Comhairle Contae Fhine Gall
Fingal County Council

Broadmeadow Way Proposed Greenway
Between Malahide Demesne and
Newbridge Demesne

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fingal.ie

Contents

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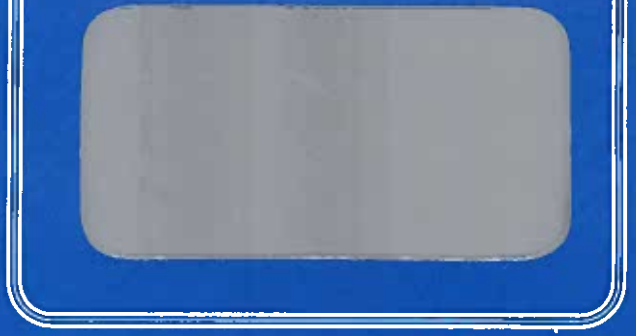
Appendix 3

Site Investigation Report

IGSL Limited



Geotechnical Report

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PROPOSED CYCLE WAY
BROADMEADOW
FINGAL CO CO

Clifton Scannell Emerson
Consulting Engineers

CONTENTS

APPENDICES

FOREWORD

The following Conditions and Notes on Site Investigation Procedures should be read in conjunction with this report.

General.

Recommendations made, and opinions expressed in the report are based on the strata observed in the exploratory holes, together with the results of in-situ and laboratory tests. No responsibility can be held for conditions which have not been revealed by exploratory work, or which occur between exploratory hole locations. Whilst the report may suggest the likely configuration of strata, both between exploratory hole locations, or below the maximum depth of the investigation, this is only indicative, and liability cannot be accepted for its accuracy.

Unless specifically stated, no account has been taken of possible subsidence due to mineral extraction below or close to the site.

Boring Procedures.

Unless otherwise stated, the 'Shell and Auger' technique of soft ground boring has been employed. All boring operations sampling and/or logging of soils and in-situ testing complies with the recommendations of the British Standard Code of Practice BS 5930 (1981), 'Site Investigation' and BS 1377:1990, 'Methods of test for soils for civil engineering purposes'.

Whilst the technique allows the maximum data to be obtained in soft ground, some disturbance and variation of soft and layered soils is unavoidable. Attention is drawn to this condition, whenever it is suspected. Where cobbles and boulders are recorded, no conclusion should be drawn concerning the size, presence, lithological nature, or numbers per unit volume of ground.

Where peat has been encountered during siteworks, samples have been logged in accordance with the Von Post Classification (ref. Von Post, L. 1992. Sveriges Gologiska Undersoknings torvinventering och nogra av dess hittils vunna resultat (SGU peat inventory and some preliminary results) Svenska-Mosskulturforeningens Tidskrift, Jonkoping, Swedden, 36, 1-37 & Hobbs N. B. Mire morphology and the properties of some British and foreign peats. QJEG, Vol. 19, 1986).

Routine Sampling.

Undisturbed samples of soils, predominantly cohesive in nature are obtainec unless otherwise stated by a 104mm diameter open-drive tube sampler. In granular soils, and where undisturbed sampling is inappropriate, disturbed samples are collected. Smaller disturbed samples are also recovered at intervals to allow a visual examination of the full strata section.

In-Situ Testing.

Standard penetration tests, utilising either the standard split spoon sampler or solid cone and automatic trip-hammer are conducted unless otherwise where required by instruction. Subsequent to a seating drive of 150mm, a summation for the number of blows for 300mm penetration is recorded on the boring records together with the blow count for each 75mm penetration. In cases where incomplete penetration is obtained, the number of blows for the recorded value of penetration are noted. In coarse granular soils, a cone end is fitted to the sampler and a similar procedure adopted.

Groundwater.

The depth of entry of any influx of groundwater is recorded during the course of boring operations. However, the normal rate of boring does not usually permit the recording of an equilibrium level for any one water strike. Where possible drilling is suspended for a period of twenty minutes to monitor the subsequent rise in water
level.

Groundwater conditions observed in the borings or pits are those appertaining to the period of investigation. It should be noted however, that groundwater levels are subject to diurnal, seasonal and climatic variations and can also be affected by drainage condition, tidal variation or other causes.

Retention of Samples.

After satisfactory completion of all the scheduled laboratory tests on any sample, the remaining material is discarded unless a period of retention of samples is agreed, it is our normal practice to discard all soil samples one month after submission of our final report.

REPORT ON A SITE INVESTIGATION
FOR A PROPOSED CYCLE NETWORK
AT BROADMEADOWS

FINGAL COUNTY COUNCIL / NTA

CLIFTON SCANNELL EMERSON ASSOCIATES
CONSULTING ENGINEERS

Report No. 16912 **JULY 2013**

I Introduction

A new pedestrian / cycle trail is proposed by Fingal County Council, extending from the Newbridge Demesne, to the Broadmeadow Estuary. The route follows the Turvey River southeastwards to the main Dublin Belfast Railway line and then parallels the railway south to Broadmeadow Estuary. Part of the route will be on a raised boardwalk

An investigation of sub-soil conditions in the area of development has been ordered by the project consulting engineers, Clifton Scannell Emerson and Associates on behalf of Fingal County Council..

The programme of the investigation envisaged the construction of ten boreholes and three dynamic probes to establish geotechnical criteria on which to base foundation and infra-structural design. All exploratory work was carried out in accordance with BS 5930, Code of Practice for Site Investigations (1999).

A programme of laboratory testing to confirm geotechnical soil parameters followed site operations.

This report includes all factual data pertaining to the project and comments on the findings relative to the proposed development.

II Fieldwork

The proposed cycleway extends from Hearse Road to Broadmeadow Estuary. Borehole and probe locations are noted on the site plan enclosed in Appendix IV.

Exploratory locations were generally as per the engineers drawing, however final as constructed locations were surveyed and plotted. All necessary precautions were taken to protect the works, given the environmentally sensitive nature of much of the route.

Ten boreholes were constructed along the route, with BH 7 and BH 8 at a proposed bridge crossing of the Turvey River. Three dynamic probes were also driven to establish a strength/depth pattern for the sub soils.

a.Boreholes

The exploratory holes were bored with conventional 200mm cable-tool methods using a Dando Exploratory Rig. Holes are referenced BH 1 to BH 10. Hand excavation was carried out to 1.20 metre in each location to ensure that shallow services were not damaged.

Detailed geotechnical records are contained in Appendix I to this report - the records give details of stratification, sampling, in-situ testing and groundwater. Note is also taken of any obstructions to normal boring requiring the use of the heavy chisel for advancement.

Boreholes BH1 to BH 6 were all terminated at relatively shallow depth (most probably the bedrock horizon), with overburden consisting of top soil or surface fill generally overlying stiff glacial till (boulder clay) with dense gravel at BH 3.

Borehole 7 and BH 8 were at a proposed bridge crossing of the Turvey River. At BH 7 rock fill overlies peaty clay with very soft organic silt underlying and extending to 4.60 metres. Underlying this soft upper zone alternating bands of stiff gravelly clay (till) and dense gravel continued to the final refusal depth of 9.50 metres.

At BH 8, top soil and clay fill extend to 1.90 metres and overlie some loose gravel. Stiff to very stiff glacial till (gravelly clay) extends from 2.80 to the final completion depth of 9.00 metres.

Finally at BH 9 and BH 10 deposits of firm to stiff to very stiff boulder clay (till) extend from about 1.50 metre to final refusal depths of 6.00 and 8.00 metres.

Ground water ingress was recorded at varying depths in almost all locations and details are noted on the individual records. Standpipes were installed as specified at BH 2 and BH 4 to facilitate long-term ground water observation.

b. Dynamic Probes

Probing was carried out at three locations to establish a pattern of soil strength with depth. Probing was in accordance with the heavy-duty probe specification of BS 1377: Part 9: 1990. In these tests, the soil resistance is measured in terms of the number of drop-hammer blows required to drive the test probe through each 100 mm increment of penetration. Probing is terminated when the blow count exceeds 25/100mm to avoid damage to the apparatus. Where loose material is present a single blow count may drive the apparatus in excess of 100mm. In this instance blow counts of zero may be recorded.

The results are presented in both graphical and tabular form in Appendix II and are summarised as follows:

Probe No.	**Soft Soils**	**Stiff / Dense Soils**	**Refusal**
DP 1	0 – 0.50	0.50 – 1.70	1.70
DP 2	0 – 0.50	0.50 – 2.20	2.20
DP 3	0 – 5.00	5.00 – 5.70	5.70

III Testing

In-Situ Standard Penetration

Standard penetration tests were carried out at approximate 1.00 metre intervals in the geotechnical boreholes to measure relative in-situ soil strength. N values are noted in the right hand column of the boring records, representing the blow count required to drive the standard sampler 300mm into the soil, following initial seating blows. Where full test penetration was not achieved the blow count for a specific penetration is recorded, or refusal is indicated where appropriate

The results of the tests are summarised as follows:

STRATUM	**N VALUE RANGE**	**COMMENT**
Made Ground	7 to 15 to Refusal	Variable
Brown gravelly CLAY	9 to 45	Firm to Stiff
Black Gravelly CLAY	41 to 72	Hard
GRAVEL	31 to 61	Dense to Very Dense
Organic SILT (BH 7)	1 to 2	Very Soft to soft

Some limited penetration SPT tests were recorded at the base of several boreholes.

In Situ CBR Tests

CBR values were determined in-situ at each borehole location in the depth range 0.30 to 0.50 metres using the TRL Dynamic Cone Penetrometer. Results are presented in Appendix III with CBR values in the range 10 to 71 % obtained. It should be noted that testing was carried out at relatively depths during very dry conditions on quite granular clay soils and the very high CBR values obtained in places may be unrepresentative of soil moisture content at construction stage. We would suggest that the lower range of values (between 10 and 15%) is more representative of more normal conditions.

(b) Geotechnical Laboratory :

All geotechnical samples from the boreholes have been returned to the IGSL accredited laboratory for initial visual inspection. A schedule of testing was prepared and tests as appropriate carried out all in accordance with BS 1377: Part 2. 1990. The programme of testing included the following elements and all results are presented in Appendix III. Chemical testing (ph and Sulphate) were carried out by Jones Environmental Ltd.

a. Classification (Liquid and Plastic Limits)
b. Particle size distribution (Sieve Analysis and Hydrometer)
c. Sulphate and pH determination
d. Triaxial Compression

Classification

The liquid and plastic limits were established for samples of the cohesive soils. The results generally falling in the CL/CI zones of the Casagrande Classification Chart, indicative of sensitive soil of low plasticity. The natural moisture content was also determined. A sample of the soft material from BH 7 falls in the MI zone, with a high moisture content of 49% indicative of organic silty soil.

Grading

The grading curves for samples of both glacial till and gravel deposits have been established by wet sieve analysis and hydrometer analysis where appropriate. The straight line grading of the glacial till is typical of the deposit. The granular deposits are graded in the sand gravel zones with little fines noted.

Sulphate and pH

Chemical tests on samples of the soil indicate low soluble sulphate concentration and near neutral pH. No special precautions are necessary to protect foundation concrete from sulphate aggression.

Triaxial Compression

The un-drained shear characteristics of two remoulded samples have been determined in the laboratory. One sample of the soft silt from NH 7 collapsed during preparation and testing was not possible. A sample of the boulder clay from BH 9 at a depth of 2.00 metres exhibited a cohesion of 35 kN/sq.m.

IV Discussion

The proposed cycleway extends from Hearse Road to Broadmeadow Estuary and includes some bridge crossings of the Turvey River. Part of the route will be on a raised boardwalk supported by piling or other proprietary system.

A detailed investigation of ground conditions has been carried out on the instructions of Clifton Scannell Emerson and Associates, Consulting Engineers, involving borehole and probe investigation. Field operations have been backed up by a programme of geotechnical laboratory testing.

General Route Construction

The general pattern of stratification reflects the presence of glacial till deposits under shallow surface top-soil or thin fill cover. The tills generally comprise initially firm gravelly clay, increasing is strength with penetration. This material will readily support any light loads imposed by a cycle or pathway. A CBR of about 10% is indicated for pavement construction at a depth between 0.30 and 0.50 metres.

Careful visual inspection of excavated formation is advised to ensure that all unsuitable or organic material is removed prior to construction of the new cycle way. Ground water, while noted in most locations, is not expected to be of concern in shallow pavement construction. Standpipe readings are included with this report.

Very soft grey silt is noted at BH 7 and very soft deposits are confirmed at DP 3. Where the proposed cycleway traverses these soft organic soils the use of small diameter piles or proprietary pier support system can be considered. Specialists should be consulted to determine the optimum support method, having due regard to the sensitive ecology of the area.

The very weak alluvial soils encountered at BH 7 and extending to approximately 5.00 metres BGL suggest that piling techniques be adopted to transfer bridge loads to the underlying strong glacial soils. At BH 8 on the southern side of the bridge, direct excavation to the very stiff brown boulder clay at 2.80 metres can be considered, with an allowable bearing pressure of 250 kN/sq.m. available at this depth. Piling can also be utilised in this area if deep excavation is precluded environmentally.

Firm to stiff brown boulder clay is present at BHs 9 and 10 with an allowable bearing pressure of 150 kN/sq.m. indicated at a depth of 1.50 metres BGL. The allowable bearing pressure increases to about 250 kN/sq.m at a depth of 2.50 metres BGL. Direct excavation or mini piled support can also be considered in this area.

IGSL/JC
July 2013

Appendix I Boring Records

GEOTECHNICAL BORING RECORD

REPORT NUMBER 16912

CONTRACT	Broadmeadow Cycle Route	BOREHOLE NO.	BH1
		SHEET	Sheet 1 of 1
CO-ORDINATES	322,120.61 E 249,378.44 N	RIG TYPE	Dando 2000
		BOREHOLE DIAMETER (mm)	200
GROUND LEVEL (m AOD)	1.85	BOREHOLE DEPTH (m)	3.00
		DATE COMMENCED	22/05/2013
		DATE COMPLETED	22/05/2013
CLIENT	Fingal County Council	SPT HAMMER REF. NO.	SPT2
ENGINEER	Clifton Scannell Emerson	ENERGY RATIO (%)	53
		BORED BY	E.Leahy
		PROCESSED BY	I.Reder

Depth (m)	Description	Legend	Elevation	Depth (m)	Samples: Ref. Number	Sample Type	Depth (m)	Recovery	Field Test Results	Standpipe Details
0	TOPSOIL		1.65	0.20						
	Firm, greyish brown, silty CLAY with some angular cobbles				AA3120	B	1.00-1.00		N = 15 (1, 1, 3, 3, 4, 5)	
1										
2					AA3121	B	2.00-2.00		N = 16 (2, 2, 2, 3, 5, 6)	
			-0.45	2.30						
	Firm to stiff, greyish brown, gravelly SILT/CLAY with some cobbles		-0.85	2.70						
	Dense, grey, very clayey angular coarse GRAVEL with many cobbles and boulders		-1.15	3.00	AA3122	B	3.00-3.00		N = 50/20 mm (25, 50)	
3	Obstruction End of Borehole at 3.00 m									
4										
5										
6										
7										
8										
9										

HARD STRATA BORING/CHISELLING

From (m)	To (m)	Time (h)	Comments
2.7	3	1.5	

WATER STRIKE DETAILS

Water Strike	Casing Depth	Sealed At	Rise To	Time (min)	Comments
2.70	2.70	NO	2.40	20	Slow

INSTALLATION DETAILS

Date	Tip Depth	RZ Top	RZ Base	Type
22-05-13	3.00	1.00	3.00	50mm SP

GROUNDWATER PROGRESS

Date	Hole Depth	Casing Depth	Depth to Water	Comments
22-05-13	3.00	3.00	2.40	
22-05-13	3.00	NIL	1.60	End of BH

REMARKS Hand dug inspection pit for services

Sample Legend
D - Small Disturbed (tub)
B - Bul Disturbed
LB - Large Bul Disturbed
Env - Environmental Sample (Jar + Vial + Tub)
UT - Undisturbed 100mm Diameter Sample
P - Undisturbed Piston Sample
W - Water Sample

IGSL BH LOG 16912.GPJ IGSL.GDT 16/7/13

GEOTECHNICAL BORING RECORD

REPORT NUMBER 16912

CONTRACT	Broadmeadow Cycle Route	BOREHOLE NO.	BH2
		SHEET	Sheet 1 of 1
CO-ORDINATES	322,269.63 E 249,206.21 N	RIG TYPE	Dando 2000
		BOREHOLE DIAMETER (mm)	200
GROUND LEVEL (m AOD)	1.63	BOREHOLE DEPTH (m)	3.60
		DATE COMMENCED	23/05/2013
		DATE COMPLETED	22/05/2013
CLIENT	Fingal County Council	SPT HAMMER REF. NO.	SPT2
ENGINEER	Clifton Scannell Emerson	ENERGY RATIO (%)	53
		BORED BY	E.Leahy
		PROCESSED BY	I.Reder

Depth (m)	Description	Legend	Elevation	Depth (m)	Samples: Ref. Number	Sample Type	Depth (m)	Recovery	Field Test Results	Standpipe Details
0	MADE GROUND (comprised of large rock boulders, rubble fill, concrete, red brick, clay, gravel, steel bars)									
1					AA3123	B	1.00-1.00		N = 50/10 mm (8, 19, 50)	
			0.23	1.40						
	Soft, grey, slightly silty CLAY									
2			-0.57	2.20	AA3124	B	2.00-2.00		N = 9 (2, 2, 2, 2, 2, 3)	
	Soft to firm, dark grey/black, gravelly silty silty CLAY with some cobbles and occasional boulders									
			-1.27	2.90						
3	Stiff, dark grey/black, gravelly CLAY with many cobbles and boulders		-1.67	3.30	AA3125	B	3.00-3.00		N = 56 (2, 7, 12, 14, 15, 15)	
	Dense, grey, very clayey angular coarse GRAVEL with many cobbles and boulders		-1.97	3.60	AA3126	B	3.60-3.60		N = 50/10 mm (25, 50)	
	Obstruction									
4	End of Borehole at 3.60 m									
5										
6										
7										
8										
9										

HARD STRATA BORING/CHISELLING

From (m)	To (m)	Time (h)	Comments
0	1.4	3	
3.3	3.6	1.5	

WATER STRIKE DETAILS

Water Strike	Casing Depth	Sealed At	Rise To	Time (min)	Comments
3.30	3.30	NO	2.90	20	Slow

INSTALLATION DETAILS

Date	Tip Depth	RZ Top	RZ Base	Type

GROUNDWATER PROGRESS

Date	Hole Depth	Casing Depth	Depth to Water	Comments
23-05-13	3.60	3.60	2.70	
23-05-13	3.60	NIL	1.30	End of BH

REMARKS Hand dug inspection pit.for services

Sample Legend
D - Small Disturbed (tub)
B - Bulk Disturbed
LB - Large Bulk Disturbed
Env - Environmental Sample (Jar + Vial + Tub)
UT - Undisturbed 100mm Diameter Sample
P - Undisturbed Piston Sample
W - Water Sample

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GEOTECHNICAL BORING RECORD

REPORT NUMBER 16912

CONTRACT	Broadmeadow Cycle Route	BOREHOLE NO.	BH3
		SHEET	Sheet 1 of 1
CO-ORDINATES	322,369.88 E 249,115.56 N	RIG TYPE	Dando 2000
		BOREHOLE DIAMETER (mm)	200
GROUND LEVEL (m AOD)	1.35	BOREHOLE DEPTH (m)	4.30
		DATE COMMENCED	24/05/2013
		DATE COMPLETED	24/05/2013
CLIENT	Fingal County Council	SPT HAMMER REF. NO.	SPT2
ENGINEER	Clifton Scannell Emerson	ENERGY RATIO (%)	53
		BORED BY	E.Leahy
		PROCESSED BY	I.Reder

Depth (m)	Description	Legend	Elevation	Depth (m)	Samples Ref. Number	Sample Type	Depth (m)	Recovery	Field Test Results	Standpipe Details
0	TOPSOIL		1.05	0.30						
	Firm, brown, gravelly slightly silty CLAY				AA3127	B	1.00-1.00		N = 14 (2, 3, 2, 4, 3, 5)	
1			-0.36	1.70						
	Dense, brown/grey, slightly silty fine to coarse GRAVEL with some angular cobbles				AA3128	B	2.00-2.00		N = 31 (3, 6, 6, 7, 7, 11)	
2			-1.66	3.00						
	Dense, brown/grey, silty fine to coarse angular flat GRAVEL with many small angular flat cobbles				AA3129	B	3.00-3.00		N = 46 (4, 5, 8, 12, 12, 14)	
3										
4			-2.86	4.20	AA3130	B	4.00-4.00		N = 48 (5, 6, 8, 10, 14, 16)	
	Dense, grey, slightly clayey angular coarse GRAVEL with many cobbles and boulders		-2.96	4.30	AA3131	B	4.30-4.30			
	Obstruction End of Borehole at 4.30 m									
5										
6										
7										
8										
9										

HARD STRATA BORING/CHISELLING

From (m)	To (m)	Time (h)	Comments
4.2	4.3	1.5	

WATER STRIKE DETAILS

Water Strike	Casing Depth	Sealed At	Rise To	Time (min)	Comments
1.70	1.70	NO	1.20	20	Slow

INSTALLATION DETAILS

Date	Tip Depth	RZ Top	RZ Base	Type

GROUNDWATER PROGRESS

Date	Hole Depth	Casing Depth	Depth to Water	Comments
24-05-13	4.30	4.30	1.60	
24-05-13	4.30	NIL	1.30	End of BH

REMARKS 1hr moving to BH3 location from BH2; Hand dug inspection pit for services

Sample Legend
D - Small Disturbed (tub)
B - Bulk Disturbed
LB - Large Bulk Disturbed
Env - Environmental Sample (Jar + Vial + Tub)
UT - Undisturbed 100mm Diameter Sample
P - Undisturbed Piston Sample
W - Water Sample

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GEOTECHNICAL BORING RECORD

REPORT NUMBER 16912

CONTRACT	Broadmeadow Cycle Route	BOREHOLE NO.	BH4
		SHEET	Sheet 1 of 1
CO-ORDINATES	322,415.05 E 249,103.10 N	RIG TYPE	Dando 2000
		BOREHOLE DIAMETER (mm)	200
GROUND LEVEL (m AOD)	1.09	BOREHOLE DEPTH (m)	1.80
		DATE COMMENCED	24/05/2013
		DATE COMPLETED	27/05/2013
CLIENT	Fingal County Council	SPT HAMMER REF. NO.	SPT2
ENGINEER	Clifton Scannell Emerson	ENERGY RATIO (%)	53
		BORED BY	E.Leahy
		PROCESSED BY	I.Reder

Depth (m)	Description	Legend	Elevation	Depth (m)	Samples Ref. Number	Samples Type	Samples Depth (m)	Samples Recovery	Field Test Results	Standpipe Details
0	TOPSOIL		0.89	0.20						
	Firm/stiff, greyish brown, silty CLAY with some angular cobbles									
1			-0.21	1.30	AA3132	B	1.00-1.00		N = 20 (2, 4, 4, 6, 5, 5)	
	Stiff, dark greyish brown, gravelly silty CLAY with many angular cobbles and occasional boulders		-0.51	1.60						
2	Dense, grey, slightly clayey angular coarse GRAVEL with many cobbles and boulders		-0.71	1.80	AA3133	B	1.60-1.80		N = 50/15 mm (25, 50)	
	Obstruction End of Borehole at 1.80 m									
3										
4										
5										
6										
7										
8										
9										

HARD STRATA BORING/CHISELLING

From (m)	To (m)	Time (h)	Comments
1.6	1.8	1.5	

WATER STRIKE DETAILS

Water Strike	Casing Depth	Sealed At	Rise To	Time (min)	Comments
1.60	1.60	NO	1.50	20	Slow

INSTALLATION DETAILS

Date	Time	Depth	RZ To	RZ Base	Type
27-05-13	1.80	0.80	1.80		50mm SP

GROUNDWATER PROGRESS

Date	Hole Depth	Casing Depth	Depth to Water	Comments
24-05-13	1.00	1.00	DRY	Depth to water at end of day
27-05-13	1.80	1.80	1.60	
27-05-13	1.80	NIL	1.20	End of BH

REMARKS Hand dug inspection pit for services

Sample Legend

D - Small Disturbed (tub)
B - Bulk Disturbed
LB - Large Bulk Disturbed
Env - Environmental Sample (Jar + Vial + Tub)
UT - Undisturbed 100mm Diameter Sample
P - Undisturbed Piston Sample
W - Water Sample

IGSL BH LOG 16912.GPJ IGSL.GDT 16/7/13

GEOTECHNICAL BORING RECORD

REPORT NUMBER 16912

CONTRACT	Broadmeadow Cycle Route	BOREHOLE NO.	BH5
		SHEET	Sheet 1 of 1
CO-ORDINATES	322,557.66 E 249,051.96 N	RIG TYPE	Dando 2000
		BOREHOLE DIAMETER (mm)	200
GROUND LEVEL (m AOD)	1.54	BOREHOLE DEPTH (m)	2.50
		DATE COMMENCED	27/05/2013
		DATE COMPLETED	27/05/2013
CLIENT	Fingal County Council	SPT HAMMER REF. NO.	SPT2
ENGINEER	Clifton Scannell Emerson	ENERGY RATIO (%)	53
		BORED BY	E.Leahy
		PROCESSED BY	I.Reder

Depth (m)	Description	Legend	Elevation	Depth (m)	Samples: Ref. Number	Sample Type	Depth (m)	Recovery	Field Test Results	Standpipe Details
0	TOPSOIL		1.24	0.30						
	Firm, greyish brown, slightly gravelly silty CLAY with some angular cobbles				AA3134	B	1.00-1.00		N = 13 (1, 1, 3, 3, 4, 3)	
1			0.14	1.40						
	Stiff, grey, very gravelly slightly silty CLAY with some cobbles and occasional boulders		-0.56	2.10	AA3135	B	2.00-2.00		N = 50 (3, 7, 12, 12, 13, 13)	
2	Dense, grey, very clayey angular coarse GRAVEL with many angular cobbles (possible very gravelly clay with many cobbles)		-0.86	2.40						
			-0.96	2.50	AA3136	B	2.40-2.40		N = 50/20 mm (25, 50)	
3	Dense, grey,angular coarse GRAVEL with many cobbles and boulders									
	Obstruction End of Borehole at 2.50 m									
4										
5										
6										
7										
8										
9										

HARD STRATA BORING/CHISELLING

From (m)	To (m)	Time (h)	Comments
2.4	2.5	1.5	

WATER STRIKE DETAILS

Water Strike	Casing Depth	Sealed At	Rise To	Time (min)	Comments
2.10	2.10	NO	1.90	20	Slow

INSTALLATION DETAILS

Date	Tip Depth	RZ Top	RZ Base	Type

GROUNDWATER PROGRESS

Date	Hole Depth	Casing Depth	Depth to Water	Comments
27-05-13	2.50	2.50	2.20	
27-05-13	2.50	NIL	1.40	End of BH

REMARKS 2.5hrs standing time due to waiting for client's instruction to move to BH5; Hand dug inspection pit for services

Sample Legend

D - Small Disturbed (tub)
B - Bulk Disturbed
LB - Large Bulk Disturbed
Env - Environmental Sample (Jar + Vial + Tub)
UT - Undisturbed 100mm Diameter Sample
P - Undisturbed Piston Sample
W - Water Sample

IGSL BH LOG 16912.GPJ IGSL.GDT 18/7/13

GEOTECHNICAL BORING RECORD

REPORT NUMBER 16912

CONTRACT	Broadmeadow Cycle Route	BOREHOLE NO.	BH6
		SHEET	Sheet 1 of 1
CO-ORDINATES	322,658.78 E 248,776.03 N	RIG TYPE	Dando 2000
		BOREHOLE DIAMETER (mm)	200
GROUND LEVEL (m AOD)	1.02	BOREHOLE DEPTH (m)	2.50
		DATE COMMENCED	29/05/2013
		DATE COMPLETED	30/05/2013
CLIENT	Fingal County Council	SPT HAMMER REF. NO.	SPT2
ENGINEER	Clifton Scannell Emerson	ENERGY RATIO (%)	53
		BORED BY	E.Leahy
		PROCESSED BY	I.Reder

Depth (m)	Description	Legend	Elevation	Depth (m)	Samples: Ref. Number	Samples: Sample Type	Samples: Depth (m)	Samples: Recovery	Field Test Results	Standpipe Details
0	MADE GROUND (comprised of large angular rock cobbles and boulders)									
			0.22	0.80						
1	Firm, greyish brown, silty CLAY with gravel and cobbles				AA3147	B	1.00-1.00		N = 16 (1, 2, 2, 4, 5, 5)	
			-0.78	1.80						
2	Dense, grey, slightly clayey angular coarse GRAVEL with many cobbles and boulders				AA3148	B	2.00-2.00		N = 43 (3, 9, 9, 9, 13, 12)	
			-1.48	2.50	AA3149	B	2.50-2.50		N = 50/25 mm (25, 50)	
3	Obstruction End of Borehole at 2.50 m									
4										
5										
6										
7										
8										
9										

HARD STRATA BORING/CHISELLING

From (m)	To (m)	Time (h)	Comments
0	0.8	4	Cobbles and boulders
2.3	2.5	1.5	

WATER STRIKE DETAILS

Water Strike	Casing Depth	Sealed At	Rise To	Time (min)	Comments
					No water strike

INSTALLATION DETAILS

Date	Tip Depth	RZ Top	RZ Base	Type

GROUNDWATER PROGRESS

Date	Hole Depth	Casing Depth	Depth to Water	Comments

REMARKS Hand dug inspection pit for services

Sample Legend

D - Small Disturbed (tub)
B - Bulk Disturbed
LB - Large Bulk Disturbed
Env - Environmental Sample (Jar + Vial + Tub)
UT - Undisturbed 100mm Diameter Sample
P - Undisturbed Piston Sample
W - Water Sample

IGSL BH LOG 16912.GPJ IGSL.GDT 19/7/13

GEOTECHNICAL BORING RECORD

REPORT NUMBER 16912

CONTRACT	Broadmeadow Cycle Route	BOREHOLE NO.	BH7
		SHEET	Sheet 1 of 1
CO-ORDINATES	322,645.64 E 248,521.03 N	RIG TYPE	Dando 2000
		BOREHOLE DIAMETER (mm)	200
GROUND LEVEL (m AOD)	1.21	BOREHOLE DEPTH (m)	9.50
		DATE COMMENCED	28/05/2013
		DATE COMPLETED	29/05/2013
CLIENT	Fingal County Council	SPT HAMMER REF. NO.	SPT2
ENGINEER	Clifton Scannell Emerson	ENERGY RATIO (%)	53
		BORED BY	E.Leahy
		PROCESSED BY	I.Reder

Depth (m)	Description	Legend	Elevation	Depth (m)	Samples: Ref. Number	Sample Type	Depth (m)	Recovery	Field Test Results	Standpipe Details
0	MADE GROUND (comprised of large angular rock cobbles and boulders)		0.61	0.60						
1	Soft, brown, slightly sandy very gravelly CLAY with some cobbles and small pieces of dark brown peat (possible fill)		-0.39	1.60	AA3137	B	1.00-1.00		N = 7 (1, 1, 2, 1, 2, 2)	
2	Very soft, light blueish grey, SILT				AA3138	B	2.00-2.00		N = 1 (0, 1, 0, 0, 1, 0)	
3					AA3139	B	3.00-3.00		N = 2 (0, 0, 0, 1, 0, 1)	
4	Very soft, light blueish grey, SILT with some organic pieces		-2.59	3.80	AA3140	B	4.00-4.00		N = 2 (0, 0, 0, 1, 1, 0)	
5	Very stiff, grey, very gravelly silty CLAY with many cobbles		-3.39	4.60	AA3141	B	5.00-5.00		N = 41 (3, 7, 7, 10, 11, 13)	
6	Dense, brown, silty GRAVEL with some cobbles		-5.09	6.30	AA3142	B	6.00-6.00		N = 51 (3, 6, 10, 13, 13, 15)	
7	Very stiff, brown, very gravelly silty CLAY with many cobbles (possible very clayey gravel with cobbles)		-5.69	6.90	AA3143	B	7.00-7.00		N = 59 (3, 8, 13, 14, 16, 16)	
8	Very dense, brown, fine to coarse GRAVEL with many cobbles		-6.19	7.40	AA3144	B	8.00-8.00		N = 61 (5, 7, 12, 15, 16, 18)	
9	Very dense, brown, clayey coarse GRAVEL with many cobbles and boulders		-7.79	9.00	AA3145	B	9.00-9.00		N = 50/85 mm (7, 15, 15, 35)	
	End of Borehole at 9.50 m		-8.29	9.50	AA3146	B	9.50-9.50		N = 50/20 mm (25, 50)	

HARD STRATA BORING/CHISELLING

From (m)	To (m)	Time (h)	Comments
5.6	5.8	0.5	
7.5	7.7	0.75	
9	9.5	1.5	

WATER STRIKE DETAILS

Water Strike	Casing Depth	Sealed At	Rise To	Time (min)	Comments
3.90	3.90	5.20	2.80	20	Rapid
5.70	5.70	NO	3.80	20	Rapid

INSTALLATION DETAILS

Date	Tip Depth	RZ Top	RZ Base	Type

GROUNDWATER PROGRESS

Date	Hole Depth	Casing Depth	Depth to Water	Comments
28-05-13	6.00	6.00	4.20	Depth to water at end of day
29-05-13	6.00	6.00	2.00	Depth to water at start of day
29-05-13	9.50	9.50	1.50	End of BH

REMARKS Hand dug inspection pit for services

Sample Legend

D - Small Disturbed (tub)
B - Bulk Disturbed
LB - Large Bulk Disturbed
Env - Environmental Sample (Jar + Vial + Tub)
UT - Undisturbed 100mm Diameter Sample
P - Undisturbed Piston Sample
W - Water Sample

IGSL BH LOG 16912.GPJ IGSL.GDT 16/7/13

GEOTECHNICAL BORING RECORD

REPORT NUMBER 16912

CONTRACT	Broadmeadow Cycle Route	BOREHOLE NO.	BH8
		SHEET	Sheet 1 of 1
CO-ORDINATES	322,641.37 E 248,479.94 N	RIG TYPE	Dando 2000
		BOREHOLE DIAMETER (mm)	200
GROUND LEVEL (m AOD)	1.72	BOREHOLE DEPTH (m)	9.00
		DATE COMMENCED	04/06/2013
		DATE COMPLETED	05/06/2013
CLIENT	Fingal County Council	SPT HAMMER REF. NO.	SPT2
ENGINEER	Clifton Scannell Emerson	ENERGY RATIO (%)	53
		BORED BY	E.Leahy
		PROCESSED BY	I.Reder

Depth (m)	Description	Legend	Elevation	Depth (m)	Samples: Ref. Number	Sample Type	Depth (m)	Recovery	Field Test Results	Standpipe Details
0	TOPSOIL		1.42	0.30						
1	Firm, brown, gravelly CLAY with large cobbles (possible made ground)				AA3150	B	1.00-1.00		N = 15 (2, 4, 4, 3, 4, 4)	
2	Loose to medium dense, brown, silty fine to coarse GRAVEL with some cobbles		-0.18	1.90	AA3151	B	2.00-2.00		N = 9 (1, 1, 1, 2, 3, 3)	
3	Very stiff, brown, slightly sandy gravelly silghty silty CLAY with many cobbles and occasional boulders		-1.08	2.80	AA3152	B	3.00-3.00		N = 50/160 mm (7, 13, 12, 13, 25)	
4			-2.58	4.30	AA3153	B	4.00-4.00		N = 54 (3, 10, 13, 13, 14, 14)	
5	Very stiff, brownish/dark grey, gravelly slightly silty CLAY with many cobbles and boulders				AA3154	B	5.00-5.00		N = 38 (4, 4, 8, 10, 10, 12)	
6					AA3155	B	6.00-6.00		N = 42 (3, 7, 8, 10, 11, 13)	
7			-5.78	7.50	AA3156	B	7.00-7.00		N = 45 (6, 7, 10, 11, 10, 14)	
8	Hard, dark grey/black, very gravelly CLAY with many cobbles and boulders				AA3157	B	8.00-8.00		N = 72 (8, 15, 16, 16, 19, 21)	
9	End of Borehole at 9.00 m		-7.28	9.00	AA3158	B	9.00-9.00		N = 50/20 mm (25, 50)	

HARD STRATA BORING/CHISELLING

From (m)	To (m)	Time (h)	Comments
2.8	3.5	1	
7.5	8	1	
8.8	9	1.5	

WATER STRIKE DETAILS

Water Strike	Casing Depth	Sealed At	Rise To	Time (min)	Comments
					No water strike

INSTALLATION DETAILS

Date	Tip Depth	RZ Top	RZ Base	Type

GROUNDWATER PROGRESS

Date	Hole Depth	Casing Depth	Depth to Water	Comments
05-06-13	9.00	NIL	8.50	End of BH

REMARKS

Sample Legend
D - Small Disturbed (tub)
B - Bulk Disturbed
LB - Large Bulk Disturbed
Env - Environmental Sample (Jar + Vial + Tub)
UT - Undisturbed 100mm Diameter Sample
P - Undisturbed Piston Sample
W - Water Sample

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GEOTECHNICAL BORING RECORD

REPORT NUMBER 16912

CONTRACT	Broadmeadow Cycle Route	BOREHOLE NO.	BH9
		SHEET	Sheet 1 of 1
CO-ORDINATES	322,622.30 E 248,142.03 N	RIG TYPE	Dando 2000
		BOREHOLE DIAMETER (mm)	200
GROUND LEVEL (m AOD)	2.79	BOREHOLE DEPTH (m)	6.00
		DATE COMMENCED	05/06/2013
		DATE COMPLETED	06/06/2013
CLIENT	Fingal County Council	SPT HAMMER REF. NO.	SPT2
ENGINEER	Clifton Scannell Emerson	ENERGY RATIO (%)	53
		BORED BY	E.Leahy
		PROCESSED BY	I.Reder

Depth (m)	Description	Legend	Elevation	Depth (m)	Samples: Ref. Number	Sample Type	Depth (m)	Recovery	Field Test Results	Standpipe Details
0	TOPSOIL		2.49	0.30						
	Soft, brown, sandy SILT/CLAY		2.09	0.70						
1	Soft to firm, brownish grey, SILT/CLAY with some gravel and cobbles				AA0359	B	1.00-1.00		N = 9 (1, 1, 1, 2, 3, 3)	
2					AA0360	B	2.00-2.00		N = 15 (1, 3, 3, 4, 4, 4)	
			0.09	2.70						
3	Very stiff, dark grey/black, very gravelly CLAY with many cobbles and boulders				AA0361	B	3.00-3.00		N = 34 (3, 6, 6, 8, 9, 11)	
4					AA0362	B	4.00-4.00		N = 39 (3, 5, 5, 9, 12, 13)	
5					AA0363	B	5.00-5.00		N = 53 (3, 8, 8, 11, 17, 17)	
			-2.81	5.60						
	Very dense, grey, slightly clayey angular coarse GRAVEL with many cobbles and boulders (weathered rock)		-3.21	6.00	AA0364	B	5.60-6.00		N = 50/75 mm (17, 8, 50)	
6	End of Borehole at 6.00 m									
7										
8										
9										

HARD STRATA BORING/CHISELLING

From (m)	To (m)	Time (h)	Comments
3.4	3.6	0.75	
5.6	6	1.5	

WATER STRIKE DETAILS

Water Strike	Casing Depth	Sealed At	Rise To	Time (min)	Comments
5.60	5.60	NO	4.80	20	Rapid

INSTALLATION DETAILS

Date	Tip Depth	RZ Top	RZ Base	Type

GROUNDWATER PROGRESS

Date	Hole Depth	Casing Depth	Depth to Water	Comments
06-06-13	6.00	6.00	5.80	
06-06-13	6.00	NIL	2.60	End of BH

REMARKS Hand dug inspection pit for services

Sample Legend

D - Small Disturbed (tub)
B - Bulk Disturbed
LB - Large Bulk Disturbed
Env - Environmental Sample (Jar + Vial + Tub)
UT - Undisturbed 100mm Diameter Sample
P - Undisturbed Piston Sample
W - Water Sample

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GEOTECHNICAL BORING RECORD

REPORT NUMBER 16912

CONTRACT	Broadmeadow Cycle Route	BOREHOLE NO.	BH10
		SHEET	Sheet 1 of 1
CO-ORDINATES	322,615.15 E 248,116.26 N	RIG TYPE	Dando 2000
		BOREHOLE DIAMETER (mm)	200
GROUND LEVEL (m AOD)	2.19	BOREHOLE DEPTH (m)	8.00
		DATE COMMENCED	06/06/2013
		DATE COMPLETED	07/06/2013
CLIENT	Fingal County Council	SPT HAMMER REF. NO.	SPT2
ENGINEER	Clifton Scannell Emerson	ENERGY RATIO (%)	53
		BORED BY	E.Leahy
		PROCESSED BY	I.Reder

Depth (m)	Description	Legend	Elevation	Depth (m)	Samples: Ref. Number	Sample Type	Depth (m)	Recovery	Field Test Results	Standpipe Details
0	MADE GROUND (comprised of topsoil, clay, gravel, cobbes, red brick)		1.89	0.30						
	Soft to firm, black, sandy gravelly CLAY (possible fill)				AA0365	B	1.00-1.00		N = 11 (1, 1, 1, 2, 4, 4)	
1			0.79	1.40						
	Stiff, dark brown, slightly gravelly CLAY with many angular cobbles				AA0366	B	2.00-2.00		N = 28 (2, 3, 6, 6, 7, 9)	
2			-0.31	2.50						
	Very stiff to hard, dark grey/black, very gravelly CLAY with many cobbles and boulders				AA0367	B	3.00-3.00		N = 47 (3, 5, 9, 11, 13, 14)	
3					AA0368	B	4.00-4.00		N = 46 (3, 7, 7, 12, 13, 14)	
4					AA0369	B	5.00-5.00		N = 61 (6, 9, 13, 15, 15, 18)	
5					AA0370	B	6.00-6.00		N = 50 (4, 7, 10, 10, 14, 16)	
6			-4.21	6.40						
	Very stiff, dark brown, sandy gravelly CLAY with large cobbles				AA0371	B	7.00-7.00		N = 56 (5, 8, 9, 14, 15, 18)	
7			-5.41	7.60	AA0372	B	7.60-8.00			
	Very dense, grey, slightly clayey angular coarse GRAVEL with many cobbles and boulders (weathered rock)		-5.81	8.00					N = 50/10 mm (25, 50)	
8	End of Borehole at 8.00 m									
9										

HARD STRATA BORING/CHISELLING

From (m)	To (m)	Time (h)	Comments
2.5	6.4	2.5	Continuous chiselling
7.6	8	1.5	

WATER STRIKE DETAILS

Water Strike	Casing Depth	Sealed At	Rise To	Time (min)	Comments
4.50	4.50	5.50	4.00	20	Slow
7.00	7.00	NO	5.20	20	Rapid

INSTALLATION DETAILS

Date	Tip Depth	RZ Top	RZ Base	Type

GROUNDWATER PROGRESS

Date	Hole Depth	Casing Depth	Depth to Water	Comments
07-06-13	8.00	8.00	4.90	
07-06-13	8.00	NIL	2.80	End of BH

REMARKS 2hrs moving to BH10 location from BH9; Hand dug inspection pit for services

Sample Legend
D - Small Disturbed (tub)
B - Bulk Disturbed
LB - Large Bulk Disturbed
Env - Environmental Sample (Jar + Vial + Tub)
UT - Undisturbed 100mm Diameter Sample
P - Undisturbed Piston Sample
W - Water Sample

IGSL BH LOG 16912.GPJ IGSL.GDT 16/7/13

Appendix II Probe Records

DYNAMIC PROBE RECORD

REPORT NUMBER 16912

CONTRACT	Broadmeadow Cycle Route	PROBE NO.	DP1
		SHEET	Sheet 1 of 1
CO-ORDINATES	322,506.16 E 248,962.73 N	DATE DRILLED	21/05/2013
GROUND LEVEL (mOD)	0.61	DATE LOGGED	21/05/2013
HAMMER MASS (kg)	50		
CLIENT	Fingal County Council	INCREMENT SIZE (mm)	100
ENGINEER	Clifton Scannell Emerson	FALL HEIGHT (mm)	500
		PROBE TYPE	DPH

Depth (m)	Geotechnical Description	Legend	Depth (m)	Elevation (mOD)	Water	Depth (m)	Probe Readings (Blows/Increment)
0.0						0.00	0
						0.10	3
						0.20	5
						0.30	4
						0.40	2
						0.50	2
						0.60	6
						0.70	7
						0.80	7
1.0						0.90	4
						1.00	5
						1.10	4
						1.20	4
						1.30	3
						1.40	5
						1.50	7
						1.60	23
						1.70	25
	End of Probe at 1.80 m			-1.19			
2.0							
3.0							
4.0							

Graphic Probe Record: 0 5 10 15 20 25

GROUNDWATER OBSERVATIONS

REMARKS

IGSL DP LOG 100MM INCREMENTS 16912.GPJ IGSL.GDT 16/7/13

DYNAMIC PROBE RECORD

REPORT NUMBER 16912

CONTRACT	Broadmeadow Cycle Route	PROBE NO.	DP2
		SHEET	Sheet 1 of 1
CO-ORDINATES	322,474.37 E 248,829.38 N	DATE DRILLED	21/05/2013
GROUND LEVEL (mOD)	0.32	DATE LOGGED	21/05/2013
CLIENT	Fingal County Council	HAMMER MASS (kg)	50
ENGINEER	Clifton Scannell Emerson	INCREMENT SIZE (mm)	100
		FALL HEIGHT (mm)	500
		PROBE TYPE	DPH

Depth (m)	Geotechnical Description	Legend	Depth (m)	Elevation (mOD)	Water	Depth (m)	Probe Readings (Blows/Increment)
0.0						0.00	0
						0.10	10
						0.20	6
						0.30	6
						0.40	1
						0.50	1
						0.60	8
						0.70	5
						0.80	4
1.0						0.90	4
						1.00	6
						1.10	7
						1.20	9
						1.30	9
						1.40	13
						1.50	21
						1.60	9
						1.70	12
						1.80	13
2.0						1.90	19
						2.00	12
						2.10	13
						2.20	25
	End of Probe at 2.30 m			-1.98			
3.0							
4.0							

Graphic Probe Record: 0 5 10 15 20 25

GROUNDWATER OBSERVATIONS

REMARKS

IGSL DP LOG 100MM INCREMENTS 16912.GPJ IGSL.GDT 16/7/13

DYNAMIC PROBE RECORD

REPORT NUMBER 16912

CONTRACT	Broadmeadow Cycle Route	PROBE NO.	DP3
		SHEET	Sheet 1 of 2
CO-ORDINATES	322,529.49 E 248,648.66 N	DATE DRILLED	21/05/2013
GROUND LEVEL (mOD)	0.49	DATE LOGGED	21/05/2013
CLIENT	Fingal County Council	HAMMER MASS (kg)	50
ENGINEER	Clifton Scannell Emerson	INCREMENT SIZE (mm)	100
		FALL HEIGHT (mm)	500
		PROBE TYPE	DPH

Depth (m)	Geotechnical Description	Legend	Depth (m)	Elevation (mOD)	Water	Depth (m)	Probe Readings (Blows/Increment)	Graphic Probe Record (0 5 10 15 20 25)
0.0						0.00	0	
						0.10	0	
						0.20	0	
						0.30	0	
						0.40	4	
						0.50	3	
						0.60	0	
						0.70	0	
						0.80	0	
						0.90	0	
1.0						1.00	0	
						1.10	0	
						1.20	0	
						1.30	0	
						1.40	0	
						1.50	0	
						1.60	0	
						1.70	0	
						1.80	0	
						1.90	0	
2.0						2.00	0	
						2.10	0	
						2.20	0	
						2.30	0	
						2.40	0	
						2.50	0	
						2.60	0	
						2.70	0	
						2.80	0	
						2.90	0	
3.0						3.00	0	
						3.10	0	
						3.20	0	
						3.30	0	
						3.40	0	
						3.50	0	
						3.60	0	
						3.70	0	
						3.80	0	
						3.90	0	
4.0						4.00	0	
						4.10	0	
						4.20	0	
						4.30	0	
						4.40	0	
						4.50	0	
						4.60	0	
						4.70	0	
						4.80	0	
						4.90	5	

GROUNDWATER OBSERVATIONS

REMARKS

IGSL DP LOG 100MM INCREMENTS 18912.GPJ IGSL.GDT 18/7/13

DYNAMIC PROBE RECORD

REPORT NUMBER 16912

CONTRACT	Broadmeadow Cycle Route	PROBE NO.	DP3
		SHEET	Sheet 2 of 2
CO-ORDINATES	322,529.49 E 248,648.66 N	DATE DRILLED	21/05/2013
GROUND LEVEL (mOD)	0.49	DATE LOGGED	21/05/2013
CLIENT	Fingal County Council	HAMMER MASS (kg)	50
ENGINEER	Clifton Scannell Emerson	INCREMENT SIZE (mm)	100
		FALL HEIGHT (mm)	500
		PROBE TYPE	DPH

Depth (m)	Geotechnical Description	Legend	Depth (m)	Elevation (mOD)	Water	Depth (m)	Probe Readings (Blows/Increment)
5.0	. *(continued)*					5.00	5
						5.10	10
						5.20	10
						5.30	9
						5.40	12
						5.50	19
						5.60	20
						5.70	25
	End of Probe at 5.80 m			-5.31			
6.0							
7.0							
8.0							
9.0							

Graphic Probe Record: 0 5 10 15 20 25

GROUNDWATER OBSERVATIONS

REMARKS

IGSL DP LOG 100MM INCREMENTS 16912.GPJ IGSL.GDT 16/7/13

Appendix III Laboratory Data

IGSL Ltd
Materials Laboratory
Unit J5, M7 Business Park
Newhall, Naas
Co. Kildare
045 846176

Test Report

Determination of Moisture Content, Liquid & Plastic Limits

Tested in accordance with BS1377:Part 2:1990, clauses 3.2, 4.3, 4.4 & 5.3

Report No. **R52692** Contract No. 16912 Contract Name: Broadmeadow Cycle Route

Customer Clifton Scannell Emerson, Seafort Lodge, Castledawson Avenue, Blackrock, Co. Dublin.

Samples Received: 24/06/13 Date Tested: 25/06/13

BH/TP	Sample No.	Depth (m)	Lab. Ref	Sample Type	Moisture Content %	Liquid Limit %	Plastic Limit %	Plasticity Index	% <425µm	Preparation	Liquid Limit Clause	Classification (BS5930)	Description
BH1	3120	1.0	A13/2029	D	18	41	23	18	70	WS	4.4	C I	Brown slightly sandy, slightly gravelly, CLAY with shell fragments
BH2	3124	2.0	A13/2031	D	18	33	21	12	73	WS	4.4	C L	Brown sandy gravelly CLAY with shell fragments
BH2	3125	3.0	A13/2032	D	6.0	22	16	6	26	WS	4.4	C L	Brown clayey, very sandy, GRAVEL with some cobbles
BH4	3132	1.0	A13/2035	D	21	32	21	11	94	WS	4.4	C L	Brown slightly sandy, slightly gravelly, CLAY
BH5	3134	1.0	A13/2036	D	15	31	22	9	37	WS	4.4	C L	Grey brown sandy gravelly CLAY
BH5	3135	2.0	A13/2037	D	4.4	NP	NP	NP	N/A	WS	4.4		Grey brown silty, sandy, GRAVEL
BH7	3138	2.0	A13/2039	D	49	42	26	16	95	WS	4.4	M I	Grey brown sandy slightly gravelly SILT
BH7	3141	5.0	A13/2040	D	27	41	23	18	98	WS	4.4	C I	Brown slightly sandy, slightly gravelly, CLAY
BH8	3150	1.0	A13/3150	D	8.8	31	21	10	32	WS	4.4	C L	Brown sandy gravelly CLAY
BH8	3154	5.0	A13/2044	D	5.9	29	19	10	53	WS	4.4	C L	Grey brown sandy gravelly CLAY
BH8	3157	8.0	A13/2045	D	14	30	18	12	69	WS	4.4	C L	Brown slightly sandy, slightly gravelly, CLAY
BH9	360	2.0	A13/2046	D	15	31	19	12	57	WS	4.4	C L	Brown sandy gravelly CLAY
BH9	362	4.0	A13/2047	D	8.0	29	17	12	52	WS	4.4	C L	Brown slightly sandy, gravelly, CLAY with some cobbles
BH10	366	2.0	A13/2048	D	14	37	24	13	54	WS	4.4	C I	Brown sandy gravelly CLAY
BH10	368	4.0	A13/2049	D	13	33	20	13	53	WS	4.4	C L	Brown slightly sandy, slightly gravelly, CLAY

Notes: Preparation: WS - Wet sieved; AR - As received; NP - Non plastic
Liquid Limit Clause: 4.3 Cone Penetrometer definitive method; 4.4 Cone Penetrometer one point method
Sample Type: B - bulk disturbed; U - Undisturbed

Remarks:

Opinions and interpretations are outside the scope of accreditation.
The results relate to the specimens tested. Any remaining material will be retained for one month.

IGSL Ltd Materials Laboratory	Persons authorized to approve reports	Approved by	Date	Page
	J Barrett (Dep. Quality Manager) H Byrne (Quality Manager)	H Byrne	08/07/13	1 of 1

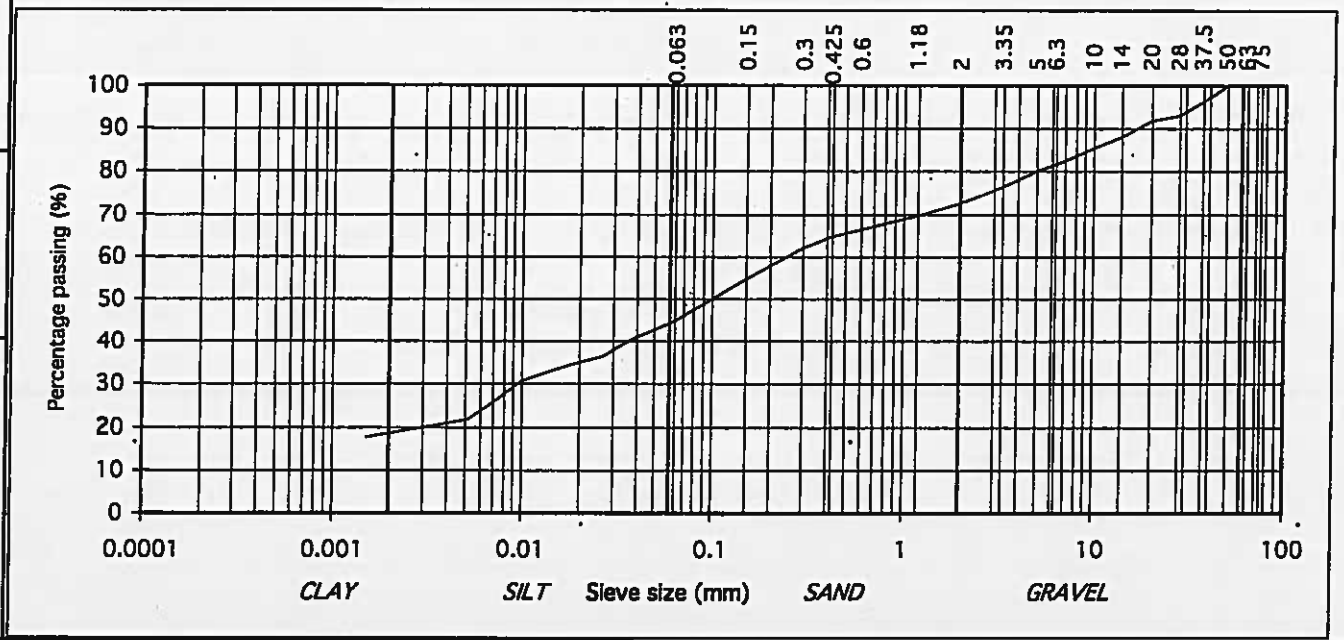
TEST REPORT
Determination of Particle Size Distribution

Tested in accordance with: BS1377:Part2:1990 , clause 9.2 & 9.5
(note: Sedimentation stage not accredited)

particle size	% passing	
75	100	COBBLES
63	100	
50	100	GRAVEL
37.5	96	
28	93	
20	92	
14	88	
10	85	
6.3	82	
5	80	
3.35	76	
2	73	
1.18	70	SAND
0.6	66	
0.425	65	
0.3	62	
0.15	55	
0.063	45	SILT/CLAY
0.037	40	
0.027	37	
0.017	34	
0.010	31	
0.007	26	
0.005	22	
0.002	18	

Contract No: 16912 Report No. R52679
Contract: Broadmeadow Cycle Route
BH: 1
Sample No. 3120 Lab. Sample No. A13/2029
Sample Type: D
Depth (m): 1.00 Customer: Clifton Scannell Emerson, Seafort Lodge, Castledawson Avenue, Blackrock, Co. Dublin.
Date Received 24/06/2013 Date Testing started 24/06/2013
Description: Brown slightly sandy, slightly gravelly, CLAY

Remarks



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Persons authorized to approve reports: J Barrett (Dep Quality Manager) H Byrne (Quality Manager)

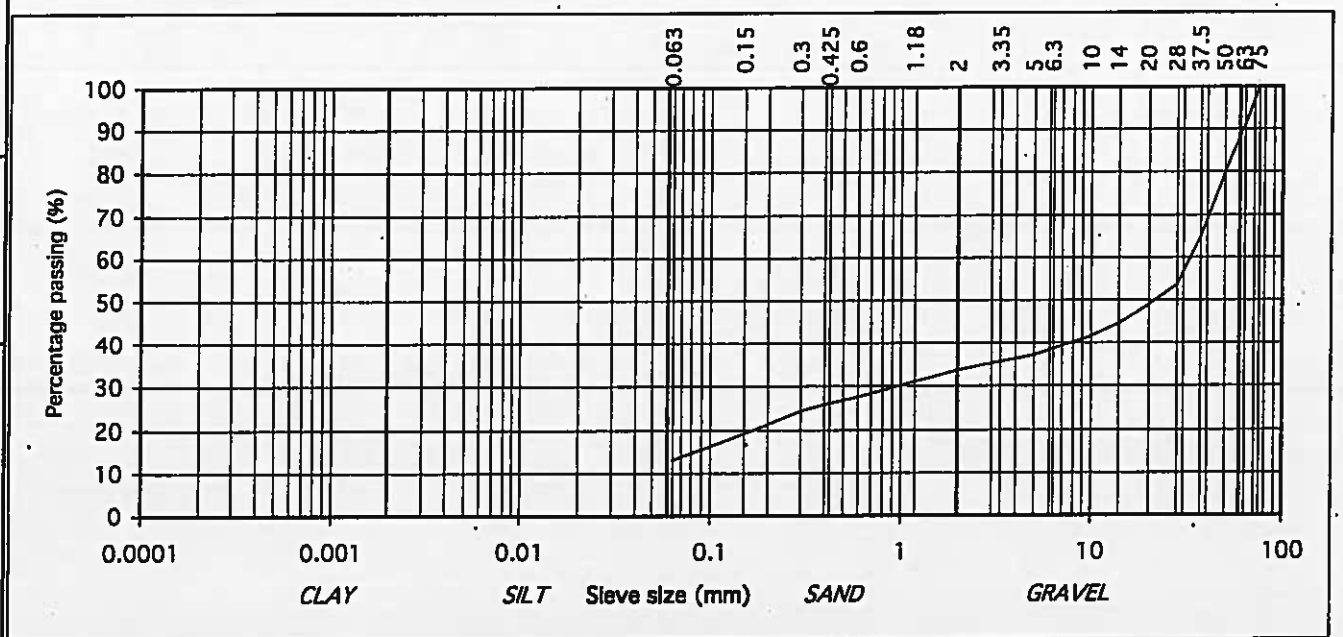
TEST REPORT
Determination of Particle Size Distribution

Tested in accordance with: BS1377:Part2:1990 , clause 9.2 & 9.5
(note: Sedimentation stage not accredited)

particle size	% passing	
75	100	COBBLES
63	91	
50	80	GRAVEL
37.5	65	
28	54	
20	49	
14	44	
10	41	
6.3	38	
5	37	
3.35	36	
2	34	
1.18	31	SAND
0.6	27	
0.425	26	
0.3	24	
0.15	19	
0.063	13	SILT/CLAY

Contract No: 16912 Report No. R52680
Contract: Broadmeadow Cycle Route
BH: 2
Sample No. 3125 Lab. Sample No. A12/2032
Sample Type: D
Depth (m): 3.00 Customer: Clifton Scannell Emerson, Seafort Lodge, Castledawson Avenue, Blackrock, Co. Dublin.
Date Received 24/06/2013 Date Testing started 24/06/2013
Description: Brown clayey, very sandy, GRAVEL with some cobbles

Remarks Sample size did not meet the requirement of BS1377



IGSL Ltd Materials Laboratory

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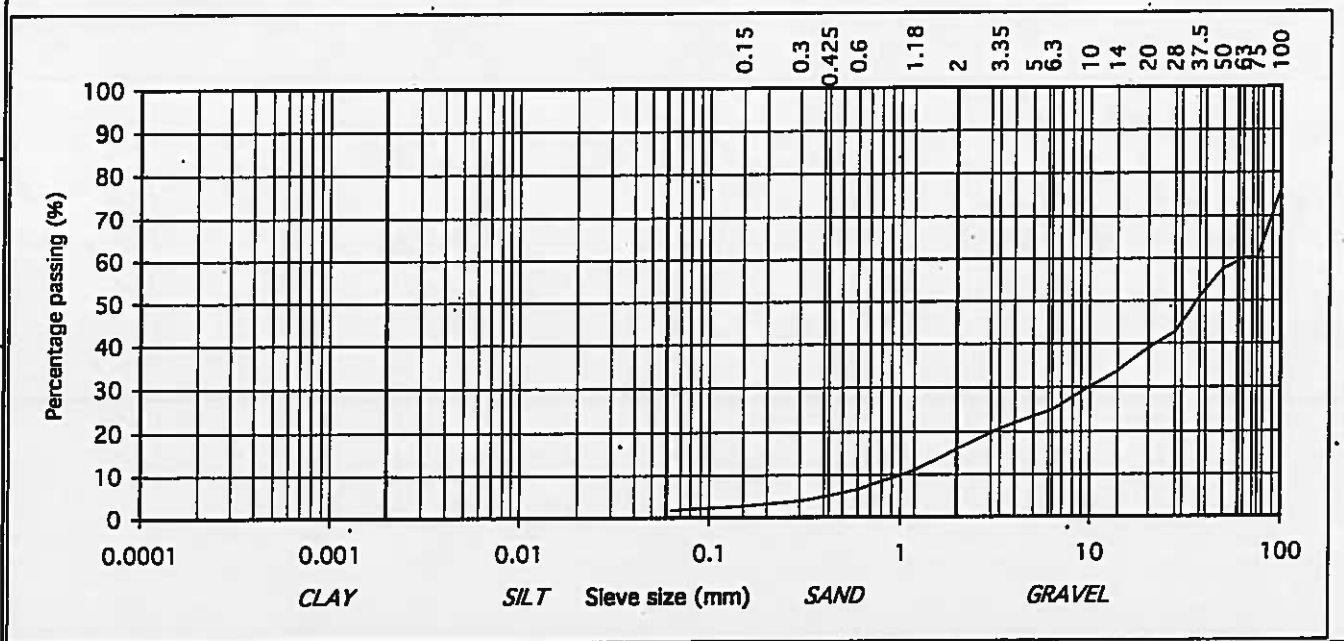
Persons authorized to approve reports: J Barrett (Dep Quality Manager) H Byrne (Quality Manager)

TEST REPORT
Determination of Particle Size Distribution

Tested in accordance with: BS1377:Part2:1990 , clause 9.2 & 9.5
(note: Sedimentation stage not accredited)

particle size	% passing	
100	76	COBBLES
75	60	
63	60	GRAVEL
50	57	
37.5	51	
28	43	
20	39	
14	34	
10	30	
6.3	25	
5	23	
3.35	20	
2	16	SAND
1.18	11	
0.6	6	
0.425	5	
0.3	4	
0.15	3	SILT/CLAY
0.063	2	

Contract No:	16912	Report No.	R52681
Contract:	Broadmeadow Cycle Route		
BH:	3		
Sample No.	3128	Lab. Sample No.	A13/2033
Sample Type:	D		
Depth (m):	2.00	Customer:	Clifton Scannell Emerson, Seafort Lodge, Castledawson Avenue, Blackrock, Co. Dublin.
Date Received	24/06/2013	Date Testing started	24/06/2013
Description:	Black slightly clayey/silty, sandy, GRAVEL with many cobbles		
Remarks	Sample size did not meet the requirement of BS1377		



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Persons authorized to approve reports: J Barrett (Dep Quality Manager) H Byrne (Quality Manager)

TEST REPORT

Determination of Particle Size Distribution

Tested in accordance with: BS1377:Part2:1990 , clause 9.2 & 9.5

(note: Sedimentation stage not accredited)

particle size	% passing	
75	100	COBBLES
63	100	
50	88	GRAVEL
37.5	74	
28	64	
20	53	
14	36	
10	29	
6.3	20	
5	17	
3.35	12	
2	8	
1.18	5	SAND
0.6	3	
0.425	3	
0.3	2	
0.15	1	
0.063	1	SILT/CLAY

Contract No: 16912 Report No. R52682

Contract: Broadmeadow Cycle Route

BH: 3

Sample No. 3130 Lab. Sample No. A13/2034

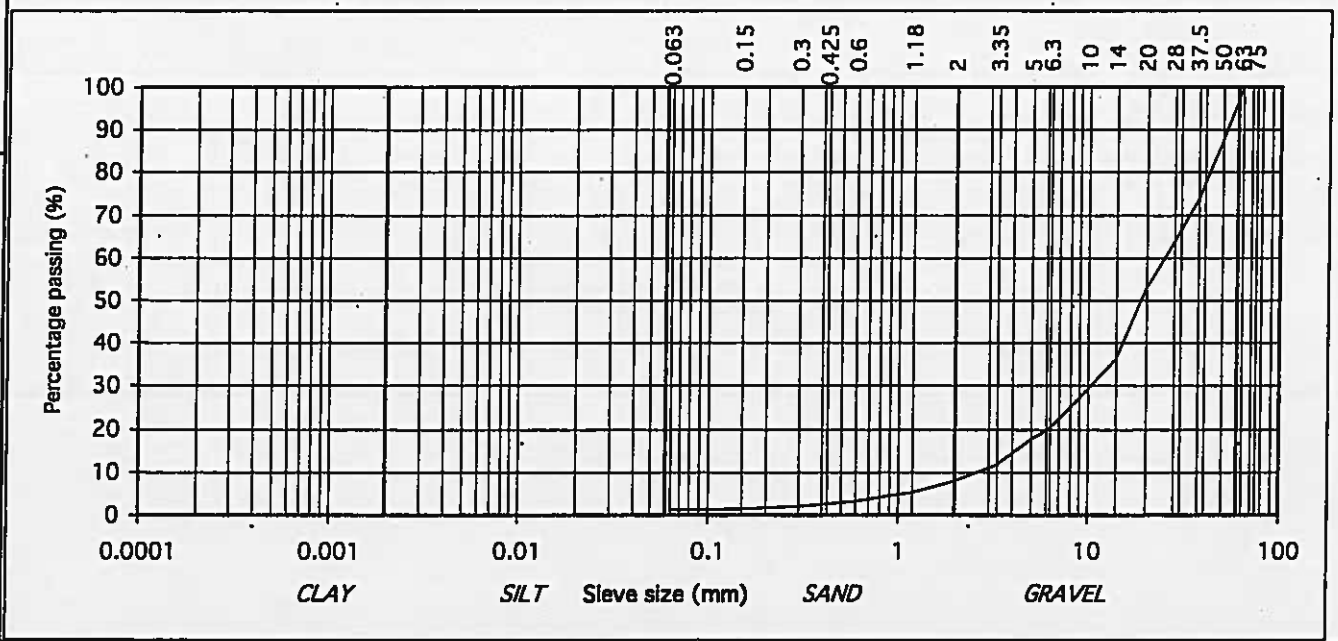
Sample Type: D

Depth (m): 4.00 Customer: Clifton Scannell Emerson, Seafort Lodge, Castledawson Avenue, Blackrock, Co. Dublin.

Date Received 24/06/2013 Date Testing started 24/06/2013

Description: Brown slightly clayey/silty, sandy, GRAVEL

Remarks Sample was did not meet the requirement of BS1377



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Persons authorized to approve reports: J Barrett (Dep Quality Manager) H Byrne (Quality Manager)

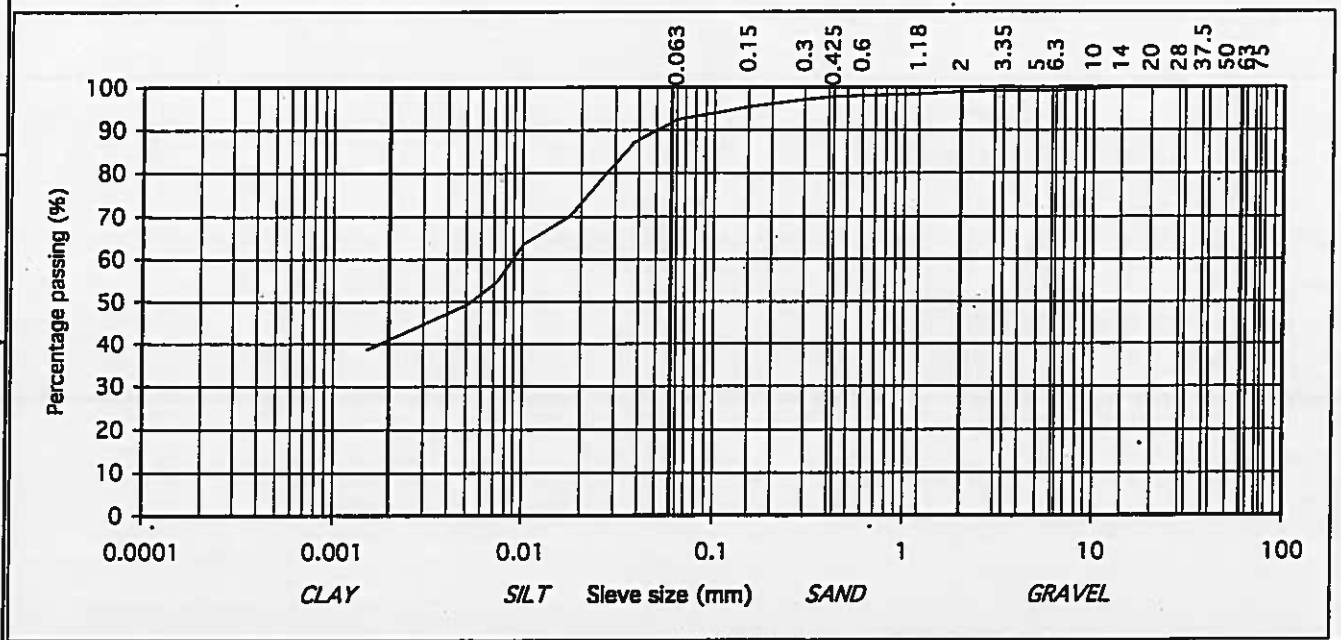
TEST REPORT
Determination of Particle Size Distribution

Tested in accordance with: BS1377:Part2:1990 , clause 9.2 & 9.5
(note: Sedimentation stage not accredited)

particle size	% passing	
75	100	COBBLES
63	100	
50	100	GRAVEL
37.5	100	
28	100	
20	100	
14	100	
10	99	
6.3	99	
5	99	
3.35	99	
2	99	
1.18	98	SAND
0.6	98	
0.425	98	
0.3	97	
0.15	95	
0.063	92	SILT/CLAY
0.038	87	
0.027	80	
0.017	70	
0.010	63	
0.007	54	
0.005	49	
0.002	39	

Contract No:	16912	Report No.	R52683
Contract:	Broadmeadow Cycle Route		
BH:	4		
Sample No.	3132	Lab. Sample No.	A13/2035
Sample Type:	D		
Depth (m):	1.00	Customer:	Clifton Scannell Emerson, Seafort Lodge, Castledawson Avenue, Blackrock, Co. Dublin.
Date Received	24/06/2013	Date Testing started	24/06/2013
Description:	Brown slightly sandy, slightly gravelly, CLAY		

Remarks



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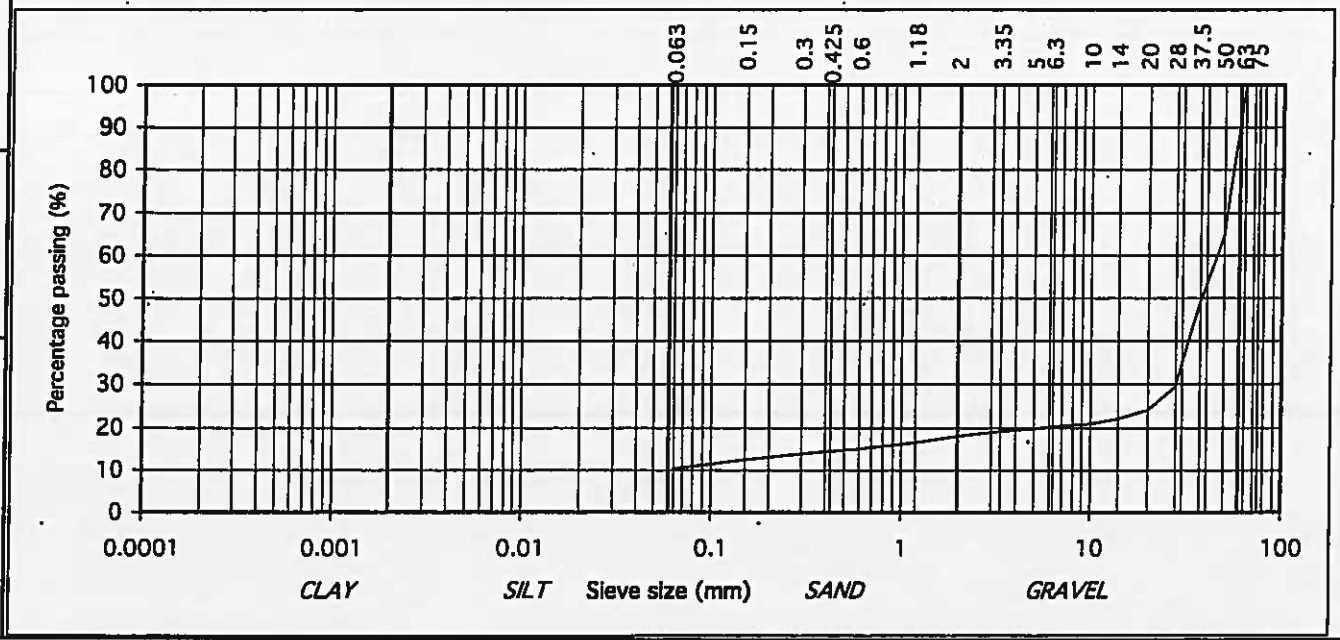
Persons authorized to approve reports: J Barrett (Dep Quality Manager) H Byrne (Quality Manager)

TEST REPORT
Determination of Particle Size Distribution

Tested in accordance with: BS1377:Part2:1990 , clause 9.2 & 9.5
(note: Sedimentation stage not accredited)

particle size	% passing	
75	100	COBBLES
63	100	
50	64	GRAVEL
37.5	49	
28	29	
20	24	
14	22	
10	21	
6.3	20	
5	20	
3.35	19	
2	18	
1.18	17	SAND
0.6	15	
0.425	14	
0.3	14	
0.15	12	
0.063	10	SILT/CLAY

Contract No:	16912	Report No.	R52684
Contract:	Broadmeadow Cycle Route		
BH:	5		
Sample No.	3135	Lab. Sample No.	A13/2037
Sample Type:	D		
Depth (m):	2.00	Customer:	Clifton Scannell Emerson, Seafort Lodge, Castledawson Avenue, Blackrock, Co. Dublin.
Date Received	24/06/2013	Date Testing started	24/06/2013
Description:	Grey brown silty, sandy, GRAVEL		
Remarks	Sample size did not meet the requirement of BS1377		



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TEST REPORT

Determination of Particle Size Distribution

Tested in accordance with: BS1377:Part2:1990 , clause 9.2 & 9.5

(note: Sedimentation stage not accredited)

particle size	% passing	
75	100	COBBLES
63	91	
50	87	GRAVEL
37.5	87	
28	84	
20	80	
14	71	
10	65	
6.3	50	
5	46	
3.35	37	
2	30	
1.18	23	SAND
0.6	14	
0.425	12	
0.3	9	
0.15	5	
0.063	3	SILT/CLAY

Contract No: 16912 Report No. R52685

Contract: Broadmeadow Cycle Route

BH: 6

Sample No. 3148 Lab. Sample No. A13/2038

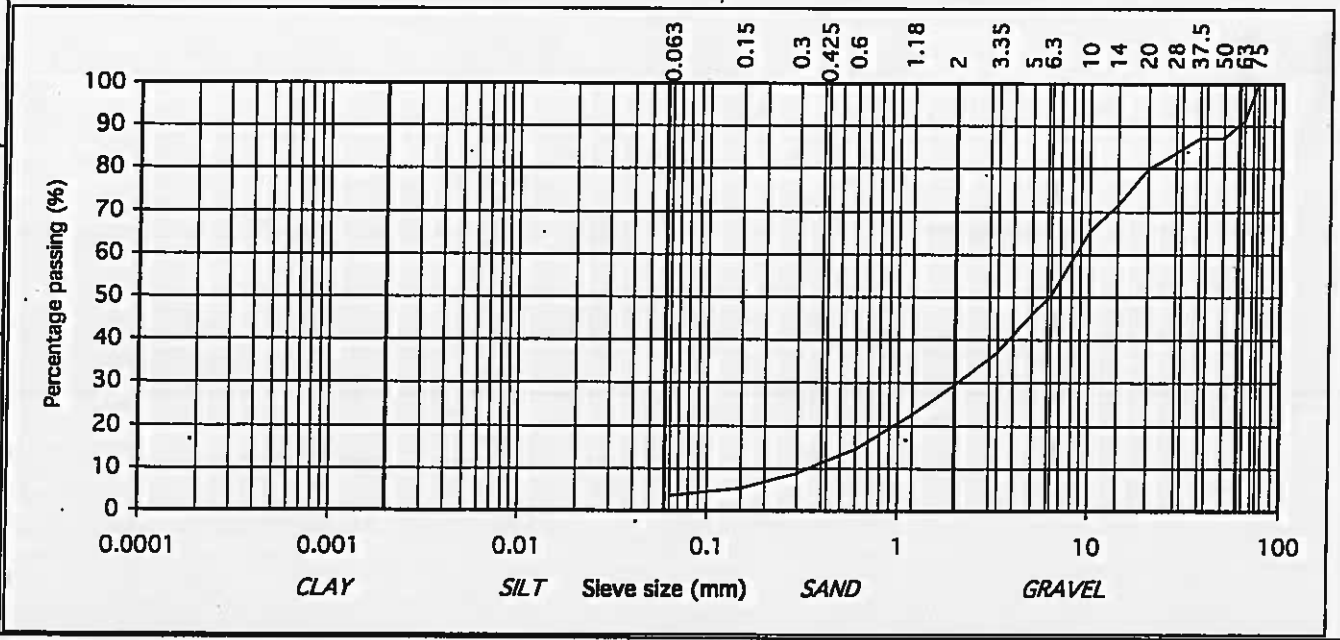
Sample Type: D

Depth (m): 2.00 Customer: Clifton Scannell Emerson, Seafort Lodge, Castledawson Avenue, Blackrock, Co. Dublin.

Date Received 24/06/2013 Date Testing started 24/06/2013

Description: Grey black slightly clayey/silty, very sandy, GRAVEL with some cobbles

Remarks



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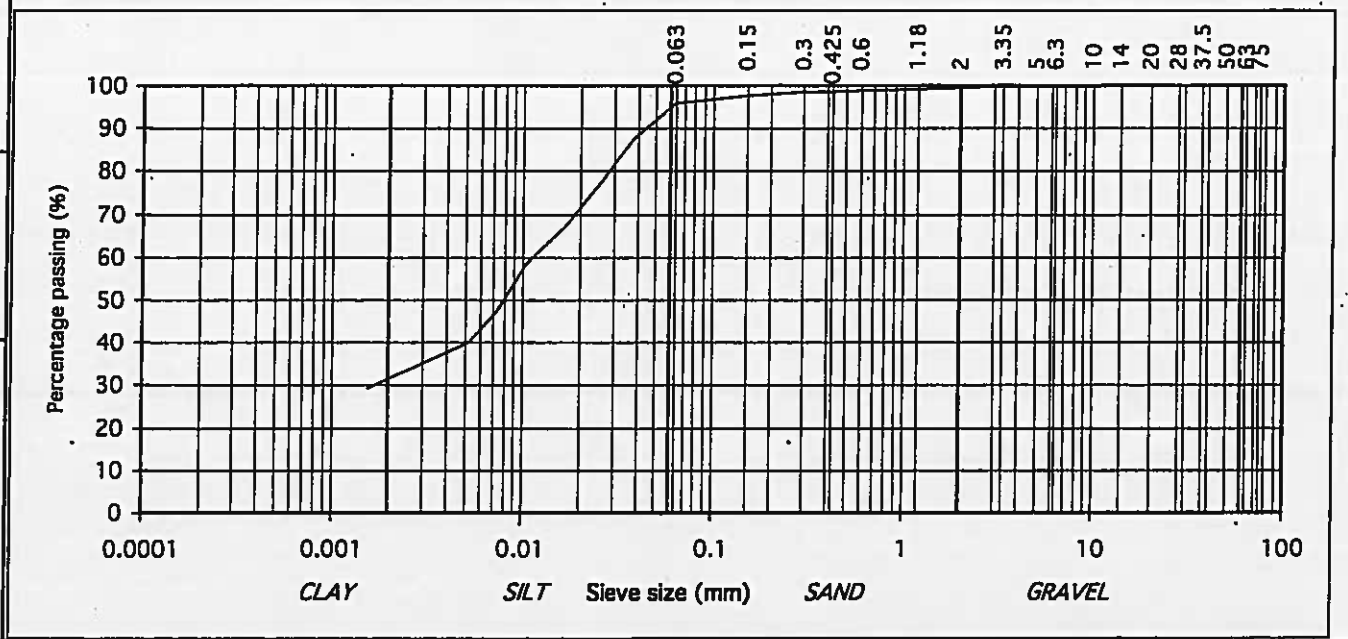
TEST REPORT
Determination of Particle Size Distribution

Tested in accordance with: BS1377:Part2:1990 , clause 9.2 & 9.5
(note: Sedimentation stage not accredited)

particle size	% passing	
75	100	COBBLES
63	100	
50	100	GRAVEL
37.5	100	
28	100	
20	100	
14	100	
10	100	
6.3	100	
5	100	
3.35	100	
2	99	
1.18	99	SAND
0.6	99	
0.425	99	
0.3	98	
0.15	98	
0.063	96	SILT/CLAY
0.038	87	
0.027	79	
0.017	68	
0.010	58	
0.007	47	
0.005	40	
0.002	29	

Contract No:	16912	Report No.	R52686
Contract:	Broadmeadow Cycle Route		
BH:	7		
Sample No.	3141	Lab. Sample No.	A13/2040
Sample Type:	D		
Depth (m):	5.00	Customer:	Clifton Scannell Emerson, Seafort Lodge, Castledawson Avenue, Blackrock, Co. Dublin.
Date Received	24/06/2013	Date Testing started	24/06/2013
Description:	Brown slightly sandy, slightly gravelly, CLAY		

Remarks



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Persons authorized to approve reports: J Barrett (Dep Quality Manager) H Byrne (Quality Manager)

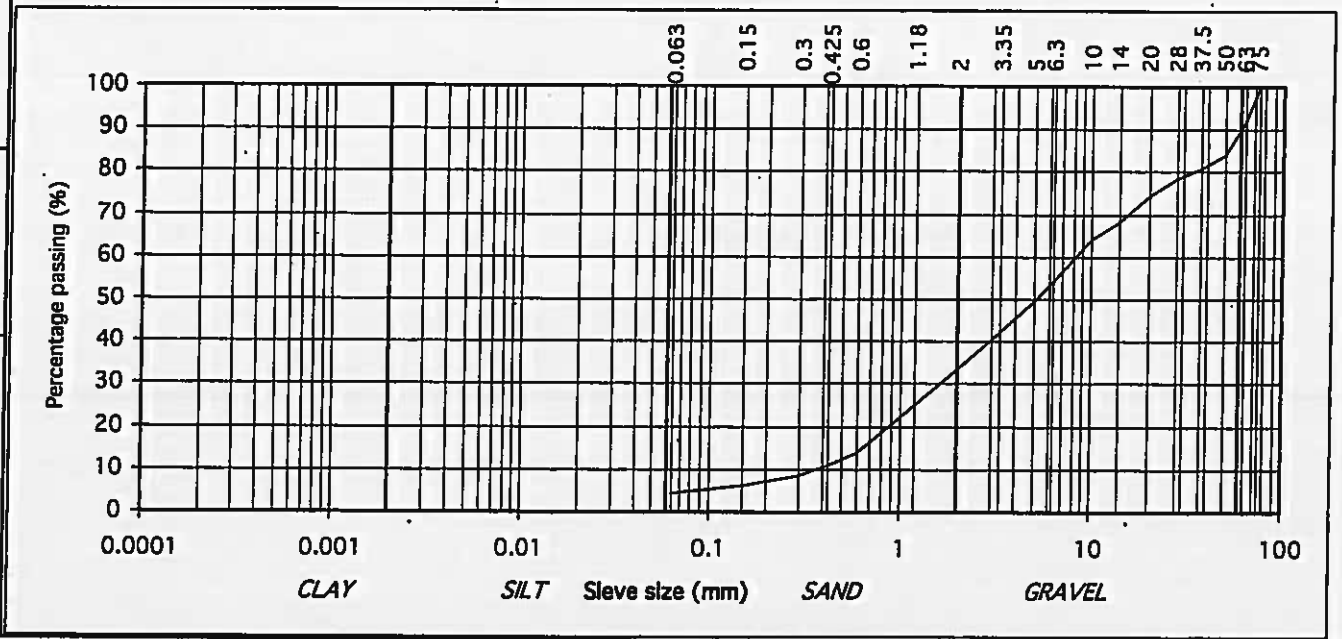
TEST REPORT

Determination of Particle Size Distribution

Tested in accordance with: BS1377:Part2:1990 , clause 9.2 & 9.5
(note: Sedimentation stage not accredited)

particle size	% passing	
75	100	COBBLES
63	92	
50	84	GRAVEL
37.5	81	
28	78	
20	74	
14	68	
10	64	
6.3	54	
5	49	
3.35	42	
2	33	
1.18	25	SAND
0.6	14	
0.425	11	
0.3	9	
0.15	6	
0.063	4	SILT/CLAY

Contract No: 16912 Report No. R52687
Contract: Broadmeadow Cycle Route
BH: 7
Sample No. 3144 Lab. Sample No. A13/2041
Sample Type: D
Depth (m): 8.00 Customer: Clifton Scannell Emerson, Seafort Lodge, Castledawson Avenue, Blackrock, Co. Dublin.
Date Received 24/06/2013 Date Testing started 24/06/2013
Description: Grey brown slightly clayey/silty, very sandy, GRAVEL with some cobbles
Remarks



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TEST REPORT

Determination of Particle Size Distribution

Tested in accordance with: BS1377:Part2:1990 , clause 9.2 & 9.5

(note: Sedimentation stage not accredited)

particle size	% passing	
75	55	COBBLES
63	55	
50	55	GRAVEL
37.5	54	
28	50	
20	46	
14	41	
10	37	
6.3	34	
5	32	
3.35	30	
2	27	
1.18	24	SAND
0.6	20	
0.425	19	
0.3	18	
0.15	15	
0.063	12	SILT/CLAY

Contract No: 16912 Report No. R52689

Contract: Broadmeadow Cycle Route

BH: 8

Sample No. 3151 Lab. Sample No. A13/2043

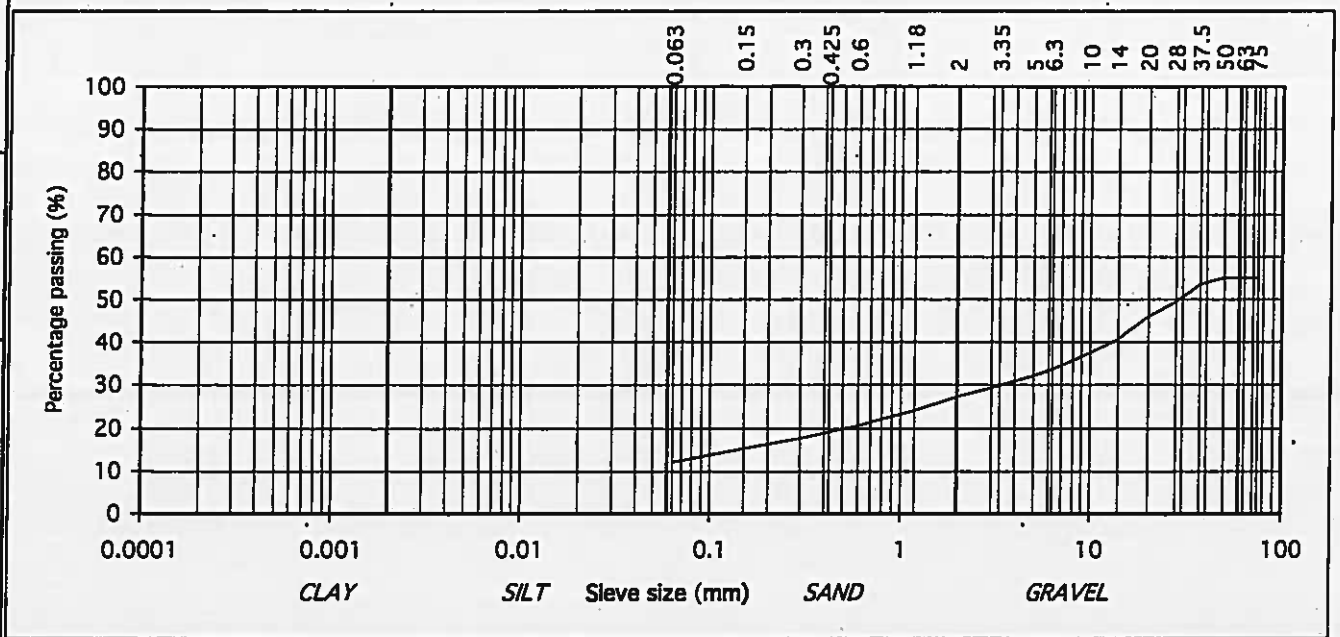
Sample Type: D

Depth (m): 2.00 Customer: Clifton Scannell Emerson, Seafort Lodge, Castledawson Avenue, Blackrock, Co. Dublin.

Date Received 24/06/2013 Date Testing started 24/06/2013

Description: Grey brown clayey/silty, sandy, GRAVEL with many cobbles

Remarks Sample size did not meet the requirement of BS1377



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Persons authorized to approve reports: J Barrett (Dep Quality Manager) H Byrne (Quality Manager)

TEST REPORT

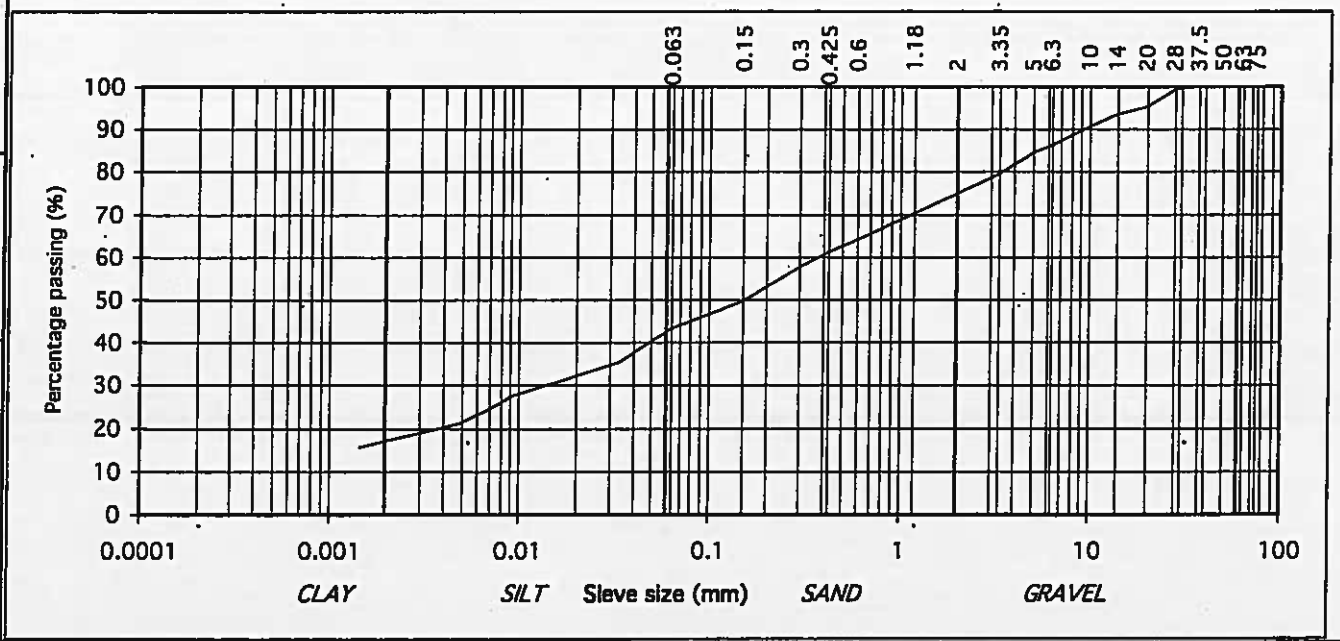
Determination of Particle Size Distribution

Tested in accordance with: BS1377:Part2:1990 , clause 9.2 & 9.5

(note: Sedimentation stage not accredited)

particle size	% passing	
75	100	COBBLES
63	100	
50	100	GRAVEL
37.5	100	
28	99	
20	95	
14	94	
10	91	
6.3	86	
5	85	
3.35	79	
2	75	
1.18	70	SAND
0.6	64	
0.425	61	
0.3	58	
0.15	50	
0.063	43	SILT/CLAY
0.034	35	
0.024	33	
0.016	31	
0.009	27	
0.007	24	
0.005	21	
0.001	15	

Contract No:	16912	Report No.	R52688
Contract:	Broadmeadow Cycle Route		
BH:	8		
Sample No.	3157	Lab. Sample No.	A13/2045
Sample Type:	D		
Depth (m):	8.00	Customer:	Clifton Scannell Emerson, Seafort Lodge, Castledawson Avenue, Blackrock, Co. Dublin.
Date Received	24/06/2013	Date Testing started	24/06/2013
Description:	Brown slightly sandy, slightly gravelly, CLAY		
Remarks			



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Persons authorized to approve reports: J Barrett (Dep Quality Manager) H Byrne (Quality Manager)

TEST REPORT

Determination of Particle Size Distribution

Tested in accordance with: BS1377:Part2:1990 , clause 9.2 & 9.5

(note: Sedimentation stage not accredited)

particle size	% passing	
75	100	COBBLES
63	86	
50	86	GRAVEL
37.5	79	
28	79	
20	77	
14	75	
10	72	
6.3	67	
5	65	
3.35	62	
2	58	
1.18	55	SAND
0.6	51	
0.425	48	
0.3	45	
0.15	38	
0.063	33	SILT/CLAY
0.037	28	
0.026	25	
0.017	22	
0.010	20	
0.007	17	
0.005	16	
0.002	10	

Contract No: 16912 Report No. R52690

Contract: Broadmeadow Cycle Route

BH: 9

Sample No. 362 Lab. Sample No. A13/2047

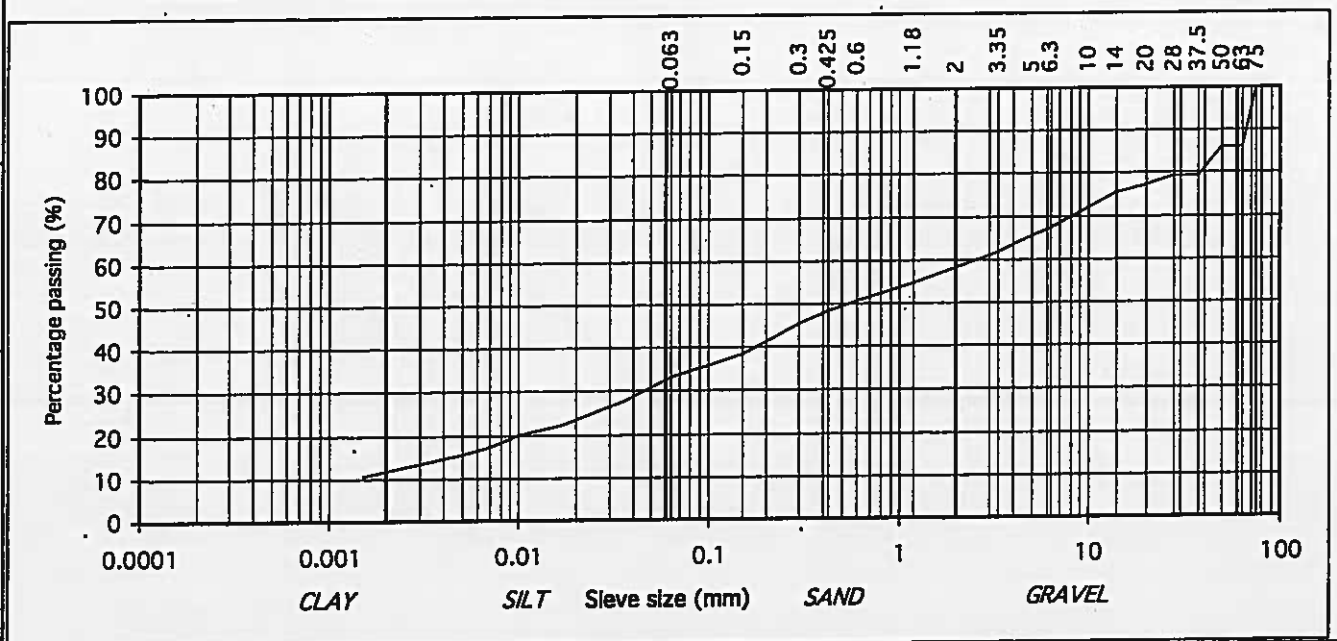
Sample Type: D

Depth (m): 4.00 Customer: Clifton Scannell Emerson, Seafort Lodge, Castledawson Avenue, Blackrock, Co. Dublin.

Date Received 24/06/2013 Date Testing started 24/06/2013

Description: Brown slightly sandy, gravelly, CLAY with some cobbles

Remarks Sample size did not meet the requirement of BS1377



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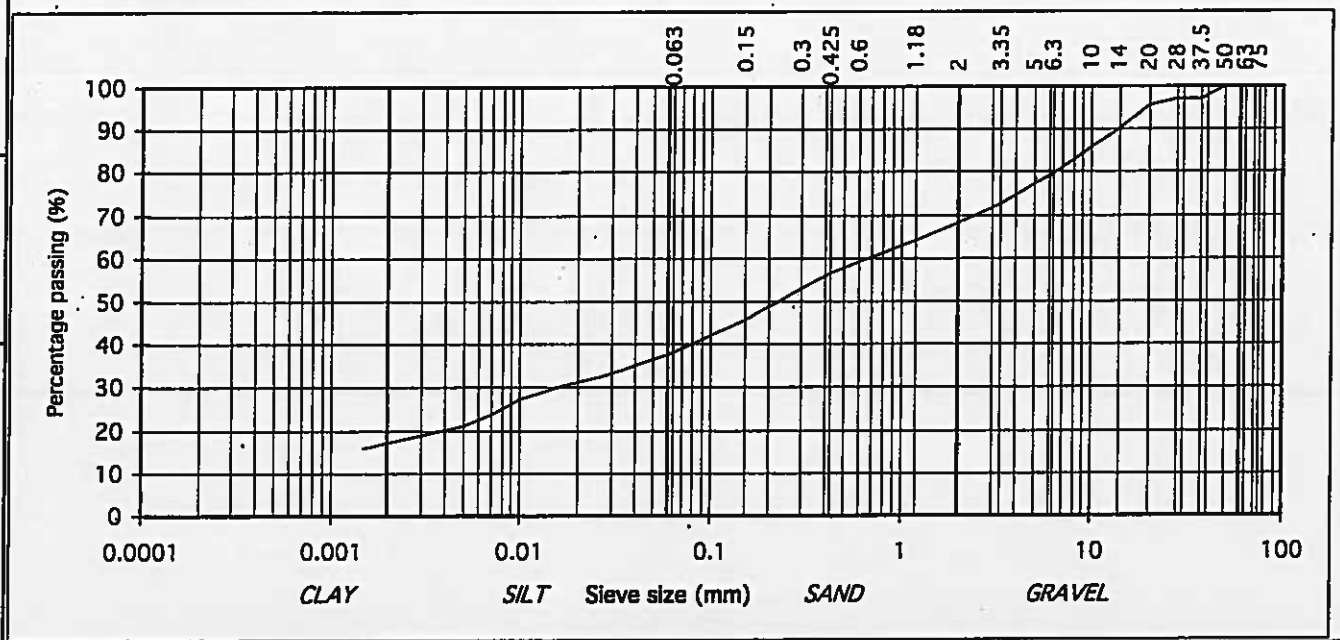
TEST REPORT
Determination of Particle Size Distribution

Tested in accordance with: BS1377:Part2:1990 , clause 9.2 & 9.5
(note: Sedimentation stage not accredited)

particle size	% passing	
75	100	COBBLES
63	100	
50	100	GRAVEL
37.5	97	
28	97	
20	95	
14	90	
10	86	
6.3	80	
5	77	
3.35	73	
2	68	
1.18	64	SAND
0.6	59	
0.425	56	
0.3	53	
0.15	46	
0.063	38	SILT/CLAY
0.037	35	
0.027	33	
0.017	30	
0.010	27	
0.007	24	
0.005	21	
0.002	16	

Contract No: 16912 Report No. R52691
Contract: Broadmeadow Cycle Route
BH: 10
Sample No. 368 Lab. Sample No. A13/2049
Sample Type: D
Depth (m): 4.00 Customer: Clifton Scannell Emerson, Seafort Lodge, Castledawson Avenue, Blackrock, Co. Dublin.
Date Received 24/06/2013 Date Testing started 24/06/2013
Description: Brown slightly sandy, slightly gravelly, CLAY

Remarks



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Persons authorized to approve reports: J Barrett (Dep Quality Manager) H Byrne (Quality Manager)

Jones Environmental Laboratory

Client Name:	IGSL
Reference:	16912
Location:	BROADMEADOW CYCLE ROUTE
Contact:	John Clancy
JE Job No.:	13/6112

Report : Solid

Solids: V=60g VOC jar, J=250g glass jar, T=plastic tub

J E Sample No.	1	2	3	4	5						LOD	Units	Method No.
Sample ID	BH01	BH02	BH04	BH08	BH09								
Depth	1.00	1.00	1.00	1.00	2.00								
COC No / misc													
Containers	J	J	J	J	J								
Sample Date	25/06/2013	25/06/2013	25/06/2013	25/06/2013	25/06/2013								
Sample Type	Soil	Soil	Soil	Soil	Soil								
Batch Number	1	1	1	1	1								
Date of Receipt	03/07/2013	03/07/2013	03/07/2013	03/07/2013	03/07/2013								
Sulphate as SO4 (2:1 Ext) #	0.1689	0.3217	0.0212	0.0141	0.0512						<0.0015	g/l	TM38/PM20
pH #	8.03	9.15	8.75	8.69	8.21						<0.01	pH units	TM73/PM11

Please see attached notes for all abbreviations and acronyms

Please include all sections of this report if it is reproduced

All solid results are expressed on a dry weight basis unless stated otherwise.

IGSL Ltd
Materialss Laboratory
M7 Business Park
Naas
Co. Kildare

Test Report

Undrained shear strength in triaxial compression
(without pore pressure measurement)

Tested in accordance with BS1377:Part 7:1990 clause 8
(definitive method)

Report no: R52694

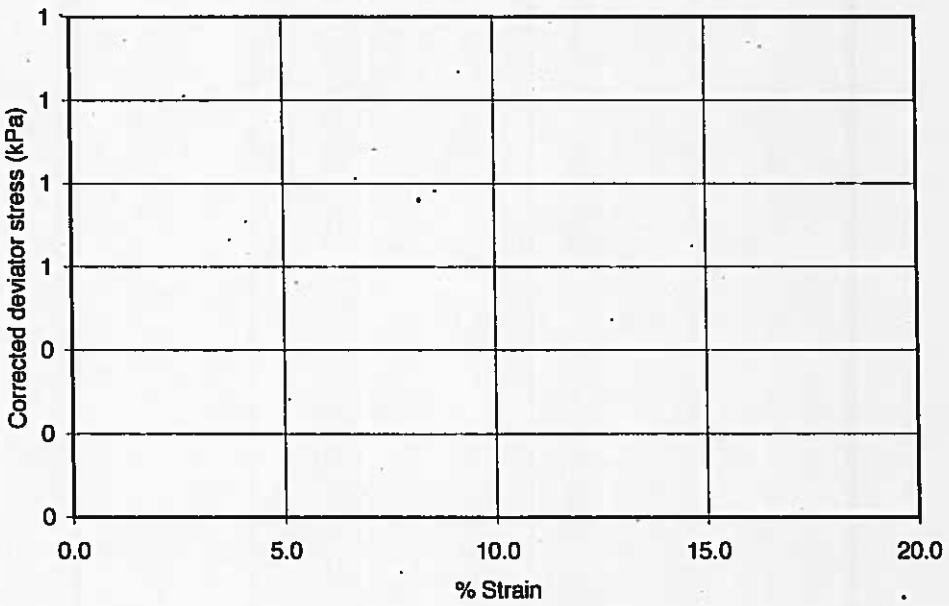
Contract Name: Broadmeadow Cycle Route Contract No: 16912

Location: Bh 7 3138 @ 2m Lab Sample No. A13/2039

Description: Grey brown sandy slightly gravelly SILT

Customer: Clifton Scannell Emerson, Seafort Lodge, Castledawson Avenue, Blackrock, Co. Dublin.

Height (mm)	200	Diameter	100	Cell pressure	200
Moisture Content %	49	Bulk density (Mg/m^3)	1.82	Dry density (Mg/m^3)	1.22



Strain at failure %	0	Cohesion C_u (kPa) (Undrained shear strength kPa)	0
Rate of strain (%/minute)	0.00		
Thickness of membrane	0.0	Membrane correction (at failure)	0
Date received	24/06/13	Date tested	06/07/13

Sample remoulded using 2.5kg rammer at "as received" moisture content in 5 layers with 25 blows per layer
Sample unable to support its own weight, not possible to test

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IGSL Ltd Materialss Laboratory M7 Business Park Naas Co. Kildare	**Test Report** Undrained shear strength in triaxial compression (without pore pressure measurement) Tested in accordance with BS1377:Part 7:1990 clause 8 (definitive method)	ISO 17025 IVNAB ACCREDITED TESTING DETAILED IN SCOPE REG NO. 1337

Report no: R52693

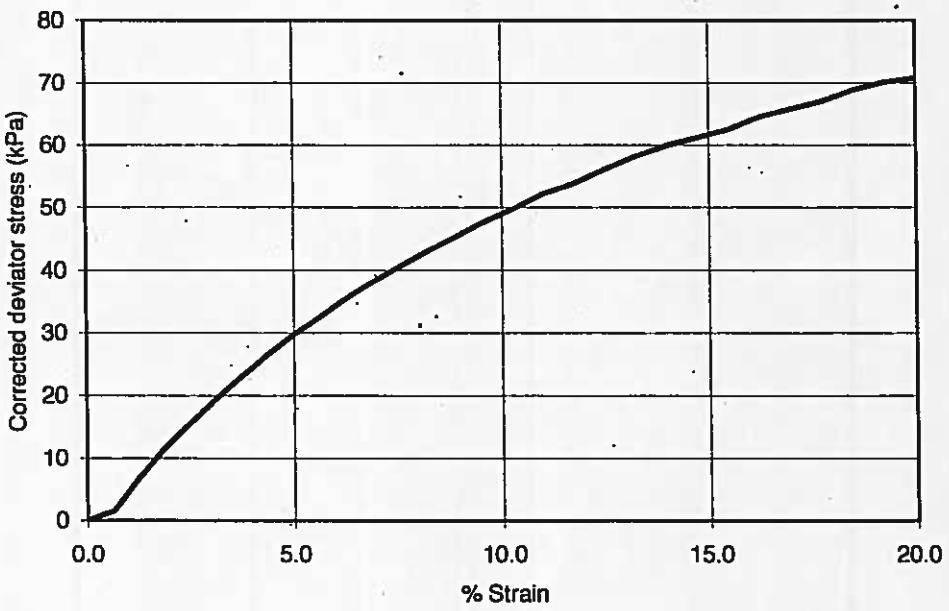
Contract Name: Broadmeadow Cycle Route Contract No: 16912

Location: Bh 9 360 @ 2m Lab Sample No. A13/2046

Description: Brown sandy gravelly CLAY

Customer: Clifton Scannell Emerson, Seafort Lodge, Castledawson Avenue, Blackrock, Co. Dublin.

Height (mm)	200	Diameter	100	Cell pressure	200
Moisture Content %	14	Bulk density (Mg/m^3)	2.35	Dry density (Mg/m^3).	2.07



Strain at failure %	20	Cohesion C_u (kPa) (Undrained shear strength kPa)	35
Rate of strain (%/minute)	1.00		
Thickness of membrane	0.4	Membrane correction (at failure)	1.49
Date received	24/06/13	Date tested	06/07/13

Sample remoulded using 2.5kg rammer at "as received" moisture content in 5 layers with 25 blows per layer

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Project No. 16912	GROUNDWATER MONITORING DATA SHEET	IGSL Ltd

Project: Broadmeadow Cycle Network

Engineer: Clifton Scannell Emerson

Exploratory Hole No.	Hole Depth (m bgl)	Response Zone Top (m bgl)	Response Zone Base (m bgl)	Groundwater Level (m bgl) (11/07/2013)	Groundwater Level (m bgl)	Groundwater Level (m bgl)	Comments
BH1	3.00	1.00	3.00	1.84			
BH 4	1.80	0.80	1.80	1.43			

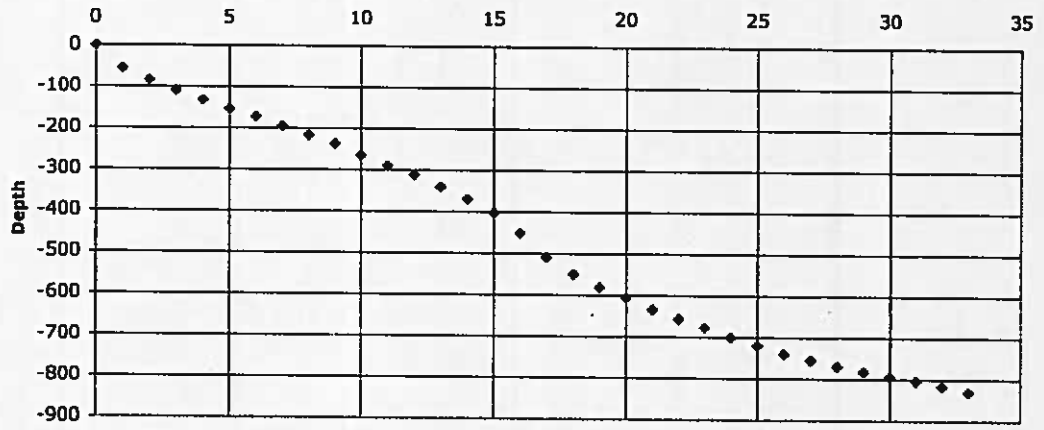
Remarks: Water levels measured using electric dipmeter
BH - denotes cable percussion borehole
RC - denotes rotary core drillhole

Dynamic Cone Penetrometer

Contract	Broadmeadow Cycle Route	**Date:**	19/07/2013
Ref No.	16912	**Test No.**	DCP1
Client	Clifton Scannell Emerson	**DCP Zero Reading**	130 mm
Location	BH1	**Start of Test at:**	0.3m below GL
Direction		**Approximate Chainage**	
Soil Description	Firm, greyish brown, silty CLAY with some cobbles		

No of Blows	Total Blows	Reading mm	No of Blows	Total Blows	Reading mm	No of Blows	Total Blows	Reading mm
0	0	130	1	21	764	1	42	
1	1	187	1	22	787	1	43	
1	2	215	1	23	806	1	44	
1	3	240	1	24	830	1	45	
1	4	263	1	25	850	1	46	
1	5	285	1	26	870	1	47	
1	6	304	1	27	885	1	48	
1	7	325	1	28	899	1	49	
1	8	347	1	29	911	1	50	
1	9	368	1	30	923	1	51	
1	10	395	1	31	933	1	52	
1	11	420	1	32	945	1	53	
1	12	443	1	33	960	1	54	
1	13	470	1	34		1	55	
1	14	500	1	35		1	56	
1	15	533	1	36		1	57	
1	16	582	1	37		1	58	
1	17	640	1	38		1	59	
1	18	680	1	39		1	60	
1	19	711	1	40		1	61	
1	20	736	1	41		1	62	

DCP Chart



	From	to	Penetration	mm / blow
Depth range (mm)	187	960	773	24.1563
Blows	1	33	32	

TRRL RN8 Log10 (CBR) = 2.48-1.057*Log10 (mm/blow)

Log10(CBR) = 1.018

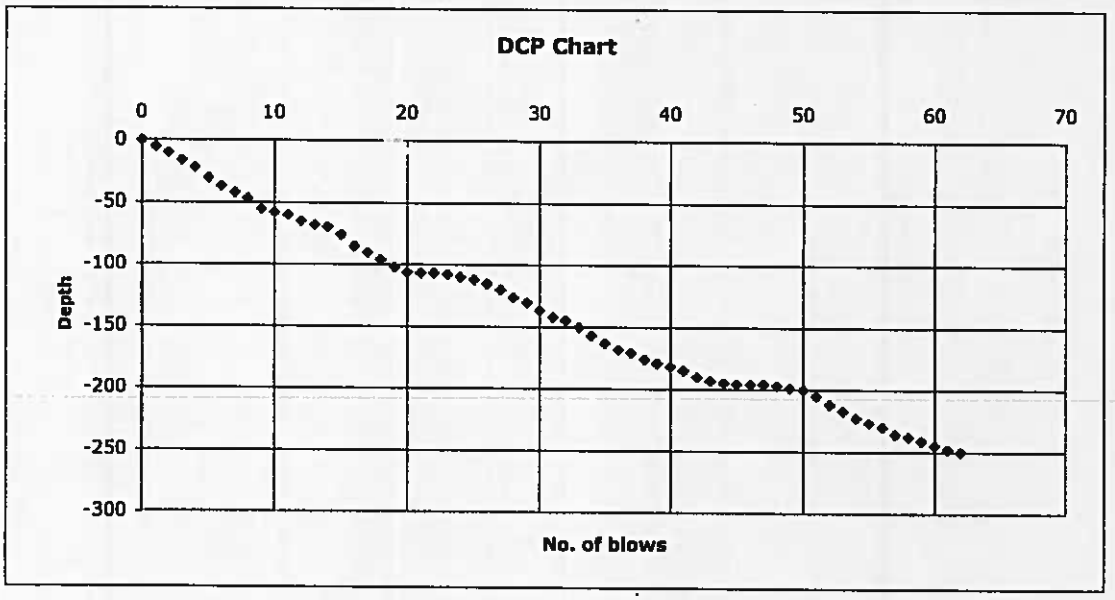
CBR = 10.426

Dynamic Cone Penetrometer

Contract	Broadmeadow Cycle Route	**Date:**	19/07/2013 **Test No.** DCP2
Ref No.	16912		
Client	Clifton Scannell Emerson	**DCP Zero Reading**	125 mm
Location	BH2		
Direction		**Start of Test at:**	0.25m below GL
Soil Description		**Approximate Chainage**	

MADE GROUND(cobbles, concrete, red brick, gravel.clay)

No of Blows	*Total Blows*	*Reading mm*	*No of Blows*	*Total Blows*	*Reading mm*	*No of Blows*	*Total Blows*	*Reading mm*
0	0	125	1	21	232	1	42	315
1	1	130	1	22	232	1	43	318
1	2	135	1	23	233	1	44	320
1	3	141	1	24	235	1	45	321
1	4	147	1	25	237	1	46	321
1	5	155	1	26	240	1	47	321
1	6	162	1	27	245	1	48	322
1	7	167	1	28	251	1	49	324
1	8	172	1	29	255	1	50	325
1	9	180	1	30	262	1	51	330
1	10	183	1	31	267	1	52	337
1	11	185	1	32	270	1	53	342
1	12	190	1	33	275	1	54	348
1	13	193	1	34	282	1	55	352
1	14	195	1	35	288	1	56	355
1	15	201	1	36	293	1	57	361
1	16	210	1	37	296	1	58	363
1	17	215	1	38	301	1	59	366
1	18	221	1	39	304	1	60	370
1	19	227	1	40	307	1	61	373
1	20	231	1	41	310	1	62	375



	From	to	Penetration	mm / blow
Depth range (mm)	130	375	245	4.0164
Blows	1	62	61	

TRRL RN8 Log10 (CBR) = 2.48-1.057*Log10 (mm/blow)

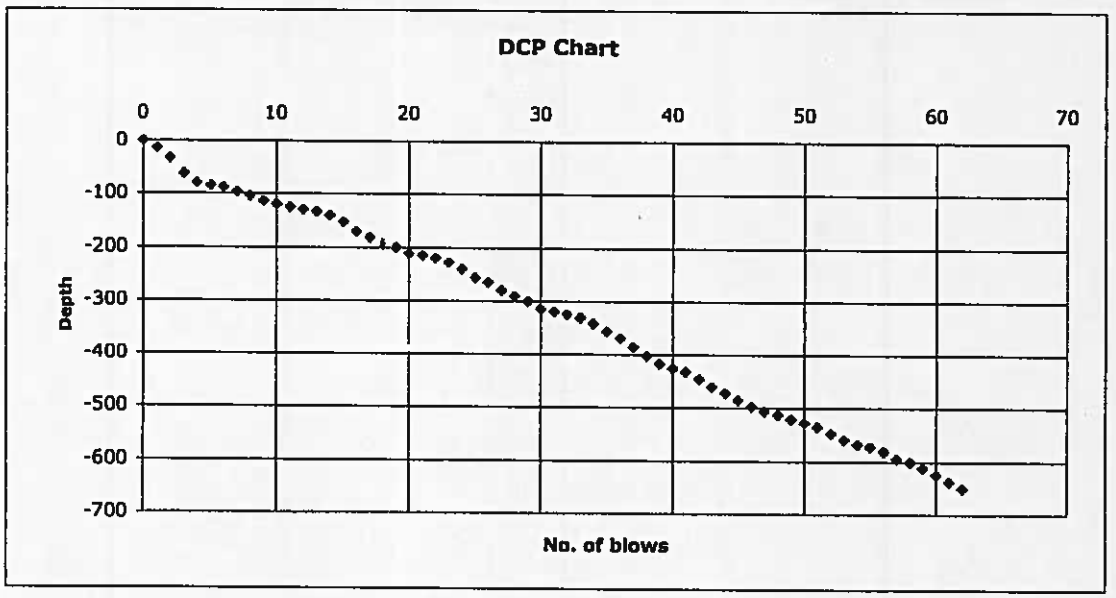
Log10(CBR) = 1.842

CBR = 69.462

Dynamic Cone Penetrometer

Contract	Broadmeadow Cycle Route	**Date:**	19/07/2013
Ref No.	16912	**Test No.**	DCP3
Client	Clifton Scannell Emerson		
Location	BH3	**DCP Zero Reading**	110 mm
Direction		**Start of Test at:**	0.3m below GL
Soil Description		**Approximate Chainage**	
Firm, brown, gravelly slightly silty CLAY			

No of Blows	*Total Blows*	*Reading mm*	*No of Blows*	*Total Blows*	*Reading mm*	*No of Blows*	*Total Blows*	*Reading mm*
0	0	110	1	21	325	1	42	555
1	1	125	1	22	330	1	43	569
1	2	143	1	23	339	1	44	582
1	3	172	1	24	351	1	45	595
1	4	190	1	25	367	1	46	607
1	5	195	1	26	375	1	47	615
1	6	199	1	27	390	1	48	622
1	7	207	1	28	401	1	49	630
1	8	215	1	29	410	1	50	638
1	9	224	1	30	425	1	51	645
1	10	230	1	31	430	1	52	657
1	11	235	1	32	435	1	53	669
1	12	240	1	33	440	1	54	677
1	13	244	1	34	452	1	55	682
1	14	251	1	35	466	1	56	691
1	15	263	1	36	478	1	57	704
1	16	281	1	37	495	1	58	710
1	17	292	1	38	512	1	59	721
1	18	304	1	39	527	1	60	735
1	19	310	1	40	535	1	61	748
1	20	321	1	41	542	1	62	760



	From	to	Penetration	mm / blow
Depth range (mm)	125	760	635	10.4098
Blows	1	62	61	

TRRL RN8 Log10 (CBR) = 2.48-1.057*Log10 (mm/blow)

Log10(CBR) = 1.405

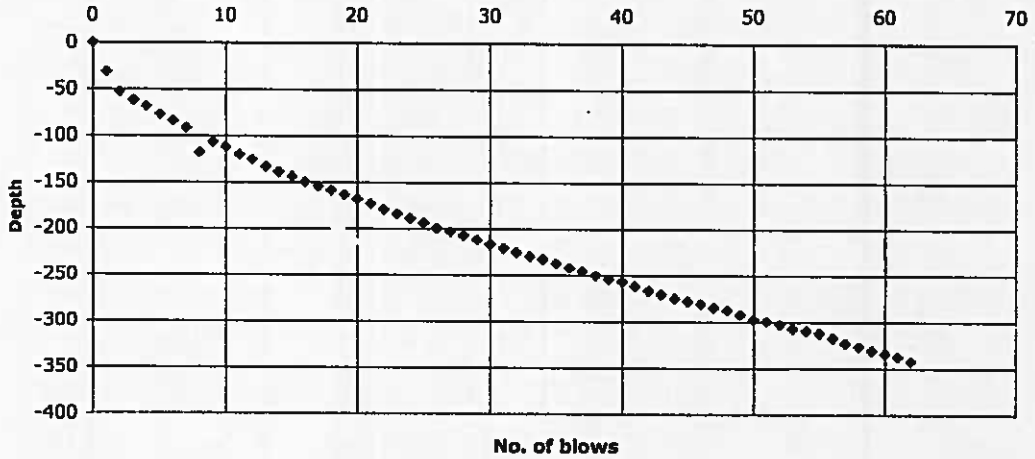
CBR = 25.384

Dynamic Cone Penetrometer

Contract	Broadmeadow Cycle Route	**Date:**	19/07/2013
Ref No.	16912	**Test No.**	DCP4
Client	Clifton Scannell Emerson		
DCP Zero Reading	113 mm		
Location	BH4		
Direction		**Start of Test at:**	0.3m below GL
Soil Description		**Approximate Chainage**	
Firm/stiff, greyish brown, silty CLAY with some cobbles			

No of Blows	*Total Blows*	*Reading mm*	*No of Blows*	*Total Blows*	*Reading mm*	*No of Blows*	*Total Blows*	*Reading mm*
0	0	113	1	21	286	1	42	380
1	1	144	1	22	292	1	43	383
1	2	166	1	23	297	1	44	387
1	3	175	1	24	302	1	45	390
1	4	181	1	25	307	1	46	393
1	5	190	1	26	312	1	47	397
1	6	197	1	27	316	1	48	400
1	7	205	1	28	320	1	49	405
1	8	231	1	29	325	1	50	410
1	9	219	1	30	330	1	51	412
1	10	225	1	31	334	1	52	416
1	11	233	1	32	338	1	53	420
1	12	239	1	33	342	1	54	422
1	13	246	1	34	345	1	55	425
1	14	252	1	35	350	1	56	430
1	15	257	1	36	355	1	57	435
1	16	262	1	37	358	1	58	439
1	17	267	1	38	363	1	59	443
1	18	271	1	39	367	1	60	446
1	19	276	1	40	370	1	61	450
1	20	281	1	41	375	1	62	455

DCP Chart



	From	to	Penetration	mm / blow
Depth range (mm)	144	455	311	5.0984
Blows	1	62	61	

TRRL RN8 Log10 (CBR) = 2.48-1.057*Log10 (mm/blow)

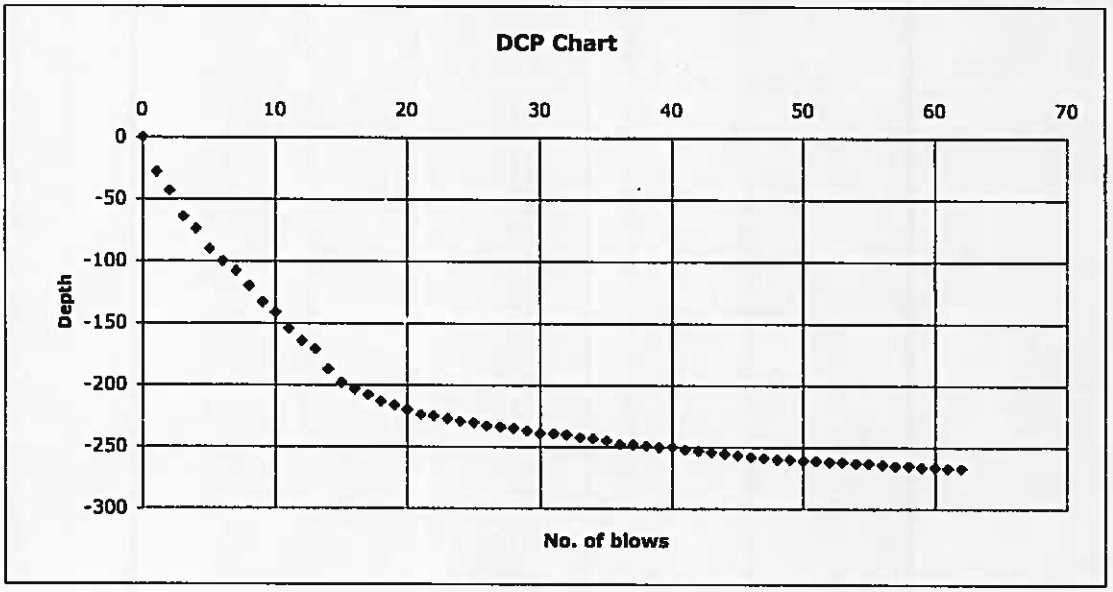
Log10(CBR) = 1.732

CBR = 53.982

Dynamic Cone Penetrometer

Contract	Broadmeadow Cycle Route	**Date:**	19/07/2013
Ref No.	16912	**Test No.**	DCP5
Client	Clifton Scannell Emerson	**DCP Zero Reading**	112 mm
Location	BH5	**Start of Test at:**	0.35m below GL
Direction		**Approximate Chainage**	
Soil Description	Firm, greyish brown, slightly gravelly silty CLAY with some cobbles		

No of Blows	*Total Blows*	*Reading mm*	*No of Blows*	*Total Blows*	*Reading mm*	*No of Blows*	*Total Blows*	*Reading mm*
0	0	112	1	21	336	1	42	365
1	1	140	1	22	337	1	43	366
1	2	155	1	23	339	1	44	367
1	3	176	1	24	341	1	45	369
1	4	186	1	25	342	1	46	370
1	5	202	1	26	345	1	47	371
1	6	212	1	27	346	1	48	372
1	7	220	1	28	347	1	49	372
1	8	232	1	29	349	1	50	373
1	9	245	1	30	351	1	51	373
1	10	253	1	31	351	1	52	374
1	11	266	1	32	352	1	53	374
1	12	276	1	33	354	1	54	375
1	13	283	1	34	355	1	55	375
1	14	299	1	35	357	1	56	376
1	15	310	1	36	360	1	57	377
1	16	315	1	37	360	1	58	377
1	17	320	1	38	361	1	59	378
1	18	325	1	39	362	1	60	378
1	19	328	1	40	362	1	61	379
1	20	332	1	41	364	1	62	379



	From	to	Penetration	mm / blow
Depth range (mm)	140	379	239	3.9180
Blows	1	62	61	

TRRL RN8 Log10 (CBR) = 2.48-1.057*Log10 (mm/blow)

Log10(CBR) = 1.853

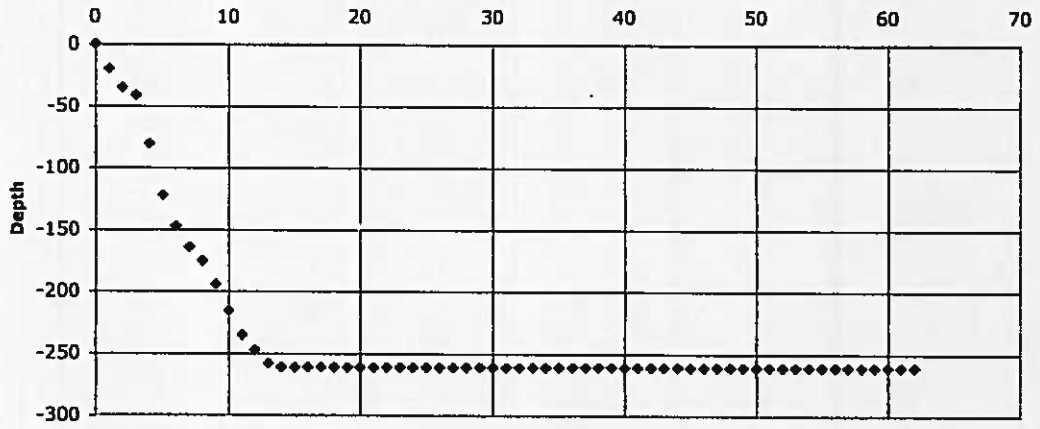
CBR = 71.306

Dynamic Cone Penetrometer

Contract	Broadmeadow Cycle Route	**Date:**	19/07/2013
Ref No.	16912	**Test No.**	DCP6
Client	Clifton Scannell Emerson	**DCP Zero Reading**	140 mm
Location	BH6	**Start of Test at:**	0.3m below GL
Direction		**Approximate Chainage**	
Soil Description	MADE GROUND (angular cobbles and boulders, gravel)		

No of Blows	*Total Blows*	*Reading mm*	*No of Blows*	*Total Blows*	*Reading mm*	*No of Blows*	*Total Blows*	*Reading mm*
0	0	140	1	21	401	1	42	401
1	1	160	1	22	401	1	43	401
1	2	175	1	23	401	1	44	401
1	3	181	1	24	401	1	45	401
1	4	220	1	25	401	1	46	401
1	5	262	1	26	401	1	47	401
1	6	287	1	27	401	1	48	401
1	7	304	1	28	401	1	49	401
1	8	315	1	29	401	1	50	401
1	9	334	1	30	401	1	51	401
1	10	355	1	31	401	1	52	401
1	11	375	1	32	401	1	53	401
1	12	387	1	33	401	1	54	401
1	13	398	1	34	401	1	55	401
1	14	401	1	35	401	1	56	401
1	15	401	1	36	401	1	57	401
1	16	401	1	37	401	1	58	401
1	17	401	1	38	401	1	59	401
1	18	401	1	39	401	1	60	401
1	19	401	1	40	401	1	61	401
1	20	401	1	41	401	1	62	401

DCP Chart



	From	to	Penetration	mm / blow
Depth range (mm)	160	401	241	18.5385
Blows	1	14	13	

TRRL RN8 Log10 (CBR) = 2.48-1.057*Log10 (mm/blow)

Log10(CBR) = 1.140

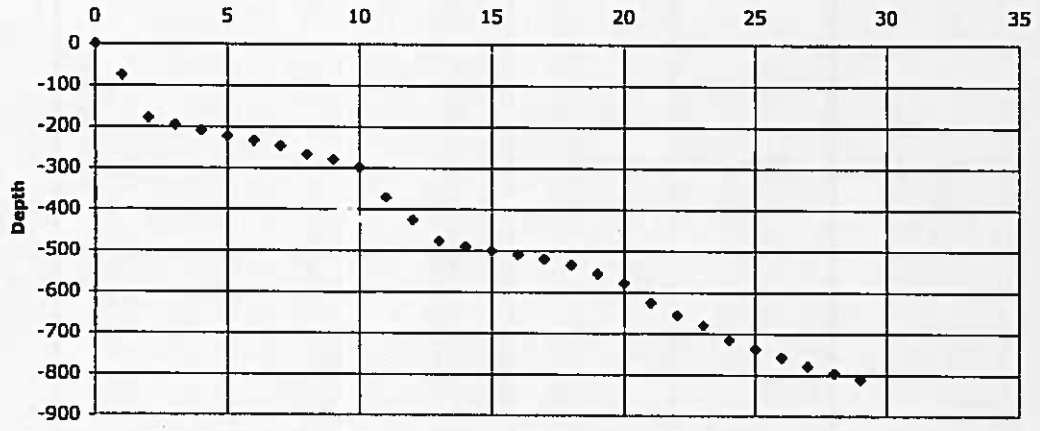
CBR = 13.793

Dynamic Cone Penetrometer

Contract	Broadmeadow Cycle Route	**Date:** 19/07/2013	**Test No.** DCP6A
Ref No.	16912		
Client	Clifton Scannell Emerson	**DCP Zero Reading**	145 mm
Location	BH6		
Direction		**Start of Test at:**	0.5m below GL
Soil Description		**Approximate Chainage**	
Firm, greyish brown, silty CLAY with gravel and cobbles			

No of Blows	*Total Blows*	*Reading mm*	*No of Blows*	*Total Blows*	*Reading mm*	*No of Blows*	*Total Blows*	*Reading mm*
0	0	145	1	21	770	1	42	
1	1	220	1	22	800	1	43	
1	2	325	1	23	825	1	44	
1	3	340	1	24	861	1	45	
1	4	355	1	25	883	1	46	
1	5	369	1	26	903	1	47	
1	6	379	1	27	923	1	48	
1	7	392	1	28	940	1	49	
1	8	412	1	29	955	1	50	
1	9	425	1	30		1	51	
1	10	443	1	31		1	52	
1	11	515	1	32		1	53	
1	12	570	1	33		1	54	
1	13	620	1	34		1	55	
1	14	634	1	35		1	56	
1	15	645	1	36		1	57	
1	16	655	1	37		1	58	
1	17	665	1	38		1	59	
1	18	680	1	39		1	60	
1	19	700	1	40		1	61	
1	20	722	1	41		1	62	

DCP Chart



	From	to	Penetration	mm / blow
Depth range (mm)	220	955	735	26.2500
Blows	1	29	28	

TRRL RN8 Log10 (CBR) = 2.48-1.057*Log10 (mm/blow)

Log10(CBR) = 0.980

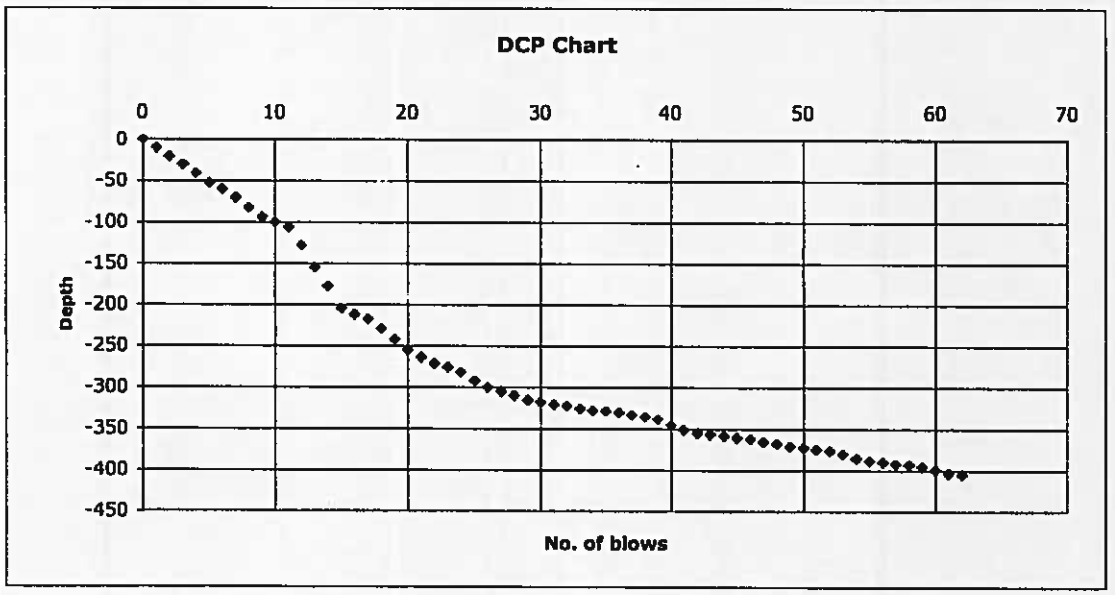
CBR = 9.549

Dynamic Cone Penetrometer

Contract	Broadmeadow Cycle Route	**Date:**	19/07/2013
Ref No.	16912	**Test No.**	DCP7
Client	Clifton Scannell Emerson	**DCP Zero Reading**	105 mm
Location	BH7		
Direction		**Start of Test at:**	0.3m below GL
Soil Description		**Approximate Chainage**	

MADE GROUND (cobbles and boulders) / Soft, brown, sl.sandy sl.gravelly CLAY with cobbles

No of Blows	*Total Blows*	*Reading mm*	*No of Blows*	*Total Blows*	*Reading mm*	*No of Blows*	*Total Blows*	*Reading mm*
0	0	105	1	21	368	1	42	460
1	1	115	1	22	375	1	43	461
1	2	125	1	23	380	1	44	463
1	3	135	1	24	386	1	45	465
1	4	146	1	25	397	1	46	467
1	5	157	1	26	405	1	47	470
1	6	165	1	27	410	1	48	472
1	7	175	1	28	414	1	49	475
1	8	187	1	29	420	1	50	477
1	9	199	1	30	422	1	51	479
1	10	205	1	31	425	1	52	481
1	11	211	1	32	427	1	53	485
1	12	233	1	33	430	1	54	490
1	13	260	1	34	432	1	55	493
1	14	282	1	35	433	1	56	495
1	15	310	1	36	435	1	57	497
1	16	317	1	37	438	1	58	498
1	17	322	1	38	440	1	59	500
1	18	334	1	39	443	1	60	504
1	19	347	1	40	450	1	61	508
1	20	360	1	41	456	1	62	510



	From	to	Penetration	mm / blow
Depth range (mm)	115	510	395	6.4754
Blows	1	62	61	

TRRL RN8 Log10 (CBR) = 2.48-1.057*Log10 (mm/blow)

Log10(CBR) = 1.622

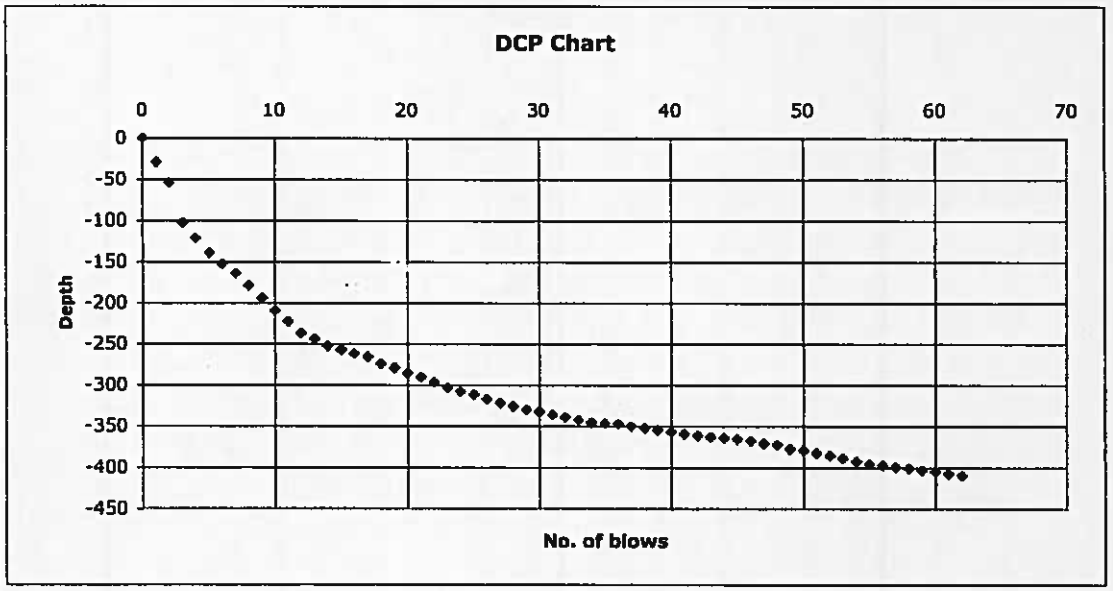
CBR = 41.927

Dynamic Cone Penetrometer

Contract	Broadmeadow Cycle Route	**Date:** 19/07/2013	**Test No.** DCP8
Ref No.	16912		
Client	Clifton Scannell Emerson	**DCP Zero Reading**	108 mm
Location	BH8		
Direction		**Start of Test at:**	0.3m below GL
Soil Description		**Approximate Chainage**	

Firm, brown, gravelly CLAY with large cobbles (possible fill)

No of Blows	*Total Blows*	*Reading mm*	*No of Blows*	*Total Blows*	*Reading mm*	*No of Blows*	*Total Blows*	*Reading mm*
0	0	108	1	21	398	1	42	470
1	1	138	1	22	404	1	43	471
1	2	162	1	23	411	1	44	472
1	3	210	1	24	416	1	45	474
1	4	230	1	25	420	1	46	476
1	5	247	1	26	425	1	47	479
1	6	260	1	27	430	1	48	481
1	7	272	1	28	434	1	49	485
1	8	287	1	29	438	1	50	487
1	9	302	1	30	440	1	51	490
1	10	317	1	31	444	1	52	493
1	11	331	1	32	447	1	53	496
1	12	345	1	33	450	1	54	500
1	13	352	1	34	453	1	55	503
1	14	360	1	35	454	1	56	505
1	15	365	1	36	455	1	57	507
1	16	370	1	37	458	1	58	509
1	17	374	1	38	460	1	59	511
1	18	382	1	39	463	1	60	513
1	19	387	1	40	465	1	61	515
1	20	393	1	41	467	1	62	517



	From	to	Penetration	mm / blow
Depth range (mm)	138	517	379	6.2131
Blows	1	62	61	

TRRL RN8 Log10 (CBR) = 2.48-1.057*Log10 (mm/blow)

Log10(CBR) = 1.641

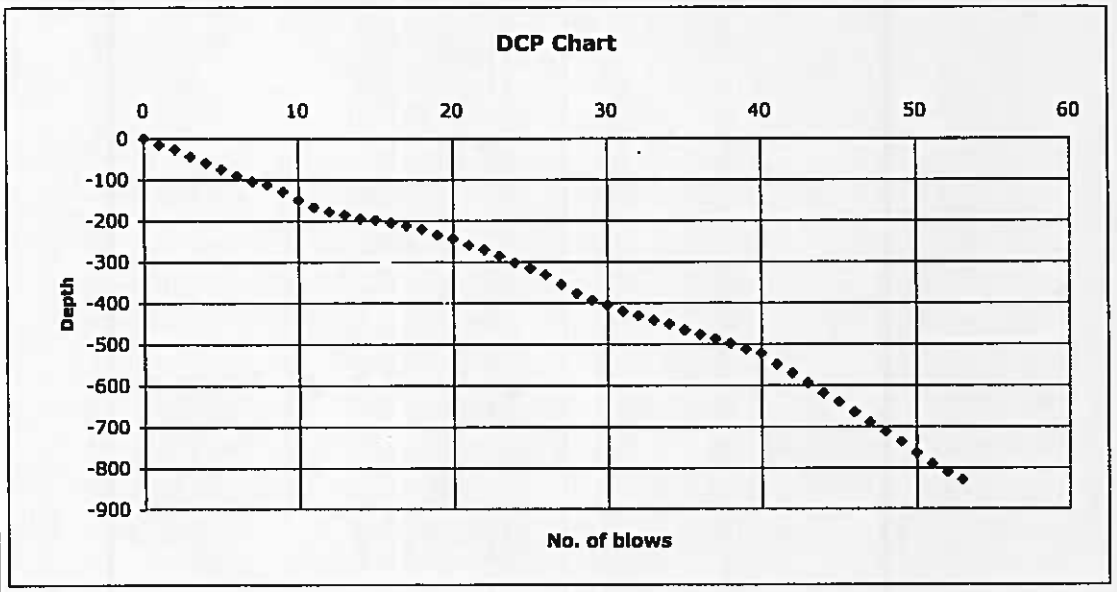
CBR = 43.800

Dynamic Cone Penetrometer

Contract	Broadmeadow Cycle Route	**Date:** 19/07/2013	**Test No.** DCP9
Ref No.	16912		
Client	Clifton Scannell Emerson	**DCP Zero Reading**	110 mm
Location	BH9		
Direction		**Start of Test at:**	0.35m below GL
Soil Description		**Approximate Chainage**	

Soft to firm, brownish grey SILT/CLAY with some gravel and cobbles

No of Blows	*Total Blows*	*Reading mm*	*No of Blows*	*Total Blows*	*Reading mm*	*No of Blows*	*Total Blows*	*Reading mm*
0	0	110	1	21	370	1	42	681
1	1	125	1	22	381	1	43	704
1	2	136	1	23	396	1	44	728
1	3	154	1	24	412	1	45	750
1	4	170	1	25	426	1	46	776
1	5	185	1	26	442	1	47	799
1	6	201	1	27	465	1	48	823
1	7	215	1	28	486	1	49	847
1	8	223	1	29	504	1	50	876
1	9	240	1	30	514	1	51	900
1	10	260	1	31	530	1	52	921
1	11	277	1	32	542	1	53	940
1	12	288	1	33	552	1	54	958
1	13	296	1	34	562	1	55	
1	14	305	1	35	575	1	56	
1	15	308	1	36	586	1	57	
1	16	315	1	37	597	1	58	
1	17	323	1	38	609	1	59	
1	18	331	1	39	622	1	60	
1	19	345	1	40	632	1	61	
1	20	353	1	41	659	1	62	



	From	to	Penetration	mm / blow
Depth range (mm)	125	958	833	15.7170
Blows	1	54	53	

TRRL RN8 Log10 (CBR) = 2.48-1.057*Log10 (mm/blow)

Log10(CBR) = 1.215

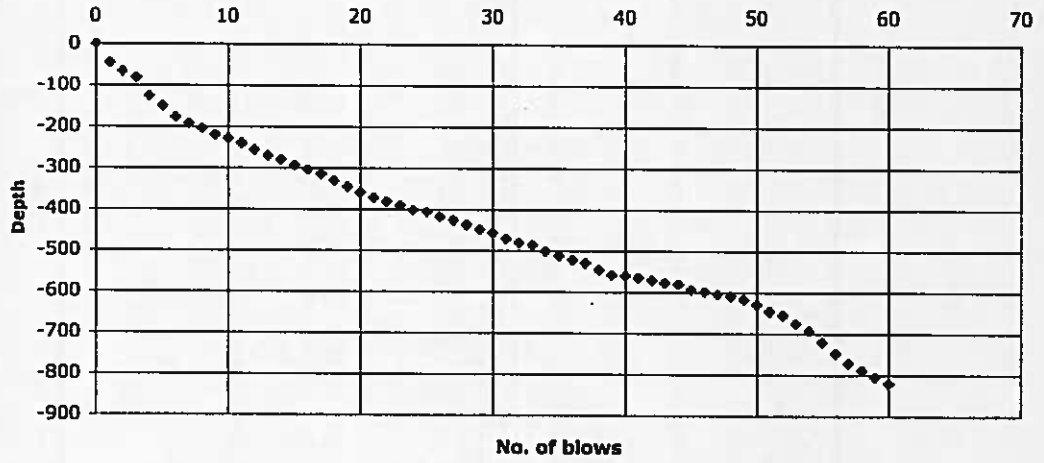
CBR = 16.422

Dynamic Cone Penetrometer

Contract	Broadmeadow Cycle Route	**Date:** 19/07/2013	**Test No.** DCP10
Ref No.	16912		
Client	Clifton Scannell Emerson	**DCP Zero Reading**	140 mm
Location	BH10		
Direction		**Start of Test at:**	0.35m below GL
Soil Description		**Approximate Chainage**	
Soft to firm, black, sandy gravelly CLAY (possible fill)			

No of Blows	*Total Blows*	*Reading mm*	*No of Blows*	*Total Blows*	*Reading mm*	*No of Blows*	*Total Blows*	*Reading mm*
0	0	140	1	21	512	1	42	710
1	1	185	1	22	522	1	43	716
1	2	205	1	23	531	1	44	720
1	3	221	1	24	541	1	45	734
1	4	267	1	25	547	1	46	739
1	5	290	1	26	558	1	47	745
1	6	316	1	27	566	1	48	750
1	7	332	1	28	577	1	49	757
1	8	345	1	29	588	1	50	770
1	9	360	1	30	597	1	51	785
1	10	369	1	31	610	1	52	795
1	11	381	1	32	620	1	53	815
1	12	396	1	33	626	1	54	832
1	13	410	1	34	641	1	55	860
1	14	420	1	35	652	1	56	887
1	15	433	1	36	662	1	57	910
1	16	444	1	37	670	1	58	928
1	17	456	1	38	686	1	59	945
1	18	471	1	39	698	1	60	960
1	19	485	1	40	700	1	61	
1	20	499	1	41	704	1	62	

DCP Chart



	From	to	Penetration	mm / blow
Depth range (mm)	185	960	775	13.1356
Blows	1	60	59	

TRRL RN8 Log10 (CBR) = 2.48-1.057*Log10 (mm/blow)

Log10(CBR) = 1.298

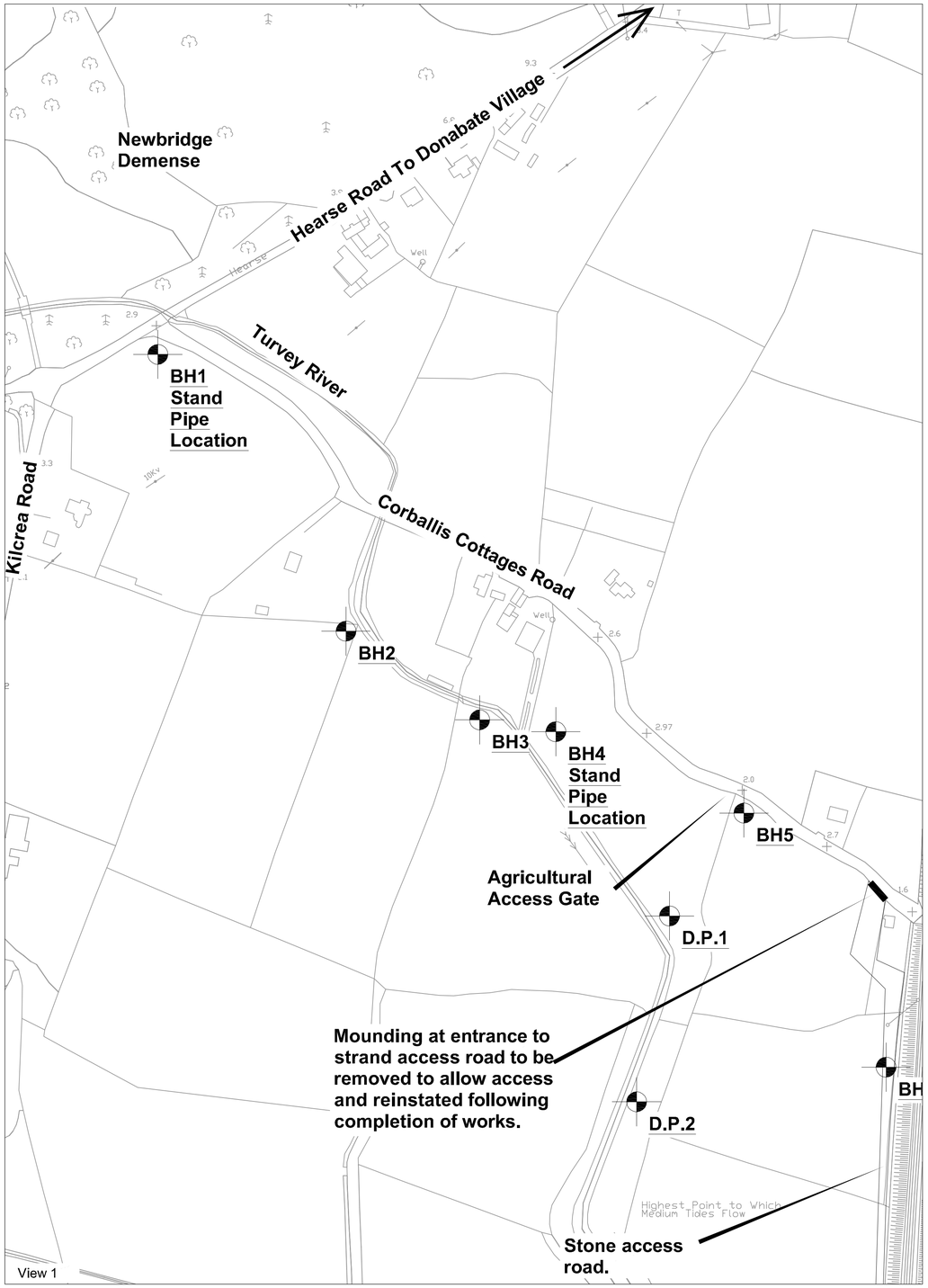
CBR = 19.852

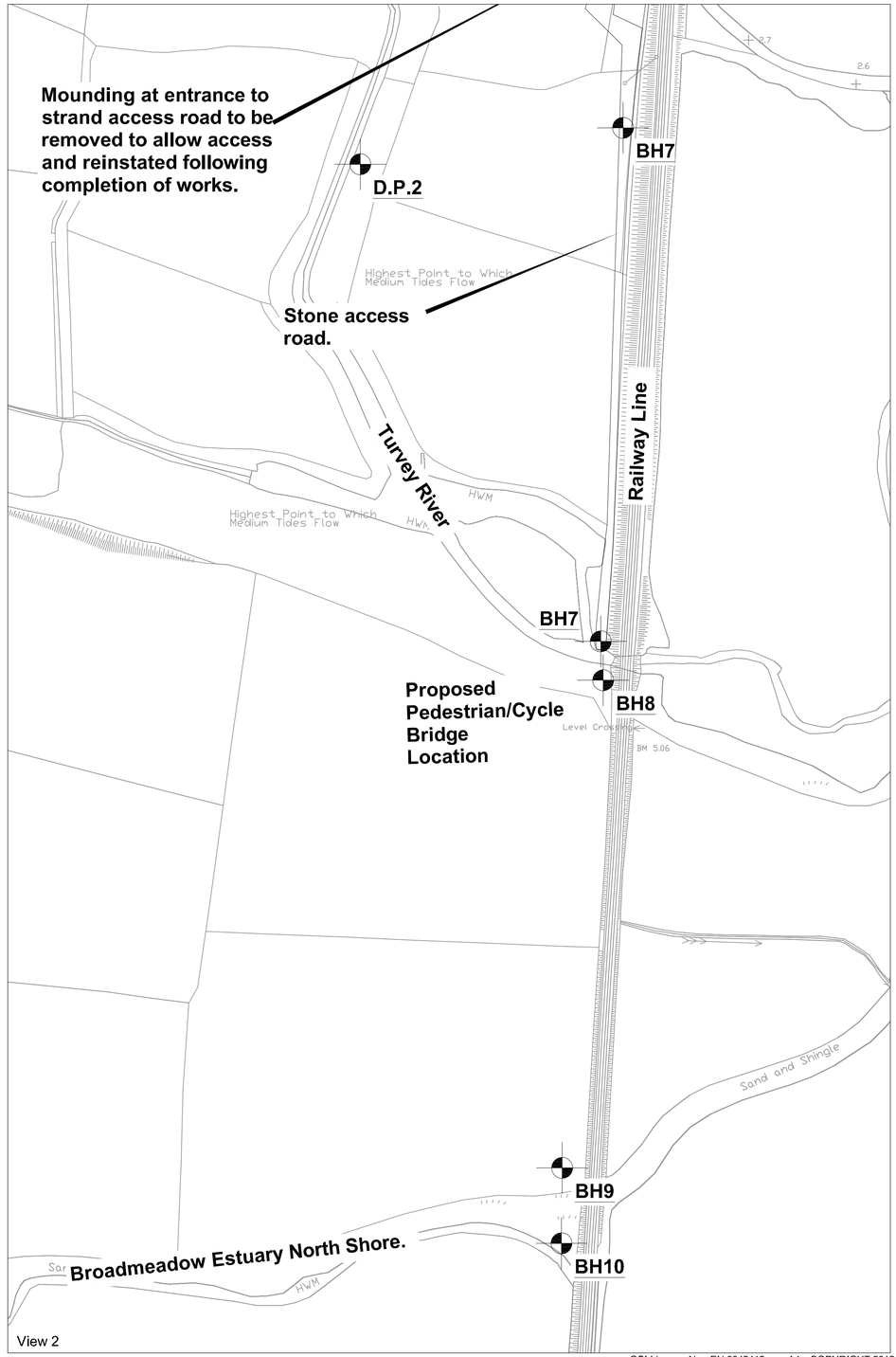
Appendix IV Site Plan

Comhairle Contae Fhine Gall
Fingal County Council

Broadmeadow Cycle Network

Údarás Náisiúnta Iompair
National Transport Authority





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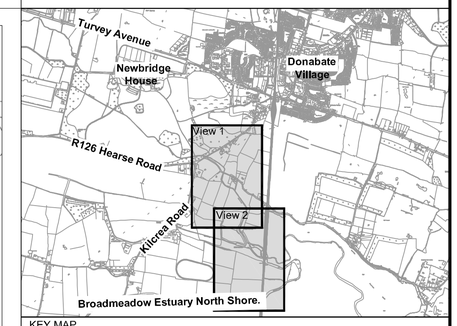

KEY MAP

Site Investigation Locations

BH1 - 322135.031 , 249380.736
BH2 - 322271.593 , 249179.791
BH3 - 322368.637 , 249115.432
BH4 - 322423.961 , 249106.838
BH5 - 322560.542 , 249047.853
D.P.1 - 322506.557 , 248973.149
BH6 - 322663.700 , 248863.354
D.P.2 - 322482.590 , 248838.248
BH7 - 322629.700 , 248510.970
BH8 - 322637.681 , 248476.700
BH9 - 322621.750 , 248146.860
BH10 - 322621.320, 248094.900

BH - Bore Hole
D.P. - Dynamic Probe

Exact location of all testing to be agreed on site with engineer prior to commencing of tests.

CLIFTON SCANNELL EMERSON ASSOCIATES

Drawing Status: *DRAFT ISSUE*
Date: 28-11-2012
Issued By: CSEA

Revision	Description	Initials	Date

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Architect
Client: FINGAL COUNTY COUNCIL / NTA
Project: BROADMEADOW WAY
Dwg. Title: Site Investigation
Drawn By: DMCE
Date: 28-11-2012
Checked by: PM
Scale: 1:2000
Dwg. No.: 12_160_022

Appendix 4

Case Studies Extracted from Dodder Greenway Economic Appraisal Report

The usage at a number of monitoring points for each case study route is known from automatic cycle counters and manual counts of all users (undertaken alongside interviews of route users). Annual usage along the routes is estimated by extrapolating usage from these points. An average trip distance for each monitoring point is first established based on the purpose of journeys (taken from survey results) and trip distances for journeys of different purpose (taken from the English Department for Transport National Travel Survey). Usage within half a trip distance of each monitoring point is assumed to be the same as measured at the monitoring point. Adjustments are made for double counting where monitoring points are located close together. For sections of routes where there are no monitoring points, an estimate of use is made based on counts at other locations on the route.

Case study 1: Comber Greenway, Northern Ireland

Description of route

The Comber Greenway is a traffic free route linking the small town of Comber, through the countryside, into the centre of East Belfast. Seven miles in length, the route follows the path of the former Belfast to Comber railway line. Opened in 2008, the route offers a green corridor for local leisure journeys and commuting access to Belfast.

Characteristics of journeys on the route

Two surveys were performed on the route during 2012; one in Comber, and the second in the Bloomfield area of Belfast. The route attracts a mix of journey types. Although leisure use is predominant (84% of trips at the Comber site, 62% of trips of the Bloomfield site), commuting trips are also recorded, particularly at the Belfast end of the route where they account for 24% of journeys.

Route usage

In estimating route usage, the Comber Greenway is divided into two sections: between Comber and Dundonald (more rural) and between Dundonald and Belfast (more urban).

The estimated annual usage on the route is presented in Table 1.

Table 1: Estimated annual usage of the Comber Greenway

	Annual route usage		
	Comber - Dundonald	Dundonald - Belfast	Total
Cycling trips	62,038	137,614	199,652
Walking trips	73,171	104,946	178,117
Total	**135,209**	**242,560**	**377,769**

Case study 3: Lagan Towpath, Northern Ireland

Description of route

The Lagan towpath, part of the Lagan and Lough Cycle way, runs between the Union Locks in Lisburn and the Stranmillis Weir in Belfast. From the Union Locks the route follows the canal towpath into Lisburn and Lagan Valley Island, going on to pass 11 miles through the Lagan Valley Regional Park to Stranmillis. The River Lagan flows through the Regional Park, which also encompasses a number of public parks.

Characteristics of journeys on the route

A survey was performed on the Stranmillis Embankment section of the Lagan Towpath in 2012. Leisure use is predominant at this location, accounting for 94% of trips. A small proportion of trips are for commuting – 2% of pedestrian trips and almost 16% of cycle trips.

Route usage

In estimating route usage, the Lagan Towpath is divided into two sections: between Lisburn and Belvoir Park Forest, and between Belvoir park Forest and Stranmillis Weir.

The estimated annual usage on the route is presented in Table 5.

Table 5: Estimated annual usage of the Lagan Towpath

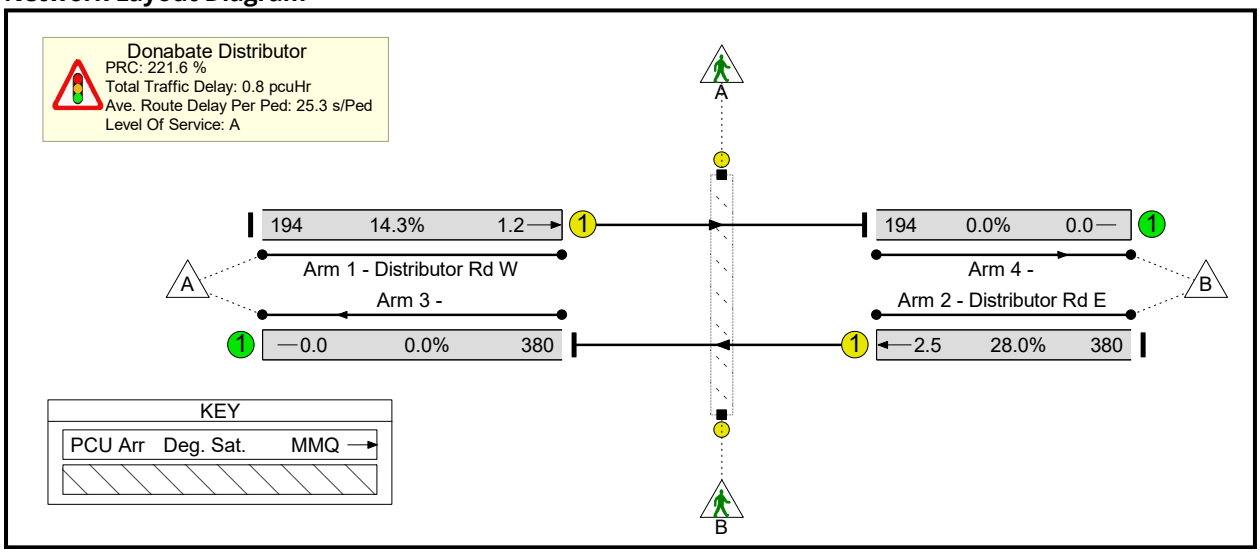
	ANNUAL ROUTE USAGE		
	Lisburn – Belvoir Park Forest	Belvoir Park Forest – Stranmillis Weir	Total
Cycling trips	106,358	77,567	183,925
Walking trips	73,119	144,396	217,515
Total	**179,477**	**221,963**	**401,440**

Appendix 5

LinSig Traffic Analyses Summaries for Toucan Crossing at Donabate Distributor Road

Scenario 1: '2013 AM' (FG1: '2013 AM', Plan 1: 'Network Control Plan 1')

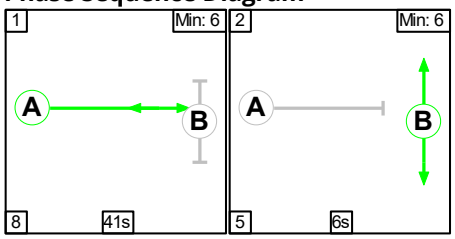
Network Layout Diagram



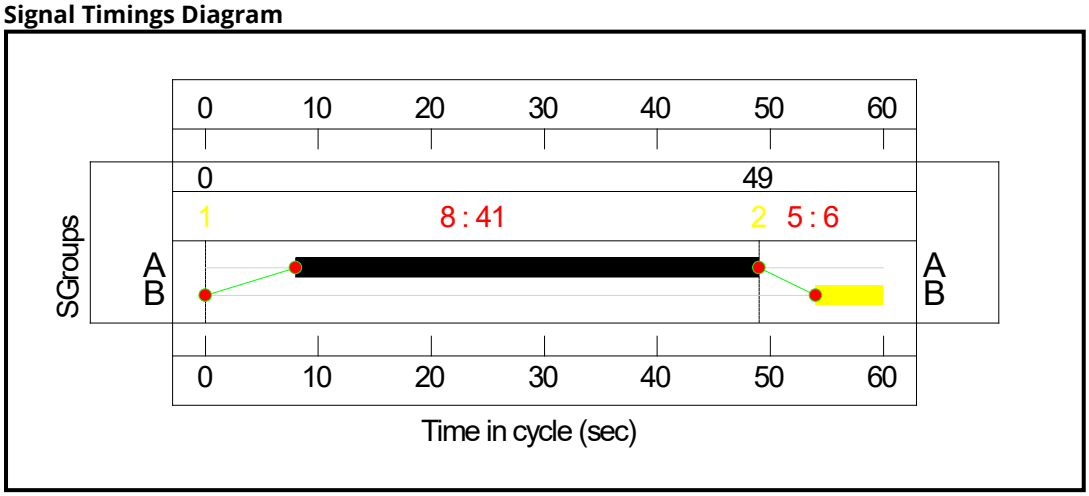
Network Summary

Total Network Delay: 0.79 pcuHr
Worst PRC: 221.63 % (On Lane 2/1)
Level Of Service: A

Phase Sequence Diagram

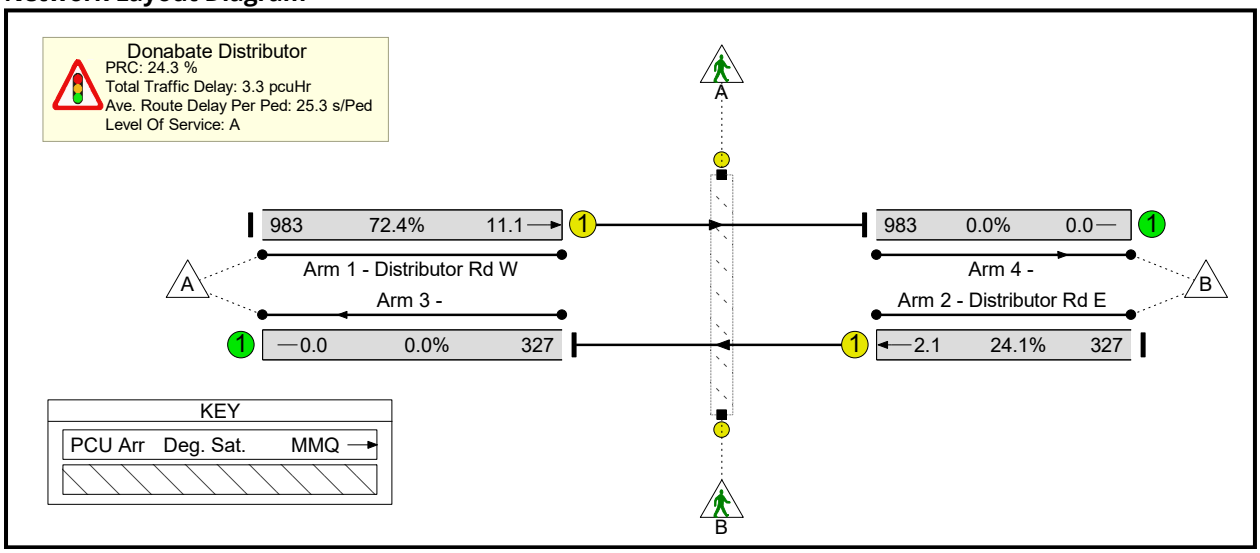


Signal Timings Diagram



Scenario 2: '2013 PM' (FG2: '2013 PM', Plan 1: 'Network Control Plan 1')

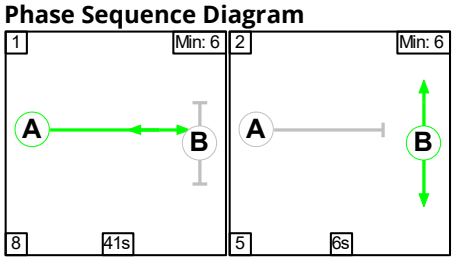
Network Layout Diagram



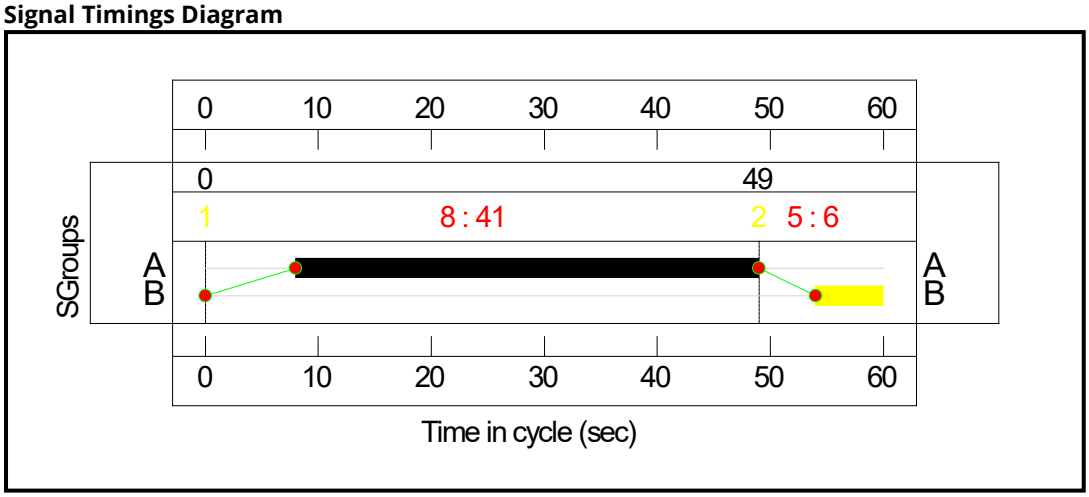
Network Summary

Total Network Delay: 3.25 pcuHr
Worst PRC: 24.33 % (On Lane 1/1)
Level Of Service: A

Phase Sequence Diagram

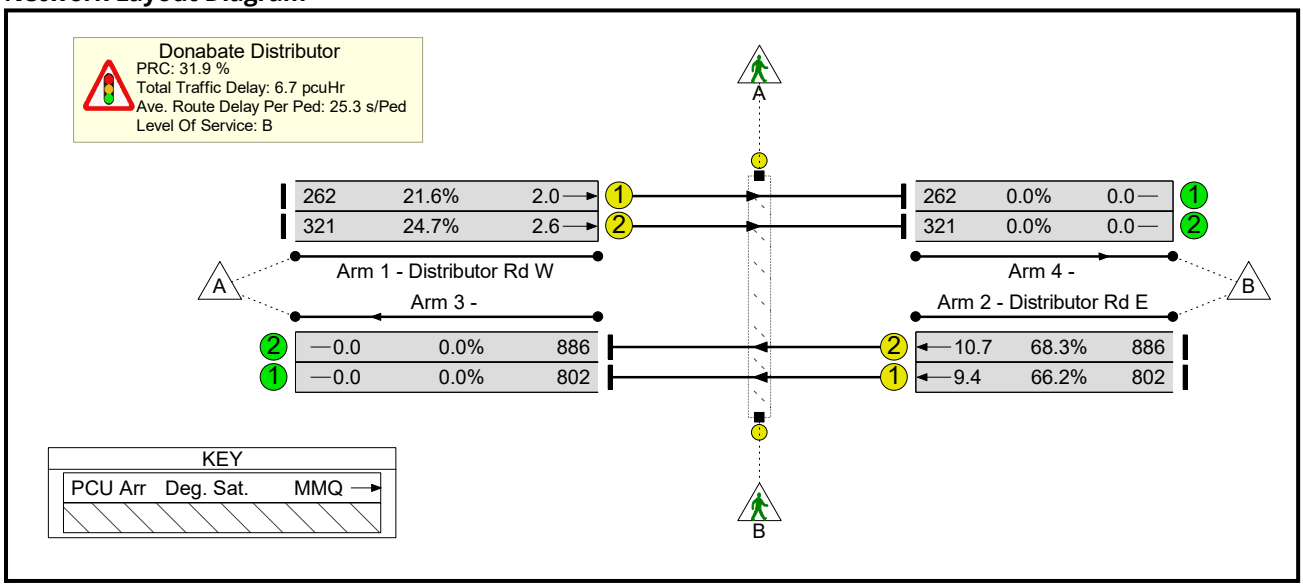


Signal Timings Diagram



Scenario 3: '2028 AM' (FG3: '2028 AM', Plan 1: 'Network Control Plan 1')

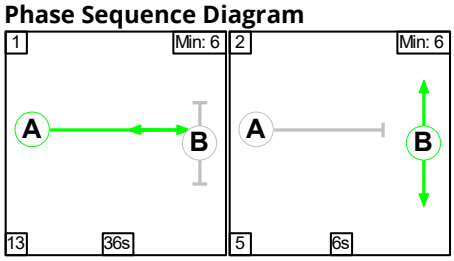
Network Layout Diagram



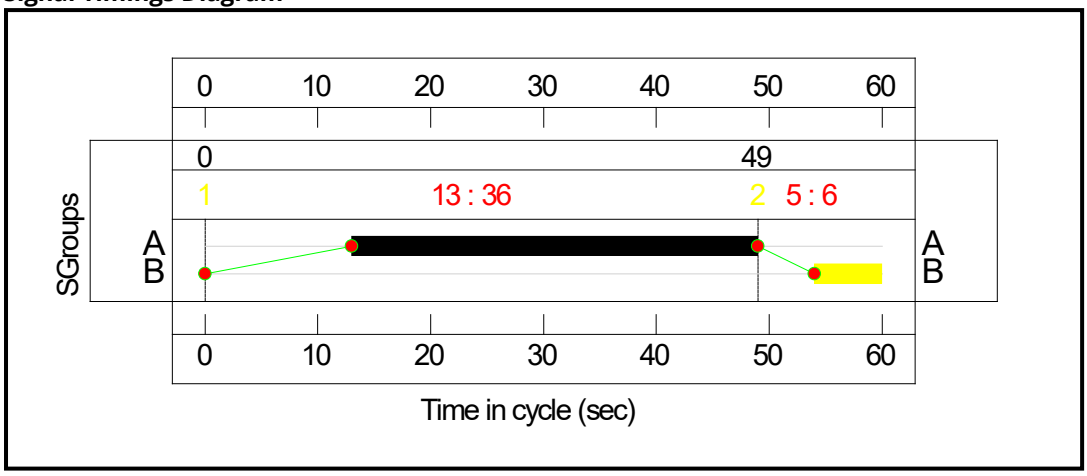
Network Summary

Total Network Delay: 6.71 pcuHr
Worst PRC: 31.86 % (On Lane 2/2)
Level Of Service: B

Phase Sequence Diagram

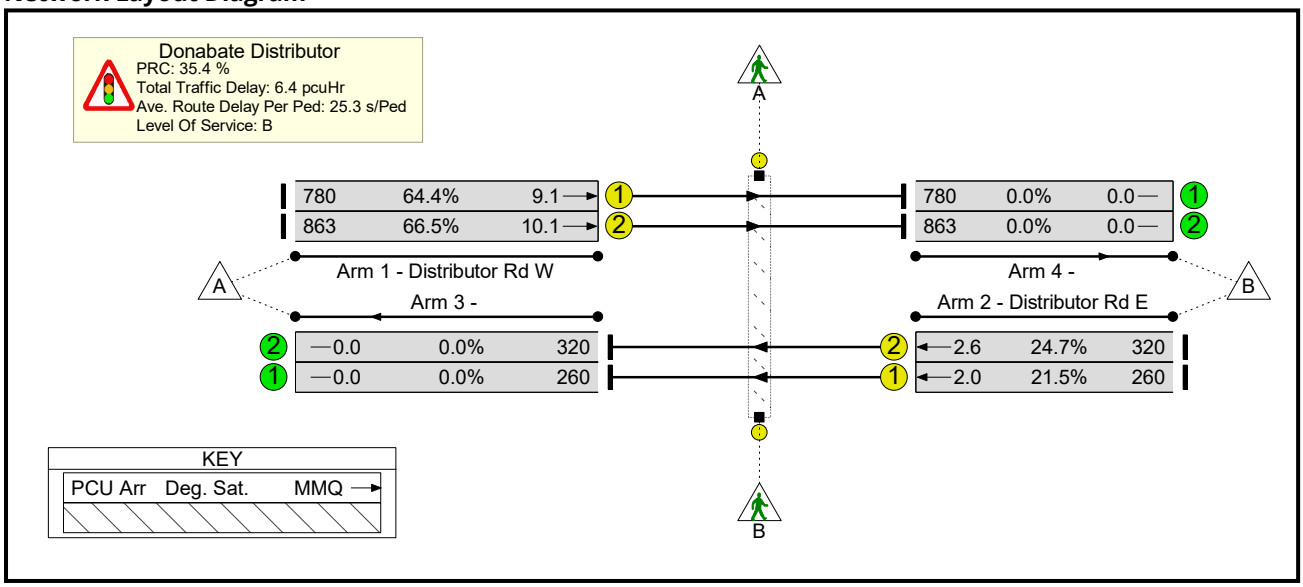


Signal Timings Diagram



Scenario 4: '2028 PM' (FG4: '2028 PM', Plan 1: 'Network Control Plan 1')

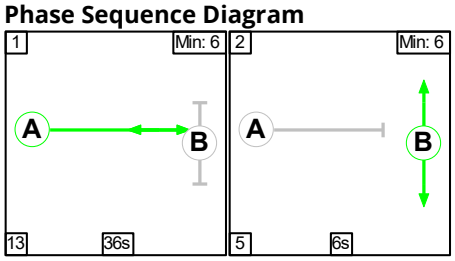
Network Layout Diagram



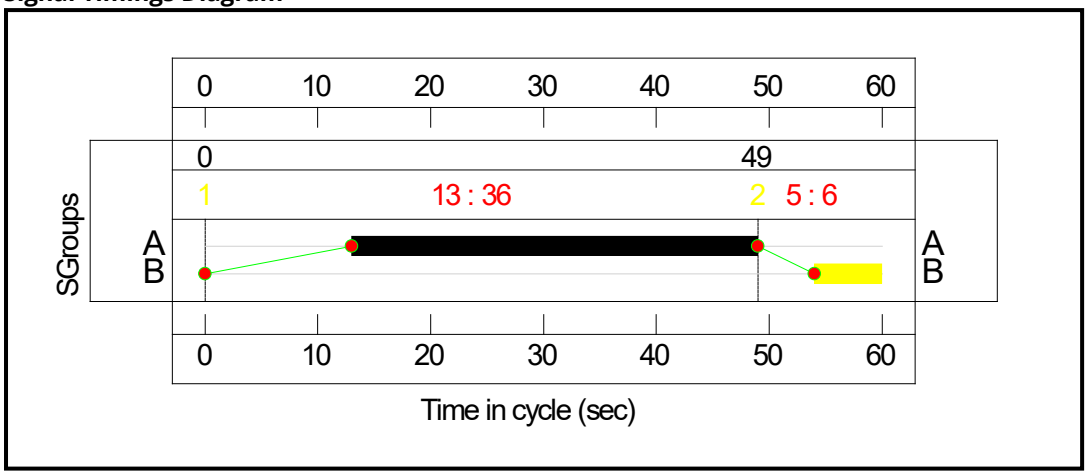
Network Summary

Total Network Delay: 6.39 pcuHr
Worst PRC: 35.37 % (On Lane 1/2)
Level Of Service: B

Phase Sequence Diagram



Signal Timings Diagram



Appendix 6

Lighting Design Report

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e-mail: info@traynorandpartners.com. Web Site: www.traynorandpartners.com

BROADMEADOW WAY
NEWBRIDGE HOUSE TO MALAHIDE
CO DUBLIN

REPORT ON
PROPOSED PUBLIC LIGHTING INSTALLATIONS

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BROADMEADOW WAY
NEWBRIDGE HOUSE TO MALAHIDE
CO DUBLIN

REPORT ON PROPOSED PUBLIC LIGHTING INSTALLATIONS

1.0 Introduction

It is envisaged that the proposed project would be a flagship scheme for tourism in the Malahide & Donabate area and be a model for recreational walking and cycling in Ireland. It will also exemplify how a sustainable trail can be built and integrated into a national cycle network, public transport, heritage sites, employment centres and local amenities.

The main objectives of this scheme are to:

- Provide an attractive first class pedestrian and cycle route;
- Encourage a larger modal shift (from private to public transport) and promote physical activity among local communities;
- Increase pedestrian and cycle activity in Malahide and Donabate villages
- Provide access to scenic areas normally inaccessible to mobility impaired users.
- Improve access within the Malahide and Donabate area and the Malahide Estuary locally.
- Provide a recreational amenity that can be recognised locally, nationally and internationally as a first rate tourist attraction.

The proposed greenway will allow the two demesnes to act together in advertising their individual attractions and also the link between the two public parks will allow for future joint development of enhanced accessibility proposals.

2.0 Requirement for Lighting of the Trail

It is envisaged that there will be a number of user types who will utilise the Broadmeadow Trail. A proportion of these users will use the trail during the hours of darkness. The projected number of persons who will use the trail is outlined in the traffic report. Examples include:

- A large number of foreign tourists visit the Malahide area throughout the entire year. It is envisaged that a number of these tourists will use the trail to travel to Malahide from the Donabate side or Donabate from the Malahide side to avail of the amenities of Malahide Castle or Newbridge House. These tourists will use this trail with the expectation of being able to travel back to their starting point by use of the trail and it is unlikely that they will be aware of the time constraints if the trail was unlit. An unlit trail will render this return journey undesirable and will effectively make the trail unsafe and undesirable particularly during late autumn and early spring.

- It is anticipated that a large number of domestic tourists will also use the trail. Malahide and Donabate provide popular destinations to the domestic market and the users will also have the expectation of being able to travel back to their starting point by use of the trail and it is unlikely that they will be aware of the time constraints if the trail was unlit.

- Local businesses and leisure attractions will be accessed via the trail by local residents. Examples would be local golf courses at Donabate and Malahide as well as the shopping facilities at Malahide Castle and Malahide Village. Many of these activities will extend into early evening / night time and an unlit trail will render their return journey undesirable thus making the trail unsafe to use and increasing car usage.

- Cyclists from the Donabate area who will use the trail to access the regular DART service from Malahide station to travel to work. Over the period between late autumn and early spring (i.e. winter), commuters will return to Malahide by Dart and will wish to complete their journey by cycling/walking but will not be prepared to do so if the trail is unlit. The only viable alternative would be to change trains to the next northern commuter service stopping at Donabate. This would be a disincentive to utilise cycling / Dart public transport. The other alternative would be for the cyclist to travel around the estuary on the road network (partly unlit) to Donabate which is not practical due to the distance involved and the absence of safe cycle paths along the entire route.

- Pedestrians from the Donabate area who will use the trail to access the regular DART service from Malahide station to travel to work. Over the period between late autumn and early spring, the pedestrians may return to Donabate by the trail. The only viable alternative would be to change trains to the next northern commuter service stopping at Donabate. This would be a disincentive to utilise Dart public transport.

- A lit trail will serve to extend the useful hours of this amenity during all times of the year as users will be aware that the trail will be lit for their return journey.

3.0 Basis of Lighting Design

There is a balance to be struck between the increased amenity and transportation value of the trail and the desire for darkness.

The benefits to be gained by adults and children being able to use the facility after dark must be balanced against the potential environmental impact. This balance is achievable by the use of controlled optics, new sources of illumination, careful placement of lighting equipment and design.

The introduction of new LED light sources has made the above goals easily achievable compared to older conventional light sources. LED light sources are easily controllable using digital signals; for example, they can easily switch on to 100% instantly or dim smoothly to 10% (or less) output and are therefore highly responsive to pedestrian traffic (i.e. the trail can be lit with a 'glow' of light with the lights dimmed at 10% and as soon as the pedestrian is detected, the lights rise to full output.

Of particular relevance to exterior lighting on this trail is the issue of light pollution in all of its forms. Any new lighting installation makes an impact on the night-time environment and this has to be balanced against the needs of the trail users in terms of amenity and safety. Lighting on this trail will extend the use of the trail well into the late evening, contributing to a real and perceived sense of security at night, enhancing the night-time experience for visitors and residents alike.

The trail lighting will also be used as a means to guide people, in much the same way as a road sign or traffic signal.

In addition to the visual impact, there are a number of other aspects that were considered in the development of the lighting design: the creation of a safe and pleasant environment, the appropriate use of energy, ease of maintenance and harmonising the appearance of the lighting equipment with its surroundings.

The trail lighting design will ensure that artificial light is delivered to the point where it is required, and nowhere else. Issues such as brightness, direction and context how being considered in the development of the external lighting design to ensure that light pollution and light spill is avoided.

In the development of the lighting scheme, the following issues were also considered:

- Visual brightness and contrast
- Light colour
- Colour rendering
- Visual clutter

Visual brightness and contrast determines the appearance of the lit installation and its relationship to the surroundings. The brightness of the installation has been addressed by controlling the light output which the directs the light onto the trail. Contrast has been addressed by the colour of the light output.

Colour rendering is the ability of the lighting to reveal the colours of various objects accurately in comparison to their true colours. This is important in facial recognition along the trail and the light source been chosen with good colour rendering ability.

Visual clutter can be defined as a visually chaotic scene, caused by the inclusion of multiple elements of street furniture without consideration of the overall scene, which detracts from the overall quality of the environment. Street furniture contributing to visual clutter can include (but is not limited to) such items as lighting columns, signage, litter bins, pedestrian barriers, planters, benches and bollards.

The proposed lighting scheme addresses the issue of visual clutter along the entire length of the trail by the specification of a common and uniform lighting design with a common mounting height of all luminaires.

4.0 Determination of Areas of Illumination & Light Levels

The trail will be used by pedestrians and cyclists only. The area to be illuminated is the surface of the trail. The design illuminance on the trail surface is proposed to be 7.5 lux with a minimum of 1.5 lux. This illuminance complies with IS EN 13201:2015 Class P3. For comparison purposes, a full moon illuminates the ground surface to approximately 0.1 lux. A bright sunny day results in an illuminance level of in excess of 100,000 lux. The new Donabate Distributor Road design illumination is 15 lux average.

The trail illumination also provides a sense of safety for users and the selection of a 7.5 lux average illuminance level makes it possible to make out facial features of other trail users. This has an added social dimension in identifying trail users to each other as opposed to simply moving dark shapes.

The trail will be used for cyclists and pedestrians and a higher light level is required in a situation in which cycling and pedestrians are using the trail as opposed to a pedestrian only trail. The factors determining the design illumination are travel speed of pedestrians / cyclists, projected intensity of usage, ambient light levels and the requirement for facial recognition.

Light spill onto the water in the estuary had been addressed and minimised in two ways. Firstly, each light fitting will have an optic which will direct light onto the trail surface only. Secondly, the light fitting will be placed such that the rear of the fitting is facing the estuary. The resultant light levels immediately behind the luminaire are 6 lux, 500mm behind the luminaire at 4 lux, 1m behind the luminaire and 2 lux reducing to 0 lux 1.5m behind he luminaire. At an average distance between the luminaire and the water's edge of 2.5m, the spill light onto the water will be zero.

The existing ambient light in the Donabate area as well as across the causeway is mainly a product of passing traffic. Traffic levels on the Hearse Road (R126) are high as this road is the main road into Donabate (approx. population circa 7,500 persons). Testing by the author on a single car travelling along a darkened road with dipped beam and full headlights has indicated a surface illuminance of approximately 20 lux for dipped lights and 30 lux for full beam headlights approximately 4m in front of the car.

The new Donabate Distributor Road will be illuminated to ME3 standard (15 lux average illuminance). The trail will be illuminated to 50% of this level at maximum output from the lighting installation.

The causeway is used by the Commuter and Intercity rail services. This usage introduces a high ambient light level due to the headlights of the trains as well as the spill light from the carriage windows. Services are frequent and are projected to become more frequent with the proposed extension of the DART system to Balbriggan. We would estimate that the illumination as a result of the headlights on a moving train would give similar illumination results than that of the car illustrated above (20 lux for dipped lights and 30 lux for full beam headlights).

Reflected light from a surface is a function of the reflective properties of that surface. The trail will generally have a Dense Bitumen Macadam (DBM) surface finish. These finishes are generally dark in colour or black and these finishes have low reflectance values (less than 10%). There will therefore not be any perceptible 'sky glow' from the trail lighting. A considerable amount of 'sky glow' is visible from the existing villages of Malahide and Donabate.

The height of the proposed luminaire above the trail surface is selected at 1.8m. The current average height for an Irish Male is approximately 1.76m. The luminaire is therefore positioned immediately above this height which will serve to provide some illumination to the pedestrian's face thus aiding in identification of facial features of other trail users.

5.0 Luminaire Design

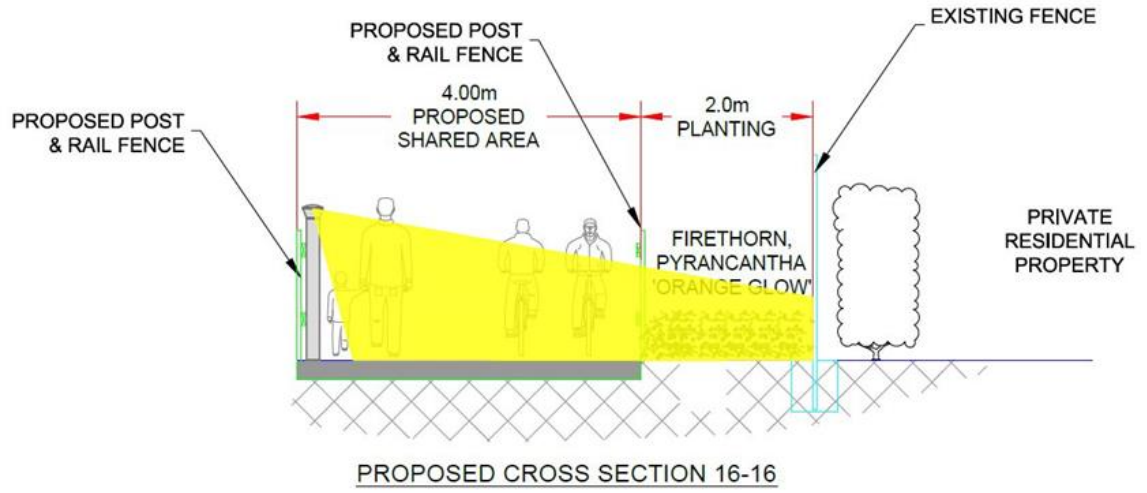
The following factors were taken into account when deciding on the specification of the luminaires:

- The luminaire design and lighting level must be consistent throughout the entire length of the trail.
- Light emission must be directed to the trail surface and light spillage to other surfaces including to the rear of the fitting must be eliminated.
- Luminaires should be high quality and robust.
- Luminaires must have high efficacy (power to lumen output ratios).
- Luminaires must have low maintenance requirements.
- Luminaires must have a constant height throughout the entire length of the trail.
- A minimum number of luminaires only must be used to achieve the required light levels.
- On the causeway, the luminaires must be positioned such that light is directed away from the estuary.
- The luminaire source must be controllable down to 10% of maximum output.
- The luminaire must be capable of being fully controllable by SCADA / PLC controls incorporating presence/absence detection and time scheduling.
- The luminaire shall be minimalist design.

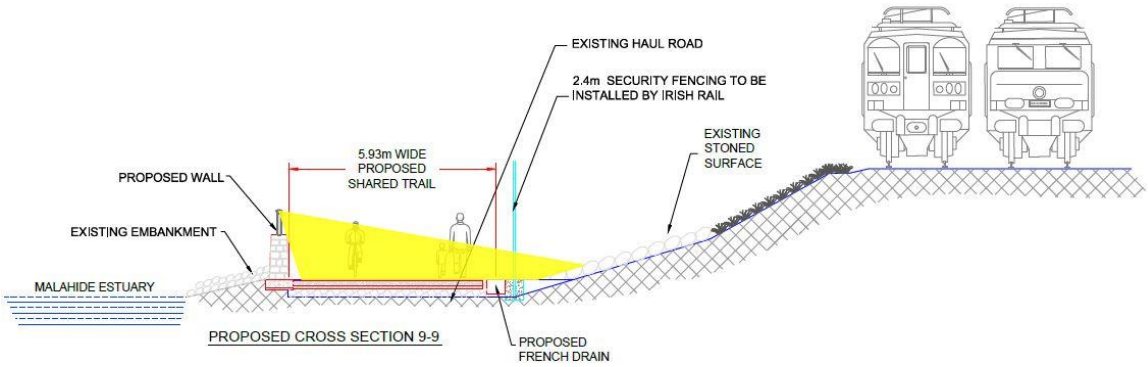
The luminaire chosen is of the asymmetric type. The fitting will have a light emission 180o below the head of the luminaire. However, the luminaire optics will be designed to prevent light emission from the rear of the luminaire (180°). Luminaires will generally be 1.8 meters high along the trail but the luminaires shall be mounted on the causeway wall crossing the estuary. The causeway wall is 1.4m high and therefore the luminaire will be shorter along this section to maintain the 1.8m mounting height for the luminaire. This will ensure consistency of height and illumination levels along the entire length of the trail. The distance between each fitting will be approximately 15m.

The light source for the entire trail will be LED. This source was chosen for its high efficacy (power to lumen output ratio) and long service life (60,000 hours). The LED chip is a high quality unit which is not affected by repeated switching on and off. The luminaire will be manufactured in cast aluminium and rated IP 65 and IK08. The lens will be polycarbonate and the entire finish of the fitting will be RAL 9006. This is a grey colour which will tend to blend into the background during daylight hours over the length of the trail.

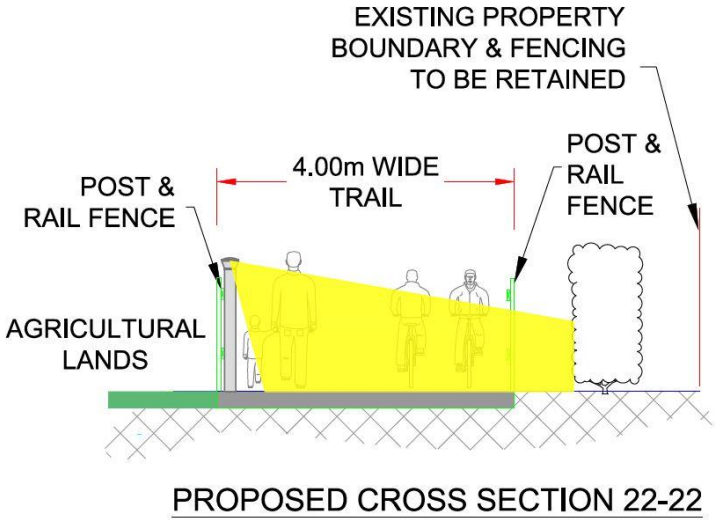
The following sections through the trail at (a) open area and (b) the causeway (c) open area illustrates the position of the luminaire along with an indication of the approximate spread of light across the trail surface.



(a) Proposed Section Through Open Lands with Luminaire Mounted on Side of Trail. Spread of Light from Luminaire Shown in Yellow.



(b) Proposed Section Through Causeway with Luminaire Mounted on Top of Wall. Spread of Light from Luminaire Shown in Yellow.



(c) Proposed Section Through Open Lands with Luminaire Mounted on Side of Trail. Spread of Light from Luminaire Shown in Yellow.

6.0 Control of Lighting Installation

It is proposed that the entire lighting installation be controlled by a PLC (Programmable Logic Controller). All luminaires will be fitted with dimmable control gear (Dali type) which will provide fully adjustable levels from less than 10% to 100% output. Lighting will be switched on by photoelectric cell control. This cell will be used to switch on the lights at a predetermined light level. This will ensure that lighting will only be activated during the hours of darkness.

It is also proposed that the lighting also be controlled by occupant detection. At dusk, the lighting in the Kilcrea area and along the causeway will be switched on at approximately 20% of output by the use of photoelectric cells to determine the availability or lack of daylight. This will ensure that persons wanting to use the trail can clearly see that lighting is available. The lighting along the trail will be controlled in groups on 10No luminaires for control / switching purposes. As soon as a person is detected on any part of the trail, the lighting in that section (10No light fittings) will be brought to 100%. If no persons are detected on the trail following a predetermined period of time, the lighting will then reduce back to 20% of output. Currently, the last trains serving Donabate and Malahide arrive or depart these stations at around midnight. It is envisaged that the lighting of the trail be switched off automatically at around 12:30am. However, if a person is detected on the trail, lighting will be energised to 100% until movement ceases.

Currently, the first morning trains serving Donabate and Malahide arrive or depart these stations around 6am. It is envisaged that the lighting of the trail be switched on at 20% of output at approximately 5.45am. Any movement on the trail will bring the lighting to 100% in the control section (10No luminaires) until the lighting is switched off for the morning under the control of the photoelectric cell (i.e. when sufficient daylight is available).

All of the above sequences may be fully controlled by the use of the PLC. A number of mini pillars containing the electrical supply to the lighting and a controller will be required at intervals along the length of the trail. These mini pillars will be recessed into structures along the trail to minimise visual clutter. Programming and any required reprogramming of the system will be by laptop.

7.0 Luminaire Layout & Resultant Lighting Levels

The following drawings are appended to this report:

- Appendix A – Illustrative Glow Plan of the general area including the effect of the new Donabate Distributor Road and ignoring the effects of passing traffic on unlit roads and passing train traffic on the causeway.

- Appendix B – Illustrative Glow Plan of the general area including the effect of the new Donabate Distributor Road and including the effects of passing traffic on unlit roads and passing train traffic on the causeway.

- Appendix C – Illustrative Glow plan of the area following luminaire installation

- Appendix D - Illuminance levels on typical sections on the surface of the trail.

- Appendix E – Illustrative rendering of resulting lighting levels on the trail following installation in comparison with the resulting lighting levels on the new Donabate Distributor Road.

APPENDIX A

Illustrative Glow Plan of the Area including the effect of the new Donabate Distributor Road and ignoring the effects of passing traffic on unlit roads and passing train traffic on the causeway.


Donabate Golf Club
Balcarrick Golf Club
Donabate
Newbridge Demesne
The Island Golf Club
Malahide
SHORELINE
SHORELINE
SHORELINE
SHORELINE
SHORELINE
SHORELINE
SHORELINE
SHORELINE
SHORELINE
SHORELINE
SHORELINE
Google

APPENDIX B

Illustrative Glow Plan of the Area including the effect of the new Donabate Distributor Road and including the effects of passing traffic on unlit roads and passing train traffic on the causeway.


Donabate Golf Club
Balcarrick Golf Club
Donabate
Newbridge Demesne
The Island Golf Club
Malahide
R127
R126
R106
SHORELINE
SHORELINE
SHORELINE
SHORELINE
SHORELINE
SHORELINE
SHORELINE
SHORELINE
SHORELINE
SHORELINE
SHORELINE
Google

APPENDIX C

Illustrative Glow Plan of the area following luminaire installation

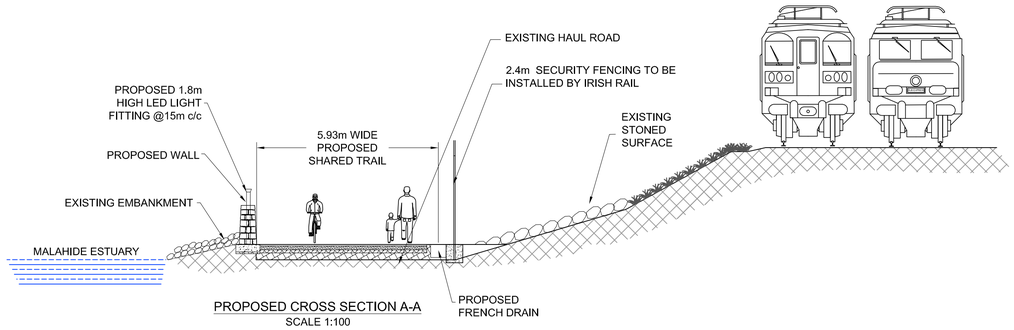

Donabate Golf Club
Balcarrick Golf Club
Donabate
Newbridge Demesne
The Island Golf Club
Malahide
R127
R126
R106
SHORELINE
SHORELINE
SHORELINE
SHORELINE
SHORELINE
SHORELINE
SHORELINE
SHORELINE
SHORELINE
SHORELINE
SHORELINE
Google

APPENDIX D

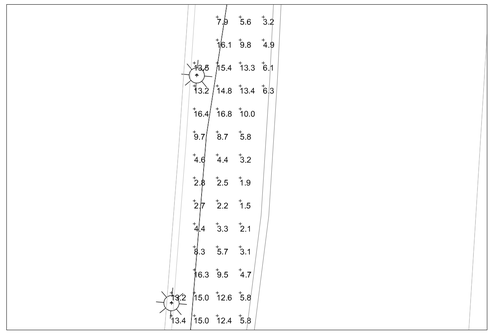
Proposed illuminance levels on typical sections on the surface of the trail.

This drawing is produced using the
Irish Grid
Geographic Coordinate System

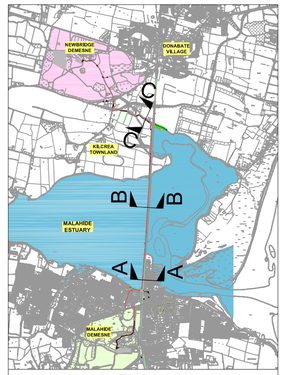
A1



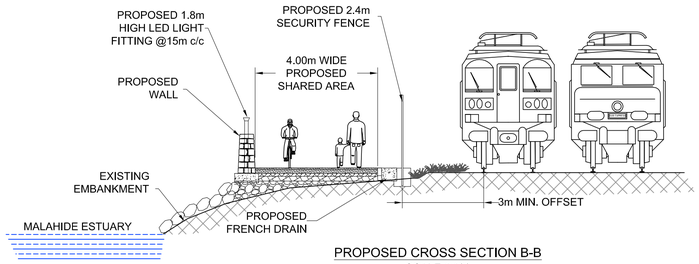
PROPOSED CROSS SECTION A-A
SCALE 1:100



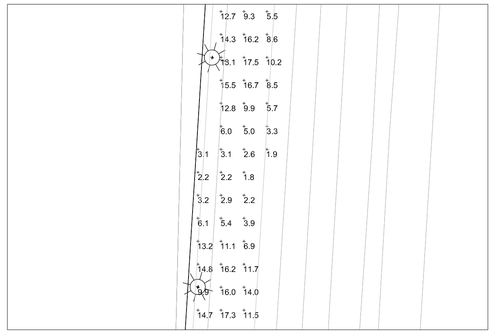
LUX LEVELS AT CROSS SECTION A-A
SCALE 1:200



KEY PLAN
SCALE 1:50



PROPOSED CROSS SECTION B-B
SCALE 1:100



LUX LEVELS AT CROSS SECTION B-B
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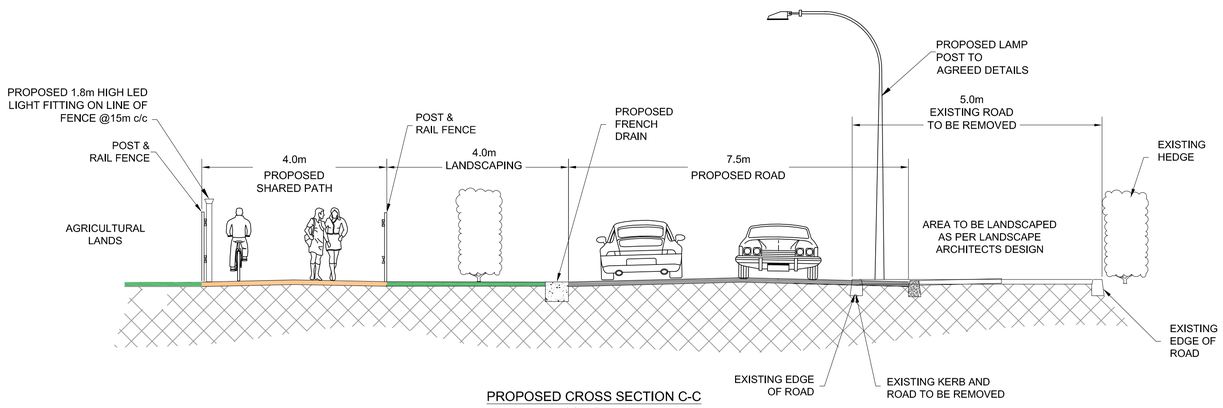
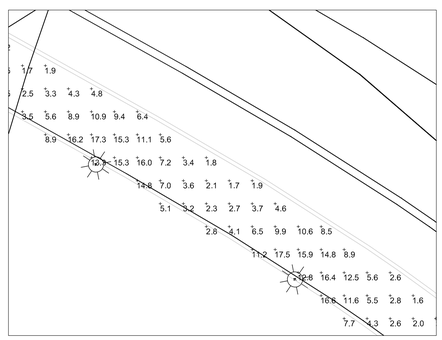


PROPOSED CROSS SECTION C-C
SCALE 1:75



LUX LEVELS AT CROSS SECTION C-C
SCALE 1:200

Clifton Scannell Emerson Associates

Drawing Status	Issue
Planning	FEB 2018
	Issued By
	CSEA

Revision	Description	Initials	Date

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Client

Broadmeadow Way

Project

Lux Levels on
Broadmeadow Way

Dwg. Title

Drawn By AMS Date Feb 2018

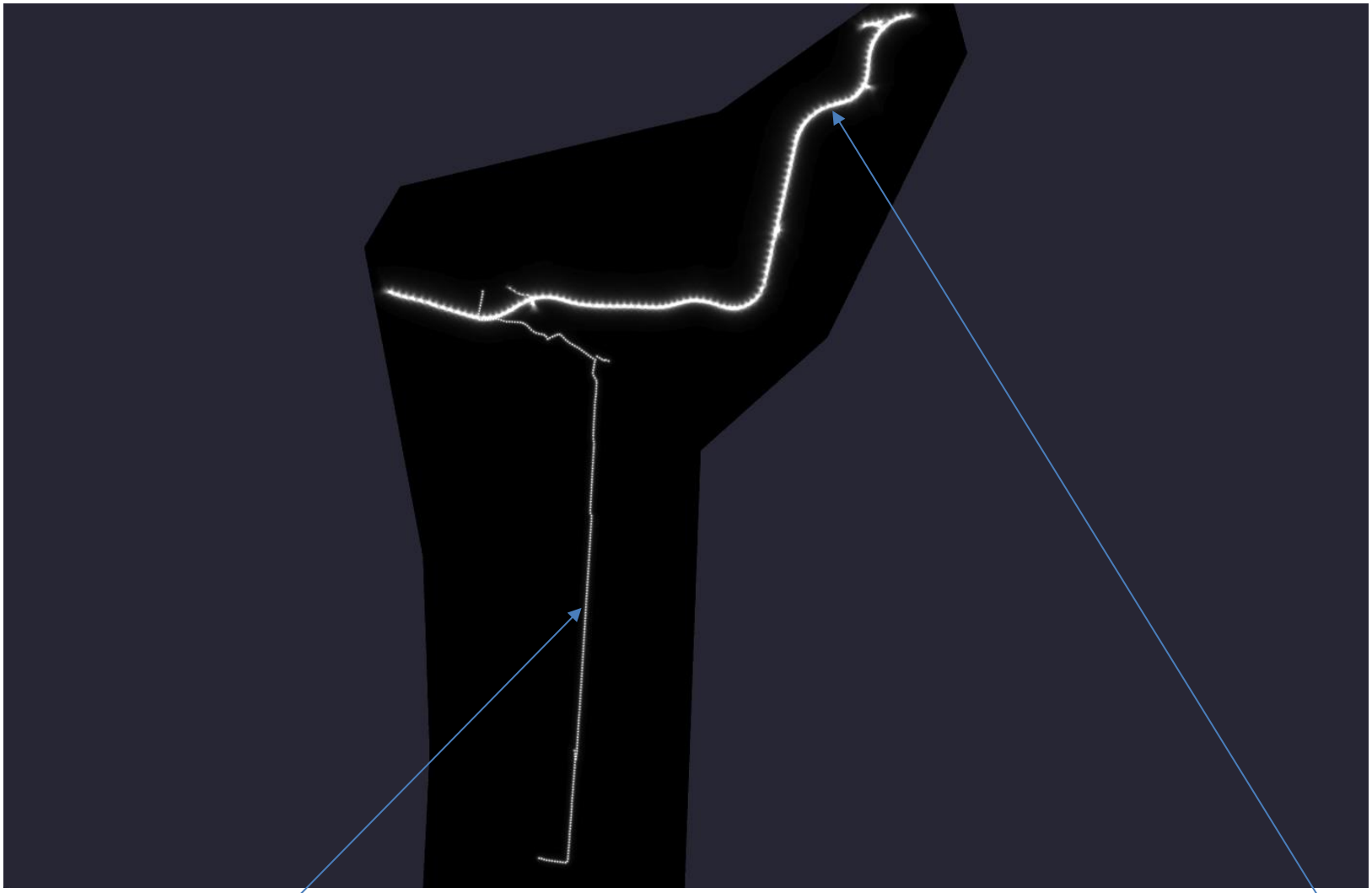
Checked by PD Scale As Shown @ A1

Dwg. Progress DRAFT

Dwg. No. 12_160_245

APPENDIX E

Illustrative rendering of resulting lighting levels on the trail following installation in comparison with the resulting lighting levels on the new Donabate Distributor Road.


Broadmeadow Trail
Donabate Distributor Road

Appendix 7

Recorded Archaeological and Cultural Heritage Sites Within the Study Area

Recorded Archaeological Sites Within the Study Area

	Townland	Site Type	Perceived Importance
DU012-004	Newbridge Demesne	Castle-tower house	Regional
DU012-005001	Donabate	Church	Regional
DU012-005002	Donabate	Castle-tower house	Regional
DU012-005003	Donabate	Graveyard	Regional
DU012-005004	Donabate	Wall monument	Local
DU012-006	Lanestown	Enclosure	Local
DU012-014	Ballymadrough	Castle-motte	Regional
DU012-016001	Kilcrea	Church	Regional
DU012-016002	Kilcrea	Graveyard	Regional
DU012-017	Kilcrea	Enclosure	Local
DU012-018	Kilcrea	Tide mill	Local
DU012-019	Corballis	Earthwork	Regional
DU012-023001	Malahide	Ritual site-holy well	Local
DU012-023002	Malahide	Church	Regional
DU012-023003	Malahide	Earthwork	Local
DU012-029	Malahide Demesne	Earthwork	Local
DU012-030	Malahide Demesne	Castle-tower house	Regional
DU012-031001	Malahide Demesne	Church	Regional
DU012-031002	Malahide Demesne	Sheela-na-gig	Local
DU012-031003	Malahide Demesne	Sheela-na-gig	Local
DU012-031004	Malahide Demesne	Architectural fragment	Local
DU012-031005	Malahide Demesne	Chest tomb	Local
DU012-031006	Malahide Demesne	Graveyard	Regional
DU012-060	Newbridge Demesne	House-18th/19th century	Local
DU012-066	Beaverstown	Habitation site	Regional
DU012-067	Beaverstown	Enclosure	Regional
DU012-072	Kilcrea	Ring ditch	Regional
DU012-074	Newbridge Demesne	Ring ditch	Regional
DU012-082001	Donabate	Excavation Miscellaneous	
DU012-082002	Donabate	Structure	
DU012-082003	Donabate	Structure	
DU012-082004	Donabate	Structure	
DU012-083	Beaverstown	Excavation Miscellaneous	

Cultural Heritage Sites Within the Study Area

CHS Number	Townland	Site Type	Perceived Importance	Distance from Route
CHS 1	Malahide, Kilcrea, Donabate	Dublin Belfast Railway	Regional	0m
CHS 2	Malahide Kilcrea	Malahide Estuary	Local	0m
CHS 3	Malahide Demesne	Malahide Demesne	Local	0m
CHS 4	Newbridge Demesne	Newbridge Demesne	Local	0m

Appendix 8

Archaeology and Cultural Heritage Plates 1-14

Plate 1: South from car park in Malahide Demesne.

Plate 2. Entrance into Bridgefield car park, looking NE.

Plate 3: Playing fields at Bridgefield car park, looking south.

Plate 4: Dublin Road, looking west.

Plate 5: O'Hanlon's Lane, south end.

Plate 6: Bissets Strand; looking east.

Plate 7: River Pill running under railway embankment into estuary. From west.

Plate 8: Bank of River Pill, west end of route. Looking east.

Plate 9: Pasture field where the greenway will cross from Corballis Cottages Road to the River Pill.

Plate 10: Kilcrea Road, looking north towards gates of Newbridge Demesne.

Plate 11: Entrance gates to Newbridge Demesne.

Plate 12: Newbridge Demesne inside Hearse Road gate, looking north.

Plate 13: Path through Newbridge demesne, looking north.

Plate 14: Path up to Newbridge House, looking northwest.

Appendix 9

Definitions, Statutory Protection and Criteria – Architectural Heritage

Definition of the Study Area

The TII (formerly NRA) guidelines recommend the definition of a route corridor at 50m on either side of the centre line of the proposed road development. For the purposes of Chapter 13 (Architectural Heritage) of the EIAR, a route corridor of 100m on either side of the centre line of the proposed greenway has been considered.

Definition of Some Terms

Definitions are provided below for some of the terms used in Chapter 13 of the EIAR. The distinction between these terms is not always clear cut, for example attendant grounds can extend to include an entire demesne. Further, the terms are not mutually exclusive, for example a building within a demesne will also have a curtilage and can incorporate a designed landscape or designed landscape features.

Protected Structure

A protected structure is defined as any structure (or specified part of a structure) which is included in the Record of Protected Structures (RPS). In relation to a protected structure, the meaning of the term 'structure' is defined by Part IV of the Planning and Development Act 2000 to include:

- The interior of the structure;
- The land lying within the curtilage of the structure;
- Any other structures lying within that curtilage and their interiors; and
- All fixtures and features which form part of the interior or exterior of the above structures.

There are no grades or categories of protected structures: a structure is either a protected structure or not.

Curtilage

The term 'curtilage' is not defined by legislation but the Architectural Heritage Protection Guidelines for Planning Authorities define it as the parcel of land immediately associated with that structure and which is (or was) in use for the purposes of that structure. A curtilage enjoys statutory protection if the structure with which it is associated is listed in the RPS, even in cases where the two are in different ownerships.

Attendant Grounds

The term 'attendant grounds' in relation to a structure is defined in Section 2 of the Planning and Development Act, 2000 as 'land lying outside the curtilage of a structure'. The Architectural Heritage Protection Guidelines for Planning Authorities further defines the term as lands outside the curtilage of the structure but which are associated with the structure and are intrinsic to its

function, setting and/or appreciation. In many cases, the attendant grounds will incorporate a designed landscape deliberately laid out to complement the design of the building or to assist in its function. In the case of a country house, the attendant grounds may include the entire demesne and any structures or features within it such as follies, plantations and lakes.

A planning authority has the power to protect all features of importance which lie within the attendant grounds of a protected structure; however, such features must be individually specified in the RPS.

Demesne

No legal definition of the term 'demesne' exists, nor can they be defined by their age, size (which can range from one or two hectares to over a thousand) or current ownership, since demesne features can remain clearly distinguished even when the demesne land is divided into multiple ownerships. The Architectural Heritage Protection Guidelines for Planning Authorities define demesne as 'that part of the historic estate associated with a country house which was reserved for the personal use and enjoyment of the owner'. The most characteristic elements commonly found on demesnes include (but are not limited to) features such as boundary and garden walls, utilitarian structures such as ice houses, coach houses, farmyards and outbuildings, ornamental features such as gazebos, follies, gate lodges, and (less frequently) statuary, and designed landscape features such as avenues and walkways, tree belts, wooded shelter belts, parkland, gardens, vistas, ornamental ponds and other water features.

In conservation terms, demesnes are sensitive sites as they contain many heritage features, both built and natural. A planning authority has the power to protect structures within demesnes; however, they must be individually specified in the RPS. Demesnes can also be protected by being designated as Architectural Conservation Areas.

Designed Landscape

The term 'designed landscape' is not defined by legislation; however, the term 'landscape' has been defined in the Heritage Act, 1995 as one that 'includes areas, sites, vistas and features of significant scenic, archaeological, geological, historical, ecological or other scientific interest'. In general terms, designed landscape can be described as a landscape that was consciously designed or laid out by a landscape architect, master gardener, architect, or horticulturist according to design principles, or by an amateur gardener working in a recognised style or tradition. A designed landscape may be associated with a significant person, trend, or event in landscape architecture; or illustrate an important development in the theory and practice of landscape architecture. According to the Guidance Notes for the Appraisal of Historic Gardens, Demesnes, Estates and their Settings, designed landscapes can include:

- Complex and elaborate gardens and parkland, with a clear outer boundary, that provides a setting for a house;
- Planned agricultural landscapes that may fall outside the demesne or parkland boundary;
- Archaeological remains of a former site that are only visible above ground as relic features such as boundaries; and
- Designed landscapes serving a public purpose such as urban squares.

In Chapter 13 of the EIAR, only designed landscapes within demesnes have been considered. A more comprehensive consideration of landscapes is provided in Chapter 14.0 (Landscape).

Designed Landscape Feature

The term 'designed landscape feature' is not defined by legislation. In general terms it can be described as a man-made landscape feature such as a wooded shelter belt laid out to produce the effect of natural scenery, or other feature such as a folly or turret. Features in the latter group are often associated with and may form a termination point of paths and vistas. Designed landscape features are thus individual elements which make up a designed landscape.

Vista

The term 'vista' is not defined by legislation. *The Guidance Notes for the Appraisal of Historic Gardens, Demesnes, Estates and their Settings* define it as a narrow and highly directed view out from the principal building to a single focal point. It is generally directed or contained by structural and formally arranged planting which can be clearly identified on maps and aerial photography.

Setting

The term 'setting' is not defined by legislation. It is defined in the Oxford English Dictionary as 'the manner or position in which anything is set, fixed, or placed'. For example, a designed landscape often forms a setting for a country house. The *Guidance Notes for the Appraisal of Historic Gardens, Demesnes, Estates and their Settings* further specifies that settings can include lowland agricultural landscapes originally designed as model farms or as a display of good architectural practice. They can also include natural landscapes such as loughs, coastlines, upland moors and mountains.

Statutory Protection of Structures

Registered Architectural Heritage Sites

Stemming from the principal conventions, acts and regulations which govern architectural heritage, there are several mechanisms for protecting architectural heritage sites in Ireland. These include the following:

- Record of Protected Structures (RPS): Buildings recorded in the RPS can include recorded monuments, structures listed in the National Inventory of Architectural Heritage (NIAH) or buildings deemed to be of architectural, historic, archaeological, artistic, cultural, scientific, social or technical interest by the Minister. Such sites receive statutory protection from injury or demolition under the 1999 Planning Act. All current RPS sites in Fingal are listed in the relevant Development Plan. Seventeen architectural heritage sites and structures within the study area are included on the Record of Protected Structures.

- Architectural Conservation Areas (ACA): The Development Plan for Fingal includes areas designated as Architectural Conservation Areas. The stated objective of ACAs is to conserve and enhance their special character, including their traditional building stock and material finishes, spaces, streetscapes, landscape and setting. There are two ACAs within the study area, namely Malahide Demesne (AHC002) and Newbridge Demesne (AH C041).

- National Inventory of Architectural Heritage (NIAH): The Architectural Heritage (National Inventory) and National Monuments (Miscellaneous Provisions) Act 1999 provided for the establishment of a National Inventory of Architectural Heritage (NIAH). The work of the NIAH involves identifying and recording the architectural heritage of Ireland, from 1700 to the present day, in a systematic and consistent manner. It is divided into two parts; The Building

Survey and Historic Garden Survey. The main function of both is to provide a source of guidance for the selection of architectural heritage for protection and to supply data to local authorities, which helps them to make informed judgments on the significance of building stock in their functional area. NIAH surveys also provide the basis for the recommendations of the Minister for Culture, Heritage and the Gaeltacht to the planning authorities for the inclusion of structures rated by the NIAH as being of regional or above importance in their Record of Protected Structures. The Architectural Inventory for Fingal was carried out in 2000. Sixteen structures within the study area have been surveyed by NIAH.

- National Monuments: Section 8 of the National Monuments (Amendment) Act, 1954, provides for the publication of a list of monuments, the preservation of which is considered to be of national importance. Ministerial consent must be granted before any works are carried out with respect to a national monument. None of the architectural heritage sites or structures within the study area is designated as a National Monument.

- Preservation Orders (PO) and Temporary Preservation Orders (TPO): The National Monuments Act 1930 provided for the making of preservation orders to protect national monuments that were considered to be under threat. A preservation order makes it unlawful to interfere in any way with a national monument without the express permission of the Minister. None of the architectural heritage sites or structures within the study area is currently subject to preservation orders (temporary or full).

- Register of Historic Monuments: Under Section 5 of the National Monuments (Amendment) Act 1987, the Minister for Culture, Heritage and the Gaeltacht is required to establish and maintain the Register of Historic Monuments. Two months' notice must be given in writing to the Minister in advance of any proposal to carry out work in relation to a historic monument or archaeological area entered in the Register. None of the architectural heritage sites and structures within the study area is listed in the Register of Historic Monuments.

- Record of Monuments and Places (RMP): Section 12(1) of the National Monuments (Amendment) Act 1994 provides that the Minister for Culture, Heritage and the Gaeltacht establish and maintain a record of monuments and places. Sites recorded on the Record of Monuments and Places all receive statutory protection under the National Monuments Act 1994. Two months' notice must be given in writing to the Minister in advance of any proposal to carry out work in relation to a site listed on the Record of Monuments and Places. Four architectural heritage sites and structures within the study area are included on the RMP.

Unregistered Architectural Heritage Sites

These include sites that are considered to be of architectural heritage value but which do not fall under the protection of any of the mechanisms listed above. Unregistered architectural heritage sites are typically (though not necessarily) named structures on the OS six-inch maps, such as country houses and associated demesnes, bridges or industrial features. There are three unregistered architectural heritage structures within the study area.

Criteria Used for Impact Assessment

The criteria applied to the assessment of impacts on architectural heritage in Chapter 13 of the EIAR are based on the recommendations made in the TII (formerly NRA) *Guidelines for the Assessment of Architectural Heritage Impacts of National Road Schemes* (2005) and on terminology outlined in the *Draft Guidelines on the Information to be Contained in Environmental Impact Assessment Reports* (EIAR) (EPA, 2017). The significance (imperceptible, not significant, slight,

moderate, significant, very significant, profound) of perceived impacts on structures and sites of architectural heritage merit was evaluated by determining the nature of potential impacts in terms of their magnitude (low, medium, high, very high) and by combining the magnitude of the impact with the architectural heritage importance (local, regional, national or international) of the structure. The relationship of these elements is illustrated in Table 1.

Table 1. Significance of Impacts.

Magnitude of Impact		Importance of Architectural Heritage			
		Local	**Regional**	**National**	**International**
Negative: A change that reduces the quality of the environment.	Very High	Significant	Very Significant	Profound	Profound
	High	Moderate	Significant	Very Significant	Profound
	Medium	Slight	Moderate	Significant	Very Significant
	Low	Not Significant	Slight	Moderate	Significant
Neutral: A change that does not affect the quality of the environment.		No impact			
Positive: A change that improves the quality of the environment.	Low	Not Significant	Slight	Moderate	Significant
	Medium	Slight	Moderate	Significant	Very Significant
	High	Moderate	Significant	Very Significant	Very Significant

This method is in accordance with the Draft EPA Guidelines (2017) which state that the significance of impacts in the context of an EIA relate to the importance of the outcome of the impact and is determined by considering the magnitude and intensity, integrity, duration and probability of the impact. The generic definitions of the various levels of significance provided in the EPA Guidelines have been further qualified in the TII (formerly NRA) Guidelines to make them more directly applicable to the assessment of architectural heritage impacts and are as follows:

- Profound negative: an impact that obliterates the architectural heritage of a structure or feature of national or international importance. These effects arise where an architectural structure or feature is completely and irreversibly destroyed by the proposed development. Mitigation is unlikely to remove adverse effects.

- Very significant negative: an impact that obliterates the architectural heritage of a structure or feature of regional importance or that by its magnitude, duration or intensity significantly alters the character and/or setting of a structure or feature of national importance. Mitigation is unlikely to remove adverse effects to more than a limited degree.

- Significant negative: an impact that, by its magnitude, duration or intensity alters the character and/or setting of the architectural heritage. These effects arise where an aspect or aspects of the architectural heritage is/are permanently impacted upon leading to a loss of character and integrity in the architectural structure or feature. Appropriate mitigation is likely to reduce the impact.

- Moderate negative: an impact that results in a change to the architectural heritage which, although noticeable, is not such that it alters the integrity of the heritage. The change is likely to be consistent with existing and emerging trends. Impacts are probably reversible and may be of relatively short duration. Appropriate mitigation is very likely to reduce the impact.

- Slight negative: an impact that causes some minor change in the character of architectural heritage of local or regional importance without affecting its integrity or sensitivities.

Although noticeable, the effects do not directly impact on the architectural structure or feature. Impacts are reversible and of relatively short duration. Appropriate mitigation will reduce the impact.

- Not significant negative: an impact on architectural heritage of local or regional importance that is capable of measurement but without significant consequences.
- Imperceptible negative: an impact on architectural heritage of local importance that is capable of measurement but without noticeable consequences.
- Significant positive: a beneficial effect that permanently enhances or restores the character and/or setting of the architectural heritage in a clearly noticeable manner.
- Moderate positive: a beneficial effect that results in partial or temporary enhancement of the character and/or setting of the architectural heritage and which is noticeable and consistent with existing and emerging trends.
- Slight positive: a beneficial effect that causes some minor or temporary enhancement of the character of architectural heritage of local or regional importance which, although positive, is unlikely to be readily noticeable.
- Not significant positive: a beneficial effect on architectural heritage of local or regional importance that is capable of measurement but without significant consequences.
- Imperceptible positive: a beneficial effect on architectural heritage of local importance that is capable of measurement but without noticeable consequences.

In compliance with the TII (formerly NRA) Guidelines, impacts are considered to be direct where a site or structure of architectural heritage merit is physically located in whole or in part within the development boundary. It should be noted that Chapter 13 of the EIAR focuses on physical impacts only, such as the demolition of structures, severance of demesne lands, removal of tree boundaries and encroachment on curtilage or attendant grounds.

Consideration of Mitigation Measures

Three types of mitigation measure can be applied to sites or structures of architectural heritage merit. The preferred mitigation measure is avoidance or retention *in situ*, particularly in the case of nationally or regionally important structures and their settings.

Where negative impacts cannot be avoided, measures will be sought to reduce them. Mitigation by reduction of impacts is always site specific but most commonly includes planting or the construction of stone walls, earthworks or other features to reduce the magnitude and level of significance of impacts.

Where a building of heritage merit is impacted directly, preservation by record may be the only option available. The purpose of documenting the structure is to set down a record of the situation, as it exists at a particular time. The site may also be subject to an archaeological investigation if a structure is to be demolished. Where a demesne landscape, historic setting or conservation area is impacted, a combination of preservation by record and other measures such as planting, earthworks or design are applied.

Appendix 10

Schedule of Architectural Heritage Within the Study Area

Sites and Structures Subject to Slight Negative Construction Impacts

Table 1 – Structure 1 of 1

Reference No.	AHC002
Map/Photograph Ref. No.	Appendix 10 – Site 1
Location Coordinates	ITM East 721763; ITM North 745333
Townland	Malahide Demesne
County	Dublin
Site Type	Demesne
Site Name	Malahide Castle
Description	This 116-hectare demesne is located on the townlands of Malahide Demesne and Mabestown. It is bounded to the north and west by the Dublin/Malahide Road (R106/R107); to the east by a railway line; and to the south by Back Road. The demesne grounds as highlighted on the First Edition Ordnance Survey map remain intact and in single ownership, the transport network following the original demesne boundaries. The demesne is used as a public amenity and sporting facility and some of the attendant grounds, while retaining virtually the entire original tree plantation, have been converted to cricket grounds, tennis and basketball courts, golf courses and football pitches. These facilities, along with a car park, are located in the northern third of the demesne. A second car park has been added a short distance to the south of Malahide Castle (AHC001). The designed landscape is characterised by a mature tree belt extending horizontally across the middle third of the demesne, providing Malahide Castle with a sheltered wooded setting. Less pronounced tree belts are located along the demesne boundaries. To the immediate east of Malahide Castle are c. 10ha of ornamental gardens, created largely by Milo, seventh Baron Talbot (1912-1973), who re-landscaped the grounds and introduced over 5000 different species and varieties of plants. The ornamental grounds incorporate a 1.8-hectare walled garden constructed in 1775, an ornamental pond and a number of greenhouses, most notably the ornate Victoria House transported to the estate in the 1990s from the Ursuline Convent in Cabinteely, Co. Dublin. Apart from Malahide Castle (AHC001) and its outbuildings (AHC003), a number of interesting architectural features are located within the demesne, including (but not limited to) the church and graveyard of Malahide Abbey (AHC005 and AHC006), a lime kiln (AHC009), several gate lodges (including AHC007 and AHC008) and a two-storey Victorian stewart's house (AHC004). A low stone wall defines part of the western boundary.
Approximate Date	1750-1950 (multi-period grounds)
Statutory Protection	ACA
Importance	Regional
Key Constraint	Yes
Distance from Centre Line	0m
Type of Impact	Direct
Quality of Impact	Negative
Nature of Impact	Encroachment on demesne lands

Extent of Impact	Construction of new footpath; construction of new pedestrian steps and cycle ramp necessitating the removal of existing plantation; widening of existing pedestrian entrance to Bridgefield car park.
Magnitude of Impact	Low
Significance of Impact	Slight
Mitigation Measures	Monitoring of demesne boundary during construction and fencing off if necessary to prevent physical damage.
Magnitude with Mitigation	Low
Significance with Mitigation	Not significant

Sites and Structures Subject to Not Significant Negative Construction Impacts

Table 2 – Structure 1 of 2

Reference No.	AHC027
Location Coordinates	ITM East 722179; ITM North 746030
Map/Photograph Ref. No.	Appendix 10 – Site 2
Townland	Malahide
County	Dublin
Site Type	Town House
Site Name	Sonas
Description	Eastern half of a two-storey four bay semi-detached red brick building comprising on the ground floor two central round-headed entrances flanked by canted bay windows. Segmental-headed window openings with one up-one down sash windows, brick string course to window heads, coursed brick cornices, slated hip-roof and tall brick chimney stacks. The building is set within its own grounds with a circular gravelled sweep, lawns, ornamental plantation and a gate entrance comprising red brick piers and cast iron gates.
Approximate Date	1860-1900
Statutory Protection	RPS (425)
Importance	Regional
Key Constraint	Yes
Distance from Centre Line	17m
Type of Impact	Direct
Quality of Impact	Negative
Nature of Impact	Encroachment on curtilage
Extent of Impact	Trimming of hedgerow.
Magnitude of Impact	Low
Significance of Impact	Not significant
Mitigation Measures	Monitoring boundary treatment of structure and fencing off if necessary during construction to prevent physical damage.
Magnitude with Mitigation	Neutral
Significance with Mitigation	No predicted impact

Table 3 – Structure 2 of 2

Reference No.	AHC028
Location Coordinates	ITM East 722189; ITM North 746030
Map/Photograph Ref. No.	Appendix 10 – Site 2
Townland	Malahide
County	Dublin

Site Type	Town House
Site Name	Rosca
Description	Western half of a two-storey four bay semi-detached red brick building comprising on the ground floor two central round-headed entrances flanked by canted bay windows. Segmental-headed window openings with one up-one down sash windows, brick string course to window heads, coursed brick cornices, slated hip-roof and tall brick chimney stacks. The building is set within its own grounds with a circular gravelled sweep, lawns, ornamental plantation and a gate entrance comprising red brick piers and cast iron gates.
Approximate Date	1860-1900
Statutory Protection	RPS (424)
Importance	Regional
Key Constraint	Yes
Distance from Centre Line	25m
Type of Impact	Direct
Quality of Impact	Negative
Nature of Impact	Encroachment on curtilage
Extent of Impact	Trimming of hedgerow
Magnitude of Impact	Low
Significance of Impact	Not significant
Mitigation Measures	Monitoring boundary treatment of structure and fencing off if necessary during construction to prevent physical damage.
Magnitude with Mitigation	Neutral
Significance with Mitigation	No predicted impact

Sites and Structures Subject to No Negative Construction Impacts

Table 4 – Structure 1 of 17

Reference No.	AHC001
Map/Photograph Ref. No.	Appendix 10 – Site 3
Location Coordinates	ITM East 721923; ITM North 745444
Townland	Malahide Demesne
County	Dublin
Site Type	Country House
Site Name	Malahide Castle
Description	*NIAH*: Detached five-bay three-storey over basement medieval mansion, c. 1450, renovated and extended, c. 1650. Partly rebuilt and extended, c. 1770, with single-bay three-storey Georgian Gothic style circular towers added at each end of the front elevation. Single-bay three-storey flat-roofed entrance block with single-bay full-height square turrets to corners added c. 1825. In use as museum, c.1975, extensively renovated, c.1990, refurbished again in 2014. ROOF: Double-pitched and hipped behind battlemented parapets; slate; concrete ridge tiles; nap rendered chimney stack; clay pots; cast-iron rainwater goods; flat-roof to towers, turrets and entrance block. WALLS: Random coursed rubble stone; nap rendered over; nap rendered courses; unpainted; stone coping to battlemented parapets. OPENINGS: Ogee-headed openings to tower to left; stone sills; moulded surrounds; Gothic style timber sash windows; square-headed window openings to right; cut-stone hood mouldings; 6/6 timber sash windows; pointed-arch door opening to centre; cut-stone surround; timber panelled door; shallow-arch window openings over; cut-stone surrounds and mullions; diamond-leaded five-pane windows; square-headed window

	openings to tower to right; diamond-leaded fixed-pane windows. INTERIOR: Restored, c. 1990, great hall; vaulted undercroft; corbel heads of Edward IV; oak room; carved timber panelled walls; pair of drawing rooms rebuilt, c. 1770 (after fire, 1760); rococo plasterwork; decorative doorcases; turret rooms. *Archaeological Inventory*: Malahide castle erected on an elevated situation in the present grounds of the Demesne is associated with the Talbot family who were granted these lands by Henry 11 in 1174. The family remained here until 1973, except for a short period in 1653 when Talbot was outlawed and the castle and lands were given to Miles Corbet but later restored in 1665 (Anon 1914, 255-257). It is large, irregular, and unequal in its height. The late medieval core of the castle is largely masked by a re-build c. 1760, which involved the construction of a long symmetrical wing with corner towers that enclosed the earlier castle thus creating a castellated structure. Externally this is of Georgian Gothic style. The castle was re-roofed and renovated in the 19th-century. The ground floor of the late medieval core is vaulted and entered by a Gothic doorway; the upper chambers are approached by a spiral staircase in a SE angle tower which projects in the E. On the first floor adjoining the hall in the medieval core of the castle is the Oak Room. This has a vaulted undercroft and corbel heads of Edward 1V, which are original (Dims L10.75m, Wth 7.15m, T 1.30m). Its walls are covered with carved panelling of 16th-century date. There is a 16th-century Flemish carving over the fireplace depicting the Assumption of the Virgin (Flanagan 1984, 25-29; Bence-Jones 1988, 198-199, O'Shea 1992, 12). *Bence-Jones*: The most distinguished of all Irish castles, probably in continuous occupation by the same family for longer than any other house in Ireland. It also contains the only surviving medieval great hall in Ireland to keep its original form and remain in domestic use – at any rate, until recently. The great hall, which continued as the dining room, dates from C15; it was re-roofed and given various features in C19; but its dimensions, its vaulted undercroft and its corbel heads of Edward IV are original. Adjoining the hall, in the early medieval core of the castle, is the Oak Room, its walls covered with carved panelling of different periods and nationalities. According to tradition, the carving of the Coronation of the Virgin above the fireplace of this room miraculously disappeared when the castle was occupied by the regicide, Myles Corbet, during the Cromwellian period, and reappeared when the Talbots returned after the Restoration. The opposite side of the castle to the great hall, dating from C16 or early C17, originally contained 4 tapestry-hung rooms; but this range was gutted by fire 1760. It was rebuilt *ca* 1770, probably by the same architect or builder who designed C18 wing at Ballinlough Castle, co Westmeath; the then owner, Richard Talbot, being married to Margaret, daughter of James O'Reilly of Ballinlough, who, after her husband's death, was created Baroness Talbot of Malahide. Externally, the rebuilt range was given a Georgian Gothic character, a slender round corner tower being added at each end of it. Inside, 2 magnificent drawing rooms were formed out of the space which had been previously occupied by the 4 smaller rooms; with ceilings of splendid rococo plaster work which can be attributed stylistically to Robert West. The doorway between the 2 rooms has on one side a doorcase with an entablature carried on Corinthian columns, and on the other a doorcase with a broken pediment on Ionic columns. The walls of the 2 drawing rooms are painted a subtle shade of orange, which makes a perfect background to the pictures in their gilt frames. Opening off each of the two drawing rooms is a charming little turret room. A 3rd round tower was subsequently added at the corner of the hall range, balancing one of

	C18 towers at the opposite side of the entrance front; and in early C19, an addition was built in the centre of this front, with 2 wide mullioned windows above an entrance door; forming an extension to the Oak Room and providing an entrance hall below it. The castle was noted for its splendid contents, which included a magnificent collection of ancestral portraits of the Talbots, and also of the Wogans and of other families to whom they were allied; including portraits of many prominent Irish Jacobites. 7th Baron, who succeeded 1948, made a notable garden here, with a collection of rare shrubs from Australasia and other parts of the world. Owing to death duties resulting from the death of 7th Baron, 1973, Malahide has been sold; the Talbots' connexion with the place, which went back to the reign of Henry II, has been brought to an end. The castle was acquired by Dublin County Council and has recently been opened to the public by Dublin Tourism, which bought some of the furniture. Some of the portraits are also still in the castle, having been bought by the National Gallery and lent to Dublin Tourism. Much of the contents, however, have been dispersed.
Approximate Date	1400-1990 (multi-period structure)
Statutory Protection	RMP (DU012-030----); RPS (383)
Importance	National
Key Constraint	Yes
Distance from Centre Line	100m
Type of Impact	No predicted impact
Quality of Impact	Neutral
Nature of Impact	None
Extent of Impact	None
Magnitude of Impact	Neutral
Significance of Impact	No predicted impact
Mitigation Measures	None required

Table 5 – Structure 2 of 17

Reference No.	AHC003
Location Coordinates	ITM East 722032; ITM North 745455
Map/Photograph Ref. No.	Appendix 10 – Site 4
Townland	Malahide Demesne
County	Dublin
Site Type	Outbuildings
Site Name	Malahide Castle
Description	*NIAH:* Two-storey stable yard complex on a U-shaped plan, c. 1840, comprising gabled central block. Pairs of carriageway arches to north and south gables attached to flanking perpendicular blocks. Remodelled c. 1990 to accommodate workshops and retail outlets, Major development work again in 2012. ROOF: Double-pitched; slate; concrete ridge tiles; red brick chimney stack; metal-framed square roof light; cast-iron rainwater goods. WALLS: Coursed rubble stone; red brick dressings. OPENINGS: Square-headed window openings; concrete sills; red brick quoined surrounds; replacement 8/8 timber sash and casement windows, c. 1990, round-and square-headed door openings; red brick quoined surrounds; replacement glazed timber doors, c.1990.
Approximate Date	1830-1850; remodelled c. 1990
Statutory Protection	RPS (383)
Importance	Regional
Key Constraint	Yes
Distance from Centre Line	8.5m

Type of Impact	No predicted impact
Quality of Impact	Neutral
Nature of Impact	None
Extent of Impact	None
Magnitude of Impact	Neutral
Significance of Impact	No predicted impact
Mitigation Measures	None required

Table 6 – Structure 3 of 17

Reference No.	AHC004
Location Coordinates	ITM East 722037; ITM North 745419
Map/Photograph Ref. No.	Appendix 10 – Site 5
Townland	Malahide Demesne
County	Dublin
Site Type	Stewarts House
Site Name	None
Description	*NIAH:* Detached three-bay two-storey house, c. 1860,retaining original features with single-bay two-storey return to rear. Repaired and refurbished in 2014. ROOF: Hipped; slate; concrete ridge tiles; red brick chimney stacks with yellow terracotta pots; cast-iron rainwater goods. WALLS: Rubble stone; red brick dressings; lime render over; unpainted. OPENINGS: Segmental-headed window openings; granite sills; 2/2 timber sash windows; square-headed to return; timber casement windows; round headed door openings; timber pilaster doorcase; timber panelled door; overlight; square-headed to return; timber door.
Approximate Date	1850-1870
Statutory Protection	RPS (383)
Importance	Regional
Key Constraint	Yes
Distance from Centre Line	10m
Type of Impact	No predicted impact
Quality of Impact	Neutral
Nature of Impact	None
Extent of Impact	None
Magnitude of Impact	Neutral
Significance of Impact	No predicted impact
Mitigation Measures	None required

Table 7 – Structure 4 of 17

Reference No.	AHC005
Location Coordinates	ITM East 721988; ITM North 745448
Map/Photograph Ref. No.	Appendix 10 – Site 6
Townland	Malahide Demesne
County	Dublin
Site Type	Church, undetermined
Site Name	Malahide Abbey
Description	*NIAH:* Ruined church with nave, chancel and sacristy to south. Late fifteenth-century nave, sixteenth-century chancel, possibly post Reformation. Sheela-na-gigs in wall. ROOF: Originally double-pitched behind battlemented parapet. WALLS: Random coursed rubble stone; cut stone bellcote to right gable end. OPENINGS: Pointed-arch door openings; carved cut stone hood moulding; trefoil-headed blind opening; cut stone surround; three pointed arch openings to bellcote.

	RMP: Located in the grounds of Malahide Castle (DU012-030----). The church contains a nave (int. dims. L 16.9m, Wth 6.8m) and chancel (int. dims. L 8.8m, Wth 5.6m) with a sacristy attached to southeastern corner. There are stepped battlements on the side walls of the nave. Built of coursed, well mortared limestone masonry. There are buttresses against the west gable either side of the window and a batter of buttress in the southwest corner. The church is entered towards the west end of the nave through opposed doorways with pointed arches, chamfered jambs and a hood moulding. Apex on the exterior of the south door contains a "mitred head" and a zoomorphic figure on the moulding stop. In the interior there is a red sandstone stoup (DU012-031004-) secured to south wall. There are fine triple light, ogee-headed W window of 15th-century date and two double-light tracery windows in the east end. Above the west gable is a triple bellcote with steps leading up to it. The chancel is entered through a pointed, segmental chancel arch. (Int. dims. L 8.80m, W 5.60m. Interior is lit by wide, flat-arched windows in the south wall. The east window is a large, limestone, triple-light, tracery window. Corbels project from the east wall at altar level. The sacristy is entered off the chancel by stepping down into a vaulted ground floor with wall presses. There is an external stairs to first floor which contains a fireplace and wall presses in the east wall. At the exterior east gable wall there is a sheela-na-gig (DU012-031003-). Another sheela-na-gig (DU012-031002-) is built into quoin at the northeast angle of the chancel of the medieval church (Healy 1975, 26; Anon 1914, 257; Hartnett 1954, 179, 181). The interior of the church has been used for burial and contains an altar tomb dedicated to Maud Plunkett (d. 1494) with a recumbent effigy of a female figure in a horned cap (DU012-031005-). There is a 19th century box tomb at the east end of the chancel. In 2010 the tree and vegetation growth which dominated the south of the church was removed opening up the entire southern facade of the church.
Approximate Date	15th-16th century
Statutory Protection	RMP (DU012-031001-); RPS (384)
Importance	National
Key Constraint	Yes
Distance from Centre Line	34.4m
Type of Impact	No predicted impact
Quality of Impact	Neutral
Nature of Impact	None
Extent of Impact	None
Magnitude of Impact	Neutral
Significance of Impact	No predicted impact
Mitigation Measures	None required

Table 8 – Structure 5 of 17

Reference No.	AHC006
Location Coordinates	ITM East 721990; ITM North 745462
Map/Photograph Ref. No.	Appendix 10 – Site 6
Townland	Malahide Demesne
County	Dublin
Site Type	Graveyard
Site Name	Malahide Abbey
Description	NIAH: Graveyard with various cut stone grave markers. RMP: Located in the grounds of Malahide Castle (DU012-030----) opposite the recently renovated Courtyard. This is a relatively small sub-circular graveyard enclosed by a battlemented wall (E-W c. 40m, N-S c. 45m. and

	curving hedgerow. It is raised in the centre and dominated by the church (DU012-031001-) the interior of which has been used for internment. The graveyard contains a number of inscribed 18th, 19th and early to mid-20th century gravestones. There are also undecorated grave markers and possibly reused architectural fragments. At least two examples of fallen slabs (one external and one internal to church) have been replaced by modern stones with original inscriptions. Monitoring (Licence no. C451; E4381) of the insertion of services during the redevelopment of the Malahide Castle & Gardens uncovered skeletal remains on the curving path 1m externally to the graveyard. These remains were uncovered at a depth of approximately 0.5m below the surface and were aligned east to west. All four individuals were truncated at the west by a modern service trench.
Approximate Date	15th to 20th century
Statutory Protection	RMP (DU012-031006-); RPS (384)
Importance	National
Key Constraint	Yes
Distance from Centre Line	34.7m
Type of Impact	No predicted impact
Quality of Impact	Neutral
Nature of Impact	None
Extent of Impact	None
Magnitude of Impact	Neutral
Significance of Impact	No predicted impact
Mitigation Measures	None required

Table 9 – Structure 6 of 17

Reference No.	AHC007
Location Coordinates	ITM East 722300; ITM North 746003
Map/Photograph Ref. No.	Appendix 10 – Site 7
Townland	Malahide Demesne
County	Dublin
Site Type	Hogan's Gate Lodge
Site Name	Malahide Castle
Description	*NIAH:* Detached three-bay single-storey gate lodge, c. 1880, with gabled advanced central bay, and open recessed entrance bay to right-hand side. Gateway, c. 1880, comprising pair of limestone ashlar piers with moulded capping and ball finials, having cast-iron gates and railings. Refurbished in 2016. ROOF: Pyramidal and gable-fronted -behind limestone parapet; slate; limestone ashlar central chimney stack; red clay pot; timber eaves; cast-iron rainwater goods. WALLS: Uncoursed cut-limestone; limestone dressings including quoins; cut-stone coping to gable-front; cut-stone plaque to gable with coat-of-arms. OPENINGS: Square-headed openings; cut-limestone surrounds and tracery; square-leaded timber casement windows; open internal porch to right; segmental-headed colonnade with carved stone posts; glazed timber panelled door.
Approximate Date	1820-1900 (modified)
Statutory Protection	RPS (383)
Importance	Regional
Key Constraint	Yes
Distance from Centre Line	8m
Type of Impact	No predicted impact
Quality of Impact	Neutral
Nature of Impact	None

Extent of Impact	None
Magnitude of Impact	Neutral
Significance of Impact	No predicted impact
Mitigation Measures	None required

Table 10 – Structure 7 of 17

Reference No.	AHC024
Location Coordinates	ITM East 722326; ITM North 746092
Map/Photograph Ref. No.	Appendix 10 – Site 8
Townland	Malahide
County	Dublin
Site Type	Vernacular House
Site Name	Casino
Description	*NIAH:* Detached eight-bay single- and two-storey thatched house, c. 1750, comprising three-bay two-storey curved entrance bow to centre. Two- and three-bay single-storey flanking end bays having pair of three-bay single-storey curved bows to left side elevation. Proposed to house Fry Model Railway Museum. ROOF: Sliced straw thatched; hazel rod pinning; red brick chimney stacks; clay pots; overhanging eaves. Double-pitched (half-conical to bows). WALLS: Rubble stone construction; whitewashed; mostly ivy-covered. OPENINGS: Square-headed; stone sills; 6/6 timber sash windows; timber panelled door; 'spider's web' fanlight; sidelights.
Approximate Date	1730-1770
Statutory Protection	RPS (381)
Importance	Regional
Key Constraint	Yes
Distance from Centre Line	76m
Type of Impact	No predicted impact however monitoring boundary treatment of structure and fencing off if necessary during construction is advised to prevent physical damage
Quality of Impact	Neutral
Nature of Impact	None
Extent of Impact	None
Magnitude of Impact	Neutral
Significance of Impact	No predicted impact
Mitigation Measures	None required

Table 11 – Structure 8 of 17

Reference No.	AHC025
Location Coordinates	ITM East 722366; ITM North 746032
Map/Photograph Ref. No.	Appendix 10 – Site 9
Townland	Malahide
County	Dublin
Site Type	Milestone
Site Name	Milestone
Description	*NIAH:* Wall-mounted cast-iron milestone, c. 1850, with cut granite surround and inscription. Inscribed: "GPO/Dublin/9/Malahide/O" Possibly originally freestanding.
Approximate Date	1825-1875
Statutory Protection	RPS (386)
Importance	Regional
Key Constraint	No
Distance from Centre Line	55m

Type of Impact	No predicted impact
Quality of Impact	Neutral
Nature of Impact	None
Extent of Impact	None
Magnitude of Impact	Neutral
Significance of Impact	No predicted impact
Mitigation Measures	None required

Table 12 – Structure 9 of 17

Reference No.	AHC026
Location Coordinates	ITM East 722263; ITM North 746047
Map/Photograph Ref. No.	Appendix 10 – Site 10
Townland	Malahide
County	Dublin
Site Type	Church, Presbyterian
Site Name	Malahide Presbyterian Church
Description	Malahide Presbyterian church was designed by William Baird and built in 1956 as the first Presbyterian church to be constructed in the Republic in the twentieth century. It is also the first building in Ireland constructed of split concrete blocks. It has a steeply pitched roof with flared eaves and a copper-clad spire. The walls are buttressed, the flared eaves of the roof resting on the buttresses. Between each buttress is a triangular-headed triple light with 1/1 sashes. There is a large arched window in the south gable with intersecting tracery.
Approximate Date	1955-1956
Statutory Protection	RPS (426)
Importance	Regional
Key Constraint	Yes
Distance from Centre Line	44m
Type of Impact	No predicted impact however monitoring boundary treatment of structure and fencing off if necessary during construction is advised to prevent physical damage
Quality of Impact	Neutral
Nature of Impact	None
Extent of Impact	None
Magnitude of Impact	Neutral
Significance of Impact	No predicted impact
Mitigation Measures	None required

Table 13 – Structure 10 of 17

Reference No.	AHC022
Location Coordinates	ITM East 722450; ITM North 746264
Map/Photograph Ref. No.	Appendix 10 – Site 11
Townland	Malahide
County	Dublin
Site Type	Railway Bridge
Site Name	Malahide Station
Description	*NIAH:* Single-arch ashlar limestone built railway bridge over road, opened 1844. Coursed snecked limestone; cut-stone piers with concrete coping; cast-iron panels to one parapet wall; red brick soffit. Round-headed arch; cut-stone voussoirs.
Approximate Date	1840-1850
Statutory Protection	RPS (423)

Importance	Regional
Key Constraint	Yes
Distance from Centre Line	0m
Type of Impact	No predicted impact however monitoring structure and fencing off if necessary during construction is advised to prevent physical damage
Quality of Impact	Neutral
Nature of Impact	None
Extent of Impact	None
Magnitude of Impact	Neutral
Significance of Impact	No predicted impact
Mitigation Measures	None required

Table 14 – Structure 11 of 17

Reference No.	AHC023
Location Coordinates	ITM East 722490; ITM North 746978
Map/Photograph Ref. No.	Appendix 10 – Site 12
Townland	Malahide
County	Dublin
Site Type	Viaduct
Site Name	Malahide Railway Viaduct
Description	*Malahide Viaduct Appropriate Assessment*: The original Malahide Viaduct was built in 1844 and was of timber construction supported on timber piles driven into the estuary bed. Within a few years of its opening the viaduct was strengthened against the effects of scour with the placing of rock armour, encapsulating the timber supports and thus forming a weir extending over the length of the bridge from abutment to abutment. In 1860 the viaduct was replaced with masonry piers and wrought iron girders; the piers founded directly on top of the weir. In the late 1960s the twelve wrought iron spans were replaced with precast post-tensioned beams placed on the masonry piers and supporting ballasted track. The masonry piers are founded directly on top of the weir and therefore were extremely vulnerable to the effects of scour. Following the collapse in 2009 the collapsed pier was reinstated and supported on piles driven through the weir to bedrock level. To protect the viaduct against the effects of potential scour, micropiles were installed at each pier and abutment, with a total of fifteen piles in each.
Approximate Date	1840-1860
Statutory Protection	RPS (420)
Importance	Regional
Key Constraint	Yes
Distance from Centre Line	0m
Type of Impact	No predicted impact
Quality of Impact	Neutral
Nature of Impact	None
Extent of Impact	None
Magnitude of Impact	Neutral
Significance of Impact	No predicted impact
Mitigation Measures	None required

Table 15 – Structure 12 of 17

Reference No.	AHC031
Location Coordinates	ITM East 722620; ITM North 748996
Map/Photograph Ref. No.	Appendix 10 – Site 13
Townland	Kilcrea
County	Dublin
Site Type	Bridge
Site Name	Railway Bridge
Description	*NIAH:* Metal railway bridge spanning between stone piers, c. 1860, with alterations, c. 1960
Approximate Date	1860
Statutory Protection	RPS (502)
Importance	Regional
Key Constraint	Yes
Distance from Centre Line	0m
Type of Impact	No predicted impact however monitoring structure and fencing off if necessary during construction is advised to prevent physical damage
Quality of Impact	Neutral
Nature of Impact	None
Extent of Impact	None
Magnitude of Impact	Neutral
Significance of Impact	No predicted impact
Mitigation Measures	None required

Table 16 – Structure 13 of 17

Reference No.	AHC044
Location Coordinates	ITM East 721969; ITM North 749393
Map/Photograph Ref. No.	Appendix 10 – Site 14
Townland	Newbridge Demesne
County	Dublin
Site Type	Gate Entrance
Site Name	Newbridge House
Description	*NIAH:* Vermiculated granite entrance piers, c. 1770, capped by crown finials. Flanked by smaller piers to form pedestrian entrances.
Approximate Date	1750-1790
Statutory Protection	RPS (494)
Importance	Regional
Key Constraint	Yes
Distance from Centre Line	0m
Type of Impact	No predicted impact however monitoring boundary treatment of structure and fencing off if necessary during construction is advised to prevent physical damage
Quality of Impact	Neutral
Nature of Impact	None
Extent of Impact	None
Magnitude of Impact	Neutral
Significance of Impact	No predicted impact
Mitigation Measures	None required

Table 17 – Structure 14 of 17

Reference No.	AHC045
Location Coordinates	ITM East 721957; ITM North 749441
Map/Photograph Ref. No.	Appendix 10 – Site 15
Townland	Newbridge Demesne
County	Dublin
Site Type	Bridge
Site Name	Mack's Bridge
Description	*NIAH:* Single-arch humpback road bridge c. 1780, with carved limestone archivolt and keystones. Random rubble stone parapet walls with wrought-iron railings and ashlar piers.
Approximate Date	1760-1800
Statutory Protection	None; but located within the Newbridge Demesne ACA
Importance	Regional
Key Constraint	Yes
Distance from Centre Line	0m
Type of Impact	No predicted impact
Quality of Impact	Neutral
Nature of Impact	None
Extent of Impact	None
Magnitude of Impact	Neutral
Significance of Impact	No predicted impact
Mitigation Measures	None required

Table 18 – Structure 15 of 17

Reference No.	AHC041
Map/Photograph Ref. No.	Appendix 10 – Site 16
Location Coordinates	ITM East 721614; ITM North 749949
Townland	Newbridge Demesne
County	Dublin
Site Type	Demesne
Site Name	Newbridge House
Description	This 150-hectare demesne is located on the townland of Newbridge Demesne in Co. Dublin. It is bounded to the north by Turvey Avenue, to the east and south by Hearse Road and to the west by Cobbe's Lane (R126). The demesne grounds as highlighted on the First Edition Ordnance Survey map remain intact and in single ownership, the transport network following the original demesne boundaries. The demesne is used as a public amenity and incorporates a number of playing fields, children's adventure ground and a large traditional farm with animal enclosures. These facilities, along with a car park, are predominantly located to the immediate southwest of Newbridge House. The designed landscape is characterised by well-defined wood belts along the boundaries and a 'Brownian' design concept of open ground alternating with naturalistic tree belts and islands. Large walled gardens adjoin Newbridge House (AHC040) to the north. A low demesne wall, missing or collapsed in parts, bounds the demesne to the south and east.
Approximate Date	1730-1800
Statutory Protection	ACA
Importance	Regional
Key Constraint	Yes
Distance from Centre Line	0m
Type of Impact	No predicted impact

Quality of Impact	Neutral
Nature of Impact	None
Extent of Impact	None
Magnitude of Impact	Neutral
Significance of Impact	No predicted impact
Mitigation Measures	None required

Table 19 – Structure 16 of 17

Reference No.	AHC040
Location Coordinates	ITM East 721586; ITM North 750061
Map/Photograph Ref. No.	Appendix 10 – Site 17
Townland	Newbridge Demesne
County	Dublin
Site Type	Country House
Site Name	Newbridge House
Description	*NIAH:* Detached six-bay two-storey over basement house with dormer attic, built 1737, of ashlar sandstone, with pedimented tripartite doorcase approached by flight of granite steps. Built for Dr. Charles Cobbe, afterwards Archbishop of Dublin. Plasterwork by Robert West. Extensive wing added to rear, c. 1765. ROOF: Hidden behind solid roof parapet wall with urns and eagles; M-shaped double pitched slate roof with clay ridge tiles; rendered chimney stacks. Many double-pitched slate subsidiary roofs to wings and return. WALLS: Sandstone ashlar with granite quoins, coping and cornice; roughcast render side and rear elevations and rear wing; OPENINGS: Square-headed window openings; lugged and kneed surrounds and granite cills; 9/9 and 6/6 timber sash windows; pedimented limestone ionic doorcase with glazed and timber panelled double leaf door; 6/6 timber sash sidelights. INTERIOR: Portland stone and slate flagged entrance hall; original joinery; rococo plasterwork; staircase; chimney pieces. *Archaeological Inventory*: A survey dated 1705 shows a schematic drawing of a large single storey house which is rectangular in plan with a pitched roof. It then belonged to John Forde of the City of Dublin (Bates 1988, 96). Possibly incorporated into the present building on this site. *Bence-Jones*: A house probably by Richard Castle, built 1737 for Dr Charles Cobbe, afterwards Archbishop of Dublin. Of 2 storeys over a high basement; ashlar-faced entrance front of 6 bays, with a pedimented tripartite doorcase. Broad flight of steps with ironwork railings up to hall door' shouldered window architraves; solid roof parapet with urns and eagles at corners. Hall with modillion cornice and large pedimented chimneypiece. Soon after the Archbishop's death, 1765, his son, Col Thomas Cobbe, MP, who had a fashionable wife, a sister of 1st Marquess of Waterford, added a wing at the back of the house containing a very large drawing room, with a ceiling of rococo plasterwork by Robert West, who also decorated the family pew in the Protestant church at Donabate. This great room, which is now hung with a scarlet wallpaper, is entered by way of a corridor and through a monumental doorway with a pediment and fluted engaged Corinthian columns.
Approximate Date	1730-1740
Statutory Protection	RMP (DU012-060----), RPS (494)
Importance	National
Key Constraint	Yes
Distance from Centre Line	38m
Type of Impact	No predicted impact

Quality of Impact	Neutral
Nature of Impact	None
Extent of Impact	None
Magnitude of Impact	Neutral
Significance of Impact	No predicted impact
Mitigation Measures	None required

Table 20 – Structure 17 of 17

Reference No.	AHC042
Location Coordinates	ITM East 721545; ITM North 750101
Map/Photograph Ref. No.	Appendix 10 – Site 18
Townland	Newbridge Demesne
County	Dublin
Site Type	Outbuildings
Site Name	Newbridge House
Description	*NIAH:* Courtyard quadrangle, c.1790, comprising two-storey stable blocks, single-storey random rubble ranges and adjoining aviary. Designed by Robert Mack. In use as a museum of late eighteenth century rural life. Renovated in 2017. ROOF: Hipped; slate; terracotta ridge tiles; red brick chimneys; gable to central three-bays of main block. WALLS: Rough-cast render with red brick strings courses to L-shape block; random rubble limestone and red brick to other ranges. OPENINGS: Square-headed windows; brick dressed openings except to L-shape blocks which are rendered; granite cills; mostly timber casements some 20th century sashes; timber panelled doors; round headed; original Gothic fanlight retained.
Approximate Date	1785-1795
Statutory Protection	RPS (494)
Importance	Regional
Key Constraint	Yes
Distance from Centre Line	0m
Type of Impact	No predicted impact
Quality of Impact	Neutral
Nature of Impact	None
Extent of Impact	None
Magnitude of Impact	Neutral
Significance of Impact	No predicted impact
Mitigation Measures	None required

Appendix 11

Sites, Features and Structures of Architectural Heritage Merit Within the Study Area

Sites, Features and Structures Subject to Slight Negative Impacts

Site 1 – AHC002: Malahide Demesne.

Sites, Features and Structures Subject to Not Significant Negative Impacts

Site 2 – AHC027: Sonas (R) and AHC028:Rosca (L), Dublin Road, Malahide.

Sites, Features & Structures Subject to No Predicted Negative Impacts

Site 3 – AHC001: Malahide Castle, Malahide Demesne.

Site 4 – AHC003: Outbuildings, Malahide Demesne.

Site 5 – AHC004: Stewart's House, Malahide Demesne.

Site 6 – AHC005: Malahide Abbey, Malahide Demesne and **AHC006**: Graveyard, Malahide Abbey, Malahide Demesne.

Site 7 – AHC007: Hogan's Gate Lodge, Malahide Demesne.

Site 8 – AHC024: The Casino, Malahide.

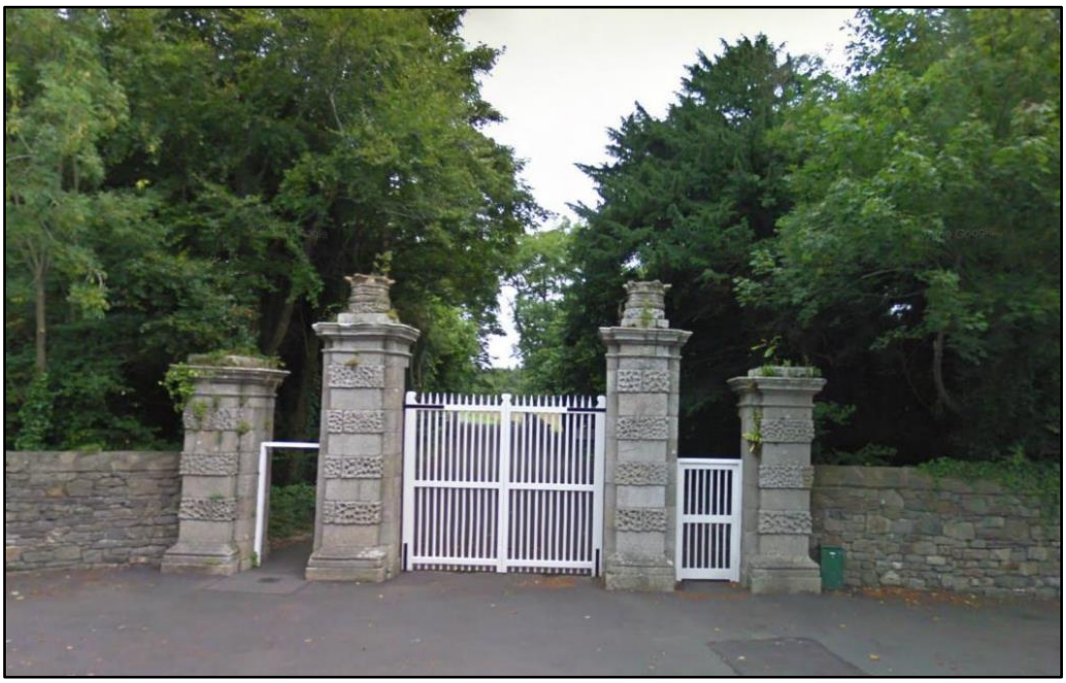
Site 9 – AHC025: Milestone, Dublin Road, Malahide.

Site 10 – AHC026: Presbyterian Church, Dublin Road, Malahide.

Site 11 – AHC022: Railway Bridge, Malahide.

Site 12 – AHC023: Malahide Railway Viaduct, Malahide.

Site 13 – AHC031: Railway Bridge, Kilcrea.



Site 14 – AHC044: Gate Entrance, Newbridge Demesne.

Site 15 – AHC045: Mack's Bridge, Newbridge Demesne.

Site 16 – AHC041: Newbridge Demesne.

Site 17 – AHC040: Newbridge House, Newbridge Demesne.

Site 18 – AHC042: Outbuildings, Newbridge Demesne.

Appendix 12

Aquatic Environment – Methodology and Plates 1-7

(A) Soft Sediment Survey, Malahide Weir Maintenance Track (September 2009)

A soft sediment survey was undertaken in September 2009 which covered the sites within the footprint of the weir maintenance track. Fieldwork was carried out on the 21st September 2009. All sampling stations were positioned using a differential GPS (Trimble Geo XM). A complete list of stations sampled are presented in Table 1 and these stations are displayed on a map (Figure 1).

Overall species abundances and diversity would be considered low with four stations returning no fauna and diversity would be considered low across all sites (Table 1). The sites in closest proximity to the maintenance track (S1-S8) had considerably lower abundances than those closest to the weir development (S9-S12). The most faunally abundant sites (S11 and S12) were present immediately to the west of the weir at Malahide. These sites are in mixed shell gravel exposed to a greater degree of water movement than the more southerly sites. The sites present in the vicinity of the track consist of low faunal diversity and abundances. Moreover, the fauna present in the area consist primarily of oligochaetes (with the exception of S9 – which contains coarser material and is dominated by keelworm, *Pomatoceros lamarcki*).

Biotope Classification

Data from the survey was compared against data for the latest JNCC Biotope classification scheme (Conor *et al.*, 2004). Results from all surveys undertaken during the present survey indicate the presence of several distinct habitats.

The area of the access track along the western side of the southern causeway has been classified as SS.SMu.SMuVS.OlVS (Oligochaetes in variable or reduced salinity infralittoral muddy sediment). This biotope is usually found towards the edges of tidal channels in estuaries where current velocities allow for the deposition of silt and the establishment of the infaunal communities identified here. This biotope is present across most of the access track route (from Grabs 1-8). This corresponds with results obtained in another survey of the Broadmeadow Estuary (Aquafact, 2008) which covered a much greater footprint than the survey reported here. Results from that survey indicated that the same habitat type is located along large parts of the southeastern area of the Broadmeadow Estuary extending well beyond the footprint of the trackway.

The remaining grab sites surveyed along the inner estuary (Grabs 9-12) consist of species and sediment, which are consistent with the SS.SCS.CCS.PomB (*Pomatoceros triqueter* with barnacles and bryozoan crusts on unstable circalittoral cobbles and pebbles). This biotope is characterised by a few robust, fast growing species, which are able to colonise benthos and are subjected to being regularly moved by wave and tidal action. The main cover organisms tend to be restricted to tube worms (*Pomatoceros* sp.) and barnacles (*Balanus crenatus*) both of which were recorded at these locations.

Table 1. Positions of subtidal biological sampling stations. All sampling locations are given in Irish National Grid. Sites highlighted in green fall within the footprint of the weir maintenance track development.

Subtidal Grab Stations	Co-ordinates (Irish National Grid)	
	Easting (m)	Northing (m)
S1	322507.571	246367.090
S2	322478.311	246374.105
S3	322471.502	246415.946
S4	322507.378	246454.032
S5	322506.994	246572.468
S6	322482.778	246575.019
S7	322492.349	246727.322
S8	322521.951	246729.182
S9	322528.983	246832.255
S10	322486.733	246842.925
S11	322510.098	246948.660
S12	322501.300	246960.564

Figure 1. Map showing locations of subtidal grab samples along the inner estuary at Malahide, Co. Dublin.

(B) Aquatic Habitats – Methodology

Sub-tidal Grab Sampling

A total of 12 stations were sampled by means of a 0.025m^2 Van-Veen Grab for benthic faunal and particle size analysis. At all sites, samples were taken where there was sufficient penetration of the Van-Veen grab.

At each station:

- 1 x 0.025m^2 Van-Veen grabs were deployed for samples for benthic faunal analysis, and the samples were transferred to separate, labelled, 10 litre buckets (12 samples).
- 1 x 0.025m^2 Van-Veen grab from which 100g of well-mixed sediment was transferred to a sealed plastic container for granulometric and organic carbon analysis (12 Samples).

Sample Processing

Granulometric Analysis

Granulometric analysis was carried out on oven dried sediment samples from each station. The sediment was passed through a series of nested brass test sieves with the aid of a mechanical shaker. The brass sieves chosen were 4mm, 2mm, 1mm, 500µm, 250µm, 125µm and 63µm. The sediments were then divided into three fractions: % Gravel (>2mm), % Sand (<2.0mm >63µm) and % Silt-Clay (<63µm). Further analysis of the sediment data was undertaken using the Gradistat package (Blott & Pye, 2001).

Organic Matter Analysis

Organic matter was estimated using the Loss on Ignition (LOI) method. One gram of dried sediment was ashed at 450˚C for 6 hours and organic carbon was calculated as % sediment weight loss.

Biological Sample Processing

On returning to the laboratory all faunal samples were sieved on a 1.0mm sieve within 24 hours of collection. Samples were preserved in 4% buffered formalin to which an organic dye (Rose-Bengal) had been added. All fauna were identified to the lowest taxonomic level possible using standard keys to northwest European fauna.

Pre-Construction Assessment Results

Results from the sediment analysis indicates that the sediment is dominated by fine sands and muds (Table 2 and Figure 2).

Grab Data

A total of 15 taxa were encountered in the grab samples along the western shore of the southern arm of the viaduct (Table 3). All species encountered are common in Irish coastal waters.

Table 2 Sediment characteristics for all subtidal grab samples.

Site ID	% Gravel	% Sand	% Mud	% LOI	Sediment Textural Group
Grab 1	2.3	45.8	51.9	3.7	Slightly gravelly sandy mud
Grab 2	0	85.9	14.1	1.7	Muddy sand
Grab 3	0	44.3	55.7	4.9	Sandy Mud
Grab 4	0.9	27.9	71.2	8.0	Slightly gravelly sandy mud
Grab 5	22.7	23.6	53.8	7.9	Gravelly mud
Grab 6	0	51.1	48.9	5.7	Muddy sand
Grab 7	0	40.4	59.6	6.0	Sandy mud
Grab 8	0	48.9	51.1	7.4	Sandy mud
Grab 9	33.7	24.9	41.4	2.2	Muddy gravel
Grab 10	93.3	4.4	2.3	5.6	Gravel

Table 3 Abundance data (per 0.025m^2) for all grab samples taken in the inner estuary at Grab sites 1-12. Sites highlighted in green are taken within the footprint of the weir maintenance track development.

	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12
Chironomdae sp.	0	0	1	0	0	0	0	0	0	0	0	0
Diptera larvae	0	1	2	0	0	0	0	0	0	0	0	0
Crangon	0	1	1	0	0	0	0	0	0	0	0	0
Carcinas maenas	0	0	0	0	1	0	0	0	1	1	0	0
Gammarus sp.	0	0	0	0	0	0	0	0	1	0	0	0
Melita palmata	0	0	0	0	0	0	0	0	0	0	1	0
Balanus crenatus	1	0	0	0	3	0	0	0	0	2	7	33
Mytilus edulis	0	0	0	0	0	0	0	0	0	0	1	0
Pomatoceros lamarcki	0	0	0	0	0	0	0	0	28	7	58	27
Tharyx sp.	2	7	0	0	0	0	0	0	0	0	14	4
Capitella capitata	2	2	0	0	0	0	0	0	0	0	0	0
Eteone longa	0	0	0	0	0	0	0	0	0	0	1	0
Heterochaeta costata	1	0	0	0	0	0	0	0	0	0	0	3
Oligochaetae	0	0	1	0	0	0	0	0	0	0	0	0
Tubificoides benedii	1	0	0	0	0	0	0	0	0	1	17	0

Table 4 Primary and derived diversity indices for all grab samples in the inner part of Malahide Estuary. Sites highlighted in green are located within the footprint of the weir maintenance track development.

	S1	S2	S3	S4	S5	S6
Number of Species	5	4	4	0	2	0
Number of Individuals	7	11	5	0	4	0
Margellef's Dominance Index	2.06	1.25	1.86	****	0.721	****
Shannon-Wiener Index	1.55	1.03	1.33	****	0.562	****
Pielou's Evenness	0.963	0.746	0.961	****	0.811	****
	S7	**S8**	**S9**	**S10**	**S11**	**S12**
Number of Species	0	0	3	4	7	4
Number of Individuals	0	0	30	11	99	67
Margellef's Dominance Index	****	****	0.588	1.25	1.31	0.713
Shannon-Wiener Index	****	****	0.291	1.03	1.22	1.02
Pielou's Evenness	****	****	0.265	0.746	0.626	0.738

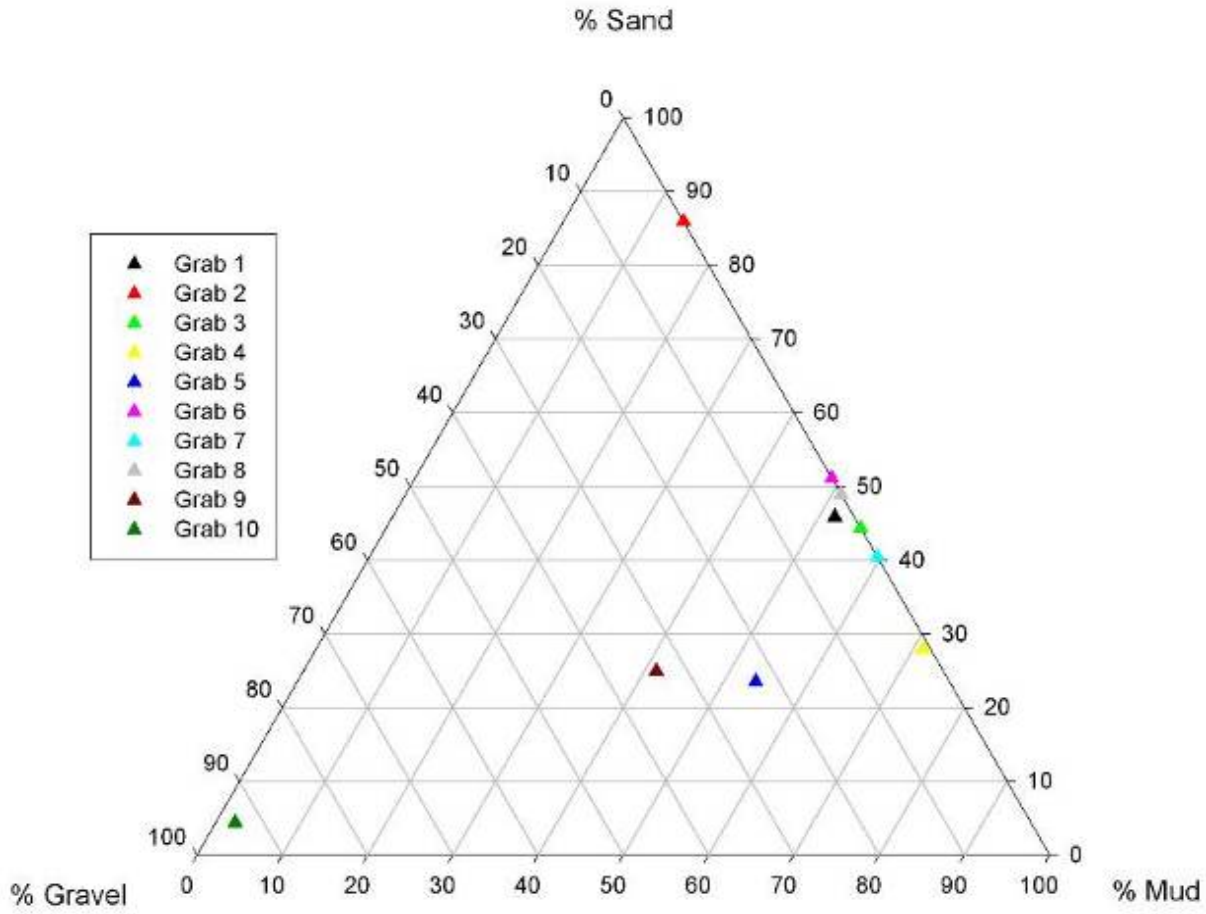


Figure 2 Ternary plot of particle size analysis along the subtidal grab sampling stations within and adjacent to the footprint of the weir maintenance track.

(C) Aquatic Environment – Plates 1 to 7

Plate 1: View of the exposed mud and sand flats of Malahide Estuary (outer) to the left of the railway embankment and of the lagoon-like Malahide Estuary (inner) to the right. View south toward Malahide.

Plate 2: View of distinct vertical zonation pattern along Malahide railway embankment – outer (eastern) face.

Plate 3: View of the tidal flaps on the River Pill outlet beneath the railway embankment viewed from the Malahide Estuary side.

Plate 4: The channel on the River Pill within the Malahide estuary at low tide viewed from its outlet under the railway embankment. Note the extensive adjoining mudflats.

Plate 5: View of the fringing saltmarsh (*Spartina*) at the top of the shore close to the Pill River outlet to the Malahide Estuary.

Plate 6: View of Pill River at kick sample site just upstream of road bridge.

Plate 7: View of Pill River channel at approximate position of proposed pedestrian bridge crossing point - view upstream.

Appendix 13

Site Synopsis Sheets – Malahide Estuary SAC and SPA

Malahide Estuary SAC (Site Code: 000205)

Malahide Estuary is situated immediately north of Malahide and east of Swords in Co. Dublin. It is the estuary of the River Broadmeadow. The site is divided by a railway viaduct which was built in the 1800s.

The site is a Special Area of Conservation (SAC) selected for the following habitats and/or species listed on Annex I/II of the EU Habitats Directive (* = priority; numbers in brackets are Natura 2000 codes):

- [1140] Tidal Mudflats and Sandflats
- [1310] *Salicornia* Mud
- [1330] Atlantic Salt Meadows
- [1410] Mediterranean Salt Meadows
- [2120] Marram Dunes (White Dunes)
- [2130] Fixed Dunes (Grey Dunes)*

The outer part of the estuary is mostly cut off from the sea by a large sand spit, known as 'the island'. The outer estuary drains almost completely at low tide, exposing sand and mud flats. There is a large bed of Eelgrass (Dwarf Eelgrass, *Zostera noltii*, and Narrow-leaved Eelgrass, *Z. angustifolia*) in the north section of the outer estuary, along with Beaked Tasselweed (*Ruppia maritima*) and extensive mats of green algae (*Enteromorpha* spp., *Ulva lactuca*). Common Cord-grass (*Spartina anglica*) is also widespread in this sheltered part of the estuary.

The dune spit has a well-developed outer dune ridge dominated by Marram Grass (*Ammophila arenaria*). The dry areas of the stabilised dunes have a dense covering of Burnet Rose (*Rosa pimpinellifolia*), Red Fescue (*Festuca rubra*) and species such as Yellow-wort (*Blackstonia perfoliata*), Autumn Gentian (*Gentianella amarella*), Hound's-tongue (*Cynoglossum officinale*), Carline Thistle (*Carlina vulgaris*) and Pyramidal Orchid (*Anacamptis pyramidalis*). Much of the interior of the spit is taken up by a golf course. The inner stony shore has frequent Sea-holly (*Eryngium maritimum*). Well- developed saltmarshes occur at the tip of the spit. Atlantic salt meadow is the principle type and is characterised by species such as Sea-purslane (*Halimoine portulacoides*), Sea Aster (*Aster tripolium*), Thrift (*Armeria maritima*), Sea Arrowgrass (*Triglochin maritima*) and Common Saltmarsh-grass (*Puccinellia maritima*). Elsewhere in the outer estuary, a small area of Mediterranean salt meadow occurs which is characterised by the presence of Sea Rush (*Juncus maritimus*). Below the salt marshes there are good examples of pioneering glasswort (*Salicornia* spp.) swards and other annual species, typified by *S. dolichostachya* and Annual Sea-blite (*Suaeda maritima*).

The inner estuary does not drain at low tide apart from the extreme inner part. Here, patches of saltmarsh and salt meadows occur, with Sea Aster, Sea Plantain (*Plantago maritima*) and Sea Club-rush (*Scirpus maritimus*). Beaked Tasselweed occurs in one of the channels.

The site includes a fine area of rocky shore south-east of Malahide and extending towards Portmarnock. This represents the only continuous section through the fossiliferous Lower Carboniferous rocks in the Dublin Basin, and is the type locality for several species of fossil coral.

The estuary is an important wintering bird site and holds an internationally important population of Brent Goose and nationally important populations of a further 15 species. Average maximum counts during the 1995/96-1997/98 period were: Brent Goose 1217; Great Crested Grebe 52; Mute Swan 106; Shelduck 471; Pochard 200; Goldeneye 333; Red-breasted Merganser 116; Oystercatcher 1228; Golden Plover 2123; Grey Plover 190; Redshank 454; Wigeon 50; Teal 78; Ringed Plover 106; Knot 858; Dunlin 1474; Greenshank 38; Pintail 53; Black-tailed Godwit 345; Bar-tailed Godwit 99. The high numbers of diving birds reflects the lagoon-type nature of the inner estuary.

The estuary also attracts migrant species such as Ruff, Curlew Sandpiper, Spotted Redshank and Little Stint. Breeding birds of the site include Ringed Plover, Shelduck and Mallard. Up to the 1950s there was a major tern colony at the southern end of the island and the habitat remains suitable for these birds.

The inner part of the estuary is heavily used for water sports. A section of the outer estuary has recently been infilled for a marina and housing development.

This site is a fine example of an estuarine system with all the main habitats represented. The site is important ornithologically, with a population of Brent Goose of international significance.

Version date: 26.05.2017

Malahide Estuary SPA (Site Code 004025)

Malahide Estuary is situated in north Co. Dublin, between the towns of Malahide and Swords. The site encompasses the estuary, saltmarsh habitats and shallow subtidal areas at the mouth of the estuary. A railway viaduct, built in the 1800s, crosses the site and has led to the inner estuary becoming lagoonal in character and only partly tidal. Much of the outer part of the estuary is well-sheltered from the sea by a large sand spit, known as “The Island”. This spit is now mostly converted to golf-course. The outer part empties almost completely at low tide and there are extensive intertidal flats exposed. Substantial stands of eelgrass (both *Zostera noltii* and *Z. angustifolia*) occur in the sheltered part of the outer estuary, along with Tasselweed (*Ruppia maritima*). Green algae, mostly *Ulva* spp., are frequent on the sheltered flats. Common Cord-grass (*Spartina anglica*) is well established in the outer estuary and also in the innermost part of the site. The intertidal flats support a typical macroinvertebrate fauna, with polychaete worms (*Arenicola marina* and *Hediste diversicolor*), bivalves such as *Cerastoderma edule*, *Macoma balthica* and *Scrobicularia plana*, the small *gastropod Hydrobia ulva*e and the crustacean *Corophium volutator*. Salt marshes, which provide important roosts during high tide, occur in parts of the outer estuary and in the extreme inner part of the inner estuary. These are characterised by such species as Sea Purslane (*Halimione portulacoides*), Sea Aster (*Aster tripolium*), Thrift (*Armeria maritima*), Sea Arrowgrass (*Triglochin maritima*) and Common Saltmarsh-grass (*Puccinellia maritima*).

The site is a Special Protection Area (SPA) under the EU Birds Directive, of special conservation interest for the following species: Great Crested Grebe, Light-bellied Brent Goose, Shelduck, Pintail, Goldeneye, Red-breasted Merganser, Oystercatcher, Golden Plover, Grey Plover, Knot, Dunlin, Black-tailed Godwit, Bar-tailed Godwit and Redshank. The EU Birds Directive pays

particular attention to wetlands and, as these form part of this SPA, the site and its associated waterbirds are of special conservation interest for Wetland and Waterbirds.

This site is of high importance for wintering waterfowl and supports a particularly good diversity of species. It has internationally important populations of Lightbellied Brent Goose (1,104 individuals or 5% of the all-Ireland total) and Black-tailed Godwit (409 individuals or 2.9% of the all-Ireland total) - figures given here and below are mean peaks for the five winters 1995/96-1999/2000. Furthermore, the site supports nationally important populations of an additional 12 species: Great Crested Grebe (63), Shelduck (439), Pintail (58), Goldeneye (215), Red-breasted Merganser (99), Oystercatcher (1,360), Golden Plover (1,843), Grey Plover (201), Knot (915), Dunlin (1,594), Bar-tailed Godwit (156) and Redshank (581). The high numbers of diving ducks reflects the lagoon-type nature of the inner estuary, and this is one of the few sites in eastern Ireland where substantial numbers of Goldeneye can be found.

A range of other species occurs, including Mute Swan (37), Pochard (36), Ringed Plover (86), Lapwing (1,542), Curlew (548), Greenshank (38) and Turnstone (112).

The estuary also attracts other migrant wader species such as Ruff, Curlew Sandpiper, Spotted Redshank and Little Stint. These occur mainly in autumn, though occasionally in spring and winter.

Breeding birds of the site include Ringed Plover, Shelduck and Mallard. Up to the 1950s there was a major tern colony at the southern end of Malahide Island. Grey Herons breed nearby and feed regularly within the site.

Malahide Estuary SPA is a fine example of an estuarine system, providing both feeding and roosting areas for a range of wintering waterfowl. The lagoonal nature of the inner estuary is of particular value as it increases the diversity of birds which occur. The site is of high conservation importance, with internationally important populations of Light-bellied Brent Goose and Black-tailed Godwit, and nationally important populations of a further 12 species. Two of the species which occur regularly (Golden Plover and Bar-tailed Godwit) are listed on Annex I of the EU Birds Directive. Malahide Estuary (also known as Broadmeadow Estuary) is a Ramsar Convention site.

Version date: 23.08.2013

Appendix 14

Ambient Air Quality Standards

National standards for ambient air pollutants in Ireland have generally ensued from Council Directives enacted in the EU (and previously the EC and EEC) (see Table 12.1). The initial interest in ambient air pollution legislation in the EU dates from the early 1980s and was in response to the most serious pollutant problems at that time. In response to the problem of acid rain, sulphur dioxide and later nitrogen dioxide were both the focus of EU legislation. Linked to the acid rain problem was urban smog associated with fuel burning for space heating purposes. Also apparent at this time were the problems caused by leaded petrol and EU legislation was introduced to deal with this problem in the early 1980s.

In recent years the EU has focused on defining a basic strategy across the EU in relation to ambient air quality. In 1996, a Framework Directive, Council Directive 96/62/EC, on ambient air quality assessment and management was enacted. The aims of the Directive are fourfold. Firstly, the Directive's aim is to establish objectives for ambient air quality designed to avoid harmful effects to health. Secondly, the Directive aims to assess ambient air quality on the basis of common methods and criteria throughout the EU. Additionally, it is aimed to make information on air quality available to the public via alert thresholds and fourthly, it aims to maintain air quality where it is good and improve it in other cases.

As part of these measures to improve air quality, the European Commission has adopted proposals for daughter legislation under Directive 96/62/EC. The first of these directives to be enacted, Council Directive 1999/30/EC, was passed into Irish Law as SI No 271 of 2002 (Air Quality Standards Regulations 2002), and has set limit values which came into operation on 17th June 2002. The Air Quality Standards Regulations 2002 detail margins of tolerance, which are trigger levels for certain types of action in the period leading to the attainment date. The margin of tolerance varies from 60% for lead, to 30% for 24-hour limit value for PM_{10}, 40% for the hourly and annual limit value for NO_2 and 26% for hourly SO_2 limit values. The margin of tolerance commenced from June 2002, and will start to reduce from 1 January 2003 and every 12 months thereafter by equal annual percentages to reach 0% by the attainment date. A second daughter directive, EU Council Directive 2000/69/EC, details limit values for both carbon monoxide and benzene in ambient air. This has also been passed into Irish law under the Air Quality Standards Regulations 2002. The most recent EU Council Directive on ambient air quality was published on 11/06/08. Council Directive 2008/50/EC combines the previous Air Quality Framework Directive and its subsequent daughter directives. Council Directive 2008/50/EC, was passed into Irish law as SI No. 180 of 2011 (Air Quality Standards Regulations 2011). Provisions were also made for the inclusion of new ambient limit values relating to $PM_{2.5}$. The margin of tolerance specific to each pollutant was also slightly adjusted from previous directives as outlined in Table 12.1.

Although the EU Air Quality Limit Values are the basis of legislation, other thresholds outlined by the EU Directives are used which are triggers for particular actions. The Alert Threshold is defined in Council Directive 2008/50/EC as "a level beyond which there is a risk to human health from brief exposure and at which immediate steps shall be taken as laid down in Directive 2008/50/EC". These steps include undertaking to ensure that the necessary steps are taken to inform the public (e.g. by means of radio, television and the press).

The Margin of Tolerance is defined in Council Directive 2008/50/EC as a concentration which is higher than the limit value when legislation comes into force. It decreases to meet the limit value by the attainment date. The Upper Assessment Threshold is defined in Council Directive 2008/50/EC as a concentration above which high quality measurement is mandatory. Data from measurement may be supplemented by information from other sources, including air quality modelling.

An annual average limit for both NO_x (NO and NO_2) is applicable for the protection of vegetation in highly rural areas away from major sources of NO_x such as large conurbations, factories and high road vehicle activity such as a dual carriageway or motorway. Annex III of EU Directive 2008/50/EC identifies that monitoring to demonstrate compliance with the NO_X limit for the protection of vegetation should be carried out at distances greater than:

- 5km from the nearest motorway or dual carriageway
- 5km from the nearest major industrial installation
- 20km from a major urban conurbation

As a guideline, a monitoring station should be indicative of approximately 1000km^2 of surrounding area.

Under the terms of EU Framework Directive on Ambient Air Quality (96/62/EC), geographical areas within member states have been classified in terms of zones. The zones have been defined in order to meet the criteria for air quality monitoring, assessment and management as described in the Framework Directive and daughter directives. Zone A is defined as Dublin and its environs, Zone B is defined as Cork City, Zone C is defined as 21 urban areas with a population greater than 15,000 and Zone D is defined as the remainder of the country. The zones were defined based on among other things, population and existing ambient air quality.

EU Council Directive 96/62/EC on ambient air quality and assessment has been adopted into Irish Legislation (SI No. 33 of 1999). The act has designated the Environmental Protection Agency (EPA) as the competent authority responsible for the implementation of the Directive and for assessing ambient air quality in the State. Other commonly referenced ambient air quality standards include the World Health Organisation. The WHO guidelines differ from air quality standards in that they are primarily set to protect public health from the effects of air pollution. Air quality standards, however, are air quality guidelines recommended by governments, for which additional factors, such as socio-economic factors, may be considered.

Appendix 15

Glossary of Acoustic Terminology

ambient noise The totally encompassing sound in a given situation at a given time, usually composed of sound from many sources, near and far.

background noise The steady existing noise level present without contribution from any intermittent sources. The A-weighted sound pressure level of the residual noise at the assessment position that is exceeded for 90 per cent of a given time interval, T ($L_{AF90,T}$).

dB Decibel - The scale in which sound pressure level is expressed. It is defined as 20 times the logarithm of the ratio between the RMS pressure of the sound field and the reference pressure of 20 micro-pascals (20μPa).

$L_{Aeq,T}$ This is the equivalent continuous sound level. It is a type of average and is used to describe a fluctuating noise in terms of a single noise level over the sample period (T).The closer the L_{Aeq} value is to either the L_{AF10} or L_{AF90} value indicates the relative impact of the intermittent sources and their contribution. The relative spread between the values determines the impact of intermittent sources, such as traffic, on the background.

L_{AF90} Refers to those A-weighted noise levels in the lower 90 percentile of the sampling interval; it is the level which is exceeded for 90% of the measurement period. It will therefore exclude the intermittent features of traffic and is used to describe a background level. Measured using the "Fast" time weighting.

L_{den} Is the 24 hour noise rating level determined by the averaging of the L_{day} with the $L_{evening}$ plus a 5 dB penalty and the L_{night} plus a 10 dB penalty. L_{den} is calculated using the following formula:

$$L_{den} = 10log\left(\frac{1}{24}\right)\left(12 * \left(10^{\frac{Lday}{10}}\right) + 4 * \left(10^{\frac{Levening+5}{10}}\right) + 8 * \left(10^{\frac{Lnight+10}{10}}\right)\right)$$

Where:

L_{day} is the A-weighted long-term average sound level as defined in ISO 1996-2, determined over all the day periods of a year;

$L_{evening}$ is the A-weighted long-term average sound level as defined in ISO 1996-2, determined over all the evening periods of a year and;

L_{night} is the A-weighted long-term average sound level as defined in ISO 1996-2, determined over all the night periods of a year.

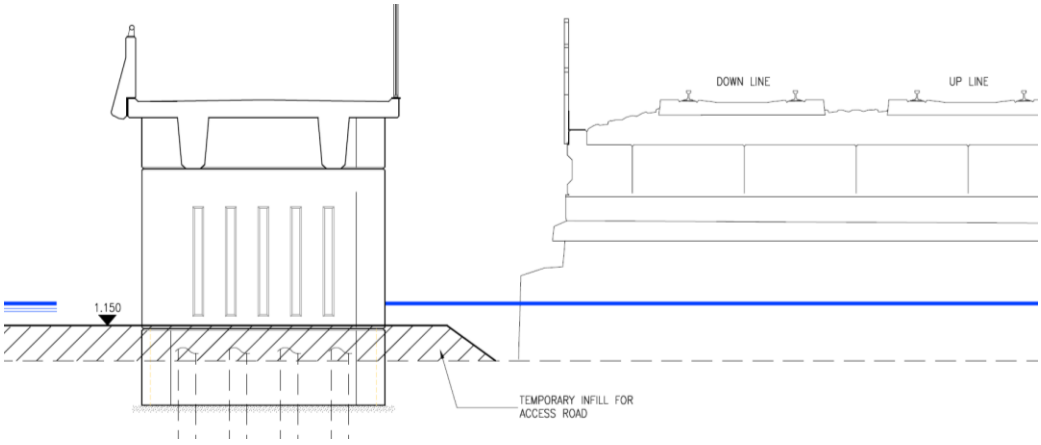
Appendix 16

Malahide Viaduct Reinstatement
Computer Modelling for Environmental Analysis

Malahide Viaduct Reinstatement

Temporary Works

Computer modelling for Environmental Analyses



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Malahide Viaduct Reinstatement

Temporary Works

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GLOSSARY OF TERMS

Terms	Definition
2-D model	A depth-averaged models that assume uniform velocity and hydrostatic pressure along water depth, and considering vertical velocities and accelerations to be negligible.
3-D model	Process of developing a mathematical representation of any three-dimensional surface of object via specialized software or in laboratory.
Armouring	Protective covering (e.g. rocks) used to prevent erosion damage to coastal and fluvial structures, banks, beds and beaches.
Attenuating	Gradual reduction
Bathymetry	A study of underwater depth of lake or ocean floors, and usually refers to the measurement of ocean depth through depth sounding.
Bed roughness	(see roughness coefficient)
Breach of defences	A structural failure at a flood defence allowing water to flow through.
Boundary condition	Conditions applied on the model open boundaries.
Catchment	The area that is drained by a river or artificial drainage system.
Climate change	Long-term variations in global temperature and weather patterns, which occur both naturally and as a result of human activity, primarily through greenhouse gas emissions.
Coastal erosion	The gradual wearing away of the coastline through a combination of wave attack and, in the case of coastal cliffs, slope processes (e.g. high groundwater levels). This may include cliff instability, where coastal processes result in the periodic reactivation of landslide systems or promote rock falls.
Coastal flooding	Flooding from the sea which is caused by higher than normal sea levels and/or high waves resulting in these a overflowing onto the land.
Computer model	(see mathematical model)
Continuity	The fundamental law of hydrodynamics, which states that, for incompressible fluids and for flow independent of time, the sun of differential changes in flow velocities in all directions must ne zero.
Conveyance function	When a river overflows its banks, it continues to flow over the flood plain, conveying water down-stream, as well as storing water where the flood plain may be obstructed and releasing it slowly.
Coriolis force	Directed normal to the direction of the movement and proportional in magnitude to the speed of the moving body.
Design iterations	Various trial designs which were tested and evaluated.
Model domain	Spatial area comprised in models.
Enhanced weir	Modified weir to provide long term stability and safety.
Environmental Impact Assessment (EIA)	Pursuant to EU Directive 85/ 337/ EEC (as amended in 1997), EIA is a legislative procedure used for identifying the environmental effects of development projects to be applied to the assessment of the environmental effects of certain public and private projects which are likely to have significant effects on the environment.
Erosion	A process of weathering and transport of solids (sediment, soil, rock and other particles) in the natural environment or their source and deposits them elsewhere.
Estuary	The mouth of a river, subject to tidal effects, where fresh water and sea water mix.

Terms	Definition
Estuarial flooding	Flooding from an estuary, where water level may be influenced by both river flows and tidal conditions, with the latter usually being dominant.
Exposure	Quantification of the receptors that may be influenced by a water.
Fetch	The area of water in which waves are generated by a wind having a fairly constant direction and speed. Sometimes used synonymously with "fetch length," the horizontal distance over which a wind generates waves.
Finite-difference model	A digital computer model based upon a rectangular grid that sets the boundaries of the model and the nodes where the model will be solved.
Flooding (or inundation)	Flooding is the overflowing of water onto land that is normally dry. It may be caused by overtopping or breach of banks or defences, inadequate or slow drainage of rainfall, underlying groundwater levels or blocked drains and sewers. It presents a risk only when people, human assets and ecosystems are present in the areas that flood.
Floodplain	A floodplain is any low-lying area of land next to a river or stream, which is susceptible to partial or complete inundation by water during a flood event.
Fluvial flooding	Flooding from a river or other watercourse.
Flume	An open channel constructed of wood, steel, or reinforced concrete and used to convey water for various purposes, including grade control.
Froudian criteria	A type of hydraulic modelling where model results are extrapolated to prototype (e.g. river or estuary) using scaling laws based on similarity of Froude Number in model and prototype.
Froude number	A hydraulic number representing the ratio of inertia forces and gravity forces action upon water, and making it possible to distinguish between subcritical and supercritical flow velocities.
GCM	Global Climate Model.
Gabions	Rock-filled wire cages used on streams for erosion control and construction of dams and other structures.
Geometrical similarity	Similarity of shape and the geometric characteristics can usually be described by a series of lengths and angles.
Geotechnical	Study of soils and rocks.
Groundwater flooding	Flooding caused by groundwater escaping from the ground when the water table rises to or above ground level.
Hybrid models	Combining two or more models (e.g. physical and mathematical) in a solution method is hybrid modelling. Hybrid models attempt to use the best modelling methods available for each "part" of hydraulic problems.
Hydraulic	Study of flow in rivers, canals, pipes and structures using fundamental laws and equations.
Hydraulic characteristic	Hydraulic performance such as relationship between water level and flow rate.
Hydraulic control	A point in open channel river or estuarine flow where there is a definite relationship between water level and flow rate.
Hydraulic jump	A phenomenon in the science of hydraulics which is frequently observed in open channel flow such as rivers and spillways. When liquid at high velocity discharges into a zone of lower velocity, a rather abrupt rise (a step or standing wave) occurs in the liquid surface.
Hydrology	The study of the occurrence, distribution and chemistry of all waters of the earth.
Hydrostatic	Conditions when the pressure on a fluid at rest is isotropic; i.e., it acts with equal magnitude in all directions.
Laboratory model	(see physical model)

Terms	Definition
Manning's number	A resistance coefficient used in the Manning equation for uniform steady flow.
Mathematical model	A model that simulates a system's behaviour by a set of equations, perhaps together with logical statements, by expressing relationships between variables and parameters.
Model calibration	The process by which the independent variables of a digital computer model are varied in order to calibrate a dependent variable against a known value.
Model verification	The process by which a computer model that has been calibrated is tested to see if it can generate a transient response that matches the known history of the water body.
Modelling	The simulation of physical or abstract phenomenon or system with another system believed to obey the same physical laws or abstract rules of logic, in order to predict the behaviour of the former by experimenting with the latter.
Neap tides	When the Moon is at first quarter or third quarter, the Sun and Moon are separated by 90° when viewed from the Earth, and the solar gravitational force partially cancels the Moon's. At these points in the lunar cycle the tide's range is at its minimum.
Non uniform flow	If at a given instant, the velocity or depth is not the same at every point the flow is non-uniform.
Numerical model	(see mathematical model)
Overtopping of defences	Failure of a flood defence or exceedance mechanism, when flood water reaches levels that are higher than the flood defence level and flows over the top of the structure. While the structure may remain stable, however, erosion of the landward face of the defence could cause the defence to collapse.
Permeability	The property of a porous substance, as rock or a membrane, of allowing the flow of a fluid through it.
Physical model	A smaller or larger physical copy of an object. The geometry of the model and the object it represents are often similar in the sense that one is a rescaling of the other. In such cases the scale is an important characteristic.
Reno mattresses	A low profile flexible wire basket filled with stones and used to control scour.
Roughness coefficient	A dimensionless parameter appearing in Manning's equation for uniform steady flow in open canals, related to surface irregularity and material retardance of the wetted perimeter.
Run-off	The flow of water, caused by rainfall, from an area which depends on how permeable the land surface is. Run-off is greatest from impermeable areas such as roofs, roads and hard standings and less from vegetated areas – moors, agricultural and forestry land.
Runoff coefficient	A parameter (0 to 1) which quantifies the degree of permeability of surfaces.
Scour	The removal of sediment around or near structures located in flowing water.
Seepage	The slow movement of water though small cracks, pores, or interstices of a material, in or out of a body if surface or subsurface water.
Sensitivity analysis	A study of how the variation (uncertainty) in the output of a mathematical model can be apportioned, qualitatively or quantitatively, to different sources of variation in the input of a model.

Terms	Definition
Simulation	A technique of representing the real world by a computer program; "a simulation should imitate the internal processes and not merely the results of the thing being simulated".
Source	Source refers to a source of hazard (e.g. the sea, heavy rainfall).
Spatial resolution	Defines the density of information produced from the flood risk assessment process across the area of interest. A mosaic of flood risk data produced by different tools and base data, with a range of certainty in the output.
Spring tides	Around new and full moon when the Sun, Moon and Earth form a line, the tidal force due to the Sun reinforces that due to the Moon. The tide's range is then at its maximum.
Steady state	A fluid motion in which the velocities at every point of the field are independent of time in either magnitude or direction.
Toe	The lower portion of a channel bank or where a levee slope meets the ground or river bed.
Topography	The configuration of a surface and the relations among its man-made and natural features.
Turbulent flow	Flow of water, agitated by cross-currents and eddies, as opposed to laminar flow. Any particle may move in any direction with respect to any other particle, and the head loss is approximately proportional to the second power of the velocity.
Uniform flow	Flow of water with no change in depth or any other element of flow (ie cross-sectional area, velocity, and hydraulic gradient) from section to section along a canal.
Unsteady flow	Flow in which the velocity changes, with time, in magnitude or direction.

1 Introduction

The computer modelling of the Malahide Weir and the Broadmeadows estuary have been explained in detail in previous Technical Papers by University College Cork in 2010 [1,2,3,4,5]. The As-Constructed 2010/2011 design of the Malahide Weir was based on those Technical Papers. In the design of weir profile in 2010 the requirements of NPWS were also adopted to reinstate the Broadmeadows Estuary to its historic condition. An important requirement was that the birdlife feeding and breeding grounds, on the mud-flats area at the western end of the estuary, be restored and have the same periods of time submerged and exposed during the tidal cycle as had existed previously. The mud-flats are on a very shallow gradient so consequently a small variation in water level has an effect over a wide area. A conservative design approach was taken in the mathematical model to ensure that the NPWS requirements were met.

To strengthen the weir stability the stone material was added to both the eastern and western faces of the weir, which considerably widened the weir width. Having strengthened and re-profiled the top face of the weir in accordance with the submission to NPWS it was found that the weir performance had 'over-shot' the target. The Broadmeadows estuary retained a lesser volume of water than before and considerably more area of mud-flats was exposed throughout the tidal cycle.

As the water levels within the Broadmeadows estuary for As-Constructed 2010/2011 weir were found to be lower than historic water levels, a revised mathematical model was developed in October 2011 [6]. In November 2011 the NPWS approved the application to adjust the weir. On the basis of the New Design Weir [6] the adjustment works were carried out in 2012 in order to improve the hydraulic effect of the weir on the wider estuary.

The performance of the New Design Weir was hydraulically tested and elaborated in University College Cork report from July 2012 [7]. A comparison of the recorded and historic water levels showed that the weir replicates the hydrodynamic conditions on entire Broadmeadows estuary and throughout the tidal cycle that occurred before the collapse of the weir.

Figure 1. New Design Weir at Malahide Viaduct during ebb tide, looking west

There is now a need for construction of a greenway on the western weir side. For the footbridge construction it is necessary to create a temporary access adjacent to the western face of the railway viaduct, extending across the full length of the viaduct. This temporary access will be constructed on the top of the weir and the road surface level will be elevated above the original weir level to a level of +1.15mOD.

As the increase of weir crest level will affect the hydrodynamic conditions of inner estuary and the mud-flats exposure during the tidal cycle, a 2-D computer model of the temporary works was developed. This report '*Malahide Viaduct Reinstatement: Temporary Works - Computer modelling for Environmental Analyses'* gives computer results and simulations for the New Design Weir (from 2011) and for the weir with temporary works in place. The Report includes:

- Set-up of a detailed Mike21 computer model for the weir with temporary works in place
- Analysis of estuary hydrodynamics at neap and spring tides
- Water extent analysis at neap low and spring low

The main aim of computer modelling was to determine the hydrodynamic performance of the weir with temporary works in place and to check the mud-flats exposure at the inner estuary. The performance was analysed by comparing water levels and water extent for the Temporary Works Weir and the New Design Weir. The water levels for the Temporary Works were also compared to the 2010 data on spring and neap water levels. The 2010 water

levels are related to the weir in the emergency conditions that prevailed after viaduct collapse with an access road constructed at similar top surface level as the temporary infill.

This study involved the analysis of the hydrodynamics of the inner and the entire Broadmeadow estuary for the Temporary Works and the New Design Weir by comparing water levels at four control points. The dynamics of the inner estuary was analysed at control point 3-1, located closer to the motorway bridge, and control point 3-2, located in the western estuary (Appendix 1, Appendix 2). In such a way, the dynamics of the inner estuary (points 3-1, 3-2) could be compared to the dynamics on the weir (point 1-1) and to the eastern estuary (point 1-2).

2 Computer model for Temporary Works

2.1 SET-UP OF A DETAILED MIKE21 COMPUTER MODEL FOR THE TEMPORARY WORKS

As presented in *Technical Paper 4* the Mike21 model of the Broadmeadow estuary was set-up on four complementary computational domains (see Appendix 9), as follows:

- A basic 9.9m grid resolution domain for the entire estuary area
- A 3.3m sub-grid domain at the inner estuary
- A sub-grid domain around the weir at 3.3m grid spacing
- A 1.1m grid spacing domain for the weir crest

The Mike21 model has two open boundaries: upper as inflow boundary from the Broadmeadow and Ward Rivers, and lower as the tidal boundary at the bay inlet (see Appendix 1 and Appendix 2).

The Mike 21 model of the weir crest (a 1.1m grid spacing domain) for Temporary Works was set-up on the basis of the New Design Weir but to include temporary infill for access road (Appendix 5 and Appendix 6). The temporary infill will be placed on the western face of the viaduct with surface level at +1.15mOD.

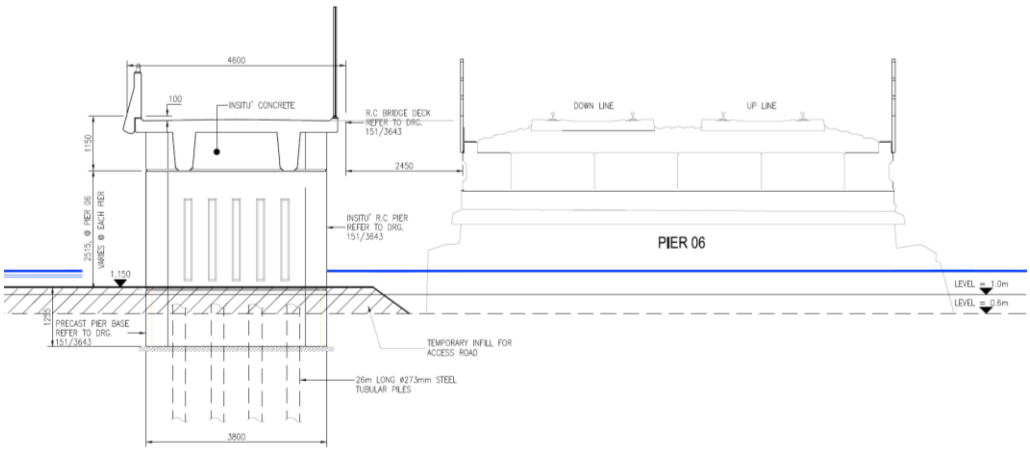


Figure 2. East-west elevation profile of the temporary infill

The infill for access road will level the weir profile on the entire length of the weir and in approx. width of 13.3m (Appendix 5 and Appendix 6). The weir profile along the viaduct centreline and along the eastern side will be unchanged (Appendix 7). The top infill at +1.15mOD is actually the lowest that

levels the weir profile (Appendix 8) and as such makes the minimum changes for the weir geometry.

Presented infill of the weir crest, together with the original bathymetry surveys, are combined into a single database with bed level specified relative to Ordnance Datum (Malin Head). A computer modelled DEM of the New Design Weir crest is shown in Appendix 3 and Appendix 4, and of the Temporary Works crest is shown in Appendix 5 and Appendix 6.

2.2 MIKE21 MODEL PARAMETERS

Using the detailed Mike21 model, simulations were performed for the entire Broadmeadow estuary. Two open boundaries are located on the Broadmeadow River (upper boundary) and on the bay inlet (lower boundary), as shown in Appendix 1. Computer simulations for the neap and spring tides were performed by using recorded water levels at control point 1-2 as the lower boundary condition, and a constant river inflow of 0.5m^3/s for neap and 1.0m^3/s for spring tides as the upper boundary condition.

The model parameters for Temporary Works were overtaken from the computer simulations for the New Design Weir, except that additional bed roughness value was used for the temporary infill. Computer simulations were performed by using bed roughness values on the outer (9.9m spacing) and middle (3.3m spacing) domains at $n_{9.9m}$=$n_{3.3m}$=0.03, together with a constant Smagorinsky coefficient at s=0.50. For the weir crest (1.1m spacing), a bed roughness value $n_{1.1m}$ is: $n_{1.1m}$ = 0.090 for neap tides (shallower depths) and $n_{1.1m}$ = 0.066 for spring tides.

Several initial test runs were simulated in order to estimate the bed roughness for the temporary infill. The infill will be most probably made of the crushed stones, so the test simulations were performed by using bed roughness values of 0.035, 0.025 and 0.015 for the infill area. Having obtained the test results the adopted value of bed roughness value for the infill area is 0.025.

3 Model results for Temporary Works

3.1 ESTUARY HYDRODYNAMICS DURING NEAP TIDES

Appendix 11 shows water levels during neap tides for New Design Weir (magenta), for Temporary Works (orange) and recorded levels in April 2010 (green). The first two figures show water levels at the weir (WSE 1-1 and WSE 1-2). Although the water levels at control point 1-2 on the eastern side are similar (New Design Weir, Temporary Works and April 2010), the water levels at control point 1-1 on the western side are the highest for the Temporary Works. The water levels on the western side (WSE 1-1) are around +0.80mOD for the New Design Weir and +0.95mOD for Temporary Works, and at constant level of +1.20mOD for the Temporary Works.

As the neap tide level in the estuary of +1.20mOD for the Temporary Works is 0.05m higher than the top infill level of +1.15mOD, the computed water levels for the neap tides are found to be reliable. The temporary infill will raise the invert levels of weir crest channels by 0.55m (from +0.60mOD to +1.15mOD), so 0.40m water level increase from the New Design Weir +0.80mOD to +1.20mOD for the Temporary Works is found to be realistic.

April 2010 recordings during neap tides (Appendix 11, second figure) show constant water level decrease on the western weir side (WSE 1-1), and most likely is a result of water seepage through the weir profile. Such decrease is not evident for the Temporary Works (orange), which may suggests that the water level of +1.20mOD in the estuary for the Temporary Works at neap tides are slightly conservative and could be somewhat lower.

The 3rd figure in Appendix 11 shows water levels in the estuary during neap tides at the weir (WSE 1-1) and on the inner estuary (WSE 3-1 and WSE 3-2). For the New Design Weir water surface slopes from the +0.90mOD at the inner estuary to +0.80mOD at the weir, while for the Temporary Works water level is constant at +1.20mOD on the entire estuary. This implies that there would be an additional back-up in the estuary during neap tides for the Temporary Works.

The 4th figure in Appendix 11 shows flow velocities in the estuary during neap tides at the weir (Vel 1-1) and on the inner estuary (Vel 3-1 and Vel 3-2). The increase of water levels at inner estuary results in the decrease in flow velocities from 0.20m/s of the New Design Weir to 0.05m/s for the Temporary Works (Vel 3-1).

3.2 ESTUARY HYDRODYNAMICS DURING SPRING TIDES

Appendix 12 shows water levels during spring tides for New Design Weir (magenta), for Temporary Works (orange) and recorded levels in March 2010 (green). The first two figures show water levels at the weir (WSE 1-1 and WSE 1-2). Although the water levels at control point 1-2 on the eastern side are similar (New Design Weir, Temporary Works and April 2010), the water levels at control point 1-1 show different behaviour. The peak flood tide levels in the estuary (WSE 1-1) are the same for the New Design Weir and for the Temporary Works (around +1.72mOD), and are lower than March 2010 recordings (around +1.80mOD). The spring lows for the Temporary Works are increased by 0.20m when compared to the spring lows for both the New Design Weir and the March 2010 recordings.

The 3rd figure in Appendix 12 shows water levels in the estuary during spring tides at the weir (WSE 1-1) and on the inner estuary (WSE 3-1 and WSE 3-2). Water levels for points 3-1 and 1-1 show no water surface slopes in the estuary for both the New Design Weir and the Temporary Works. Apart from the water level increase for the Temporary Works there will be no significant change of estuary hydrodynamics during spring tides.

The 4th figure in Appendix 12 shows flow velocities in the estuary during spring tides at the weir (Vel 1-1) and on the inner estuary (Vel 3-1 and Vel 3-2). The increase of water levels at inner estuary results in the decrease in flow velocities from 0.10m/s the New Design Weir to 0.05m/s for the Temporary Works (Vel 3-1).

3.3 EXPOSURE AT NEAP LOW AND SPRING LOW

The morphology of the inner estuary can be divided into two parts: the upper and the lower part. The upper part has generally higher ground levels, and it is characterised by distinctive streams together with well defined and steeper channel banks. In the lower part streams are shallow, and the channel banks are less defined and shallow. This morphological difference gives different hydrodynamics and water extent at these two parts of the inner estuary.

During a four-day simulated tidal event (12th to 16th March 2011), neap low in the western Broadmeadow estuary occurred on the 15th March, at 06:09

hours (Appendix 11), resulting in maximum land exposure for the simulated neap tide period. Appendix 13 shows water surface maps on the inner estuary at neap low for the New Design Weir (magenta) and the Temporary Works (orange). The 3rd figure shows a comparison of water surfaces between two geometry cases. It can be seen that in the upper part of the inner estuary the water extent is similar between two geometry cases. In the lower part it can be seen that land exposure for the Temporary Works is significantly smaller compared to the New Design Weir.

For the simulated tidal event of the 19th to 21st March 2011, the spring low in the western Broadmeadow estuary occurred on the 20th March 2011, at 09:34 hours (Appendix 12), resulting in a maximum land exposure for the simulated spring tide period. Appendix 14 shows water surface maps on the inner estuary at spring low for the New Design Weir (magenta) and the Temporary Works (orange). The 3rd figure shows a comparison of water surfaces between two geometry cases. It can be seen that there is no significant land exposure difference between the two geometry cases in the lower part. In the upper part the land surface is somewhat less exposed for the Temporary Works compared to the New Design Weir.

4 Conclusions

1. The top of the temporary infill at +1.15mOD provides minimal changes to the New Design Weir while enables a reasonable amount of access to the footbridge during tidal cycle.

2. Several computer simulations have been carried out for spring and neap tides to test the weir performance with the temporary infill. Computed water levels at the weir and in the estuary for the Temporary Works during neap and spring tides are found to be realistic.

3. The access road construction will raise the neap and spring tide water levels in the Broadmeadows estuary and will raise the volume of water retained within the estuary during the tidal cycle. A consequent effect will be that the mud-flats on the inner estuary will be submerged for a longer period of time during the tidal cycle.

4. The weir profile currently in place (New Design Weir) must be maintained into the future. Therefore, whatever temporary works are to be carried out when constructing the footbridge must, on completion of those works, reinstate the weir to its current profile and in accordance with the approval granted by NPWS from November 2011.

5 References

[1] Eamon McKeogh, Damir Bekic, *Malahide Viaduct Reinstatement: Technical Paper 1 - Collapse Mechanism and Initial Emergency Works*, Flood Study Group University College Cork, May 2010.

[2] Eamon McKeogh, Damir Bekic, *Malahide Viaduct Reinstatement: Technical Paper 2 - Physical Models*, Flood Study Group University College Cork, May 2010.

[3] Eamon McKeogh, Damir Bekic, *Malahide Viaduct Reinstatement: Technical Paper 3 - Computer Models and Hybrid Modelling*, Flood Study Group University College Cork, May 2010.

[4] Eamon McKeogh, Damir Bekic, *Malahide Viaduct Reinstatement: Technical Paper 4 - Computer modelling for Environmental Analyses*, Flood Study Group University College Cork, May 2010.

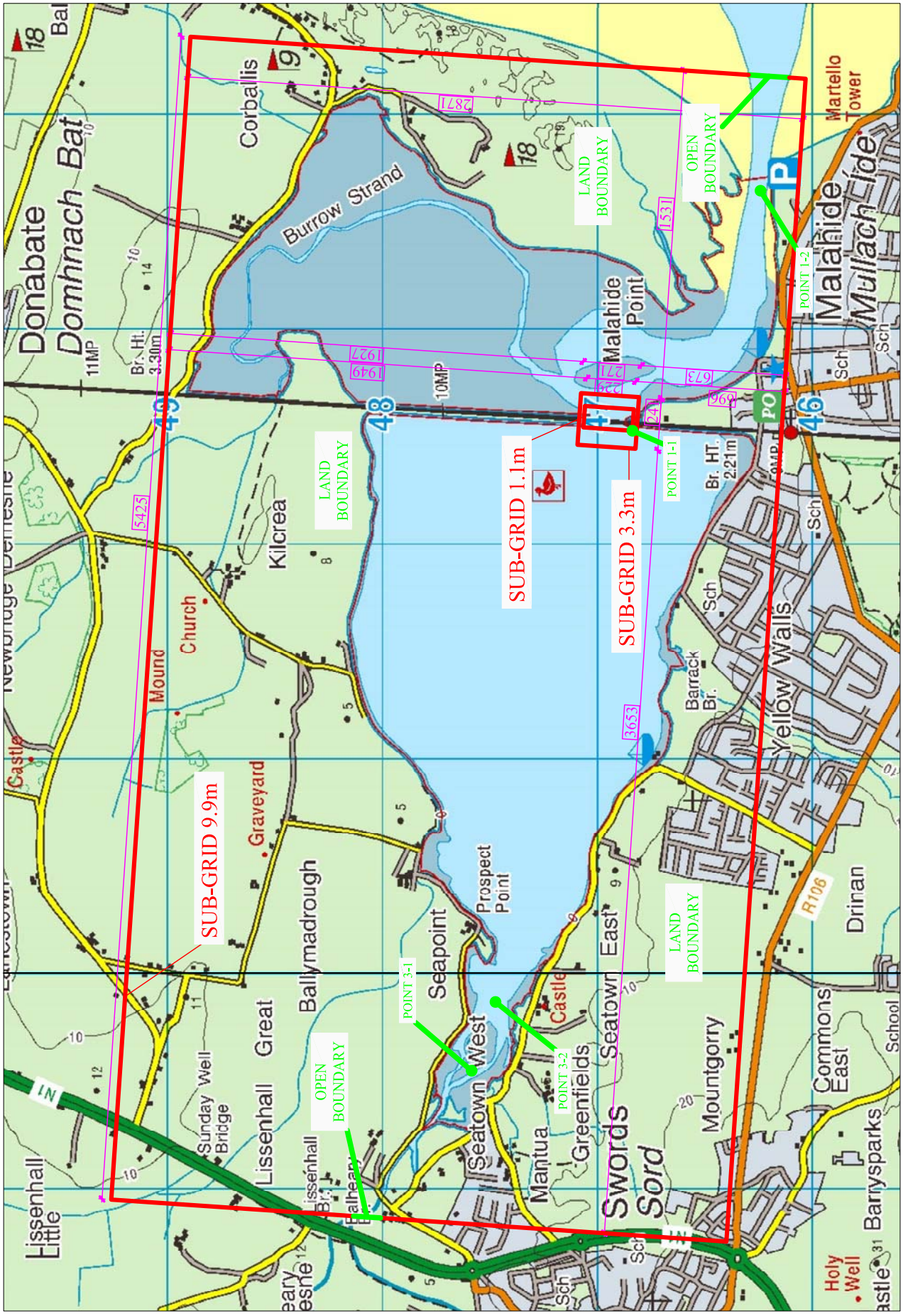
[5] Eamon McKeogh, Damir Bekic, *Malahide Viaduct Reinstatement: Technical Paper 5 - Final Design and Performance Simulations*, Flood Study Group University College Cork, July 2010.

[6] Eamon McKeogh, Damir Bekic, *Malahide Viaduct Reinstatement: New Design Weir - Computer modelling for Environmental Analyses*, Flood Study Group University College Cork, October 2011.

[7] Eamon McKeogh, Damir Bekic, *Monitoring of Malahide Viaduct - Report on water level recordings*, Flood Study Group University College Cork, July 2012.

6 Appendices

Appendix 1	Broadmeadows estuary with extents of model domains on OS map
Appendix 2	Broadmeadows estuary with field survey data on Google Earth
Appendix 3	New Design Weir - DEM with locations of cross-sections
Appendix 4	New Design Weir - DEM detail
Appendix 5	Temporary Works - DEM with locations of cross-sections
Appendix 6	Temporary Works - DEM detail
Appendix 7	New Design Weir and Temporary Works - Elevation profile for cross-sections
Appendix 8	New Design Weir and Temporary Works - Elevation profile for Viaduct central axis
Appendix 9	Refined Mike21 model
Appendix 10	Water levels in 2010 at control points 1-1, 1-2
Appendix 11	Hydrodynamic at neap tides
Appendix 12	Hydrodynamic at spring tides
Appendix 13	Exposure at neap low
Appendix 14	Exposure at spring low



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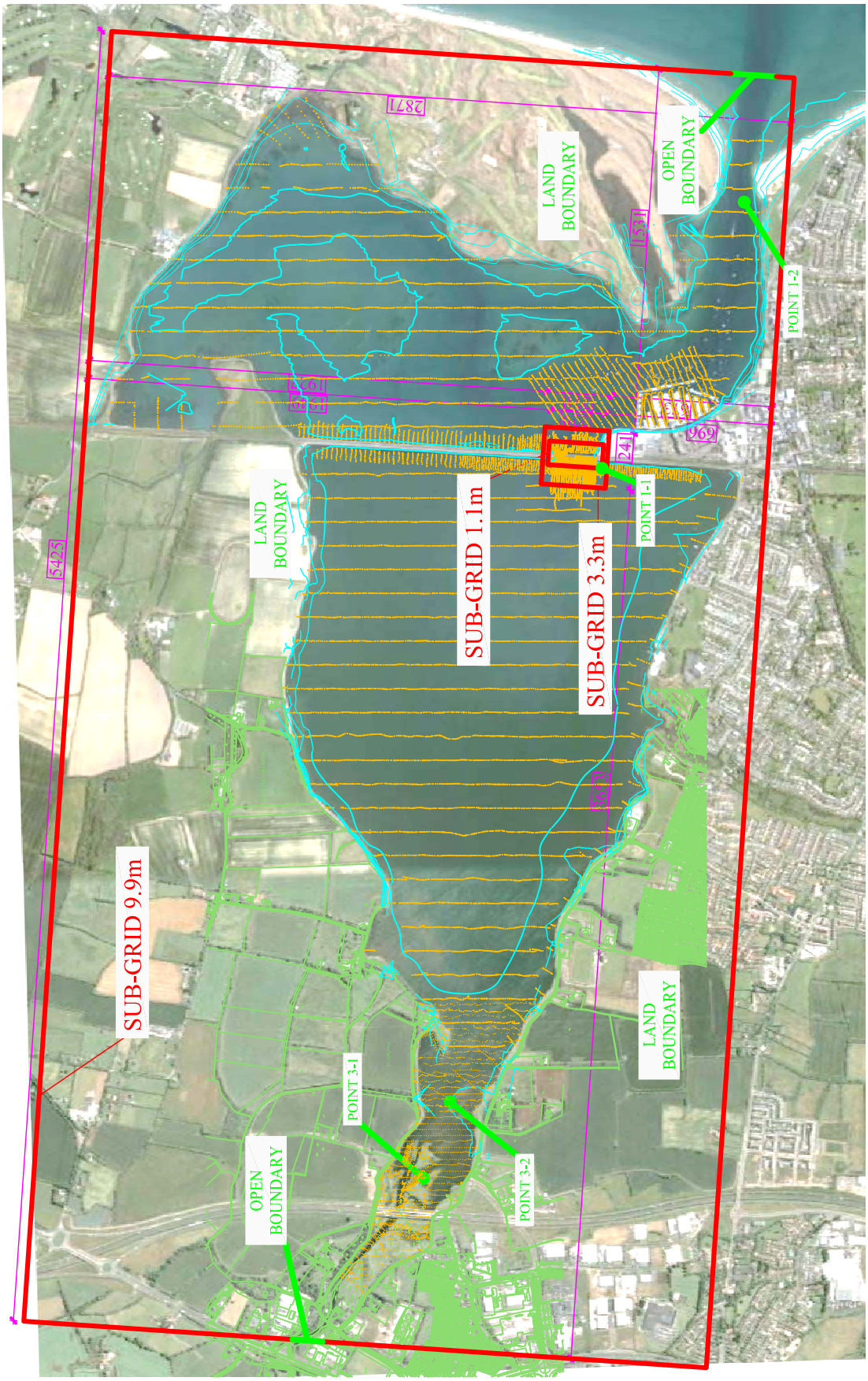
MALAHIDE VIADUCT REINSTATEMENT

Broadmeadow estuary with extents of model domains on OS map

Scale 1:25000

Appendix 1



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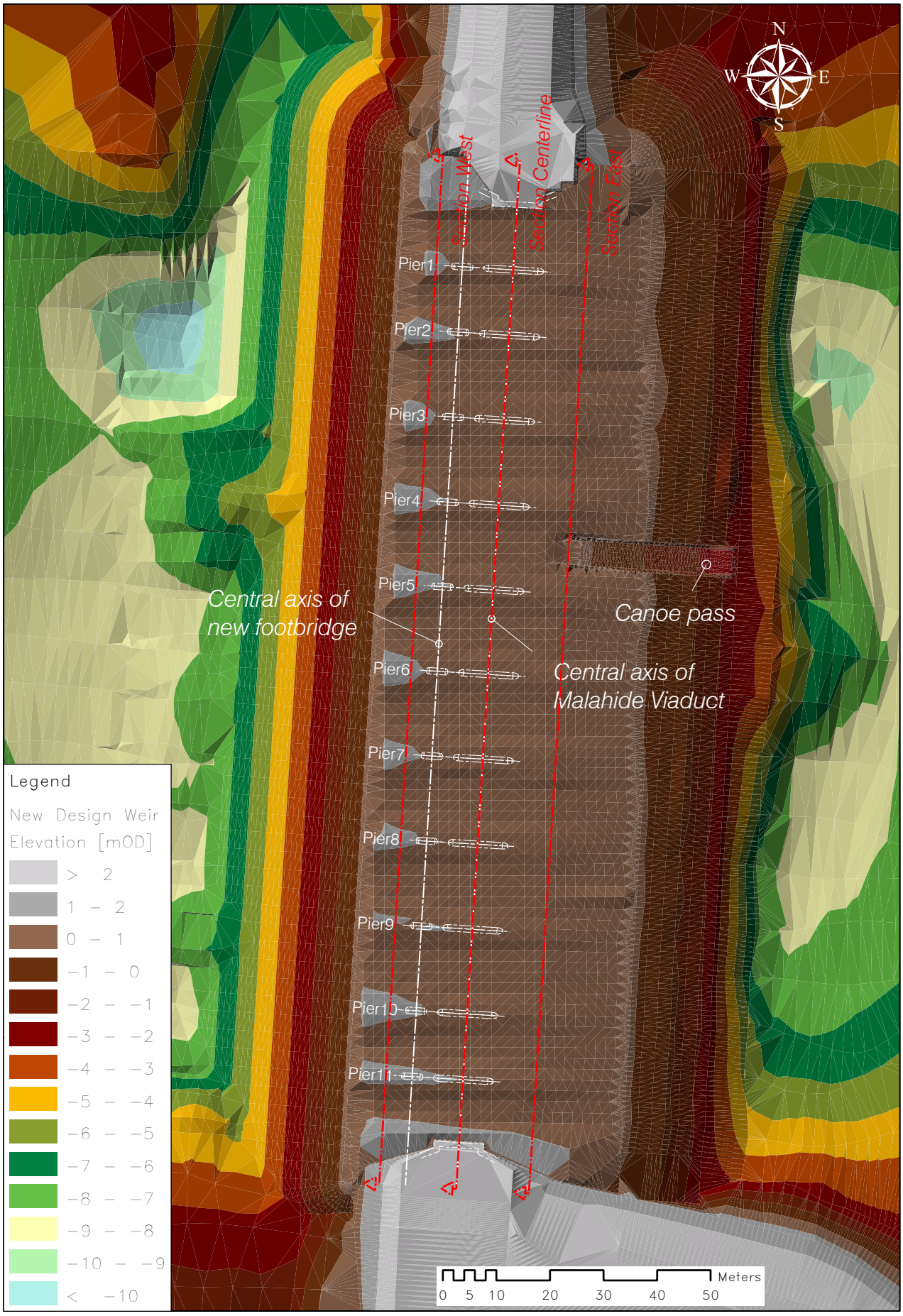
Hydrological and Hydraulic Engineering

MALAHIDE VIADUCT REINSTATEMENT

Broadmeadow estuary with field survey data on Google Earth

Scale 1:25000

Appendix 2



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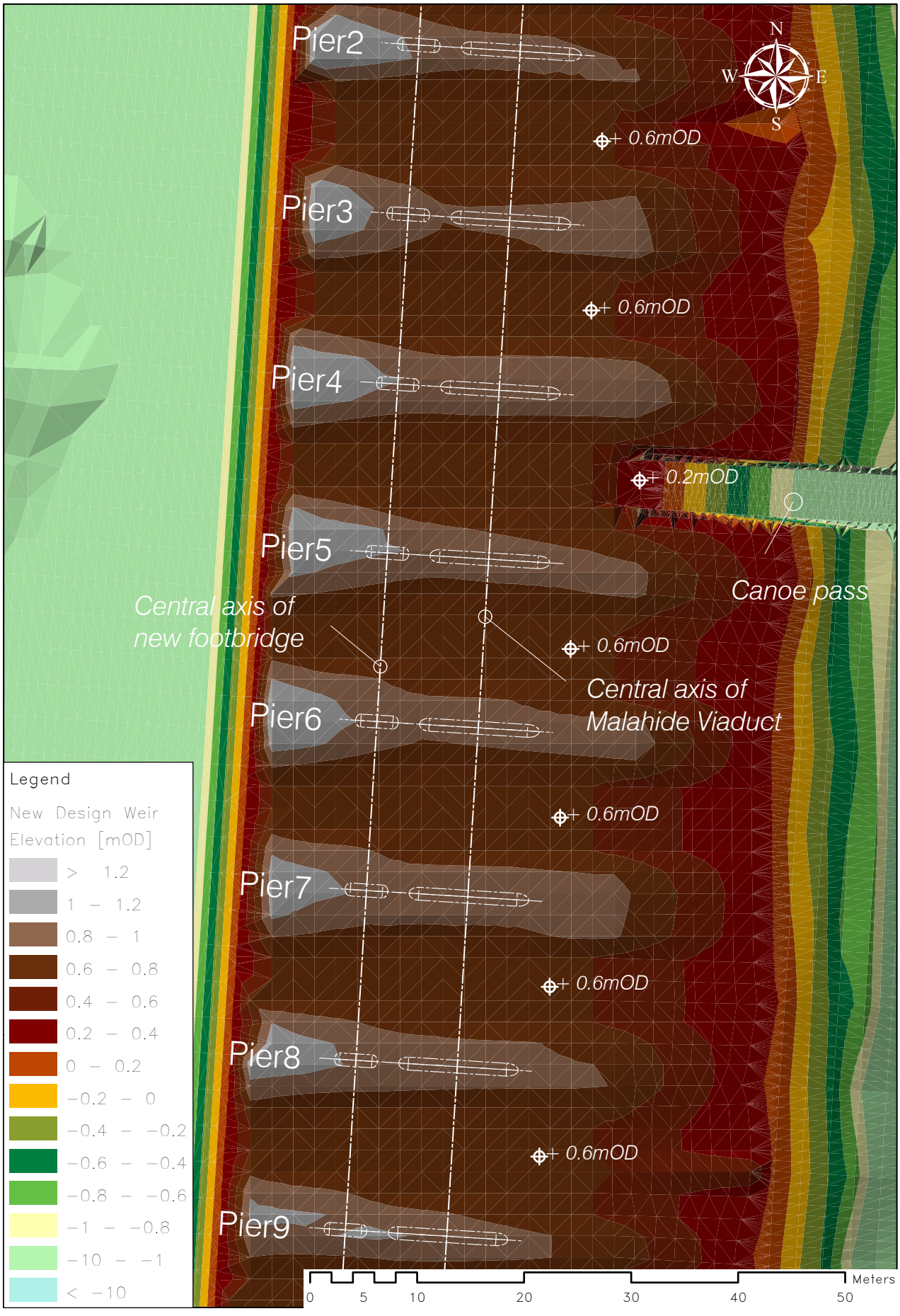
MALAHIDE VIADUCT REINSTATEMENT

New Design Weir – DEM
with locations of cross-sections

Scale 1:1000

Appendix 3



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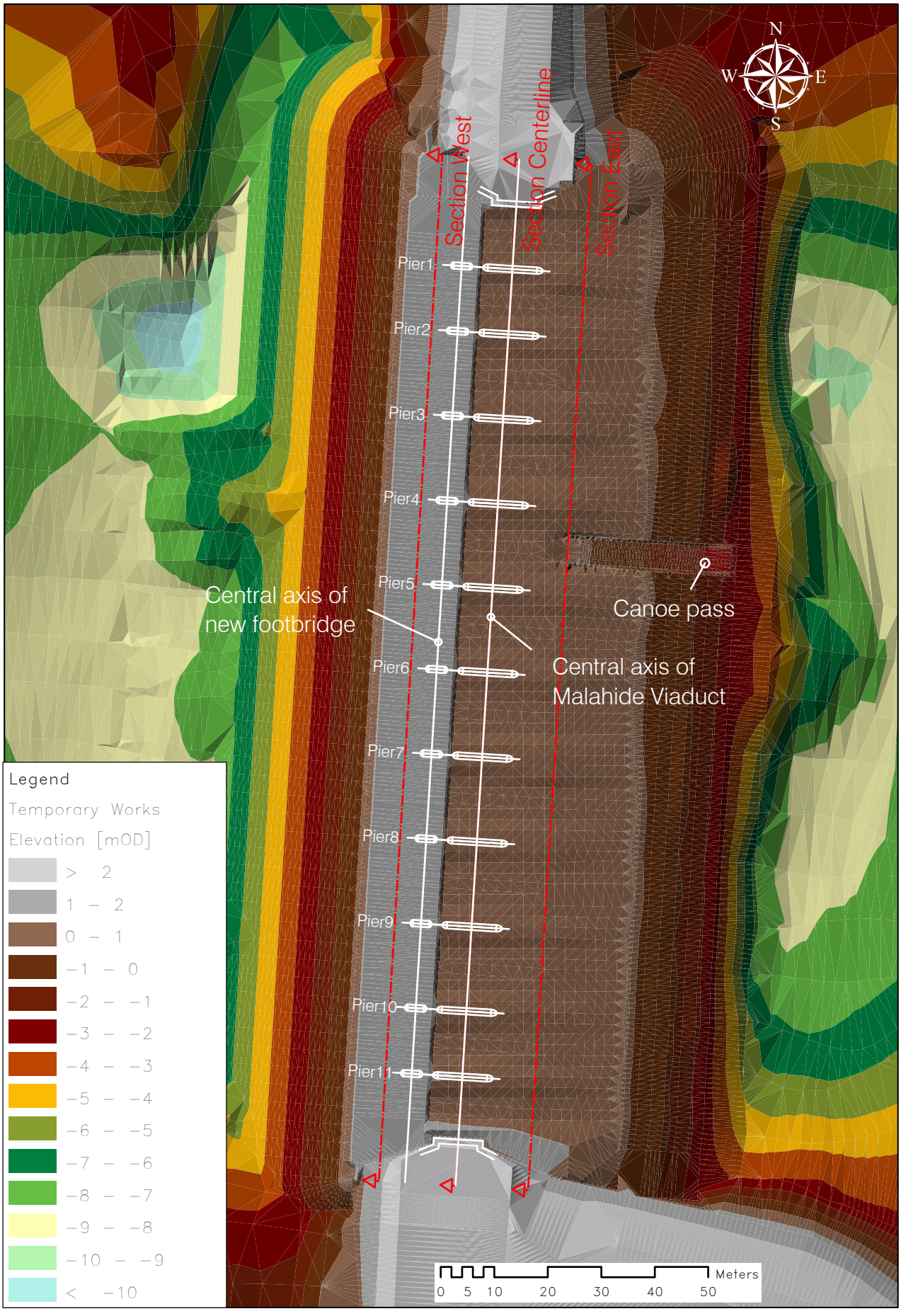
MALAHIDE VIADUCT REINSTATEMENT

New Design Weir – DEM detail

Scale 1:500

Appendix 4



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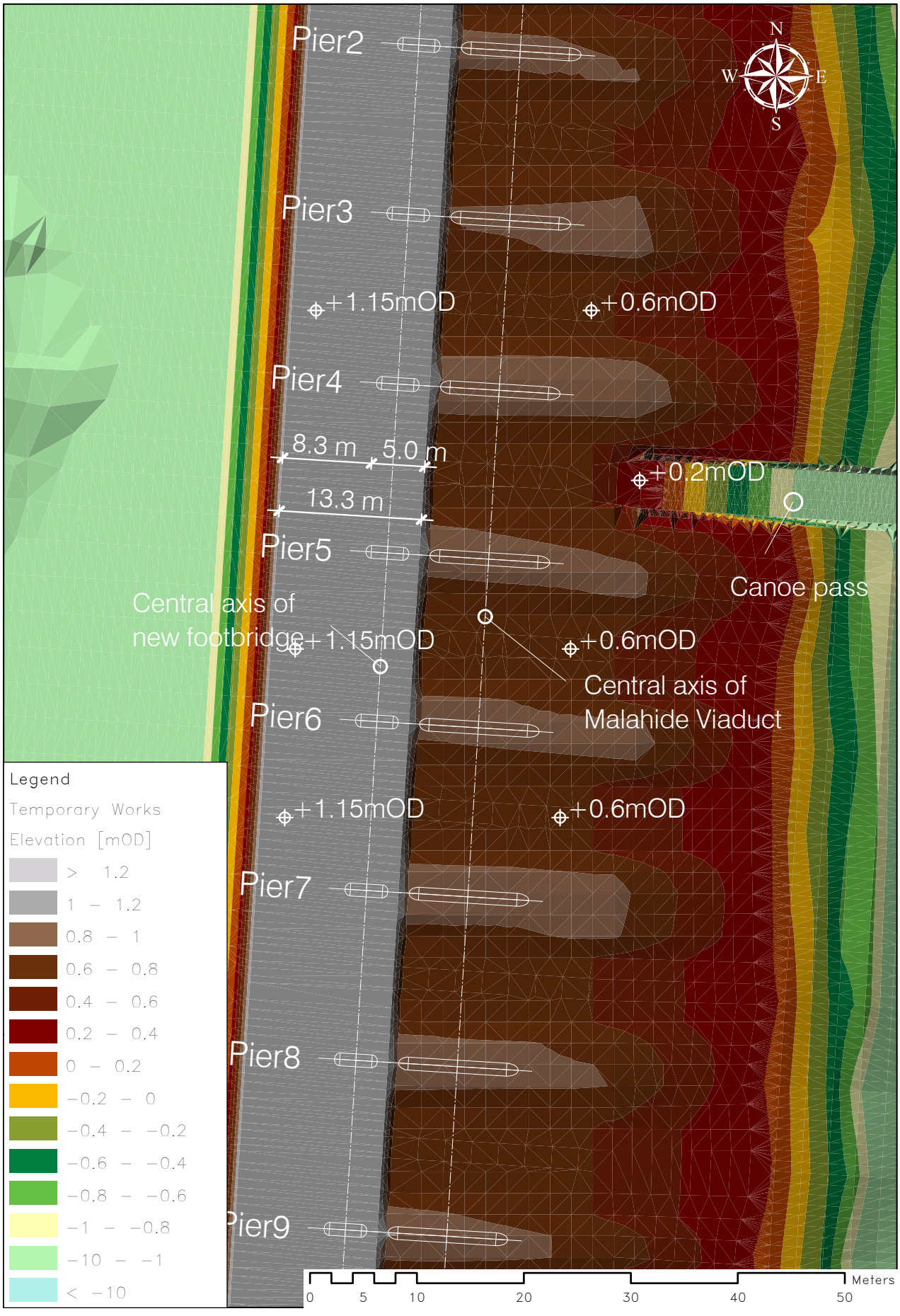
MALAHIDE VIADUCT REINSTATEMENT

Temporary Works
DEM with locations of cross-sections

Scale 1:1000

Appendix 5



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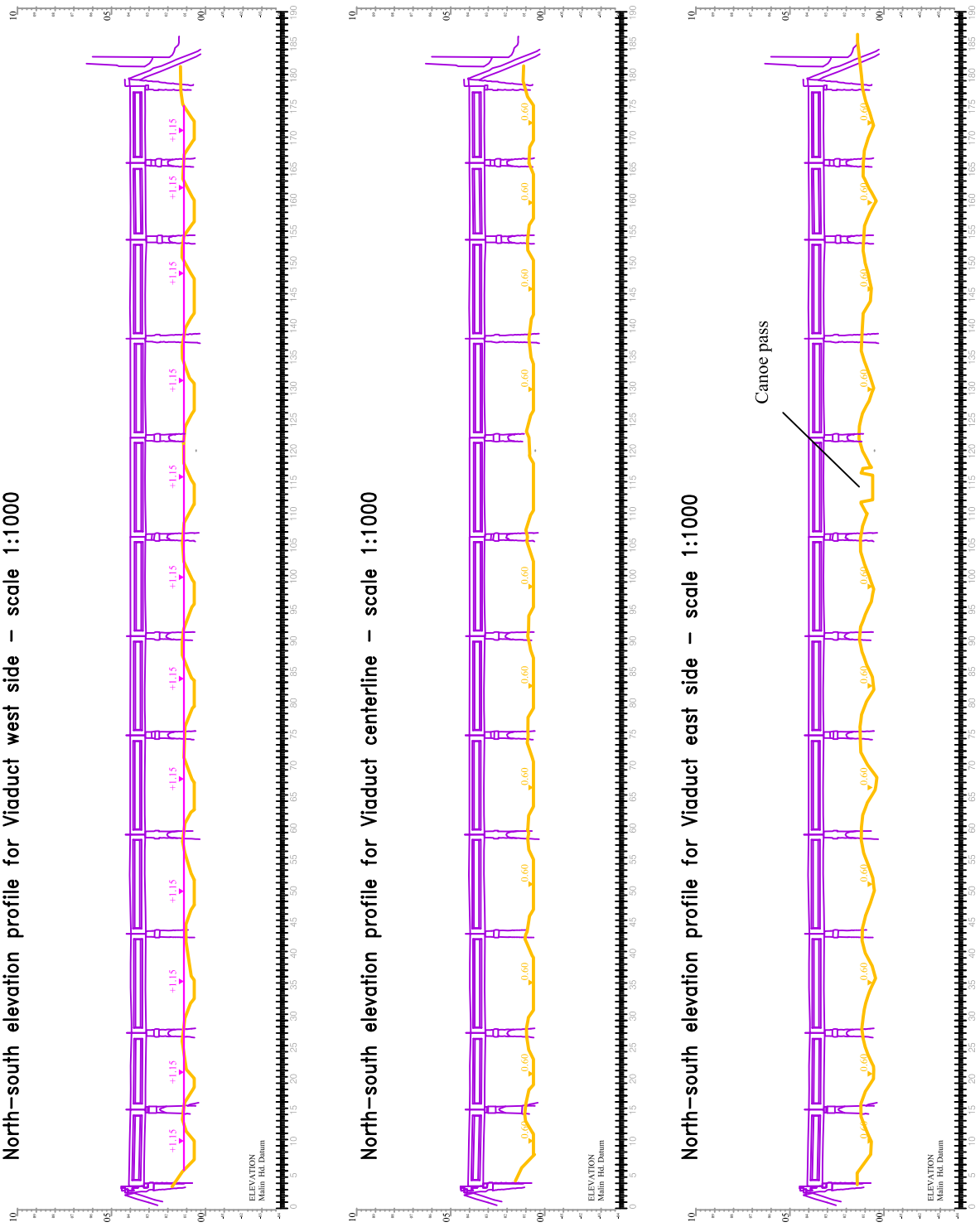
MALAHIDE VIADUCT REINSTATEMENT

Temporary Works – DEM detail

Scale 1:500

Appendix 6



LEGEND:

New Design Weir
Temporary

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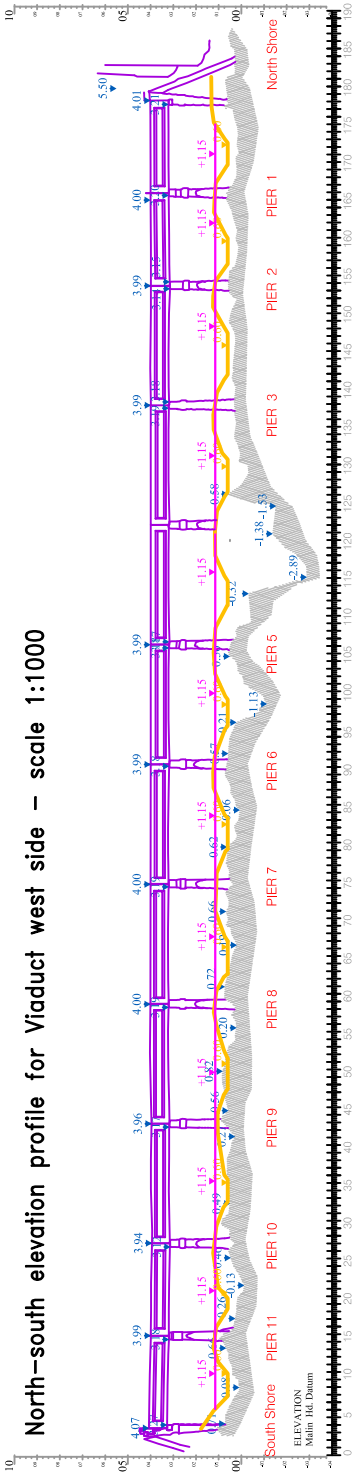
MALAHIDE VIADUCT REINSTATEMENT

New Design Weir and Temporary Works
- Elevation profile for cross-sections

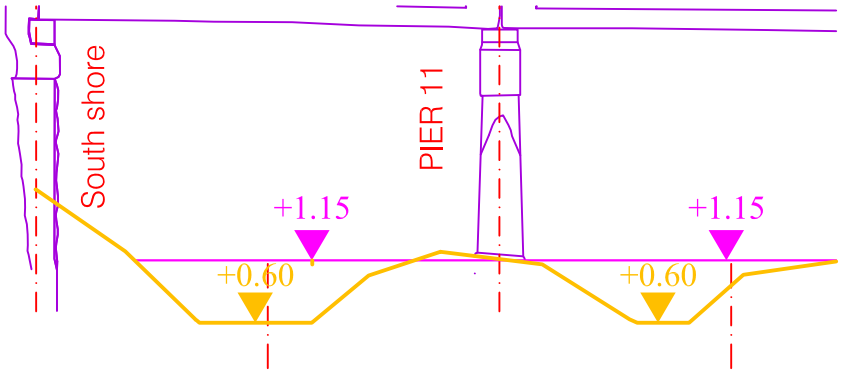
Scale 1:1000

Appendix 7

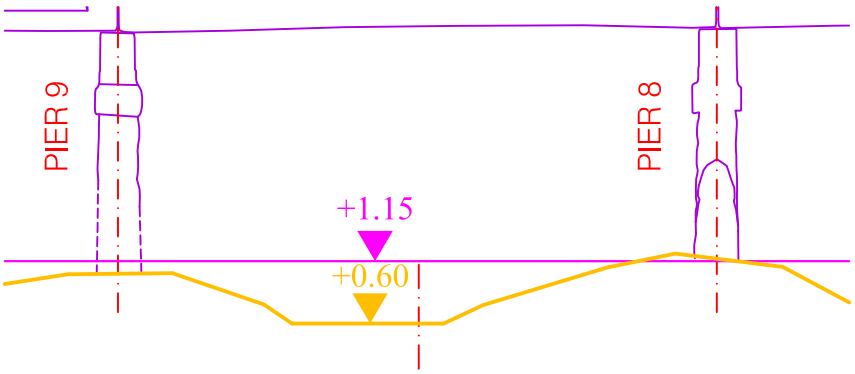
North–south elevation profile for Viaduct west side – scale 1:1000



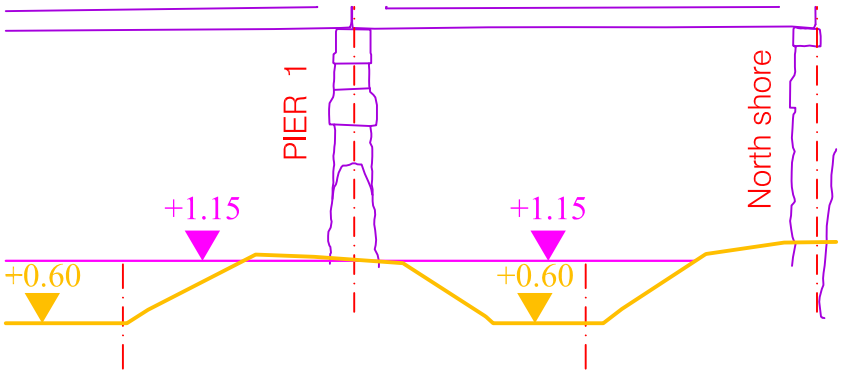
North–south elevation profile at South shore – scale 1:200



North–south elevation profile at piers 8&9 – scale 1:200



North–south elevation profile at North shore – scale 1:200



LEGEND:

New Design Weir
Temporary

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MALAHIDE VIADUCT REINSTATEMENT

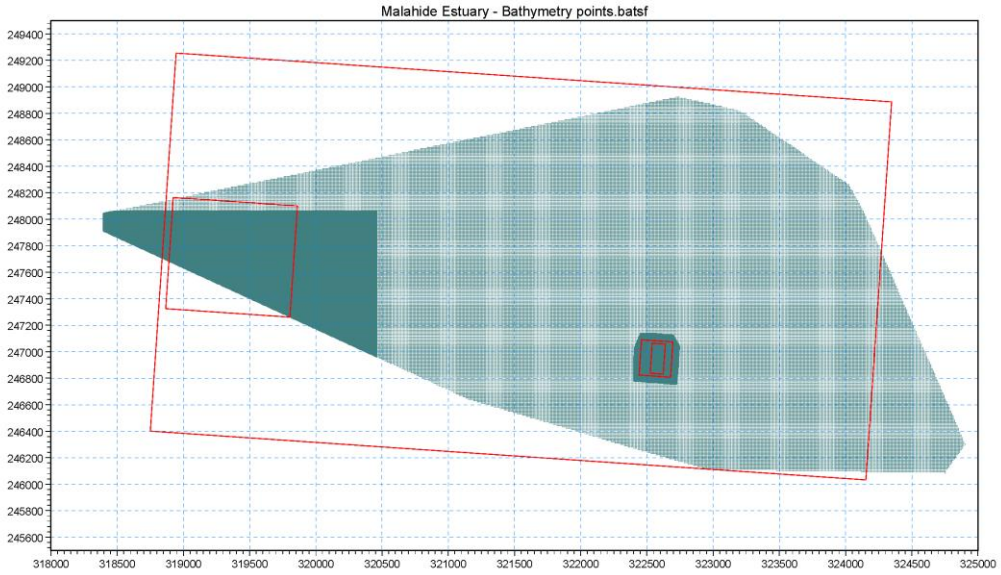
New Design Weir and Temporary Works
- Elevation profile for Viaduct central axis

Scale 1:1000
1:200

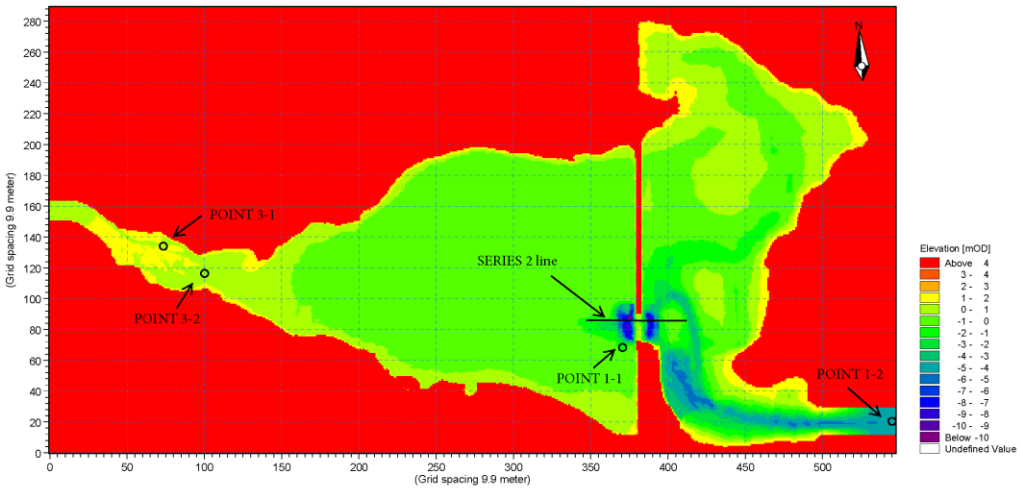
Appendix 8

Appendix 9 Refined Mike21 model

Mike21 sub-grid domains and DEM points

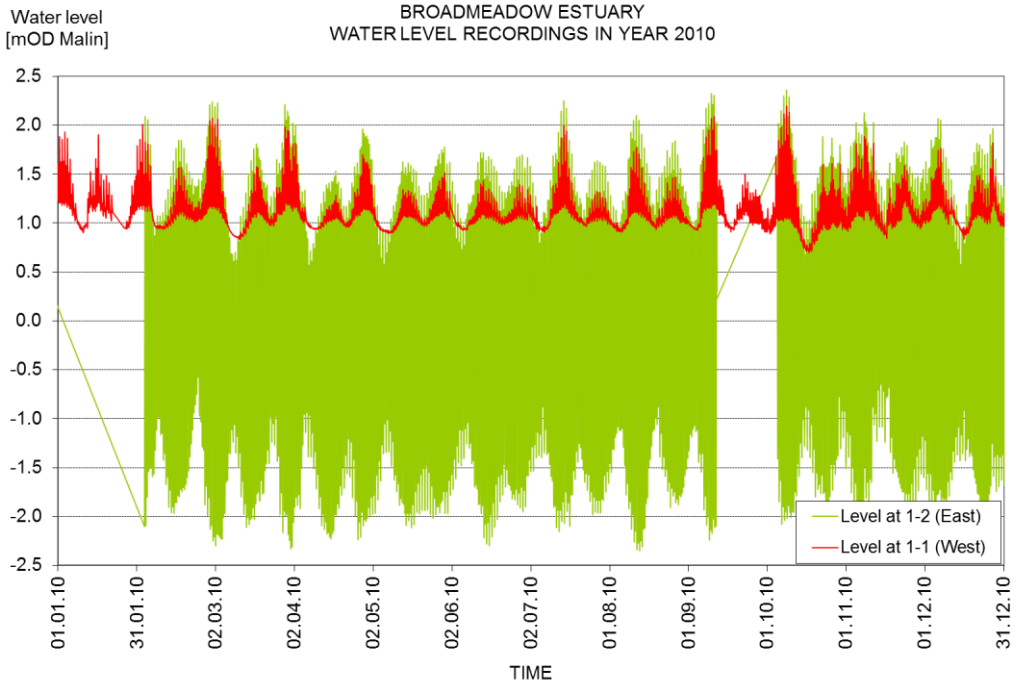


Mike21 sub-grid domain 9.9m resolution with control points

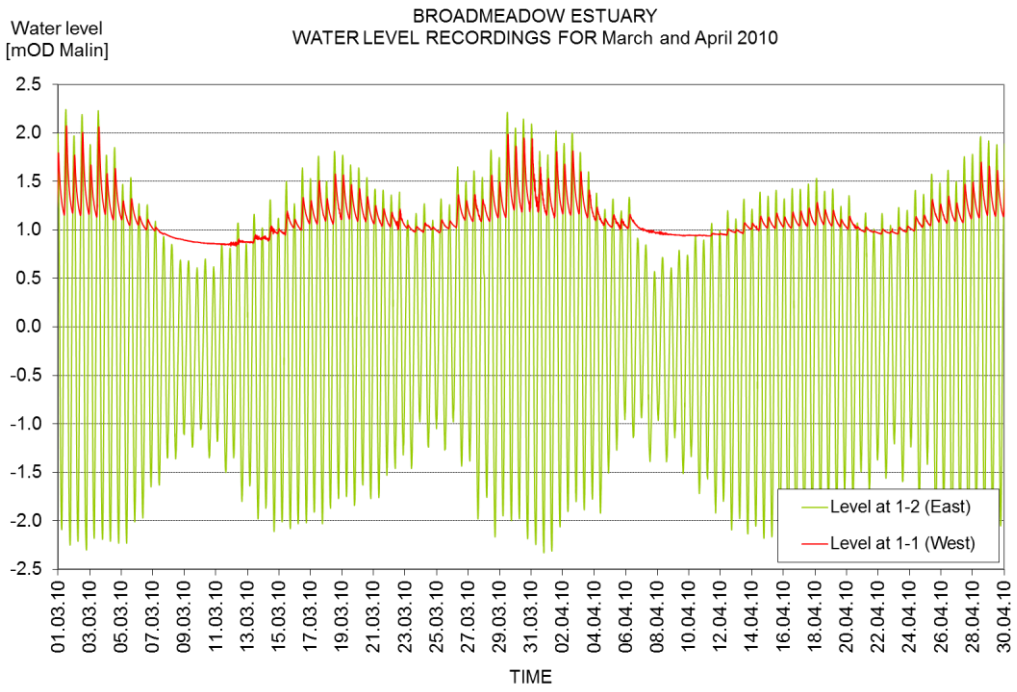


Appendix 10 Water levels in 2010 at control points 1-1, 1-2

Water level recordings in 2010



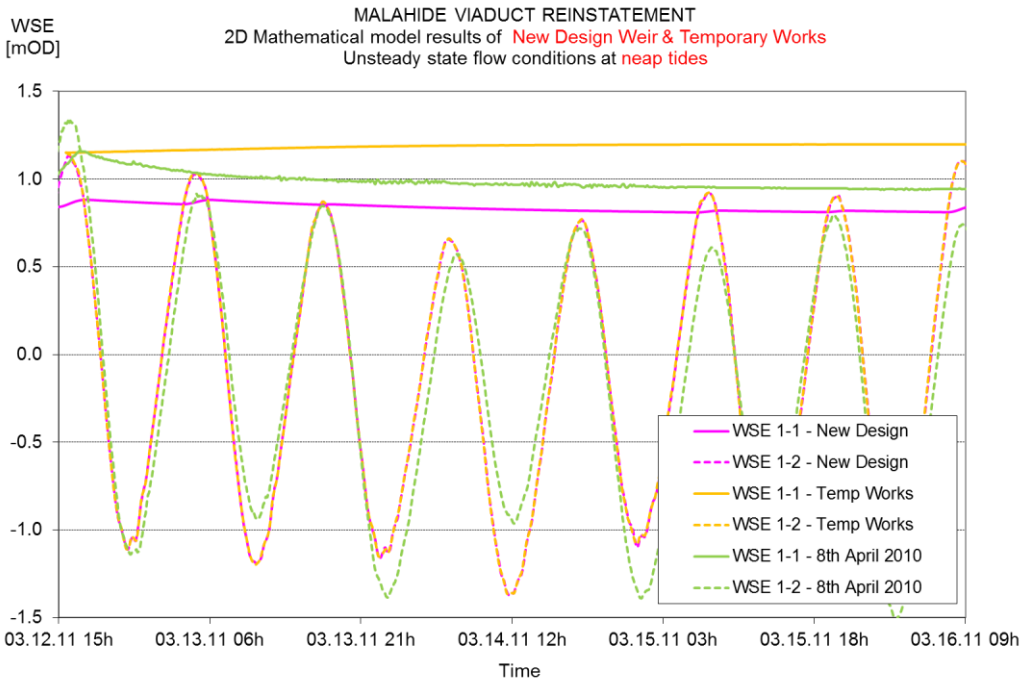
Water level recordings in March and April 2010

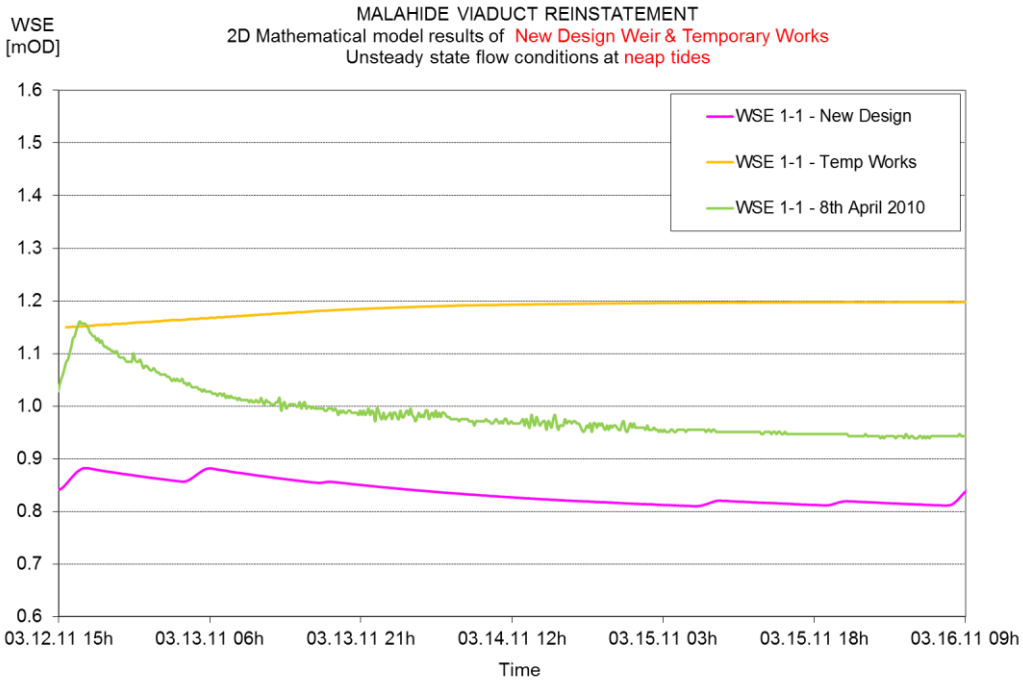


Appendix 11 Hydrodynamic at neap tides

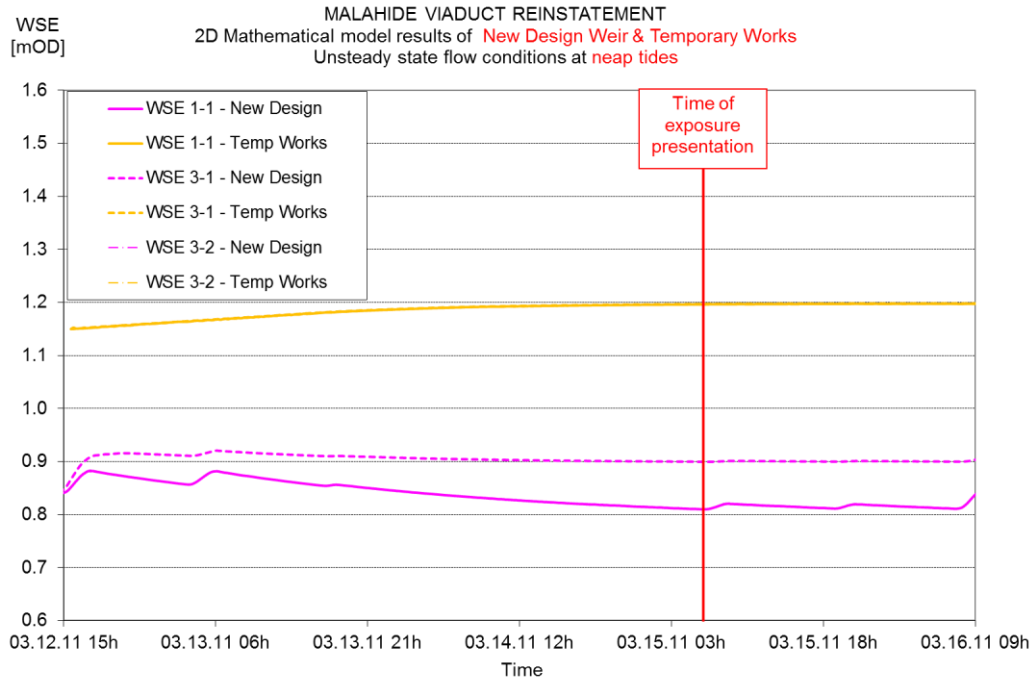
West boundary conditions: Q_{west} = 0.5m^3/s
East boundary conditions: WSE_{east} = Recorded water levels
Manning roughness values: $n_{9.9m}$ = $n_{3.3m}$ = 0.03; $n_{1.1m}$ = 0.09 and 0.025
Smagorinsky coefficient: s = 0.5

Water levels at the weir (control points 1-1 and 1-2)

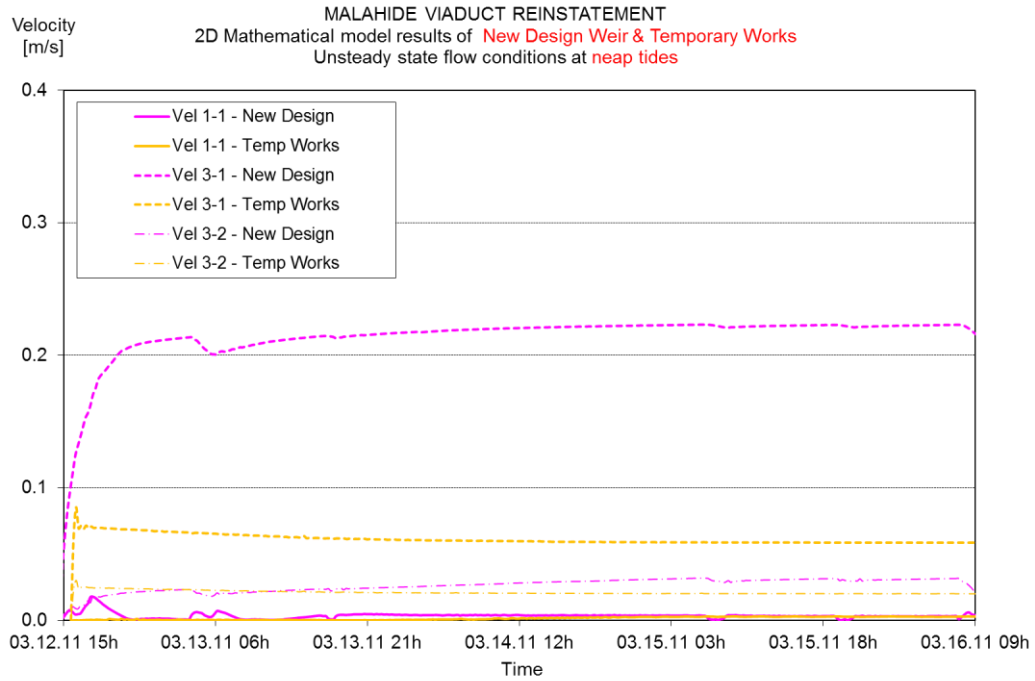




Water levels at the weir (control point 1-1) and on the inner estuary (control points 3-1 and 3-2)



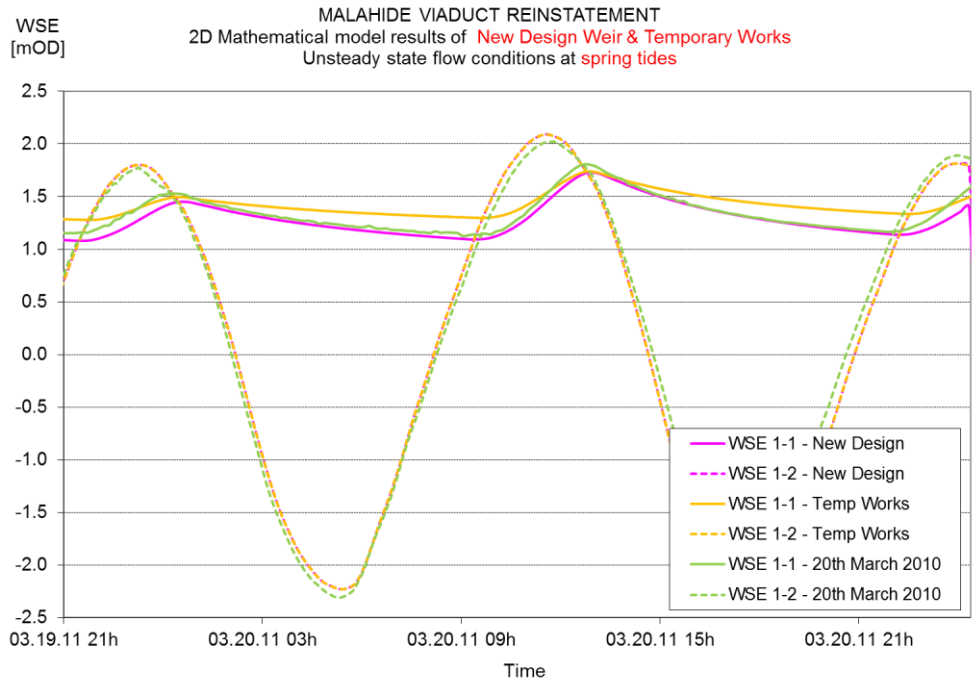
Flow velocities at the weir (control point 1-1) and on the inner estuary (control points 3-1 and 3-2)

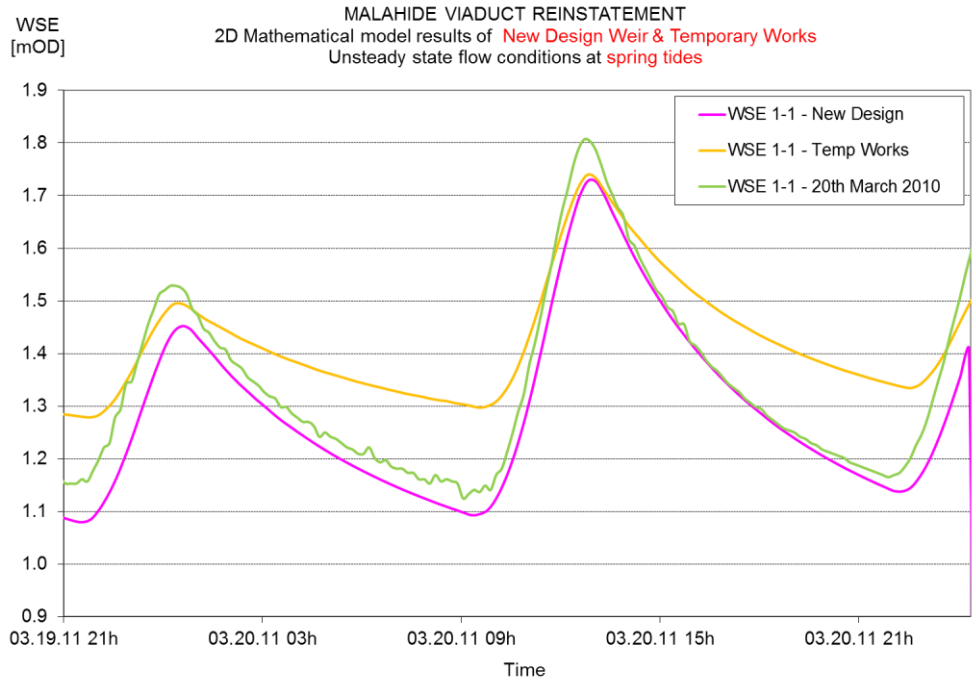


Appendix 12 Hydrodynamic at spring tides

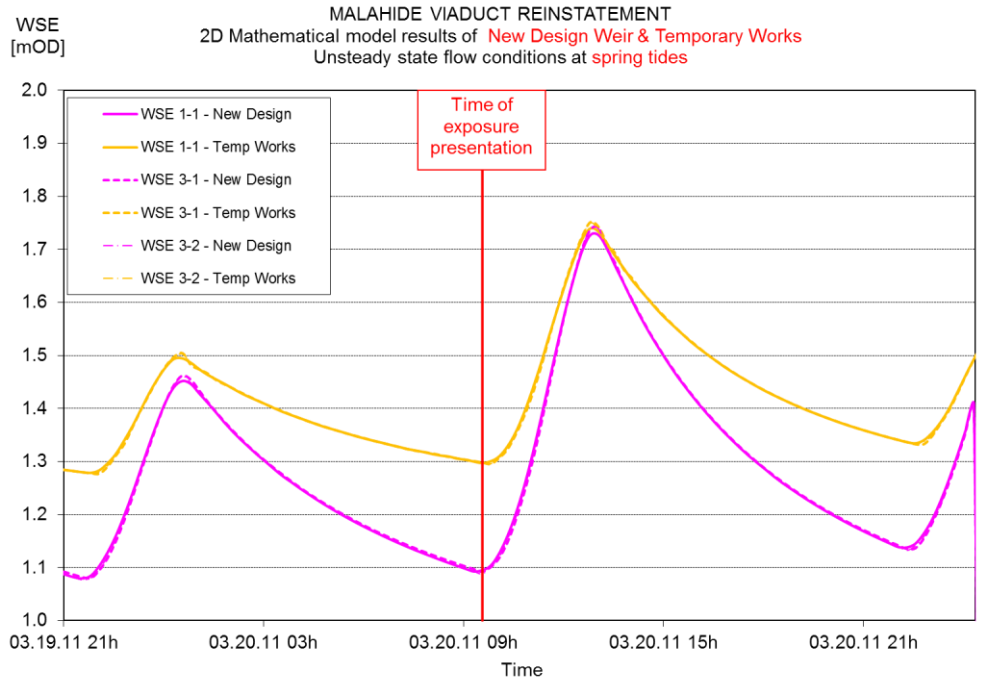
West boundary conditions: Q_{west} = 1.0m^3/s
East boundary conditions: WSE_{east} = Recorded water levels
Manning roughness values: $n_{9.9m}$ = $n_{3.3m}$ = 0.03; $n_{1.1m}$ = 0.066 and 0.025
Smagorinsky coefficient: s = 0.5

Water levels at the weir (control points 1-1 and 1-2)

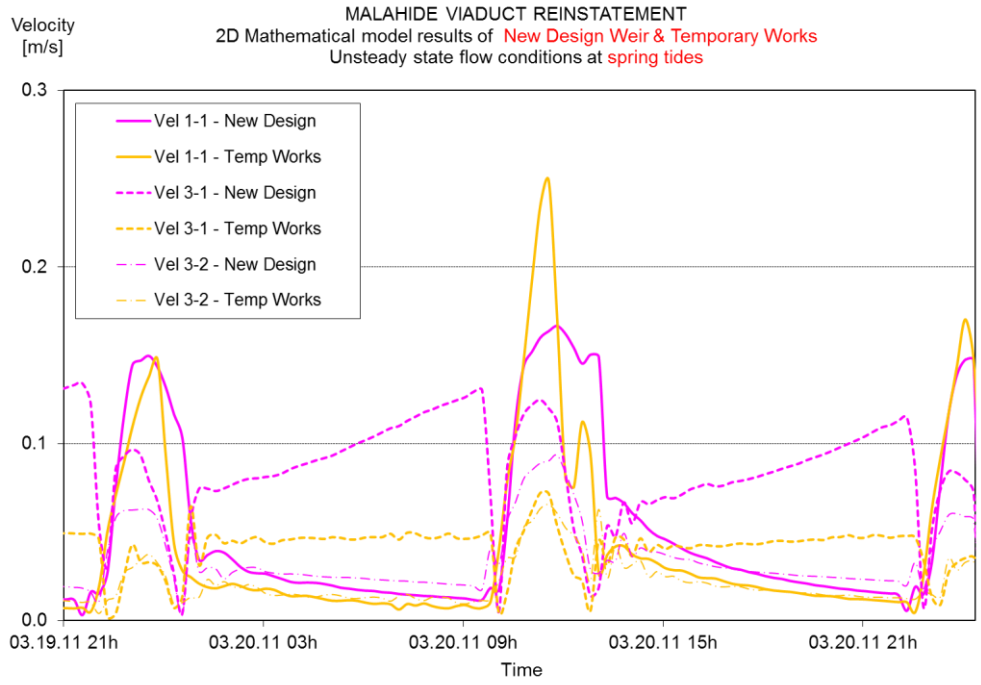




Water levels at the weir (control point 1-1) and on the inner estuary (control points 3-1 and 3-2)



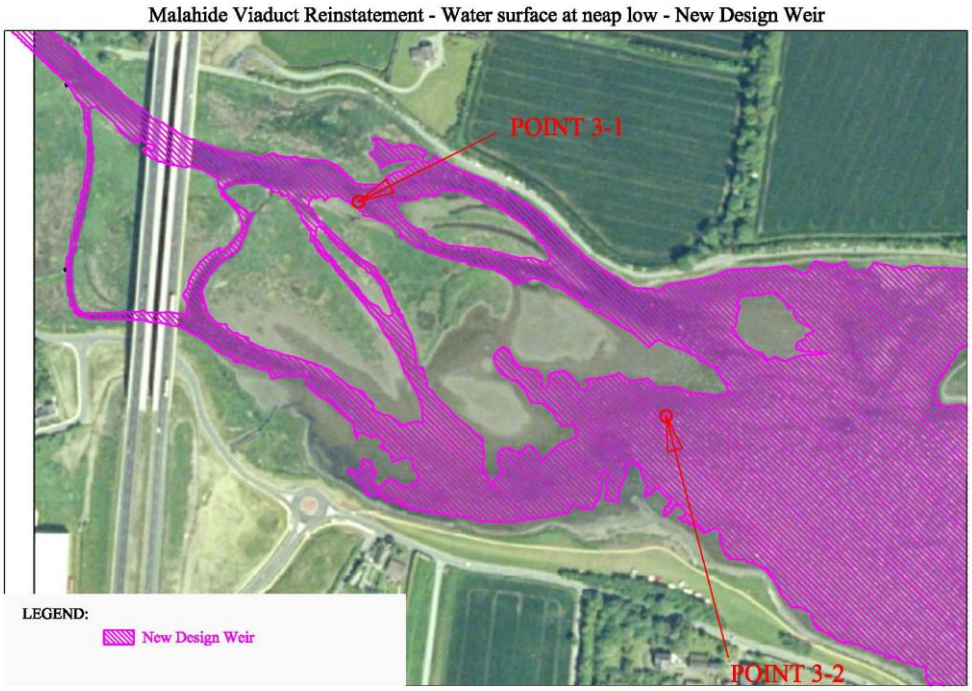
Flow velocities at the weir (control point 1-1) and on the inner estuary (control points 3-1 and 3-2)



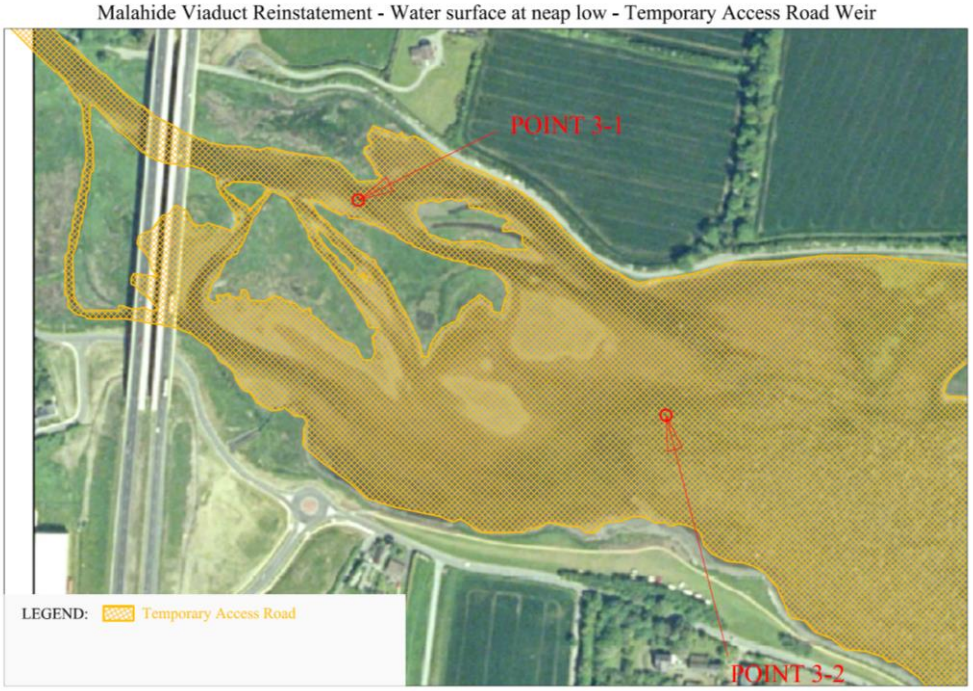
Appendix 13 Exposure at neap low

Time of presentation: 15th March 2011, 06:09 hrs

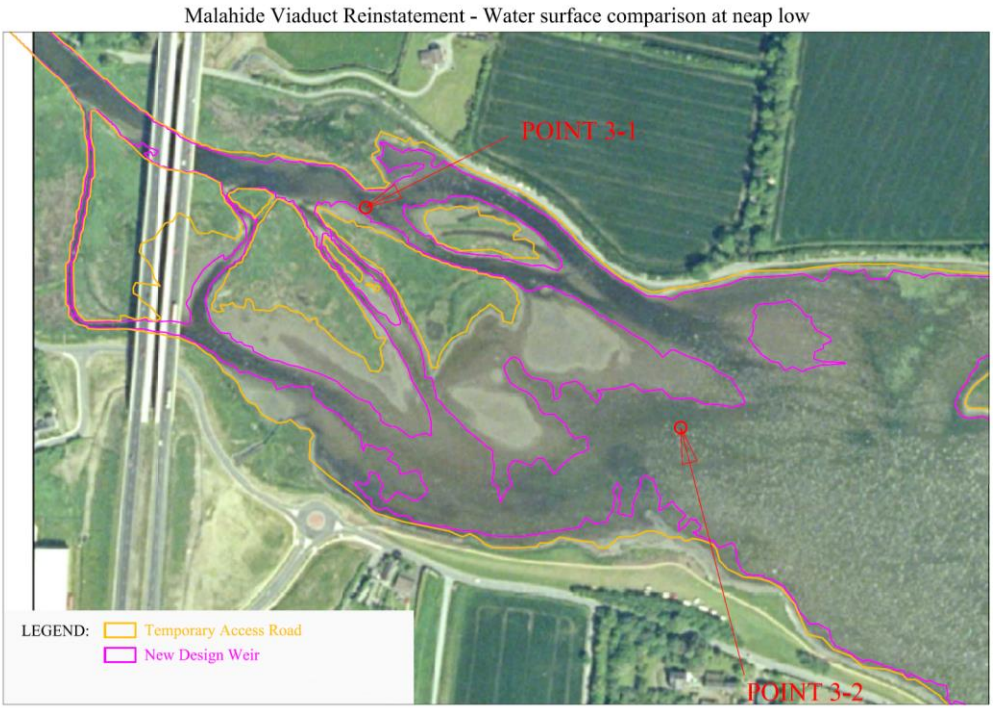
Water surface for New Design Weir



Water surface for Temporary Access Road Weir



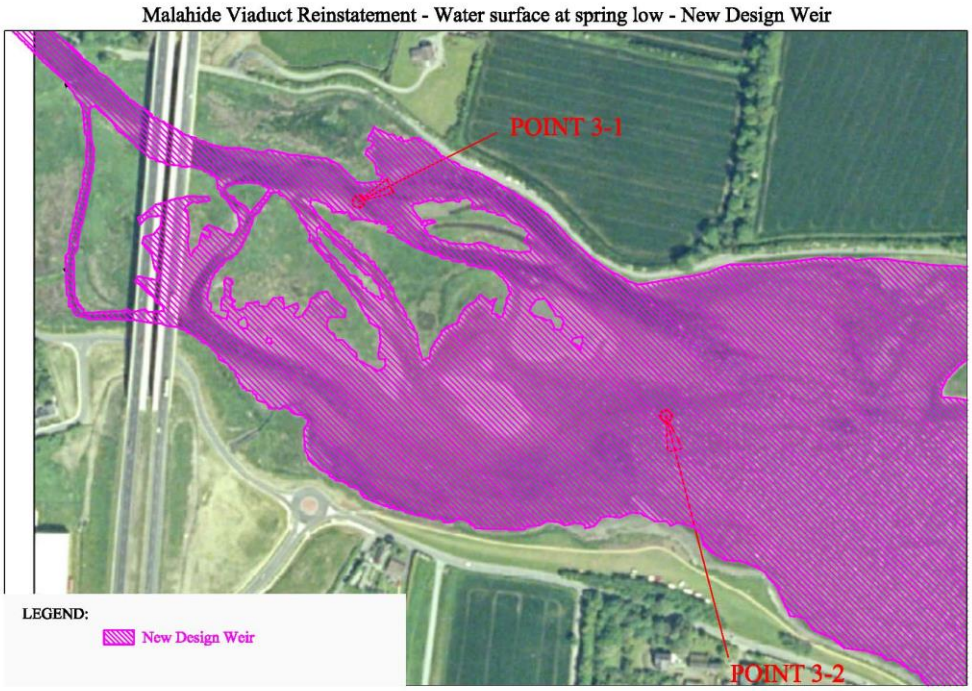
Water surface comparison for neap low



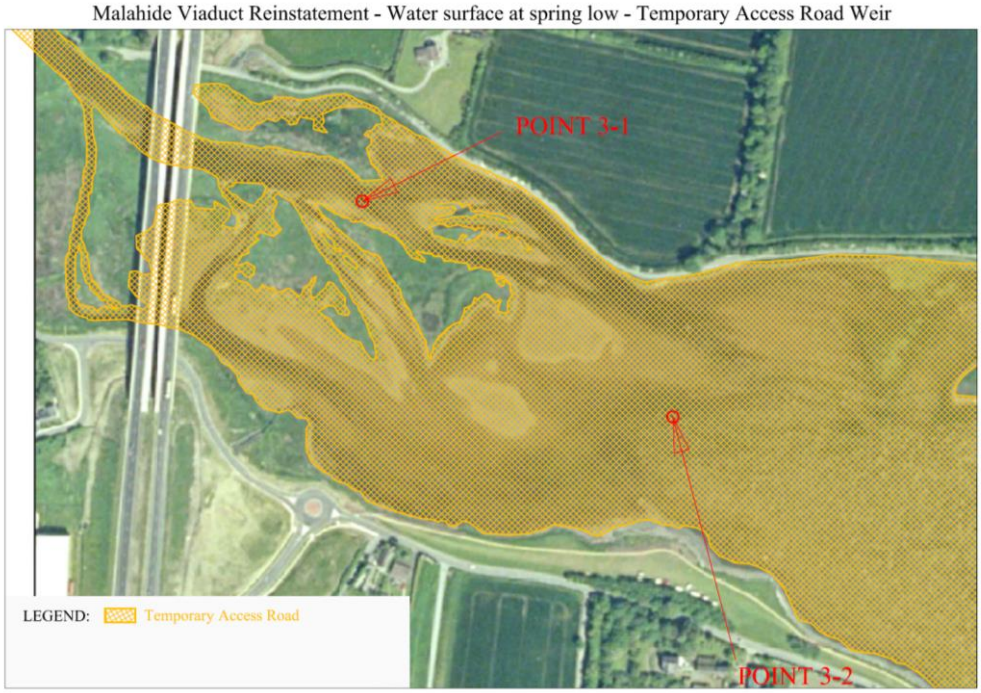
Appendix 14 Exposure at spring low

Time of presentation: 20th March 2011, 09:34 hrs

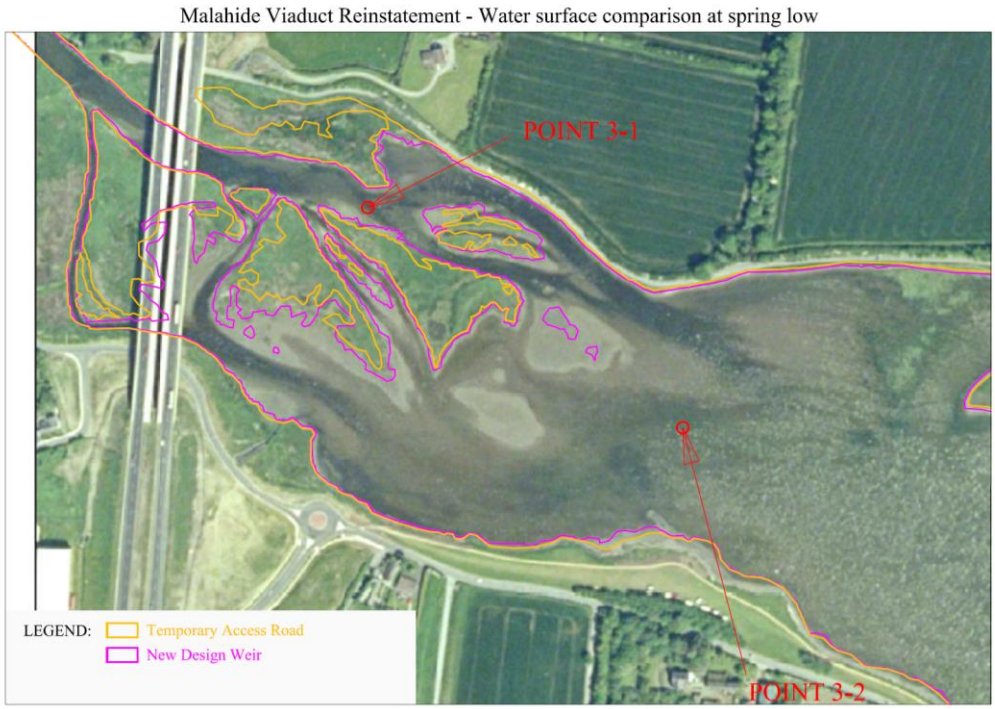
Water surface for New Design Weir



Water surface for Temporary Access Road Weir



Water surface comparison for spring low



Appendix 17

Flood Risk Assessment Report

Clifton Scannell Emerson Associates

Broadmeadow Way

Flood Risk Assessment Report

Comhairle Contae Fhine Gall
Fingal County Council

Client: Fingal County Council

Date: 21st May 2019

Job Number: 12_160

CONSULTING ENGINEERS

Civil Engineering | Structural Engineering | Transport Engineering | Environmental Engineering | Project Management | Health and Safety

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Document Control Sheet

Project Name:	Broadmeadow Way
Project Number:	12_160
Report Title:	Flood Risk Assessment Report
Filename:	RPT-12_160-001

Clifton Scannell Emerson Associates

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Issue No.	Issue Status	Date	Prepared by	Checked by
1st	DRAFT	07 December 2018	SE	PD
2nd	FINAL	14 December 2018	SE	PD
3rd	FINAL	11 March 2019	SE	PD
4th	FINAL	08 April 2019	SE	PD
5th	FINAL	21/05/2019	SE	PD

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1 Introduction

This is the Flood Risk Assessment Report for the proposed Broadmeadow Way. It has been undertaken in accordance with the Guidelines for Planning Authorities on 'The Planning System and Flood Risk Management', November 2009, (Office of Public Works, Department of Environment, Heritage and Local Government.

The proposed development comprises the provision of the Broadmeadow Way – a new greenway (shared footpath and cycleway) of c.6km in length. The greenway links Malahide Demesne to Newbridge Demesne near Donabate, County Dublin. The development includes:

- Provision of a pedestrian/cycleway greenway along c.900m of existing pathways within Malahide Demesne, extending from the main carpark located southeast of Malahide Castle to the Hogan's Gate entrance on the R106, Dublin Road, including new route signage and bicycle parking facilities.
- Provision of approximately 140m of new footpath construction at Bridgefield carpark and new ramp/access upgrade works at the existing pedestrian entrance leading to the R106 Dublin Road;
- Reconfiguration of c.220m of the R106 Dublin Road between Bridgefield car park and O'Hanlon's Lane to facilitate the provision a new off-road shared pedestrian and cyclist facility along the northern side of the road, and a new signal-controlled crossing;
- Provision of approximately 135m of road resurfacing, 230m of shared surface road markings, signage and boundary hedge trimming along O'Hanlon's Lane;
- The reconfiguration of the junction of Bissets Strand and O'Hanlon's Lane;
- Provision of two signal-controlled crossings and new traffic signals at the railway bridge on Bissets Strand;
- The construction of approximately 260m of off-road shared pedestrian and cyclist facilities and associated landscaping and ancillary works on Bissets Strand;
- Works to facilitate the provision of a new greenway facility some 615m in length along the existing weir maintenance access track adjoining the western embankment of the Dublin-Belfast railway causeway, extending north from Bissets Strand into Malahide Estuary, to include new surfacing, fencing, boundary walls, rock armour, route lighting and signage, and a viewing area;
- Provision of a new 12-span pedestrian/cycleway bridge deck of approximately 180m in length on the existing piers located alongside the Dublin-Belfast railway bridge situated on the weir in Malahide Estuary;
- Works to facilitate provision of a new greenway facility of approximately 1,000m in length along the western embankment of the Dublin-Belfast railway causeway, from the proposed pedestrian/cycleway bridge over the weir in Malahide Estuary extending as far as the northern shoreline of Malahide Estuary at Kilcrea, to include new surfacing, fencing, boundary walls, rock armour, route lighting and signage;
- Provision of c.910m of new greenway along the western side of the Dublin-Belfast railway through agricultural lands in Kilcrea on the north

side of the estuary, between the northern shore of Malahide Estuary and the L-6165-0 Coast Road/Corballis Road, with works to include new surfacing, fencing, route lighting and signage, and a new 3 span bridge over the Pill River of 50m in length constructed in timber and concrete;

- Provision of c.230m of new greenway along the southern side of the L-6165-0 Coast Road/Corballis Road, Kilcrea to include to include surfacing, fencing, route lighting and signage;
- Upgrading and re-alignment along c.450m of the L-6165-0 Coast Road/Corballis Road adjacent to the Dublin-Belfast railway bridge, including the installation of signal-controlled pedestrian and cyclist crossing points;
- Provision of c.370m of new greenway, including a bridge crossing of c.12m span, of concrete/timber construction, of the Pill River through agricultural lands in Kilcrea and along the southern bank of the Pill River;
- Resurfacing works along c.140m of the existing L-6135-0 Kilcrea Road north to the R126 Hearse Road;
- Reconfiguration of the junction of the L-6135-0 Kilcrea Lane and the R126 Hearse Road to facilitate pedestrian and cyclist access to Newbridge Demesne;
- Provision of a pedestrian/ cycleway greenway c.900m of existing pathways including new route signage and bicycle parking at Newbridge Demesne;
- Ancillary works along the route including drainage works, provision of fencing, boundary treatments, agricultural accesses, noise barrier (close to the Donabate Distributor Road), public lighting, landscaping and other minor works.

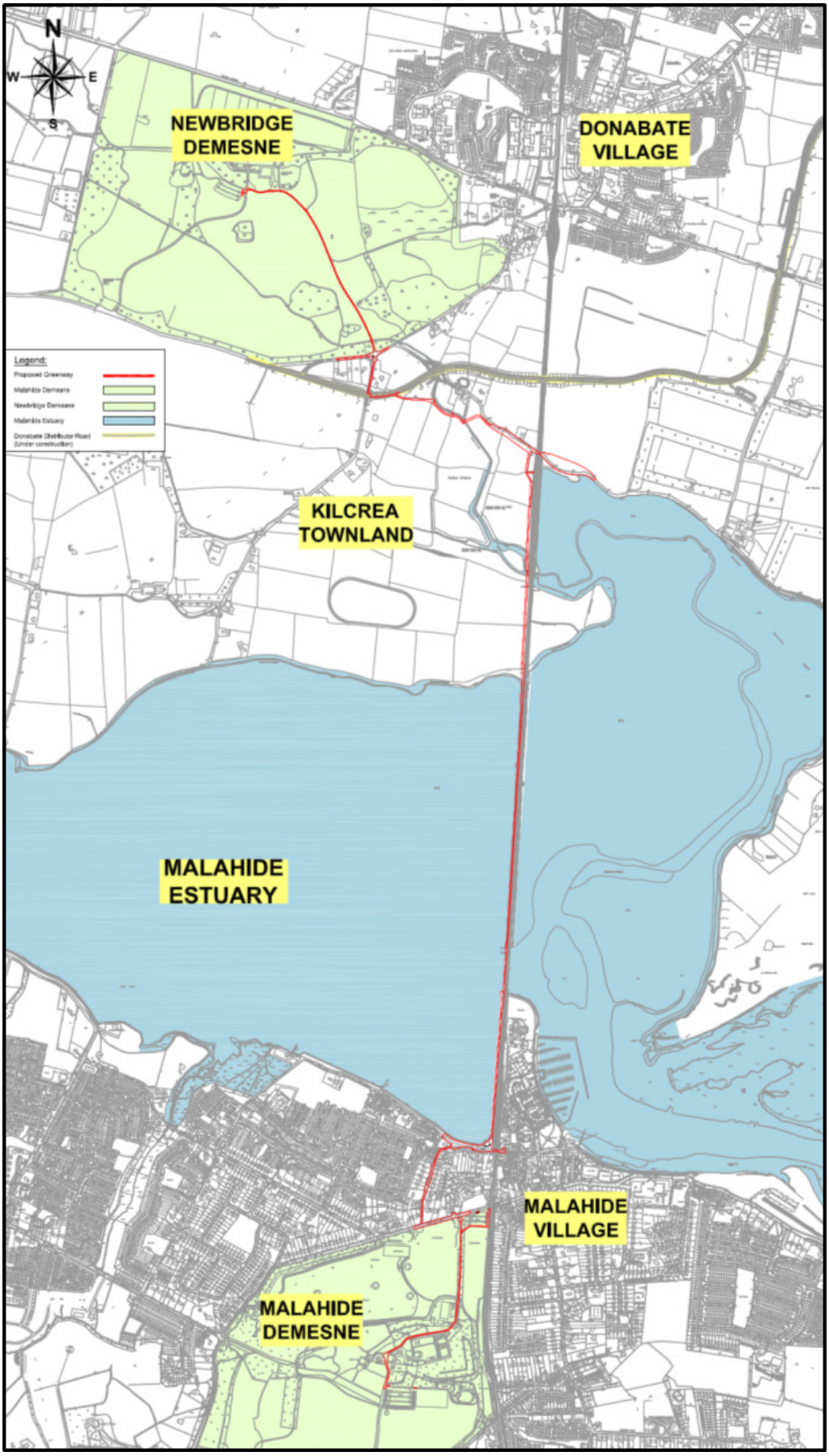


Figure 1 Overall Layout of the Proposed Greenway

2 Background Information

2.1 Catchment-based Flood Risk Assessment and Management

Catchment-based Flood Risk Assessment and Management (CFRAM) program has been implemented by the Office of Public Works (OPW) as a competent authority in Ireland for the EU floods directive. Over 29 Flood Risk Management Plans (FRMPs) have been prepared in coordination with the implementation of the Water Framework Directive (WFD). The FRMPs involved undertaking detailed engineering assessment and producing flood protection measures. The assessment addressed the potential impact of the proposed measures on waterbodies hydromorphology and quality status.

2.2 OPW Flood Guidelines for Planning Authorities

The purpose of The Planning System and Flood Risk Management Guidelines for Planning Authorities published by the OPW in 2009 (OPW Guidelines) is to introduce comprehensive mechanisms for the incorporation of flood risk identification, assessment and management into the planning process.

2.2.1 Objectives of OPW Guidelines

Floods can have broad range of impact on people, property, infrastructure and the environment. Flood can cause damage to the infrastructure including electricity and other utilities with significant detrimental impacts on local and regional economies. This may also cause long-term closure of businesses leading to economic loss other than the damage caused during the event.

The core objectives of the OPW Guidelines include:

- Avoid inappropriate development in areas at risk of flooding;
- Avoid new developments increasing flood risk elsewhere, including that which may arise from surface water run-off;
- Ensure effective management of residual risks for development permitted in floodplains;
- Improve the understanding of flood risk among relevant stakeholders; and
- Ensure that the requirements of EU and national law in relation to the natural environment and nature conservation are complied with at all stages of flood risk management.

2.2.2 Flood Risk Assessment FRA Key Concepts

For carrying out a Flood Risk Assessment (FRA), the OPW Guidelines recommend using Source-Path-Receptor concept model to identify where the flood originates from, what is the floodwaters path and the areas in which assets and people might be affected by such flooding (section 2.18 of the OPW Guidelines, 2009). Figure 2 show a schematic representation of S-P-R model.

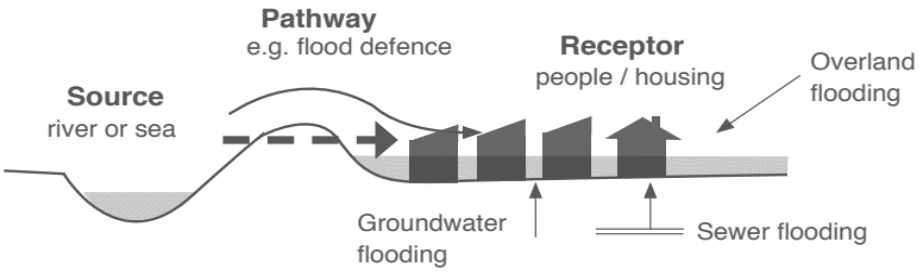


Figure 2 Source-Path-Receptor Model (extracted from OPW Guidelines, 2009)

The other key concept in flood management is the "Flood Risk". it is "the combination of the likelihood of flooding and the potential consequences arising". Consideration of flood risk must be addressed in terms of:

- The likelihood of flooding. Expressed as percentage probability or exceedance each year; and
- The consequences of flooding as the associated hazard e.g. flood depth and velocity.

Flood risk is then expressed with the relationship:

Flood Risk = Likelihood of flooding x Consequences of flooding

2.2.3 Flood Zones

Flood Zone is the spatial inundation area that fall within a range of likelihood of flooding. The OPW Guidelines specified three levels of flood zones:

- **Flood Zone A** – where the probability of flooding from rivers and the sea is highest (greater than 1% Annual Exceedance Probability (AEP) or 1 in 100 for river flooding or 0.5% AEP or 1 in 200 for coastal flooding);
- **Flood Zone B** – where the probability of flooding from rivers and the sea is moderate (between 0.1% AEP or 1 in 1000 and 1% AEP or 1 in 100 for river flooding and between 0.1% AEP or 1 in 1000 year and 0.5% AEP or 1 in 200 for coastal flooding);
- **Flood Zone C** – where the probability of flooding from rivers and the sea is low (less than 0.1% AEP or 1 in 1000 for both river and coastal flooding). Flood Zone C covers all areas of the plan which are not in Zones A or B.

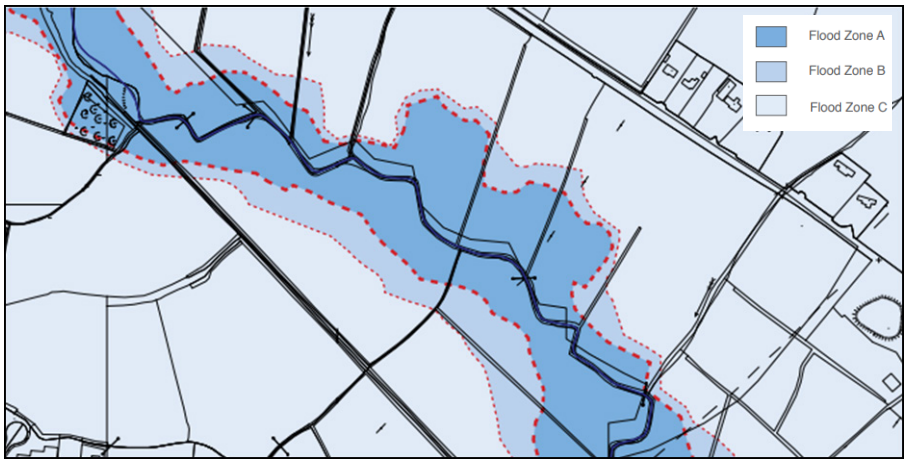


Figure 3 Example of the three flood risk zones (extracted from OPW Guidelines, 2009)

According to the OPW Guidelines, the planning implication of each of the zones mentioned above are:

Zone A - High probability of flooding. Most types of development would be considered inappropriate in this zone.

Zone B - Moderate probability of flooding. Highly vulnerable development, such as hospitals, residential care homes, Garda, fire and ambulance stations, dwelling houses and primary strategic transport and utilities infrastructure, would generally be considered inappropriate in this zone

Zone C - Low probability of flooding. Development in this zone is appropriate from a flood risk perspective (subject to assessment of flood hazard from sources other than rivers and the coast) but would need to meet the normal range of other proper planning and sustainable development considerations.

2.2.4 Sequential Approach

Sequential approach is an important tool used in the planning process which gives preference to locate a new development in the Low Flood Risk Zone and ensures that it does not have an adverse impact of flooding.

According to the sequential approach, If the development lies within a Flood Zone, it is required to consider measures for mitigating flood impact to an acceptable level. It is also required to provide justifications and strategic reasons for locating a proposed development on a higher risk flood zone (see Figure 4 below).

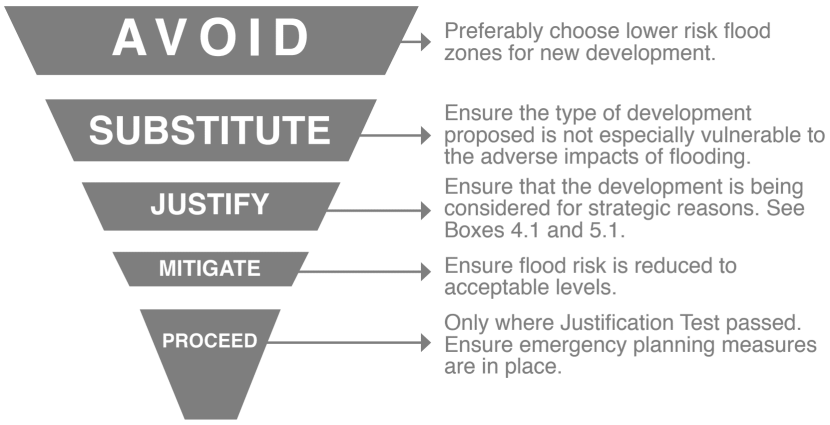


Figure 4 FRA Sequential Approach (extracted from OPW Guidelines, 2009)

2.2.5 Development Classification

The OPW Guidelines provided three vulnerability categories based on the type of development which are:

- **Highly vulnerable:** This includes essential infrastructure, such as primary transport and utilities distribution, electricity generating power stations and sub-stations
- **Less vulnerable:** This category includes Land and buildings used for holiday or short-let caravans and camping, subject to specific warning and evacuation plans;
- **Water compatible:** Includes water-based flood control and recreational developments and other amenity open space, outdoor sports and recreation and essential facilities such as changing rooms.

The OPW Guidelines, as described in Section 2.2.4 of this report, sets out a sequential approach which makes use of flood risk assessment and classifies vulnerability of flooding of different types of development.

Table 3.2 of the OPW Guidelines illustrates those types of development that would be appropriate to each flood zone (reproduced in Table 1 below) and those that would be required to meet a Justification Test in accordance to Box. 5.1 in the Guidelines (refer to Appendix F).

	Flood Zone A	Flood Zone B	Flood Zone C
Highly vulnerable development (including essential infrastructure)	Justification Test	Justification Test	Appropriate
Less vulnerable development	Justification Test	Appropriate	Appropriate
Water-compatible development	Appropriate	Appropriate	Appropriate

Table 1 Matrix of vulnerability versus flood zone (extracted from OPW Guidelines, 2009)

2.3 Fingal East Meath Flood Risk Assessment and Management Study (FEM-FRAMS)

In 2008, Fingal County Council FCC, Meath County Council MCC and the OPW commenced work on a Flood Risk Assessment and Management Study for the Fingal and East Meath area (FEM-FRAMS), as a mean of addressing existing flood risk in the study area and the potential for significant increases in this risk in the future. FEM-FRAMS was one of four pilot CFRAM studies for the new Flood Risk Assessment and Management Programme.

The main stated objectives for FEM-FRAMS were included:

- Assess flood risk, through the identification of flood hazard areas and the associated impacts of flooding;
- Build the strategic information base necessary for making informed decisions in relation to managing flood risk
- Identify viable structural and non-structural measures and options for managing the flood risks for localised high-risk areas.

FEM FRAMS recommendations which impact on the adjacent Malahide Estuary and Turvey River (Pill River) are discussed in Section 3 of this report.

2.4 Strategic Flood Risk Assessment for the Fingal Development Plan 2017-2023

The OPW Guidelines, 2009 recommend that a Strategic Flood Risk Assessment (SFRA) is to be prepared to support the Strategic Environmental Assessment (SEA) of any proposed development plans. Fingal City Council SFRA for the Draft Development Plan 2017-2023 is available at https://consult.fingal.ie. The SFRA adopts a policy that requires flood risk assessments to be undertaken for developments and zoning being proposed in flood prone areas. The objective of SFRA is to identify flooding and surface water management issues related to the County that warranted further investigation. The SFRA also highlights relevant recommendations to identify potential land zonings using sequential approach and justification test required as per OPW Guidelines.

2.5 Impact of Climate Change on Flood Risk

The OPW states in the "Climate Change Sectoral Adaptation Plan 2015-2019" that climate change will significantly increase the flood risk by different mechanisms including:

- Sea level rising
- Increase in Rainfall/Runoff
- Increase in wind speed and hence extreme storms surge events.

The OPW specified two main Climate Change Scenarios for the Pilot CFRAMS Studies, which are: (1) Mid-Range Future Scenario MRFS and; (2) High-End Future Scenario HEFS. Table 2 below shows the parameters of each scenario.

Parameter	MRFS	HEFS
Rainfall	+20%	+30%
Flood Flows	+20%	+30%
Sea Level Rising	+500 mm	+1000 mm

Table 2 Flood Parameters for the Mid-Range Future and High-End Future Scenarios. Adopted From "Climate Change Sectoral Adaptation Plan 2015-2019"

In FEM-FRAMS study, all options were developed and assessed with a potential increase in flood risk taken into consideration based on the modelling and mapping of the MRFS (Ref. p-96, FEMFRAMS Final Report, 2014). Therefore, and due to data limitation, an allowance of climate change based on MRFS data is adopted in this FRA as FEM-FRAMS maps is the key sources of the information we used in this report.

2.6 Irish Coastal Protection Strategy Study

Three phases of the Irish Coast Protection Strategy Study (ICPSS) have been completed by the OPW since 2004. Phase III of ICPSS presents findings of coastal flood and erosion extent modelling including the North East Coastline from Dalkey Island to Omeath, Co. Louth.

ICPSS has used hydrodynamic modelling and statistical techniques to analyse the combined tidal and storm surge impact along the coast of Ireland. The final output of the ICPSS shows extreme water levels (Combined Tidal and Storm Surge) at 29 locations along the North East Coast. ICPSS produced flood maps for the 0.1% AEP and 0.5 % AEP events as an Indicative flood extent maps. These maps consider an allowance for the climate change based on MRFS scenario.

According to ICPSS, the extreme water level at Malahide Estuary is represented by the model's node number (NE_16) as shown in Figure 5. ICPSS flooding map No. NE/RA/EXT/MRFS/16 (Refer to Appendix D) is available at the OPW website which will impact different locations along the proposed Greenway route.

Figure 5 Points of extraction along ICPSS East Coast Study Area (Ref. ICPSS III, 2010)

2.7 OPW Flood Risk Maps

The OPW Flood Maps Viewer available in www.floodinfo.ie, allows access to flood mapping data through an interactive map search. The available OPW Flood Risk Maps for the study area account for coastal flooding (Tidal) and Fluvial Flooding (Rivers). For each type of flooding, the current and future flooding scenarios are also available.

As discussed in Section 2.5, this FRA considers the climate change allowance of MRFS and therefore, only MRFS flood risk maps will be reviewed in this report. Information on coastal flooding for the study area found in map No. COA/EXT/MRFS/006 (Refer to Appendix A), gives flood extent for the entire coastline along Malahide estuary. It also shows flood levels and their corresponding probabilities. Similarly, the coastal flooding from tidal propagation upstream into Turvey River (Pill River) which affects the study area in Kilcare Land is shown on map No. TUR/HPW/EXT/MRFS/T/002 (Refer to Appendix B).

Fluvial Flooding of Turvey River (Pill River) in the extent of the study area in Kilcrea Land is shown by the map No. TUR/HPW/EXT/MRFS/002 (Refer to Appendix C).

3 Flood Risk Identification in the Study Area

3.1 Historic Flood Events

Malahide is at risk from tidal flooding only from the Malahide Estuary. Potential flooding in Malahide town centre has its source from two main locations: overtopping of the coastline, flooding the town centre and spilling of floodwater under the railway underpass from the coast road west of the railway embankment. Table 3 below (extracted from the FEMFRAMS report) gives the major historic floods since 1924;

Table 3 Major Historic Floods since 1924 (extracted from the FEMFRAMS report)

Flood Event Date	Main Flood Mechanism	Rivers/Coast Affected	Areas Affected:
1924*	Tidal	Coastal	Coastal area of Fingal and Meath counties
December 1954	Fluvial	Nanny River	Washed away Drogheda Bridge
November 1982	Fluvial	Ward River, Broadmeadow River, Mill Stream	Swords, Malahide, Skerries
February 2002	Tidal	Ward River, Mayne River, Turvey River (Pill River), Sluice River	Swords, Portmarnock, Maynetown, Skerries, Portrane, Bettystown, Malahide, Rush
October/November 2002	Fluvial	Ward River, Sluice River, Mill Stream, Ballyboghill River	Portmarnock, Swords, Malahide, Skerries, Ballyboghil, Donabate, Portrane, Rush, Balbriggan
August 2008	Pluvial/fluvial	Sluice River, Hazelbrook Stream, Gaybrook Stream near Swords, Corduff Stream	Lusk, Ashbourne, Malahide, Swords, Kinsaley Village

From reviewing past flood records in www.floodinfo.ie database, it appears that Bissets Strand and Estuary Road Malahide are recorded to have a recurring flood event. It has been stated that "*Regular tidal flooding. Tidal flooding a few times a year. No houses effected but road impassable*" (EBS, 2005). Figure 2 below shows a screen view of the past flood event around Malahide Estuary indicating the Bissets Strand record.

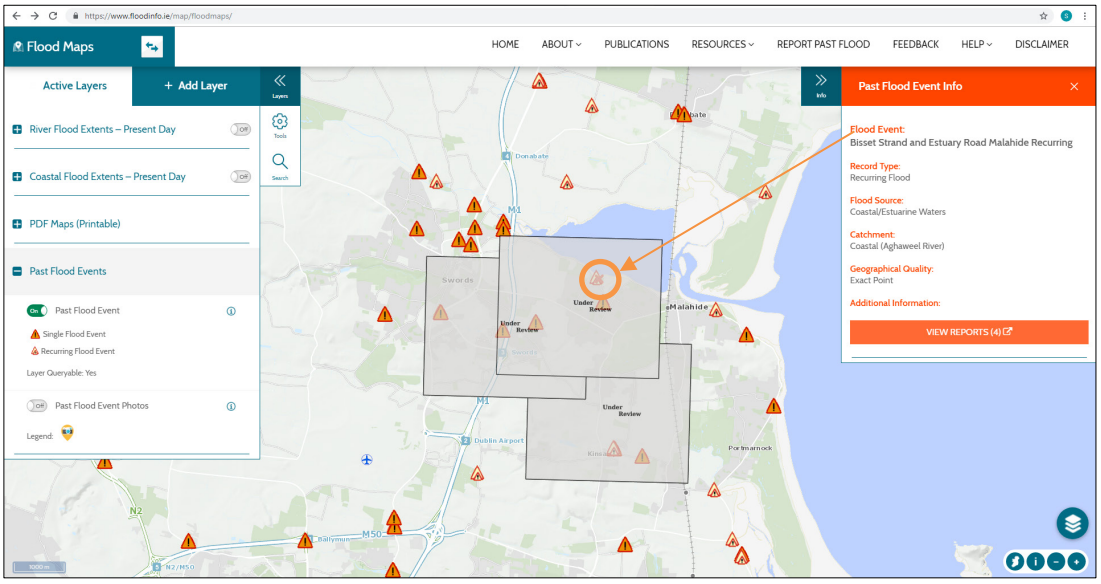


Figure 6 Screenshot of past Flood event around Malahide estuary (www.floodinfo.ie)

The historic flooding information in the study area presents evidence of coastal flooding occurrence which will likely affect the proposed scheme particularly on the sections running through or near to the coastline.

3.2 Flood Risk Identification in the Study Area

3.2.1 Coastal Flooding

The area along Bissets Strand (See figure 7) has a history of flooding, particularly during high tides (as discussed in section 3.1). The OPW Flood Hazard Mapping indicates that a serious flooding event occurred at lunchtime on the 1st February 2002. This included flooding of Mill View Lawn and Memory Shop on the Strand Road. The flooding was caused by an Elevated Storm Surge combined with a High Astro Tide which led to the highest tide on record which also caused widespread flooding throughout the entire Dublin area.

Costal Flood Extent Map No. COA/EXT/MRFS/006 shows the coastal flooding model results at MRFS climate change allowance. Flood level data are being extracted from 3 nodes in the map. The Nodes that will give the best indication of the flood levels which may affect the proposed greenway route are listed in Table 4 below. The total length of the greenway under the potential coastal flooding effect is c.2.35km (from chainage 1+300 to 3+650). Figure 7 shows the extent of the identified region in the scheme where coastal flooding is likely to have an impact as listed in Table 4. The figure shows an approximated centreline overlaid on the COA/EXT/MRFS/006 background map.

Table 4 Sections vulnerable to Coastal Flooding in the scheme and the adjacent FEMFRAMS Model nodes

Section/Area of the Proposed Scheme	Chainage		Approximate Length m	*Hydraulic Model Node No.
	From	To		
Bissets Strand	1+300	1+580	280	62
Weir Maintenance Track	1+580	2+150	570	62
Footbridge	2+150	2+330	180	64
Causeway Embankment	2+330	3+225	895	64
Causeway Embankment	3+225	3+650	425	55
* These Nodes are shown in FEM-FRAMS Maps. In ICPSS study, only one node (EN_16) will be used to assess at the same identified sections (refer to section 2.6 of this report).				

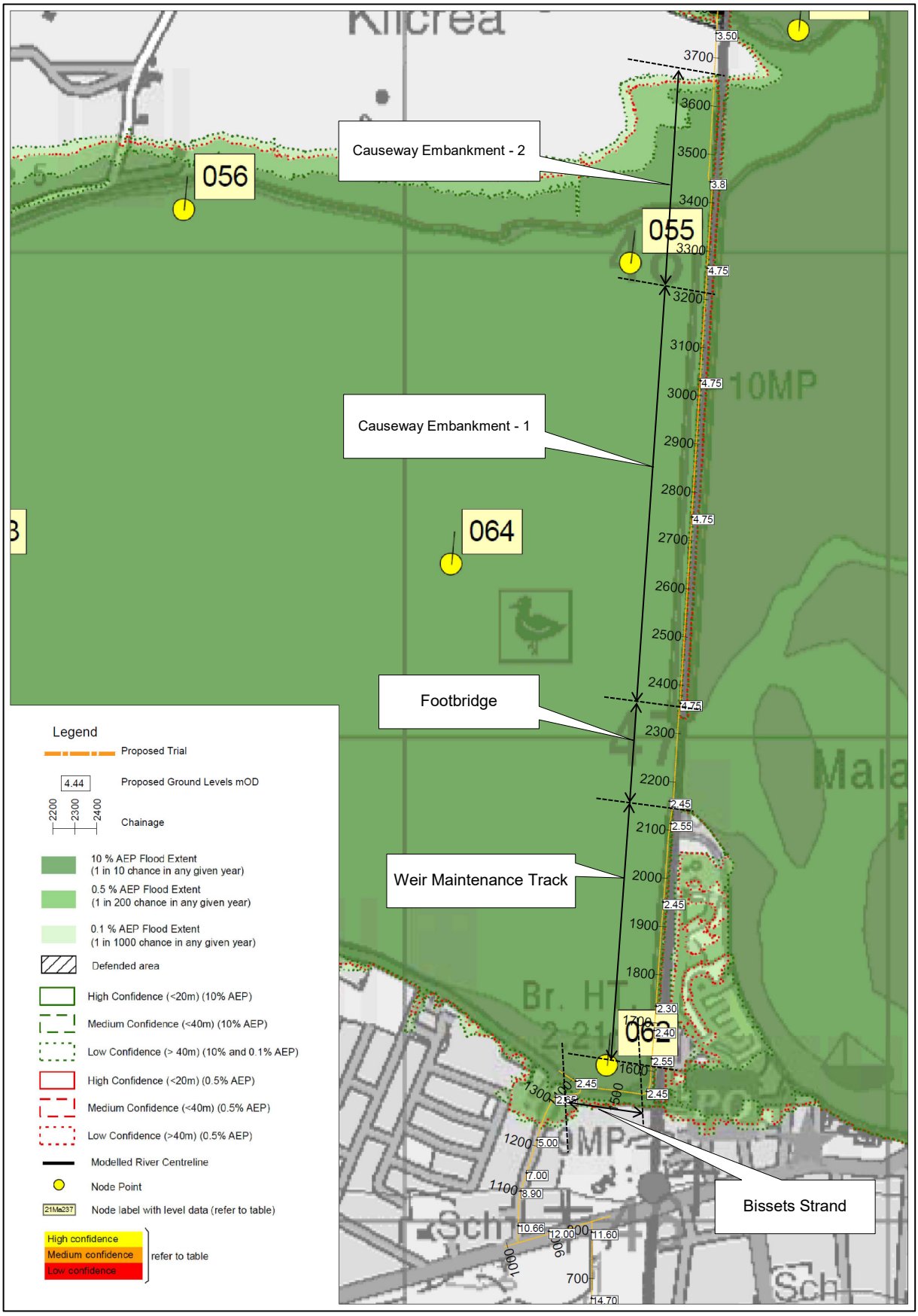


Figure 7 Coastal Flooding vulnerable area in the scheme

3.2.2 Fluvial Flooding

Sections of the proposed Greenway between the North Shore of Malahide Estuary and the Newbridge Demesne are within the flood plain of the Turvey River (Pill River) (The last section of the Turvey River (Pill River) near the outfall is also known as the Pill River) (see figure 8).

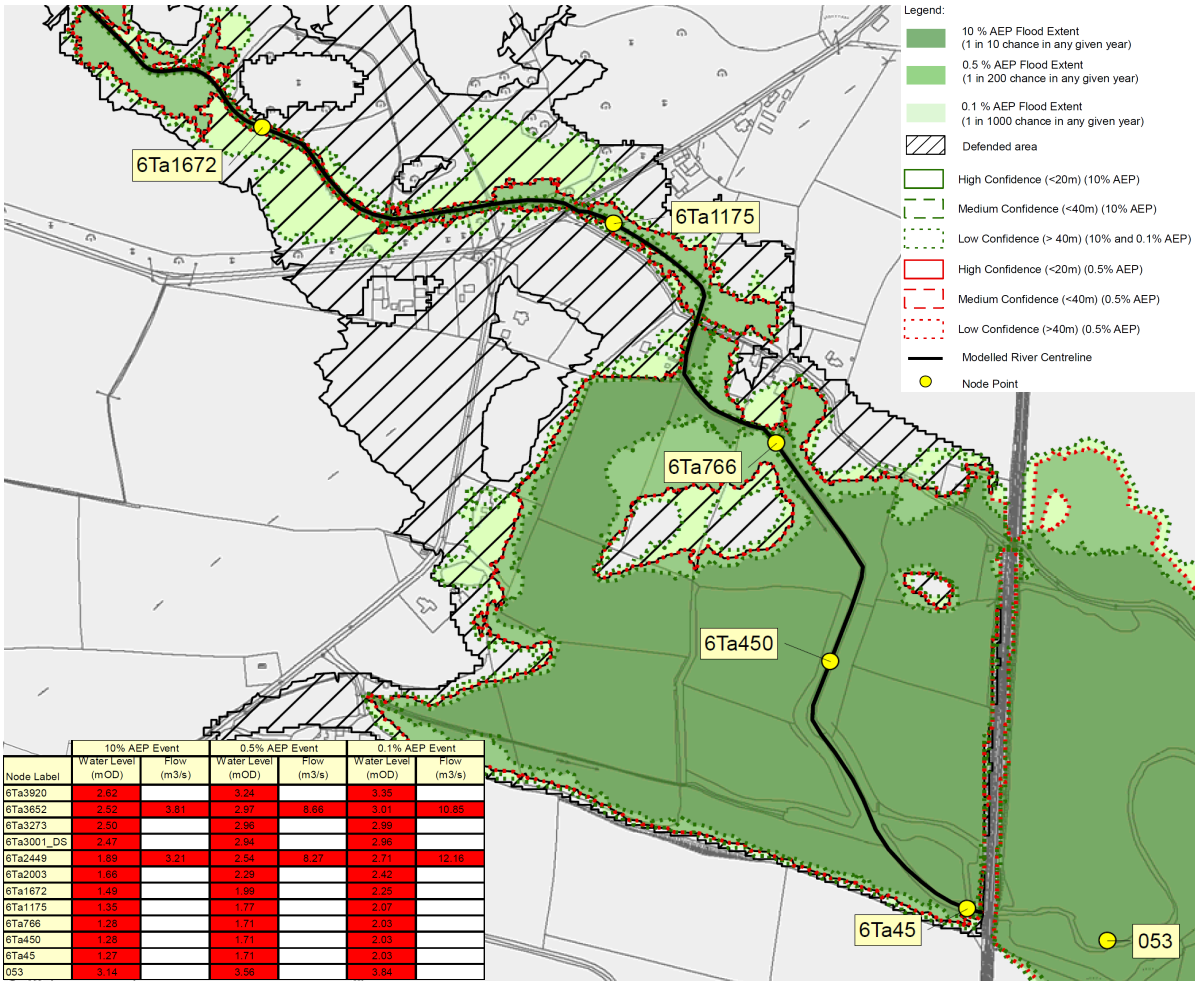
FEMFRAMS has modelled the Turvey River (Pill River) and has issued reports and mapping for the present and future risk of flooding, both Fluvial and Tidal along the length of the river.

It should be noted that the presence of the flapped outfall at the estuary (shown in Figure 8) will lead to a reduction in the risk of such high tidal flooding or storm surge event from propagating into the river through the Kilcrea Lands. The effect of the flapped outfall was discussed in detail in FEM-FRAMS Hydraulic Report. It was stated that *"The flapped outfall at the downstream end of the model is considered a formal flood defence. The flapped outfalls prevent the high tides from propagating upstream at any modelled AEP event."* (Ref. FEMFRAMS Hydraulics Report). The area benefitting from the operation of the flapped outfall is highlighted as *Defended Areas* in the FEM-FRAMS flood risk maps (see Figure 9).

Figure 8 Photo of the flapped outfall at Malahide Estuary – River Turvey mouth (Extracted from FEM-FRAMS, hydraulic Report, 2011)

Notwithstanding the presence of this tidal defence mechanism the river was modelled 'without defences scenario' which gives the 'worst case scenario' for potential flooding in the estuary at the event of high tides and of high fluvial flooding at the same time.

The comparison of tidal and fluvial flooding in Kilcrea Land based on flood risk maps No. TUR/HPW/EXT/MRFS/002 and TUR/HPW/EXT/MRFS/T/002 show that fluvial flood levels are slightly higher in all AEP events. Therefore, the assessment of this part of the scheme will only review flood levels shown on fluvial flooding map (TUR/HPW/EXT /MRFS/002).



Node Label	10% AEP Event Water Level (mOD)	10% AEP Event Flow (m3/s)	0.5% AEP Event Water Level (mOD)	0.5% AEP Event Flow (m3/s)	0.1% AEP Event Water Level (mOD)	0.1% AEP Event Flow (m3/s)
6Ta3920	2.62		3.24		3.35	
6Ta3652	2.52	3.81	2.97	8.66	3.01	10.85
6Ta3273	2.50		2.96		2.99	
6Ta3001_DS	2.47		2.94		2.96	
6Ta2449	1.89	3.21	2.54	8.27	2.71	12.16
6Ta2003	1.66		2.29		2.42	
6Ta1672	1.49		1.99		2.25	
6Ta1175	1.35		1.77		2.07	
6Ta766	1.28		1.71		2.03	
6Ta450	1.28		1.71		2.03	
6Ta45	1.27		1.71		2.03	
053	3.14		3.58		3.84	

Figure 9 Extraction from Coastal Flooding Map No. TUR/HPW/EXT/MRFS/T/002 showing Defended Areas

Figure 8 shows an approximated Greenway centreline overlaid on the adopted FEM-FRAMS flood map. The extent of the impact on the section of the route which fall within Turvey River (Pill River) floodplains is c.2.41km (from Chainage 3+550 to 6+066). The Nodes that will give best indication of the flood levels in the proposed greenway are listed in Table 5 below.

Table 5 Sections vulnerable to Fluvial Flooding in the scheme and the adjacent FEMFRAMS Model nodes

Section/Area of the Proposed Scheme	Chainage		Approximate Length m	*Hydraulic Model Node No.
	From	To		
Causeway Embankment	3+650	3+762	112	6Ta45
Pill River Bridge Crossing-1	3+762	3+812	50	6Ta45
Kilcrea Land	3+812	4+000	188	6Ta45
Kilcrea Land	4+000	4+330	330	6Ta450
Kilcrea Land	4+330	4+572	242	6Ta766
Pill River Bridge Crossing-2	4+572	4+586	14	6Ta766
Kilcrea Land	4+586	4+800	214	6Ta766
Kilcrea Land	4+800	5+150	350	6Ta1175
Newbridge Demesne	5+150	5+600	450	6Ta1672
Newbridge Demesne	5+600	6+066	466	6Ta2003

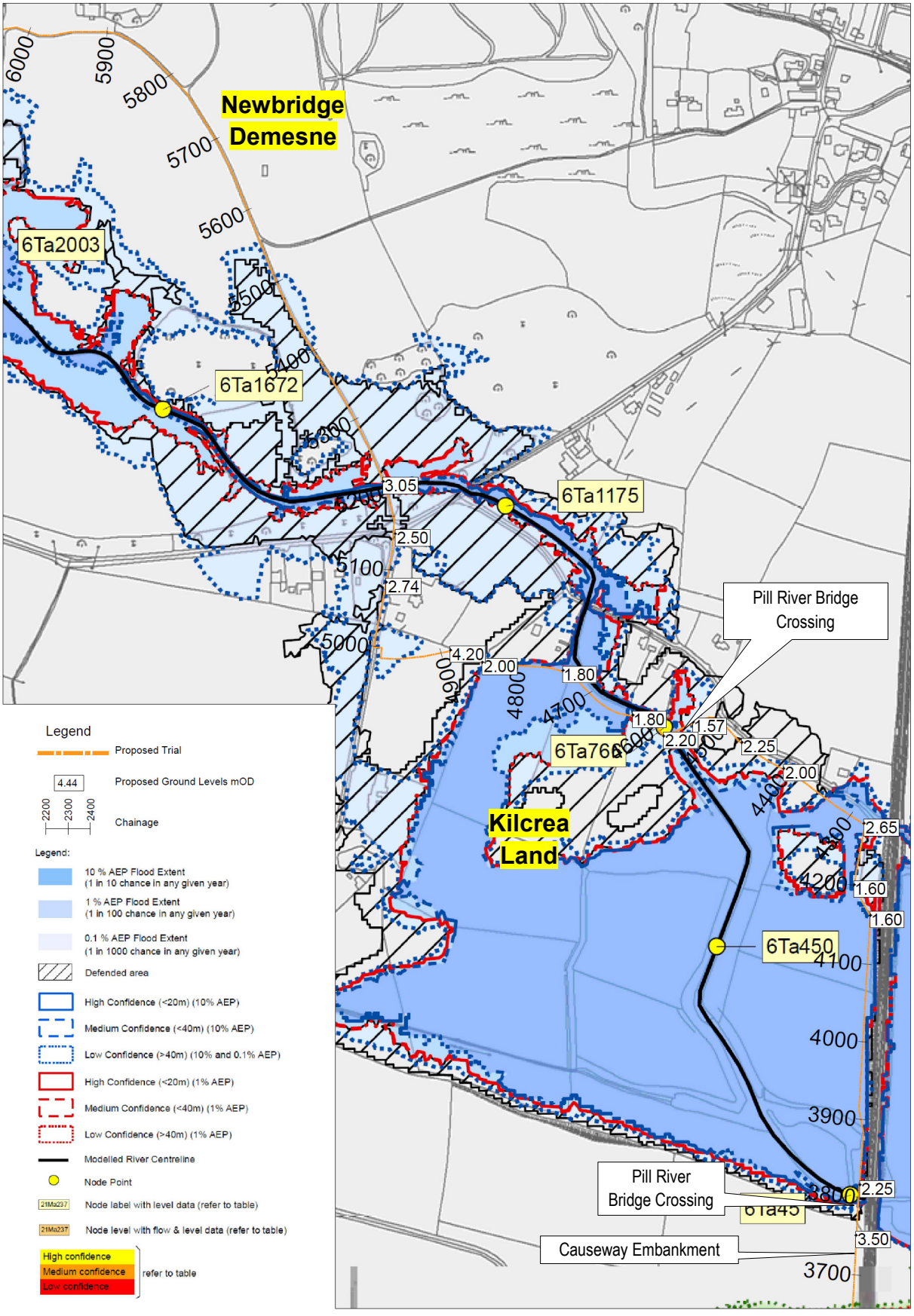


Figure 10 Fluvial Flooding vulnerable area in the scheme

3.3 Summary of Identified Flood Risk in the Study Area

As demonstrated in Section 3.1 there is a potential coastal flooding impact on the adjacent part of the scheme to Bissets Strand Road.

In Section 3.2.1, a total extent of 2.35km length was identified as subject to potential Coastal Flooding, that includes sections of the scheme run through the causeway embankment of Dublin-Belfast Railway (see Figure 11 and 12).

Along the Greenway section that runs through Kilcrea Land, an approximated length of 2.41km was identified as having a potential Fluvial Flooding impact. It is also confirmed that tidal/storm surge flood impact in this area of the scheme is reduced by the operation of an existing flapped outfall at the mouth of Turvey River (Pill River).

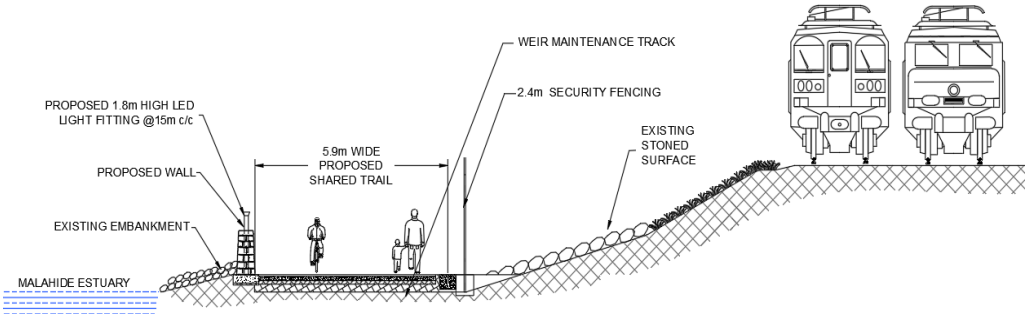


Figure 11 Cross section showing the proposed Greenway at the Weir Maintenance Track

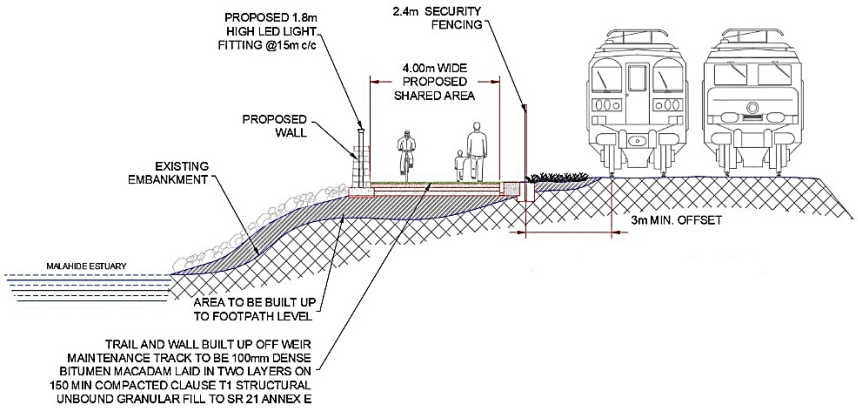


Figure 12 Cross section of the Proposed Greenway at the Causeway Embankment

Figure 13 Photo of the existing Weir Maintenance Track

4 Assessment of Flood Risk Identified for the Proposed Scheme

4.1 Vulnerability Classification

Table 3.1 of the OPW Guidelines provides description of each vulnerability categories (Highly vulnerable, less vulnerable and water-compatible), as previously illustrated in Section 2.2.5 of this report. According to Table 3.1 of the OPW Guidelines (See Appendix E), local transport infrastructure including non-residential lands used for leisure and holidays are considered as Less Vulnerable Type of Development. It is appropriate then to consider the proposed Broadmeadow Way in this category.

While we would agree that the greenway constitutes 'less vulnerable development'; however, 'open, amenity space' is deemed 'water compatible' by the OPW Guidelines so there is a planning / flood risk precedent that lands used by people for recreational activities is appropriate within Flood Zone A

As indicated in Table 1, "Matrix of vulnerability versus flood zone (extracted from OPW Guidelines, 2009)", the justification test will only be required for sections of the scheme that lay within Flood Risk Zone A. All proposed sections of the scheme lay on Zone B or Zone C will be considered as "Appropriate for Development" with an exception of the proposed bridges at which assessment as per the OPW Section-50 application is required.

4.2 Flood Risk Assessment for the Proposed Greenway

The total length of the proposed scheme is c.5.96km. As discussed in Section 3, the identified sections of the scheme as potential flood *Receptors* are c.2.35km and c.2.41km for Coastal and Fluvial *Sources* of Flooding respectively.

According to the OPW Guidelines, Flood Risk Zones are associated with flood levels of an annual exceedance probability (AEP) as follows:

- Zone A: 0.5 AEP (Coastal) 1% AEP (Fluvial): High Flood Risk
- Zone B: 0.1% AEP (Coastal & Fluvial): Moderate Flood Risk
- Zone C: <0.1% APE (Coastal & Fluvial): Low Flood Risk

Information on flood levels in the study area is provided from the adopted flood maps as discussed in previous sections of this report. The flood risk maps used in the assessment can be summarized as shown in Table 6.

Table 6 Source of the adopted flood levels for Sit-specific Flood Risk Assessment

	Map No.	Flooding Mechanism	Climate Change Allowance	Source of Information	Appendix (in this Report)
1.	COA/EXT/MRFS/006	Coastal	MRFS	FEM-FRAMS	A
2.	TUR/HPW/EXT/MRFS/002	Fluvial	MRFS	FEM-FRAMS	C
3.	NE / RA / EXT / MRFS / 16	Coastal	MRFS	ICPSS	D

It should be noted that coastal flood levels used in the assessment are extracted from two maps, FEM-FRAMS and ICPSS, in which higher flood levels will be considered for the assessment.

Figure 7 and 8 in Section 3.2, show a preliminary proposed design levels along the Greenway. In the following tables (Table 7 and 8) we will examine the proposed ground levels at the identified sections with reference to flood levels.

Table 7 Coastal Flooding Status along sections of interest in the scheme

Section/Area of the Proposed Scheme	Chainage		Length m	Lowest Proposed Finish Level (Aprx.) mOD	*Hydraulic Model Node No.	MRFS Flood Levels mOD FEM-FRSAMS		MRFS Flood Levels mOD ICPSS (III)		Flooding Status/ Remarks	**Difference between flood level and finish surface ± m
	From	To				0.5% AEP Zone A	0.1% AEP Zone B	0.5% AEP Zone A	0.1% AEP Zone B		
Bissets Strand	1+300	1+580	280	2.45	62	3.53	3.81	3.71	3.93	FEM-FRAMS: Zone A ICPSS: Zone A	+1.26
Weir Maintenance Track	1+580	2+150	570	2.3	62	3.53	3.81	3.71	3.93	FEM-FRAMS: Zone A ICPSS: Zone A	+1.41
Footbridge	2+150	2+330	180	4.2	64	3.49	3.78	3.71	3.93	Zone C (0.5%AEP + 300mm freeboard is provided)	-0.49
Causeway Embankment	2+330	3+225	895	4.5	64	3.49	3.78	3.71	3.93	Zone C	-0.79
Causeway Embankment	3+225	3+650	425	3.75	55	3.53	3.81	3.71	3.93	FEM-FRAMS: Zone B ICPSS: Zone B	-0.04

* Nodes here are referred to FEM-FRAMS flood risk maps. ICPSS levels extracted from node (EN_16).
** (+) indicates that flood level is above the proposed finish level, (-) is below.

Table 8 Fluvial Flooding Status along sections of interest in the scheme

Section/Area of the Proposed Scheme	Chainage		Length m	Lowest Proposed Finish Level (Aprx.) mOD	Hydraulic Model Node No.	MRFS Flood Levels mOD FEM-FRSAMS		Flooding Status/ Remarks	**Difference between flood level and finish surface ± m
	From	To				1% AEP Zone A	0.1% AEP Zone B		
Causeway Embankment	3+650	3+762	112	3.5	6Ta45	1.54	2.14	Zone C	-1.36
Pill River Bridge Crossing-1	3+762	3+812	50	1.94	6Ta45	1.54	2.14	Zone B (1%AEP + 400mm freeboard)	-0.11
Kilcrea Land	3+812	4+000	188	1.6	6Ta45	1.54	2.14	Zone B	-0.06
Kilcrea Land	4+000	4+330	330	1.6	6Ta450	1.55	2.17	Zone B	-0.05
Kilcrea Land	4+330	4+572	242	1.57	6Ta766	1.55	2.19	Zone B (Defended)	-0.02
Pill River Bridge Crossing-2	4+572	4+586	14	1.94	6Ta766	1.55	2.19	Zone B (1%AEP + 390mm freeboard)	-0.01
Kilcrea Land	4+586	4+800	214	1.6	6Ta766	1.55	2.19	Zone B	-0.05
Kilcrea Land	4+800	5+150	350	2	6Ta1175	1.78	2.63	Zone B	-0.22
Newbridge Demesne	5+150	5+600	450	3.05	6Ta1672	2.24	2.88	Zone C Including existing bridge crossing at 5+100	-0.81
Newbridge Demesne	5+600	6+066	466	3.14	6Ta2003	2.48	3.02	Zone C	-0.12
** (+) indicates that flood level is above the proposed finish level, (-) is below									

Table 9 Summary of percentage of the scheme in each Flood Risk Zones

Flood Risk Zone	Length	% from Total Length	Remarks
Zone A	850	14.01%	Justification Test required
Zone B	1815	29.89%	Appropriate for development
Zone C	3403	56.10%	Appropriate for development

4.3 Summary of Flood Risk Assessment for the Scheme

Findings from table 7 which gives the Coastal flooding impact on the scheme can be summarized as follows:

- It is noted that for both events (0.5% and 0.1% AEP), flood levels of FEM-FRAMS nodes are lower than the single node (EN_16) shown in ICPSS.
- The part of the Greenway runs on Bissets Strand and the Weir Maintenance Track (W.M.T) are in Flood Zone A.
- Maximum flood level of 1% AEP is 1.26 m above the proposed ground levels in Bissets Strand and 1.41 m above the Weir Maintenance Track section.
- no impact of flooding on the proposed pedestrian/cycleway bridge as the proposed deck level is above the flood level at least by 300mm (see figure 13)
- Approximately 895 m length of the proposed Greenway that runs in the causeway embankment (from 2+330 to 3+225) is laid on Flood Zone C which is above the flooding level 0.1%AEP.
- Approximately 425 m length of the proposed Greenway that runs in the causeway embankment (from 3+225 to 3+650) to be laid within Flood Zone B which is above the flooding level 1% AEP but below 0.1% AEP.

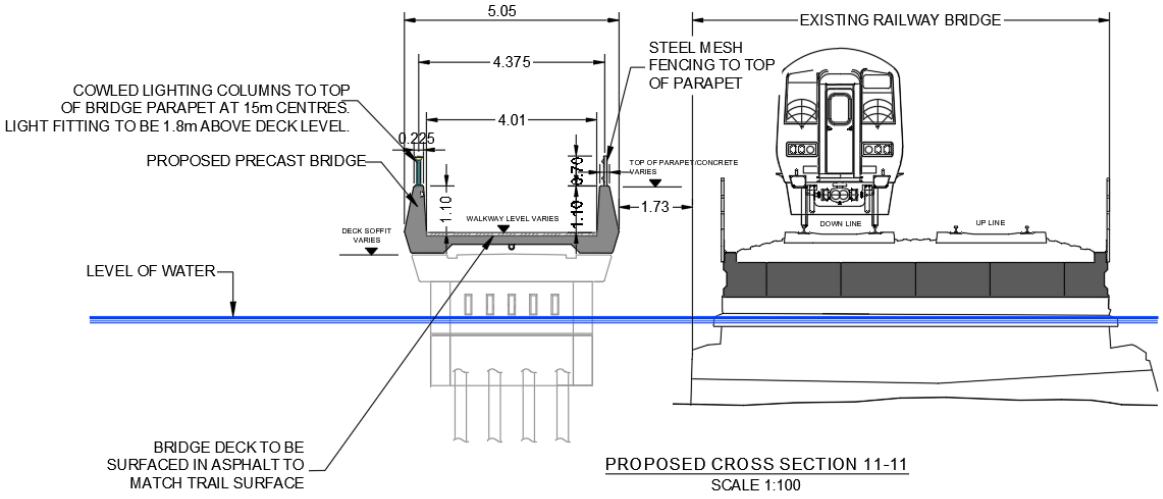


Figure 14 Cross section showing pedestrian/cycleway bridge details

Findings from table 8 which gives the fluvial flooding impact on the scheme can be summarized as follows:

- There are two proposed pedestrian/cycling bridges as part of the scheme at chainage 3+762 and 4+572. These bridges will be in Zone B with at least 390mm freeboard maintained (see Figure 14). The bridges will further be assessed in the context of OPW Section-50 Application.
- The Northern section of the causeway embankment will be located at least 1.36m above the medium flood level (0.1% AEP) in Zone C.
- The entire length of the Greenway between Pill River Bridge (at 3+762) and Newbridge Demesne will be within Zone B.
- The part of the scheme that runs through Newbridge Demesne will be in Zone C.

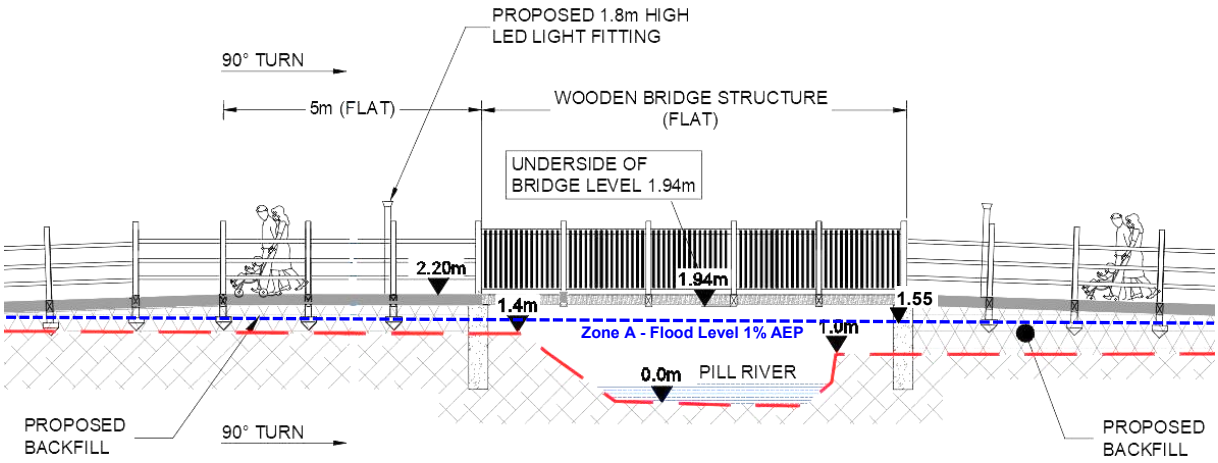


Figure 15 Proposed bridge section at chainage 4+472 (Pill River Bridge Crossing-2)

4.4 Justification Test

In order to assess the appropriateness of such development, Section 5 of the OPW Guidelines outlines the criteria for Justification Test for Development Management in areas at high or risk of flooding that include types of development that are less vulnerable to flooding.

As noted in Table 9, only 14.01 % of the total length of the proposed scheme is located within Flood Zones A which are at high risk of flooding. As noted in Section 4.1 the scheme is classified as less vulnerable, accordingly, the Justification Test for length of the scheme that will be subject to flooding of the 1% AEP in Zone A has been carried out. The Justification Test and the assessment are outlined in Table 10.

Table 10 Justification Test Criteria– Assessment

Ref	OPW Criteria	CSEA Assessment
1	The subject lands have been zoned or otherwise designated for the particular use or form of development in an operative development plan, which has been adopted or varied taking account of these Guidelines.	The scheme is located within lands of 3 main zoning objectives as per Fingal Development Plan (2017 – 2023); Refer to Sheet No.7 and Sheet No.9: • Protect and enhance high amenity areas • To Preserve Views • Cycle/Pedestrian routes Hence, the subject lands of the scheme meet the operative developments plans of FCC.
2	The proposal has been subject to an appropriate flood risk assessment that demonstrates:	
2(i)	The development proposed will not increase flood risk elsewhere and, if practicable, will reduce overall flood risk	• The proposed ground surface for the entire Greenway will be hardstanding. It is estimated that for every 100m length of the Greenway will generate approximately 1.2 l/s/100m of surface water in 1% AEP. The surface water will be drained via free flow to the sides of the Greenway where verge and open space areas exist/ proposed. • The scheme will not result in significant alterations to existing ground levels.
2(ii)	The development proposal includes measures to minimise flood risk to people, property, the economy and the environment as far as reasonably possible.	• The proposed Greenway route runs through either coastal or open space areas. The estimated development runoff as result of the scheme is very low and will be drained to the adjacent verged sites (as discussed in criteria 2(i)). • During the 0.5% AEP flood event, the scheme will only be flooded in a continuous length at Bissets Strand and along the weir maintenance track. During these events, the Greenway will be closed and there will be no possibility of people being cut off from returning to their original starting point.
2(iii)	The development proposed includes measures to ensure that residual risks to the area and/or development can be managed to an acceptable level as regards the adequacy of existing flood protection measures or the design, implementation and funding of any future flood risk management measures and provisions for emergency services access	• Weir Maintenance Track section of the proposed greenway will be subject to flooding during 0.5% AEP coastal flooding event. The flooding will be minor in nature but will result in the closing of the greenway at these times. Installing flood defences as part of this project would be impractical because the extent of the defences would have to encompass the entire Malahide Estuary to be effective. • Bissets Strand Road and the surrounding areas would also be flooded during the 0.5% AEP coastal flooding event and access from the Malahide side will be not possible at these times. • Provisions for public awareness and early flood warning are provided by FCC to the best practices.
2(iv)	The development proposed addresses the above in a manner that is also compatible with the achievement of wider planning objectives in relation to development of good urban design and vibrant and active streetscapes.	As assessed in criteria (1) above, the scheme is compatible with wider plans.

5 Conclusion

The Broadmeadow Way is proposed to be a high-quality greenway linking Malahide Demesne and Newbridge Demesne and will be used by locals, visitors and commuters at all times of the year. Much of the routing of the greenway is in place and follows existing pathways and roads. The principal new construction elements include utilisation of the western embankment of the railway causeway and a hard surfaced Greenway through the Kilcrea agricultural lands. The Greenway will have a designed lighting system which will allow for usage at night with minimal effect on the local wildlife.

The flood assessment report, and the design of the levels for the proposed greenway, are such that the majority of the length greenway are in Flood Risk Zone B and Zone C as indicated in the previous sections of the report and will therefore be usable at all times up to the .1% AEP. The area adjacent to Bissets Strand and along the weir maintenance track, as far as the new pedestrian bridge, are subject to flooding in the 1% AEP. Unfortunately, because of the local topography, it is impossible to design a flood protection system that would allow for this area to be protected during these events. The OPW has proposed to design and install a flood protection system to protect Malahide Village during these events. Two proposals have been made. One proposal is to install a demountable barrier at Bissets Strand Bridge. This will help to protect Malahide Village but will not have any effect on potential flooding in Bissets Strand Road. A second proposal is to install a demountable flood barrier along the Estuary boundary. This formal flood protection will prevent flooding on Bissets Strand Road and Malahide Village. Neither of these proposals have been time-scaled to date, but if implemented will only help to improve the situation.

FCC as part of its adverse weather emergency preparation has in place arrangements to receive early weather warnings from Met Eireann and put in place controls to mitigate hazards when operating during adverse / inclement weather. These controls consist of a major emergency plan; a severe weather plan; flood emergency response plan; risk assessment for working in adverse / inclement weather; and winter service plans. Risk assessment registers are contained in the relevant ancillary safety statement. During any of these emergency FCC will take a view on the possible closure of the Greenway to insure the safety of potential users of the Greenway. Because the potential flood risk is restricted to one area only, there is no possibility of users being marooned at any stage during a flood event. Users will always have the potential to return to their starting point.

As noted above the Greenway will be used by locals, visitors and commuters and therefore we expect the Greenway to have a high level of usage on a regular basis at all times of the year. However, we are of the opinion that flooding in the 1% AEP will be managed by Fingal County Council to ensure the safety of the public, that there will be significant weather and flood alerts during any potential flood event and that therefore there will be no potential of any risk to users of the Greenway during these 1 in a 100 year event.

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Appendix 18

Risk of Major Accidents and/or Disasters Report

Introduction

This assessment considers the likely significant adverse effects on the environment arising from the vulnerability of the proposed development to risks of major accidents and/or natural disasters.

The revised EIA Directive 2014/52/EU (new EIA Directive) entered into force on 16th May 2017 and states the need to assess "the expected significant adverse effects of the project on the environment deriving from the vulnerability of the project to risks of major accidents and/or natural disasters which are relevant to the project concerned".

The underlying objective of the assessment is to ensure that appropriate precautionary actions are taken for those projects which "because of their vulnerability to major accidents and/or natural disasters, are likely to have significant adverse effects on the environment".

Based on the requirements of the new EIA Directive, this assessment answers the following questions:

- What major accidents and/or natural disasters could the proposed development be vulnerable to?
- Could these major accidents and/or natural disasters result in likely significant adverse environmental effect(s) and, if so, what would these be?
- What measures are in place, or need to be in place, to prevent or mitigate the likely significant adverse effects of such events on the environment?

Assessment Methodology

The starting point for the scope and methodology of this assessment is that the proposed development will be designed, built and operated in line with best international current practice and, as such, major accidents will be very unlikely.

The following sections set out the requirements as stated in the new EIA Directive and in the EPA draft *Guidelines on the information to be contained in Environmental Impact Assessment Reports (EIAR)*. The scope and methodology presented is based on the new EIA Directive, the draft EPA guidelines, on other published risk assessment, and on professional judgement.

A risk analysis based methodology, which covers the identification, likelihood and consequence of major accidents and/or natural disasters, has been used for the assessment.

The sections below provide further detail on this approach.

Major accidents or natural disasters are hazards which have the potential to affect the proposed development. The assessment of the risk of major accident and/or disaster has considered all factors defined in the new EIA Directive, i.e. population and human health, biodiversity, land, soil, water, air and climate, material assets, cultural heritage, and the landscape.

Legal and Regulatory Framework

The following paragraphs set out the requirements of the new EIA Directive (2014/52/EU) in relation to major accidents and/or natural disasters.

Recital 15 of the new EIA Directive states that:

> *(15) In order to ensure a high level of protection of the environment, precautionary actions need to be taken for certain projects which, because of their vulnerability to major accidents, and/or natural disasters (such as flooding, sea level rise, or earthquakes) are likely to have significant adverse effects on the environment. For such projects, it is important to consider their vulnerability (exposure and resilience) to major accidents and/or disasters, the risk of those accidents and/or disasters occurring and the implications for the likelihood of significant adverse effects on the environment. In order to avoid duplications, it should be possible to use any relevant information available and obtained through risk assessments carried out pursuant to Union legislation, such as Directive 2012/18/EU of the European Parliament and the Council[1] and Council Directive 2009/71/Euratom[2], or through relevant assessments carried out pursuant to national legislation provided that the requirements of this Directive are met.*

It is clear from the directive that a major accident and/or natural disaster assessment should be mainly applied to Control of Major Accident Hazards (COMAH) sites or nuclear installations.

However, this assessment is carried out for completeness.

Article 3 of the new EIA Directive requires that the EIA shall identify, describe and assess in the appropriate manner, the direct and indirect significant effects on population and human health, biodiversity, land, soil, water, air and climate, material assets, cultural heritage and landscape deriving from (amongst other things) the "vulnerability of the project to risks of major accidents and/or disasters that are relevant to the project concerned".

Annex IV of the new EIA Directive: The information relevant to major accidents and/or disasters to be included in the EIA Report is set out in Section 8 of Annex IV of the new EIA Directive as follows:

> *(8) A description of the expected significant adverse effects of the project on the environment deriving from the vulnerability of the project to risks of major accidents and/or disasters which are relevant to the project concerned. Relevant information available and obtained through risk assessments pursuant to Union legislation such as Directive 2012/18/EU of the*

[1] Directive 2012/18/EU of the European Parliament and the Council of 4 July 2012 on the control of major-accident hazards involving dangerous substances, amending and subsequently repealing Council Directive 96/82/EC (OJ L 197, 24.7.2012, p. 1).

[2] Council Directive 2009/71/Euratom of 25 June 2009 establishing a Community framework for the nuclear safety of nuclear installations (OJ L 172, 2.7.2009, p. 18).

> *European Parliament and of the Council or Council Directive 2009/71/Euratom or relevant assessments carried out pursuant to national legislation may be used for this purpose provided that the requirements of this Directive are met. Where appropriate, this description should include measures envisaged to prevent or mitigate the significant adverse effects of such events on the environment and details of the preparedness for and proposed response to such emergencies.*

EPA Draft Guidelines 2017

The 2017 EPA *Draft Guidelines on the Information to be Contained in an EIAR* refer to major accidents and/or disasters in a number of sections:

- Characteristics of the Project: The draft guidelines state that the project characteristics should include "a description of the Risk of Accidents – having regard to substances or technologies used."
- Impact Assessment: The draft guidelines state that the impact assessment should include "the risks to human health, cultural heritage or the environment (for example due to accidents or disasters)."
- Likelihood of Impacts: The draft guidelines state the following:

> *"To address unforeseen or unplanned effects the Directive further requires that the EIAR takes account of the vulnerability of the project to risk of major accidents and/or disasters relevant to the project concerned and that the EIAR therefore explicitly addresses this issue. The extent to which the effects of major accidents and/or disasters are examined in the EIAR should be guided by an assessment of the likelihood of their occurrence (risk). This may be supported by general risk assessment methods or by systematic risk assessments required under other regulations, e.g. a COMAH (Control of Major Accident Hazards involving Dangerous Substances) assessment."*

EPA Guidelines on Assessing and Costing Environmental Liabilities

The approach used in this assessment is derived from the EPA's Guidance Document *Guidance on Assessing and Costing Environmental Liabilities 2014*. This guidance presents a systematic approach for assessing and costing environmental liabilities associated with:

- Closure and restoration/aftercare; and
- Incidents.

Current Practice

As discussed above, the starting point for the scope and methodology of this assessment is that the proposed development will be designed, built and operated in line with best international current practice and, as such, major accidents will be very unlikely.

Current EIA practice already includes an assessment of some accidents and disasters such as pollution incidents to ground and watercourses as well as assessment of flooding events. Refer to the relevant sections of the EIAR such as Chapter 3–Construction Environmental Management Plan (CEMP) and Chapter 8–Water.

Site Specific Risk Assessment Methodology

The site specific risk assessment identifies and quantifies risks due to the proposed development focusing on unplanned, but possible and plausible, events occurring during the construction and operational phases. This approach is derived from EPA's guidance document *Guidance on Assessing and Costing Environmental Liabilities 2014*.

The impact ratings are taken from the *Guide to Risk Assessment in Major Emergency Management* (Department of the Environment, Heritage & Local Government, 2010), and are outlined in Table 1 and Table 2 below.

Risk Identification, Likelihood and Consequence

The following steps were undertaken as part of the preparation of the site specific risk assessment:

- Risk identification;
- Risk classification, likelihood and consequence;
- Risk evaluation.

Risk Identification

Risks were reviewed through the identification of plausible risks in consultation with relevant specialists, focusing on abnormal but plausible incidents that may occur on the proposed Broadmeadow Way.

Risk Classification – Likelihood

Having identified the potential risk, the likelihood of its occurrence is assessed.

An analysis of existing safety procedures and proposed environmental controls was considered when estimating likelihood of identified potential risks occurring.

Table 1 defines the likelihood ratings. The impact ratings are taken from the *Guide to Risk Assessment in Major Emergency Management* (Department of the Environment, Heritage & Local Government, 2010).

Table 1. Definition of Likelihood Ratings.

Ranking	Category	Description
1	Extremely Unlikely	May occur only in exceptional circumstances; once every 500 or more years.
2	Very Unlikely	Is not expected to occur; and/or no recorded incidents or anecdotal evidence; and/or very few incidents in associated organisations, facilities or communicates; and/or little opportunity, reason or means to occur; may occur once every 100-500 years.
3	Unlikely	May occur at some time; and/or few, infrequent, random recorded incidents or little anecdotal evidence; some incidents in associated or comparable organisations worldwide; some opportunity, reason or means to occur; may occur once per 10-100 years.
4	Likely	Likely to or may occur; regular recorded incidents and strong anecdotal evidence and will probably occur once per 1-10 years.
5	Very Likely	Very likely to occur; high level of recorded incidents and/or strong anecdotal evidence. Will probably occur more than once a year.

Risk Classification – Consequence

The consequence of the impact if the event occurs is assigned as per Table 2.

It should be noted that when categorising the consequence rating, the rating assigned assumes that all proposed mitigation measures and safety procedures have failed to prevent the major accident and/or disaster.

In addition, Fingal County Council have in place a 'Major Emergency Plan' which, if implemented as intended, will work to reduce the effect of any major accident or disaster.

As outlined, the impact ratings are taken from the *Guide to Risk Assessment in Major Emergency Management* (Department of the Environment, Heritage & Local Government, 2010).

Table 2. Risk Classification Table – Consequences.

Ranking	Classification	Impact	Description
1	Minor	Life, Health, Welfare Environment Infrastructure Social	Small number of people affected; no fatalities and small number of minor injuries with first aid treatment. No contamination, localised effects. <0.5M Euros. Minor localised disruption to community services or infrastructure (<6 hours).
2	Limited	Life, Health, Welfare Environment Infrastructure Social	Single fatality; limited number of people affected; a few serious injuries with hospitalisation and medical treatment required. Localised displacement of a small number of people for 6-24 hours. Personal support satisfied through local arrangements. Simple contamination, localised effects of short duration. 0.5-3M Euros. Normal community functioning with some inconvenience.
3	Serious	Life, Health, Welfare Environment Infrastructure Social	Significant number of people in affected area impacted with multiple fatalities (<5), multiple serious or extensive injuries (20), significant hospitalisation. Large number of people displaced for 6- 24 hours or possibly beyond; up to 500 evacuated. External resources required for personal support. Simple contamination, widespread effects or extended duration. 3-10M Euros. Community only partially functioning, some services available.
4	Very Serious	Life, Health, Welfare Environment Infrastructure Social	5 to 50 fatalities, up to 100 serious injuries, up to 2000 evacuated. Heavy contamination, localised effects or extended duration. 10-25M Euros. Community functioning poorly, minimal services available.

Ranking	Classification	Impact	Description
5	Catastrophic	Life, Health, Welfare Environment Infrastructure Social	Large numbers of people impacted with significant numbers of fatalities (>50), injuries in the hundreds, more than 2000 evacuated. Very heavy contamination, widespread effects of extended duration. >25M Euros. Serious damage to infrastructure causing significant disruption to, or loss of, key services for prolonged period. Community unable to function without significant support.

Risk Evaluation

The likelihood and consequence ratings are multiplied to form a risk score for risk evaluation.

A risk matrix outlined in Table 3 provides a broad indication of the critical nature of each risk. This risk matrix will then be applied to the risk evaluation.

The risk matrix is colour coded to provide a broad indication of the critical nature of each risk. The red zone represents 'high risk' scenarios', the amber zone represents 'medium risk scenarios' and the green zone represents 'low risk scenarios.'

Table 3

Likelihood Rating							
	Very Likely	**5**					
	Likely	**4**					
	Unlikely	**3**					
	Very Unlikely	**2**					
	Extremely Unlikely	**1**					
			Minor	**Limited**	**Serious**	**Very Serious**	**Catastrophic**
			1	**2**	**3**	**4**	**5**
			Consequence Rating				

The Proposed Development

Construction Phase

The construction of the proposed Broadmeadow Way will be in two stages:

1) The construction of the bridge and abutments across the Malahide Estuary.
2) The construction of the remainder of the project.

The Construction and Environmental Management Plan (refer to EIAR Volume 2, Chapter 3, Section 3.13) outlines the site safety procedures that will be implemented during the construction phase. The effective implementation of the CEMP will reduce the potential risks associated with the construction phase of the project.

The project involves the following:

- Use of c. 900m of existing pathways within Malahide Demesne, extending from the main car park located southeast of Malahide Castle to the Hogan's Gate entrance on the R106, Dublin Road, including new route signage and bicycle parking facilities.

- Approximately 140m of new footpath construction at Bridgefield car park and new ramp/access upgrade works at the existing pedestrian entrance leading to the R106 Dublin Road.
- Reconfiguration of c. 220m of the R106 Dublin Road between Bridgefield car park and O'Hanlon's Lane to facilitate the provision a new off-road shared pedestrian and cyclist facility along the northern side of the road, and a new signal controlled crossing.
- Approximately 135m of road resurfacing, 230m of shared surface road markings, signage and boundary hedge trimming along O'Hanlon's Lane.
- The reconfiguration of the junction of Bissets Strand and O'Hanlon's Lane.
- Two signal controlled crossings and new traffic signals at the railway bridge on Bissets Strand.
- The construction of approximately 260m of off-road shared pedestrian and cyclist facilities and associated landscaping and ancillary works on Bissets Strand.
- Works to facilitate a new greenway some 615m in length along the existing weir maintenance access track on the western embankment of the Dublin-Belfast railway causeway, extending north from Bissets Strand into Malahide Estuary, to include new surfacing, fencing, boundary walls, local stone fill, route lighting and signage, and a viewing area.
- Provision of a new 12-span pedestrian/cycleway bridge deck of approximately 180m in length on the existing piers located alongside the Dublin-Belfast railway bridge situated on the weir in Malahide Estuary.
- Works to facilitate a new greenway of approximately 1,000m in length along the shoulder of the western embankment of the Dublin-Belfast railway causeway, from the railway bridge on the weir in Malahide Estuary extending as far as the northern shoreline of Malahide Estuary at Kilcrea, to include new surfacing, fencing, boundary walls, local stone fill, route lighting and signage.
- Provision of c. 910m of new greenway along the western side of the Dublin-Belfast railway through agricultural lands in Kilcrea on the north side of the estuary, between the northern shore of Malahide Estuary and the L-6165-0 Coast Road/Corballis Road, with works to include new surfacing, fencing, route lighting and signage, and a new three span bridge over the Pill River of 50m in length constructed in timber and concrete.
- Provision of c. 230m of new greenway along the southern side of the L-6165-0 Coast Road/Corballis Road, Kilcrea to include to include surfacing, fencing, route lighting and signage.
- Upgrading and re-alignment along c.450m of the L-6165-0 Coast Road/Corballis Road adjacent to the Dublin-Belfast railway bridge, including the installation of signal-controlled pedestrian and cyclist crossing points.
- Provision of c. 370m of new greenway, including a single span (12m) bridge crossing, constructed in concrete and timber, of the Pill River through agricultural lands in Kilcrea and along the southern bank of the Pill River.
- Crossing of the newly constructed Donabate Distributor Road and the pedestrian lights for same.
- Resurfacing works along c. 140m of the existing L-6135-0 Kilcrea Road north to the R126 Hearse Road.
- Reconfiguration of the junction of the L-6135-0 Kilcrea Lane and the R126 Hearse Road to facilitate pedestrian and cyclist access to Newbridge Demesne.

- Use of approximately c. 900m of existing pathways including new route signage and bicycle parking at Newbridge Demesne.
- Ancillary works along the route including drainage works, provision of fencing, boundary treatments, agricultural accesses, noise barrier (close to the Donabate Distributor Road), public lighting, landscaping and other minor works.

Predictive Impacts – Risk of Major Accidents

Impact Assessment

A risk register has been developed which contains the initial list of major accidents and emergencies identified with the operation of the Broadmeadow Way. This is presented in Table 4.

Table 4. Risk Register.

Risk ID	Event	Possible Cause
1	Severe Weather - Storms	Winter storms exacerbated by global warming.
2	Severe Weather – Extreme temperature	Summer weather exacerbated by global warming.
3	Floods	Winter storms exacerbated by global warming.
4	Storm surges	Winter storms with high tides and potential storm surges.
5	Train derailments	Possible train derailment along the Dublin/Belfast line adjacent to the greenway along the Malahide Estuary and the Kilcrea Lands.
6	Collapse/Damage to structures	Possible collapse of the footbridge.
7	Urban Fires	Caused by accident or deliberate act.
8	Terrorist Incidents	Deliberate collision – act of terrorism.
9	Major Road traffic accident on the Dublin Road/ Corballis Cottages Road.	Accidental collision.
10	Risk of injury or health problems for pedestrians	Heart attack/stroke or a fall on rocks or bicycle collisions.
11	Pedestrian/cyclist collision	Improper use/ non-use of cycle track by cyclists along the route.
12	Crime risk	Robbery or assault.

These risks were assessed against the risk classification tables provided and the resulting risk analysis is given in Table 5. The risk register is based upon possible risks associated with the proposed development.

Table 5. Risk Analysis.

Risk ID	Potential Risk	Possible Cause	Environmental Effect	Rating	Basis	Consequence Rating	Basis	Risk Score
1	Safety of greenway users	Severe weather: Storms; High winds/rain	Injury or loss of life	4	The section of greenway across the Malahide Estuary is very open and would be potentially unsafe to users during time of heavy winds. The proposal is for the wall to be constructed at 1400m high as recommended for bridge parapets to mitigate any potential problems.	2	Number of people potentially involved would be low and the correct mitigation measures will be installed.	8
2	Safety of greenway users	Severe Weather: High temperatures	Injury/loss of mobility especially in the very young and the elderly.	4	Possibility of high temperatures during hot summer months.	1	Number of people potentially involved would be low.	4
3	Safety of users	Floods: Possibility of heavy rain and flooding taking into account climate change	Injury or loss of life	4	The area has been the subject of minor flooding in previous flood events.	2	Number of people potentially involved would be low.	8
4	Safety of users	Storm Surges: Possibility of high tides and storm surges taking into account climate change.	Injury or loss of life	4	The area has been subject to flooding because of high tides and storm surges in the past.	1	The public area of the greenway has been designed to be above the potential flood level in all areas except Bissets Strand. This area will be closed in times of potential flooding.	4

Risk ID	Potential Risk	Possible Cause	Environmental Effect	Rating	Basis	Consequence Rating	Basis	Risk Score
5	Safety of users adjacent to the railway line	Derailment of a train	Injury and loss of life	2	Commission of Railway Regulation report, 'Railway Safety Performance in Ireland', Dec. 2016 states that there are favourable comparisons evident with all other major railways in the EU, in regard to the Irish Rail record.	5	Derailment could be potentially a catastrophic occurrence.	10
6	Safety of users of the greenway and of the railway	Collapse/Damage to Structures	Injury and loss of life	2	Iarnród Éireann has systems in place to monitor the stability of all bridge piers to minimise the potential of undercutting of the supports for bridges.	5	Bridge failure could be potentially a catastrophic occurrence.	10
7	Safety of users	Urban Fires: Fires in the Malahide area or fires in the Kilcrea area during summer droughts.	Injury from smoke inhalation or burns from fires	2	Potential of fires in Malahide area are limited and the Kilcrea lands are arable lands and would not be likely to burn during a drought.	1	Small numbers may be affected by localised fires.	2
8	Safety of users and the general public	Urban terrorist actions	Injury and loss of life	1	Unlikely that terrorists would target this area.	3	Significant numbers could be affected in the event of a terrorist attack.	3
9 & 11	Safety of greenway users and the general public	High speeds Driver error; Pedestrian/cyclist error	Injury and loss of life	2	Traffic management measures such as speed restrictions and traffic controls will reduce the possibility of serious traffic collisions.	3	Serious injury or loss of life could occur.	6

Risk ID	Potential Risk	Possible Cause	Environmental Effect	Rating	Basis	Consequence Rating	Basis	Risk Score
10	Safety of users	Accidental fall or health problem	Injury and loss of life	5	The greenway is designed to be used by all.	2	Single fatality occurrence most likely, mitigated by the access along the greenway to the most isolated areas from Bissets Strand and the Corballis Cottages Road by ambulance/fire brigade.	10
12	Safety of users	Crime Risk: Robbery or assault	Injury, trauma or loss if life	3	Access to the greenway is open to all and may be used by anti-social elements	2	Crime rates are generally high in urban centres but this area is a very settled suburban area with a low crime rate. Lighting along the greenway will minimise the potential use by anti-social elements during the hours of darkness.	6

The risk evaluation provided above is summarised in Table 6 below in order of risk.

Table 6. Risk Evaluation Summary.

Risk ID	Potential Risk	Likelihood Rating	Consequence Rating	Risk Score
5	Derailment of train	2	5	10
6	Collapse of bridge	2	5	10
10	Risk of injury or health problems for pedestrians	5	2	10
1	High winds/rain	4	2	8
3	Possibility of heavy rain and flooding taking into account climate change	4	2	8
9 & 11	High speeds driver error; pedestrian/cyclist error	2	3	6
12	Robbery or assault	3	2	6
2	High temperatures	4	1	4
4	Possibility of high tides and storm surges taking into account climate change.	4	1	4
8	Urban terrorist actions	1	3	3
7	Fires in the Malahide area or fires in the Kilcrea area during summer droughts	2	1	2

From examining the plausible risks presented in Table 6 above the scenario with the highest risks in terms of a major accident are Risk ID numbers 5, 6, 10, 1 and 3.

Risk of Train Derailment (Risk ID 5)

The Broadmeadow Way will be immediately adjacent to the Belfast railway line over a distance of approximately 1.8km, extending from Bissets Strand to the northern shoreline of the Estuary. A 2.4m high palisade fence will separate the two. Trains travel at speeds up to 90mph over this length. The line is perfectly straight from Malahide Station to Donabate Station. There is a facing points cross-over just north of Bissets Strand road bridge (UBB29).

Consideration must be given to the possibility of a train derailment anywhere along the entire interface between Broadmeadow Way and the railway. Derailments can occur for a number of reasons: infrastructure defects, including rail-breaks, loss of ballast, temperature effects, etc; mechanical defects on a passenger or freight train; operational reasons, including running through a set of points, speeding, etc; or due to external factors, including vandalism, a vehicle coming on to the railway at a level crossing, including an agricultural use crossing, and fouling the line, etc.

Mitigation Measures

Irish Rail has a safety management system in place to ensure that all risks throughout the entire railway operations are assessed, mitigated and effectively managed. Frequent audits are carried out to ensure that the system is effective and robust. To that end, each element of the railway infrastructure (including track, bridges, coastal protection, etc) and the rolling stock (including carriages, wagons, bogies, etc) is frequently inspected and rail operations are monitored on an ongoing basis.

Risk of Collapse of the Footbridge (Risk ID 6)

A single pier and two adjacent spans on the railway viaduct collapsed in August 2009. In the subsequent reconstruction works, the weir, on which the bridge and its piers are supported, was

significantly strengthened both to the east and west of the bridge. The piers were further strengthened by the addition of micro piles at each pier and abutment.

Mitigation Measures

The foundations to the proposed new footbridge were constructed in conjunction with the weir strengthening works. The piers and abutments are supported on piled foundation, the piles have been driven through the weir, down to rock level. As a further precaution the piles have been designed to withstand a possible scour of 3.0m.

The condition of the railway viaduct and the weir is monitored in accordance with the technical standards of the Chief Civil Engineer Irish Rail, specifically CCE-TMS-415 *Flood and Scour Management Standard*, CCE-TMS-408 *Technical Standards for Structural Inspections*, and CCE-STR-PSD-007 *Management of Scour at Bridges*.

Risk of Injury or Health Problems for Pedestrians (Risk ID 10)

Because of the isolated nature of a large section of the greenway, from Bissets Strand along the causeway through Kilcrea and onto Hearse Road, there is always the potential of an accident or health emergency at any time in an isolated area of the greenway. The greenway is designed to allow for ambulance and fire brigade access from Bissets Strand, from Corballis Cottages and from the completed Donabate Distributor Road. This access will allow for access to any area of the greenway in an emergency. All other areas on the greenway are fully accessible.

Mitigation Measures

The isolated area of the greenway in Kilcrea or along the causeway can be accessed from Bissets Strand beside the landscaped area, from Corballis Cottages Road and from the Donabate Distributor Road. Both An Garda Síochána and the Fire Brigade will be informed of the access to the site and will be given access through any vehicle restrictors at both ends of the greenway. An emergency procedure will be in place, as part of Fingal County Council's emergency action plan, to ensure all parties are aware of their individual responsibilities in the case of an accident. These procedures will form part of the detailed design of the greenway and will be part of the safety file on completion of the scheme.

Possibility of High Winds/Rain or Heavy Rain and Flooding (Risk ID 1 and ID 3)

The potential of risk in times of heavy rain and/or flooding will also form part of Fingal County Council's emergency action plan and procedures will be in place for all eventualities. The greenway is designed to allow for ambulance and fire brigade access from Bissets Strand, from Corballis Cottages, and from the completed Donabate Distributor Road. This access will allow for access to any area of the greenway in an emergency. All other areas on the greenway are fully accessible.

Mitigation Measures

The parapet along the causeway will be 1.4m high which is a safe parapet height for cyclists and will protect all users in times of heavy wind. The elevation of the proposed greenway is above the 1 in 100 year flood level except at Bissets Strand. Bissets Strand will flood in times of high tides/storm surges but the design of the greenway will be that nobody can be cut off from a safe evacuation route at any time.

Residual Impacts

While the likelihood of recurrence of the above risks are high on a year by year basis, Fingal County Council, An Garda Síochána and the Fire Brigade will have the procedures in place to mitigate any residual impacts caused by flooding accidents or high winds including the possibility of closing the more exposed areas of the greenway during dangerous periods. The robust design of the greenway will minimise any long term damage from a large flooding incident in any area of the greenway.

References

Guidance on Assessing and Costing Environmental Liabilities (Environmental Protection Agency, 2014).

A Framework for Major Emergency Management (Department of Environment, Heritage and Local Government, 2010).

Railway Safety Performance in Ireland (Commission for Railway Regulation, 2016).

Sustrans Design Manual Chapter 8.

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