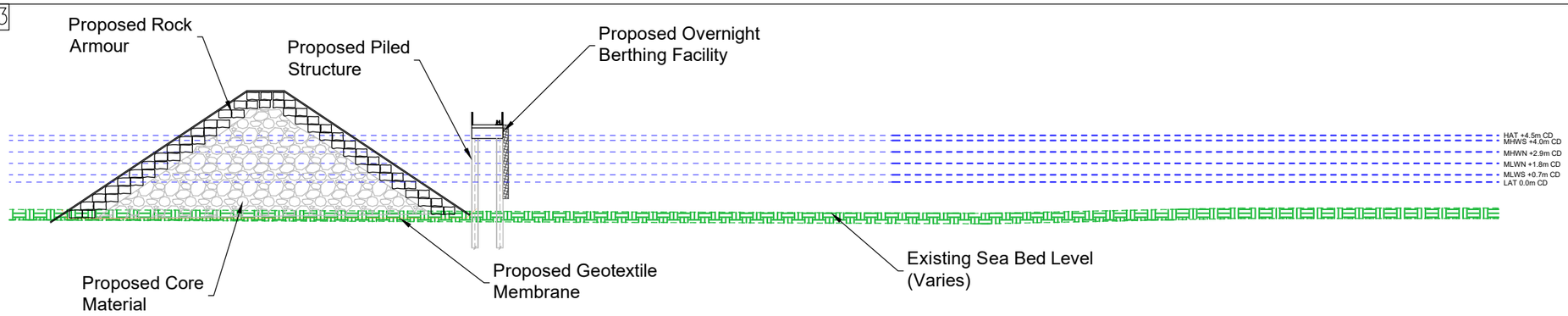
Members of Iona Community Council
Representative(s) of South West Mull and Iona Development
Representative(s) of Mull and Iona Community Trust
Representative(s) of Mull and Iona Ferry Committee
Residents/General Public – Iona approx. 20-25 no.
Residents/General Public – Fionnphort approx. 20-25 no.

1	**Iona** Key Issues/Concerns:- ➢ Height of breakwater / crest height (clarification on 10.5m C.D.); ➢ Sedimentation transport / siltation on north berth and end of existing slipway; ➢ Addition of piles to south of slipway; ➢ Appearance – rock preferable to concrete or other material; Other Comments:- ➢ Public access; ➢ Lighting; ➢ Duration of works and disruption to services; ➢ Utilise local material where possible.	
2	**Fionnphort** Key Issues/Concerns:- ➢ Height of breakwater / crest height; ➢ Extension to existing aligning structure to accommodate larger vessel – dolphin/single piles; ➢ Capacity to berth 2 vessels in event of breakdown. 2nd vessel could utilise berth extension or original aligning structure location on the NE face of the breakwater; ➢ Sedimentation transport / siltation – shallow patch at end of breakwater; ➢ Appearance – rock preferable to concrete or other material; Other Comments:- ➢ Public access; ➢ Community benefits – viewing platform / path / benches ➢ Incorporate surge chambers within structure which could be used as berthing face; ➢ Fuelling of Calmac vessel; ➢ Balance between functionality and visual impact; ➢ Utilise local material where possible.	

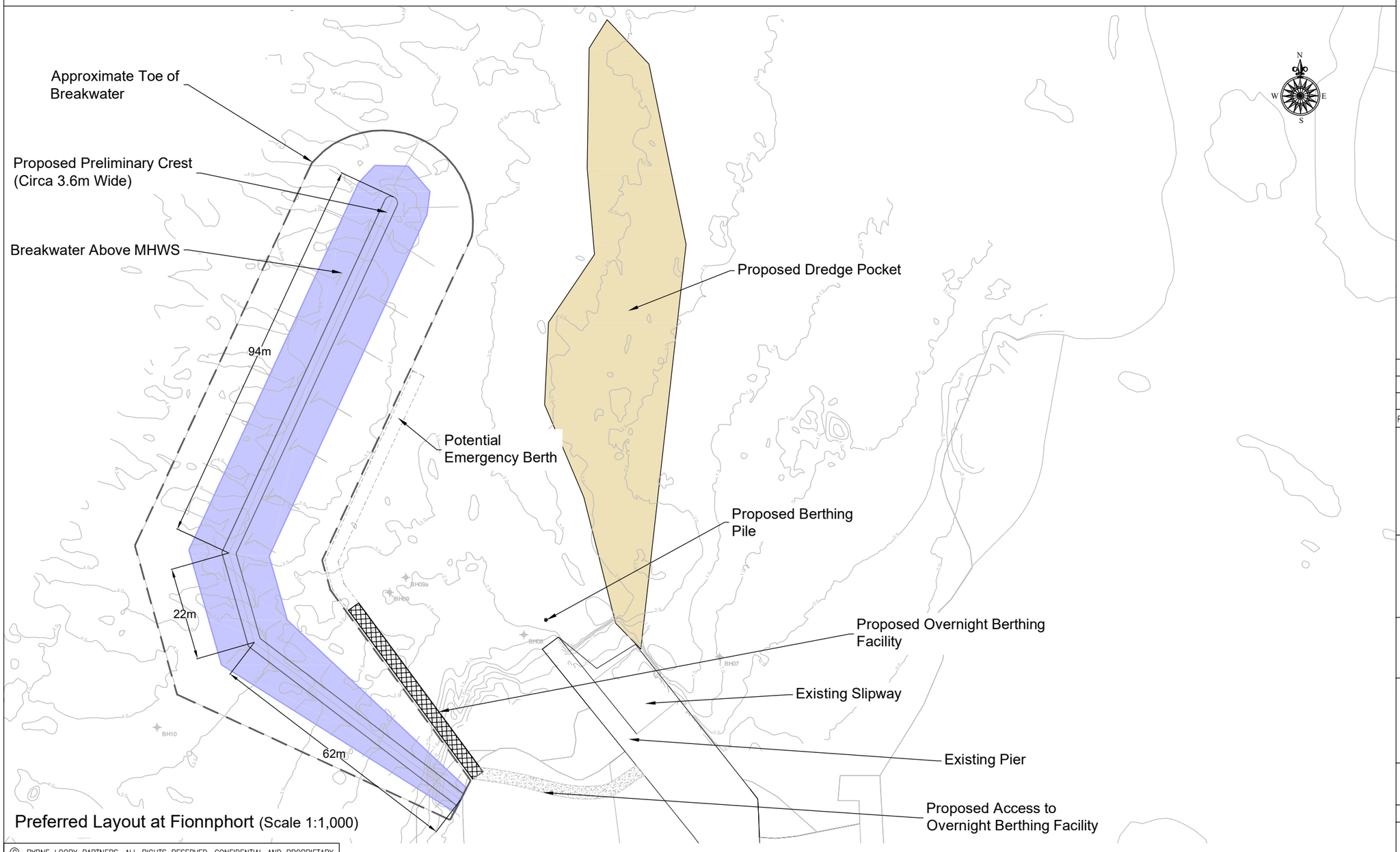
Appendix D – Wave Modelling

Appendix E – Preferred Layouts

A3



Cross-Section Through Overnight Berthing Facility (Scale 1:500)



Preferred Layout at Fionnphort (Scale 1:1,000)

GENERAL NOTES

Notes;

1. This drawing is to be read with all other ByrneLooby drawings and any other relevant documents.
2. Do not scale off drawings.
3. Dimensions in millimetres unless noted otherwise.
4. Levels in metres relative to site datum.
5. Breakwater subject to detailed design and consenting.

Rev	Date	Description	By	Chk	App
00	31/07	Feasibility Study	PM	SMC	AC

BYRNELOOBY

www.ByrneLooby.com

IRELAND UK UNITED ARAB EMIRATES BAHRAIN

CLIENT

Argyll & Bute Council

PROJECT

Iona and Fionnphort Marine Access Improvements

DRAWING TITLE

Preferred Layout at Fionnphort

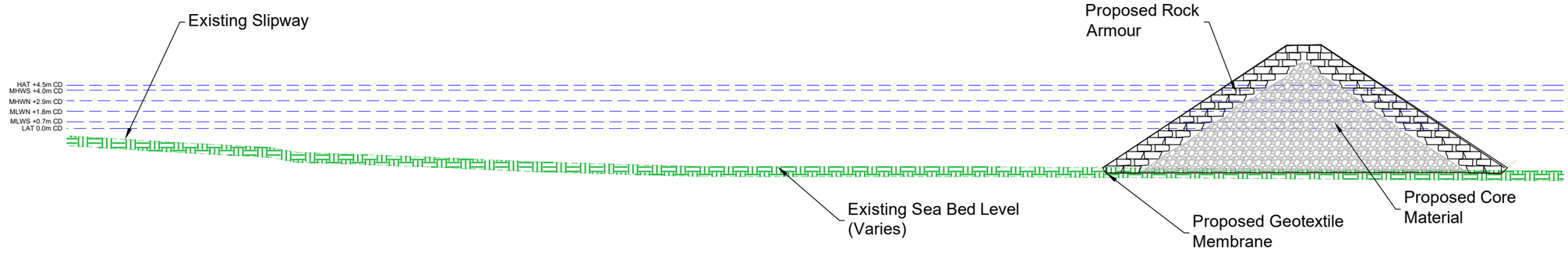
STATUS

Feasibility Study

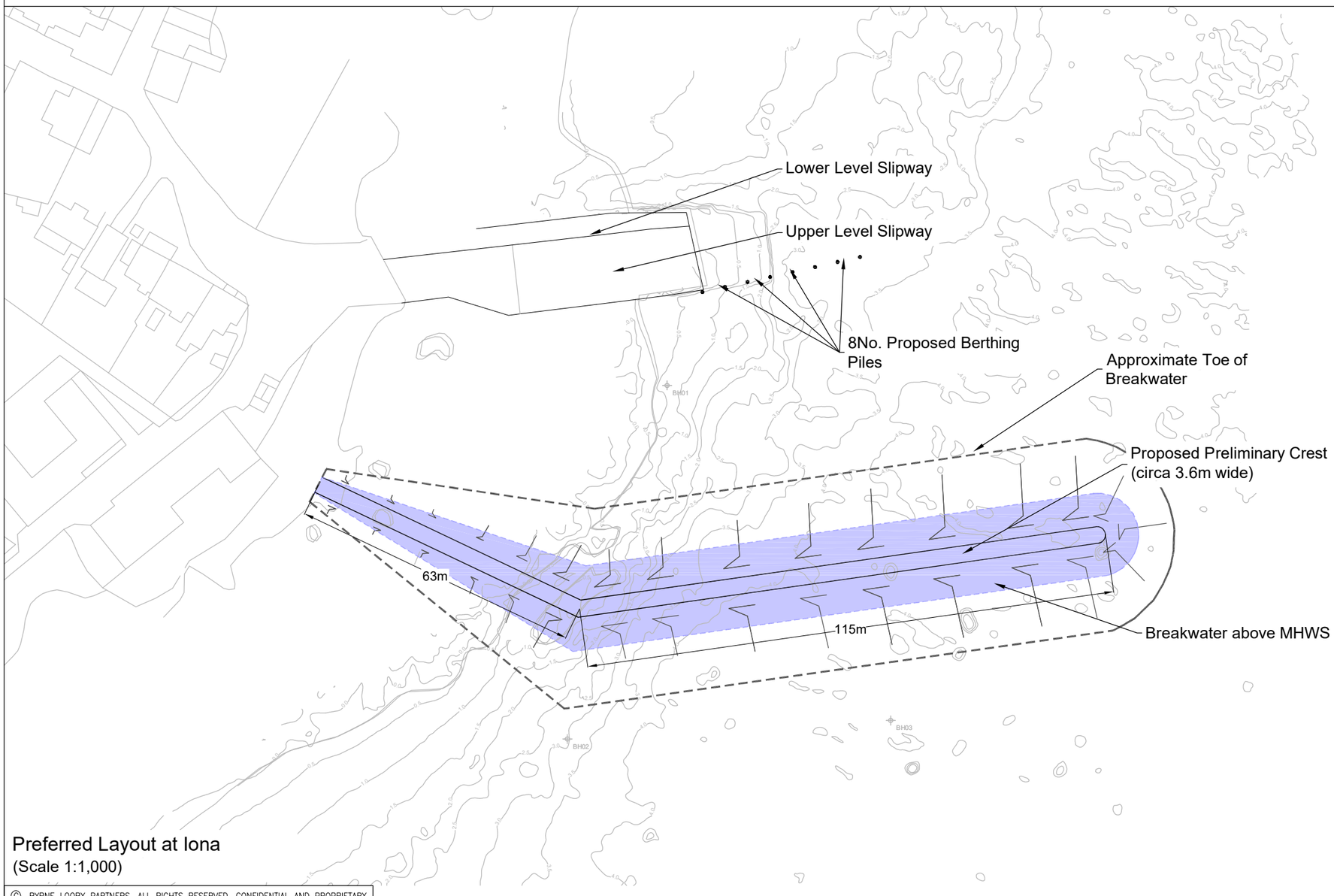
Date: **30/07/2019**	Scale: **Varies @ A3**	Drawn: **PM**	Chk: **SMC**	App: **AC**

Project No:	Drg. No:	Rev:
CM1052	**CM1052_MA_0802_DWG**	**00**

A3



Cross-Section Through Proposed Breakwater
(Scale 1:500)



Preferred Layout at Iona
(Scale 1:1,000)

GENERAL NOTES

Notes;

1. This drawing is to be read with all other ByrneLooby drawings and any other relevant documents.
2. Do not scale off drawings.
3. Dimensions in millimetres unless noted otherwise.
4. Levels in metres relative to site datum.
5. Breakwater subject to detailed design and consenting.

Rev	Date	Description	By	Chk	App
00	31/07	Feasibility Study	PM	SMC	AC

BYRNELOOBY
www.ByrneLooby.com
IRELAND UK UNITED ARAB EMIRATES BAHRAIN

CLIENT
Argyll & Bute Council

PROJECT
Iona and Fionnphort
Marine Access Improvements

DRAWING TITLE
Preferred Layout at Iona

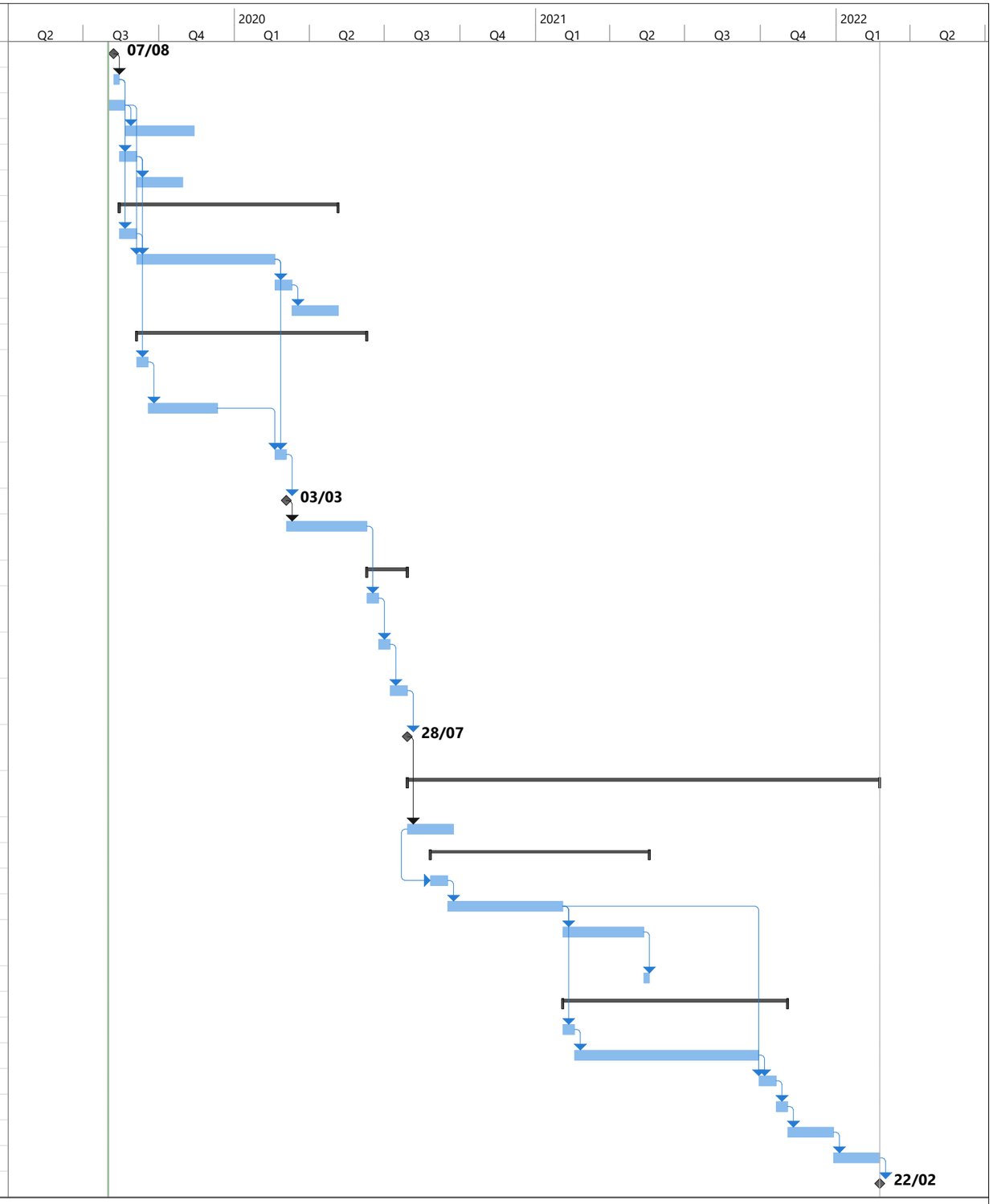
STATUS
Feasibility Study

Date: 30/07/2019	Scale: Varies @ A3	Drawn: PM	Chk: SMC	App: AC

Project No:	Drg. No:	Rev:
CM1052	CM1052_MA_0803_DWG	00

Appendix F – Outline Programme

ID	Task Mode	Task Name	Duration	Start	Finish	Predecessors
1		Feasibility Study	0 days	Wed 07/08/1	Wed 07/08/1	
2		Stakeholder Consultation	1 wk	Wed 07/08/1	Tue 13/08/19	1
3		Procure Erosion Deposition Modellers	3 wks	Wed 31/07/1	Tue 20/08/19	
4		Erosion Deposition Modelling	3 mons	Wed 21/08/1	Tue 12/11/19	3
5		Procure Designers	3 wks	Wed 14/08/1	Tue 03/09/19	2
6		Detailed Design	2 mons	Wed 04/09/1	Tue 29/10/19	5
7		**Planning Permission**	**190 days**	**Wed 14/08/1**	**Tue 05/05/2(**	
8		EIAR Screening	3 wks	Wed 14/08/1	Tue 03/09/19	2
9		EIAR Preparation	6 mons	Wed 04/09/1	Tue 18/02/2(	8,3
10		Preparation of Planning Application	3 wks	Wed 19/02/2	Tue 10/03/2(	9
11		Planning Process	2 mons	Wed 11/03/2	Tue 05/05/2(	10
12		**Marine Scotland Licensing**	**200 days**	**Wed 04/09/1**	**Tue 09/06/2(**	
13		Marine Scotland PAC Screening	10 days	Wed 04/09/19	Tue 17/09/19	5
14		MS Pre Application Consultation Process	12 wks	Wed 18/09/19	Tue 10/12/19	13
15		Preparation of Application	2 wks	Wed 19/02/20	Tue 03/03/20	14,9
16		Submission of Application	0 days	Tue 03/03/2(	Tue 03/03/2(	15
17		MS Licence Processing	14 wks	Wed 04/03/20	Tue 09/06/20	16
18		**Contractor Procurement**	**35 days**	**Wed 10/06/2**	**Tue 28/07/2(**	
19		Amendments to Detailed Design	2 wks	Wed 10/06/20	Tue 23/06/20	17
20		Preparation of Tender Package	2 wks	Wed 24/06/20	Tue 07/07/20	19
21		Procurement of Contractor	3 wks	Wed 08/07/20	Tue 28/07/20	20
22		Appointment of Contractor	0 days	Tue 28/07/20	Tue 28/07/20	21
23		**Construction Phase - Fionnphort Option 5 & Iona 2B**	**410 days**	**Wed 29/07/20**	**Tue 22/02/22**	
24		Production of Rock (Core and Armour)	8 wks	Wed 29/07/2	Tue 22/09/2(	22
25		**Fionnphort**	**190 days**	**Wed 26/08/2**	**Tue 18/05/2**	
26		Mobilisation and Site Establishment	3 wks	Wed 26/08/2	Tue 15/09/2(	24SS+4 wks
27		Breakwater Construction	20 wks	Wed 16/09/2	Tue 02/02/21	26
28		Overnight Berth and Monopile Construction	14 wks	Wed 03/02/21	Tue 11/05/21	27
29		Demobilisation	1 wk	Wed 12/05/2	Tue 18/05/21	28
30		**Iona**	**195 days**	**Wed 03/02/2**	**Tue 02/11/2**	
31		Mobilisation and Site Establishment	2 wks	Wed 03/02/2	Tue 16/02/21	27
32		Breakwater Construction	32 wks	Wed 17/02/2	Tue 28/09/21	31
33		Berthing Pile Installation	3 wks	Wed 29/09/2	Tue 19/10/21	32,27
34		Demobilisation	2 wks	Wed 20/10/2	Tue 02/11/21	33
35		Weather Risk Float	8 wks	Wed 03/11/2	Tue 28/12/21	34
36		Contingency	8 wks	Wed 29/12/2	Tue 22/02/22	35
37		Completion	0 days	Tue 22/02/22	Tue 22/02/22	36



Project: CM1052 Feasibility Pro
Date: Thu 01/08/19

Task	Project Summary	Manual Task	Start-only	Deadline	
Split	Inactive Task	Duration-only	Finish-only	Progress	
Milestone	Inactive Milestone	Manual Summary Rollup	External Tasks	Manual Progress	
Summary	Inactive Summary	Manual Summary	External Milestone		