

# **ARGYLL & BUTE COUNCIL**



## **IONA/FIONNPHORT OVERNIGHT BERTH**

**Project Reference 135114**

### **FEASIBILITY STUDY**

**September 2015**



**Arch Henderson LLP  
142 St. Vincent Street,  
Glasgow G2 5LA**

## Document Control

### Notice

This document has been produced by Arch Henderson LLP for Argyll & Bute Council solely for the purpose of assessing an overnight berth either at Iona or Fionnphort.

It may not be used by any person for any other purpose other than that specified without the express written permission of Arch Henderson LLP. Any liability arising out of use by a third party of this document for purposes not wholly connected with the above shall be the responsibility of that party who shall indemnify Arch Henderson against all claims costs damages and losses arising out of such use.

## Document Information

	Information
Document Id	135114 Iona overnight berth options report
Document Owner	Argyll & Bute Council
Issue Date	
Last Saved Date	23 September 2015
File Name	135114 Iona Overnight Berth Option Report Rev B.docx

## Document History

Version	Issue Date	Changes
1 <sup>st</sup> issue	22/09/2015	Issue to Client

## Document Approvals

Role	Name	Signature	Date
Project Partner	A Kilbride		22/09/2015
Project Review Group	A F Carr		22/09/2015
Project Engineer	L Ferreira		22/09/2015

## Contents

<b>1</b>	<b>EXECUTIVE SUMMARY .....</b>	<b>1</b>
<b>2</b>	<b>INTRODUCTION .....</b>	<b>2</b>
<b>3</b>	<b>DESCRIPTION OF THE SITES .....</b>	<b>3</b>
<b>4</b>	<b>ENVIRONMENTAL CONDITIONS .....</b>	<b>4</b>
4.1	TIDES.....	4
4.2	WAVES .....	4
4.3	TOPOGRAPHY/BATHYMETRY .....	5
4.4	GEOTECHNICAL CONDITIONS .....	5
<b>5</b>	<b>ROCK ARMOUR SIZING .....</b>	<b>6</b>
<b>6</b>	<b>ASSESSMENT OF OPTIONS .....</b>	<b>7</b>
6.1	OPTION 1: COFFERDAM AT IONA .....	7
6.1.1	<i>Description.....</i>	7
6.1.2	<i>Merits and disadvantages.....</i>	7
6.1.3	<i>Cost estimate .....</i>	7
6.2	OPTION 2: SHEET PILED BERTHING WALL AT IONA.....	9
6.2.1	<i>Description.....</i>	9
6.2.2	<i>Merits and disadvantages.....</i>	9
6.2.3	<i>Cost estimate .....</i>	9
6.3	OPTION 3: SUSPENDED DECK AT IONA .....	11
6.3.1	<i>Description.....</i>	11
6.3.2	<i>Merits and disadvantages.....</i>	11
6.3.3	<i>Cost estimate .....</i>	11
6.4	OPTION 4: COFFERDAM AT FIONNPHORT .....	13
6.4.1	<i>Description.....</i>	13
6.4.2	<i>Merits and disadvantages.....</i>	13
6.4.3	<i>Cost estimate .....</i>	13
6.5	OPTION 5: NEW HARBOUR - COFFERDAM AT FIONNPHORT.....	15
6.5.1	<i>Description.....</i>	15
6.5.2	<i>Merits and disadvantages.....</i>	15
6.5.3	<i>Cost estimate .....</i>	15
6.7	OPTION 6: NEW HARBOUR - SHEET PILED BERTHING WALL AT FIONNPHORT .....	17
6.7.1	<i>Description.....</i>	17
6.7.2	<i>Merits and disadvantages.....</i>	17
6.7.3	<i>Cost estimate .....</i>	17
6.8	OPTION 7: NEW HARBOUR - SUSPENDED DECK AT FIONNPHORT .....	19
6.8.1	<i>Description.....</i>	19
6.8.2	<i>Merits and disadvantages.....</i>	19
6.8.3	<i>Cost estimate .....</i>	19
<b>7</b>	<b>POTENTIAL FUTURE EXTENSION OF PROPOSED NEW HARBOUR AT FIONNPHORT .....</b>	<b>21</b>
<b>8</b>	<b>FURTHER WORKS .....</b>	<b>22</b>
<b>9</b>	<b>RECOMMENDATION.....</b>	<b>23</b>
<b>10</b>	<b>APPENDIX I - DRAWINGS.....</b>	<b>24</b>

## 1 Executive summary

Arch Henderson have been instructed by Argyll & Bute Council to undertake a feasibility study for the construction of an overnight berth at either Iona or Fionnphort to replace the deteriorated Bull Hole facility.

Three and four options have been analysed at Iona and Fionnphort respectively, concluding that the most cost-effective solution is a double-wall cofferdam structure constructed in sheet steel piles at either Iona or Fionnphort. The approximate cost of this type of berth would be £2,560,000 at Iona and £2,380,000 at Fionnphort at current prices.

In order to develop the design of the overnight berth further, the following works will need to be undertaken:

- Numerical wave modelling study
- Sediment transport study
- Geotechnical investigation



## 2 Introduction

Arch Henderson has been instructed by Argyll & Bute Council to undertake a feasibility study for the construction of an overnight berth at either Iona or Fionnphort. The purpose of this new facility is to replace the existing Bull Hole overnight berth, as a number of inspections in recent years have proved it to be deteriorated.

Three options have been analysed at Iona and four options have been analysed at Fionnphort. The information considered in the assessment of these options is listed below:

- The vessel considered is the Loch Buie.
- The available topographic and bathymetric information has been used to develop the options at Iona. Due to the lack of topography and bathymetry at Fionnphort a topographic and bathymetric survey was instructed at this location and was undertaken by Aspect Surveys in April 2015.
- JONSWAP linear wave analysis and engineering judgement has been applied to estimate the wave conditions at Iona and Fionnphort.
- No geotechnical information was available; engineering judgement has been applied in assessing the existing ground conditions. The proposed solutions have been analysed considering a thin layer of sand overlaying rock.

A brief description, merits and disadvantages and cost estimate for each option is provided in Section 6.

## 3 Description of the sites

The new overnight berthing facility is proposed to be located in the Sound of Iona, at either the Isle of Iona or the Isle of Mull.

The proposed locations in the Isle of Iona are situated at Baile Mòr; the proposed options show the overnight berth by the existing slipway or in the small cove south of the existing slipway.

The proposed locations in the Isle of Mull are situated at Fionnphort; the proposed options show the overnight berth by the existing pier/slipway or in the cliffs south of the existing pier/slipway.

The Sound of Iona has a tidal range of over 4m and it is exposed to waves coming from South to South-westerly directions (see Section 4 for further information on environmental conditions).

## 4 Environmental conditions

### 4.1 Tides

The tidal levels at Iona and Fionnphort are shown in the following table.

**Table 4-1 Tidal levels**

Level	Referred to CD	Referred to OD
MHWS	+4.0m	+2.2m
MHWN	+3.0m	+1.2m
ML	+2.4m	+0.6m
OD	+1.8m	+0.0m
MLWN	+1.5m	-0.3m
MLWS	+0.5m	-1.3m
CD	+0.0m	-1.8m

### 4.2 Waves

The wave climate in the Sound of Iona has been analysed by means of JONSWAP model, which predicts the wind generated wave growth in fetch-limited areas. According to this model, the wave height is proportional to the wind speed and fetch, which represents the length of water over which the considered wind speed has blown.

The basic hourly wind speed considered for the wave prediction has been obtained from BS 6399, which recommends a wind speed of 26.5 m/s in the Sound of Iona for a return period of 50 years and a direction of 240°. This wind speed has been corrected applying factors to account for altitude, direction, seasonality, return period, duration and acceleration of wind speed over water specific for the conditions in the Sound of Iona.

The fetch for waves coming from the South is much longer than the fetch for waves coming from the North. Consequently, the wave heights obtained for waves arriving to the Sound of Iona from South are larger than the obtained wave heights coming from the North, as it was expected.

Additionally, in order to take into account the channel effect that occurs when waves coming from Southerly directions enter the Sound of Iona (only the energy coming from a range of directions enters the channel), a directional dispersion function has been applied to the wave height obtained by means of JONSWAP.

Taking into account the morphology of the Sound of Iona, fetch and prevailing winds, the following wave characteristics (significant wave height, peak period and mean period) have been obtained for southerly and northerly waves:

**Table 4-2 Waves coming from South**

Return period (years)	H <sub>s</sub> (m)	T <sub>p</sub> (s)	T <sub>m</sub> (s)
1	1.8	9.6	7.9
10	2.4	10.7	8.8
50	2.7	11.3	9.3
100	2.9	11.5	9.4
200	3	11.7	9.6

**Table 4-3 Waves coming from North**

Return period (years)	H <sub>s</sub> (m)	T <sub>p</sub> (s)	T <sub>m</sub> (s)
1	1	3.6	3
10	1.4	4	3.3
50	1.5	4.3	3.5
100	1.6	4.3	3.5
200	1.7	4.4	3.6

Note that the JONSWAP wave analysis undertaken only provides a rough estimation of wave heights. In order to develop the design of the overnight berth in detail a numerical wave modelling study will need to be carried out to obtain reliable wave information.

## 4.3 Topography/bathymetry

Topographic and bathymetric information is available at Iona and, thus, no survey had to be instructed at this site.

However, due to the lack of topography and bathymetry at Fionnphort, a topographic and bathymetric survey had to be instructed at this location, which was undertaken by Aspect Surveys in April 2015.

## 4.4 Geotechnical conditions

No geotechnical information is available at either Iona or Fionnphort; the proposed solutions have been analysed considering a thin layer of sand overlaying rock.

Note that a geotechnical investigation will need to be carried out in order to develop the design of the overnight berth in detail.

## 5 Rock armour sizing

In some of the options, a breakwater is proposed to be constructed in the south side of the structure to protect the berthing line from waves coming from South, since the largest waves will arrive from this direction (see Section 4.2).

To calculate the required armour size, Van der Meer formulae has been applied, in which armour size is a function of the significant wave height, among other parameters.

Since the site is exposed to large waves coming from the South, big stones are required so that the breakwater has no damage during storms.

A design significant wave height of 3m (200 years of return period) has been considered to calculate the required armour size. For this wave height and considering a slope of 1:2.5, a mean armour stone of 7 tonnes is required.

## 6 Assessment of options

### 6.1 Option 1: Cofferdam at Iona

#### 6.1.1 *Description*

Option 1 is a double-wall cofferdam structure. This is located adjacent to the existing slipway and has an overall plan size of 41.00m x 10.50m with the slab surface level being 2.50m above MHWS. The plan layout and typical section of the proposed solution is shown on drawing 135114/SK05 in Appendix I.

The cofferdam is constructed using sheet steel piles with tie rods, rock fill and an RC surface slab and cope. A 2.0m high RC wave return wall is provided to the south elevation.

Access to the berth is provided by means of a structural steel walkway that runs parallel to the existing slipway.

#### 6.1.2 *Merits and disadvantages*

The advantages and disadvantages of the cofferdam option at Iona are listed below:

- This option gives shelter for waves coming from South, but it does not provide shelter for waves coming from North. However, it is noted that the biggest waves at this location come from South.
- This option has a small footprint, which is beneficial in terms of environmental impact; however, visual impact would be high, particularly at low tides, as the faces of the structure are made of steel.
- This option is the most cost-effective.

#### 6.1.3 *Cost estimate*

The cost estimate for this option is £2,560,000.

This cost allows for the design and construction of the overnight berth, including:

- Sheet steel piling including surface treatments and cathodic protection
- RC slab, cope (with opepe upstand) and wave return wall
- Imported rock fill
- Structural steel walkway with supports
- V fenders 6.30m long on the North face
- 30 t bollards at 5.0 m centres
- Ladders and handholds to comply with Dock Regulations

## *Cost estimate (Cont'd)*

- Basic lighting and water supplies extended to the berth
- Contractors general items
- Geotechnical investigation
- Design fees and statutory consents
- Contingency allowance

No allowances for a sediment transport study, dredging and a numerical wave modelling study are included in the cost estimate.

## 6.2 Option 2: Sheet Piled Berthing Wall at Iona

### 6.2.1 *Description*

Option 2 is a rock armour breakwater with an anchored sheet piled wall. This is located south of the existing slipway and has an overall plan size of 52.00m x 4m with the slab surface level being 2.50m above MHWS. The plan layout and typical section is shown on drawing 135115/SK06 in Appendix I. The breakwater is constructed using rock fill with rock armour protection. The berthing structure is constructed of sheet steel piles with rock anchors and an RC surface slab. The breakwater is taken onto the slab and to a level 4.0m above slab level to provide wave protection.

Access to the berth is provided by means of a 75.0m long causeway constructed as a continuation of the breakwater with an RC surface walkway.

### 6.2.2 *Merits and disadvantages*

The advantages and disadvantages of the sheet pile wall and breakwater option at Iona are listed below:

- This option gives shelter for waves coming from South, but it does not provide shelter for waves coming from North. However, note that the biggest waves at this location come from South.
- This option has a bigger footprint than Option 1, but visual impact is smaller as the South face is constructed in rock armour.
- This option is less cost-effective than Option 1.

### 6.2.3 *Cost estimate*

The cost estimate for this option is £6,580,000.

This cost allows for the design and construction of the overnight berth, including:

- Breakwater and causeway; rock fill, geotextiles and two layers of rock armour protection
- Sheet steel piling with rock anchors including surface treatments and cathodic protection
- RC slab and cope (with opepe upstand)
- V fenders 6.30m long on the North face
- 30 t bollards at 5.0 m centres
- Ladders and handholds to comply with Dock Regulations
- Basic lighting and water supplies extended to the berth
- Contractors general items



## *Cost estimate (Cont'd)*

- Geotechnical investigation
- Design fees and statutory consents
- Contingency allowance

No allowances for a sediment transport study, dredging and a numerical wave modelling study are included in the cost estimate.

## 6.3 Option 3: Suspended deck at Iona

### 6.3.1 *Description*

Option 3 is a rock armour breakwater with an open suspended deck on piles. This is located south of the existing slipway and has an overall plan size of 50.00m x 15.50m with the slab surface level being 2.50m above MHWS. The plan layout and typical section is shown on drawing 135115/SK07 in Appendix I. The breakwater is constructed using rock fill with rock armour protection. The berthing structure is constructed of tubular steel piles with a suspended RC surface slab with PC main beams and bridge beams. The open underside of the suspended deck has rock fill with rock armour protection. The breakwater is taken to a level 4.0m above slab level to provide wave protection.

The armour breakwater and suspended deck structure is continued landward for 91.0m to provide access to the berth.

### 6.3.2 *Merits and disadvantages*

The advantages and disadvantages of the suspended deck and breakwater option at Iona are listed below:

- This option gives shelter for waves coming from South, but it does not provide shelter for waves coming from North. However, note that the biggest waves at this location come from South.
- This option has a bigger footprint than Option 1, but visual impact is smaller as the South face is constructed in rock armour.
- This option provides larger deck area than Options 1 and 2.
- The option is less cost-effective than Options 1 and 2.

### 6.3.3 *Cost estimate*

The cost estimate for this option is £7,360,000.

This cost allows for the design and construction of the overnight berth, including:

- Breakwater and open deck protection; rock fill, geotextiles and two layers of rock armour protection
- Tubular steel piling including surface treatments and cathodic protection
- PC main and bridge beams
- RC rear wall, slab and cope (with opepe upstand)

## *Cost estimate (Cont'd)*

- V fenders 6.30m long on the North face
- 30 t bollards at 5.0 m centres
- Ladders and handholds to comply with Dock Regulations
- Basic lighting and water supplies extended to the berth
- Contractors general items
- Geotechnical investigation
- Design fees and statutory consents
- Contingency allowance

No allowances for a sediment transport study, dredging and a numerical wave modelling study are included in the cost estimate.

## 6.4 Option 4: Cofferdam at Fionnphort

### 6.4.1 *Description*

Option 4 is a double-wall cofferdam structure. This is located at the end of the existing pier and has an overall plan size of 41.00m x 10.50m with the slab surface level being 2.50m above MHWS. The plan layout and typical section of the proposed solution is shown on drawing 135114/SK08 in Appendix I.

The cofferdam is constructed using sheet steel piles with ties rods, rock fill and an RC surface slab and cope. A 2.0m high RC wave return wall is provided to the south elevation.

Access to the berth is provided by the existing pier.

### 6.4.2 *Merits and disadvantages*

The advantages and disadvantages of the cofferdam option at Fionnphort are listed below:

- This option gives shelter for waves coming from South, but it does not provide shelter for waves coming from North. However, it is noted that the biggest waves at this location come from South.
- This option has a small footprint, which is beneficial in terms of environmental impact; however, visual impact would be high, particularly at low tide, as the faces of the structure are made of steel.
- The existing pier can be used as access path, so there is no requirement for the walkway included in Option 1.
- This option is the most cost-effective.

### 6.4.3 *Cost estimate*

The cost estimate for this option is £2,380,000.

This cost allows for the design and construction of the overnight berth, including:

- Sheet steel piling including surface treatments and cathodic protection
- RC slab, cope (with opepe upstand) and wave return wall
- Imported rock fill
- V fenders 6.30m long on the North face
- 30 t bollards at 5.0 m centres
- Ladders and handholds to comply with Dock Regulations

## *Cost estimate (Cont'd)*

- Basic lighting and water supplies extended to the berth
- Contractors general items
- Geotechnical investigation
- Design fees and statutory consents
- Contingency allowance

No allowances for a sediment transport study, dredging and a numerical wave modelling study are included in the cost estimate.

## 6.5 Option 5: New Harbour - Cofferdam at Fionnphort

### 6.5.1 *Description*

Option 5 consists of a large L-shaped double-wall cofferdam structure south of the existing slipway at Fionnphort that provides shelter and berthing space for several vessels. It has an overall plan size of 183.00m x 10.50m with the slab surface level being 2.50m above MHWS. The plan layout and typical section of the proposed solution is shown on drawing 135114/SK09 in Appendix I.

The cofferdam is constructed using sheet steel piles with tie rods, rock fill and an RC surface slab and cope. A 2.0m high RC wave return wall is provided to the south and west elevations.

Landfall is remote from the existing installations which will necessitate the formation of roads etc., to provide access.

### 6.5.2 *Merits and disadvantages*

The advantages and disadvantages of this option are listed below:

- In this options vessels are totally sheltered for waves coming from all directions.
- This option proposes the construction of a new harbour providing berthing facilities for several vessels.
- An access road is required to be constructed in order to access the berth.
- The environmental impact of building this option would be much higher than the environmental impact of Options 1 to 4, as it has a much bigger footprint. Additionally, visual impact would be high, particularly at low tide, as the faces of the structure are made of steel.
- This structure could be easily extended in the future if a bigger harbour is required (see Section 7)
- The cost of this option is higher compared to the cost of Options 1 to 4.

### 6.5.3 *Cost estimate*

The cost estimate for this alternative is £8,130,000

This cost allows for the design and construction of the overnight berth, including:

- Sheet steel piling including surface treatments and cathodic protection
- RC slab, cope (with opepe upstand) and wave return wall.
- Imported rock fill

## *Cost estimate (Cont'd)*

- V fenders 6.30m long on the North face
- 30 t bollards at 5.0 m centres
- Ladders and handholds to comply with Dock Regulations
- Basic lighting and water supplies extended to the berth
- Contractors general items
- Geotechnical investigation
- Design fees and statutory consents
- Contingency allowance

No allowances for roads, land based facilities etc., are included in the cost estimate.

No allowances for a sediment transport study, dredging and a numerical wave modelling study are included in the cost estimate.

## **6.7 Option 6: New Harbour - Sheet Piled Berthing Wall at Fionnphort**

### ***6.7.1 Description***

Option 6 consists of a large breakwater south of the existing slipway at Fionnphort that provides shelter and berthing space for several vessels.

The structure is a rock armour breakwater with an anchored sheet piled wall. This is located south of the existing slipway and has an overall plan size of 183.00m x 4.00m with the slab surface level being 2.50m above MHWS. The plan layout and typical section is shown on drawing 135115/SK10 in Appendix I. The breakwater is constructed using rock fill with rock armour protection. The berthing structure is constructed of sheet steel piles with rock anchors and an RC surface slab. The breakwater is taken onto the slab and to a level 4.0m above slab level to provide wave protection.

Access to the structure is by way of a short causeway. Landfall is remote from the existing installations which will necessitate the formation of roads etc., to provide access.

### ***6.7.2 Merits and disadvantages***

The advantages and disadvantages of the sheet pile wall and breakwater option at Fionnphort are listed below:

- In this option vessels are totally sheltered for waves coming from all directions.
- This option proposes the construction of a new harbour providing berthing facilities for several vessels.
- An access road is required to be constructed in order to access the berth.
- The environmental impact of building this option would be much higher than the environmental impact of Options 1 to 4, as it has a much bigger footprint.
- This structure could be easily extended in the future if a bigger harbour is required (see Section 7).
- The cost of this option is higher compared to the cost of Options 1 to 5.

### ***6.7.3 Cost estimate***

The cost estimate for this alternative is £14,840,000.

This cost allows for the design and construction of the berthing facility, including:

- Breakwater and causeway; rock fill, geotextiles and two layers of rock armour protection
- Sheet steel piling with rock anchors including surface treatments and cathodic protection



## *Cost estimate (Cont'd)*

- RC slab and cope (with opepe upstand)
- V fenders 6.30m long on the North face
- 30 t bollards at 5.0 m centres
- Ladders and handholds to comply with Dock Regulations
- Basic lighting and water supplies extended to the berth
- Contractors general items
- Geotechnical investigation
- Design fees and statutory consents
- Contingency allowance

No allowances for roads, land based facilities etc., are included in the cost estimate.

No allowances for a sediment transport study, dredging and a numerical wave modelling study are included in the cost estimate.

## 6.8 Option 7: New Harbour - Suspended Deck at Fionnphort

### 6.8.1 *Description*

Option 7 consists of a large breakwater south of the existing slipway at Fionnphort that provides shelter and berthing space for several vessels.

The structure is a rock armour breakwater with a suspended RC deck on tubular piles. This is located south of the existing slipway and has an overall plan size of 183.00m x 15.50m with the slab surface level being 2.50m above MHWS. The plan layout and typical section is shown on drawing 135115/SK11 in Appendix I. The breakwater is constructed using rock fill with rock armour protection. The berthing structure is constructed of tubular steel piles with a suspended RC surface slab with PC main beams and bridge beams. The open underside of the suspended deck has rock fill with rock armour protection. The breakwater is taken to a level 4.0m above slab level to provide wave protection.

Access to the structure is by way of a short causeway. Landfall is remote from the existing installations which will necessitate the formation of roads etc., to provide access.

### 6.8.2 *Merits and disadvantages*

The advantages and disadvantages of the suspended deck and breakwater option at Fionnphort are listed below:

- In this options vessels are totally sheltered for waves coming from all directions.
- This option proposes the construction of a new harbour providing berthing facilities for several vessels.
- This option provides larger deck area.
- An access road is required to be constructed in order to access the berth.
- The environmental impact of building this option would be much higher than the environmental impact of Options 1 to 4, as it has a much bigger footprint.
- This structure could be easily extended in the future if a bigger harbour is required (see Section 7).
- The cost of this option is high compared to the cost of Options 1 to 5.

### 6.8.3 *Cost estimate*

The cost estimate this alternative is £17,170,000.

This cost allows for the design and construction of the overnight berth, including:

- Breakwater and open deck protection; rock fill, geotextiles and two layers of rock armour protection

## *Cost estimate (Cont'd)*

- Tubular steel piling including surface treatments and cathodic protection
- PC main and bridge beams
- RC rear wall, slab and cope (with opepe upstand)
- V fenders 6.30m long on the North face
- 30 t bollards at 5.0 m centres
- Ladders and handholds to comply with Dock Regulations
- Basic lighting and water supplies extended to the berth
- Contractors general items
- Geotechnical investigation
- Design fees and statutory consents
- Contingency allowance

No allowances for roads, land based facilities etc., are included in the cost estimate.

No allowances for a sediment transport study, dredging and a numerical wave modelling study are included in the cost estimate.

## 7 Potential future extension of proposed new harbour at Fionnphort

As mentioned before, Options 5, 6 and 7 in Fionnphort have a potential to be extended if there is a requirement to provide berthing facilities for a higher number of vessels in the future.

The extensions of Options 5, 6 and 7 are shown on drawings 135114/SK12 (Option 8), 135114/SK13 (Option 9) and 135114/SK14 (Option 10) respectively, where the berthing line parallel to shore has been extended by 93m.

The costs of Options 8, 9 and 10 is indicated in the table below.

Cost of Option 8– extension of Option 5	£11,990,000
Cost of Option 9 – extension of Option 6	£20,995,000
Cost of Option 10 – extension of Option 7	£24,260,000

## 8 Further works

The design of the overnight berth is very dependent on the wave climate and it needs to be pointed out that the JONSWAP wave analysis undertaken at this time only provides a rough estimation of wave heights. In order to develop any of these options further a numerical wave modelling study will need to be carried out, as all the complex hydrodynamic processes to which waves are subjected when they approach the shore need to be considered to obtain reliable wave height information. The output obtained from the wave numerical modelling would be used to:

- Establish the wave height for the design of the structure
- Characterize the wave climate at the berthing line to assess the suitability of the proposed solutions in terms of weather downtime

Additionally, a sediment transport study will be required in order to analyse sedimentation issues and to assess the requirement of periodical maintenance dredging.

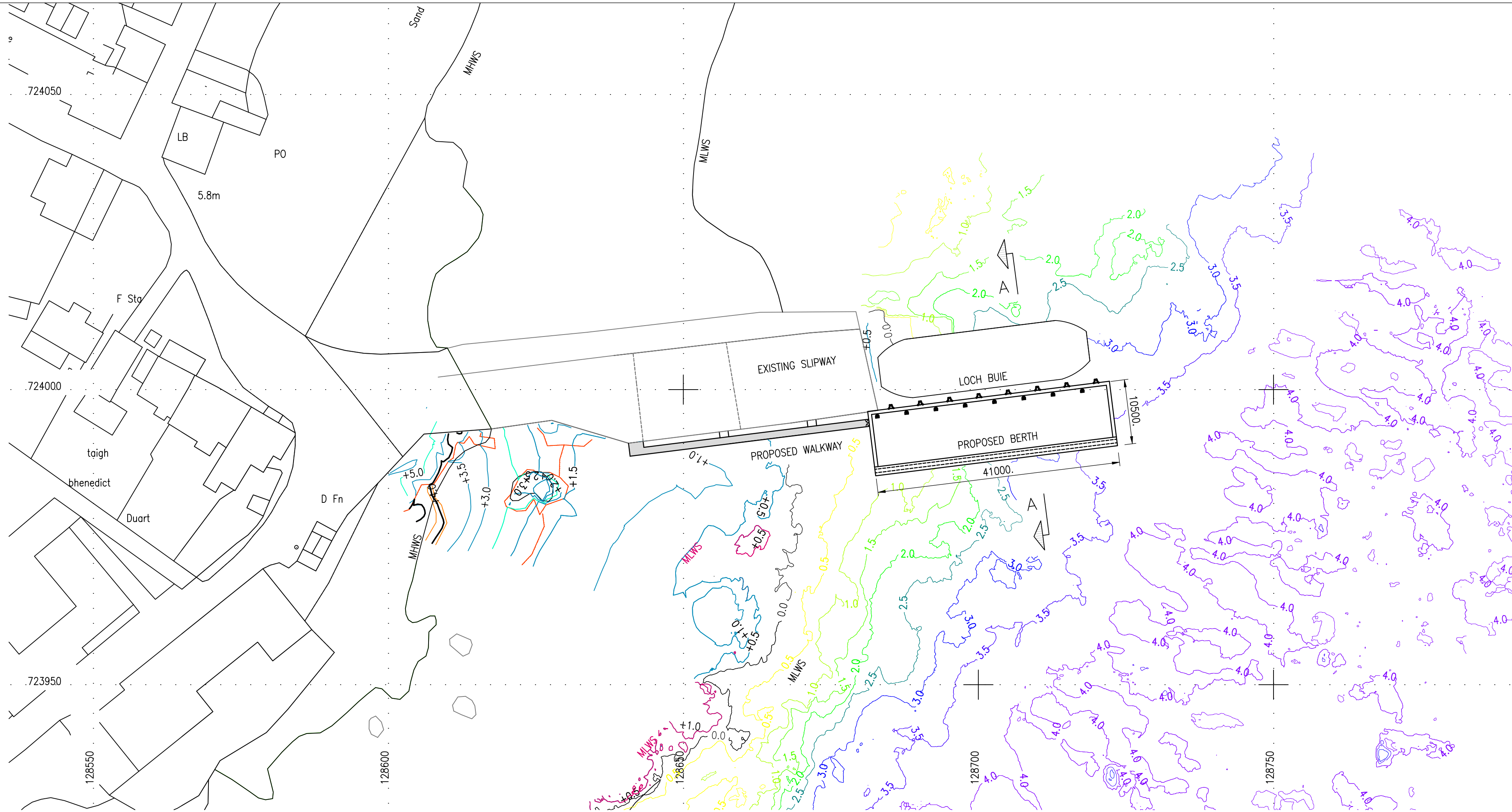
Moreover, due to the lack of geotechnical information and to the sensitivity of the design to soil properties, a geotechnical investigation will be required to develop any of these options further.

## 9 Recommendation

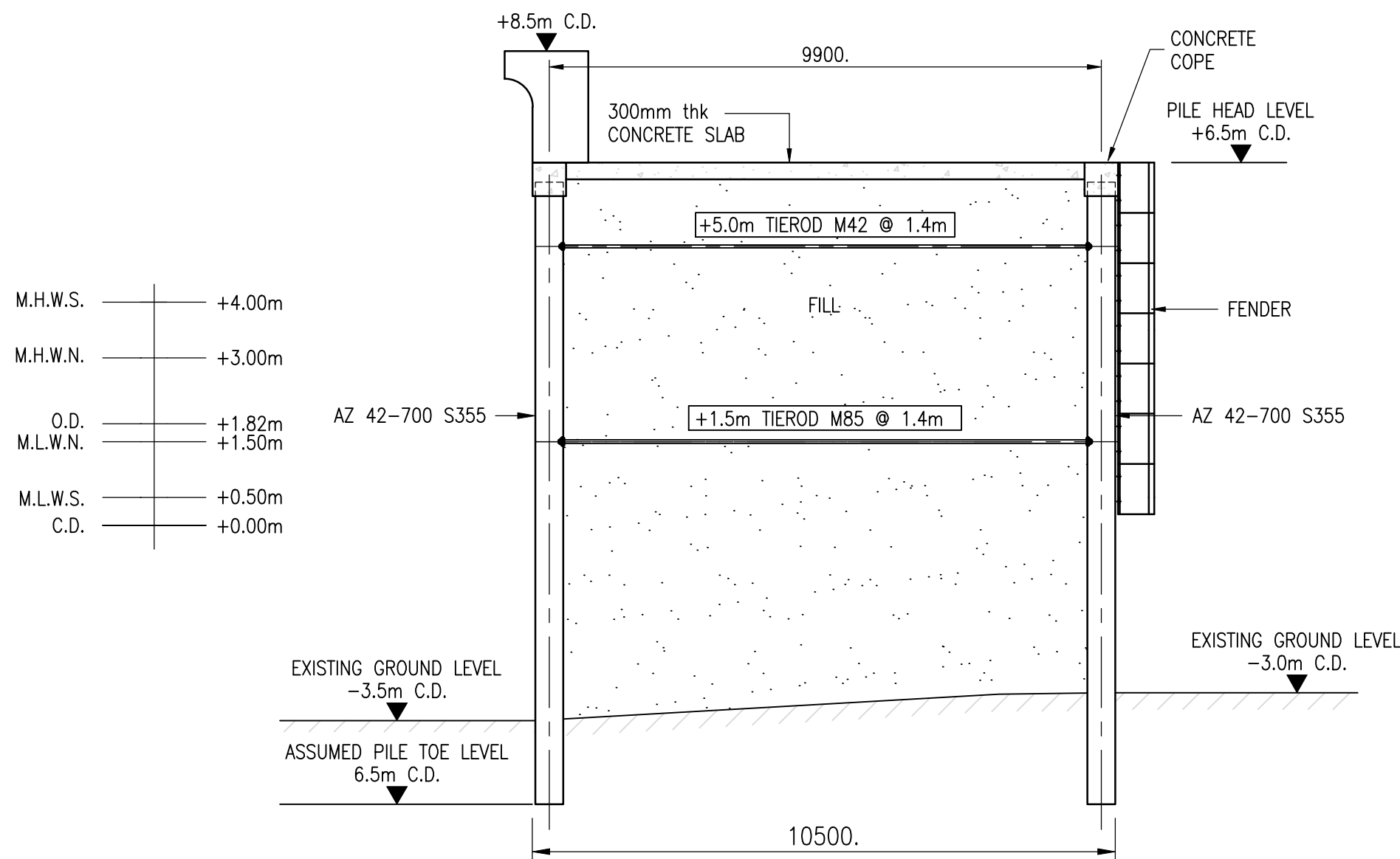
The most cost-effective solution is the cofferdam option, either at Iona or Fionnphort (Option 1 or Option 4) and, thus, it is recommended to adopt this solution for the new overnight berth.

## 10 Appendix I - Drawings

<u>Reference</u>	<u>Description</u>
135114/SK05	Option 1 - Cofferdam - Iona
135114/SK06	Option 2 – Sheet Piled Berthing Wall - Iona
135114/SK07	Option 3 – Suspended Deck - Iona
135114/SK08	Option 4 – Cofferdam – Fionnphort
135114/SK09	Option 5 – New harbour - Cofferdam – Fionnphort
135114/SK10	Option 6 – New harbour - Sheet Piled Berthing Wall - Fionnphort
135114/SK11	Option 7 – New harbour - Suspended Deck - Fionnphort
135114/SK12	Option 8 – Extension of Option 5 - Fionnphort
135114/SK13	Option 9 – Extension of Option 6 - Fionnphort
135114/SK14	Option 10 – Extension of Option 7 - Fionnphort



LOCATION PLAN  
SCALE 1:500



SECTION A-A  
(SCALE 1:100)

NOTES:

1. SECTIONS AND LEVELS INDICATED IN THE DRAWING ARE FOR COSTING PURPOSES ONLY.
2. ALL DIMENSIONS ARE IN mm U.N.O.
3. ALL LEVELS ARE RELEVANT TO C.D. U.N.O.

REV	DATE	REVISION DESCRIPTION	DRN	VER
-----	------	----------------------	-----	-----

THIS DRAWING IS COPYRIGHT © DO NOT SCALE FROM THIS DRAWING

**Arch  
Henderson**

142 St. Vincent Street, Glasgow G2 5LA  
Tel : 0141 227 3060 - Fax : 0141 248 9542  
www.arch-henderson.co.uk - email : glasgow@arch-henderson.co.uk

Offices in : Aberdeen, Dundee, Glasgow, Lerwick, Stromness and Thurso

Civil Engineers  
Structural Engineers  
Architects  
CDM Co-ordinators  
Geotechnical services  
Environmental services

PROJECT :  
ARGYLL & BUTE COUNCIL  
IONA OVERNIGHT BERTH

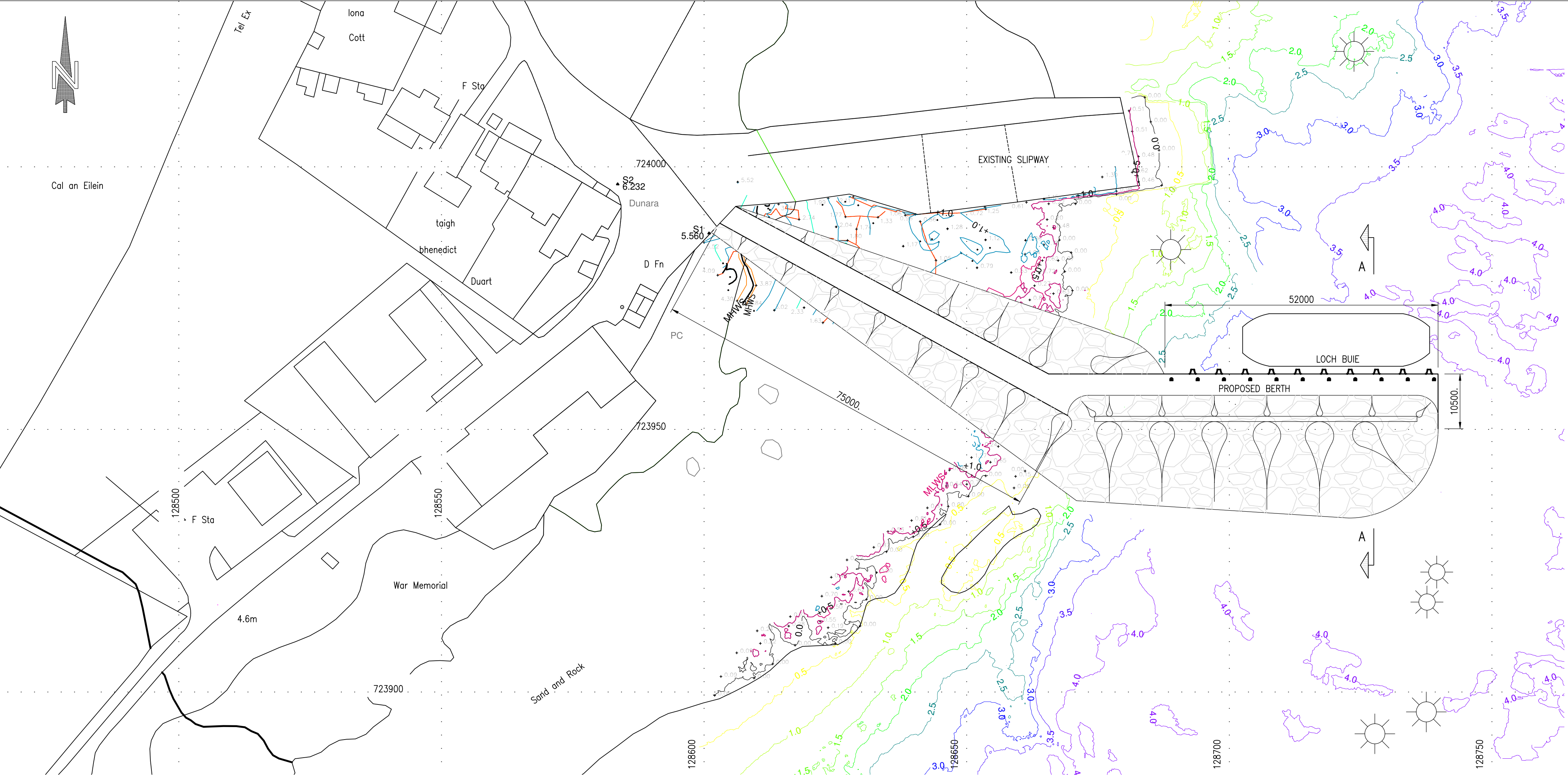
TITLE :  
OPTION 1  
COFFERDAM - IONA

DRAWN : G.A.M.	DATE : 07.08.15	VERIFIED : L.F.	APPROVED : A.A.K.
-------------------	--------------------	--------------------	----------------------

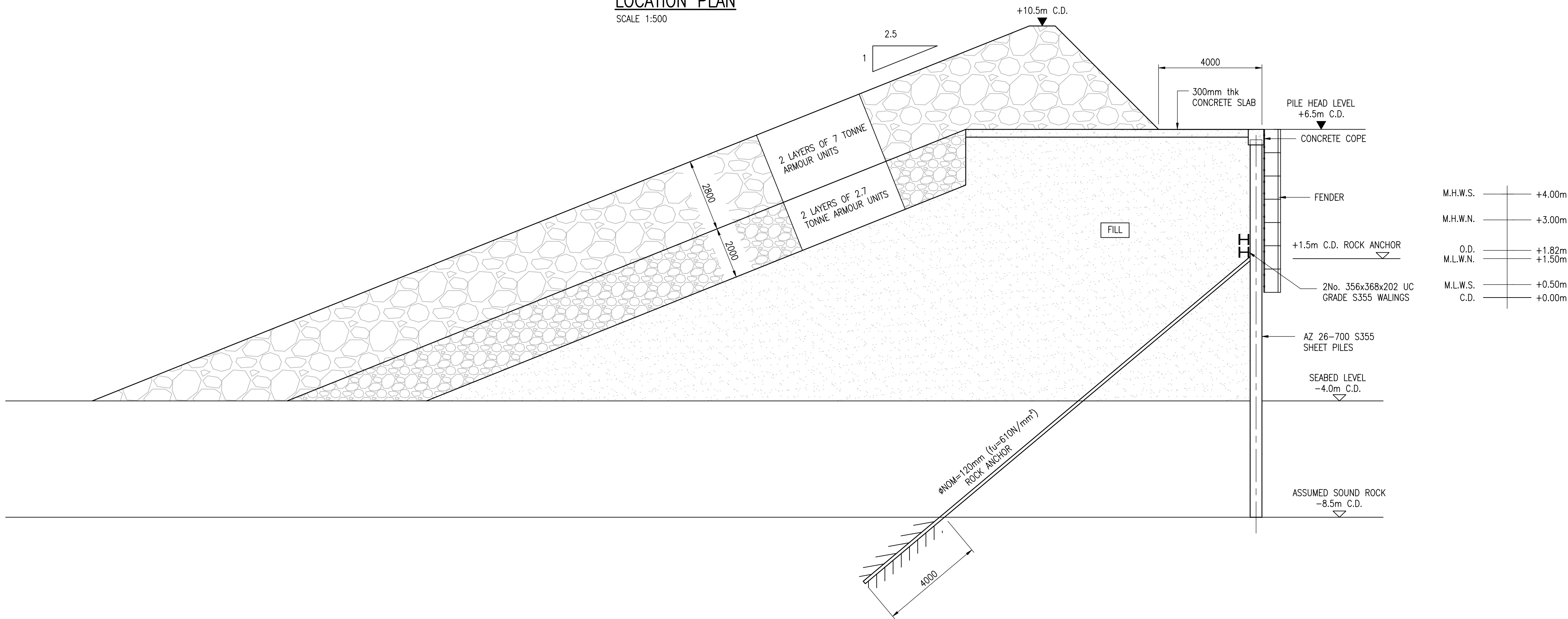
SCALE : (A1) AS SHOWN	DRAWING STATUS : PRELIMINARY
--------------------------	---------------------------------

DRAWING No : 135114/SK05	REV : /
-----------------------------	------------






LOCATION PLAN  
SCALE 1:500



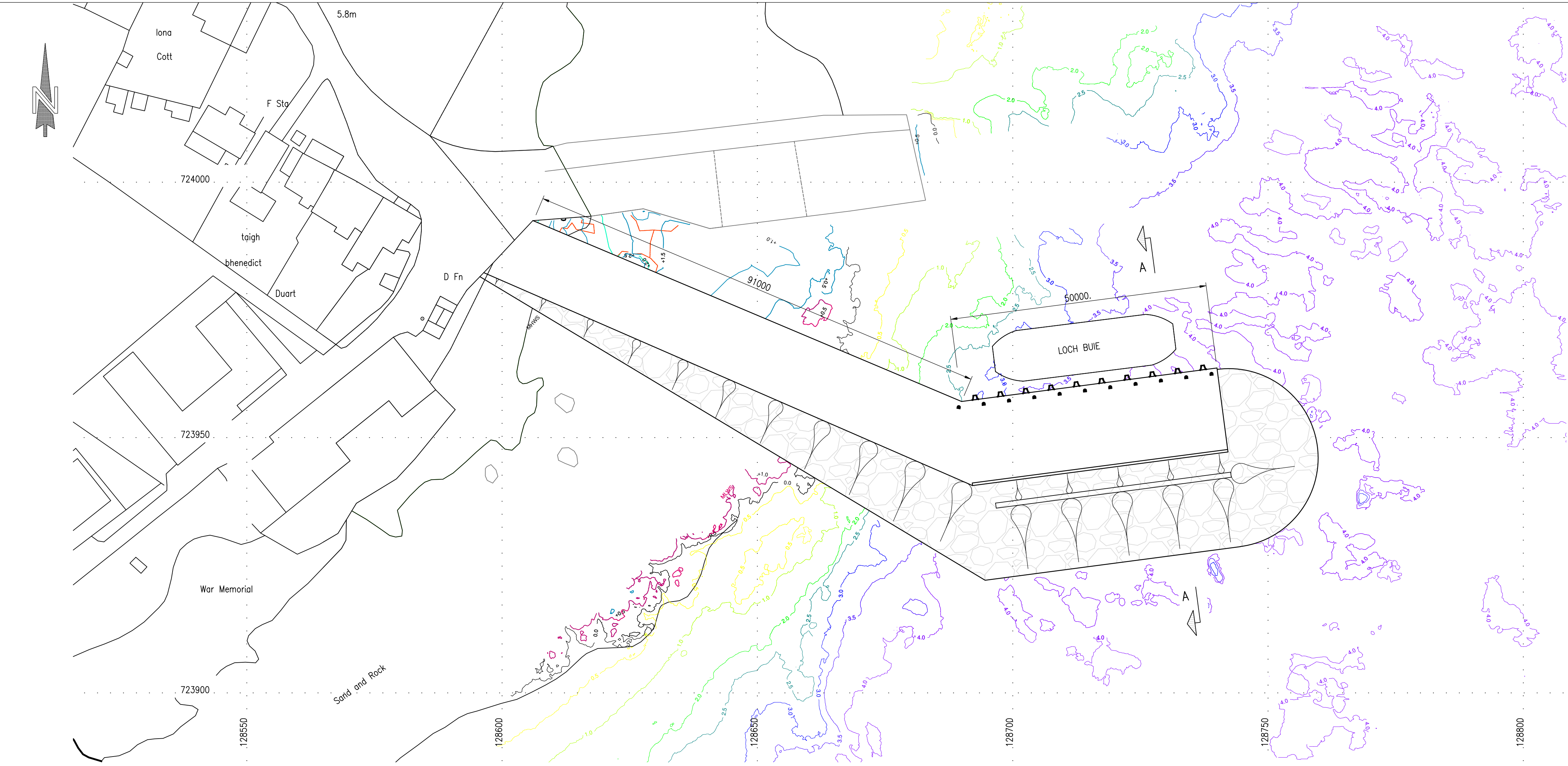
SECTION A-A  
(SCALE 1:100)

NOTES:

1. SECTIONS AND LEVELS INDICATED IN THE DRAWING ARE FOR COSTING PURPOSES ONLY.
2. ALL DIMENSIONS ARE IN mm U.N.O.
3. ALL LEVELS ARE RELEVANT TO C.D. U.N.O.

REV	DATE	REVISION DESCRIPTION	DRN	VER
THIS DRAWING IS COPYRIGHT . DO NOT SCALE FROM THIS DRAWING.				
<div><div><div>Arch Henderson</div><div></div></div><div><div>Civil Engineers</div><div>Structural Engineers</div><div>Architects</div><div>CDM Co-ordinators</div><div>Geotechnical services</div><div>Environmental services</div></div></div>				
142 St. Vincent Street, Glasgow G2 5LA. Tel: 0141 227 3060 - Fax: 0141 248 9542 www.arch-henderson.co.uk - email: glasgow@arch-henderson.co.uk				
Offices in : Aberdeen, Dundee, Glasgow, Lerwick, Stromness and Thurso				
PROJECT : ARGYLL & BUTE COUNCIL IONA OVERNIGHT BERTH				
TITLE : OPTION 2 SHEET PILED BERTHING WALL - IONA				
DRAWN : G.A.M.		DATE : 06.08.15	VERIFIED : L.F.	APPROVED : A.A.K.
SCALE : (A1) AS SHOWN		DRAWING STATUS : PRELIMINARY		
DRAWING No : 135114/SK06			REV : /	

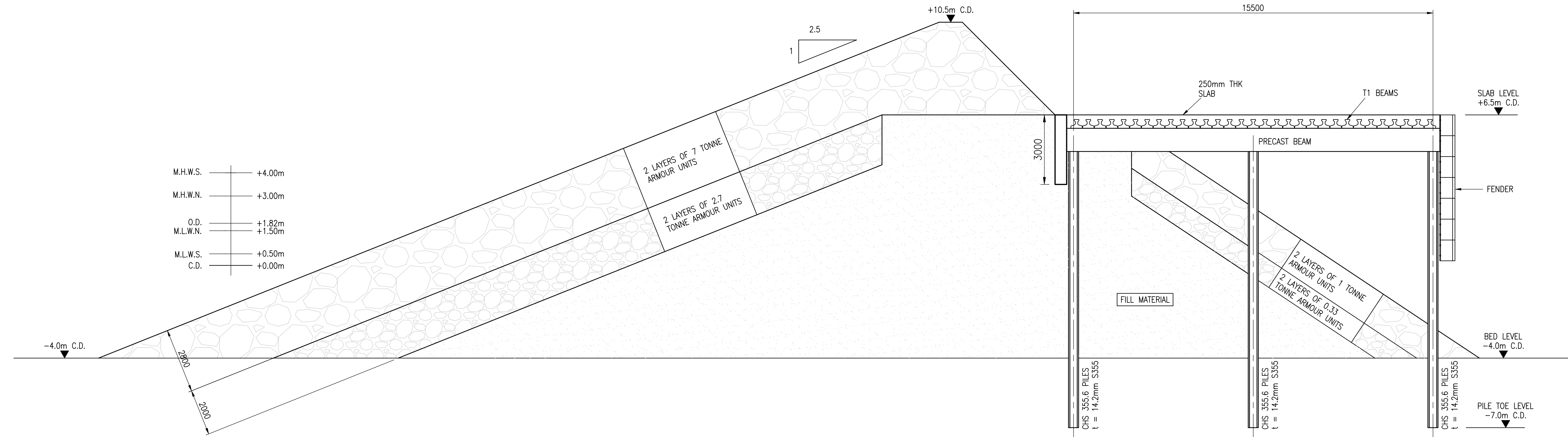




LOCATION PLAN  
SCALE 1:500

NOTES:

1. SECTIONS AND LEVELS INDICATED IN THE DRAWING ARE FOR COSTING PURPOSES ONLY.
2. ALL DIMENSIONS ARE IN mm U.N.O.
3. ALL LEVELS ARE RELEVANT TO C.D. U.N.O.



SECTION A-A  
(SCALE 1:100)

REV	DATE	REVISION DESCRIPTION	DRN	VER
-----	------	----------------------	-----	-----

THIS DRAWING IS COPYRIGHT. DO NOT SCALE FROM THIS DRAWING.

**Arch Henderson**  
1919

142 St. Vincent Street, Glasgow G2 5LA  
Tel : 0141 227 3060 - Fax : 0141 248 9542  
www.arch-henderson.co.uk - email : glasgow@arch-henderson.co.uk

Offices in : Aberdeen, Dundee, Glasgow, Lerwick, Stromness and Thurso

Civil Engineers  
Structural Engineers  
Architects  
CDM Co-ordinators  
Geotechnical services  
Environmental services

PROJECT :  
ARGYLL & BUTE COUNCIL  
IONA OVERNIGHT BERTH

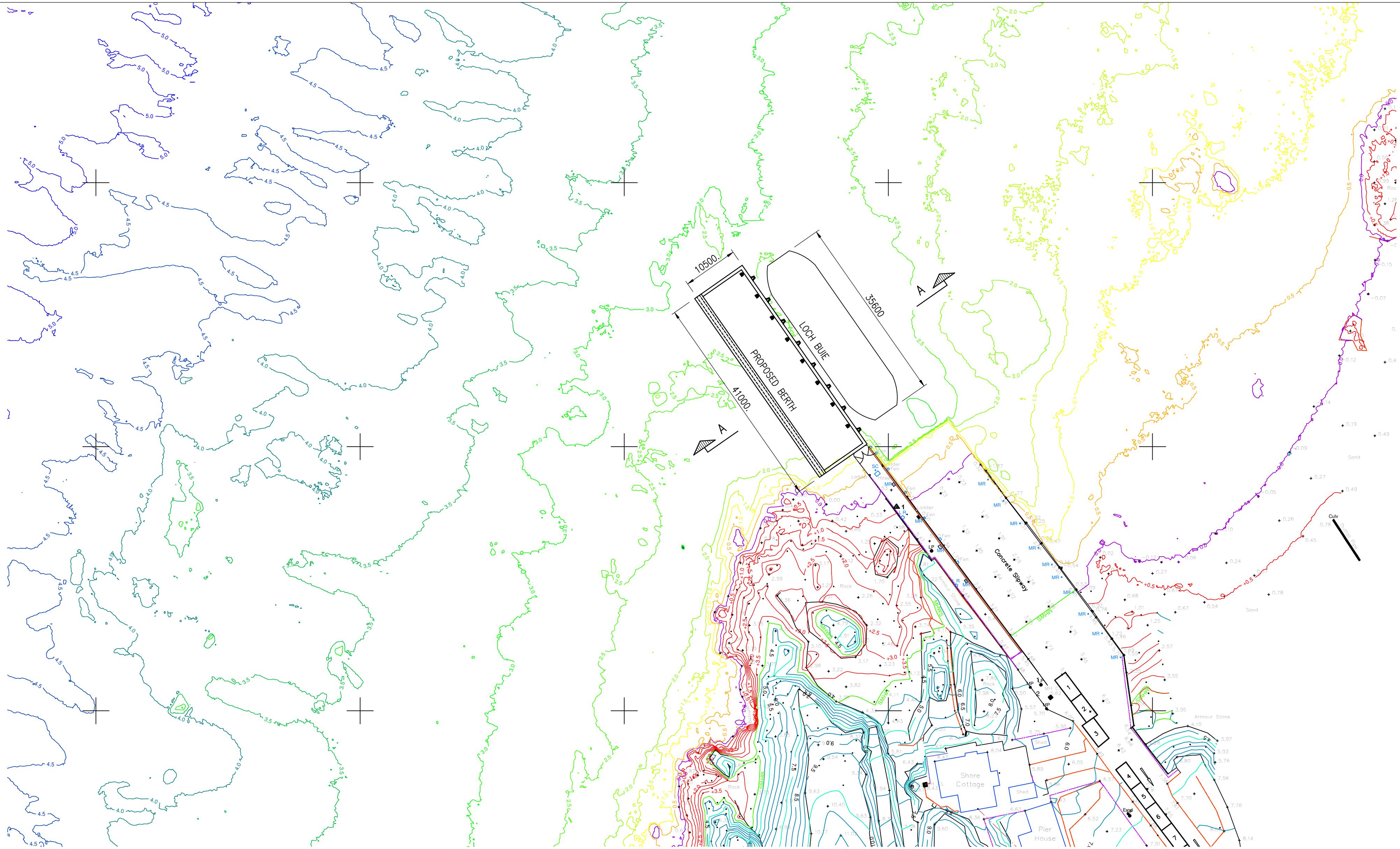
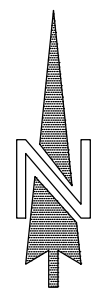
TITLE :  
OPTION 3  
SUSPENDED DECK - IONA

DRAWN : G.A.M.	DATE : 06.08.15	VERIFIED : L.F.	APPROVED : A.A.K.
-------------------	--------------------	--------------------	----------------------

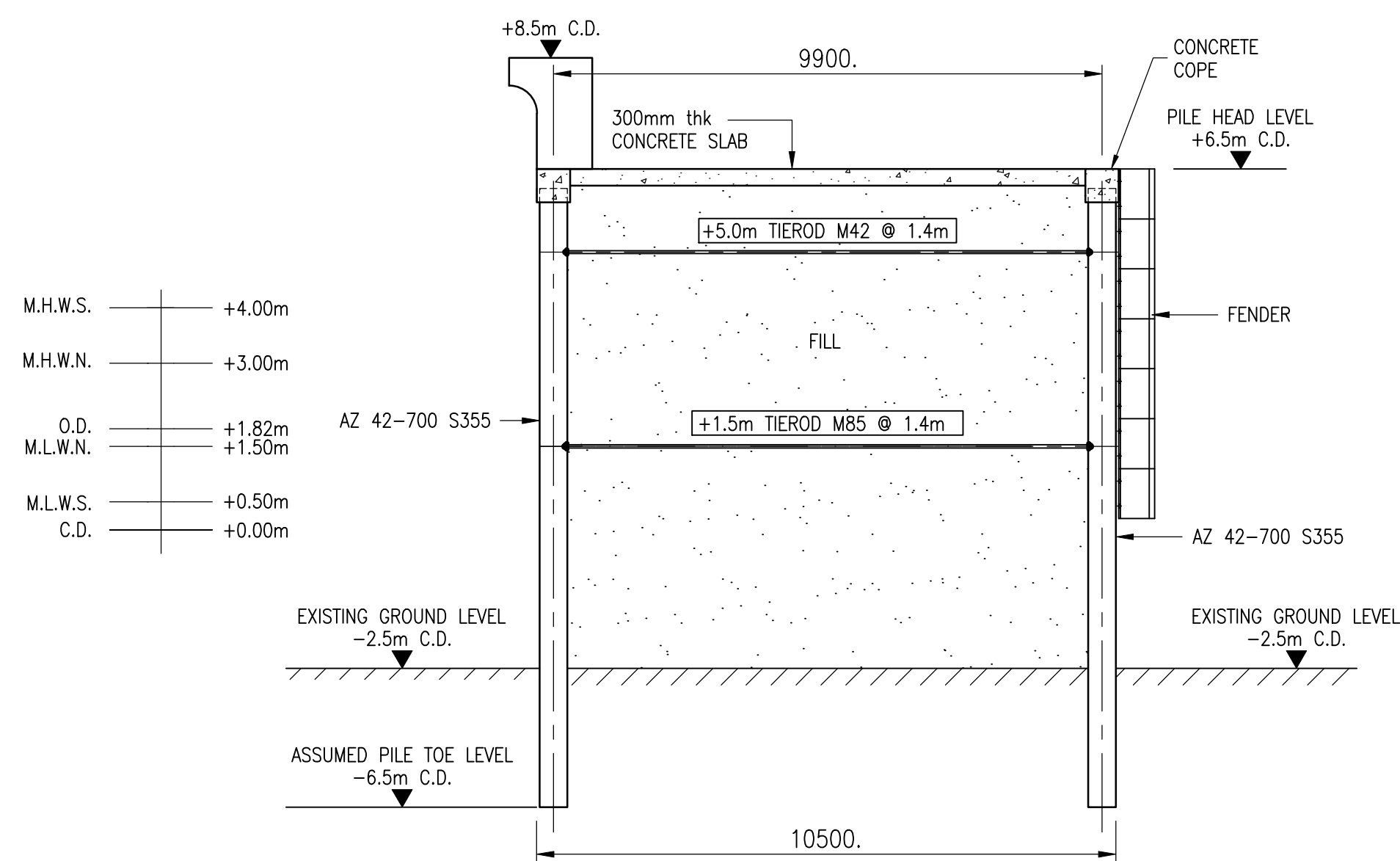
SCALE : (A1) AS SHOWN	DRAWING STATUS : PRELIMINARY
--------------------------	---------------------------------

DRAWING No : 135114/SK07	REV : /
-----------------------------	------------





LOCATION PLAN  
SCALE 1:500



SECTION A-A  
(SCALE 1:100)

NOTES:

1. SECTIONS AND LEVELS INDICATED IN THE DRAWING ARE FOR COSTING PURPOSES ONLY.
2. ALL DIMENSIONS ARE IN mm U.N.O.
3. ALL LEVELS ARE RELEVANT TO C.D. U.N.O.

REV	DATE	REVISION DESCRIPTION	DRN	VER
-----	------	----------------------	-----	-----

THIS DRAWING IS COPYRIGHT © DO NOT SCALE FROM THIS DRAWING.

**Arch  
Henderson**  
1919

142 St. Vincent Street, Glasgow G2 8LA  
Tel : 0141 227 3060 - Fax : 0141 249 9542  
www.arch-henderson.co.uk - email : glasgow@arch-henderson.co.uk

Offices in : Aberdeen, Dundee, Glasgow, Lerwick, Stromness and Thurso

Civil Engineers  
Structural Engineers  
Architects  
CDM Co-ordinators  
Geotechnical services  
Environmental services

PROJECT :  
ARGYLL & BUTE COUNCIL  
FIONNPHORT BERTH

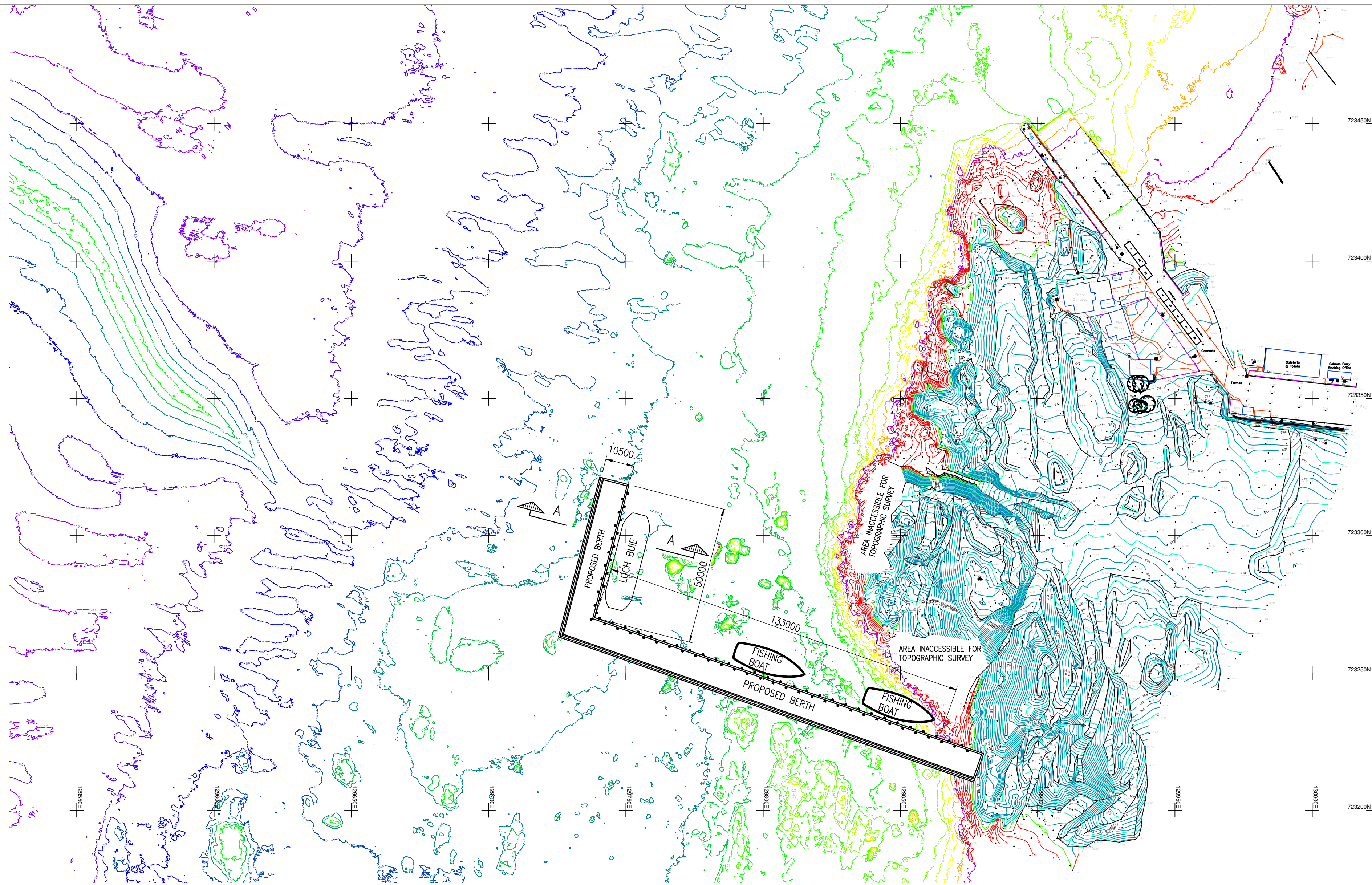
TITLE :  
OPTION 4  
COFFERDAM - FIONNPHORT

DRAWN : G.A.M.	DATE : 06.08.15	VERIFIED : L.F.	APPROVED : A.A.K.
-------------------	--------------------	--------------------	----------------------

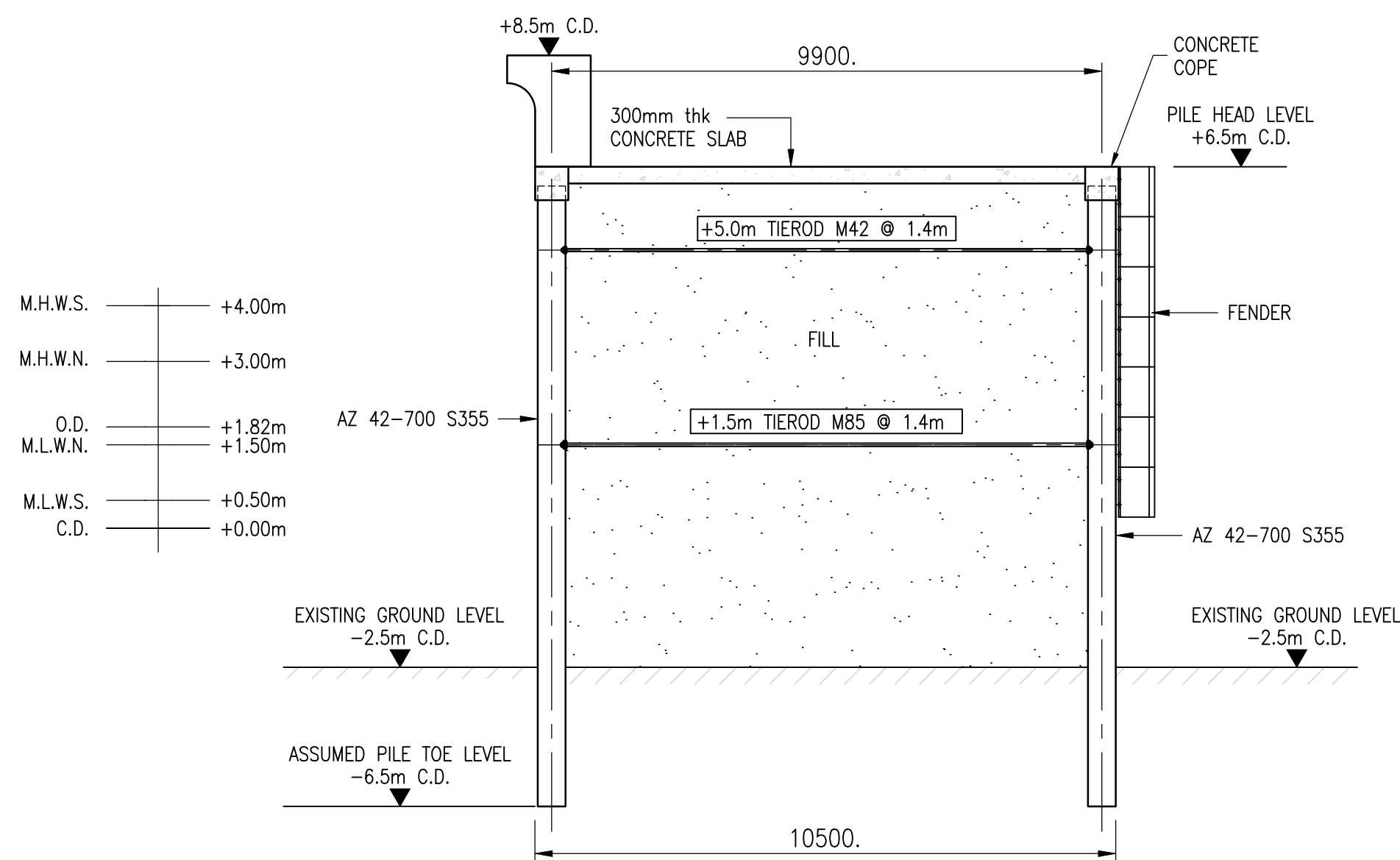
SCALE : (A1) AS SHOWN	DRAWING STATUS : PRELIMINARY
--------------------------	---------------------------------

DRAWING No : 135114/SK08	REV : /
-----------------------------	------------





LOCATION PLAN  
SCALE 1:1000



SECTION A-A  
(SCALE 1:100)

NOTES:

1. SECTIONS AND LEVELS INDICATED IN THE DRAWING ARE FOR COSTING PURPOSES ONLY.
2. ALL DIMENSIONS ARE IN mm U.N.O.
3. ALL LEVELS ARE RELEVANT TO C.D. U.N.O.

REV	DATE	REVISION DESCRIPTION	DRN	VER
-----	------	----------------------	-----	-----

THIS DRAWING IS COPYRIGHT © DO NOT SCALE FROM THIS DRAWING.

**Arch  
Henderson**

142 St. Vincent Street, Glasgow G2 5LA  
Tel : 0141 227 3060 - Fax : 0141 248 9542  
www.arch-henderson.co.uk - email : glasgow@arch-henderson.co.uk

Offices in : Aberdeen, Dundee, Glasgow, Lerwick, Stromness and Thurso

Civil Engineers  
Structural Engineers  
Architects  
CDM Co-ordinators  
Geotechnical services  
Environmental services

PROJECT :  
ARGYLL & BUTE COUNCIL  
FIONNPHORT BERTH

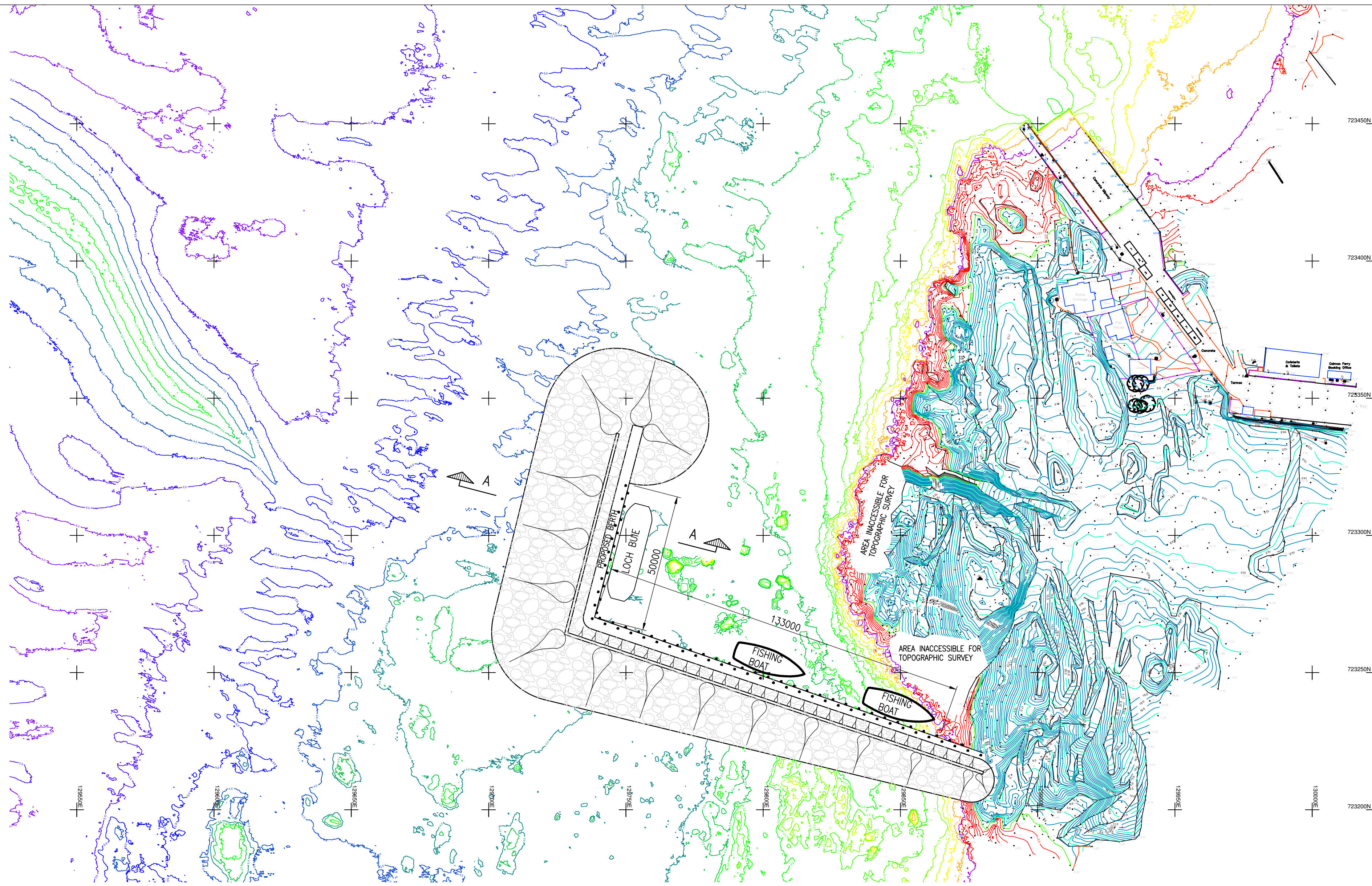
TITLE :  
OPTION 5 - NEW HARBOUR  
COFFERDAM - FIONNPHORT

DRAWN : G.A.M.	DATE : 07.09.15	VERIFIED : L.F.	APPROVED : A.A.K.
-------------------	--------------------	--------------------	----------------------

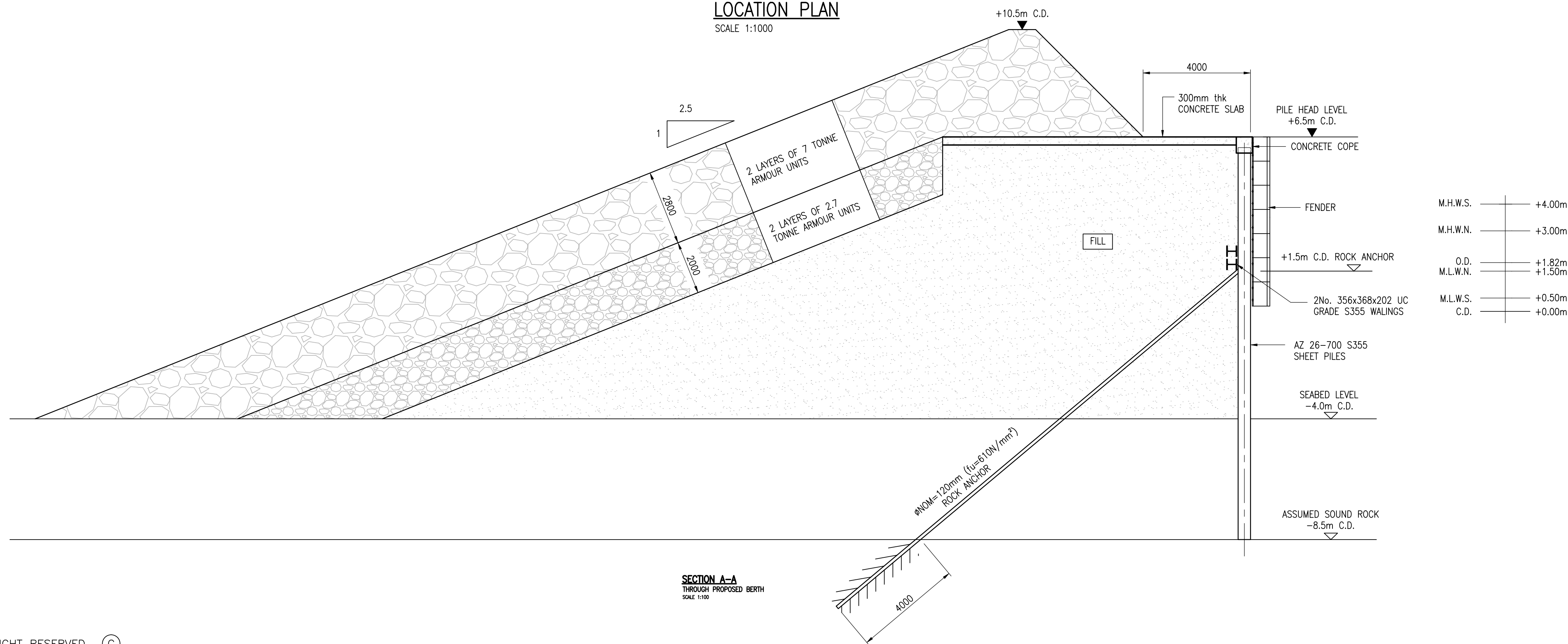
SCALE : (A1) AS SHOWN	DRAWING STATUS : PRELIMINARY
--------------------------	---------------------------------

DRAWING No : 135114/SK09	REV : /
-----------------------------	------------





LOCATION PLAN  
SCALE 1:1000



SECTION A-A  
THROUGH PROPOSED BERTH  
SCALE 1:100

NOTES:

1. SECTIONS AND LEVELS INDICATED IN THE DRAWING ARE FOR COSTING PURPOSES ONLY.
2. ALL DIMENSIONS ARE IN mm U.N.O.
3. ALL LEVELS ARE RELEVANT TO C.D. U.N.O.

REV	DATE	REVISION DESCRIPTION	DRN	VER
-----	------	----------------------	-----	-----

THIS DRAWING IS COPYRIGHT © DO NOT SCALE FROM THIS DRAWING

**Arch  
Henderson**  
1919

142 St. Vincent Street, Glasgow G2 5LA  
Tel : 0141 227 3060 - Fax : 0141 248 9542  
www.arch-henderson.co.uk - email : glasgow@arch-henderson.co.uk

Offices in : Aberdeen, Dundee, Glasgow, Lerwick, Stromness and Thurso

Civil Engineers  
Structural Engineers  
Architects  
CDM Co-ordinators  
Geotechnical services  
Environmental services

PROJECT :  
**ARGYLL & BUTE COUNCIL  
FIONNPHORT BERTH**

TITLE :  
**OPTION 6 - NEW HARBOUR  
SHEET PILED BERTHING WALL - FIONNPHORT**

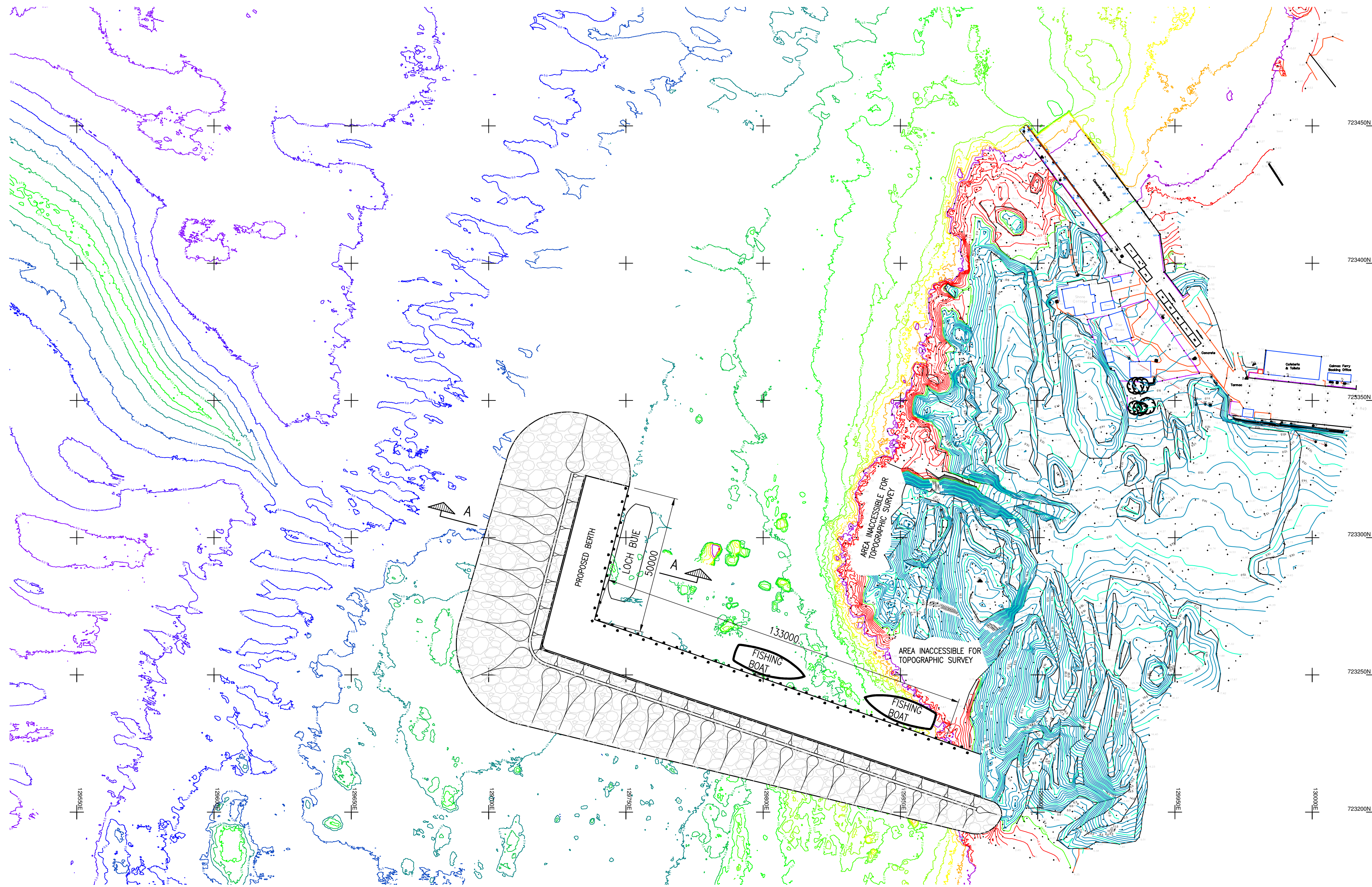
DRAWN : G.A.M.	DATE : 07.08.15	VERIFIED : L.F.	APPROVED : A.A.K.
-------------------	--------------------	--------------------	----------------------

SCALE : (A1) AS SHOWN	DRAWING STATUS : PRELIMINARY
--------------------------	---------------------------------

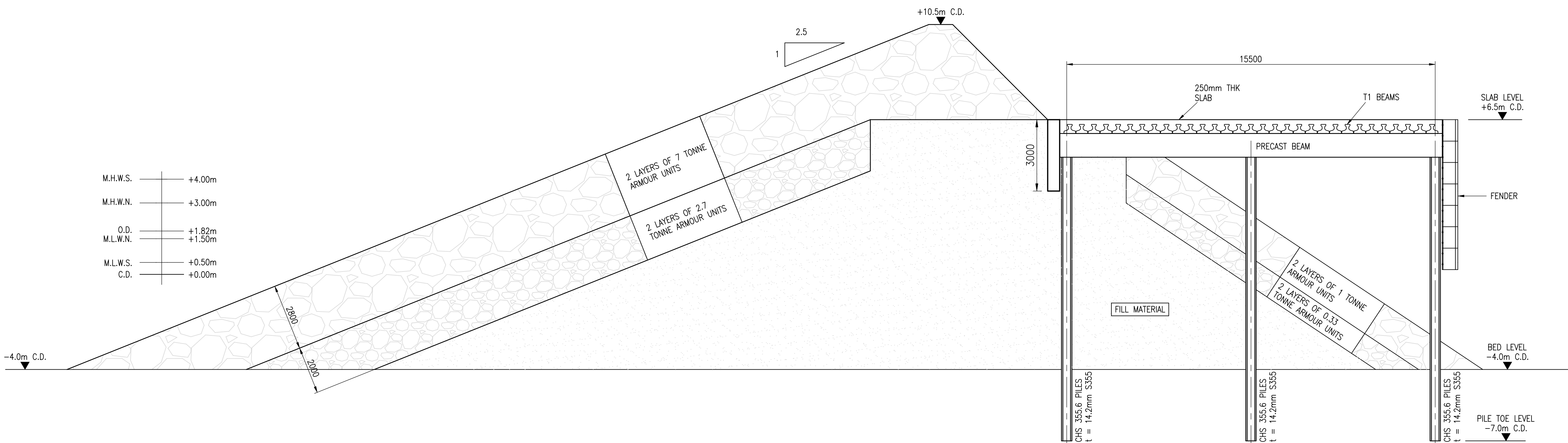
DRAWING No : 135114/SK10	REV : /
-----------------------------	------------

DO NOT SCALE





LOCATION PLAN  
SCALE 1:1000



SECTION A-A  
(SCALE 1:100)

NOTES:

1. SECTIONS AND LEVELS INDICATED IN THE DRAWING ARE FOR COSTING PURPOSES ONLY.
2. ALL DIMENSIONS ARE IN mm U.N.O.
3. ALL LEVELS ARE RELEVANT TO C.D. U.N.O.

REV	DATE	REVISION DESCRIPTION	DRN	VER
THIS DRAWING IS COPYRIGHT - DO NOT SCALE FROM THIS DRAWING				

**Arch Henderson**  
1919

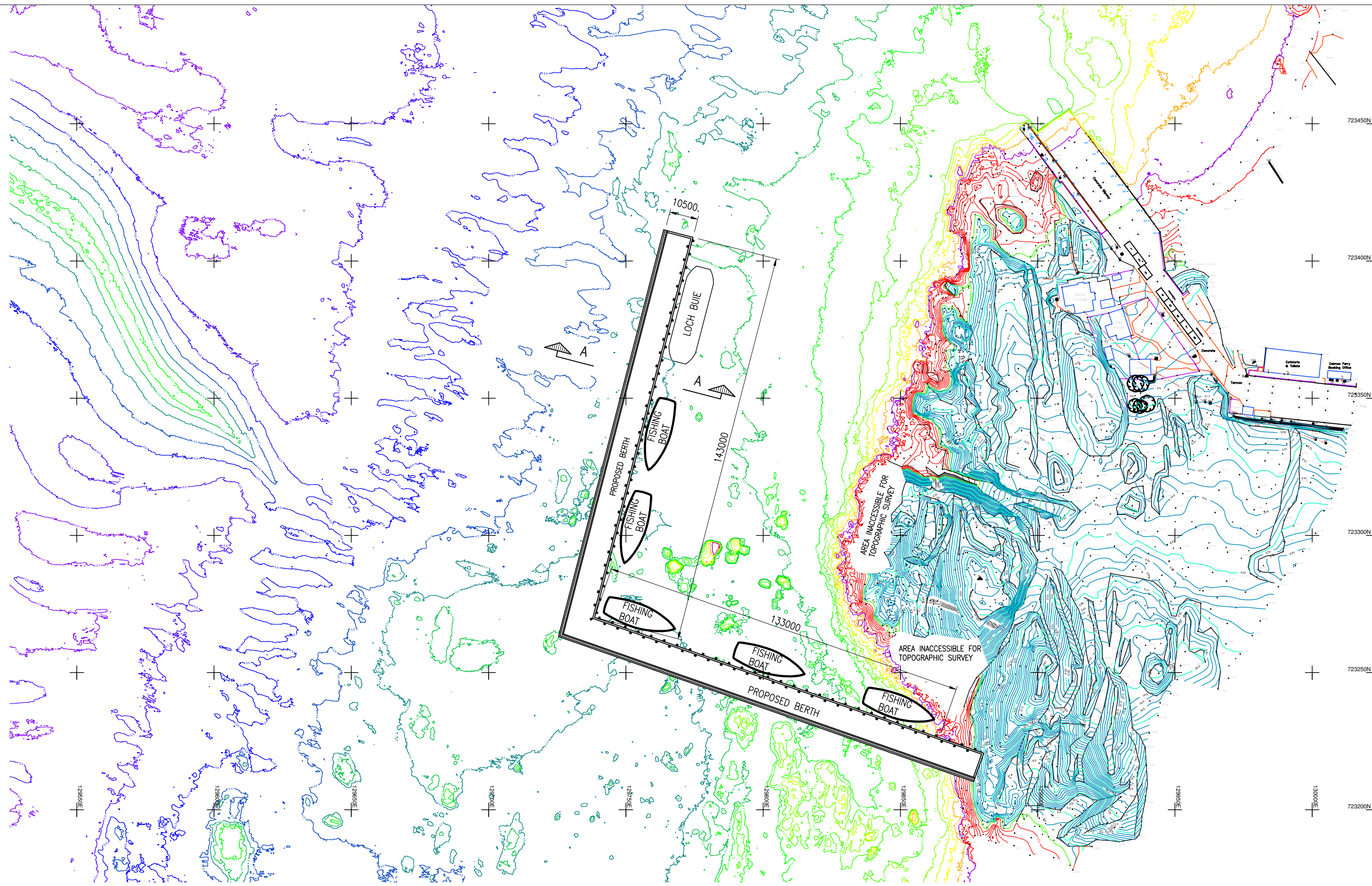
142 St. Vincent Street, Glasgow G2 5LA  
Tel : 0141 227 3060 - Fax : 0141 248 9542  
www.arch-henderson.co.uk - email : glasgow@arch-henderson.co.uk

Offices in : Aberdeen, Dundee, Glasgow, Lerwick, Stromness and Thurso

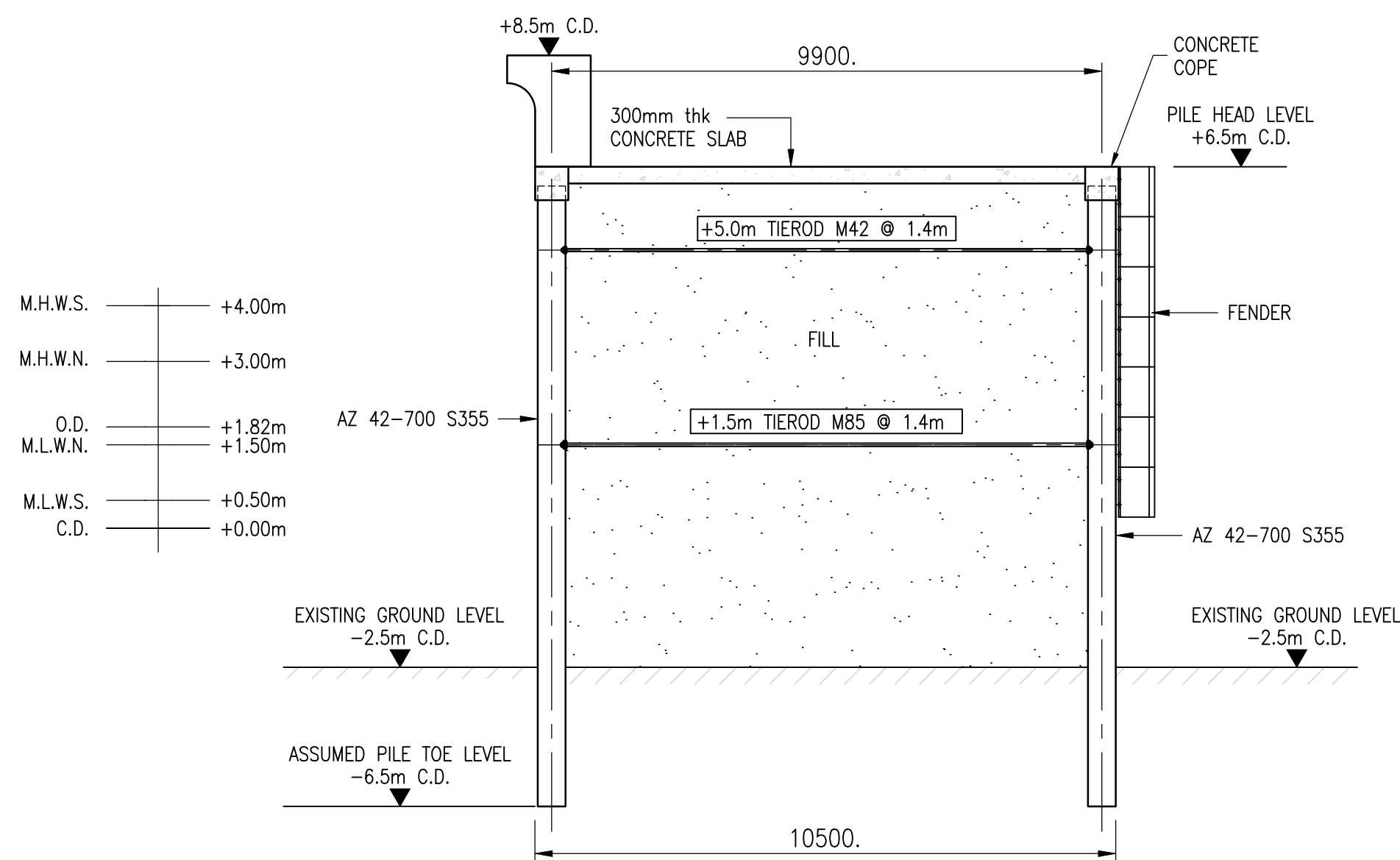
Civil Engineers  
Structural Engineers  
Architects  
CDM Co-ordinators  
Geotechnical services  
Environmental services

PROJECT : ARGYLL & BUTE COUNCIL FIONNPHORT BERTH			
TITLE : OPTION 7 - NEW HARBOUR SUSPENDED DECK - FIONNPHORT			
DRAWN : G.A.M.	DATE : 07.08.15	VERIFIED : L.F.	APPROVED : A.A.K.
SCALE : (A1) AS SHOWN		DRAWING STATUS : PRELIMINARY	
DRAWING No : 135114/SK11		REV : /	





LOCATION PLAN  
SCALE 1:1000



SECTION A-A  
(SCALE 1:100)

NOTES:

1. SECTIONS AND LEVELS INDICATED IN THE DRAWING ARE FOR COSTING PURPOSES ONLY.
2. ALL DIMENSIONS ARE IN mm U.N.O.
3. ALL LEVELS ARE RELEVANT TO C.D. U.N.O.

REV	DATE	REVISION DESCRIPTION	DRN	VER
THIS DRAWING IS COPYRIGHT © DO NOT SCALE FROM THIS DRAWING				

Arch  
Henderson

1919

Civil Engineers  
Structural Engineers  
Architects  
CDM Co-ordinators  
Geotechnical services  
Environmental services

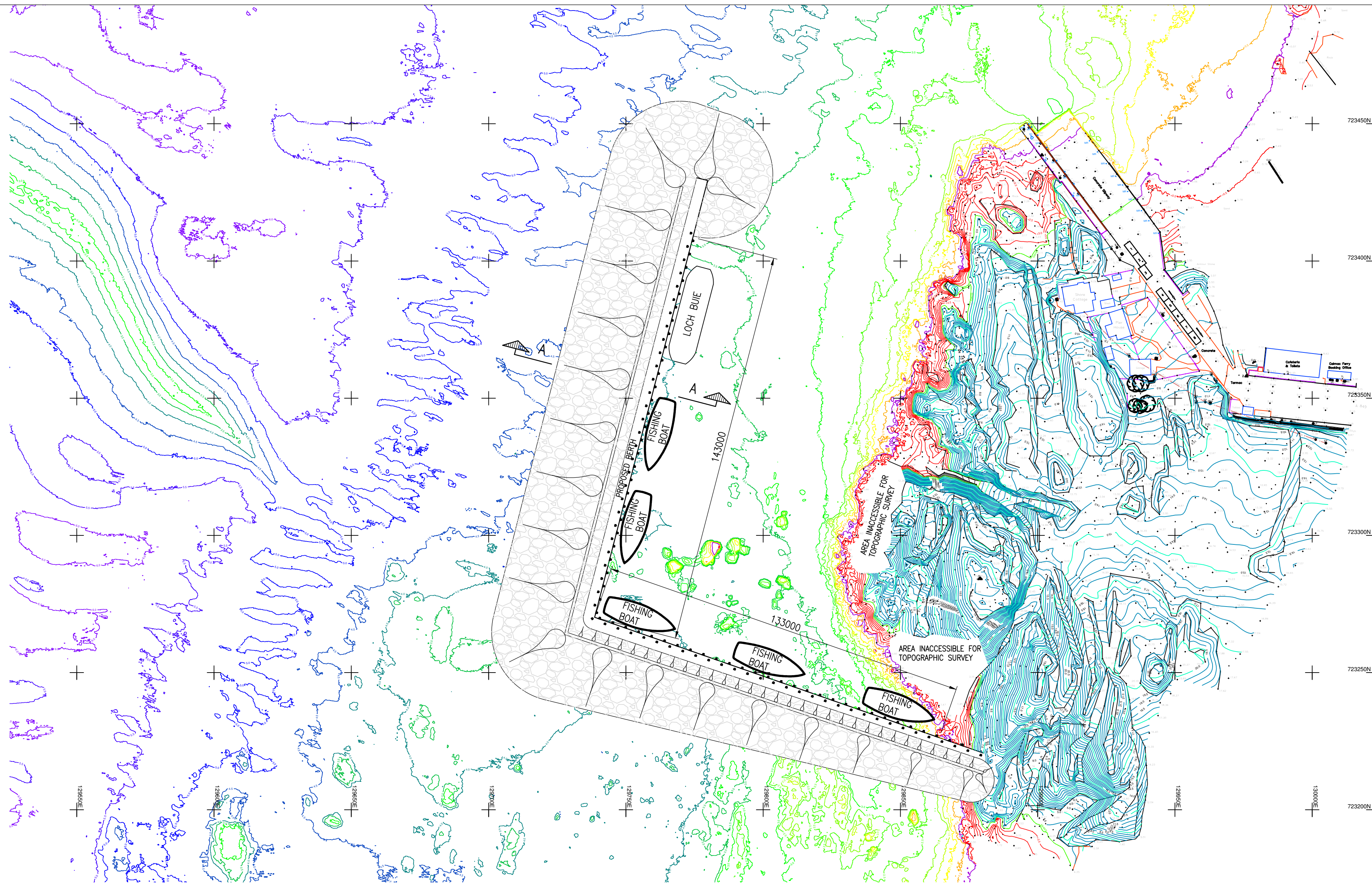
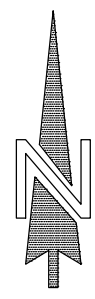
142 St. Vincent Street, Glasgow G2 8LA  
Tel : 0141 227 3060 - Fax : 0141 248 9542  
www.arch-henderson.co.uk - email : glasgow@arch-henderson.co.uk

Offices in : Aberdeen, Dundee, Glasgow, Lerwick, Stromness and Thurso

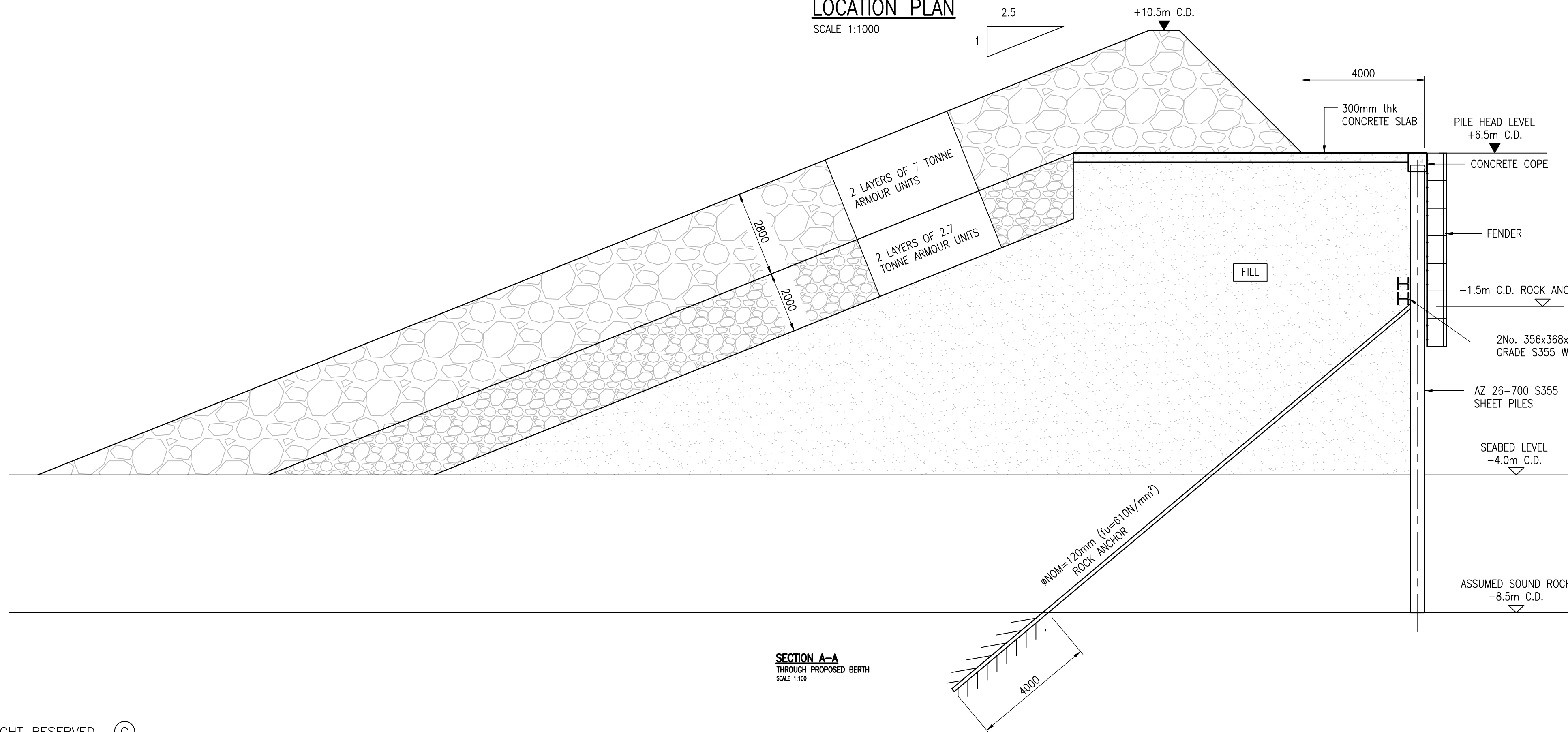
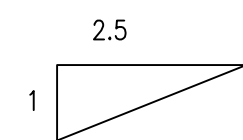
PROJECT : ARGYLL & BUTE COUNCIL FIONNPHORT BERTH			
TITLE : OPTION 8 EXTENSION OF OPTION 5 - FIONNPHORT			
DRAWN : G.A.M.	DATE : 07.09.15	VERIFIED : L.F.	APPROVED : A.A.K.
SCALE : (A1) AS SHOWN		DRAWING STATUS : PRELIMINARY	
DRAWING No : 135114/SK12		REV : /	

DO NOT SCALE





LOCATION PLAN  
SCALE 1:1000



M.H.W.S.	+4.00m
M.H.W.N.	+3.00m
O.D.	+1.82m
M.L.W.N.	+1.50m
M.L.W.S.	+0.50m
C.D.	+0.00m

#### NOTES:

1. SECTIONS AND LEVELS INDICATED IN THE DRAWING ARE FOR COSTING PURPOSES ONLY.
2. ALL DIMENSIONS ARE IN mm U.N.O.
3. ALL LEVELS ARE RELEVANT TO C.D. U.N.O.

REV	DATE	REVISION DESCRIPTION	DRN	VER
-----	------	----------------------	-----	-----

THIS DRAWING IS COPYRIGHT . DO NOT SCALE FROM THIS DRAWING.

**Arch Henderson**  
1919

142 St. Vincent Street, Glasgow G2 8LA.  
Tel : 0141 227 3060 - Fax : 0141 249 9542  
www.arch-henderson.co.uk - email : glasgow@arch-henderson.co.uk

Offices in : Aberdeen, Dundee, Glasgow, Lerwick, Stromness and Thurso

Civil Engineers  
Structural Engineers  
Architects  
CDM Co-ordinators  
Geotechnical services  
Environmental services

PROJECT :  
**ARGYLL & BUTE COUNCIL  
FIONNPHORT BERTH**

TITLE :  
**OPTION 9  
EXTENSION OF OPTION 6 - FIONNPHORT**

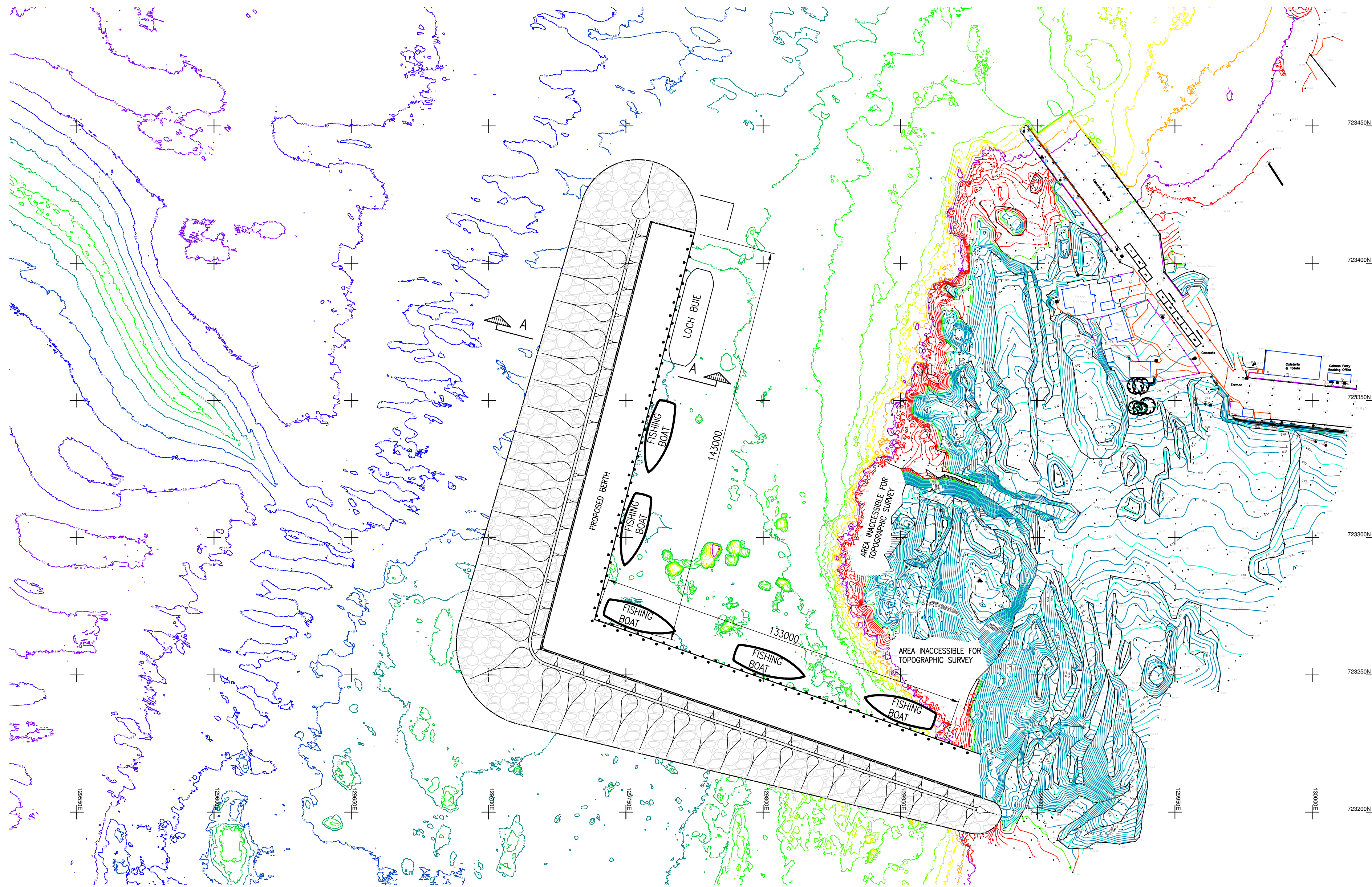
DRAWN : G.A.M.	DATE : 07.08.15	VERIFIED : L.F.	APPROVED : A.A.K.
-------------------	--------------------	--------------------	----------------------

SCALE : (A1) AS SHOWN	DRAWING STATUS : PRELIMINARY
--------------------------	---------------------------------

DRAWING No : 135114/SK13	REV : /
-----------------------------	------------

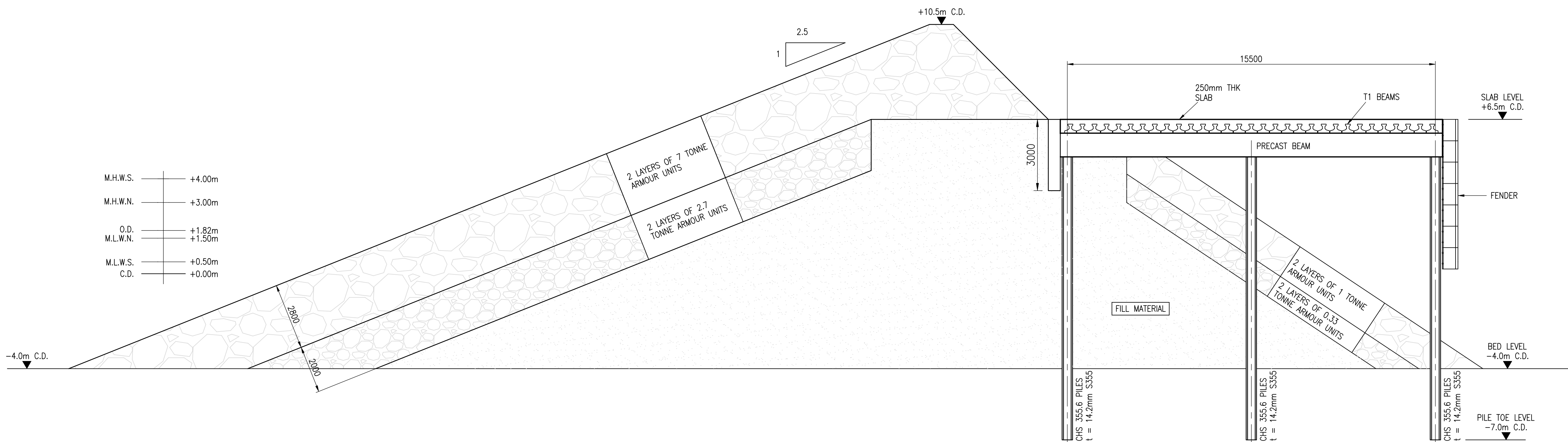
DO NOT SCALE





LOCATION PLAN

SCALE 1:1000




SECTION A-A

(SCALE 1:100)

NOTES:

1. SECTIONS AND LEVELS INDICATED IN THE DRAWING ARE FOR COSTING PURPOSES ONLY.
2. ALL DIMENSIONS ARE IN mm U.N.O.
3. ALL LEVELS ARE RELEVANT TO C.D. U.N.O.

REV	DATE	REVISION DESCRIPTION	DRN	VER
THIS DRAWING IS COPYRIGHT . DO NOT SCALE FROM THIS DRAWING.				
<div><div><div>Arch Henderson</div><div></div></div><div>142 St. Vincent Street, Glasgow G2 5LA Tel : 0141 227 3060 - Fax : 0141 248 9542 www.arch-henderson.co.uk - email : glasgow@arch-henderson.co.uk</div><div>Offices in : Aberdeen, Dundee, Glasgow, Lerwick, Stromness and Thurso</div></div>			<div>Civil Engineers Structural Engineers Architects CDM Co-ordinators Geotechnical services Environmental services</div>	
PROJECT : ARGYLL & BUTE COUNCIL FIONNPHORT BERTH				
TITLE : OPTION 10 EXTENSION OF OPTION 7 - FIONNPHORT				
DRAWN : G.A.M.		DATE : 07.08.15	VERIFIED : L.F.	APPROVED : A.A.K.
SCALE : (A1) AS SHOWN			DRAWING STATUS : PRELIMINARY	
DRAWING No : 135114/SK14			REV : /	