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APPENDIX 4

Report on Site Investigation for Proposed Knock/Claremorris By-pass

Report 2402

KNOCK -
CLAREMORRIS

MAYO COUNTY COUNCIL

CONTENTS

APPENDICES

REPORT ON A SITE INVESTIGATION

FOR PROPOSED KNOCK\CLAREMORRIS BY-PASS

FOR MAYO COUNTY COUNCIL

Report No.2402 **January 1994**

1.INTRODUCTION

A new by-pass road is to be constructed by Mayo County Council from Claremorris to Knock .

An investigation of sub-soil conditions has been carried out by IGSL on the instructions of Mayo County Council .

The investigation consisted of conventional cable-tool borehole drilling with in-situ testing and sampling at specified chainages along the route . Where rock was encountered (relevent to the development) it was diamond drilled and core was recovered to establish rock type , RQD etc.

The field operations were followed by a programme of laboratory tests to establish soil classification , grading characteristics , CBR and strength where relevant .

This report details the findings of the investigation and discusses the findings for each section of the route examined .

II.FIELDWORK

(a) Boreholes : Conventional cable-tool boreholes (200mm) were sunk using a Pilcon Wayfarer Rig in locations set out on site by Mayo County Council and shown on the drawing enclosed with this report .

A total of 22 locations were examined involving 25 boreholes .

Descriptions and depths of the strata encountered are given in the detailed boring records enclosed in Appendix I to this report . These records also give details of samples taken and in-situ tests carried out as well as comment on ground water conditions pertaining at the time of the investigation .

(b) Cored Holes : An Edeco Strata drilling rig , equipped with NQ wireline equipment , permitting recovery of 50mm rock core , was used to recover core at a total of 6 locations .

Core was returned to the IGSL laboratory and was accurately logged by our geotechnical engineer . Full details of rock type , weathering , discontinuities , RQD etc . are noted on the detailed core records enclosed in Appendix II .

III .TESTING

(a) In-Situ Penetration Tests : During the course of the investigation , standard in-situ penetration tests were carried out at intervals in each borehole to establish relative soil strength . The N values recorded are noted in the right hand column of the boring records and will be discussed in the following paragraphs .

(b) Laboratory : All soil samples have been returned to the laboratory for careful examination and testing has been carried out in accordance with the requirements of Mayo County Council .

Strength tests (Triaxial Compression Tests) have been performed on cohesive soils at structural locations while grading analyses have been carried out to assess particle size distribution . CBR tests have been carried out on selected samples to provide data for road pavement design .

Chemical analyses have also been carried out at structural locations to determine sulphate content and acidity relative to below ground concrete.

All laboratory data is enclosed in Appendix II to this report .

IV. DISCUSSION ON GROUND CONDITIONS RELATIVE TO FOUNDATION DESIGN

(a) Chainage 800 : Road Construction : At this location 1.70 metres of gravelly clay fill overlies soft peat to a depth of 3.60 metres . Gravelly clays and silts extend from 3.60 to 4.20 metres and overlie compact silty sandy gravel The borehole was terminated at 6.00 metres , probably on boulders .

A vane test in the peat gave a cohesion of 27KN\sq.m , the remoulded value of 20.7 KN\sq.m would suggest that the stratum is quite silty . The moisture content for the sample of peat at 2.50 metres was 193 percent .

For optimum road construction we would suggest the removal of the peat stratum and construction of the new road on the underlying sandy gravelly clays . An N value of 18 at 4.00 indicates an allowable bearing capacity of 150 KN\sq.m.

A grading analyses of the gravel base stratum shows well graded material in the sand gravel range . A CBR value of 11.3 percent has been obtained from a sample of gravel at 4.50 metres .

(b) Chainage 1250 - Bridge over Railway : Two holes were bored at this location . In borehole 1250R , 1.00 metres of filling overlies a 2.00 metres peat stratum . Coarse compact gravel was noted from 3.00 to 3.80 metres with Limestone rock found at 3.80 metres.

In Borehole 1250L , fill and peat again occurred to a depth of 1.40 metre, overlying a firm stiff gravelly clay . Gravel was noted from 2.70 to 3.70 metres with refusal (probably rock) at 3.70 metres .

Diamond drilling methods were used to recover NQ (50mm) core at both locations .

At 1250R good quality core was recovered from 3.70 metres below ground level to 7.00 metres , while at Borehole 1250L , solid rock core

was recovered from 4.90 to 6.70 metres . Some weathered rock was noted in Borehole 1250L above the solid horizon .

Laboratory testing at this location includes grading analyses of the gravel stratum and a remoulded triaxial test on the clay stratum . A chemical test on a water samples indicate low sulphate concentrations .

Foundations for the proposed structure should be taken below the upper fill and peat strata . At Borehole 1250R , the gravel stratum below the peat is very thin , with Limestone rock at 3.70 metres and the foundations at this location will obviously be taken to the rock .

To ensure uniformity of founding medium it will therefore be necessary to carry all structural loadings to the Limestone , where the allowable bearing capacity will easily exceed design requirements . (A safe bearing pressure in the strong Limestone of 1000KN/sq.m can be taken).

Some groundwater ingress can be expected from th gravel stratum in deep excavation and this should be borne in mind by the contractor .

Approach embankments , if placed at existing ground level , will obviously cause settlements in the peat stratum . To avoid differential settlements between the bridge structures and approach embankments we would advise the removal of the peat stratum . The gravels or gravelly clays below the peat will adequately support new embankment loading.

Chemical tests indicate that no special precautions need be taken to protect buried foundation concrete.

(c) Chainage 1875 - Bridge Structure :

The investigation has shown 0.80 metres of clayey fill overlying a stratum of grey-brown silty sandy gravelly clay (boulder clay). The clay is initially firm, but increases in strength to stiff, below a depth of 2.00 metres. The cable-tool borehole was terminated at 5.00 metres in the boulder clays.

Rotary core diamond drilling techniques were used to extend this borehole to a depth of 30 metres. Rock was not encountered within this range.

Some cutting is anticipated at this location. Tests in the gravelly clay below about 2.00 metres, indicate an allowable bearing pressure of

250 kN/m^2 for pad foundations. Because of the highly granular nature of the sub-soils and the preconsolidation of the glacial tills. settlements should be negligible under this load. As no groundwater was encountered to a depth of 5.00 metres, problems in this regard are not anticipated.

Should depth of cutting exceed the 5.0 metres achieved with the cable-tool boring equipment, we would suggest that a boring be carried out to determine soil type and strength to the appropriate depth.

A chemical analysis of the subsoil shows negligible sulphate concentrations and no problems are envisaged with deterioration of foundation concrete.

(d) Chainage 2400 - Road Construction :

Peat extends to 3.70 at this location overlying a soft white marl.

Compact fine to coarse sandy gravel lies below the soft upper soils from 4.90 to 5.70m. Groundwater was noted in association with the gravel stratum.

Vane tests carried out in the peat and marl indicate strengths of 22 and 13 kN/m^2 in the respective strata.

The moisture content of the peat determined in the laboratory was 236 per cent, while an index property test in the marl established high plasticity characteristics.

To avoid difficulties associated with settlements of new road construction on the peat, we would advise total removal of the very soft organic material and replacement by selected fill material. Coarse granular material should be placed at the base of the excavated area and graded towards 804 or similar closer to formation level.

(e) Chainage 3200 - Road Construction :

The records show gravelly clays from G.L. to 1.60m overlying a medium dense to dense gravel (1.60 - 3.70). Further deposits of stony clay (Boulder Clay) extended from 3.70 - 6.00m. Groundwater was noted at 1.60 in the gravel stratum.

A C.B.R. was carried out on the gravelly clay at 1.30 and a value of 3.7 per cent obtained.

No problems are anticipated with road construction in this vicinity. Embankments supported on the gravelly clay or gravel stratum should be stable.

(f) 3675 - Road : Construction :

Peat extends to a depth of 1.60m and overlies a medium dense to dense gravel. To avoid problems with settlement of road construction, removal of the peat stratum is recommended.

A grading analysis of the gravel confirms that it is clean and well-graded in the fine sand to coarse gravel range. A C.B.R. test on the gravel gave a value of 14.3 per cent.

(g) 4325 : Road Construction :

Topsoil and loose organic soil extends to 1.30, overlying a firm sandy or silty clay, extending to 4.10 metres where compact coarse gravels occur. The borehole was terminated at 6.50m in gravel, water was noted at 3.60 below ground level.

In-situ penetration tests in the silty clay stratum gave N-values of 8 and 14. indicating an allowable bearing pressure of 100 kN/m^2 which should be adequate for embankment support.

A CBR test carried out on the silty clay sample from 1.00m below ground gave a low result of 1.1 per cent. An index property test shows the clay to be of low plasticity. Groundwater should not present a problem at this location.

(h) Chainage 6200 - Road Construction :

Some topsoil with loose sandy clay was noted overlying a thin gravelly clay layer, with gravels noted from 1.60 to 3.50m. No free groundwater was encountered.

Assuming removal of the upper organic soils, construction of embankments on the underlying gravelly clay or gravel stratum should present no difficulties.

A high CBR value was obtained from the gravel stratum at 2.50m.

(i) Ch. 6950 - Road Construction :

An 0.90 stratum of silty clay overlies a stiff grey sandy gravelly clay. Boring was terminated at 3.60m in this stratum. No groundwater was observed.

A grading analysis was carried out on the gravelly clay, using wet sieve and hydrometer methods. The graph shows typical strength line grading for glacial tills.

No difficulties are envisaged, with road or embankment construction at this chainage, assuming that the upper organic material is removed.

(j) Ch. 7625 : Road Construction :

A surface 1.50 metres of soft mottled slightly organic grey-brown silt clay overlies grey sandy gravelly clay, in turn overlying a gravel stratum, proved from 2.20 to 3.70m. Groundwater was noted at 1.90m. Road construction should be kept above the water table, if possible. A CBR of 3.55 was obtained from the gravelly clay stratum.

(k) Chainage 8525 : Road Construction :

A brown silty clay extends to 1.70 and overlies a grey silty sandy gravelly clay. Boring was completed at 3.70m. No free water was encountered.

A CBR on the upper stratum of 2.6% was obtained while an improved CBR value of 4.45 was obtained from the more granular underlying material.

A grading analysis of the lower soil was also carried out and confirms the typical glacial till grading. No difficulties are envisaged with construction in the vicinity of this chainage. The upper silty clay can support loadings of 150 kN/m^2 (N value = 18) and this should safely support any proposed embankment loading.

(l) Chainage 9275 - Road Construction :

Topsoil (0 to 0.20) overlies a yellow-grey mottled silty sandy gravelly clay. A stiff grey silty sandy gravelly clay (glacial till) extends from 1.70 to the final depth of 3.80m.

The N-value of 17 at 1.50m indicates an allowable bearing pressure in the soil of 150 kN/m^2 which will be satisfactory for embankment support.

A CBR test has been carried out on the upper yellow grey silty sandy gravelly clay and a result of 2.85m obtained.

No water was found at this location and no difficulties are envisaged in road construction.

(m) Ch. 9600 : Bridge over Existing Road :

Two boreholes were constructed to examine overburden soils at the vicinity of the above bridge. Rotary diamond core methods were utilised to determine depth of overburden and proof-drill bedrock at one location.

At Borehole 9000 (L), fill and organic clay with a thin silt layer extends to 2.00m where a medium dense clayey silty sandy gravel was found. This gravel stratum was penetrated to a depth of 5.00 metres.

In Borehole 9000 (R), clayey soils extend to 2.40m where the gravels again occurred. This hole was extended to 4.90 metres.

Water was noted in the gravel stratum in both boreholes - details are given on the record sheets.

The rock coring rig continued penetration of gravels at one location to a depth of 9.20m. Limestone rock was recovered as core from 9.20 to 12.30m.

A vane test in the upper soils at 9600 (L) gave a shear value of 14.6 kN/m^2 confirming the unsuitability of this material as a founding medium.

The gravel stratum found at 2.00 and 2.40m in the respective boreholes is reasonably uniformly graded (see graphs) and the N-values of 10 and 13

would suggest an allowable bearing capacity of about 75 kN/m^2 for bridge foundations placed on the gravel.

This intensity of allowable bearing pressure is unlikely to be sufficient and foundations will have to be transferred to more competent material.

While the gravels improve rapidly in strength, and an allowable bearing pressure of 300 kN/m^2 can be taken at about 4.00 metres, the depth of required excavation and associated dewatering difficulties may preclude the economic construction of excavated footings. The use of piling is, therefore, suggested. Piles should be driven or bored to the limestone bedrock at about 9.50 metres below ground level.

Chemical analyses indicate that no special precautions are necessary to protect below ground concrete.

(n) Chainage 10500 : Road Construction :

A fine to stiff grey silty sandy gravelly clay (glacial till) was noted from ground level to 1.80m, where refusal of boring apparatus occurred.

An index property (liquid and plastic limit) test and a CBR test was performed on a sample of soil from 1.00. The material is of low plasticity, with a CBR of 3.2 per cent.

No problems are envisaged in this vicinity.

(o) Chainage 11150 : (Proposed New Bridge) :

At this location, two holes were initially bored using 200mm cable-tool techniques. The records show a little made ground (approximately 0.50 metres) overlying firm to stiff grey silty sandy gravelly clay. Medium dense gravels were noted at about 2.70m, increasing in density to compact below 4.00 metres. Holes were terminated at 7.80 (left) and 6.80 (right) on large boulders.

Rotary diamond coring was utilised to proof-drill and establish bedrock level. Continuing strata of compact gravels, gravelly clays and boulders were cored from surface to 23.30 metres. Limestone bedrock was cored and recovered from 23.30 to 25.00 metres in BH 11150(R). A cored hole at 11150(L) achieved a depth of 20.00 metres without encountering bedrock. Coring was terminated at this point.

Groundwater was struck in association with the gravel stratum at about 2.70m, final standing level was recorded at an average depth of 1.30 metres.

Standard penetration tests have been carried out to establish soil strength and N-values of 20 and 24 have been recorded in the upper granular clay stratum.

Grading analyses have been carried out on the lower gravel deposits. Graphs indicate a uniform well-graded, slightly silty in places, sand and gravel.

Chemical analysis of two samples has indicated very low sulphate concentrations and no special precautions need be taken to protect foundation concrete.

Foundations for the proposed structure can be supported on the granular clay stratum. Footings placed at 2.00 metres can be designed using an allowable bearing pressure of 200 kN/m^2. Settlements at this intensity of load in preconsolidated glacial till will be low, differential settlement should be negligible.

Should an increase in allowable bearing pressure be required, foundation loads could be carried on piles, founded in the compact gravel stratum. A precast concrete pile, driven to, say 10.00 metres should support a minimum of 80 tonnes (assuming a 300mm x 300mm pile section).

(p) Ch. 11950 : Road Construction

At this location an upper 1.0m of peaty clay was encountered, overlying a firm to stiff grey silty sandy gravelly clay. The borehole extended to 5.00 metres with slight water seepage at 4.10m.

A CBR test at 1.00m gave a result of 3.6 per cent.

The N-value of 18 at 1.50m suggests an allowable bearing capacity of 150 kN/m^2 which should be sufficient for embankment support. No problems are anticipated with road/embankment construction in this vicinity.

(q) Ch. 13050 : Road Construction :

Soft silty fibrous peat extends to 2.60 metres overlying medium dense to dense gravels which extended to the final depth bored of 4.50 metres. An SPT in the peat gave an N-value of 1 while in-situ vanes indicate a shear strength of 12.8 kN/m^2.

We would suggest the removal of the very soft organic material and construction of the roadway on the gravel stratum, which is in a compact condition and is well-graded. Coarse rock fill should be utilised at the base of the road construction grading to fine selected material (804 or similar) closer to final grade.

(r) Chainage 13775 : Road Construction :

At this location, a claybound gravel was found from GL to 0.90m with compact sandy gravels from 0.90 to 2.70m. Water level was noted at 2.30 in the gravels.

A grading analysis and a CBR test has been carried out on a gravel sample from 0.90m below ground level.

The material is well-graded with a CBR greater than 10 and no problems are envisaged with road construction in this area, providing construction is maintained above the water table.

(s) Chainage 14025 : Road Construction :

A thin (0.30) stratum of peat overlies a very soft silty clay to a depth of 2.10 metres. Sandy gravel extends from 2.10 to 4.40m, the material is quite compact. Boring was terminated at 4.40 and groundwater was encountered at 2.90m, with a final water level of 1.50m.

A CBR test carried out at 1.00m gave a value of 0.7 per cent which is very low. Should the upper clay stratum be utilised as a base material, we would recommend the use of a geotechnical membrane (terram) and a suitable thickness of selected fill material.

(t) Chainage 14675 : Road Construction :

The borehole at this position shows a firm sandy gravelly clay from GL. to 1.20m overlying medium dense to dense gravels, terminating at 4.00m. Water was noted at 1.90m.

No problems are anticipated with road construction at this chainage. A CBR test at 1.00m on the upper gravelly clay gave a value of 1.85 per cent.

(u) Chainage 15250 : Road Construction :

A grey gravelly clay extends from GL to 1.50 at this location overlying a thin gravel stratum, in turn overlying a stiff glacial till. Water was noted in the gravels. In-situ tests indicate that all soils are competent and no problems are expected at this chainage.

(v) Chainage 15625 : Road Construction :

Sandy gravels were noted extending from ground level to the final depth of 3.60m. Water was noted at 3.00. A grading analysis of the gravel has been carried out and a CBR of 13.4 established. No problems are anticipated at this location.

GENERAL :

Structures :

Where piling techniques are recommended, guideline proposals have been given on the basis of precast concrete driven piles. Various other techniques are obviously available and specialist contractors should be consulted to prepare competitive quotations. Where structural bearing pressures are in the medium range, the use of reinforced earth construction could also be considered.

Soft Soils :

Where very soft soils, peats, peaty clays or silt/marls have been encountered, the depth of such deposits generally does not exceed 3.00 metres and the recommendation to remove such material has been given.

Any such excavation should obviously include for minimum 1 : 1 side slopes.

Some excavation of soft soils may be below water table, however, the use of coarse fill (rock fill) at the base of the construction will ensure that any soft soils remaining following excavation will be displaced into the voids in the rock fill.

Other techniques of dealing with peaty deposits could be considered, including installation of vertical drains and surcharge loading of soft areas.

Any such procedures would require some further soil investigation and the installation of equipment to monitor settlement behaviour of embankments.

APPENDIX I (a) .... BORING RECORDS

APPENDIX I(b) ..... CORE LOGS

REPORT NO	GEOTECHNICAL CORE LOG RECORD	I.G.S.L.
CONTRACT WESTPORT AND SRAHLEA		BOREHOLE NO 1250R
		SHEET
CLIENT MAYO COUNTY COUNCIL	CORE DIAMETER (mm)	DATE STARTED 21.9.93
	GROUND LEVEL (mOD)	DATE COMPLETED 22.9.93
LOCATION KNOCK CLAREMORRIS BY-PASS	INCLINATION Vertical	DRILLED BY IGSL
	FLUSH Water	LOGGED BY I G S L

DOWNHOLE DEPTH (m)	CORE RUN LENGTH (m)	T C R %	S C R %	R Q D %	DISCONTINUITIES	SYMBOLIC LOG	ELEVATION (mOD)	DEPTH (m)	GEOTECHNICAL DESCRIPTION
1									Stiff dark brown peaty CLAY/clayey peat Predominantly fine to medium-grained gravel size fragments of limestone
2	3.7	17	0	0					
3									
4					From 3.70 to 3.85m, highly fractured and non-intact with fine to medium-grained size fragments			3.7	Dark grey/grey black fine grained, moderately and slightly weathered LIMESTONE, moderately strong to strong
5	2.0	91	48	33	From 3.85 to 4.05m, black shaley limestone with very closely spaced sub-horizontal discontinuities subplanar to irregular with slight calcareous clay smearing			5.7	From 4.60 to 4.85m, prominent highly weathered shaley LIMESTONE, weak to mid-weak
6									
7	1.3	86	73	36				7.0	
8									END OF DRILLHOLE
9									

REMARKS:

GEOTECHNICAL CORE LOG RECORD

I.G.S.L.

REPORT NO			
CONTRACT	WESTPORT AND SRAHLEA		BOREHOLE NO 1250L SHEET
CLIENT	MAYO COUNTY COUNCIL	CORE DIAMETER (mm) 47NQ GROUND LEVEL (mOD)	DATE STARTED 22.9.93 DATE COMPLETED 22.9.93
LOCATION	KNOCK CLAREMORRIS BY-PASS	INCLINATION Vertical FLUSH Water	DRILLED BY IGSL LOGGED BY I G S L

DOWNHOLE DEPTH (m)	CORE RUN LENGTH (m)	T C R %	S C R %	R Q D %	DISCONTINUITIES	SYMBOLIC LOG	ELEVATION (mOD)	DEPTH (m)	GEOTECHNICAL DESCRIPTION
1	2.50	26	11	0					Overburden (fragments of limestone with slight clay smearing present)
2					From 2.0m, generally highly fractured and non-intact with widely spaced sub-vertical discontinuities, subplanar, smooth and slightly rough, clean			2.0	
3								2.5	Dark grey fine-grained slightly weathered siliceous LIMESTONE, moderately strong or strong
4	1.4	60	0	0				3.9	From approx. 3.50m locally moderately weathered and becoming increasingly carbonaceous/shaley from 4.10 to 4.40m
5	1.8	85	63	48	From 5.25m, widely spaced sub-horizontal discontinuities, subplanar, slightly rough with some calcareous shale smearing				From circa 5.05 to 5.25m highly fractured/non-intact with much of core represented as fine-grained size angular fragments
6								5.7	
7	1.0	83	76	52					From 5.70m, becoming generally slightly weathered, strong to very strong.
								6.7	
8									END OF DRILLHOLE
9									

REMARKS:

GEOTECHNICAL CORE LOG RECORD

I.G.S.L.

REPORT NO			
CONTRACT			BOREHOLE NO 1875L SHEET
CLIENT	MAYO COUNTY COUNCIL	CORE DIAMETER (mm) GROUND LEVEL (mOD)	DATE STARTED 23.4.93 DATE COMPLETED 24.9.93
LOCATION	KNOCK CLAREMORRIS BY-PASS	INCLINATION Vertical FLUSH Water	DRILLED BY IGSL LOGGED BY I G S L

DOWNHOLE DEPTH (m)	CORE RUN LENGTH (m)	T C R %	S C R %	R Q D %	DISCONTINUITIES	SYMBOLIC LOG	ELEVATION (mOD)	DEPTH (m)	GEOTECHNICAL DESCRIPTION
2	5.5	3	1	0					Overburden (coarse gravel-size fragments of LIMESTONE)
4								5.50	
6	1.9	24	0	0				7.40	
8	1.1	38	13	0				8.50	
10	3.0	3	0	0				11.5	
12	3.5	9	6	6					From 11.50 to 15.0m, very stiff brown silty CLAY with some fine gravel
14								15.0	
16									From 15.0m, becoming hard silty CLAY: highly weathered MUDSTONE
18	2.5	54	29	6				17.5	

REMARKS:

GEOTECHNICAL CORE LOG RECORD

I.G.S.L.

REPORT NO			
CONTRACT			BOREHOLE NO 1875L
			SHEET
CLIENT	MAYO COUNTY COUNCIL	CORE DIAMETER (mm)	DATE STARTED 23.4.93
		GROUND LEVEL (mOD)	DATE COMPLETED 24.9.93
LOCATION	KNOCK CLAREMORRIS BY-PASS	INCLINATION Vertical	DRILLED BY IGSL
		FLUSH Water	LOGGED BY I G S L

DOWNHOLE DEPTH (m)	CORE RUN LENGTH (m)	T C R %	S C R %	R Q D %	DISCONTINUITIES	SYMBOLIC LOG	ELEVATION (mOD)	DEPTH (m)	GEOTECHNICAL DESCRIPTION
	1.5	58	51	24					(As previous sheet)
								19.0	
20	1.5	55	37	6					
								20.50	
22	3.0	32	12	0					From approx. 22.50m, generally greyish white fragments of LIMESTONE with much clay infill, medium-gravel size, angular to sub-angular
								23.50	
24									
26	6.5	4	0	0					
28									
30								30.0	
									END OF DRILLHOLE
32									
34									
36									

REMARKS:

GEOTECHNICAL CORE LOG RECORD

I.G.S.L.

REPORT NO			
CONTRACT		BOREHOLE NO	9600
		SHEET	
CLIENT	MAYO COUNTY COUNCIL	CORE DIAMETER (mm)	
		GROUND LEVEL (mOD)	
		DATE STARTED	4.10.93
		DATE COMPLETED	5.10.93
LOCATION	KNOCK CLAREMORRIS BY-PASS	INCLINATION	Vertical
		FLUSH	Water
		DRILLED BY	IGSL
		LOGGED BY	I G S L

DOWNHOLE DEPTH (m)	CORE RUN LENGTH (m)	T C R %	S C R %	R Q D %	DISCONTINUITIES	SYMBOLIC LOG	ELEVATION (mOD)	DEPTH (m)	GEOTECHNICAL DESCRIPTION
1	2.5	14	4	0					Overburden (Predominantly medium to coarse gravel and cobble size fragments of LIMESTONE)
2								2.50	
3	1.8	9	0	0					
4								4.30	
5	1.4	64	46	38				5.70	From 4.30 to 5.25m, highly fragmented and non-intact medium to coarse gravel size LIMESTONE, intact stick (representing boulder horizon from 5.25 to 5.60m)
6									
7	3.5	7	0	0					
8									
9								9.2	

REMARKS:

REPORT NO.

GEOTECHNICAL CORE LOG RECORD

I.G.S.L.

CONTRACT			BOREHOLE NO. 9600 SHEET
CLIENT	MAYO COUNTY COUNCIL	CORE DIAMETER (mm) GROUND LEVEL (mOD)	DATE STARTED DATE COMPLETED
LOCATION	KNOCK CLAREMORRIS BY-PASS	INCLINATION Vertical FLUSH Water	DRILLED BY IGSL LOGGED BY I G S L

DOWNHOLE DEPTH (m)	CORE RUN LENGTH (m)	T.C.R. %	S.C.R. %	R.Q.D. %	DISCONTINUITIES	SYMBOLIC LOG	ELEVATION (mOD)	DEPTH (m)	GEOTECHNICAL DESCRIPTION
10	1.5	97	97	91	From 9.20m, very widely spaced subjhorizontal discontinuities, subplanar, aperture <1mm, clean to 10.45 and 10.50m, sub-horizontal discontinuation, subplanar to planar with slight smearing, predominantly carbonaceous smearing.			10.70	Dark grey black fine-grained slightly weathered siliceous LIMESTONE, strong to very strong.
11	1.6	100	100	81					
12								12.30	
									END OF DRILLHOLE

REMARKS:

REPORT NO 2263\A	GEOTECHNICAL CORE LOG RECORD	I.G.S.L.
CONTRACT		BOREHOLE NO 1150R SHEET
CLIENT MAYO COUNTY COUNCIL	CORE DIAMETER (mm 47 (NQ) GROUND LEVEL (mOD)	DATE STARTED 28 9 93 DATE COMPLETI 30 9 93
LOCATION KNOCK\CLA E MORRIS BY-PASS	INCLINATION Vertical FLUSH Water	DRILLED BY I G S L LOGGED BY I G S L

DOWNHOLE DEPTH (m)	CORE RUN LENGTH (m	T C R %	S C R %	R Q D %	DISCONTINUITIES	SYMBOLIC LOG	ELEVATION (mOD)	DEPTH (m)	GEOTECHNICAL DESCRIPTION
	2 50	3	0	0				2 50	Overburden (Predominantly medium to coarse gravel-size fragments of limestone)
4	3 00	13	6	0				5 50	
6	3 00	32	13	0				8 50	
-8									From approx 8 50m occasional clay present
-10	3 00	16	16	0				11 50	
-12	3 00	7	0	0				14 50	
-14									From 14 50 to 17 50m very stiff to hard brown slightly sandy gravelly CLAY
-16	3 00	56	56	34				17 50	
-18	0 50	96	96	96				18 00	

REPORT NO	GEOTECHNICAL CORE LOG RECORD	I.G.S.L.
CONTRACT		BOREHOLE NO 11150R SHEET 2
CLIENT MAYO COUNTY COUNCIL	CORE DIAMETER (mm 47 (NQ) GROUND LEVEL (mOD)	DATE STARTED 28 9 93 DATE COMPLETI 30 9 93
LOCATION KNOCK CLAREMORRIS BY-PASS	INCLINATION Vertical FLUSH Water	DRILLED BY I G S L LOGGED BY I G S L

DOWNHOLE DEPTH (m)	CORE RUN LENGTH (m)	T C R %	S C R %	R Q D %	DISCONTINUITIES	SYMBOLIC LOG	ELEVATION (mOD)	DEPTH (m)	GEOTECHNICAL DESCRIPTION
-18									
	2 50	48	38	29	From 19 0m very widely spaced subhorizontal discontinuities with prominent clay infill (10-20mm)				Dark grey black fine-grained siliceous LIMESTONE strong and very strong with slight clay infill
20								20 50	From 20 50m much stiff to very stiff clay infill with gravel size fragments in limestone
	0 80	70	30	19				21 30	
22	1 00	61	28	11				22 30	From 22 30m slightly weathered with much highly fragmented and non-intact bands. clay infill from 23 10 to 23 30m Moderately strong to strong
	1 00	91	49	32	From 23 80m becoming fresh to slightly weathered. very strong good quality massive and intact with widely-spaced subhorizontal discontinuities aperture <1mm			23 30	
24	1 70	89	71	63				25 00	
									End of drillhole
26									
28									
30									
32									
34									
36									
38									

REMARKS

GEOTECHNICAL CORE LOG RECORD

I.G.S.L.

REPORT NO.			
CONTRACT			BOREHOLE NO 1150L SHEET
CLIENT MAYO COUNTY COUNCIL	CORE DIAMETER (mm) GROUND LEVEL (mOD)		DATE STARTED 27.9.93 DATE COMPLETED 28.9.93
LOCATION KNOCK CLAREMORRIS BY-PASS	INCLINATION Vertical FLUSH Water		DRILLED BY IGSL LOGGED BY I G S L

DOWNHOLE DEPTH (m)	CORE RUN LENGTH (m)	TCR %	SCR %	RQD %	DISCONTINUITIES	SYMBOLIC LOG	ELEVATION (mOD)	DEPTH (m)	GEOTECHNICAL DESCRIPTION
2	3.3	9	7	5				3.30	Overburden (dark grey black fine-grained fragments of siliceous LIMESTONE) From approx. 3.30m, medium to coarse gravel and cobble size fragments, angular to subangular
4	2.2	12	5	5				5.50	
6	1.5	26	26	21				7.00	
8	1.5	18	18	18				8.50	
10	1.5	14	11	7				11.00	
12	4.0	4	0	0				15.00	
14									
16	3.0	3	0	0				18.0	
18									

REMARKS:

Drillhole terminated at 20.0 b.g.l. in overburden

GEOTECHNICAL CORE LOG RECORD

I.G.S.L.

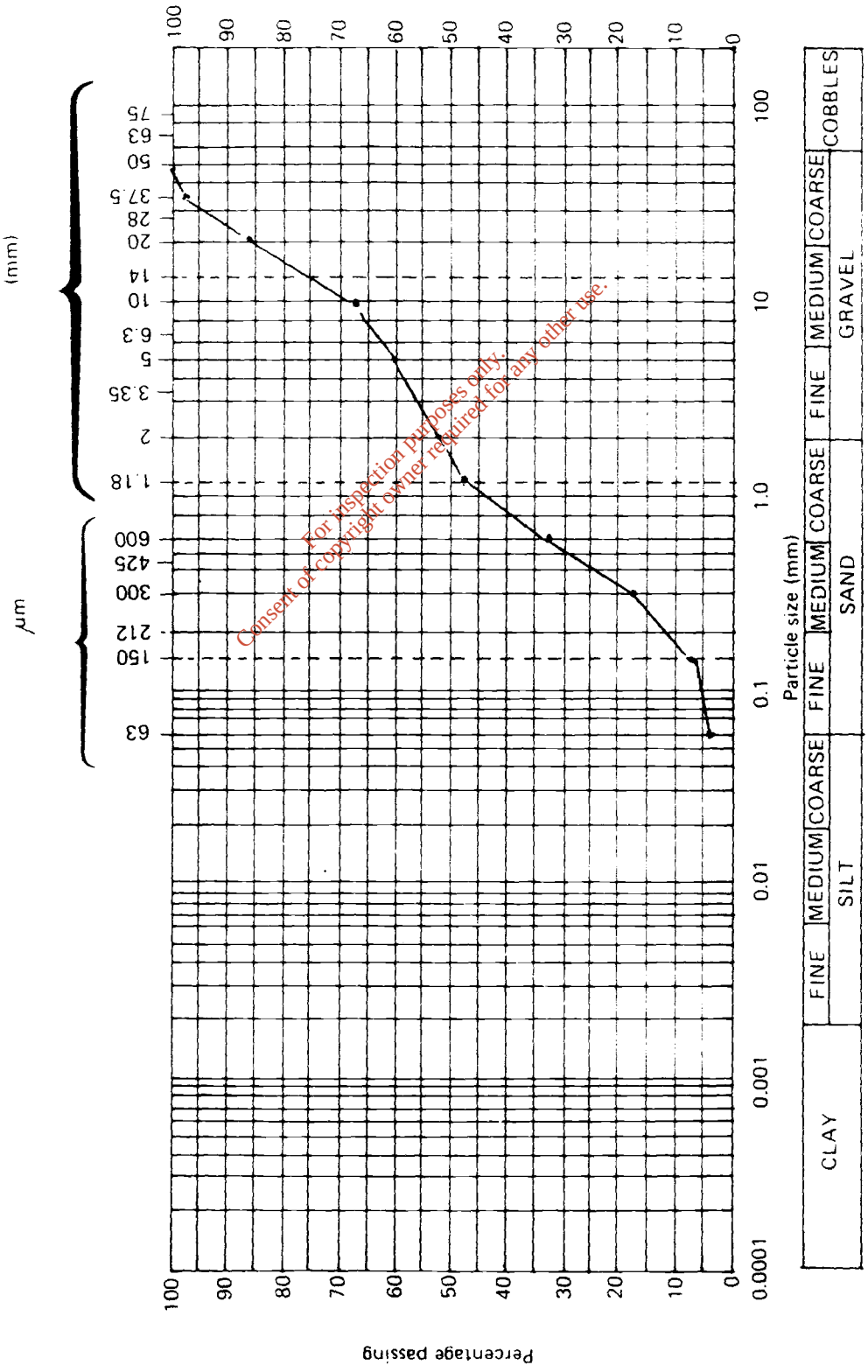
REPORT NO			
CONTRACT			BOREHOLE NO 11150L SHEET
CLIENT	MAYO COUNTY COUNCIL	CORE DIAMETER (mm) GROUND LEVEL (mOD)	DATE STARTED DATE COMPLETED
LOCATION	KNOCK CLAREMORRIS BY-PASS	INCLINATION Vertical FLUSH Water	DRILLED BY IGSL LOGGED BY I G S L

DOWNHOLE DEPTH (m)	CORE RUN LENGTH (m)	T C R %	S C R %	R Q D %	DISCONTINUITIES	SYMBOLIC LOG	ELEVATION (mOD)	DEPTH (m)	GEOTECHNICAL DESCRIPTION
18	2.0	7	0	0				20.0	END OF DRILLHOLE
20									

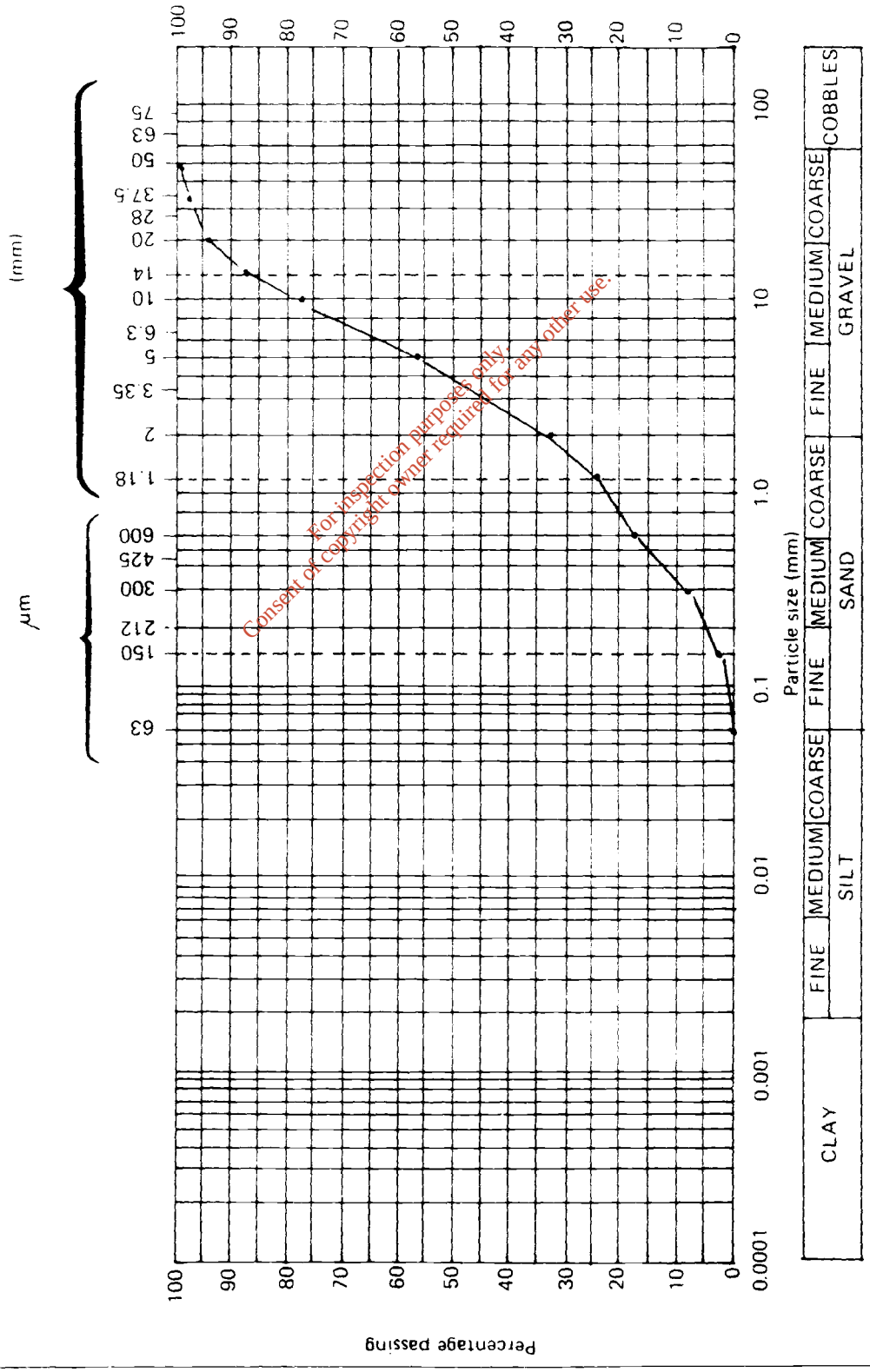
REMARKS:

APPENDIX II ..... TEST DATA

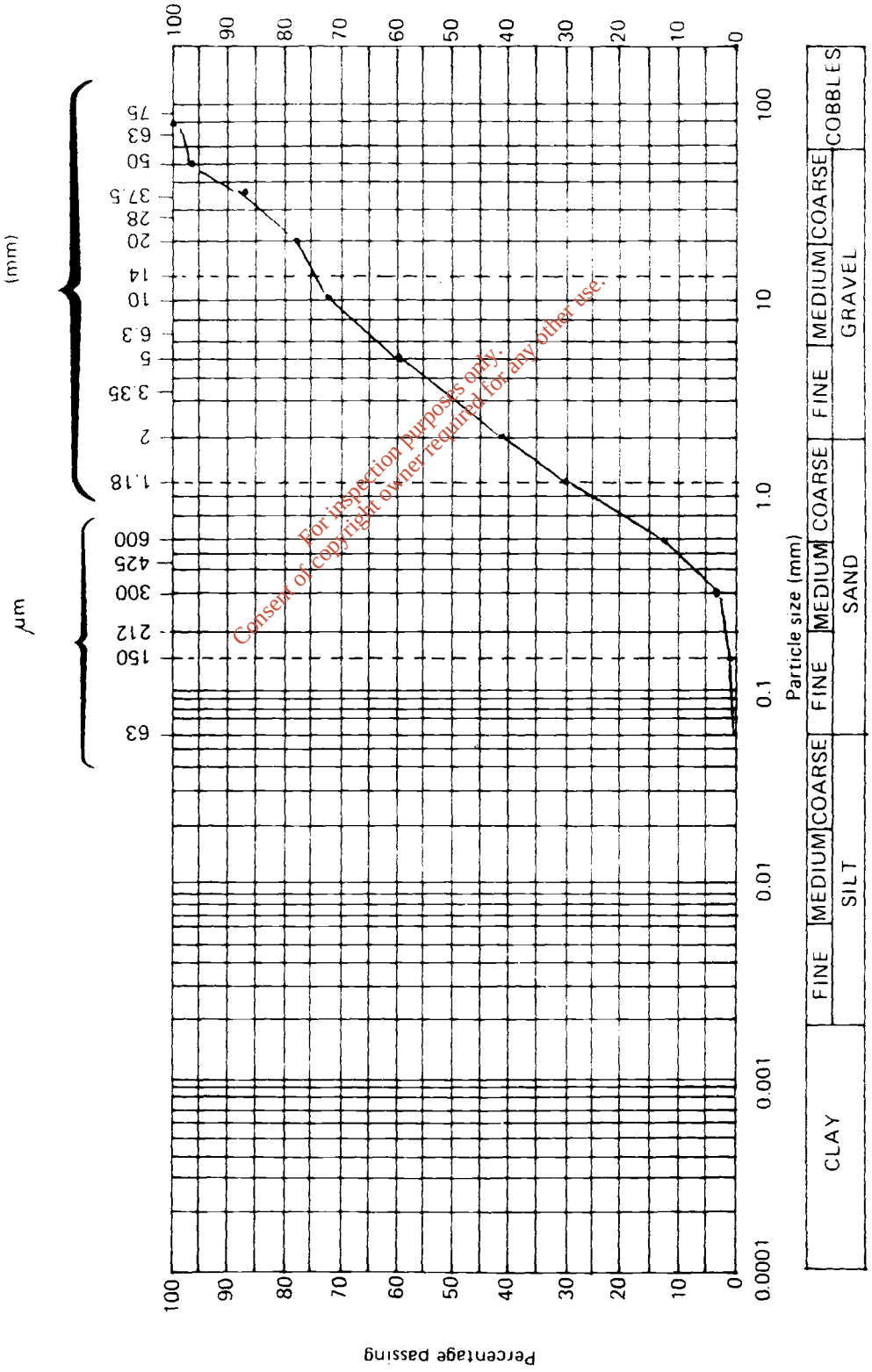
Report No.	PARTICLE SIZE ANALYSIS	
Contract	KNOCK - CLAREMORRIS	Borehole No. 8 00
		Sample No. 2278
Method of Test	Wet Sieve	Depth 4.50
Sample Description	Grey slightly silty sandy GRAVEL	



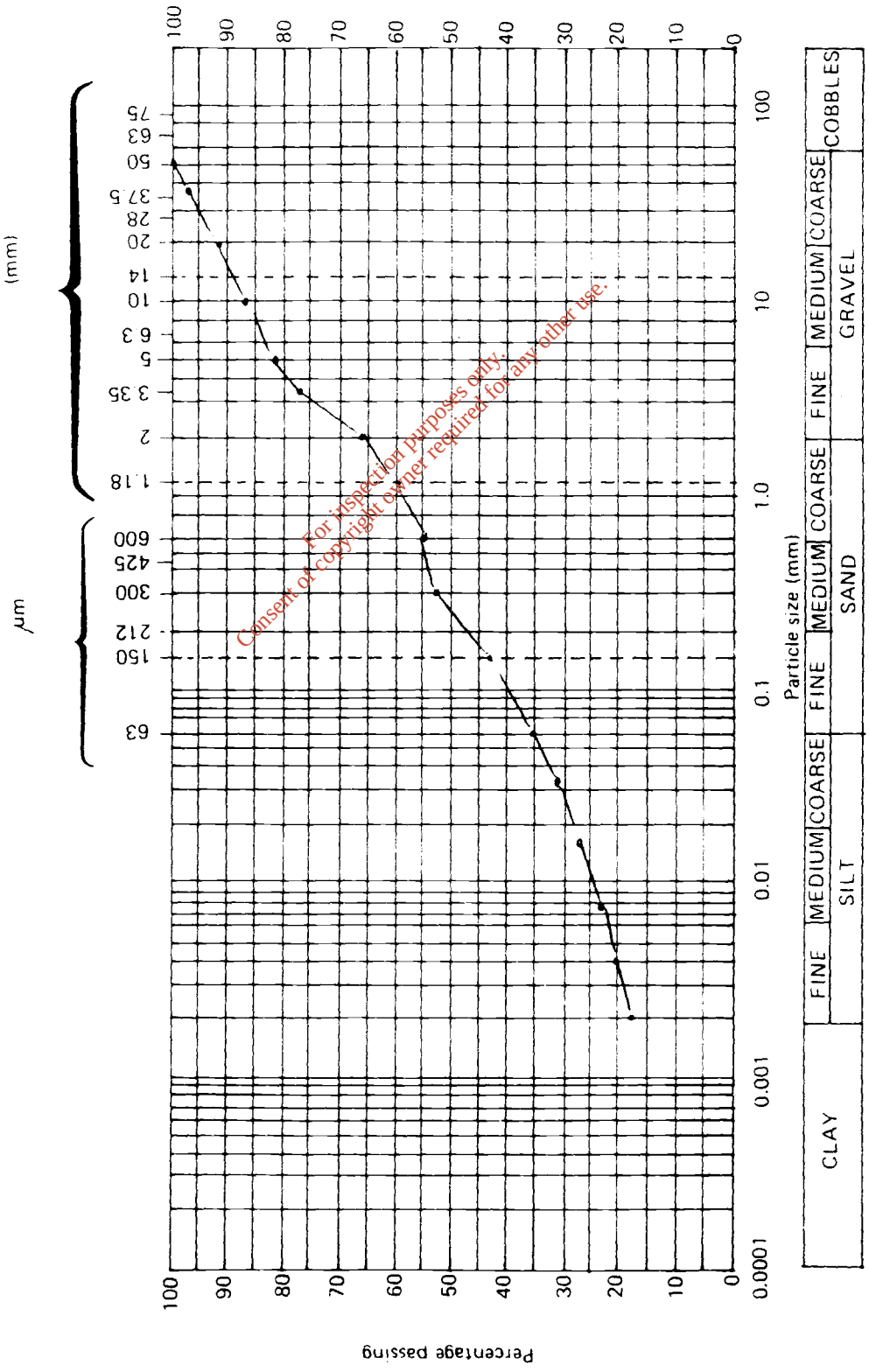
Report No	PARTICLE SIZE ANALYSIS		
Contract	KNOCK - WESTPORT	Borehole No	1250
		Sample No	2272
Method of Test	Wet Sieve	Depth	2.80
Sample Description	Grey brown sandy GRAVEL (angular and sub-angular)		



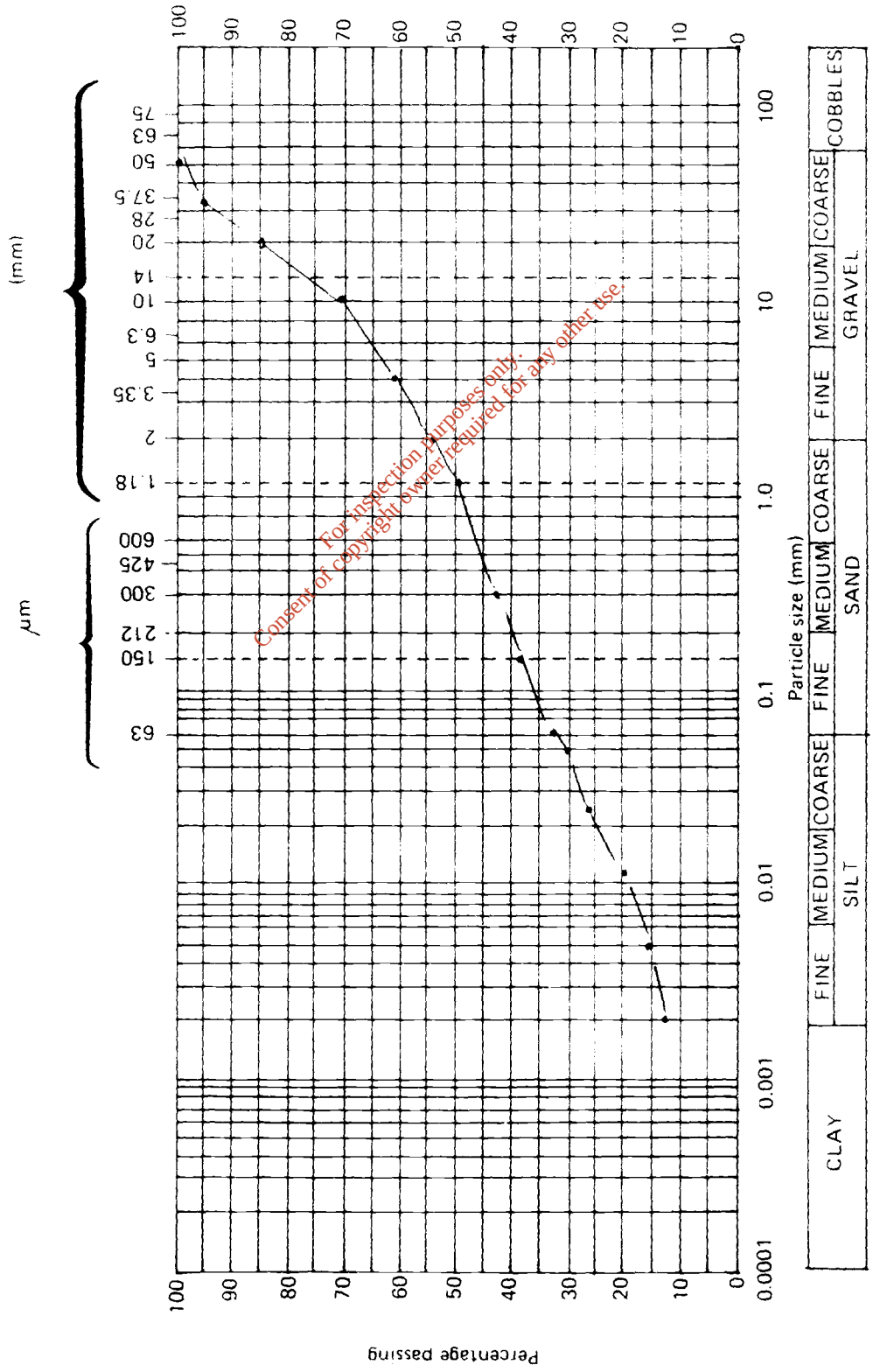
Report No.	PARTICLE SIZE ANALYSIS		
Contract	KNOCK - CLAREMORRIS	Borehole No.	3675
		Sample No	2292
Method of Test	Wet Sieve	Depth	2.50
Sample Description	Grey-brown fine to coarse sandy GRAVEL		



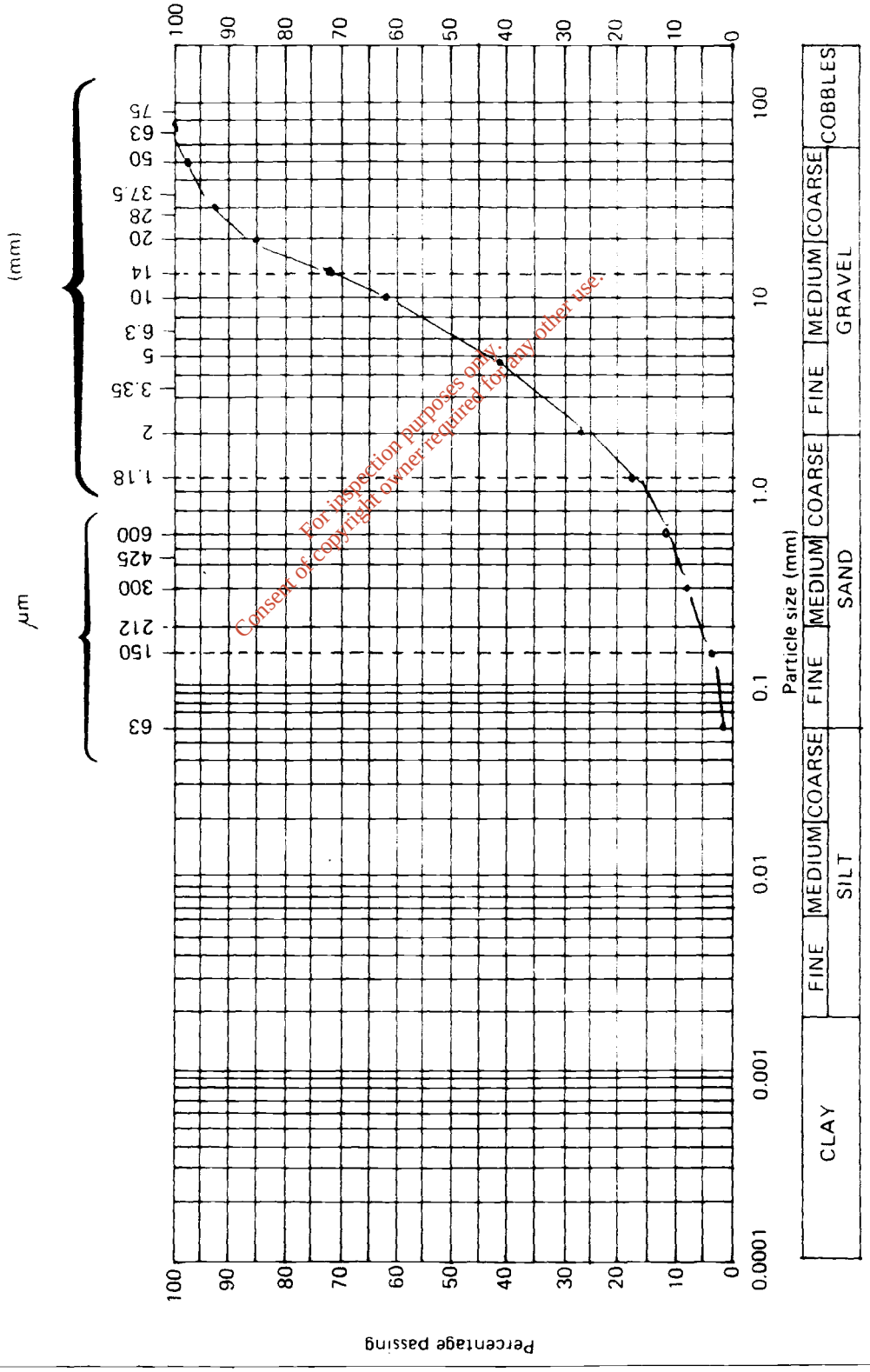
Report No	PARTICLE SIZE ANALYSIS		
Contract	KNOCK - CLAREMORRIS	Borehole No.	6950
		Sample No.	7206
Method of Test	Wet Sieve & Hydrometer	Depth	2.00
Sample Description	Grey silty sandy gravelly CLAY		



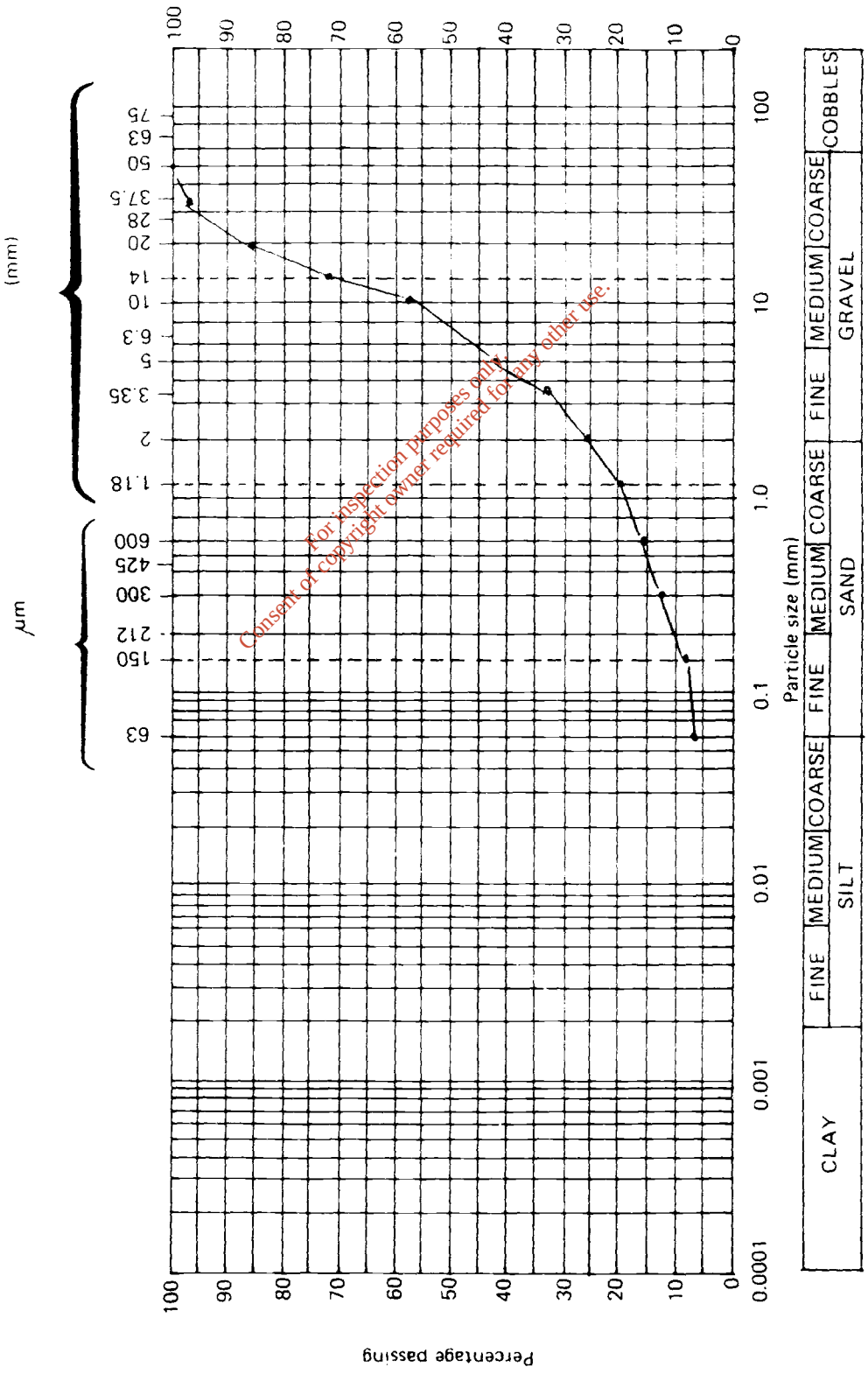
Report No.	PARTICLE SIZE ANALYSIS	
Contract	KNOCK - CLAREMORRIS	Borehole No. 8525
Method of Test	Wet Sieve & Hydrometer	Sample No. 7218
Sample Description	Grey silty sandy gravelly CLAY	Depth 2.00



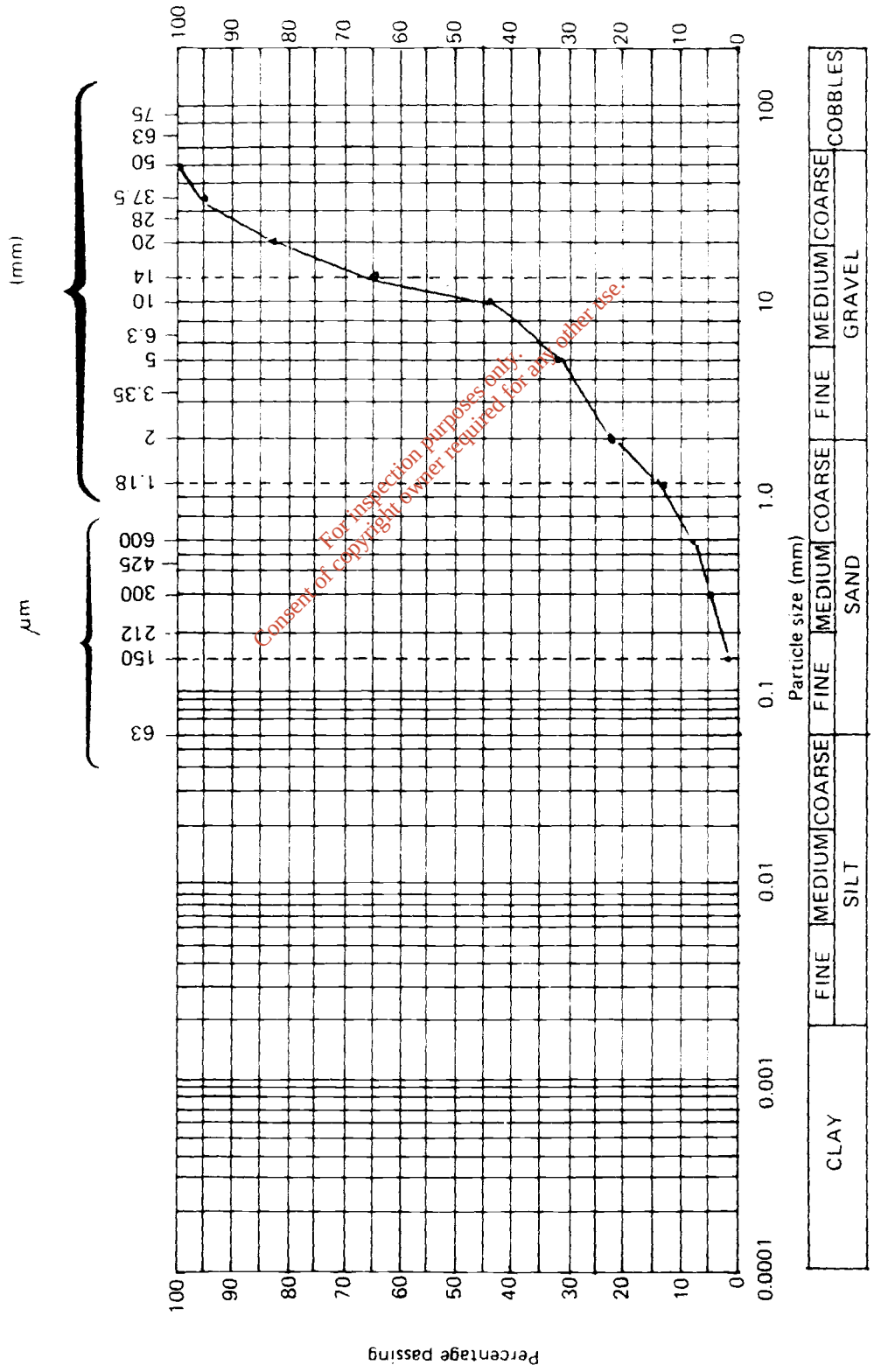
Report No.	PARTICLE SIZE ANALYSIS	
Contract	KNOCK - CLAREMORRIS	Borehole No. 9600R
Method of Test	Wet Sieve	Sample No. 7223
Sample Description	Grey brown sandy GRAVEL	Depth 2.50



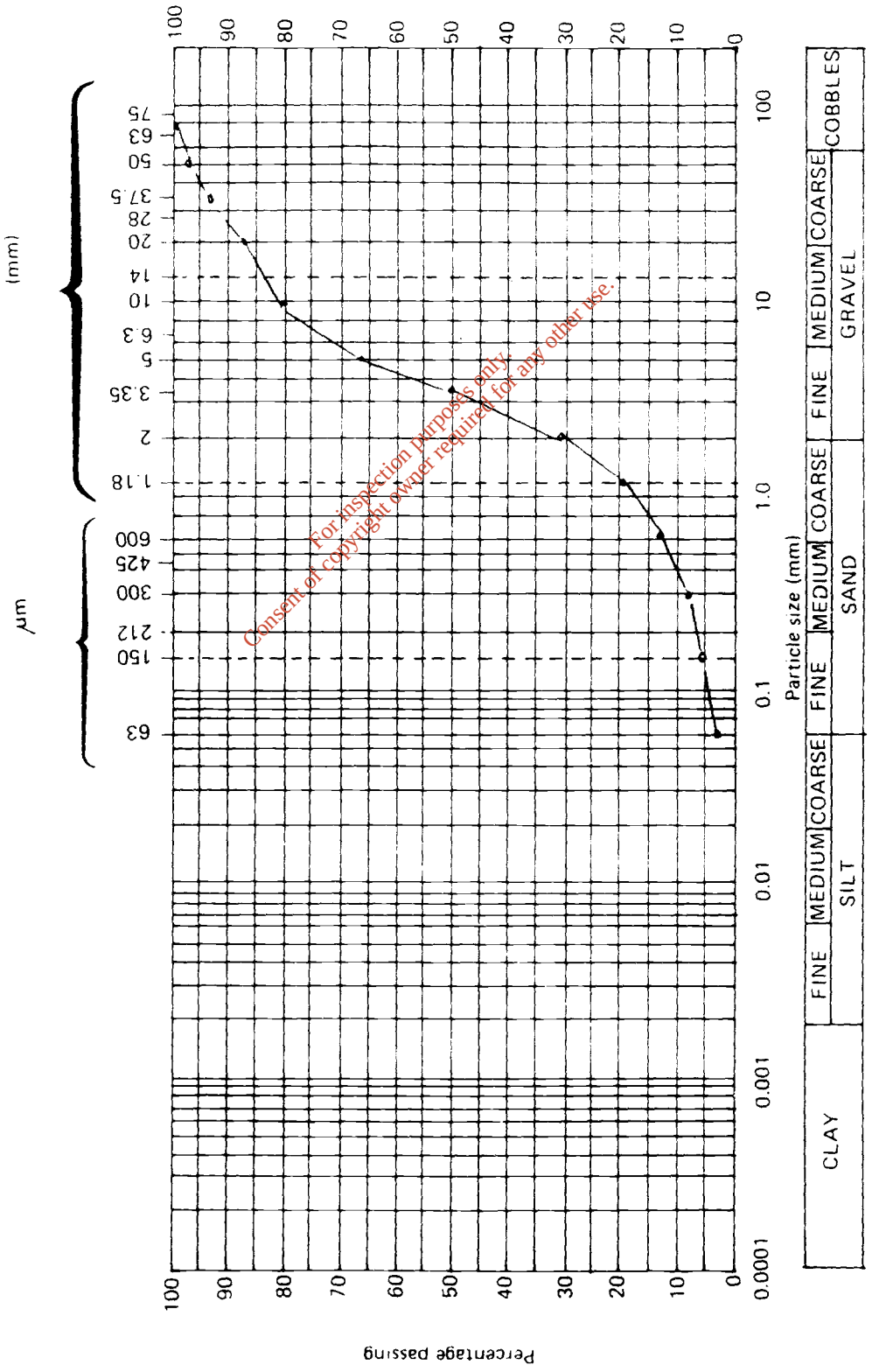
Report No.	PARTICLE SIZE ANALYSIS	
Contract	KNOCK - CLAREMORRIS	Borehole No. 9600L
		Sample No 7212
Method of Test	Wet Sieve	Depth 2.50
Sample Description	Slightly clayey/silty sandy GRAVEL	



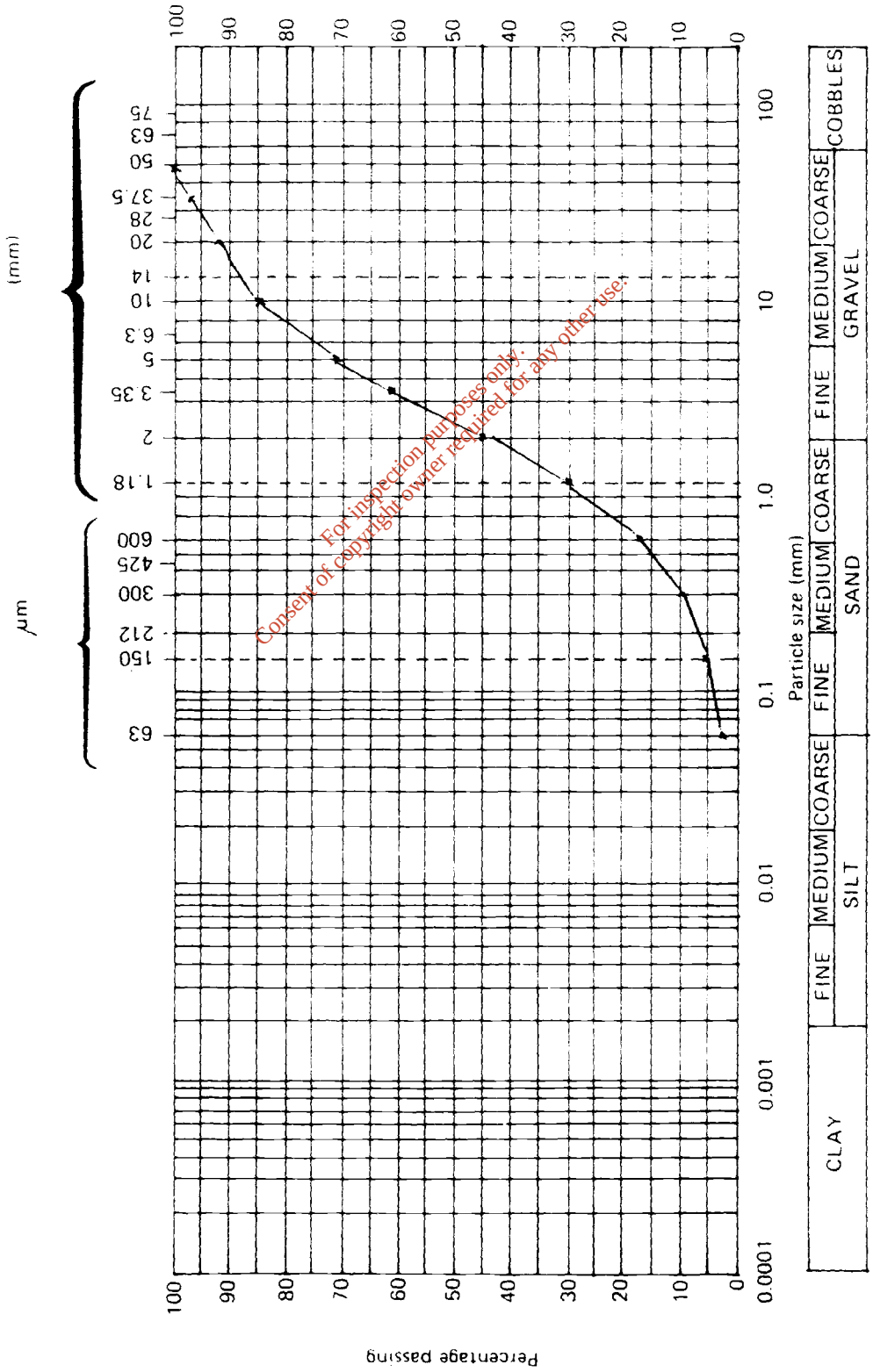
Report No.	PARTICLE SIZE ANALYSIS	
Contract	KNOCK - CLAREMORRIS	Borehole No 11150
Method of Test	Wet Sieve	Sample No 7225
Sample Description	Fine to coarse sandy GRAVEL	Depth 3.00



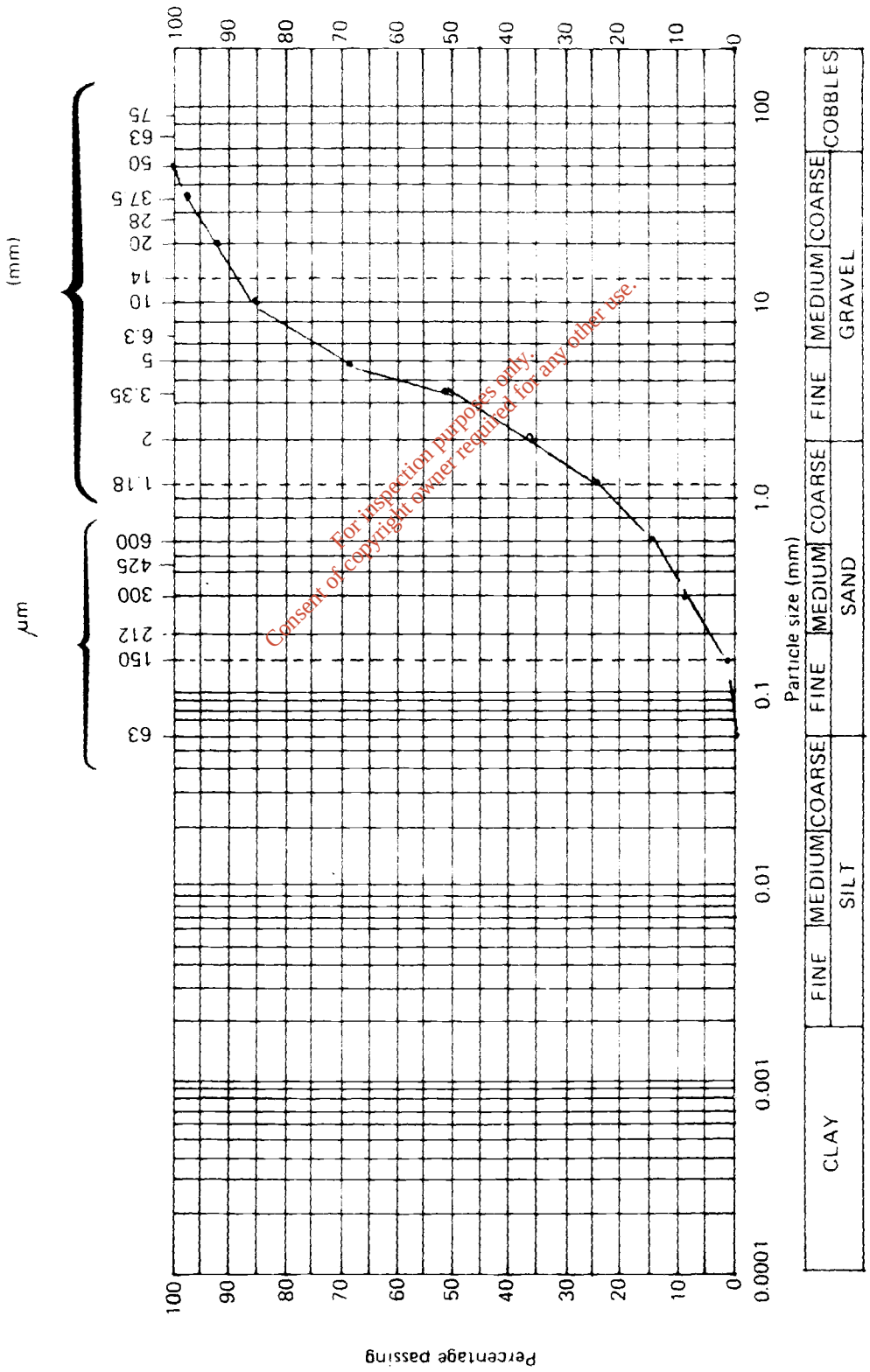
Report No.	PARTICLE SIZE ANALYSIS		
Contract	KNOCK - CLAREMORRIS	Borehole No.	1150R
		Sample No	7230
Method of Test	Wet Sieve	Depth	5.50
Sample Description	Grey fine to coarse slightly silty sandy GRAVEL		



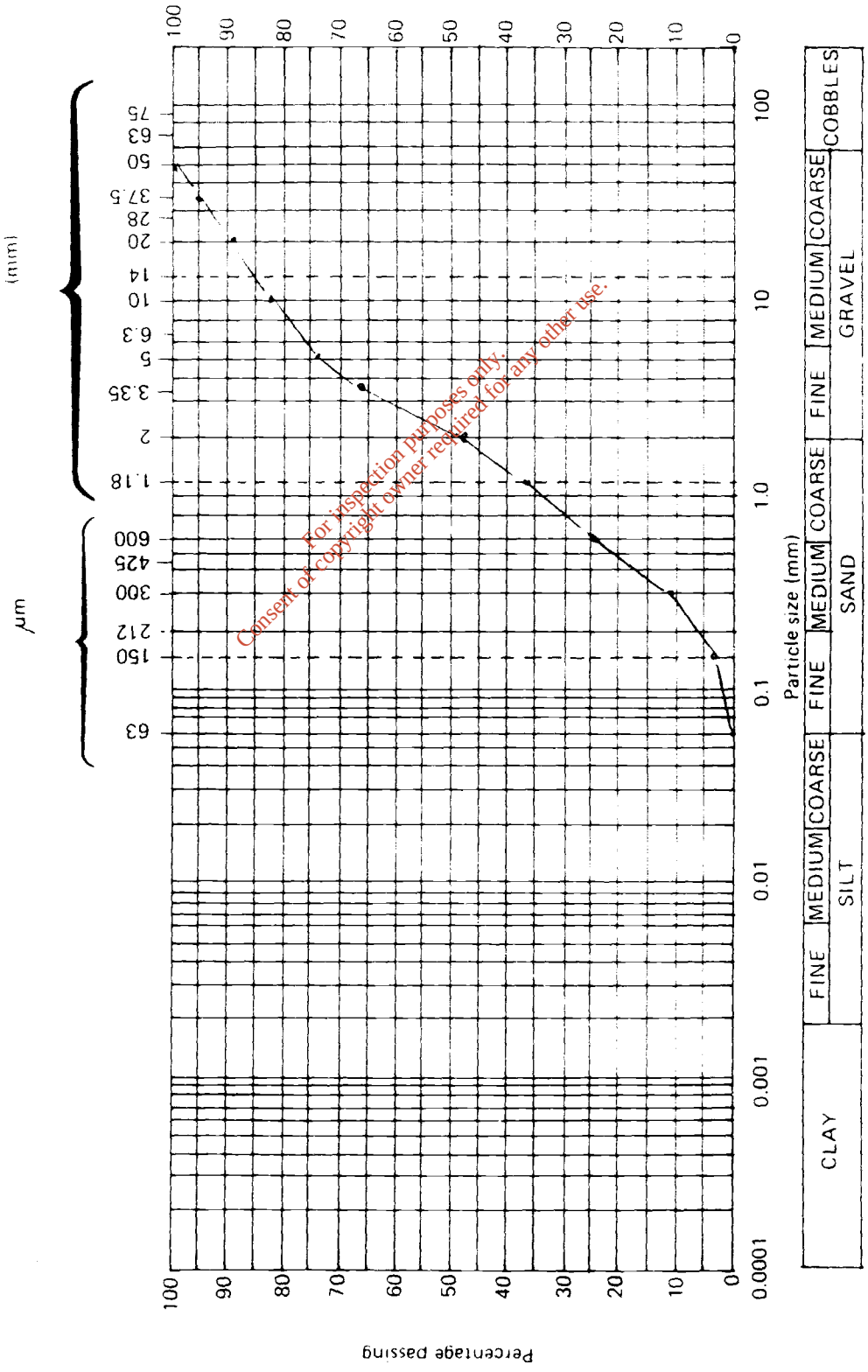
Report No.	PARTICLE SIZE ANALYSIS		
Contract	KNOCK - CLAREMORRIS	Borehole No.	13050
		Sample No	7234
Method of Test	Wet Sieve	Depth	3.00
Sample Description	Slightly silty sandy GRAVEL		



Report No	PARTICLE SIZE ANALYSIS		
Contract	KNOCK - CLAREMORRIS	Borehole No.	13775
		Sample No.	7248
Method of Test	Wet Sieve	Depth	0.90
Sample Description	Grey brown sandy GRAVEL		



Report No	PARTICLE SIZE ANALYSIS	
Contract	KNOCK - CLAREMORRIS	Borehole No. 15625
Method of Test	Wet Sieve	Sample No. 7259
Sample Description	Brown sandy GRAVEL	Depth 1.00



Report No.

CALIFORNIA BEARING RATIO

IGSL

Contract

KNOCK - CLAREMORRIS

Location	Sample No	Depth of Sample	Description of Sample	Water Content (% dry Weight)	Dry Density Mg/m^3	Test Code	Top Water Content %	Base Water Content %	C.B.R. Top %	C.B.R. Base %	C.B.R. Average %
Ch 800	2278	4.50	Grey silty sandy GRAVEL			95% St. H			11.0	11.6	11.3
3200	2286	1.30	Grey silty sandy gravelly CLAY	15.2		95% St. H			3.8	3.7	3.75
4325	2299	1.50	Brown silty sandy CLAY	17.3		do			0.9	1.2	1.15
6200	2298	2.50	Grey brown silty sandy GRAVEL			95% St. H			16.3	16.5	16.4
7025	7208	2.00	Grey silty sandy gravelly CLAY	13.7		95% St. H			3.6	3.5	3.55
8525	7217	1.00	Brown silty CLAY	16.5		do			2.5	2.7	2.6
8525	7218	2.00	Grey sandy gravelly CLAY	12.9		do			4.5	4.4	4.45
9275	7215	1.00	Yellow-brown silty sandy CLAY	13.10		95% St. H			3.0	2.7	2.85
10500	7220	1.00	Grey sandy gravelly CLAY	12.9		do			3.2	3.2	3.2
11950	7231	1.00	Grey silty sandy gravelly CLAY	14.21		95% H			3.7	3.6	3.65
13775	7248	0.90	Fine to coarse very sandy GRAVEL						11.8	12.2	12.0
14025	7250	1.00	Grey silty CLAY, some organic fibres and small gravel-sized stone	21.37					0.7	0.7	0.7

Test Code

St. - Static Compaction
D - Dynamic Compaction
U - Undisturbed Sample

L - 2.5 kg Rammer
H - 4.5 kg Rammer

A/5 - 5% Air Voids Ratio
A/10 - 10% Air Voids Ratio

V - Vibrating Hammer
M - BS1377 Method number (ex. D.L.M.I.)

Report No.

CALIFORNIA BEARING RATIO

IGSL

Contract

KNOCK - CLAREMORRIS

Location	Sample No	Depth of Sample	Description of Sample	Water Content (% dry Weight)	Dry Density Mg/m³	Test Code	Top Water Content %	Base Water Content %	C.B.R. Top %	C.B.R. Base %	C.B.R. Average %
14675	7253	1.00	Brown sandy gravelly CLAY	16.52					1.90	1.80	1.85
15625	7259	1.00	Grey-brown sandy GRAVEL			95% St. H			13.6	13.2	13.4

Test Code

St. - Static Compaction
D - Dynamic Compaction
U - Undisturbed Sample

L - 2.5 kg Rammer
H - 4.5 kg Rammer

A/5 - 5% Air Voids Ratio
A/10 - 10% Air Voids Ratio

V - Vibrating Hammer
M - BS1377 Method number (ex. D.L.M.I.)

Borehole No.	Sample No.	Depth (Metres)	Description of Sample	Triaxial Compression							Remarks
				Test Code	Lateral Pressure km/m²	Compression Strength kN/m²	Cohesian kN/m²	Angle of Friction (degrees)	Bulk Density Mg/m³	Water Content % dry Weight	
1250L	2271	1.50	Grey silty sandy gravelly CLAY	38U R	100 200 300	170 190 200	93	0	1.97 1.99 1.98	13.41 13.63 13.77	

Triaxial Compression Code:
38 - 38mm dia specimen
102 - 102mm dia specimen
U - Undrained
CD - Consolidated Drainer
CU - Consolidated Undrained
M - Multi-stage
R - Remoulded

Contract: KNOCK - CLAREMORRIS

Report No.

TRIAXIAL COMPRESSION TEST

Report No

CLASSIFICATION TEST RESULTS

Contract

KNOCK - CLAREMORRIS

Borehole No	Sample No	Depth (Metres)	Sample Description	Percentage Passing 425 µm Sieve	Liquid Limit (LL)	Plastic Limit (PL)	Plasticity Index (PI)	Water Content %
800	2276	2.50	Brown silty PEAT					193.0
2400	2280	2.00	Brown silty fibrous PEAT					236.0
	2282	4.20	Grey white very silty MARL		56	35	21	57.7
4325	7202	2.00	Grey brown silty CLAY		29	17	12	13.4
10500	7220	1.00	Grey sandy gravelly CLAY		28	18	10	12.9

REPORT NO.

CHEMICAL ANALYSIS

IGSL

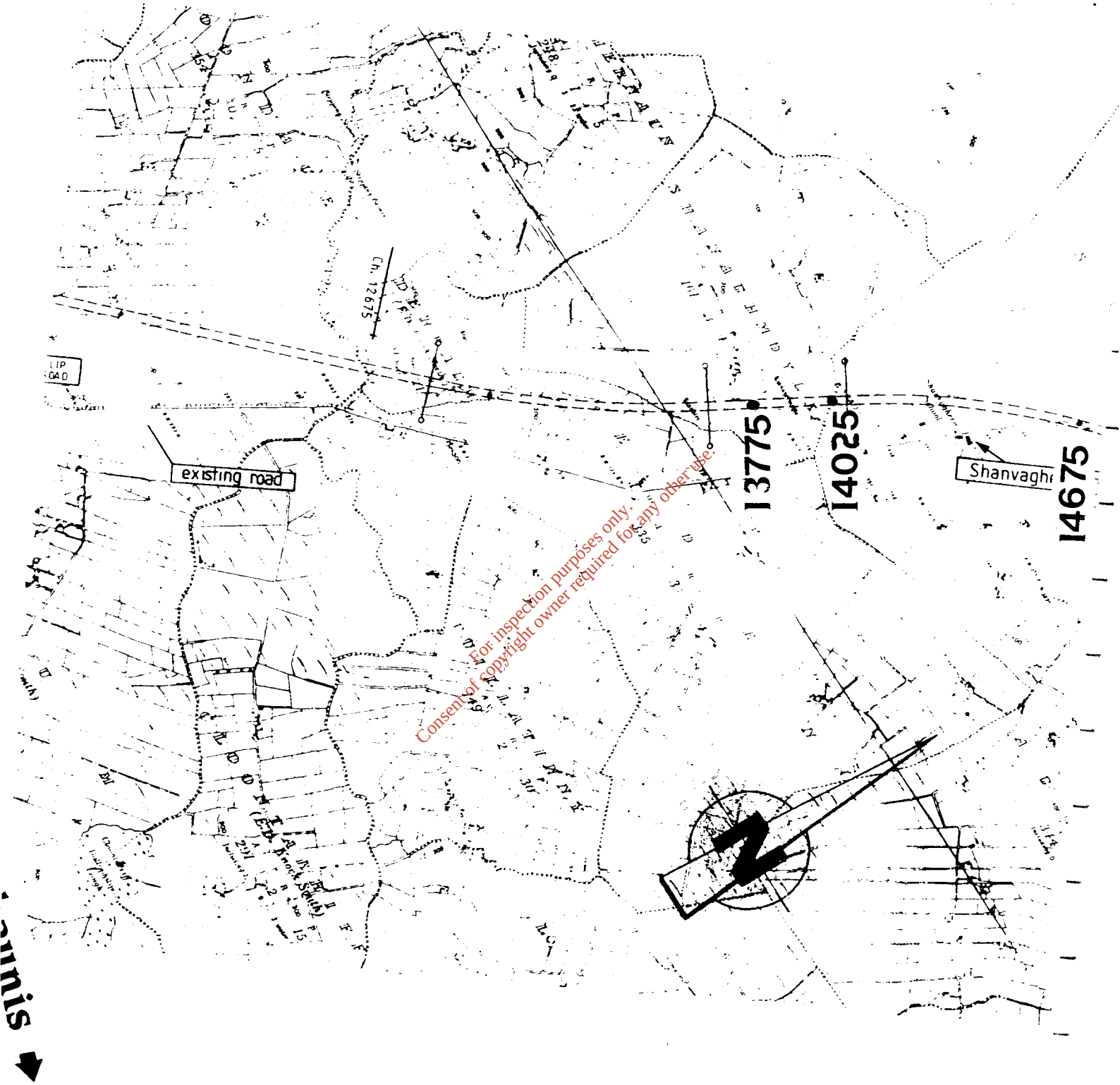
CONTRACT

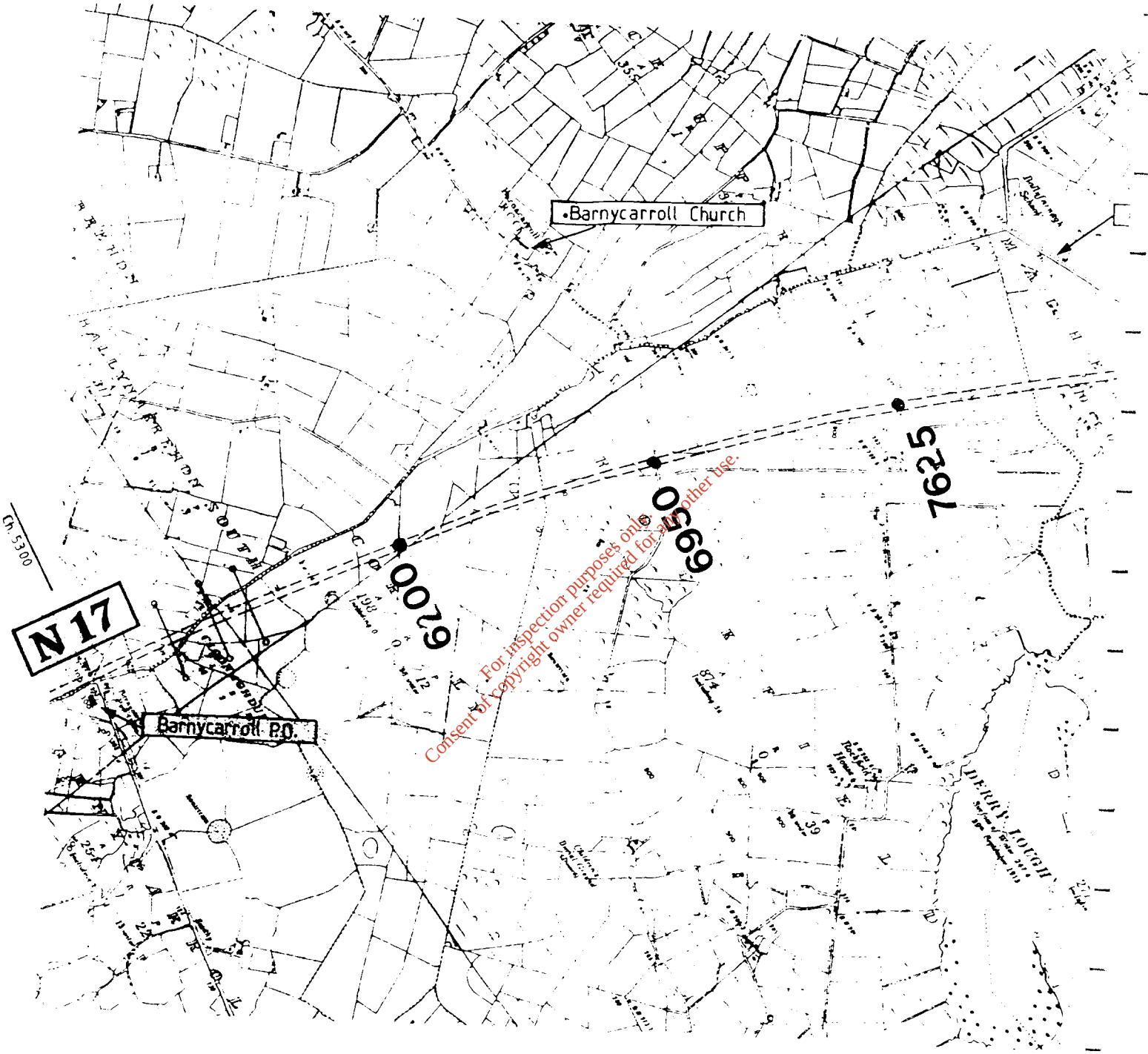
KNOCK - CLAREMORRIS

BOREHOLE NO	SAMPLE NO	DEPTH (METRES)	SAMPLE TYPE	TEST CODE	SULPHUR TRIOXIDE		PH VALUE
					PARTS SO_3 PER 100,000 WATER	PER CENT SO_3 SOIL	
12502	2269		Water	-	17.2		7.6
18756	2295	2.20	Clay	S		0.04	7.5
9600 (L)	7210	1.00	Peaty clay	S		0.11	7.6
9600	7222	1.50	Gravelly Clay	S		Negligible	7.5
11150L	7224	1.00	Clay	S		0.07	7.6
1150R	7228	1.00	Clay	S		0.05	7.6

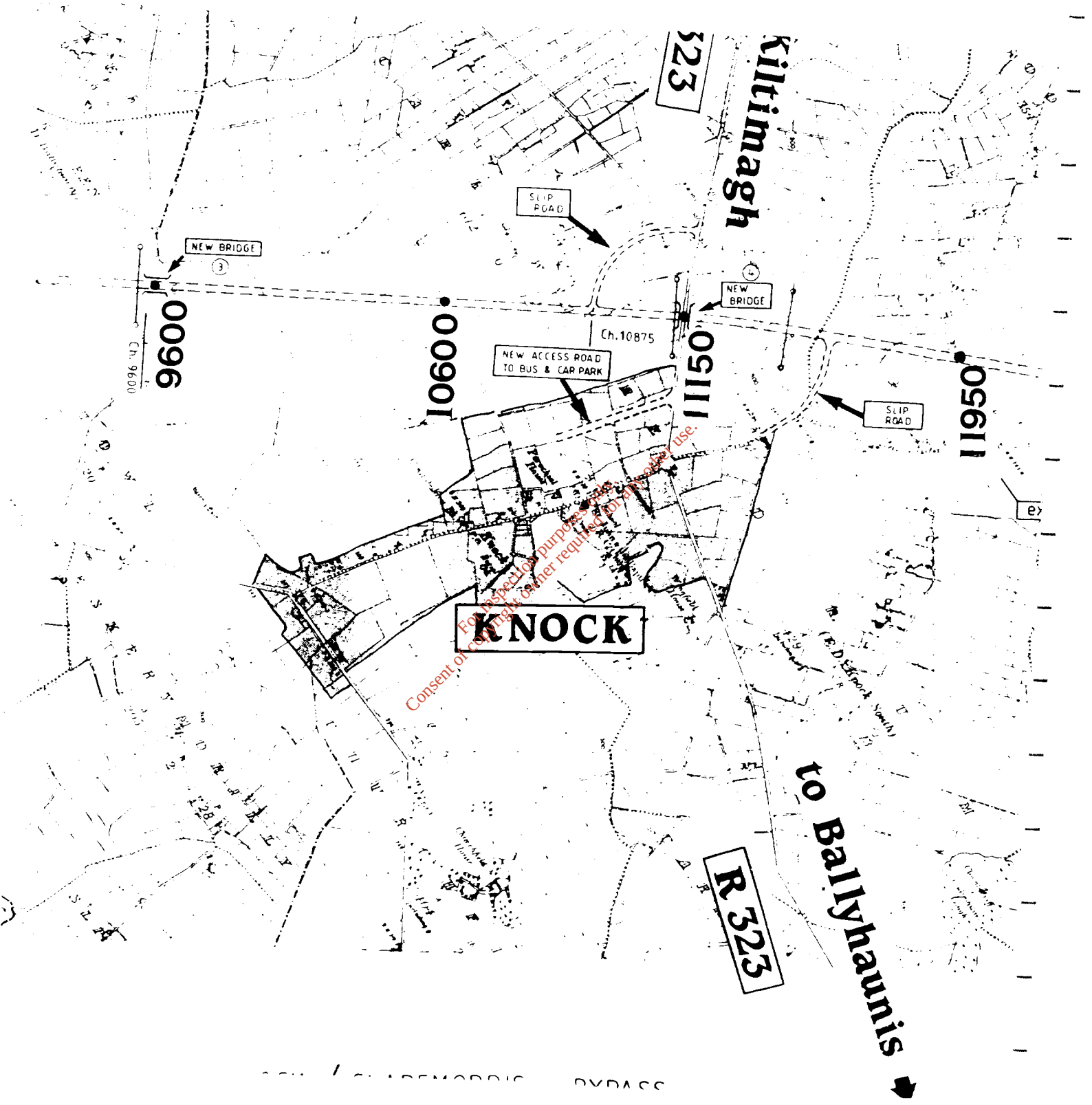
TEST CODE W -WATER S .- SOIL A - AQUEOUS SOIL EXTRACT.

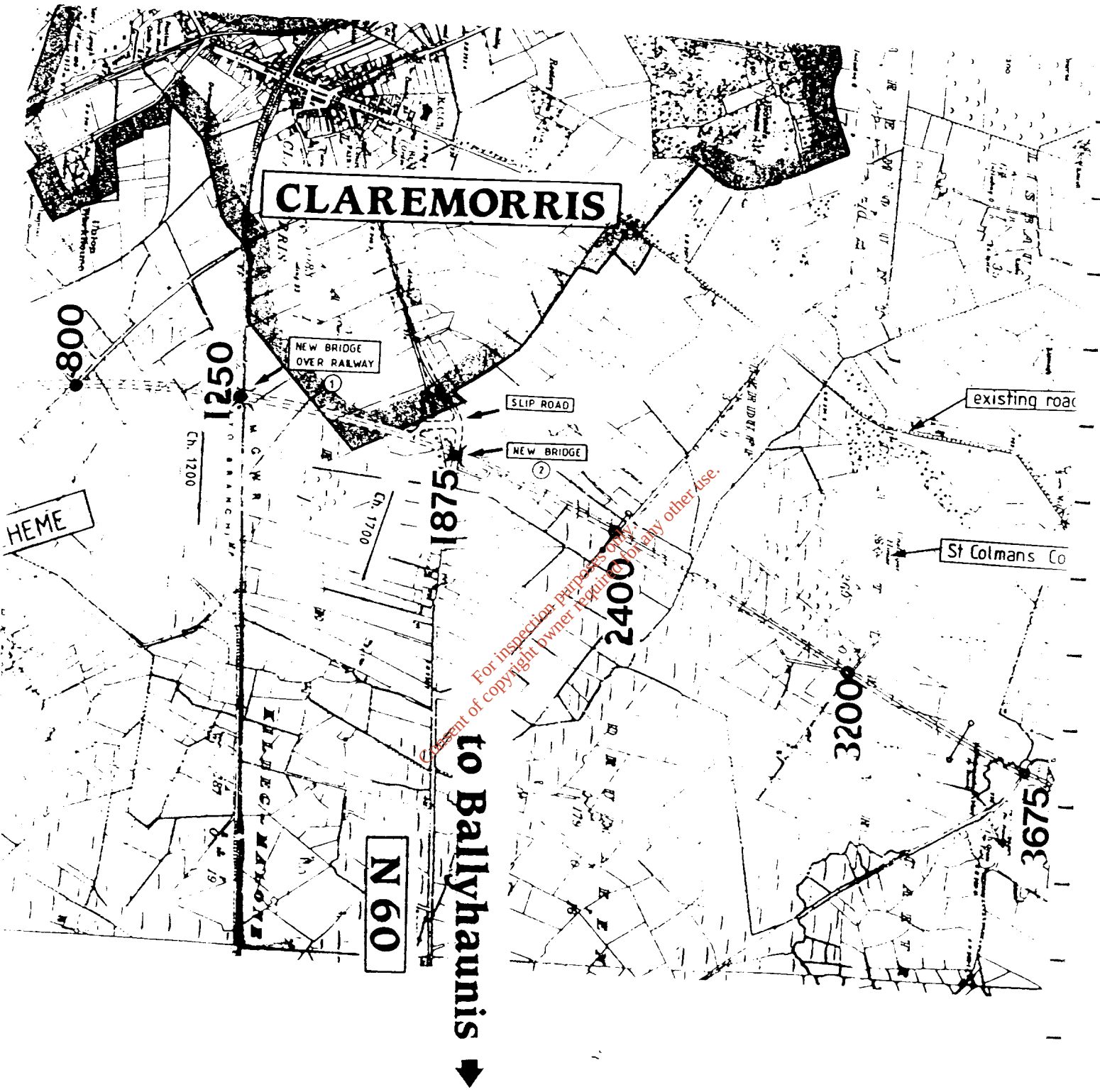
APPENDIX III ..... SITE PLAN





MAP 2





86054

Report No. 2263/C

BORING RECORD

Contract: KNOCK/CLAREMORRIS BY-PASS

Borehole No. 9600

Sheet (L)

Location

Type and Diameter: Cable Tool 200mm

Client: MAYO COUNTY COUNCIL

Ground Level

Date: 15.7.93

Description	Reduced Level	Legend	Depth	Samples Ref No	Samples Type	Samples Depth	Field Records And Tests
MADE GROUND-gravel			0.90				
Soft dark very organic CLAY			1.90	7210	D	1.00	
Soft grey stony SILT			2.00	7211	D	2.00	(2.00)N=10
Medium dense clay bound silty sandy GRAVEL				7212	D	2.50	
Compact fine to coarse sandy GRAVEL with cobbles			3.40				(3.50)99/150 & refusal
				7213	D	4.00	
							(4.50)N=71
Refusal at 5.00m			5.00				
*Vane Test @ 1.20m							
Shear strength : 14.6 kN/m² Remould : 10.1 kN/m²							

Water Level Observations during Boring

Date	Hole Depth	Casing Depth	Depth to Water	Remarks
15.2.93	2.90	2.90	2.90	Water noted
	5.00	Nil	1.00	End of boring

Remarks

Chiselling at 3.70=1hr
Chiselling 3.40-3.50=2hrs

Sample/Test key
U-Tube Sample
D-Disturbed Sample
W-Water Sample
S-Standard Penetration Test
C-Cone Penetration Test
N-Blows/0.3 metres
R-Refusal
V-Vane

8604

Report No	BORING RECORD	
2263/C		

Contract: KNOCK/CLAREMORRIS BY-PASS

Borehole No: 800

Sheet:

Location:

Type and Diameter: Cable Tool 200mm

Client: MAYO COUNTY COUNCIL

Ground Level:

Date: 6.7.93 - 7.7.93

Description	Reduced Level	Legend	Depth	Samples Ref No.	Type	Depth	Field Records And Tests
MADE GROUND - gravelly CLAY with cobbles and boulders				2274	D	1.00	
			1.70	2275	D	1.80	
Soft dark brown silty PEAT							2.00 Vane
				2276	U	2.50	
			3.60				
Grey sandy gravelly CLAY			4.00	2277	D	4.00	4.00 N=18
Firm grey gravelly SILT			4.20				
Compact grey slightly silty sandy GRAVEL with cobbles (Refusal at 6.00)				2278	D	4.50	
							5.50 N=36
			6.00				
Clearing area for rig : 1½ hrs							
Vane test at 2.00							
Shear strength : 27 kN/m² Remoulded : 197 kN/m²							

Water Level Observations during Boring

Date	Hole Depth	Casing Depth	Depth to Water	Remarks
6.7.93	-	-	-	No free water

Remarks

Chiselling in fill : 1hr
do boulder at 3.60: 1 hr
do at 6.00: 2 hrs.

Sample/Test key	
U-Tube Sample	C-Cone Penetration Test
D-Disturbed Sample	N-Blows/0.3 metres
W-Water Sample	R-Refusal
S-Standard Penetration Test	V-Vane

86056

Report No 2263

BORING RECORD

Contract: KNOCK / CLAREMORRIS BY-PASS

Borehole No. 10500

Sheet

Location: CO.MAYO

Type and Diameter: Cable Tool 200mm

Client: MAYO COUNTY COUNCIL

Ground Level

Date: 19.7.93

Description	Reduced Level	Legend	Depth	Samples Ref No.	Samples Type	Samples Depth	Field Records And Tests
Firm to stiff grey sandy gravelly CLAY with cobbles				7220	D	1.00	(1.50)35/150R
			1.80				(1.80)N=R
Refusal at 1.80 (Possibly bedrock)							
*Difficult location - 3hrs setting up rig							

Water Level Observations during Boring

Date	Hole Depth	Casing Depth	Depth to Water	Remarks
19.7.93			DRY	No free water

Remarks

Chiselling at 1.80=2hrs

Sample/Test key
U-Tube Sample
D-Disturbed Sample
W-Water Sample
S-Standard Penetration Test
C-Cone Penetration Test
N-Blows/0.3 metres
R-Refusal
V-Vane

36055

Report No 2263

BORING RECORD

Contract: KNOCK / CLAREMORRIS BY-PASS

Borehole No: 9600R

Sheet:

Location: CO.MAYO

Type and Diameter: Cable Tool 200mm

Client: MAYO COUNTY COUNCIL

Ground Level:

Date: 20.7.93

Description	Reduced Level	Legend	Depth	Samples Ref No	Samples Type	Samples Depth	Field Records And Tests
TOPSOIL			0.40				
Firm grey silty sandy gravelly CLAY				7221	D	1.00	
			1.30	7222	D	1.50	(1.50) N=11
Firm brown sandy gravelly CLAY with cobbles							
			2.40	7223	D	2.50	
Medium dense to compact fine to coarse sandy GRAVEL with cobbles							(3.00) N=13
							(4.00) N=54
			4.90				
Refusal at 4.90m							

Water Level Observations during Boring

Date	Hole Depth	Casing Depth	Depth to Water	Remarks
20.7.93	2.80	2.80	2.80	Water noted
	4.90	Nil	2.00	End of boring

Remarks

Chiselling at 2.30=1hr

Chiselling at 4.90 = 2hrs

Sample/Test key
U-Tube Sample
D-Disturbed Sample
W-Water Sample
S-Standard Penetration Test
C-ConePenetration Test
N-Blows/0.3 metres
R-Refusal
V-Vane

86057

Report No. 2263

BORING RECORD

Contract: KNOCK / CLAREMORRIS BY-PASS

Borehole No. 11150L

Sheet

Location: CO.MAYO

Type and Diameter: Cable Tool 200mm

Client: MAYO COUNTY COUNCIL

Ground Level

Date: 21.7.93

Description	Reduced Level	Legend	Depth	Samples Ref No	Samples Type	Samples Depth	Field Records And Tests
MADE GROUND			0.40				
Firm to stiff grey silty sandy gravelly CLAY				7224	D	1.00	(1.50)N=20
Medium dense fine to coarse GRAVEL with some sand			2.80	7225	D	3.00	(3.00)N=24
Compact fine to coarse angular slightly sandy GRAVEL with a slight silt binding			3.70	7226	D	4.00	(4.00)N=14 (5.00)N=37 (6.00)N=44 (7.20)N=47
Fragments of boulders			7.70				
Refusal at 7.80m			7.80	7227	D	7.80	

Water Level Observations during Boring

Date	Hole Depth	Casing Depth	Depth to Water	Remarks
21.7.93	2.80	2.80	2.80	Water sealed
	7.80	Nil	1.00	End of boring

Remarks

Chiselling cobbles at 6.80=1hr
Chiselling 7.70-7.80=2hrs

Sample/Test key
U-Tube Sample
D-Disturbed Sample
W-Water Sample
S-Standard Penetration Test
C-Cone Penetration Test
N-Blows/0.3 metres
R-Refusal
V-Vane

86058

Report No	2263	BORING RECORD	
Contract	KNOCK / CLAREMORRIS BY-PASS	Borehole No	11150R
		Sheet	
Location	CO.MAYO	Type and Diameter	Cable Tool 200mm
Client	MAYO COUNTY COUNCIL	Ground Level	
		Date	22.7.93

Description	Reduced Level	Legend	Depth	Samples Ref No	Type	Depth	Field Records And Tests
FILL-Stones,gravels			0.60				
Firm to stiff grey silty sandy gravelly CLAY				7228	D	1.00	(1.50)N=24
			2.70				
medium dense fine to coarse sandy GRAVEL				7229	D	3.00	(3.00)N=24
			4.10				(4.00)N=23
Compact grey angular fine to coarse silty sandy GRAVEL with cobbles and boulders				7230	D	5.50	(5.50)N=42
			6.80				(6.50)30/150mm
Refusal at 6.80m Probably boulders							(6.80)N=R

Water Level Observations during Boring

Date	Hole Depth	Casing Depth	Depth to Water	Remarks
22.7.93	2.70	2.70	2.70	Water noted
	6.80	Nil	1.60	End of boring

Remarks

Chiselling at 6.40m=¼hr

Chiselling at 6.80m=2hrs

Sample/Test key	C-Cone Penetration Test
U-Tube Sample	N-Blows/0.3 metres
D-Disturbed Sample	R-Refusal
W-Water Sample	V-Vane
S-Standard Penetration Test	

86059

Report No. 2263

BORING RECORD

Contract: KNOCK / CLAREMORRIS BY-PASS

Borehole No. 11950

Sheet

Location: CO.MAYO

Type and Diameter: Cable Tool 200mm

Client: MAYO COUNTY COUNCIL

Ground Level

Date: 23.7.93

Description	Reduced Level	Legend	Depth	Samples Ref No	Samples Type	Samples Depth	Field Records And Tests
Soft dark brown peaty silty CLAY			1.00	7231	D	1.00	
Firm grey silty sandy gravelly CLAY improving to stiff with penetration							(1.50)N=18
							(3.00)N=29
			4.50	7232	D	4.50	
Stiff grey very gravelly CLAY with boulders			5.00				(5.00)N=R
Refusal at 5.00m							

Water Level Observations during Boring

Date	Hole Depth	Casing Depth	Depth to Water	Remarks
23.7.93	4.10	4.10	4.10	Water seepage
	5.00	Nil	3.10	End of boring

Remarks

Chiselling at 5.00m = 2hrs

Sample/Test key
U-Tube Sample
D-Disturbed Sample
W-Water Sample
S-Standard Penetration Test
C-Cone Penetration Test
N-Blows/0.3 metres
R-Refusal
V-Vane

36060

Report No. 2263	BORING RECORD	
Contract: KNOCK / CLAREMORRIS BY-PASS		Borehole No. 13050 / Sheet
Location: CO.MAYO		Type and Diameter: Cable Tool 200mm
Client: MAYO COUNTY COUNCIL		Ground Level / Date: 26.7.93

Description	Reduced Level	Legend	Depth	Samples: Ref No.	Type	Depth	Field Records And Tests
MADE GROUND-coarse material, boulders and cobbles			0.70				
Soft dark brown PEAT with fragments of decomposed timber				7233	D	1.00	(1.20)Vane Te (1.50)N=1
Medium dense silty sandy GRAVEL with cobbles			2.60	7234	D	3.00	(3.00)N=25
Compact grey silty sandy GRAVEL with cobbles			3.70	7235	D	4.00	(4.00)33/15
Refusal at 4.50m			4.50				(4.50)N=R
Vane at 1.20m Shear strength : 12.8 kN/m² Remould : 9.1 kN/m²							

Water Level Observations during Boring

Date	Hole Depth	Casing Depth	Depth to Water	Remarks
26.7.93	4.50	4.50	4.50	Water noted
	4.50	Nil	3.60	End of boring

Remarks

Chiselling FILL=1hr

Chiselling at 4.50m=2hrs

Sample/Test key	C-Cone Penetration Test
U-Tube Sample	N-Blows/0.3 metres
D-Disturbed Sample	R-Refusal
W-Water Sample	V-Vane
S-Standard Penetration Test	

8606

Report No	2263	BORING RECORD	
Contract	KNOCK / CLAREMORRIS BY-PASS	Borehole No	13775
		Sheet	
Location	CO.MAYO	Type and Diameter	Cable Tool 200mm
Client	MAYO COUNTY COUNCIL	Ground Level	
		Date	28.7.93

Description	Reduced Level	Legend	Depth	Samples Ref No	Samples Type	Samples Depth	Field Records And Tests
Brown sandy claybound GRAVEL with cobbles							
			0.90	7248	D	0.90	
Compact fine to coarse sandy GRAVEL with cobbles and boulders							(1.50)N=50
				7249	D	2.50	
Refusal at 2.70m			2.70				(2.70)N=R

Water Level Observations during Boring

Date	Hole Depth	Casing Depth	Depth to Water	Remarks
28.7.93	2.30	2.30	2.30	Water noted
	2.70	Nil	2.30	End of boring

Remarks
Chiselling at 0.90m=¾hr
Chiselling at 2.70m=2hrs

Sample/Test key
U-Tube Sample
D-Disturbed Sample
W-Water Sample
S-Standard Penetration Test
C-Cone Penetration Test
N-Blows/0.3 metres
R-Refusal
V-Vane

86062

Report No. 2263

BORING RECORD

Contract: KNOCK / CLAREMORRIS BY-PASS

Borehole No. 14025

Sheet

Location: CO.MAYO

Type and Diameter: Cable Tool 200mm

Client: MAYO COUNTY COUNCIL

Ground Level

Date: 28.7.93

Description	Reduced Level	Legend	Depth	Samples Ref No	Samples Type	Samples Depth	Field Records And Tests
Soft dark PEAT			0.30				
Soft grey silty CLAY with traces of gravel and occ. cobbles				7250	D	1.00	(1.60)N=6
Compact grey fine to coarse silty GRAVEL			2.10	7251	D	2.50	(3.00)N=46
Compact fine to coarse angular slightly sandy GRAVEL with cobbles and boulders			3.20	7252	D	4.00	(4.00)18/150mm
Borehole complete at 4.40m			4.40				(4.40)N=R

Water Level Observations during Boring

Date	Hole Depth	Casing Depth	Depth to Water	Remarks
28.7.93	2.90	2.90	2.90	Water noted
	4.40	Nil	1.50	End of boring

Remarks

Chiselling at 4.40m=2hrs

Sample/Test key
U-Tube Sample
D-Disturbed Sample
W-Water Sample
S-Standard Penetration Test
C-Cone Penetration Test
N-Blows/0.3 metres
R-Refusal
V-Vane

3603

Report No	2263	BORING RECORD	

Contract: KNOCK / CLAREMORRIS BY-PASS

Borehole No: 14675

Sheet:

Location: CO.MAYO

Type and Diameter: Cable Tool 200mm

Client: MAYO COUNTY COUNCIL

Ground Level:

Date: 29.7.93

Description	Reduced Level	Legend	Depth	Samples Ref No	Samples Type	Samples Depth	Field Records And Tests
Firm brown sandy gravelly CLAY				7253	D	1.00	
			1.20				
Medium dense fine to coarse sandy GRAVEL with occasional cobbles							(1.50)N=26
				7254	D	2.00	
			2.30				
Compact fine to coarse sandy GRAVEl with cobbles							(3.00)N=36
				7255	D	3.50	
			4.00				
Borehole complete at 4.00m							

Water Level Observations during Boring

Date	Hole Depth	Casing Depth	Depth to Water	Remarks
29.7.93	1.90	1.90	1.90	Water noted
	4.00	Nil	1.50	End of boring

Remarks

Chiselling cobbles 2 hours

Sample/Test key
U-Tube Sample
D-Disturbed Sample
W-Water Sample
S-Standard Penetration Test
C-Cone Penetration Test
N-Blows/0.3 metres
R-Refusal
V-Vane

86053

Report No 2263/C

BORING RECORD

Borehole No 9275

Sheet

Contract KNOCK/CLAREMORRIS BY-PASS

Location

Type and Diameter Cable Tool 200mm

Client MAYO COUNTY COUNCIL

Ground Level

Date 15.7.93

Description	Reduced Level	Legend	Depth	Samples Ref No	Samples Type	Samples Depth	Field Records And Tests
TOPSOIL			0.20				
Firm to stiff yellow grey silty sandy CLAY with some stones				7215	D	1.00	(1.50)N=17
			1.70				
Stiff grey silty sandy gravelly CLAY				7216	D	2.50	(3.00)N=56
			3.80				
Refusal at 3.80m							
*Attempted U100 Samples on two occasions-ground too granular							

Water Level Observations during Boring

Date	Hole Depth	Casing Depth	Depth to Water	Remarks
15.7.93	3.80	3.80	Nil	No free water

Remarks

Chiselling boulders=2½hrs

Sample/Test key
U Tube Sample
D Disturbed Sample
W Water Sample
S Standard Penetration Test
C Cone Penetration Test
N Blows/0.3 metres
R Refusal
V Vane

86042

Report No	BORING RECORD	
2263/C		

Contract: KNOCK/CLAREMORRIS BY-PASS

Borehole No: 1250 L

Sheet:

Location:

Client: MAYO COUNTY COUNCIL

Type and Diameter: Cable Tool 200mm

Ground Level:

Date: 6.7.93

Description	Reduced Level	Legend	Depth	Samples Ref No	Samples Type	Samples Depth	Field Records And Tests
MADE GROUND (gravel)							
Soft brown fibrous PEAT			0.60	2270	D	1.00	1.20 Vane
			1.40	2271	D	1.50	1.50 N=24
Firm to stiff grey silty sandy gravelly CLAY with cobbles				2272	D	2.80	
			2.80				3.20 N=44
Compact fine to coarse angular sandy GRAVEL with cobbles			3.70	2273	W	Water	
Refusal at 3.70							
Vane Test at 1.20							
Shear strength : 11.5 kN/m² Remould : 8.7 kN/m²							

Water Level Observations during Boring

Date	Hole Depth	Casing Depth	Depth to Water	Remarks
6.7.93	2.70	2.70	2.70	Water noted
	3.70	Nil	1.50	Final Level

Remarks

Chiselling cobbles @ 1.70: 45 m.
" at 3.70 : 2 hrs

Sample/Test key
U-Tube Sample
D-Disturbed Sample
W-Water Sample
S-Standard Penetration Test
C-Cone Penetration Test
N-Blows/0.3 metres
R-Refusal
V-Vane

86052

Report No	BORING RECORD	
2263/C		

Contract: KNOCK/CLAREMORRIS BY-PASS

Borehole No: 8525

Sheet:

Location:

Type and Diameter: Cable Tool 200mm

Client: MAYO COUNTY COUNCIL

Ground Level:

Date: 16.7.93

Description	Reduced Level	Legend	Depth	Samples Ref No	Samples Type	Samples Depth	Field Records And Tests
Stone FILL			0.30				
Firm brown silty CLAY				7217	D	1.00	(1.50)N=18
			1.70				
STiff grey silty sandy gravelly CLAY with cobbles				7218	D	2.00	
				7219	D	3.00	(3.00)N=42
Borehole complete at 3.70m to refusal			3.70				

Water Level Observations during Boring

Date	Hole Depth	Casing Depth	Depth to Water	Remarks
16.7.93				No free water

Remarks
Chiselling 0.00-0.30=½hr
Chiselling at 3.70=1hr

Sample/Test key
U-Tube Sample
D-Disturbed Sample
W-Water Sample
S-Standard Penetration Test
C-Cone Penetration Test
N-Blows/0.3 metres
R-Refusal
V-Vane

8605

Report No 2263/C

BORING RECORD

Contract: KNOCK/CLAREMORRIS BY-PASS

Borehole No 7625

Sheet

Location

Type and Diameter: Cable Tool 200mm

Client: MAYO COUNTY COUNCIL

Ground Level

Date: 14.7.93

Description	Reduced Level	Legend	Depth	Samples Ref No	Samples Type	Samples Depth	Field Records And Tests
Soft mottled grey brown silty sandy CLAY							
			1.50	7207	D	1.40	(1.50)N=23
Firm grey silty sandy gravelly CLAY				7208	D	2.00	
			2.20				
Compact fine to coarse slightly sandy GRAVEL with cobbles				7209	D	3.00	(3.00)N=33
			3.70				
Refusal at 3.70							

Water Level Observations during Boring

Date	Hole Depth	Casing Depth	Depth to Water	Remarks
14.7.93	1.90	1.90	1.90	Water noted
	3.70	Nil	1.30	End of boring

Remarks

&hiselling at 3.70=2hrs

Sample/Test key
U Tube Sample
D Disturbed Sample
W Water Sample
S Standard Penetration Test
C Cone Penetration Test
N Blows/0.3 metres
R Refusal
V Vane

36045

Report No	BORING RECORD
2263/C	

Contract: KNOCK/CLAREMORRIS BY-PASS

Borehole No: 2400

Sheet:

Location:

Type and Diameter: Cable Tool 200mm

Client: MAYO COUNTY COUNCIL

Ground Level:

Date: 7.7.93

Description	Reduced Level	Legend	Depth	Samples: Ref No	Samples: Type	Samples: Depth	Field Records And Tests
MADE GROUND (gravel)			0.90				
Soft dark brown silty fibrous PEAT				2279	D	1.00	1.20 Vane
				2280	U	2.00	
			3.70				
Soft grey-white silty MARL				2281	D	3.80	4.00 Vane
				2282	U	4.20	
			4.60	2283	D	4.70	
Soft grey sandy SILT			4.90	2284	D	5.00	4.90 N=17
Compact fine to coarse sandy GRAVEL with cobbles				2285	D	5.50	5.40 N=45
			5.70				
(Refusal at 5.70)							
Vane Tests : At 1.20							
Shear strength : 22.4 kN/m²							
Remould : 14.8 kN/m²							
At 4.00							
Shear strength : 13.5 kN/m²							
Remould : 9.60 kN/m²							

Water Level Observations during Boring

Date	Hole Depth	Casing Depth	Depth to Water	Remarks
7.7.93	4.90	4.90	4.90	Water noted
	5.70	Nil	5.70	End of boring

Remarks

Chiselling at 5.70: 2 hrs.

Sample/Test key	C-Cone Penetration Test
U-Tube Sample	N-Blows/0.3 metres
D-Disturbed Sample	R-Refusal
W-Water Sample	V-Vane
S-Standard Penetration Test	

86044

Report No	BORING RECORD	
2263/C		

Contract: KNOCK/CLAREMORRIS BY-PASS

Borehole No: 1875 L

Sheet:

Location:

Type and Diameter: Cable Tool 200mm

Client: MAYO COUNTY COUNCIL

Ground Level:

Date: 9.7.93 - 12.7.93

Description	Reduced Level	Legend	Depth	Samples Ref No.	Samples Type	Samples Depth	Field Records And Tests
MADE GROUND -stony clay			0.80				
Firm to stiff brown silty sandy gravelly CLAY with cobbles				2294	D	1.00	1.50 N 11
				2295	D	2.20	3.00 N 59
				2296	U	4.50	
			5.00				
*Excavated by hand to 1.00m for services							

Water Level Observations during Boring

Date	Hole Depth	Casing Depth	Depth to Water	Remarks
9.7.93			Dry	No free water

Remarks

Chiselling cobbles : 1 hr.
do @ 5.00 : 1 hr.

Sample/Test key
U-Tube Sample
D-Disturbed Sample
W-Water Sample
S-Standard Penetration Test
C-Cone Penetration Test
N-Blows/0.3 metres
R-Refusal
V-Vane

86013

Report No.	BORING RECORD	
2263/C		

Contract: KNOCK/CLAREMORRIS BY-PASS

Borehole No: 1250R

Sheet:

Location:

Type and Diameter: Cable Tool 200mm

Client: MAYO COUNTY COUNCIL

Ground Level:

Date: 5.7.93

Description	Reduced Level	Legend	Depth	Samples Ref No.	Samples Type	Samples Depth	Field Records And Tests
MADE GROUND (sandy gravel)			1.10	2266	D	1.10	
Soft dark brown silty fibrous PEAT							1.50 Vane
			3.00	2267	D	3.10	3.00 19/150: & Refus:
Compact fine to coarse angular sandy GRAVEL with some cobbles			3.80				
Fragments of grey ROCK			3.90	2268	D	3.90	3.90 Refusa.
				2269	W	Water	
Vane test at 1.50							
Shear strength : 7.7 kN/m2 Remould : 5.2 kN/m2							

Water Level Observations during Boring

Date	Hole Depth	Casing Depth	Depth to Water	Remarks
5.7.93	2.90	2.90	2.90	Water noted
	3.90	Nil	2.00	End of boring

Remarks

Chiselling at 3.40 : 1½ hrs.
do at 3.80-3.90: 2 hrs

Sample/Test key
U-Tube Sample
D-Disturbed Sample
W-Water Sample
S-Standard Penetration Test
C-Cone Penetration Test
N-Blows/0.3 metres
R-Refusal
V-Vane

86064

Report No 2263

BORING RECORD

Contract
KNOCK / CLAREMORRIS BY-PASS

Borehole No 15250

Sheet

Location CO.MAYO

Type and Diameter Cable Tool 200mm

Client
MAYO COUNTY COUNCIL

Ground Level

Date 29.7.93

Description	Reduced Level	Legend	Depth	Samples Ref No	Samples Type	Samples Depth	Field Records And Tests
Firm grey silty sandy gravelly CLAY with cobbles							
			1.50	7256	D	1.40	(1.50)N=22
Medium dense fine to coarse sandy GRAVEL				7257	D	2.00	
			2.30				
Stiff brown silty sandy gravelly CLAY							(3.00)N=44
				7258	D	3.50	
							(4.00)N=56
			4.50				
Borehole complete at 4.50m							

Water Level Observations during Boring

Date	Hole Depth	Casing Depth	Depth to Water	Remarks
29.7.93	1.70	1.70	1.70	Water noted
	2.40	2.40	Nil	Water sealed
	4.50	4.50	4.50	Water noted
	4.50	Nil	1.70	End of boring

Remarks

Chiselling cobbles at 1.20=¼hr

Sample/Test key
U-Tube Sample
D-Disturbed Sample
W-Water Sample
S-Standard Penetration Test
C-Cone Penetration Test
N-Blows/0.3 metres
R-Refusal
V-Vane

86065

Report No 2263

BORING RECORD

Contract: KNOCK / CLAREMORRIS BY-PASS

Borehole No 15625

Sheet

Location: CO.MAYO

Type and Diameter: Cable Tool 200mm

Client: MAYO COUNTY COUNCIL

Ground Level

Date: 29.7.93

Description	Reduced Level	Legend	Depth	Samples Ref No	Samples Type	Samples Depth	Field Records And Tests
Medium dense brown sandy GRAVEL				7259	D	1.00	
			1.50				(1.50)N=27
Compact fine to coarse sandy GRAVEL with cobbles				7260	D	2.00	
							(3.00)N=51
			3.60	7261	D	3.60	
Refusal at 3.60m							

Water Level Observations during Boring

Date	Hole Depth	Casing Depth	Depth to Water	Remarks
29.7.93	3.00	3.00	3.00	Water noted
	3.60	Nil	3.00	End of boring

Remarks

Chiselling at 3.60m=1hr

25

Sample/Test key
U-Tube Sample
D-Disturbed Sample
W-Water Sample
S-Standard Penetration Test
C-Cone Penetration Test
N-Blows/0.3 metres
R-Refusal
V-Vane

86046

Report No	BORING RECORD
2263/C	

Contract: KNOCK/CLAREMORRIS BY-PASS

Borehole No: 3200

Sheet:

Location:

Type and Diameter: Cable Tool 200mm

Client: MAYO COUNTY COUNCIL

Ground Level:

Date: 8.7.93

Description	Reduced Level	Legend	Depth	Samples Ref No	Samples Type	Samples Depth	Field Records And Tests
Firm brown sandy gravelly CLAY with cobbles							
			1.20	2286	D	1.30	
Firm grey sandy gravelly CLAY			1.60				1.50 N=13
Compact silty sandy GRAVEL with cobbles							3.00 N=35
			3.70				
Stiff grey sandy gravelly CLAY with cobbles				2288	D	4.00	
				2289	D	4.50	4.50 Refusa
			5.50	2290	D	5.50	5.50 25/150 & Refusa
Stiff brown sandy stony CLAY with cobbles			6.00				

Water Level Observations during Boring

Date	Hole Depth	Casing Depth	Depth to Water	Remarks
8.7.93	1.60	1.60	1.60	Water noted
	2.90	2.90	Nil	Water sealed
	5.80	5.80	5.80	Water noted
	6.00	Nil	1.80	End of boring

Remarks

Chiselling @ 6.00 : 1½ hrs
do @ 4.50 : 1 hr.

Sample/Test key
U-Tube Sample
D-Disturbed Sample
W-Water Sample
S-Standard Penetration Test
C-Cone Penetration Test
N-Blows/0.3 metres
R-Refusal
V-Vane

86047

Report No.	BORING RECORD	
2263/C		

Contract: KNOCK/CLAREMORRIS BY-PASS

Borehole No: 3675

Sheet:

Location:

Type and Diameter: Cable Tool 200mm

Client: MAYO COUNTY COUNCIL

Ground Level:

Date: 8.7.93

Description	Reduced Level	Legend	Depth	Samples Ref No	Samples Type	Samples Depth	Field Records And Tests
FILL (brown sandy CLAY)			0.70	2291	D	1.00	
Soft dark brown PEAT			1.60				1.60 N=22
Medium dense to dense fine to coarse sandy GRAVEL with cobbles and boulders				2292	D	2.50	
							3.00 N=32
				2293	D	3.80	
Refusal at 4.50			4.50				4.50 Refusa

Water Level Observations during Boring

Date	Hole Depth	Casing Depth	Depth to Water	Remarks
8.7.93	1.80	1.80	1.80	Water noted
	4.50	Nil	1.30	End of boring

Remarks

Chiselling in cobbles: 1 hr

Sample/Test key
U Tube Sample
D Disturbed Sample
W Water Sample
S Standard Penetration Test
C Cone Penetration Test
N Blows/0.3 metres
R Refusal
V Vane

86098

Report No	BORING RECORD	
2263/C		

Contract: KNOCK/CLAREMORRIS BY-PASS

Borehole No: 4325

Sheet:

Location:

Type and Diameter: Cable Tool 200mm

Client: MAYO COUNTY COUNCIL

Ground Level:

Date: 13.7.93

Description	Reduced Level	Legend	Depth	Samples Ref No	Samples Type	Samples Depth	Field Records And Tests
TOPSOIL with loose sandy clay and root fibres			1.30				
Firm brown sandy CLAY			1.60	2299	D	1.50	1.50 N=14
Firm mottled grey brown silty CLAY			2.30	7202	D	2.00	
Firm brown silty sandy CLAY			4.10	7203	D	2.50	3.00 N=9
Compact fine to coarse slightly silty sandy GRAVEL with cobbles and boulders			6.50	7204	D	4.50	4.50 N=28 6.00 N=47
Refusal at 6.50m							

Water Level Observations during Boring

Date	Hole Depth	Casing Depth	Depth to Water	Remarks
13.7.93	3.90	3.90	3.90	Water noted
	6.50	Nil	3.60	End of boring

Remarks: Chiselling 4.10 - 6.50: 2 hrs

Sample/Test key

- U-Tube Sample
- D-Disturbed Sample
- W-Water Sample
- S-Standard Penetration Test
- C-Cone Penetration Test
- N-Blows/0.3 metres
- R-Refusal
- V-Vane

86049

Report No	BORING RECORD	
2263/C		

Contract: KNOCK/CLAREMORRIS BY-PASS

Borehole No: 6200

Sheet:

Location:

Type and Diameter: Cable Tool 200mm

Client: MAYO COUNTY COUNCIL

Ground Level:

Date: 13.7.93

Description	Reduced Level	Legend	Depth	Samples Ref No	Samples Type	Samples Depth	Field Records And Tests
TOPSOIL with loose sandy CLAY			1.30				
Firm brown sandy gravelly CLAY with cobbles			1.60	2297	D	1.40	1.50 N=13
Compact silty clayey sandy GRAVEL with cobbles				2298	D	2.50	3.00 21/15 & Ref.
			3.50				
REFUSAL at 3.50							

Water Level Observations during Boring

Date	Hole Depth	Casing Depth	Depth to Water	Remarks
13.7.93	3.50	-	Nil	No free water

Remarks

Chiselling at 3.50 : 2 hrs.

Sample/Test key
- U-Tube Sample
- D-Disturbed Sample
- W-Water Sample
- S-Standard Penetration Test
- C-Cone Penetration Test
- N-Blows/0.3 metres
- R-Refusal
- V-Vane

86050

Report No	BORING RECORD	
2263/C		

Contract: KNOCK/CLAREMORRIS BY-PASS

Borehole No: 6950

Sheet:

Location:

Type and Diameter: Cable Tool 200mm

Client: MAYO COUNTY COUNCIL

Ground Level:

Date: 14.7.93

Description	Reduced Level	Legend	Depth	Samples Ref No	Samples Type	Samples Depth	Field Records And Tests
Firm brown silty CLAY with some cobbles			0.90	7205	D	0.80	
Firm tostiff grey silty sandy gravelly CLAY with large cobbles				7206	D	2.00	1.50 Refusal (Boulder 3.00 22/150 & Refus
Refusal at 3.60m			3.60				

Water Level Observations during Boring

Date	Hole Depth	Casing Depth	Depth to Water	Remarks
14.7.93	3.60	3.60	Nil	No free water

Remarks:
Chiselling at 1.50: 1½ hrs.
do at 3.60: 2 hrs.

Sample/Test key
U-Tube Sample
D-Disturbed Sample
W-Water Sample
S-Standard Penetration Test
C-Cone Penetration Test
N-Blows/0.3 metres
R-Refusal
V-Vane

FEHILY TIMONEY
30 YEARS

CONSULTANTS IN ENGINEERING,
ENVIRONMENTAL SCIENCE & PLANNING

APPENDIX 5

LandGEM Summary Reports

Summary Report

Landfill Name or Identifier: Claremorris Historical Landfill - Co.Kerry

Date: Thursday 27 February 2020

Description/Comments:

About LandGEM:

First-Order Decomposition Rate Equation:

$$Q_{CH_4} = \sum_{i=1}^{n} \sum_{j=0.1}^{1} kL_o \left(\frac{M_i}{10} \right) e^{-kt_{ij}}$$

Where,

Q_{CH4} = annual methane generation in the year of the calculation ($m^3/year$)
i = 1-year time increment
n = (year of the calculation) - (initial year of waste acceptance)
j = 0.1-year time increment
k = methane generation rate ($year^{-1}$)
L_o = potential methane generation capacity (m^3/Mg)
M_i = mass of waste accepted in the i^{th} year (Mg)
t_{ij} = age of the j^{th} section of waste mass M_i accepted in the i^{th} year (*decimal years*, e.g., 3.2 years)

LandGEM is based on a first-order decomposition rate equation for quantifying emissions from the decomposition of landfilled waste in municipal solid waste (MSW) landfills. The software provides a relatively simple approach to estimating landfill gas emissions. Model defaults are based on empirical data from U.S. landfills. Field test data can also be used in place of model defaults when available. Further guidance on EPA test methods, Clean Air Act (CAA) regulations, and other guidance regarding landfill gas emissions and control technology requirements can be found at http://www.epa.gov/ttnatw01/landfill/landflpg.html.

LandGEM is considered a screening tool — the better the input data, the better the estimates. Often, there are limitations with the available data regarding waste quantity and composition, variation in design and operating practices over time, and changes occurring over time that impact the emissions potential. Changes to landfill operation, such as operating under wet conditions through leachate recirculation or other liquid additions, will result in generating more gas at a faster rate. Defaults for estimating emissions for this type of operation are being developed to include in LandGEM along with defaults for convential landfills (no leachate or liquid additions) for developing emission inventories and determining CAA applicability. Refer to the Web site identified above for future updates.

Input Review

LANDFILL CHARACTERISTICS

Landfill Open Year	**1982**	
Landfill Closure Year (with 80-year limit)	**1996**	
Actual Closure Year (without limit)	***1996***	
Have Model Calculate Closure Year?	**Yes**	
Waste Design Capacity	**168,000**	*megagrams*

MODEL PARAMETERS

Methane Generation Rate, k	**0.050**	*year^{-1}*
Potential Methane Generation Capacity, L_o	**170**	*m^3/Mg*
NMOC Concentration	**4,000**	*ppmv as hexane*
Methane Content	**50**	*% by volume*

GASES / POLLUTANTS SELECTED

Gas / Pollutant #1:	**Total landfill gas**
Gas / Pollutant #2:	**Methane**
Gas / Pollutant #3:	**Carbon dioxide**
Gas / Pollutant #4:	**NMOC**

WASTE ACCEPTANCE RATES

Year	Waste Accepted		Waste-In-Place	
	(Mg/year)	*(short tons/year)*	*(Mg)*	*(short tons)*
1982	11,200	12,320	0	0
1983	11,200	12,320	11,200	12,320
1984	11,200	12,320	22,400	24,640
1985	11,200	12,320	33,600	36,960
1986	11,200	12,320	44,800	49,280
1987	11,200	12,320	56,000	61,600
1988	11,200	12,320	67,200	73,920
1989	11,200	12,320	78,400	86,240
1990	11,200	12,320	89,600	98,560
1991	11,200	12,320	100,800	110,880
1992	11,200	12,320	112,000	123,200
1993	11,200	12,320	123,200	135,520
1994	11,200	12,320	134,400	147,840
1995	11,200	12,320	145,600	160,160
1996	11,200	12,320	156,800	172,480
1997	0	0	168,000	184,800
1998	0	0	168,000	184,800
1999	0	0	168,000	184,800
2000	0	0	168,000	184,800
2001	0	0	168,000	184,800
2002	0	0	168,000	184,800
2003	0	0	168,000	184,800
2004	0	0	168,000	184,800
2005	0	0	168,000	184,800
2006	0	0	168,000	184,800
2007	0	0	168,000	184,800
2008	0	0	168,000	184,800
2009	0	0	168,000	184,800
2010	0	0	168,000	184,800
2011	0	0	168,000	184,800
2012	0	0	168,000	184,800
2013	0	0	168,000	184,800
2014	0	0	168,000	184,800
2015	0	0	168,000	184,800
2016	0	0	168,000	184,800
2017	0	0	168,000	184,800
2018	0	0	168,000	184,800
2019	0	0	168,000	184,800
2020	0	0	168,000	184,800
2021	0	0	168,000	184,800

WASTE ACCEPTANCE RATES (Continued)

Year	Waste Accepted		Waste-In-Place	
	(Mg/year)	*(short tons/year)*	*(Mg)*	*(short tons)*
2022	0	0	168,000	184,800
2023	0	0	168,000	184,800
2024	0	0	168,000	184,800
2025	0	0	168,000	184,800
2026	0	0	168,000	184,800
2027	0	0	168,000	184,800
2028	0	0	168,000	184,800
2029	0	0	168,000	184,800
2030	0	0	168,000	184,800
2031	0	0	168,000	184,800
2032	0	0	168,000	184,800
2033	0	0	168,000	184,800
2034	0	0	168,000	184,800
2035	0	0	168,000	184,800
2036	0	0	168,000	184,800
2037	0	0	168,000	184,800
2038	0	0	168,000	184,800
2039	0	0	168,000	184,800
2040	0	0	168,000	184,800
2041	0	0	168,000	184,800
2042	0	0	168,000	184,800
2043	0	0	168,000	184,800
2044	0	0	168,000	184,800
2045	0	0	168,000	184,800
2046	0	0	168,000	184,800
2047	0	0	168,000	184,800
2048	0	0	168,000	184,800
2049	0	0	168,000	184,800
2050	0	0	168,000	184,800
2051	0	0	168,000	184,800
2052	0	0	168,000	184,800
2053	0	0	168,000	184,800
2054	0	0	168,000	184,800
2055	0	0	168,000	184,800
2056	0	0	168,000	184,800
2057	0	0	168,000	184,800
2058	0	0	168,000	184,800
2059	0	0	168,000	184,800
2060	0	0	168,000	184,800
2061	0	0	168,000	184,800

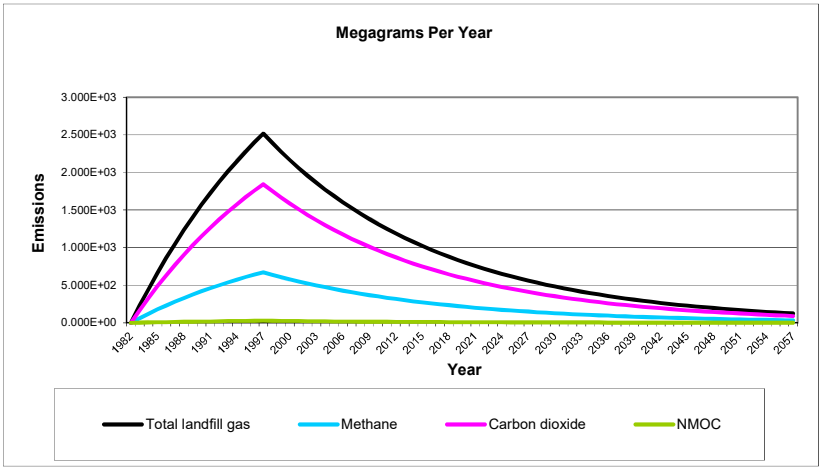
Pollutant Parameters

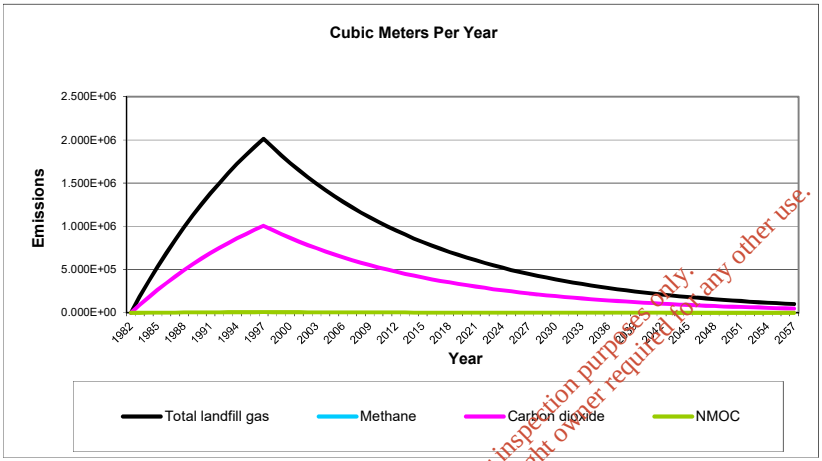
		Gas / Pollutant Default Parameters:		*User-specified Pollutant Parameters:*	
	Compound	Concentration (*ppmv*)	Molecular Weight	Concentration (*ppmv*)	Molecular Weight
Gases	Total landfill gas		0.00		
	Methane		16.04		
	Carbon dioxide		44.01		
	NMOC	4,000	86.18		
Pollutants	1,1,1-Trichloroethane (methyl chloroform) - HAP	0.48	133.41		
	1,1,2,2-Tetrachloroethane - HAP/VOC	1.1	167.85		
	1,1-Dichloroethane (ethylidene dichloride) - HAP/VOC	2.4	98.97		
	1,1-Dichloroethene (vinylidene chloride) - HAP/VOC	0.20	96.94		
	1,2-Dichloroethane (ethylene dichloride) - HAP/VOC	0.41	98.96		
	1,2-Dichloropropane (propylene dichloride) - HAP/VOC	0.18	112.99		
	2-Propanol (isopropyl alcohol) - VOC	50	60.11		
	Acetone	7.0	58.08		
	Acrylonitrile - HAP/VOC	6.3	53.06		
	Benzene - No or Unknown Co-disposal - HAP/VOC	1.9	78.11		
	Benzene - Co-disposal - HAP/VOC	11	78.11		
	Bromodichloromethane - VOC	3.1	163.83		
	Butane - VOC	5.0	58.12		
	Carbon disulfide - HAP/VOC	0.58	76.13		
	Carbon monoxide	140	28.01		
	Carbon tetrachloride - HAP/VOC	4.0E-03	153.84		
	Carbonyl sulfide - HAP/VOC	0.49	60.07		
	Chlorobenzene - HAP/VOC	0.25	112.56		
	Chlorodifluoromethane	1.3	86.47		
	Chloroethane (ethyl chloride) - HAP/VOC	1.3	64.52		
	Chloroform - HAP/VOC	0.03	119.39		
	Chloromethane - VOC	1.2	50.49		
	Dichlorobenzene - (HAP for para isomer/VOC)	0.21	147		
	Dichlorodifluoromethane	16	120.91		
	Dichlorofluoromethane - VOC	2.6	102.92		
	Dichloromethane (methylene chloride) - HAP	14	84.94		
	Dimethyl sulfide (methyl sulfide) - VOC	7.8	62.13		
	Ethane	890	30.07		
	Ethanol - VOC	27	46.08		

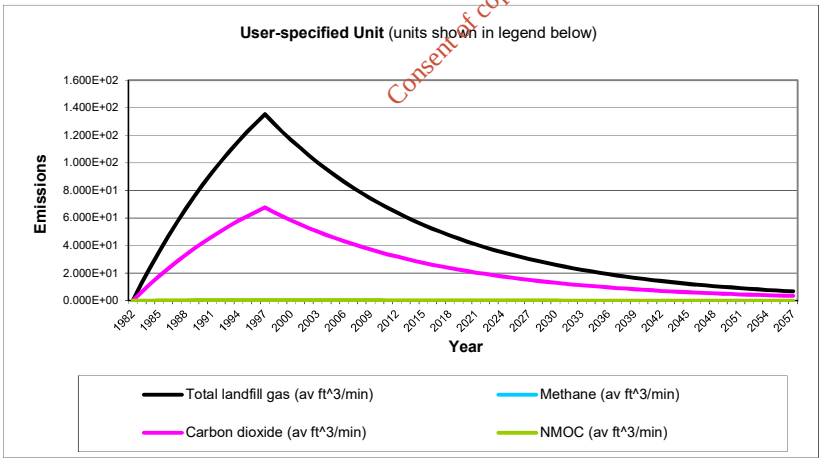
Pollutant Parameters (Continued)

		Gas / Pollutant Default Parameters:		*User-specified Pollutant Parameters:*	
	Compound	Concentration (*ppmv*)	Molecular Weight	Concentration (*ppmv*)	Molecular Weight
Pollutants	Ethyl mercaptan (ethanethiol) - VOC	2.3	62.13		
	Ethylbenzene - HAP/VOC	4.6	106.16		
	Ethylene dibromide - HAP/VOC	1.0E-03	187.88		
	Fluorotrichloromethane - VOC	0.76	137.38		
	Hexane - HAP/VOC	6.6	86.18		
	Hydrogen sulfide	36	34.08		
	Mercury (total) - HAP	2.9E-04	200.61		
	Methyl ethyl ketone - HAP/VOC	7.1	72.11		
	Methyl isobutyl ketone - HAP/VOC	1.9	100.16		
	Methyl mercaptan - VOC	2.5	48.11		
	Pentane - VOC	3.3	72.15		
	Perchloroethylene (tetrachloroethylene) - HAP	3.7	165.83		
	Propane - VOC	11	44.09		
	t-1,2-Dichloroethene - VOC	2.8	96.94		
	Toluene - No or Unknown Co-disposal - HAP/VOC	39	92.13		
	Toluene - Co-disposal - HAP/VOC	170	92.13		
	Trichloroethylene (trichloroethene) - HAP/VOC	2.8	131.40		
	Vinyl chloride - HAP/VOC	7.3	62.50		
	Xylenes - HAP/VOC	12	106.16		

Graphs







Results

Year	Total landfill gas			Methane		
	(Mg/year)	(m^3/year)	(av ft^3/min)	(Mg/year)	(m^3/year)	(av ft^3/min)
1982	0	0	0	0	0	0
1983	2.325E+02	1.862E+05	1.251E+01	6.211E+01	9.309E+04	6.255E+00
1984	4.537E+02	3.633E+05	2.441E+01	1.212E+02	1.816E+05	1.220E+01
1985	6.641E+02	5.318E+05	3.573E+01	1.774E+02	2.659E+05	1.786E+01
1986	8.642E+02	6.920E+05	4.650E+01	2.308E+02	3.460E+05	2.325E+01
1987	1.055E+03	8.444E+05	5.674E+01	2.817E+02	4.222E+05	2.837E+01
1988	1.236E+03	9.894E+05	6.648E+01	3.300E+02	4.947E+05	3.324E+01
1989	1.408E+03	1.127E+06	7.575E+01	3.761E+02	5.637E+05	3.787E+01
1990	1.572E+03	1.259E+06	8.456E+01	4.198E+02	6.293E+05	4.228E+01
1991	1.728E+03	1.383E+06	9.295E+01	4.615E+02	6.917E+05	4.647E+01
1992	1.876E+03	1.502E+06	1.009E+02	5.011E+02	7.510E+05	5.046E+01
1993	2.017E+03	1.615E+06	1.085E+02	5.387E+02	8.075E+05	5.426E+01
1994	2.151E+03	1.722E+06	1.157E+02	5.746E+02	8.612E+05	5.786E+01
1995	2.279E+03	1.825E+06	1.226E+02	6.086E+02	9.123E+05	6.130E+01
1996	2.400E+03	1.922E+06	1.291E+02	6.411E+02	9.609E+05	6.456E+01
1997	2.515E+03	2.014E+06	1.353E+02	6.719E+02	1.007E+06	6.767E+01
1998	2.393E+03	1.916E+06	1.287E+02	6.391E+02	9.580E+05	6.437E+01
1999	2.276E+03	1.823E+06	1.225E+02	6.080E+02	9.113E+05	6.123E+01
2000	2.165E+03	1.734E+06	1.165E+02	5.783E+02	8.668E+05	5.824E+01
2001	2.059E+03	1.649E+06	1.108E+02	5.501E+02	8.246E+05	5.540E+01
2002	1.959E+03	1.569E+06	1.054E+02	5.233E+02	7.844E+05	5.270E+01
2003	1.863E+03	1.492E+06	1.003E+02	4.978E+02	7.461E+05	5.013E+01
2004	1.773E+03	1.419E+06	9.537E+01	4.735E+02	7.097E+05	4.769E+01
2005	1.686E+03	1.350E+06	9.072E+01	4.504E+02	6.751E+05	4.536E+01
2006	1.604E+03	1.284E+06	8.630E+01	4.284E+02	6.422E+05	4.315E+01
2007	1.526E+03	1.222E+06	8.209E+01	4.075E+02	6.109E+05	4.104E+01
2008	1.451E+03	1.162E+06	7.808E+01	3.877E+02	5.811E+05	3.904E+01
2009	1.381E+03	1.105E+06	7.427E+01	3.687E+02	5.527E+05	3.714E+01
2010	1.313E+03	1.052E+06	7.065E+01	3.508E+02	5.258E+05	3.533E+01
2011	1.249E+03	1.000E+06	6.721E+01	3.337E+02	5.001E+05	3.360E+01
2012	1.188E+03	9.515E+05	6.393E+01	3.174E+02	4.757E+05	3.196E+01
2013	1.130E+03	9.051E+05	6.081E+01	3.019E+02	4.525E+05	3.041E+01
2014	1.075E+03	8.609E+05	5.785E+01	2.872E+02	4.305E+05	2.892E+01
2015	1.023E+03	8.189E+05	5.502E+01	2.732E+02	4.095E+05	2.751E+01
2016	9.728E+02	7.790E+05	5.234E+01	2.599E+02	3.895E+05	2.617E+01
2017	9.254E+02	7.410E+05	4.979E+01	2.472E+02	3.705E+05	2.489E+01
2018	8.803E+02	7.049E+05	4.736E+01	2.351E+02	3.524E+05	2.368E+01
2019	8.373E+02	6.705E+05	4.506E+01	2.237E+02	3.352E+05	2.252E+01
2020	7.965E+02	6.378E+05	4.285E+01	2.127E+02	3.189E+05	2.143E+01
2021	7.576E+02	6.067E+05	4.076E+01	2.024E+02	3.033E+05	2.038E+01
2022	7.207E+02	5.771E+05	3.877E+01	1.925E+02	2.885E+05	1.939E+01
2023	6.855E+02	5.489E+05	3.688E+01	1.831E+02	2.745E+05	1.844E+01
2024	6.521E+02	5.222E+05	3.508E+01	1.742E+02	2.611E+05	1.754E+01
2025	6.203E+02	4.967E+05	3.337E+01	1.657E+02	2.484E+05	1.669E+01
2026	5.900E+02	4.725E+05	3.175E+01	1.576E+02	2.362E+05	1.587E+01
2027	5.613E+02	4.494E+05	3.020E+01	1.499E+02	2.247E+05	1.510E+01
2028	5.339E+02	4.275E+05	2.873E+01	1.426E+02	2.138E+05	1.436E+01
2029	5.079E+02	4.067E+05	2.732E+01	1.357E+02	2.033E+05	1.366E+01
2030	4.831E+02	3.868E+05	2.599E+01	1.290E+02	1.934E+05	1.300E+01
2031	4.595E+02	3.680E+05	2.472E+01	1.227E+02	1.840E+05	1.236E+01

Results (Continued)

Year	Total landfill gas			Methane		
	(Mg/year)	(m^3/year)	(av ft^3/min)	(Mg/year)	(m^3/year)	(av ft^3/min)
2032	4.371E+02	3.500E+05	2.352E+01	1.168E+02	1.750E+05	1.176E+01
2033	4.158E+02	3.330E+05	2.237E+01	1.111E+02	1.665E+05	1.119E+01
2034	3.955E+02	3.167E+05	2.128E+01	1.056E+02	1.584E+05	1.064E+01
2035	3.762E+02	3.013E+05	2.024E+01	1.005E+02	1.506E+05	1.012E+01
2036	3.579E+02	2.866E+05	1.926E+01	9.559E+01	1.433E+05	9.628E+00
2037	3.404E+02	2.726E+05	1.832E+01	9.093E+01	1.363E+05	9.158E+00
2038	3.238E+02	2.593E+05	1.742E+01	8.650E+01	1.297E+05	8.711E+00
2039	3.080E+02	2.467E+05	1.657E+01	8.228E+01	1.233E+05	8.286E+00
2040	2.930E+02	2.346E+05	1.576E+01	7.827E+01	1.173E+05	7.882E+00
2041	2.787E+02	2.232E+05	1.500E+01	7.445E+01	1.116E+05	7.498E+00
2042	2.651E+02	2.123E+05	1.426E+01	7.082E+01	1.062E+05	7.132E+00
2043	2.522E+02	2.019E+05	1.357E+01	6.736E+01	1.010E+05	6.784E+00
2044	2.399E+02	1.921E+05	1.291E+01	6.408E+01	9.605E+04	6.454E+00
2045	2.282E+02	1.827E+05	1.228E+01	6.095E+01	9.136E+04	6.139E+00
2046	2.171E+02	1.738E+05	1.168E+01	5.798E+01	8.691E+04	5.839E+00
2047	2.065E+02	1.653E+05	1.111E+01	5.515E+01	8.267E+04	5.555E+00
2048	1.964E+02	1.573E+05	1.057E+01	5.246E+01	7.864E+04	5.284E+00
2049	1.868E+02	1.496E+05	1.005E+01	4.990E+01	7.480E+04	5.026E+00
2050	1.777E+02	1.423E+05	9.562E+00	4.747E+01	7.115E+04	4.781E+00
2051	1.691E+02	1.354E+05	9.095E+00	4.516E+01	6.768E+04	4.548E+00
2052	1.608E+02	1.288E+05	8.652E+00	4.295E+01	6.438E+04	4.326E+00
2053	1.530E+02	1.225E+05	8.230E+00	4.086E+01	6.124E+04	4.115E+00
2054	1.455E+02	1.165E+05	7.829E+00	3.887E+01	5.826E+04	3.914E+00
2055	1.384E+02	1.108E+05	7.447E+00	3.697E+01	5.542E+04	3.723E+00
2056	1.317E+02	1.054E+05	7.084E+00	3.517E+01	5.271E+04	3.542E+00
2057	1.252E+02	1.003E+05	6.738E+00	3.345E+01	5.014E+04	3.369E+00
2058	1.191E+02	9.539E+04	6.409E+00	3.182E+01	4.770E+04	3.205E+00
2059	1.133E+02	9.074E+04	6.097E+00	3.027E+01	4.537E+04	3.048E+00
2060	1.078E+02	8.632E+04	5.800E+00	2.879E+01	4.316E+04	2.900E+00
2061	1.025E+02	8.211E+04	5.517E+00	2.739E+01	4.105E+04	2.758E+00
2062	9.753E+01	7.810E+04	5.248E+00	2.605E+01	3.905E+04	2.624E+00
2063	9.278E+01	7.429E+04	4.992E+00	2.478E+01	3.715E+04	2.496E+00
2064	8.825E+01	7.067E+04	4.748E+00	2.357E+01	3.533E+04	2.374E+00
2065	8.395E+01	6.722E+04	4.517E+00	2.242E+01	3.361E+04	2.258E+00
2066	7.985E+01	6.394E+04	4.296E+00	2.133E+01	3.197E+04	2.148E+00
2067	7.596E+01	6.083E+04	4.087E+00	2.029E+01	3.041E+04	2.043E+00
2068	7.226E+01	5.786E+04	3.888E+00	1.930E+01	2.893E+04	1.944E+00
2069	6.873E+01	5.504E+04	3.698E+00	1.836E+01	2.752E+04	1.849E+00
2070	6.538E+01	5.235E+04	3.518E+00	1.746E+01	2.618E+04	1.759E+00
2071	6.219E+01	4.980E+04	3.346E+00	1.661E+01	2.490E+04	1.673E+00
2072	5.916E+01	4.737E+04	3.183E+00	1.580E+01	2.369E+04	1.591E+00
2073	5.627E+01	4.506E+04	3.028E+00	1.503E+01	2.253E+04	1.514E+00
2074	5.353E+01	4.286E+04	2.880E+00	1.430E+01	2.143E+04	1.440E+00
2075	5.092E+01	4.077E+04	2.739E+00	1.360E+01	2.039E+04	1.370E+00
2076	4.843E+01	3.878E+04	2.606E+00	1.294E+01	1.939E+04	1.303E+00
2077	4.607E+01	3.689E+04	2.479E+00	1.231E+01	1.845E+04	1.239E+00
2078	4.383E+01	3.509E+04	2.358E+00	1.171E+01	1.755E+04	1.179E+00
2079	4.169E+01	3.338E+04	2.243E+00	1.114E+01	1.669E+04	1.121E+00
2080	3.965E+01	3.175E+04	2.134E+00	1.059E+01	1.588E+04	1.067E+00
2081	3.772E+01	3.020E+04	2.029E+00	1.008E+01	1.510E+04	1.015E+00
2082	3.588E+01	2.873E+04	1.930E+00	9.584E+00	1.437E+04	9.652E-01

Results (Continued)

Year	Total landfill gas			Methane		
	(Mg/year)	(m^3/year)	(av ft^3/min)	(Mg/year)	(m^3/year)	(av ft^3/min)
2083	3.413E+01	2.733E+04	1.836E+00	9.117E+00	1.367E+04	9.182E-01
2084	3.247E+01	2.600E+04	1.747E+00	8.672E+00	1.300E+04	8.734E-01
2085	3.088E+01	2.473E+04	1.662E+00	8.249E+00	1.236E+04	8.308E-01
2086	2.938E+01	2.352E+04	1.581E+00	7.847E+00	1.176E+04	7.903E-01
2087	2.794E+01	2.238E+04	1.503E+00	7.464E+00	1.119E+04	7.517E-01
2088	2.658E+01	2.129E+04	1.430E+00	7.100E+00	1.064E+04	7.151E-01
2089	2.528E+01	2.025E+04	1.360E+00	6.754E+00	1.012E+04	6.802E-01
2090	2.405E+01	1.926E+04	1.294E+00	6.424E+00	9.630E+03	6.470E-01
2091	2.288E+01	1.832E+04	1.231E+00	6.111E+00	9.160E+03	6.155E-01
2092	2.176E+01	1.743E+04	1.171E+00	5.813E+00	8.713E+03	5.854E-01
2093	2.070E+01	1.658E+04	1.114E+00	5.530E+00	8.288E+03	5.569E-01
2094	1.969E+01	1.577E+04	1.059E+00	5.260E+00	7.884E+03	5.297E-01
2095	1.873E+01	1.500E+04	1.008E+00	5.003E+00	7.500E+03	5.039E-01
2096	1.782E+01	1.427E+04	9.587E-01	4.759E+00	7.134E+03	4.793E-01
2097	1.695E+01	1.357E+04	9.119E-01	4.527E+00	6.786E+03	4.559E-01
2098	1.612E+01	1.291E+04	8.674E-01	4.306E+00	6.455E+03	4.337E-01
2099	1.534E+01	1.228E+04	8.251E-01	4.096E+00	6.140E+03	4.126E-01
2100	1.459E+01	1.168E+04	7.849E-01	3.897E+00	5.841E+03	3.924E-01
2101	1.388E+01	1.111E+04	7.466E-01	3.707E+00	5.556E+03	3.733E-01
2102	1.320E+01	1.057E+04	7.102E-01	3.526E+00	5.285E+03	3.551E-01
2103	1.256E+01	1.005E+04	6.756E-01	3.354E+00	5.027E+03	3.378E-01
2104	1.194E+01	9.564E+03	6.426E-01	3.190E+00	4.782E+03	3.213E-01
2105	1.136E+01	9.098E+03	6.113E-01	3.035E+00	4.549E+03	3.056E-01
2106	1.081E+01	8.654E+03	5.815E-01	2.887E+00	4.327E+03	2.907E-01
2107	1.028E+01	8.232E+03	5.531E-01	2.746E+00	4.116E+03	2.765E-01
2108	9.779E+00	7.830E+03	5.261E-01	2.612E+00	3.915E+03	2.631E-01
2109	9.302E+00	7.448E+03	5.005E-01	2.485E+00	3.724E+03	2.502E-01
2110	8.848E+00	7.085E+03	4.761E-01	2.363E+00	3.543E+03	2.380E-01
2111	8.417E+00	6.740E+03	4.528E-01	2.248E+00	3.370E+03	2.264E-01
2112	8.006E+00	6.411E+03	4.307E-01	2.139E+00	3.205E+03	2.154E-01
2113	7.616E+00	6.098E+03	4.097E-01	2.034E+00	3.049E+03	2.049E-01
2114	7.244E+00	5.801E+03	3.898E-01	1.935E+00	2.900E+03	1.949E-01
2115	6.891E+00	5.518E+03	3.707E-01	1.841E+00	2.759E+03	1.854E-01
2116	6.555E+00	5.249E+03	3.527E-01	1.751E+00	2.624E+03	1.763E-01
2117	6.235E+00	4.993E+03	3.355E-01	1.665E+00	2.496E+03	1.677E-01
2118	5.931E+00	4.749E+03	3.191E-01	1.584E+00	2.375E+03	1.596E-01
2119	5.642E+00	4.518E+03	3.035E-01	1.507E+00	2.259E+03	1.518E-01
2120	5.367E+00	4.297E+03	2.887E-01	1.433E+00	2.149E+03	1.444E-01
2121	5.105E+00	4.088E+03	2.747E-01	1.364E+00	2.044E+03	1.373E-01
2122	4.856E+00	3.888E+03	2.613E-01	1.297E+00	1.944E+03	1.306E-01

Results (Continued)

Year	Carbon dioxide			NMOC		
	(Mg/year)	*(m^3/year)*	*(av ft^3/min)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*
1982	0	0	0	0	0	0
1983	1.704E+02	9.309E+04	6.255E+00	2.669E+00	7.447E+02	5.004E-02
1984	3.325E+02	1.816E+05	1.220E+01	5.209E+00	1.453E+03	9.764E-02
1985	4.867E+02	2.659E+05	1.786E+01	7.624E+00	2.127E+03	1.429E-01
1986	6.334E+02	3.460E+05	2.325E+01	9.922E+00	2.768E+03	1.860E-01
1987	7.729E+02	4.222E+05	2.837E+01	1.211E+01	3.378E+03	2.269E-01
1988	9.056E+02	4.947E+05	3.324E+01	1.419E+01	3.958E+03	2.659E-01
1989	1.032E+03	5.637E+05	3.787E+01	1.616E+01	4.509E+03	3.030E-01
1990	1.152E+03	6.293E+05	4.228E+01	1.805E+01	5.034E+03	3.383E-01
1991	1.266E+03	6.917E+05	4.647E+01	1.983E+01	5.533E+03	3.718E-01
1992	1.375E+03	7.510E+05	5.046E+01	2.154E+01	6.008E+03	4.037E-01
1993	1.478E+03	8.075E+05	5.426E+01	2.316E+01	6.460E+03	4.340E-01
1994	1.576E+03	8.612E+05	5.786E+01	2.470E+01	6.890E+03	4.629E-01
1995	1.670E+03	9.123E+05	6.130E+01	2.616E+01	7.298E+03	4.904E-01
1996	1.759E+03	9.609E+05	6.456E+01	2.755E+01	7.687E+03	5.165E-01
1997	1.844E+03	1.007E+06	6.767E+01	2.888E+01	8.057E+03	5.414E-01
1998	1.754E+03	9.580E+05	6.437E+01	2.747E+01	7.664E+03	5.149E-01
1999	1.668E+03	9.113E+05	6.123E+01	2.613E+01	7.290E+03	4.898E-01
2000	1.587E+03	8.668E+05	5.824E+01	2.486E+01	6.935E+03	4.659E-01
2001	1.509E+03	8.246E+05	5.540E+01	2.365E+01	6.597E+03	4.432E-01
2002	1.436E+03	7.844E+05	5.270E+01	2.249E+01	6.275E+03	4.216E-01
2003	1.366E+03	7.461E+05	5.013E+01	2.139E+01	5.969E+03	4.010E-01
2004	1.299E+03	7.097E+05	4.769E+01	2.035E+01	5.678E+03	3.815E-01
2005	1.236E+03	6.751E+05	4.536E+01	1.936E+01	5.401E+03	3.629E-01
2006	1.175E+03	6.422E+05	4.315E+01	1.841E+01	5.137E+03	3.452E-01
2007	1.118E+03	6.109E+05	4.104E+01	1.752E+01	4.887E+03	3.283E-01
2008	1.064E+03	5.811E+05	3.904E+01	1.666E+01	4.648E+03	3.123E-01
2009	1.012E+03	5.527E+05	3.714E+01	1.585E+01	4.422E+03	2.971E-01
2010	9.624E+02	5.258E+05	3.533E+01	1.508E+01	4.206E+03	2.826E-01
2011	9.155E+02	5.001E+05	3.360E+01	1.434E+01	4.001E+03	2.688E-01
2012	8.708E+02	4.757E+05	3.196E+01	1.364E+01	3.806E+03	2.557E-01
2013	8.284E+02	4.525E+05	3.041E+01	1.298E+01	3.620E+03	2.432E-01
2014	7.880E+02	4.305E+05	2.892E+01	1.234E+01	3.444E+03	2.314E-01
2015	7.495E+02	4.095E+05	2.751E+01	1.174E+01	3.276E+03	2.201E-01
2016	7.130E+02	3.895E+05	2.617E+01	1.117E+01	3.116E+03	2.094E-01
2017	6.782E+02	3.705E+05	2.489E+01	1.062E+01	2.964E+03	1.992E-01
2018	6.451E+02	3.524E+05	2.368E+01	1.011E+01	2.819E+03	1.894E-01
2019	6.137E+02	3.352E+05	2.252E+01	9.613E+00	2.682E+03	1.802E-01
2020	5.837E+02	3.189E+05	2.143E+01	9.145E+00	2.551E+03	1.714E-01
2021	5.553E+02	3.033E+05	2.038E+01	8.699E+00	2.427E+03	1.631E-01
2022	5.282E+02	2.885E+05	1.939E+01	8.274E+00	2.308E+03	1.551E-01
2023	5.024E+02	2.745E+05	1.844E+01	7.871E+00	2.196E+03	1.475E-01
2024	4.779E+02	2.611E+05	1.754E+01	7.487E+00	2.089E+03	1.403E-01
2025	4.546E+02	2.484E+05	1.669E+01	7.122E+00	1.987E+03	1.335E-01
2026	4.324E+02	2.362E+05	1.587E+01	6.774E+00	1.890E+03	1.270E-01
2027	4.114E+02	2.247E+05	1.510E+01	6.444E+00	1.798E+03	1.208E-01
2028	3.913E+02	2.138E+05	1.436E+01	6.130E+00	1.710E+03	1.149E-01
2029	3.722E+02	2.033E+05	1.366E+01	5.831E+00	1.627E+03	1.093E-01
2030	3.541E+02	1.934E+05	1.300E+01	5.546E+00	1.547E+03	1.040E-01
2031	3.368E+02	1.840E+05	1.236E+01	5.276E+00	1.472E+03	9.890E-02

Results (Continued)

Year	Carbon dioxide			NMOC		
	(Mg/year)	(m^3/year)	(av ft^3/min)	(Mg/year)	(m^3/year)	(av ft^3/min)
2032	3.204E+02	1.750E+05	1.176E+01	5.019E+00	1.400E+03	9.407E-02
2033	3.047E+02	1.665E+05	1.119E+01	4.774E+00	1.332E+03	8.948E-02
2034	2.899E+02	1.584E+05	1.064E+01	4.541E+00	1.267E+03	8.512E-02
2035	2.757E+02	1.506E+05	1.012E+01	4.320E+00	1.205E+03	8.097E-02
2036	2.623E+02	1.433E+05	9.628E+00	4.109E+00	1.146E+03	7.702E-02
2037	2.495E+02	1.363E+05	9.158E+00	3.909E+00	1.090E+03	7.326E-02
2038	2.373E+02	1.297E+05	8.711E+00	3.718E+00	1.037E+03	6.969E-02
2039	2.258E+02	1.233E+05	8.286E+00	3.537E+00	9.866E+02	6.629E-02
2040	2.147E+02	1.173E+05	7.882E+00	3.364E+00	9.385E+02	6.306E-02
2041	2.043E+02	1.116E+05	7.498E+00	3.200E+00	8.927E+02	5.998E-02
2042	1.943E+02	1.062E+05	7.132E+00	3.044E+00	8.492E+02	5.706E-02
2043	1.848E+02	1.010E+05	6.784E+00	2.895E+00	8.078E+02	5.428E-02
2044	1.758E+02	9.605E+04	6.454E+00	2.754E+00	7.684E+02	5.163E-02
2045	1.672E+02	9.136E+04	6.139E+00	2.620E+00	7.309E+02	4.911E-02
2046	1.591E+02	8.691E+04	5.839E+00	2.492E+00	6.953E+02	4.672E-02
2047	1.513E+02	8.267E+04	5.555E+00	2.371E+00	6.614E+02	4.444E-02
2048	1.439E+02	7.864E+04	5.284E+00	2.255E+00	6.291E+02	4.227E-02
2049	1.369E+02	7.480E+04	5.026E+00	2.145E+00	5.984E+02	4.021E-02
2050	1.302E+02	7.115E+04	4.781E+00	2.040E+00	5.692E+02	3.825E-02
2051	1.239E+02	6.768E+04	4.548E+00	1.941E+00	5.415E+02	3.638E-02
2052	1.179E+02	6.438E+04	4.326E+00	1.846E+00	5.151E+02	3.461E-02
2053	1.121E+02	6.124E+04	4.115E+00	1.756E+00	4.899E+02	3.292E-02
2054	1.066E+02	5.826E+04	3.914E+00	1.671E+00	4.661E+02	3.131E-02
2055	1.014E+02	5.542E+04	3.723E+00	1.589E+00	4.433E+02	2.979E-02
2056	9.649E+01	5.271E+04	3.542E+00	1.512E+00	4.217E+02	2.833E-02
2057	9.178E+01	5.014E+04	3.369E+00	1.438E+00	4.011E+02	2.695E-02
2058	8.731E+01	4.770E+04	3.205E+00	1.368E+00	3.816E+02	2.564E-02
2059	8.305E+01	4.537E+04	3.048E+00	1.301E+00	3.630E+02	2.439E-02
2060	7.900E+01	4.316E+04	2.900E+00	1.238E+00	3.453E+02	2.320E-02
2061	7.515E+01	4.105E+04	2.758E+00	1.177E+00	3.284E+02	2.207E-02
2062	7.148E+01	3.905E+04	2.624E+00	1.120E+00	3.124E+02	2.099E-02
2063	6.800E+01	3.715E+04	2.496E+00	1.065E+00	2.972E+02	1.997E-02
2064	6.468E+01	3.533E+04	2.374E+00	1.013E+00	2.827E+02	1.899E-02
2065	6.153E+01	3.361E+04	2.258E+00	9.638E-01	2.689E+02	1.807E-02
2066	5.852E+01	3.197E+04	2.148E+00	9.168E-01	2.558E+02	1.719E-02
2067	5.567E+01	3.041E+04	2.043E+00	8.721E-01	2.433E+02	1.635E-02
2068	5.296E+01	2.893E+04	1.944E+00	8.296E-01	2.314E+02	1.555E-02
2069	5.037E+01	2.752E+04	1.849E+00	7.891E-01	2.201E+02	1.479E-02
2070	4.792E+01	2.618E+04	1.759E+00	7.506E-01	2.094E+02	1.407E-02
2071	4.558E+01	2.490E+04	1.673E+00	7.140E-01	1.992E+02	1.338E-02
2072	4.336E+01	2.369E+04	1.591E+00	6.792E-01	1.895E+02	1.273E-02
2073	4.124E+01	2.253E+04	1.514E+00	6.461E-01	1.802E+02	1.211E-02
2074	3.923E+01	2.143E+04	1.440E+00	6.146E-01	1.715E+02	1.152E-02
2075	3.732E+01	2.039E+04	1.370E+00	5.846E-01	1.631E+02	1.096E-02
2076	3.550E+01	1.939E+04	1.303E+00	5.561E-01	1.551E+02	1.042E-02
2077	3.377E+01	1.845E+04	1.239E+00	5.290E-01	1.476E+02	9.915E-03
2078	3.212E+01	1.755E+04	1.179E+00	5.032E-01	1.404E+02	9.432E-03
2079	3.055E+01	1.669E+04	1.121E+00	4.786E-01	1.335E+02	8.972E-03
2080	2.906E+01	1.588E+04	1.067E+00	4.553E-01	1.270E+02	8.534E-03
2081	2.765E+01	1.510E+04	1.015E+00	4.331E-01	1.208E+02	8.118E-03
2082	2.630E+01	1.437E+04	9.652E-01	4.120E-01	1.149E+02	7.722E-03

Results (Continued)

Year	Carbon dioxide			NMOC		
	(Mg/year)	*(m^3/year)*	*(av ft^3/min)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*
2083	2.501E+01	1.367E+04	9.182E-01	3.919E-01	1.093E+02	7.345E-03
2084	2.379E+01	1.300E+04	8.734E-01	3.728E-01	1.040E+02	6.987E-03
2085	2.263E+01	1.236E+04	8.308E-01	3.546E-01	9.892E+01	6.646E-03
2086	2.153E+01	1.176E+04	7.903E-01	3.373E-01	9.409E+01	6.322E-03
2087	2.048E+01	1.119E+04	7.517E-01	3.208E-01	8.951E+01	6.014E-03
2088	1.948E+01	1.064E+04	7.151E-01	3.052E-01	8.514E+01	5.721E-03
2089	1.853E+01	1.012E+04	6.802E-01	2.903E-01	8.099E+01	5.442E-03
2090	1.763E+01	9.630E+03	6.470E-01	2.761E-01	7.704E+01	5.176E-03
2091	1.677E+01	9.160E+03	6.155E-01	2.627E-01	7.328E+01	4.924E-03
2092	1.595E+01	8.713E+03	5.854E-01	2.499E-01	6.971E+01	4.684E-03
2093	1.517E+01	8.288E+03	5.569E-01	2.377E-01	6.631E+01	4.455E-03
2094	1.443E+01	7.884E+03	5.297E-01	2.261E-01	6.307E+01	4.238E-03
2095	1.373E+01	7.500E+03	5.039E-01	2.151E-01	6.000E+01	4.031E-03
2096	1.306E+01	7.134E+03	4.793E-01	2.046E-01	5.707E+01	3.835E-03
2097	1.242E+01	6.786E+03	4.559E-01	1.946E-01	5.429E+01	3.648E-03
2098	1.182E+01	6.455E+03	4.337E-01	1.851E-01	5.164E+01	3.470E-03
2099	1.124E+01	6.140E+03	4.126E-01	1.761E-01	4.912E+01	3.300E-03
2100	1.069E+01	5.841E+03	3.924E-01	1.675E-01	4.673E+01	3.140E-03
2101	1.017E+01	5.556E+03	3.733E-01	1.593E-01	4.445E+01	2.986E-03
2102	9.674E+00	5.285E+03	3.551E-01	1.515E-01	4.228E+01	2.841E-03
2103	9.202E+00	5.027E+03	3.378E-01	1.442E-01	4.022E+01	2.702E-03
2104	8.753E+00	4.782E+03	3.213E-01	1.371E-01	3.826E+01	2.570E-03
2105	8.327E+00	4.549E+03	3.056E-01	1.304E-01	3.639E+01	2.445E-03
2106	7.920E+00	4.327E+03	2.907E-01	1.241E-01	3.462E+01	2.326E-03
2107	7.534E+00	4.116E+03	2.765E-01	1.180E-01	3.293E+01	2.212E-03
2108	7.167E+00	3.915E+03	2.631E-01	1.123E-01	3.132E+01	2.104E-03
2109	6.817E+00	3.724E+03	2.502E-01	1.068E-01	2.979E+01	2.002E-03
2110	6.485E+00	3.543E+03	2.380E-01	1.016E-01	2.834E+01	1.904E-03
2111	6.168E+00	3.370E+03	2.264E-01	9.663E-02	2.696E+01	1.811E-03
2112	5.868E+00	3.205E+03	2.154E-01	9.192E-02	2.564E+01	1.723E-03
2113	5.581E+00	3.049E+03	2.049E-01	8.744E-02	2.439E+01	1.639E-03
2114	5.309E+00	2.900E+03	1.949E-01	8.317E-02	2.320E+01	1.559E-03
2115	5.050E+00	2.759E+03	1.854E-01	7.912E-02	2.207E+01	1.483E-03
2116	4.804E+00	2.624E+03	1.763E-01	7.526E-02	2.100E+01	1.411E-03
2117	4.570E+00	2.496E+03	1.677E-01	7.159E-02	1.997E+01	1.342E-03
2118	4.347E+00	2.375E+03	1.596E-01	6.810E-02	1.900E+01	1.276E-03
2119	4.135E+00	2.259E+03	1.518E-01	6.477E-02	1.807E+01	1.214E-03
2120	3.933E+00	2.149E+03	1.444E-01	6.162E-02	1.719E+01	1.155E-03
2121	3.741E+00	2.044E+03	1.373E-01	5.861E-02	1.635E+01	1.099E-03
2122	3.559E+00	1.944E+03	1.306E-01	5.575E-02	1.555E+01	1.045E-03

Calculator		S-P-R Values	Maximum Score	Linkage	Normalised Score
Leachate migration through combined groundwater and surface water pathways					
SPR1	1a x (2a + 2b + 2c) x 3e	**63**	300	Leachate => surface water	21%
SPR2	1a x (2a + 2b + 2c) x 3b	**0**	300	Leachate => SWDTE	0%
Leachate migration through groundwater pathway					
SPR3	1a x (2a + 2b) x 3a	**49**	240	Leachate => human presence	20%
SPR4	1a x (2a + 2b) x 3b	**0**	240	Leachate => GWDTE or SWDTE	0%
SPR5	1a x (2a + 2b) x 3c	**245**	400	Leachate => Aquifer	**61%**
SPR6	1a x (2a + 2b) x 3d	**147**	560	Leachate =>Public Supply	26%
SPR7	1a x (2a + 2b) x 3e	**49**	240	Leachate => Surface Water	20%
Leachate migration through surface water pathway					
SPR8	1a x 2c x 3e	**14**	60	Leachate => Surface Water	23%
SPR9	1a x 2c x 3b	**0**	60	Leachate => SWDTE	0%
Landfill gas migration pathway (lateral & vertical)					
SPR10	1b x 2d x 3f	**35**	150	Landfill Gas => Human Presence	23%
SPR11	1b x 2e x 3f	**35**	250	Landfill Gas => Human Presence	14%
Site maximum S-P-R Score					**61%**
Risk Classification					**Class B**

- Highest Risk (Class A): Greater than 70 for any individual SPR linkage
- Moderate Risk (Class B): 41-69 for any individual SPR linkage
- Lowest Risk (Class C): Less than 40 for any individual SPR linkage

FEHILY TIMONEY
30 YEARS

CONSULTANTS IN ENGINEERING,
ENVIRONMENTAL SCIENCE & PLANNING

APPENDIX 6

Japanese Knotweed Management and Treatment Plan Including Biosecurity Measures

Japanese Knotweed Management & Treatment Plan Including Biosecurity Measures

Proposed Solar Farm at Clare, Claramorris, Co Mayo

<table>
<tr><td rowspan="2">Management Plan
Doc. File Name: 089/JKM/20</td><td rowspan="2">Main Office – Meanus, Killorglin, Co

Kerry - 066 9796612

Dublin – 01 539 4189

Mayo – 096 54102</td><td>Client Information

Mayo County Council – Claremorris & Western District Energy Co-Op</td></tr>
<tr><td>Site Address
Clare, Claremorris Co Mayo</td></tr>
<tr><td colspan="2">Authorisation Report

A | 1 | 14/02/2020
Status | Rev | Date</td><td>Designed & Created by:
Peter Byrne
16/01/2020

Checked by:
Kieren O' Shea
14/02/2020</td></tr>
</table>

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1.0 Introduction & Background to Japanese Knotweed

The optimum survey period for Japanese knotweed requires an understanding of the plant's complex life cycle. In order to provide details, and supporting information, with respect to the optimum survey period, it is important to first illustrate the origin, habitats, invasive qualities & dispersal mechanisms, life cycle and growth forms of this invasive species.

1.1 Origins of Plant

Native to Japan & northern China, Japanese knotweed (Fallopia japonica) is an invasive perennial herbaceous plant which was introduced to Europein the 1820's. The first record for Japanese knotweed in Europe appears to be from an artificial swamp habitat created in a garden of the UK Horticultural Society in Chiswick, London.

A second introduction to Europe is known from 1847, to a nursery in The Netherlands by the German physician and botanist Philippe von Siebold. Japanese knotweed plants were made available for sale by von Siebold at his nursery, as an ornamental species. Thereafter, in the same year Japanese knotweed was awarded a gold medal by the Society of Agriculture & Horticulture at Utrecht as "the most interesting new ornamental plant of the year".

In 1850, Japanese knotweed plants were sent to the Royal Botanical Gardens at Kew, UK, (Conolly, 1977) by Philippe von Siebold; in an unsolicited parcel of plants from his nursery. By 1854, the plant, had also arrived at the Royal Botanic Gardens in Edinburgh, from where it was further distributed across the UK. Japanese knotweed plants were sold by a large number of commercial nursery gardens around the UK (Bailey & Conolly 2000) and Europe and soon became one of the most popular garden plants of the 19th Century; the sharing of cuttings and the discarding of unwanted rhizomes became the primary pathway for dispersal. While it was originally planted for its foliage and "attractive" white flowers, in later years Japanese knotweed was also promoted as a potential source of forage or animal fodder.

Further dispersal occurred by vegetative means as Japanese knotweed spread naturally along watercourses, and in later years Japanese knotweed was dispersed by anthropogenic means in soil containing rhizome fragments; which was moved during road building and construction schemes. The first naturalised record of Japanese Knotweed in Ireland is dated 1905 from a garden in Dublin. Since its introduction to Ireland, it has spread across the island, particularly along watercourses, transport routes and in waste or disturbed ground. Of note is that the plant could still be found widely available for sale in garden centres in the 1930s and even up until the 1980s in the UK (Bailey & Connolly, 2000).

1.2 Habitats

Native Countries

In its native countries, Japanese knotweed is found growing along riverbanks, roadside verges, managed pastures and in sunny places on hills and high mountains. Over thousands of years, it has evolved to become one of the first species to colonise lands within 20 years of volcanic activity and is replaced by other herbaceous species after 50 years or so.
It typically reaches 0.3 - 1.5m tall and is attacked by a suite of 226 natural enemies, including insects and fungi, which keep it in check.

Ireland

In Ireland (and other countries to which it has been introduced worldwide), the absence of natural enemies, combined with its ability to colonise and penetrate volcanic landscapes, means that the plant can grow unchecked reaching heights of up to 3-4m, to form dense stands, and like a number of tree species has the capability of accessing existing weaknesses

or joints in bitumen, concrete, masonry and hard standing areas. No correlation between soil type, plant size or vigour has been identified, suggesting that it can grow on any substrate.
Its ability to penetrate existing weaknesses and joints comes from its underground network of stems known as rhizomes and its large central 'crown'.

1.3 Invasive Qualities
1.3.1 Growth Stages

Crown
In more mature Japanese Knotweed plants (typically 4 years old), a central rhizome 'crown', develops from which the main stems emerge above ground.

Underneath, the crown, the radial rhizomes twist together to form a sizeable and considerable upward penetrating force. As the plant matures the crown expands. Where Japanese knotweed is growing in close proximity to hard landscaping, the expanding crown can open up existing weaknesses in cracks or joints which may cause damage to footpaths and other infrastructure.
The crown also acts as the plants' carbohydrate food store during the winter months when the leaves die back and the plant goes into its natural winter dormancy period.

Rhizomes
When the rhizome network of a Japanese knotweed plant is spreading, it sends out new radial rhizomes (or underground stems) laterally underground from the central crown. The plant will then send up new shoots and adventitious roots along the length of these rhizomes. The new shoots are not only a sign that a rhizome network is spreading, they also provide an indication of the direction of new rhizome growth, and the overall pattern of growth of the plant.

While most of the plants' rhizomes are found in the top 1 metre of the soil, they can also go deep into the soil and extend up to several metres out from the plant, depending on ground conditions and disturbance regimes. The standard 7m rule or buffer zone described in Irish and UK government guideline documents, suggests that Japanese knotweed rhizomes may extend seven metres laterally from a crown or parent plant.

Fennell et al. (2018) demonstrated that even large stands of Japanese knotweed do not usually produce rhizomes that extend further than 4m. The study found that Japanese knotweed rhizomes rarely extend more than 4m from above ground plants and are typically found within 2m for small stands and 2.5m for large stands. Similarly, the mean vertical extent recorded averaged between 1.02m for the small stands and 1.64m for the large stands, (with a maximum of 3.2m recorded).

In terms of ecology, landscapes and amenities, Japanese knotweed is known to have potential significant negative ecological impacts on native habitats and species, on landscape character and quality, and on visual and recreational amenities. With regards to increased flood risk, built infrastructure and land-uses, Japanese knotweed once established can dominate watercourses where it may impede water flow through the obstruction of conveyance (or drainage) in ditches, streams and rivers particularly when water levels are high; thus, contributing to flooding. During winter dieback, Japanese knotweed may leave river banks exposed to erosion, leading to bank collapse. Land use and access to lands and infrastructure can also be impacted or impeded where large dense monospecific stands block access routes, invade landscaped areas such as gardens and urban parks/woodlands, impact on the quiet

enjoyment and use of domestic gardens, encroach on roadways and agricultural fields and occupy large swathes of lands. Signage and sightlines on roadways can also be impinged. In addition to these impacts as described above, Japanese knotweed, like certain tree species also has the ability to access existing weaknesses and joints, and may in certain situations cause damage to hard landscaping and infrastructure.

1.3.2 Reproduction

Sexual Reproduction

Japanese Knotweed is generally not considered capable of producing viable seed. In simplistic terms only female cloned (male sterile1) plants are considered to be present in Ireland (Bailey & Connolly, 2002). Reproduction is, therefore, almost entirely asexual with very little viable seed produced (0% to <2%) (Tiébré et al.2007).

Japanese knotweed, does however have the ability to hybridise with close relatives e.g. Giant Knotweed (Fallopia sachalinensis) to produce Bohemian Knotweed (Fallopia x bohemica) which is capable of producing viable seed. It can also hybridise with Russian Vine (Fallopia baldschuanica) to produce Connolly's Knotweed (Fallopia connollyana); and may backcross with Russian Vine to produce viable seeds (Bailey, 2001; Tiébré et al., 2007); although limited numbers survive beyond one year's growth.

Asexual Reproduction - vegetative

In Ireland (and other countries into which it has been introduced worldwide) the plant species displays an extraordinary ability to disperse and rapidly regenerate from rhizome or stem fragments to colonise and invade disturbed land. Less than 0.7g of a rhizome can produce roots and shoots in 10 days.

1.3.3 Dispersal

During landscaping and construction activities Japanese Knotweed can be disturbed by machinery, and spread within or be brought onto a site, in the form of plant fragments within the soil load or on the tyres of machinery and dumpsters, especially on machinery with tracks. The maintenance of Japanese Knotweed by mechanical methods such as cutting and strimming can distribute fragments, which can then be carried along road corridors by wind or on the tyres of vehicles including cars (see Wace, 1977; Wilcox, 1989). Fragments can also be carried on the footwear of pedestrians.

In relation to semi-natural habitats, the species out-competes native herbaceous and juvenile woody plants, reducing species diversity. Once established the height, dense canopy and aggressive nature of the plant essentially excludes other species. In addition, Japanese Knotweed has also been shown to have allelopathic effects on native vegetation; permitting germination but limiting biomass. Along riverbanks, new shoots have been observed developing primarily from floating stems from which fragments can be broken off by floods which lodge downstream to form new outlier populations; therefore, an upstream catchment wide management approach is required to achieve eradication of knotweed species along habitats where there is upstream surface water connectivity.

It is found primarily in open sites. Under favourable conditions the plant can grow up to 10cm a day and can rapidly invade disturbed ground in the absence of native vegetation. It tolerates semi-shaded but not fully shaded areas.

In the presence of dense native vegetation, it can in certain situations struggle for resources due to competition. Its growth and abundance are depressed in heavily shady sites (Beerling, 1991; Seiger, 1993); and it is consequently unable to successfully dominate the ground flora, shrub and tree layer in the understorey of dense woodland canopies; it rarely flowers beneath woodland canopies.

In Ireland, Japanese Knotweed is associated with roadsides, railways, car parks, quarries, maintenance depots, landfill sites, abandoned waste ground and in particular, disturbed areas where native vegetation is absent and where fly-tipping of spoil has occurred.

1.3.4 Plant Defence Mechanisms

In terms of undertaking surveys for Japanese knotweed, it is important to understand the plants' defence mechanisms. The use of chemical herbicide and the mowing of Japanese knotweed can result in the creation of bonsai regrowth which can go undetected unless surveys are undertaken by a specialist. In response to the use of chemical herbicide and burial at depth, the plant also has the ability to remain dormant or persist for long periods of time underground. In this regard the importance of completing a thorough forensic investigation including a detailed desktop study which examines existing records of Japanese knotweed (plant databases), and a review of available aerial imagery and Google Streetview to identify historic and ongoing sources and pathways for dispersal cannot be underestimated as part of a survey report.

Japanese Knotweed can respond to cutting or burial by deploying a number of plant defence mechanisms. Cutting, flailing, mowing, digging or burying the plant may result in:

- Dispersal of plant fragments which can regrow elsewhere
- Bonsai regrowth
- Rapid regrowth and increase in the height and extent of the plant
- Lateral growth of rhizomes and the development of new radial shoots
- Regrowth of buried rhizomes (buried rhizomes can survive for several years)

Knotweed also has the ability to execute a number of plant defence mechanisms in response to chemical herbicide including:

- Sub-lethal bonsai regrowth
- Lateral growth of rhizomes and development of new radial shoots
- Dormancy - rhizomes can lay dormant and viable for a number of years before regrowth
- Compartmentalisation

Given its complex reproductive capabilities, Japanese Knotweed has essentially two 'lifecycles' in the Irish context (in the absence of viable seed).

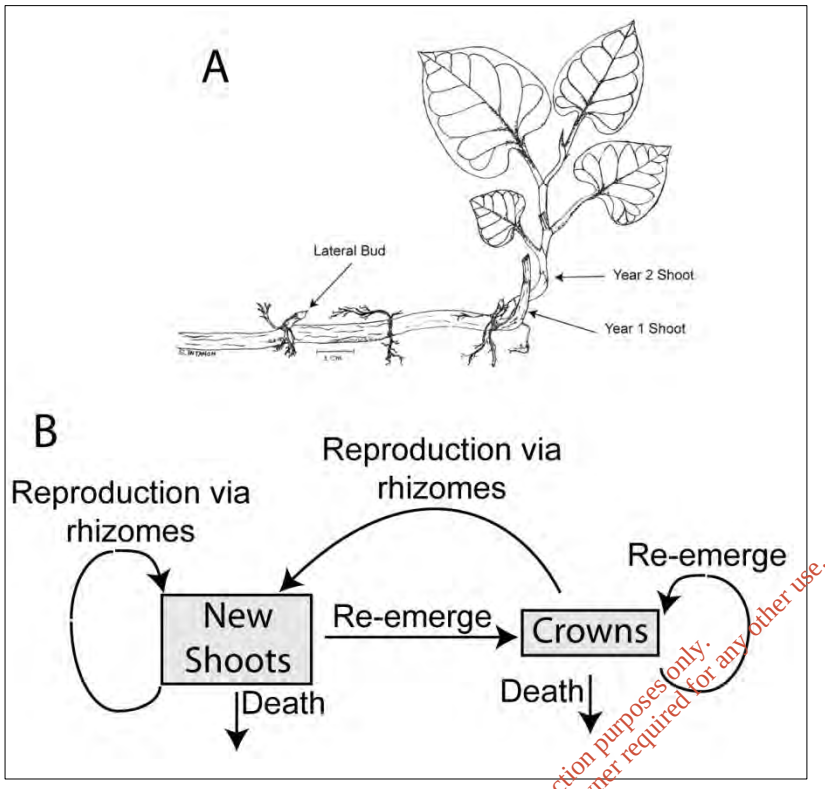
- The first is the lifecycle of Japanese knotweed which revolves around the 'crown' structure
- The second is the lifecycle of a rhizome fragment which has broken away from the crown as a result of disturbance e.g. soil movement

1.3.5 Lifecycle of a Japanese Knotweed Crown

A crown will typically produce shoots which are much 'stronger' than those produced from a rhizome fragment and will display the following characteristics

- Red/purple shoots appear early in spring which often resemble an 'asparagus' like appearance but, as the canes grow, the leaves unfurl and the plant takes on its more characteristic appearance.
- The mature canes are like bamboo, being hollow, and are light green with characteristic reddish-brown flecks. The plant can grow to over 3m in height.
- Flowering occurs in late summer/autumn (end July – typically August) and consists of small off-white- creamy to greenish flowers.

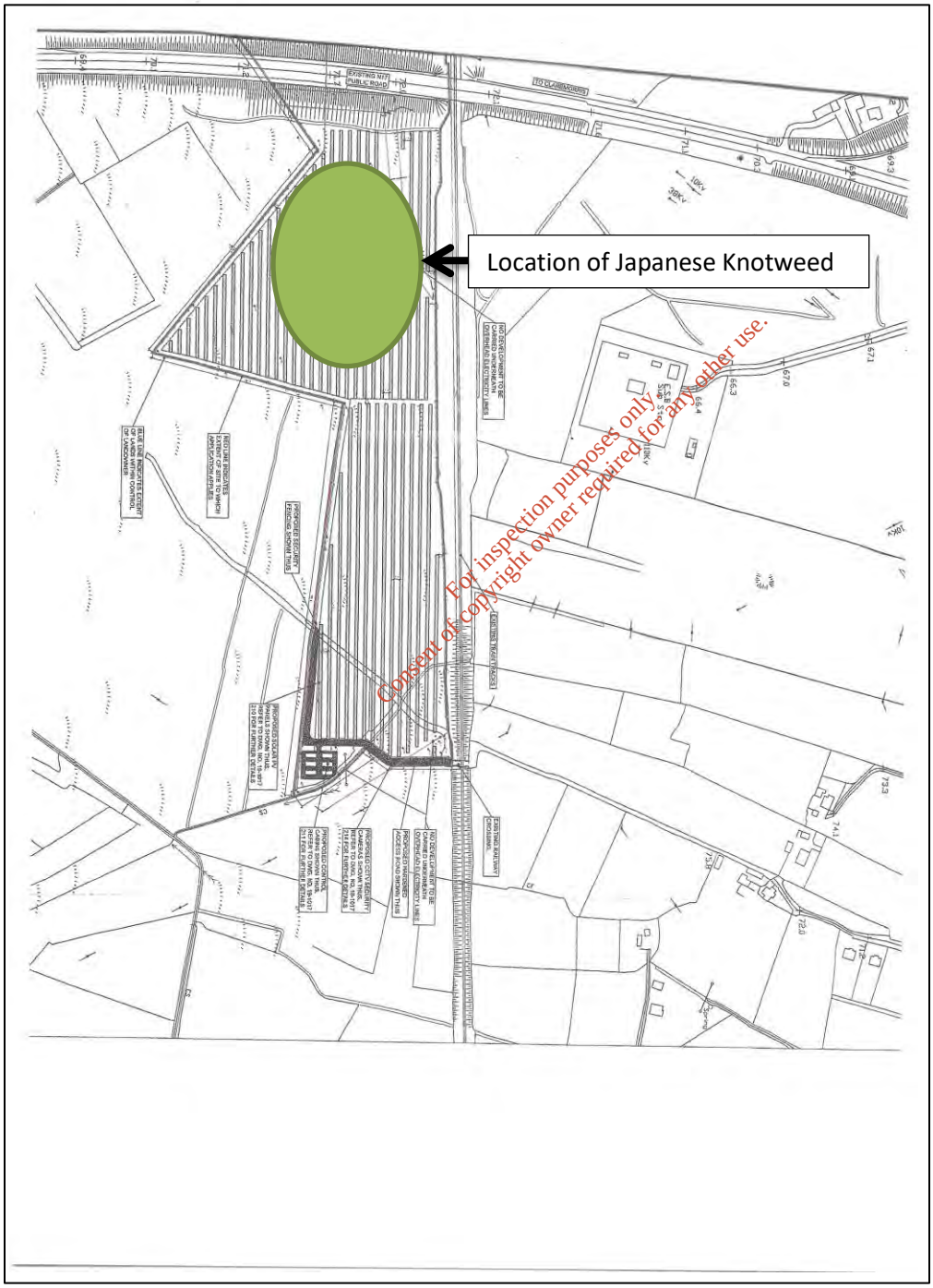
- In autumn, the leaves turn yellow as senescence (winter dieback) sets in.
- During the winter the canopy of leaves die back to reveal the crown and the orange/brown woody erect “zig-zag” stems - which later turn silver.



2.0 Introduction to Site

2.1 Description of the Site

This site is located to the east of the N17 highway in the townland of Clare, Claremorris, Co. Mayo, (Easting 532068 & Northing 776300). This site was previously used as a county council landfill, however, the landfill activity has ceased since a number of years. Native scrub and flora are present throughout this site, no protected plant species were present on this site during the site surveys that have been carried out to date. The non-native invasive plant Japanese knotweed is present at several locations throughout this site, the area of infestation is indicated on the map below.



2.2 Known Herbicide Treatment History at Site

Mayo county council employed contractors to carry out herbicide treatments at this site in September 2014 & 2015 and a non-persistent herbicide designed for aquatic use was administered to the Japanese knotweed infestations that are present on this site. There were no further treatments carried out on this site, however monitoring of the infestations was carried out in August 2018 & 2019. In September 2019, an updated report created by The Japanese Knotweed Company recommended that a further herbicide treatment be carried out at these lands for a minimum of 4 years going forward and this was to be followed by an ongoing monitoring programme.

2.3 Site Management Objectives

The site management objectives relevant to this management plan are to gain control and subsequent management of the infestations of Japanese Knotweed that are present, so that no further threat is posed to this site as a whole or to the biodiversity of the surrounding environments. The solar PV farm that is proposed for this site will afford an opportunity for access to be gained to all areas of these lands so that herbicide treatments and the aforementioned ongoing monitoring programme can be implemented in conjunction with the proposed works. All essential biosecurity measures as set out in this document must be strictly adhered to at all times, no proposed works should be carried out without the presence of a certified surveyor of non-native invasive plants.

2.4 Limitations and Threats to Management Objectives

Herbicide treatment that is administered correctly by qualified personnel at the correct time of year will achieve management and control of the Japanese Knotweed infestation present on this site over the 4 year herbicide treatment programme. This methodology gains control by forcing the growth of the plant into a state of consequential dormancy, however, re-emergence of the plant in the form of bonsai growth will occur, the ongoing monitoring programme will identify this regrowth and herbicide treatment of this regrowth will be necessary in order to keep control of the plant maintained throughout the site as a whole.

As machinery will be imported to site to carry out tree felling, site clearance & the creation of hard standings, the essential biosecurity measures as detailed throughout this document will need to be strictly adhered to in full. Machinery can act as a vector for the further spread of this non-native invasive plant throughout the site, thereby posing a threat to the management objectives.

2.5 Legislative Framework

At an international level Ireland has signed up to a number of treaties and conventions, including the **Convention on Biological Diversity.** Such treaties and conventions require the Irish Government to address issues of invasive alien species. This has been implemented through the **Wildlife Act 1976 and 2000** and further regulated through the **European Communities (Birds and Natural Habitats) Regulations 2011 (SI 477 of 2011)**

Regulation 49

'a person shall be guilty of an offence if they: plant; disperse; allow or cause to disperse; spread or cause to grow the plant in the Republic of Ireland'. The list of species in the Third Schedule includes Japanese Knotweed, Giant Knotweed and their hybrid Bohemian Knotweed.

Regulation 50

'an offence to or intend to; import; buy; sell; breed; reproduce or propagate; offer or expose for sale; advertise; publish a price list; transport; and distribute any plant species or vector material listed in the Third Schedule'.

Non-native species subject to restrictions under Regulations 49 and 50 are included in the third schedule of the European Communities (Birds and Natural Habitats) Regulations 2011 (S.I 477 of 2011. The invasive species listed in the Third Schedule include: Japanese Knotweed, Giant Knotweed, Giant Rhubarb, Himalayan Balsam, Himalayan Knotweed, Bohemian Knotweed and Rhododendron.

The vector material (i.e. facilitates spread), referred to in the regulations (Third Schedule Part 3) which applies to Knotweed species is:

"Soil or spoil taken from places infested with Japanese Knotweed, Giant Knotweed or their hybrid Bohemian Knotweed"

The Waste Management Act 1996, as amended and associated regulations must be complied with if Japanese Knotweed contaminated material is to be moved off site.

It is a requirement to dispose of this material to a fully licenced wasted facility, capable of accepting such contaminated material. This disposal requirement applies to all Japanese Knotweed material including untreated and treated plant material. It also applies to soil containing the plant material, i.e. a 7m radius around the above ground stand and up to 3m deep below the stand, this is site specific.

If Japanese Knotweed contaminated material is removed off site it will require a **licence from the National Parks and Wildlife Service** in advance of any removal, in accordance with the European Communities (Birds and Natural Habitats) Regulations 2011 (SI 477)

2.6 Guidance Documents

The following guidance documents and literature sources were consulted during the preparation of this report:

- National Roads Authority NRA (2010). *Guidelines on management of noxious weeds and non-native invasive plant species on national roads.*
- Crushell, P., Foss P., Hurley C. & O' Loughlin B. (2011). *County Kerry Invasive Species Survey 2011 – Pilot Mapping Study of the River Lee Catchment, Tralee.* Report prepared for Kerry County Council and The Heritage Council
- Environmental Agency (UK) (2013). *The Knotweed Code of Practice: Managing Japanese Knotweed on Development Sites (Version 3, amended in 2013*
- Stokes, K., O' Neill K., & McDonald R.A*. (2004) Invasive Species in Ireland* Unpublished Report
- NPWS (2011) *Actions for Biodiversity* 2011-2016, *Irelands second National Biodiversity Plan.* Department of Arts Heritage and the Gaeltacht.
- Department of Environment (2013). An invasive alien Species Strategy for Northern Ireland. www.doeni.gov.uk
- Irish Water Report. Information and Guidance Document on Japanese Knotweed Asset Strategy and Sustainability

3.0 Overview of Management Plan

3.1 Prevention Measures Prior to Development Stage

The proposed access route that is located at the north eastern corner of the site will require a fenced in clean down zone to be created. This clean down zone will require a layer of high quality geotextile membrane to be laid over an area large enough to be able to accept incoming machinery and vehicles to be inspected and cleaned down where necessary prior to gaining access to the site.

A 150mm layer of 804 hardcore will need to be placed on top of the geotextile membrane to protect the membrane from being punctured and to ensure no cross contamination occurs.
It is recommended that a high quality geotextile membrane is laid prior to the hardcore being placed along this route that runs from north to south allowing access to be gained to the proposed control cabins.

Access to and from the proposed solar PV farm should be controlled at points along the access route, each access point will require a footbath and clean down station to be created as machinery and footwear can act as vectors for the spread of the non-native invasive plant Japanese Knotweed. Signage highlighting the presence of the non-native invasive plant Japanese Knotweed will need to be erected throughout the site and remain in place for the duration of these works.

Should the proposed works commence within the botanical growing season, from early March to September it is recommended that a herbicide treatment be administered to the Japanese Knotweed 21 days prior to the commencement of works. The herbicide administrator will be required to have a registered pesticide user number (PUN) and be trained in PA1, PA6, PA6AW & PA6ING (City & Guilds PTC) The Herbicide administrator must complete, sign & date a **Site Herbicide Recording Sheet (Appendix B)** identifying their individual PUN.

3.2 Works At Development Stage

All personnel involved in these works must attend a tool box talk on working in close proximity to non-native invasive plants and the ease with which these plants can be spread unwittingly or accidentally further on the site as a whole or indeed off site and onto another.
This tool box talk will be delivered by a certified surveyor of non-native invasive plants.
All machinery that gains access to the works area of this site must use the dedicated access routes and must not be allowed to leave identified infested areas without being inspected and cleaned down where necessary, by trained personnel.

It is understood at this stage that the solar panels will be placed on precast concrete bases, this will be dependent on ground conditions. It is inevitable that given the size of the planned solar PV farm that some ground disturbance will have to take place. It is therefore recommended that any ground disturbance or any movement of soils within this site is carried out under the supervision of a certified surveyor of non-native invasive plants.
All planned works must adhere to the biosecurity measures in full, as set out in **Section 4.3 Biosecurity Measures** of this document. It is recommended that these biosecurity measures are carried out under the supervision of a certified surveyor of non-native invasive plants, the individual that is tasked with the implementation of these biosecurity measures must complete, sign & date the **Daily Onsite Biosecurity & Management Forms (Appendix A)**

3.3 Four Year Herbicide Treatment Programme
It is recommended that a 4 year herbicide treatment programme be carried out on an annual basis from late August time to the middle of October. Foliar spray, weed wipe and stem injection are the treatment administration methods that will be utilised on the infestations that are present on this site, the condition of the plant on the day that the treatment is to be administered, will determine the method that is to be utilised for maximum effect.

A non-persistent herbicide application shall be delivered using an approved applicator by a trained operative equipped with suitable personal protective equipment (PPE). The operator must have completed relevant training including City & Guilds NPTC Pesticide Training PA1 – Safe use of pesticides in conjunction with PA2a and PA6 as a minimum qualification. The operator must be registered as a Professional User (with valid PU number) with the Department of Agriculture's Pesticides Registration & Control Divison.

The herbicide shall be applied at a rate and in a manner that is in accordance with the manufacturer's specification. Application of the herbicide shall not occur during periods of rainfall or during windy conditions. The application of herbicide shall also not occur at any stage where rainfall is predicted or expected within 1 hour of the chemical application. Extreme care shall be exercised during application of the herbicide to ensure pedestrians or passing vehicular traffic are not affected or contaminated by the herbicide application.

The herbicide application shall be conducted in a manner to ensure the following are not affected:

- Domestic Water Supply contamination
- Rivers, streams, ditches and other natural sources of water
- Neighbouring crops, pets and livestock
- Wildlife and beneficial insects
- Hedgerows, surrounding vegetation and gardens
- SAC's, SPA's, NHA's etc.

The Herbicide administrator must complete, sign & date a **Site Herbicide Recording Sheet (Appendix B)** identifying their individual PU number.

It is recommended that on completion of year 1 herbicide that a site walkover survey be carried out in May of the following year to evaluate the regrowth, this action should occur after each treatment has been administered throughout the 4 year programme.

3.4 Ongoing Monitoring
On the completion of the 4 year herbicide treatment programme a twice yearly monitoring programme should commence, the initial monitoring should commence in the middle of May of the following year and any minute regrowth should be marked on a map and identified on the ground with a precaution sign erected in the regrowth area. A further monitoring should take place in middle of August and all identified regrowth subjected to a further herbicide treatment as required.

All monitoring should be documented photographically and this documentation attached to the management plan, all further herbicide treatment that maybe required must be carried out as detailed in **Section 3.3 Four Year Herbicide Treatment Programme** of this document.

4.0 Specific Control Plans for Japanese Knotweed

4.1 Management Objectives

The objectives of this management plan are to gain control of the infestations of Japanese Knotweed that are present on this site in a sustainable and environmentally sensitive manner. Once control of the Japanese Knotweed has been achieved, the management and ongoing monitoring of this site in conjunction with the planned solar PV farm, will ensure that this non-native invasive plant poses no further threat to the surrounding biodiversity and environment of the site as a whole.

4.2 Management Options Rationale

The 4 year herbicide treatment programme with subsequent ongoing monitoring was the preferred management options for this site both environmentally and economically. Other options that were explored proved to be unsustainable and non-viable for a site such as this.

4.3 Biosecurity

- A clean down zone is to be identified and created at the entrance to the access road prior to the commencement of any works, this clean down zone must be clearly identified with signage
- Footbaths and clean down stations must be placed at all entry and exit locations to the site prior to the commencement of any works, these clean down stations must be clearly identified by signage
- All clean down areas must be clearly identified and a suitable membrane put in place to protect the soils beneath from further infestation, this membrane must be protected with a 150mm layer of 804 hardcore
- Tool box talks on invasive plant material to be provided to all relevant personnel involved in the works being undertaken prior to access to site being permitted
- A 3 metre buffer zone should be erected outside of the identified infested areas, no unauthorised personnel to be admitted within this 3 metre buffer zone, all works carried out within this buffer zone should be done so under the supervision of a certified surveyor in non-native invasive plants
- All machinery being brought to site must be inspected at the clean down zone for any soils that may contain invasive plant material before being allowed to enter the work zone
- At no time should the excavators or vehicles involved in the works breach the 3 metre buffer zone – should it be necessary for an excavator to work within the 3 metre zone, a certified surveyor in invasive plants should be present
- Excavators or machinery used within the 3 metre buffer zone must not be allowed to leave this area without being thoroughly inspected and cleaned down by the certified surveyor
- No delivery vehicles are to be allowed entry or exit to this site without being thoroughly inspected and cleaned to ensure that no non-native invasive material is unwittingly or accidently imported to site or escapes off site onto another
- On completion of these works all machinery must be thoroughly inspected and cleaned down before being allowed to leave this site
- As materials / aggregates will be imported to this site, it is vital that these materials be inspected at source to ensure that no non-native invasive plant material is imported to site
- All debris that is collected at the clean down areas and footbath stations needs to be deposited back into the already infested areas of the site
- At no time should any soils be removed from this site without this management plan being updated and a licence being obtained from the National Parks & Wildlife Services

On completion of the planned works for the solar PV farm, all footbath and clean down stations must remain on site and continue to be utilised for maintenance staff and the ongoing treatment of the Japanese Knotweed that is present.

4.4 Actions Planned on site

All works will be carried out in accordance with this management plan, should this management plan need to be amended due to any unforeseen constraints, these changes must be documented, dated and signed by a certified surveyor of invasive plants.

Records of all inductions and biosecurity checks must be documented and attached to this management plan for transparency. Clear signage must be erected throughout the site highlighting the dangers associated with cross contamination of the non-native invasive plant Japanese Knotweed.

4.5 How Actions will be Evaluated

The certified surveyor will conduct monitoring prior to any works being carried out to act as a baseline for future monitoring. Recording sheets will document any further visits and action taken.

4.6 Resources Required to Design & Create Management Plan

- Liaise with Mayo county council – Parks department
- Site surveyed
- Desk top study
- Design & create management plan

4.7 Results of evaluations

Site inspection forms contained within the appendix, this activity is carried out during the process. An audit trail shall be part of the completion package.

5.0. Summary of Information

The Japanese Knotweed that is present at this site can be controlled and managed successfully to allow the proposed solar PV farm to proceed. This management plan and the site specific biosecurity details are based on the condition of the site and data that was collected at the initial site survey.

All access routes and entry points referred to throughout this management plan were identified on the site layout maps supplied to The Japanese Knotweed Company by Claremorris & Western District Co-Op

Table 1	Priority Areas	Risk
Japanese Knotweed	The site as a whole	Medium Risk

Table 2	Control Methods	Risk
Japanese Knotweed	Implementation of biosecurity measures	Medium Risk
Japanese Knotweed	4 year herbicide treatment	Medium Risk
Japanese Knotweed	Ongoing monitoring programme	Medium Risk

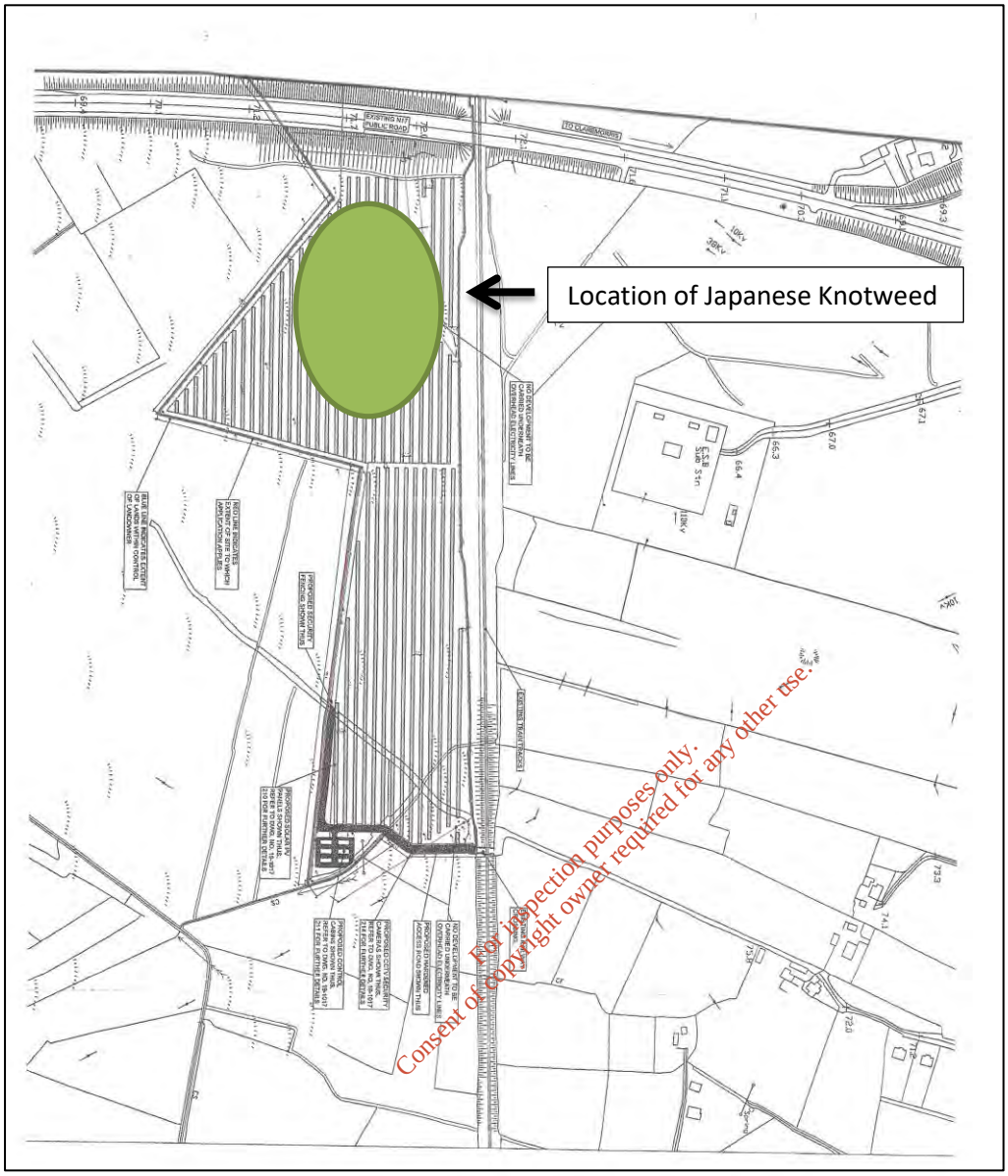
Table 3	Implementation Schedule
Phase 1: Initial site survey	Completed 06th & 07th January 2020
Phase 2: Management Plan	Completed 27th Januaray 2020
Phase 3: Enabling works / Tool box talks/fencing & signage	To be Confirmed
Phase 4: Implementation of pre-works biosecurity measures	To be Confirmed
Phase 5: Initial herbicide treatment prior to the commencement of works (21 days)	To be Confirmed
Phase 6: Development stage	To be Confirmed
Phase 7: Implementation of 4 year herbicide treatment programme	To be Confirmed
Phase 8: Implementation of ongoing monitoring on completion of 4 year herbicide treatment programme	To be Confirmed
Phase 9: All recording sheets & documentation to be attached to this management plan	All attachments to be added on an ongoing basis

6.0 Tier 3 Capping Option

A tier 3 treatment option for the historic landfill at Claremorris, Co Mayo is being discussed for this site. Should an application for a tier 3 capping be successful this management plan will be updated to include and reflect same.

Appendix A – Location Map

Appendix B – Location of JK



Appendix C

Daily Onsite Biosecurity & Management Forms

Date:		
Inspected by:	Initial:	Sign:
Site:		
Client:		

Transport routes free of soils/debris	**Yes**	**No**	**Comment**
Fencing	**Still in place**	**Damaged/Removed**	**Comment**
Clear Signage	**Still in place**	**Damaged/Removed**	**Comment**
Clean Zones Inspected	**Yes**	**No**	**Comment**
All Machinery/Plant inspected			
Have any vehicles left or entered the site ?			
Is the site secure?			
Notes/Comments			

A new form is to be used on each working day – it must be signed and dated by the appointed certified surveyor – it must be attached to the management plan at all times for transparency

Appendix D: Site Herbicide Record Sheet

Date:		
Inspected by:	Initial:	Sign:
Site:		
Client:		

Dose of Product	Volume Applied	Product	Total area Treated	Start Time	Finish Time

Names / Certificate Nos of Other Operators	

PPE		WORN
Gloves		
Boots		
Coverall		
Apron		
Face Shield		
Hard Hat		
Respirator		

Notes: Harvest interval, exclusion period, problems, equipment faults/repairs, notification of neighbour	**Wind Direction**	N	NE	E	SE	S	SW	W	NW
Technicians need to be fully qualified in PA1, PA6, PA6 AW & PA6 ING – Must also be a registered pesticide user Registered Pesticide Number Signed By:	**Wind Speed**	Nil		Light		Moderate		Strong	
	Temperature	Cold		Cool		Warm		Hot	
	COSHH Sheets Present	Yes				No			
	Warning signs in place	Yes				No			

This form is to be used on each separate site visit and herbicide treatment – it must be attached to the management plan at all times for transparency

Appendix E: Environmental Risk Assessment **Classifications – Extreme – High – Medium – Low Risk – No Risk**

Hazard	Source	Pathway	Receptor	Risk	Abatement Measures
Hybrid Knotweed & Infested soils	Excavation of soils	Ground	Cross contamination onsite		All infested areas on infestation are to be fenced off 7 m from the nearest stems using high visibility fencing; signs will be displayed notifying all workers on site of the presence of invasive weeds. All infested soils to be contained within identified holding area. All machinery to be cleaned before moving to a different area.
Particulates	Plant & Machinery	Air	Residents - site staff		Ensure vehicles and plant in good operating condition.
Spillage's of oils & fuels	Plant & Machinery	Ground	Ground Water		Bulk Fuels to be contained within a bunded fuel tank. Vehicles to be inspected for leaks. Ensure vehicles & plant in good operation condition. Provide spillage control equipment.
Noise	Plant & Machinery	Air	Residents – site staff		Ensure vehicles and plant in good operation with silencers. Locate plant to minimise effect. Use plant at appropriate time.
Mud & Debris	Plant & Machinery	Ground	Public roadway - residents		All machinery shall be cleaned before leaving site. If required provide wheel wash facilities. If required provide road sweeper.
Dust	Plant Movement	Air	Adjoining land Residents Site staff		Spray water during dry spells. Deploy water bowser. Employ road sweeper to damp down roads.
Dated:			**Signed:**		

This form is to be used on each separate site visit and herbicide treatment – it must be attached to the management plan at all times for transparency

Appendix F: Control of Substances Hazardous to Health Assessment

Substance/Contaminant/Chemical : Herbicides

Activity / Element	Hazards in contact with	Who / What Risk	Initial Rating L	C	R	Control Measures Specified	Residual Risk Rating L	C	RRR
Decanting	Eyes	Operatives				Training/ Awareness of the task, the equipment and the chemicals involved must be given to anyone about to use this system. Attention must be drawn and information must be given and readily available for refresher reasons on the effects of this chemical; • How to store it safely. • How to decant it safely. • How to use it. • What to do in case someone has been affected by it. First Aid Eyes – flush immediately with water for about 15 mins. If the irritation persists seek medical advice Skin – Remove affected clothing and wash the underlying skin with copious amounts of soap and water. If the irritation persists seek medical advice Swallowing – Seek medical aid immediately and take the chemicals information (Material Safety Data Sheet) with you			
Spraying	Skin	Other site personnel							
Storage	Air passage ways	Members of the public							
Transport	Digestive System	Other							
Other	Other								
Notes:	Notes	Notes							

L = Likelihood	1 = Improbable, 2 = Unlikely, 3 = Likely, 4 = Very Likely, 5 = Certain
C = Consequence	1 = Injury no lost time, 2 = Minor injury less than 3 days, 3 = Injury more than 3 lost days, 4 = Major Injury, 5 = Fatality
R = Risk Rating	The risk rating is the value given to the Risk when the likelihood is multiplied by the Consequence
RRR = Residual Risk	The residual risk rating is the value of the risk once all the control measures have been put into place and practise

In the case of an environmental affect the Consequences rating should reflect the severity of that effect

Date of Assessment:		**Name of Assessor:**	
Review Date:		**Reviewed By:**	

This form is to be used on each separate site visit and herbicide treatment – it must be attached to the management plan at all times for transparency

All information relevant to this management plan will be attached on an ongoing basis for the duration of the proposed works identified within this document. All monitoring and results of evaluations to be fully documented and recorded with photographic evidence to be attached to this management plan

Kieren O' Shea 27/01/2020

Certified Surveyor

The Japanese Knotweed Company

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APPENDIX 7

Remediation Design Drawings

Legend

- Site Boundary/Extent of Solar Development
- Proposed SW Monitoring Locations (T.B.A)
- Approximate Capping Boundary 31,925m² (to be Confirmed by Additional SI)
- Existing Boreholes
- Proposed Boreholes (Locations T.B.A)
- Surface Water
- Flow Direction

Notes:

All remediation works subject to EPA approval, detailed design and Certificate of Authorisation.

Historic Landfill Engineered Cap

Engineered cap shall comprise:

- 200 mm topsoil, on
- 800 mm subsoil, on
- Subsurface drainage geocomposite and collection pipework or similar, on
- 1mm LLDPE Barrier, on
- Gas collection geocomposite and collection pipework or similar,
- Reprofiled Existing/Imported Layer, above
- Historical Waste

Subject to detailed design and Certificate of Authorisation.

Topsoil

Topsoil shall be compliant to BS3882:2015 or equal approved and graded to ensure no localized surface depressions are present.

Subsoil

Subsoil shall be provided using a uniformly graded material with stone sizes not greater that 100 mm or equal approved.

Subsurface Drainage

A subsurface drainage layer on the cap barrier (hydraulic conductivity should be equal to or greater than 1x10-4 m/s for a thickness of 500 mm) or equal approved geocomposite

Surface Drainage

Surface drainage layouts using grassed waterways shall collect and direct surface water runoff including subsurface drainage outfall flows to one or more dedicated surface drainage outfalls into existing surface water perimeter drain(s).

LLDPE Barrier System

The barrier system shall use 1.0 mm LLDPE or similar approved.

This barrier will require vertical cut-offs on all boundaries to mitigate the risk of landfill gas migration and leachate egress following secondary consolidation. Subject to Detailed Design

Landfill Gas Management

Shall comprise a under-liner gas collection geocomposite or similar approved stone drainage later. As per EPA Landfill Site Design manual, should not be less than a 150 mm stone layer with a hydraulic permeability of 1x10-4m/s or equivalent.

Landfill gas management subject to risk assessment and detailed design

Environmental Monitoring

Environmental Monitoring infrastructure as per Remediation Plan schedule and Certificate of Authorisation

Invasive Species

All works subject to the recommendation of the prepared Invasive Species management plan.

Solar Farm Development

All proposed works to be cognisant of proposed after use of site as a solar farm as appropriate

0m 10m 20m 30m 40m 50m 60m 70m 80m 90m 100m

Scale 1:1000

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Rev.	Description	App By	Date
A	ISSUE FOR COMMENT	BG	03.03.20

PROJECT
CLAREMORRIS HISTORIC LANDFILL REMEDIATION PLAN

CLIENT
MAYO COUNTY COUNCIL

SHEET
LOCATIONS OF PROPOSED ENVIRONMENT MONITORING POINTS

Date 03.03.20	Project number P2348	Scale (@ A1-) 1:1000	
Drawn by SOC	Drawing Number P2348-0400-0001		Rev A
Checked by JON			

O:\ACAD\2020\P2348\P2348-0400-0001

05 March 2020

Legend

- Site Boundary/Extent of Solar Development
- Approximate Capping Boundary 31,925m² (to be Confirmed by Additional SI)

Notes:

All remediation works subject to EPA approval, detailed design and Certificate of Authorisation.

Historic Landfill Engineered Cap

Engineered cap shall comprise:

- 200 mm topsoil, on
- 800 mm subsoil, on
- Subsurface drainage geocomposite and collection pipework or similar, on
- 1mm LLDPE Barrier, on
- Gas collection geocomposite and collection pipework or similar,
- Reprofiled Existing/Imported Layer, above
- Historical Waste

Subject to detailed design and Certificate of Authorisation.

Topsoil

Topsoil shall be compliant to BS3882:2015 or equal approved and graded to ensure no localized surface depressions are present.

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Subsoil shall be provided using a uniformly graded material with stone sizes not greater that 100 mm or equal approved.

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Landfill gas management subject to risk assessment and detailed design

Environmental Monitoring

Environmental Monitoring infrastructure as per Remediation Plan schedule and Certificate of Authorisation

Invasive Species

All works subject to the recommendation of the prepared Invasive Species management plan.

Solar Farm Development

All proposed works to be cognisant of proposed after use of site as a solar farm as appropriate

TYPICAL CAPPING DETAIL - HISTORIC LANDFILL

Scale 1:25

PLAN

Scale 1:500

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Rev.	Description	App By	Date
A	ISSUE FOR COMMENT	BG	03.03.20

PROJECT

CLAREMORRIS HISTORIC LANDFILL REMEDIATION PLAN

CLIENT

MAYO COUNTY COUNCIL

SHEET

PROPOSED REMEDIATION PLAN

Date	Project number	Scale (@ A1-)
03.03.20	P2348	As Shown

Drawn by	Drawing Number	Rev
SOC	P2348-0400-0002	A
Checked by JON		

O:\ACAD\2020\P2348\P2348-0400-0002

05 March 2020

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APPENDIX 3

Parameters for Monitoring of Groundwater, Surface Water and Leachate

Table 1: Parameters for Monitoring of Groundwater, Surface Water and Leachate

Monitoring Parameter[35] See Footnote	Frequency*	Surface Water	Groundwater	Leachate
Level	Quarterly+	-	-	-
Flow Rate		-	-	-
Temperature		✓	✓	✓
Dissolved Oxygen		✓	-	-
pH		✓	✓	✓
Electrical Conductivity[36]		✓	✓	✓
Total suspended solids		✓	-	-
Total dissolved solids		-	✓	
Ammonia (as N)		✓	✓	✓
Total oxidized nitrogen (as N)		✓	✓	✓
Total organic carbon		-	✓	-
Biochemical Oxygen Demand		✓	-	✓
Chemical Oxygen Demand		✓	-	-
Metals[37]		✓	✓	✓
Total Alkalinity (as $CaCO_3$)		✓	✓	-
Sulphate		✓	✓	✓
Chloride		✓	✓	✓
Molybdate Reactive Phosphorous[38]		✓	✓	✓
Cyanide (Total)		✓	✓	✓
Fluoride		✓	✓	✓
Trace organic substances[39]	Annually	✓	✓	✓
Faecal and Total Coliforms[40]		-	✓	-
Biological assessment	-	-	-	-

[35] Tables D.1 and D.2 of the EPA Landfill Monitoring manual recommend guideline minimum reporting values for parameters

[36] Where saline influences are suspected, a salinity measurement should also be taken

[37] Metals for analysis should include: calcium, magnesium, sodium, potassium, iron, manganese, cadmium, chromium (total), copper, nickel, lead, zinc, arsenic, boron and mercury.

[38] Total Phosphorus should be measured in leachate samples where colorimetric interference is likely.

[39] Table D.2 of the EPA Landfill Monitoring manual recommends trace organic substances that should be included in the determination. Surface water should be analysed for the pesticide sand solvents listed in the Water Quality (dangerous Substances) Regulations (S.I No. 12 of 2001)

[40] Required for drinking water supplies within 500m of the landfill

***Note: Parameters proposed to be monitored on a quarterly basis should initially be monitored monthly for a duration of 12-months following the issuing of a Certificate of Authorisation (CoA) for the purpose of establishing baseline characteristics at each monitoring location**

[+]Annual parameters may be reduced to annual with the agreement on the agency dependant on the results and variation observed with time and versus the baseline assessment.

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APPENDIX 4

Stage 1 Appropriate Assessment Screening Report for the Proposed Solar Farm at Claremorris, Co. Mayo

Screening Statement for Appropriate Assessment

SOLAR PV FARM AT CLARE CLAREMORRIS

Environment, Climate Change & Agriculture Section

Mayo County Council

Áras an Chontae

Co. Mayo

TABLE OF CONTENTS

TABLES

FIGURES

1 INTRODUCTION

This report comprises of an Appropriate Assessment Screening for the proposed Solar PV Farm at Clare, Claremorris Co. Mayo in order determine whether or not this project, alone and in combination with other plans or projects, could have a significant effect on a Natura 2000 sites (EC Habitats Directive 92/43/EEC), in view of the site's conservation objectives. The Natura network is made up of Special Protection Areas for Birds (SPA) and Special Conservation Areas (SAC) for habitats and species. The proposed development is not directly connected with or necessary to the management of a Natura 2000 site. The findings of the assessment will determine whether the proposed development requires an Appropriate Assessment and a Natura Impact Statement under Article 6(3) of the EU Habitats Directive 92/43/EEC.

1.1 STATEMENT OF AUTHORITY

The ecological survey for this report was carried out on December 20th 2019 by Leo Brogan (B. Env., Sc. M. Sc and Dip. Field Ecol.) who has the relevant academic qualifications and experience to undertaking habitat surveys and appropriate assessments.

1.2 GUIDANCE

This report has been carried out using the following guidance:

- Appropriate Assessment under Article 6 of the Habitats Directive: Guidance for Planning Authorities. Circular NPW 1/10 & PSSP 2/10[1].
- Appropriate Assessment of Plans and Projects in Ireland - Guidance for Planning Authorities. (Department of Environment, Heritage and Local Government, 2010)[2].
- Managing Natura 2000 Sites: the provisions of Article 6 of the 'Habitats' Directive 92/43/EEC, Office for Official Publications of the European Communities, Luxembourg (EC 2000)[3].
- Assessment of Plans and Projects Significantly Affecting Natura 2000 Sites: Methodological guidance on the provisions of Article 6(3) and (4) of the Habitats Directive 92/43/EEC, Office for Official Publications of the European Communities, Luxembourg (EC 2002)[4].

[1] NPWS (2010). Legislation Unit, NPWS Department of Environment, Heritage and Local Government, 7 Ely Place Dublin 2.

[2] National Parks and Wildlife Services (2010): http://www.npws.ie/sites/default/files/publications/pdf/NPWS_2009_AA_Guidance.pdf

[3] European Commission (2000) http://ec.europa.eu/environment/nature/natura2000/management/docs/art6/provision_of_art6_en.pdf

[4] European Commission (2000) http://ec.europa.eu/environment/nature/natura2000/management/docs/art6/natura_2000_assess_en.pdf

- Guidance document on Article 6(4) of the 'Habitats Directive' 92/43/EEC – Clarification of the concepts of: alternative solutions, imperative reasons of overriding public interest, compensatory measures, overall coherence, opinion of the commission. Office for Official Publications of the European Communities, Luxembourg (EC 2007)[5].

2 SCREENING ASSESSMENT

2.1 PROJECT BACKGROUND

The Claremorris and Western District Energy Co-operative is a community enterprise, founded in March 2015, focused on the development and commercialization of renewable energy technologies in the West of Ireland. The group's focus is to develop financially viable renewable energy projects through education programmes with key competencies in solar and Micro grid applications.

The proposed Solar PV project will be in partnership with Mayo County Council and proposes to be the first community/local council led solar project in Ireland. The project will lead the District in achieving an increase in Renewable Energy integration and a reduction in the Districts carbon footprint.

2.2 PROJECT LOCATION

The location for the proposed solar farm project as shown in Figure 1, is in the townland of Clare, 900m due east of Claremorris town. It is bounded to the north by the Westport to Athlone railway line, to the west by the N17 and to the east and south by lands comprising of scrub, heavily drained peatlands and agricultural grasslands.

2.3 DESCRIPTION OF THE PROPOSED DEVELOPMENT

2.3.1 Description of Project

Mayo County Council and the Claremorris and Western District Energy Co-operative have entered a partnership to construct a 5 MW Solar Farm in Clare, Claremorris, Co Mayo. The planning boundary for the development can be divided into 3 subsites, a historic landfill site owned by Mayo County Council (approx. 5.0 H), a site leased from local farmers (4.0 Ha) and a 3rd site west of the N17. The Partnership have secured a grid connection to ESB Networks and the proposed next stage is to seek planning permission through the Part 8 process.

Access to the site is via an existing railway crossing in the north east of the site as shown in Figure 2. The main internal access road for construction and operational phases is along the eastern boundary of

[5] European Commission (2007)
http://ec.europa.eu/environment/nature/natura2000/management/docs/art6/guidance_art6_4_en.pdf

the site. The 6 control cabins will be located in the south-eastern corner of the site (See Insert Figure 2). The area within the red line boundary to the west of the N17 will not be developed due to the presence of overhead powerlines.

The PV panel array will be on ground mounted steel frames, and the development will include electricity control cabins, inverter units, cable ducts, hardstanding area, boundary security fence, site entrance, access track, landscaping, CCTV, together with all ancillary site works and services.

Each panel will be approximately 1925mm x 996mm and will be laid in rows and tilted so that they are south facing. The maximum height of the panels will be 3 m above ground level and they will be anchored using either a steel frame driven 1.7m below ground level or alternatively a precast concrete slab depending on ground conditions.

Gaps of 5.5m will be left between panel rows to allow for maintenance and for livestock to graze after the installation is completed.

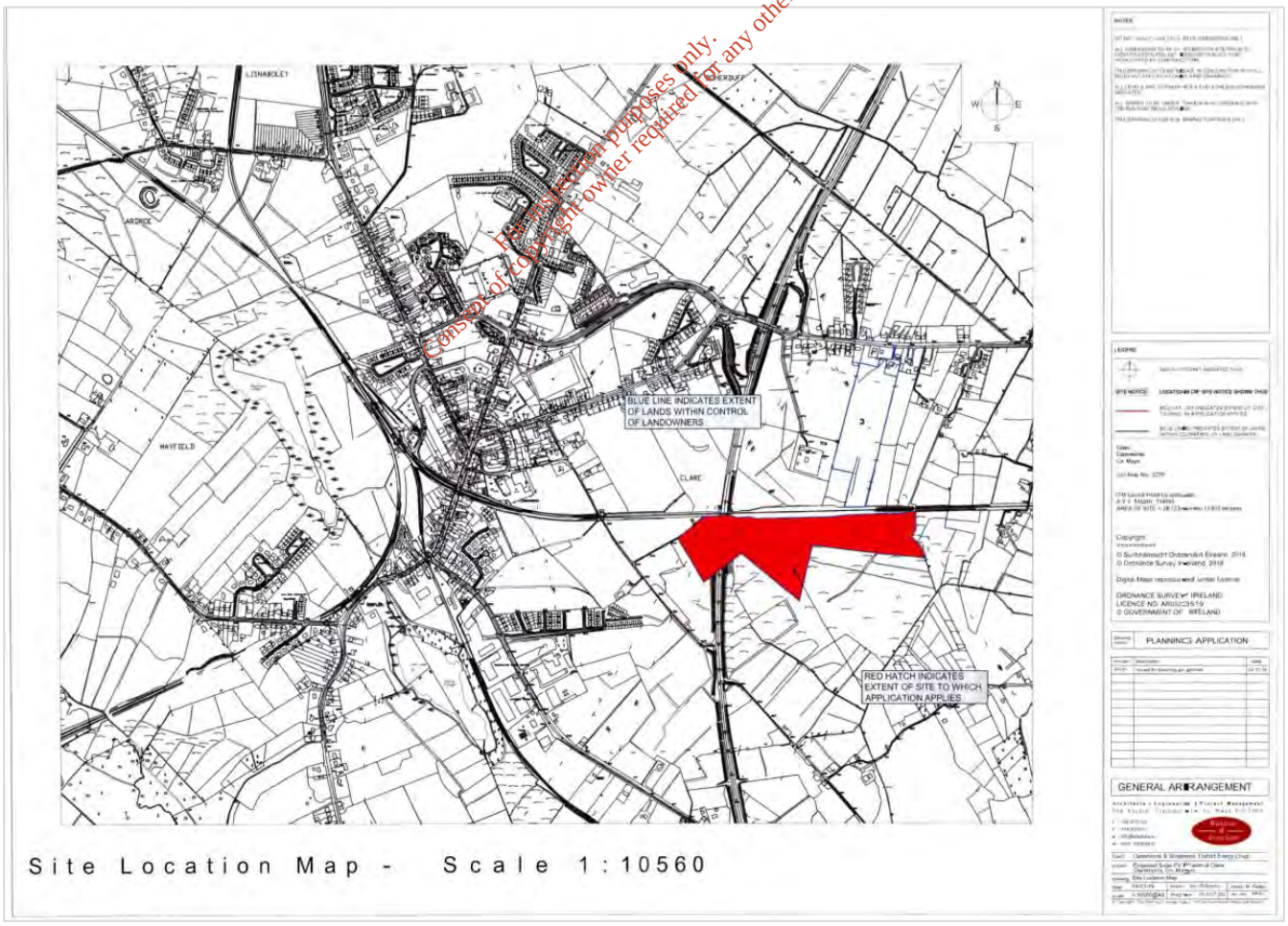

Figure 1 Location of Solar PV Farm at Clare Claremorris

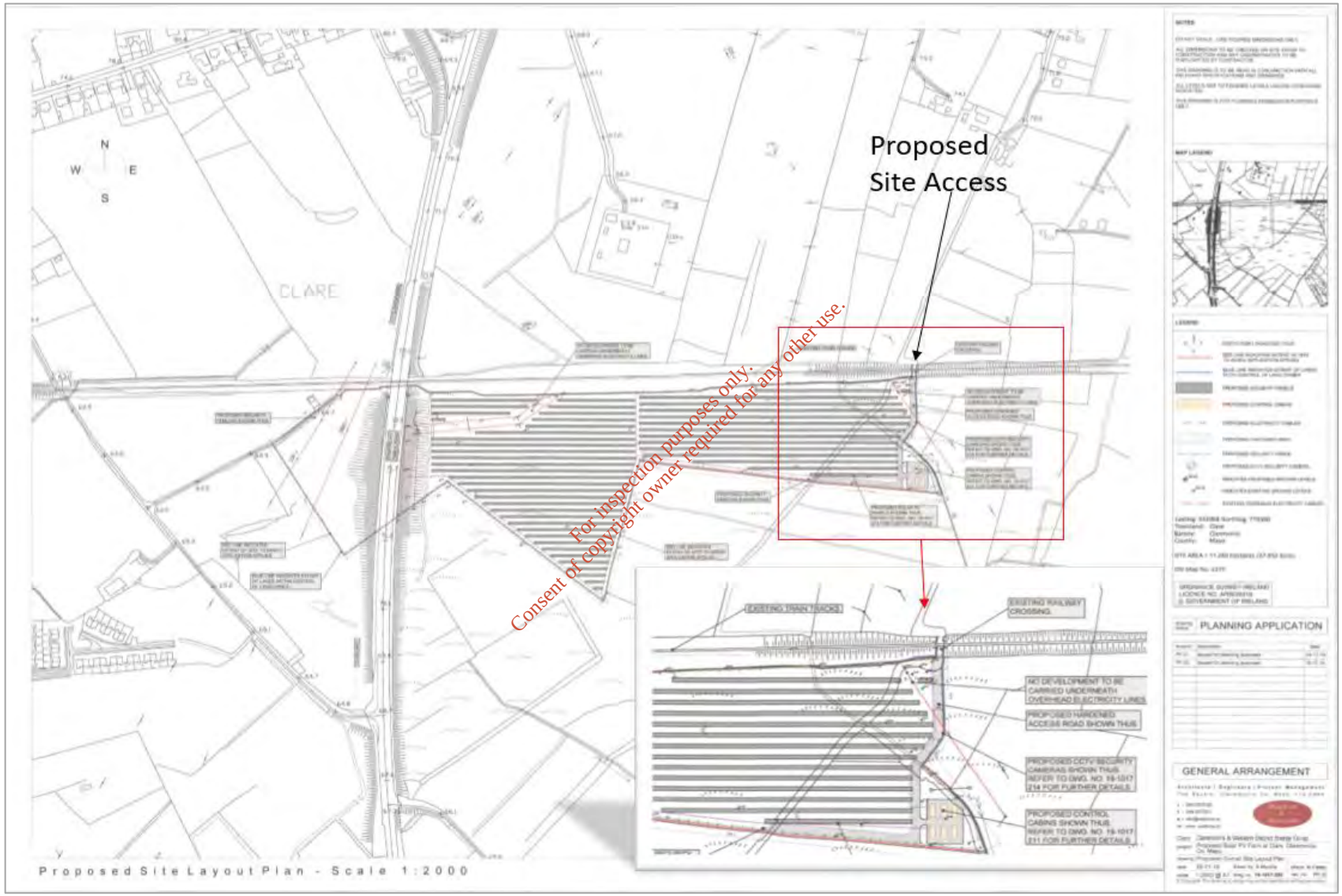

Figure 2 Proposed Layout of Solar PV Farm at Clare Claremorris

2.4 DESCRIPTION OF THE EXISTING ENVIRONMENT

2.4.1 Information Sources

The ecological desktop study to inform the Appropriate Assessment Screening completed for the proposed development comprised the following elements:

- Identification of European Sites within the Zone of Influence (ZoI) of the proposed development area through the identification of potential pathways/ links from the proposed development area and European sites and/ or supporting habitats;
- Review of the National Parks and Wildlife Service (NPWS) site synopses (Natura 2000 data form) and conservation objectives for European Sites[6] with identification of potential pathways from the proposed development; and
- Review of available literature and online data. This included a detailed review of the NPWS website including mapping and available reports[7] for relevant sites and in particular Qualifying Interests described and their conservation objectives.

An outline of the key datasets and information sources reviewed as part of the study are provided below:

- National Parks and Wildlife Service (NPWS) database of areas designated (and proposed) for nature conservation
- National Biodiversity Data Centre database (NBDC)[8];
- EDEN Application [9]; and
- EPA Appropriate Assessment Geo Tool[10]
- OSI and Bing Maps aerial photography and mapping were used to identify non-designated semi-natural habitats of local ecological importance.

2.4.2 Existing Environment

2.4.2.1 Terrestrial Habitats

The landscape within the proposed application site is relatively flat and low-lying and can be divided into 3 subsites. The majority of the first subsite to the west of the N17 is made up agricultural grassland (GA1) and a mosaic of habitats including patches of Scrub (WS1), treelines (WL2) and artificial surfaces along the embankments of the N17 road.

[6] National Parks and Wildlife Service: http://www.npws.ie/protectedsites/ (accessed January, 2020)

[7] National Parks and Wildlife Service: http://www.npws.ie/mapsanddata/ (accessed January, 2020)

[8] NBDC https://maps.biodiversityireland.ie/Map (accessed January, 2020)

[9] EPA https://www.edenireland.ie/home/secure (accessed January, 2020)

[10] EPA AA Geotool (https://gis.epa.ie/EPAMaps/AAGeoTool) (accessed January, 2020)

The second subsite to the east of the N17 has a steep embankment which has recolonised following the N17 upgrade works in the early 2000s. The remainder of this subsite is composed of lands which has recolonised into mostly scrub (WS1), recolonised bare ground (ED3) and dense stands of impenetrable brambles, following its use a landfill for the Claremorris urban area prior to 2000 (see Figures 3 and 4). There is a small mixed conifer plantation (WD3) to the north of the historic landfill and a wet ditch running along the base of the railway line embankment. The footprint of the historic landfill has Japanese Knotweed (*Fallopia Japonica)* stands scattered throughout. Winter heliotroph (*Petasites fragrans*) was also identified in the northwest of Subsite 2 during the site visit which took place on December 20th 2019.

Figure 3 View east from N17 of Subsite 2 (note conifer plantation and scrublands in the background)

Figure 4 View South from the western side of Subsite 2 (note recolonised bare ground and grazing ponies)

The 3rd subsite in the east of the planning boundary would have been formerly part of a large tract of blanket bog which has been extensively drained in a herringbone formation for the purpose of low intensity peat harvesting. A trackway (BL3) through this subsite from the railway crossing is present running in a south-westerly direction. Small sections of scrub have encroached (WS1) while scattered immature willow trees have established along the drainage ditches.

2.4.2.2 Freshwater Habitats

The headwater stream of the Robe_020 rises immediately north of the railway line and flows in southerly direction through the eastern fringes of the site before it exits the site boundary to flow outside the eastern boundary. The stream then flows generally south for 2 km where it enters the main channel and flows in a south easterly direction for 35 kms before into Lough Mask (part of the Lough Carra / Mask Complex SAC) 4.5 km west of Ballinrobe town.

There is a ditch allong the north boundary of the site which has standing water.

The white-clawed crayfish (*Austropotamobius pallipes*), an Annex II listed species, is recorded from the Robe_020 at the bridge southwest of Meelick (NBDC database). This crustacean requires waters of a high alkalinity, typically only occurring in water with pH of 7.0 or greater with calcium concentrations of at least 5 mg/l. This is upstream of the confluence of the stream which flows through the application site.

2.4.2.3 Water Quality

A review of the EPA Eden website[11] indicates the Robe_020 waterbody, is currently at High Ecological Status based on Q values of 4.5 achieved in 2013 and 2018[12] at Crossboyne Bridge approximately 7 km downstream of the proposed solar PV farm.

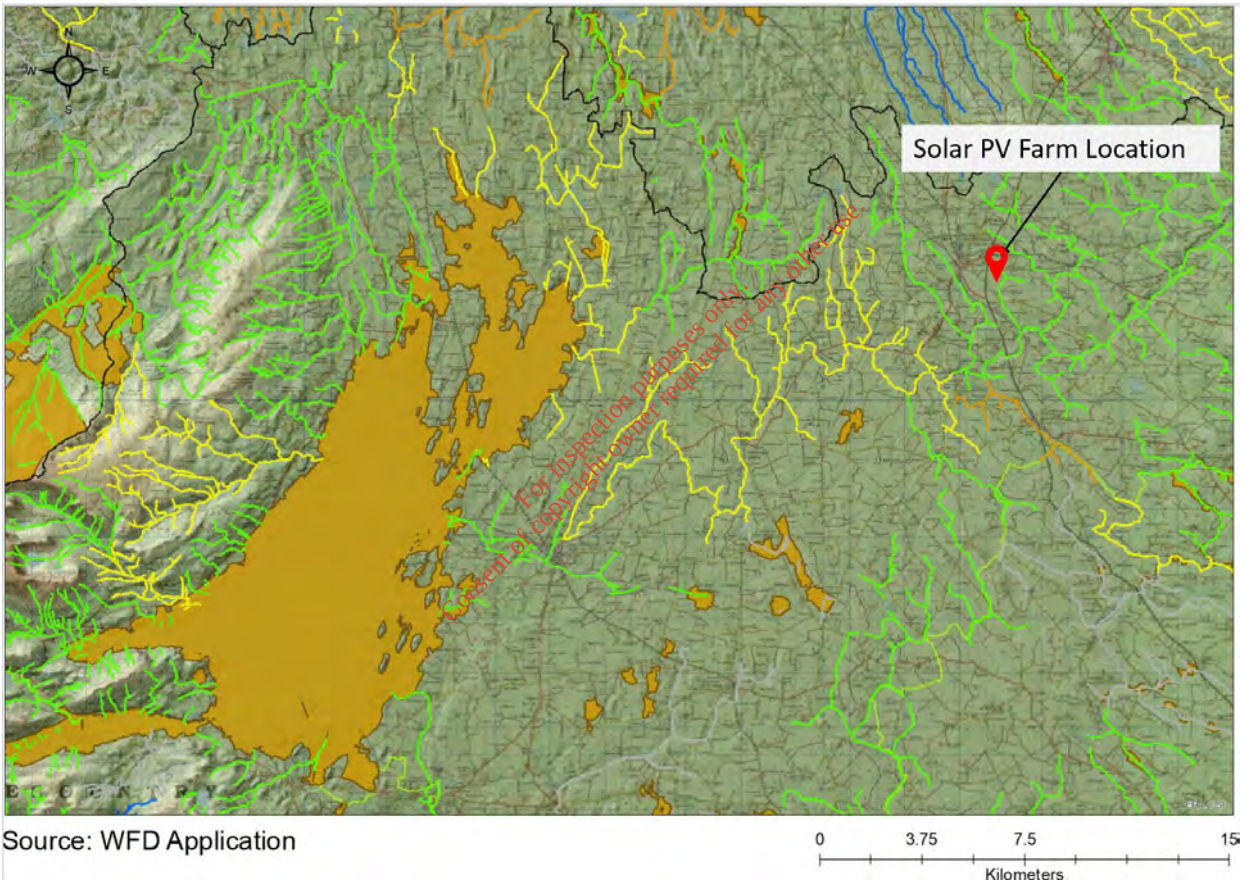

Figure 5 Solar Farm PV site and Waterbody Quality Status downstream (Note: Robe_020 is good, Robe_030 & _040 are moderate and Robe_050 is good)

The groundwater boundary within which the development is located, Cong-Robe (IE_WE_G_0019), is currently at Good quantitative and qualitative Status. Based on the contour lines, the groundwater flow direction is generally in a south-easterly direction towards Ballinrobe.

[11] EPA Eden Website https://wfd.edenireland.ie/ Accessed (17th Dec 2019)

[12] Figure 5 shows WFD status under current River Basin Management Plan (2018- 2021) based on 2010 to 2015 data

2.5 IDENTIFICATION OF RELEVANT NATURA 2000 SITES

A standard source-receptor-pathway conceptual model was used to identify a preliminary list of 'relevant' European sites (i.e. those which could be potentially affected). This conceptual model is a standard tool in environmental assessment. In order for an effect to occur, all three elements of this mechanism must be in place. The absence or removal of one of the elements of the mechanism means there is no likelihood for the effect to occur. In the context of the proposed development, the model comprises:

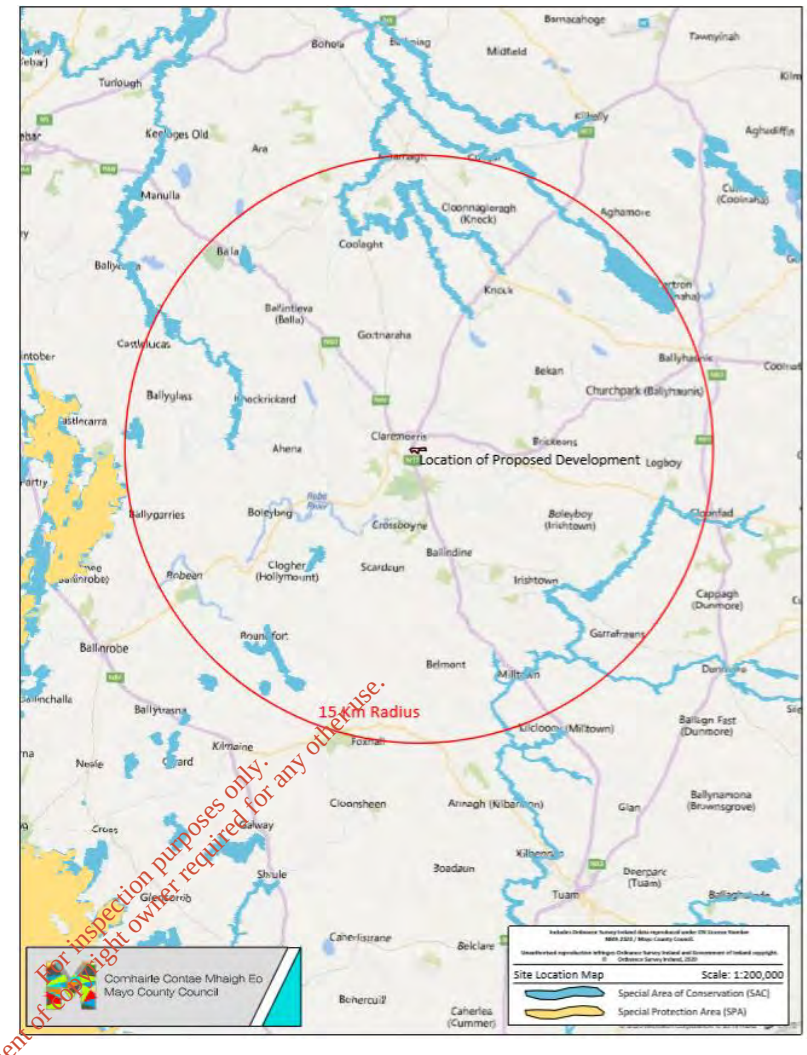

Figure 6 Natura 2000 Sites with 15 km radius of proposed Solar PV Farm

- Source (s) – e.g. sediment run-off from the proposed development
- Pathway (s) – e.g. drains and streams connecting to a European site
- Receptor (s) – Qualifying habitats and species of European sites

There are 8 European sites located within 15km of the proposed development site (Figure 6). In addition, this screening assessment includes an evaluation of whether there are any pathways for effects on European Sites located outside of the 15km buffer potentially arising from the proposed development.

The pathways for effects with reference to the European sites listed below are presented in Table 2.2 below.

Table 2-1 Designated Natura 2000 Sites within a 15km radius of the proposed development

Site Name	Site Code	Status	Distance overland from Proposed Project	Description and Features	Pathway
Carrowkeel Turlough	000475	SAC/pNHA	6.9km	Carrowkeel turlough is contained within a linear basin with no obvious signs of successful external drainage. The southern end of the turlough retains water throughout the year.	Potential indirect groundwater connection
River Moy	002298	SAC	9.3km	The SAC comprises almost the entire freshwater element of the River Moy and its tributaries. The site supports populations of several species listed on Annex II of the E.U. Habitats Directive, and habitats listed on Annex I of the Directive.	No connection Development outtside Moy Catchment
Lough Corrib	000297	SAC	9.8km	Lough Corrib is one the best examples of a large lacustrine catchment system in Ireland, with a range of habitats and species well represented. These include 15 habitats listed on Annex I of the E.U.Habitats Directive, six of which are priority habitats, and nine species which are listed on Annex II. A number of rivers are included within the SAC as they are important for Atlantic Salmon.	No hydrological connection to River Dalgan
Kilglassan/Caheravoostia Turlough Complex	000504	SAC/pNHA	11.5km	This SAC comprises two turloughs separated by a rise of land which includes a pond and a small floating fen. Both turloughs occupy relatively flat basins that remain wet even in summer.	Potential indirect groundwater connection
Towerhill House	002179	SAC	14km	This SAC is designated for Lesser Horseshoe Bat. The site comprises the ruins of Towerhill House, the surrounding woodlands, Lough Beg and its associated swamp vegetation.	No connection
Ardkill Turlough	000461	SAC/pNHA	14.2km	This is one of a group of five turloughs that occupy hollows in rolling countryside. It is set amongst low limestone knolls with drift around the south and east.	Potential indirect groundwater connection
Lough Carra/Mask Complex	001774	SAC	15 km	This site is dominated by two large lakes, Lough Mask and Lough Carra, and includes the smaller Cloon Lough. This site is of considerable conservation importance as it has good examples of nine habitats listed on Annex I of the E.U. Habitats Directive, four of which are listed with priority status. It is also selected for two Annex II mammal species and an Annex II moss.	Connected indirectly via River Robe 40km distant
Lough Carra	004051	SPA	15km	The site is dominated by Lough Carra and Mask and is of National importance for inland breeding gulls and Common Tern. It hosts nationally important population of Tufted Ducks , Whooper Swans and Greenland White Fronted Geese.	Connected ~40km distance via River Robe
Skealoughan Turlough	000541	SAC/pNHA	15.4km	Skealoughan Turlough is of conservation interest for its diversity of vegetation types, particularly the oligotrophic (nutrient-poor) sedge communities.	Potential indirect groundwater connection

There are six Natura 2000 sites from Table 2.2 above that are determined to be within the zone of influence of the proposed project based on having indirect hydrogeological/surface water connections. Figure 7 shows the location of the proposed project in relation to these SACs.[13]

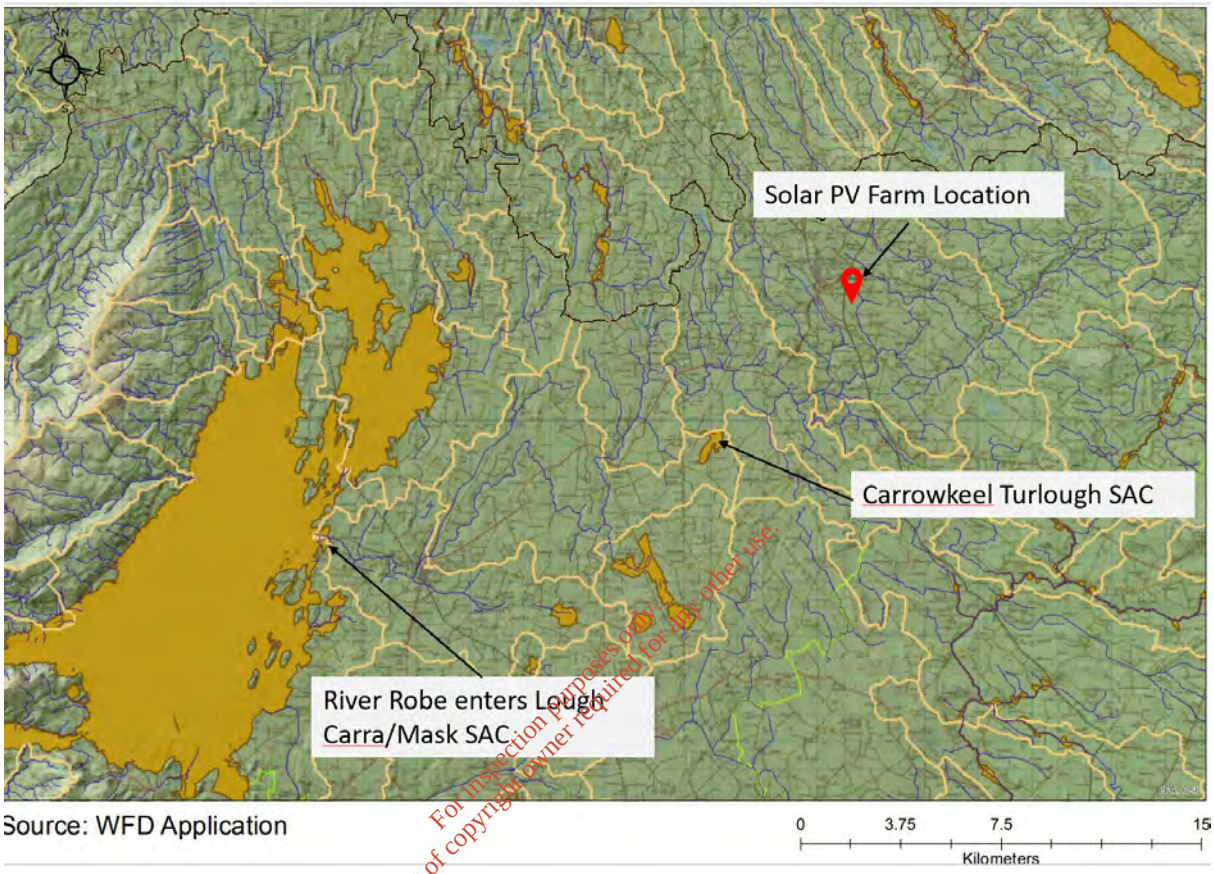

Figure 7 Solar PV Farm at Claremorris with Natura 2000 Sites (orange), Rivers and Sub-catchments boundaries

2.5.1 Potential for in-combination or cumulative effects

A search of the Mayo County Council on-line planning portal[14] was completed on the December 18th 2019 to identify other planning application in the vicinity of the proposed project (See Table 2-2).

There are no other projects or plans or any significance currently listed and therefore potential for in combination effects are considered to be non-existent.

[13] Carrowkeel Turlough represents SACs with an indirect groundwater connection as it is the closest at 6.9km.

[14] http://www.mayococo.ie/PlanSearch/mcc4/PlanningViewer/SelectPlan.asp (Accessed on December 18th 2019)

Table 2-2 Planning Application in the vicinity of proposed project

Planning reference	Development Address	Description	Status	In combination Effects
P14 144 Electricity Supply Board	CLARE (KILBEG), CLAREMORRIS, CO. MAYO (200m North of proposed solar farm)	ALTERATIONS TO THE EXISTING STATION TO INCLUDE A SINGLE STOREY EXTENSION TO THE SIDE OF THE EXISTING CONTROL BUILDING, NEW BUNDED 110 KV POWER TRANSFORMER AND ASSOCIATED TRANSFORMER BAY, NEW 6M HIGH FIREWALL BETWEEN THE NEW TRANSFORMER AND THE CONTROL BUILDING EXTENSION, NEW BUNDED ARC SUPPRESSION COIL (ASC), NEW 38KV COMBINED CABLE/TRANSFORMER CUBICLE, NEW 110KV SECTIONALISER BAY, I NO. NEW 18M HIGH MONOPOLE LIGHTNING MAST, 5M EXTENSION TO STATION COMPOUND FENCING ON EASTERN SIDE, NEW OIL SEPARATOR AND ASSOCIATED DRAINAGE, ASSOCIATED SITE WORKS	Constructed	In combination effects unlikely to occur due to the nature and scale of the development
P18 23 Highfield Storage Ltd	CLARE, CLAREMORRIS, CO. MAYO (Adjacent to P14 144 above)	10 YEAR PERMISSION FOR THE CONSTRUCTION OF AN ENERGY STORAGE FACILITY WITHIN A TOTAL SITE AREA OF UP TO 1.14HA, TO INCLUDE ONE SINGLE STOREY ELECTRICAL SUBSTATION BUILDING AND ELECTRICAL COMPOUND, ELECTRICAL TRANSFORMER/INVERTER STATION MODULES, CONTAINERISED BATTERY STORAGE MODULES ON CONCRETE SUPPORT STRUCTURES, ACCESS TRACKS, ASSOCIATED ELECTRICAL DUCTING, CABLE RACKING AND CABLING, SECURITY FENCING AND CCTV SECURITY MONITORING SYSTEM, LIGHTING PROTECTION POLES, COMMUNICATIONS EQUIPMENT AND ANCILLARY INFRASTRUCTURE	Refused by Mayo Co Co but modified on appeal to An Board Pleanala.	In combination effects unlikely to occur due to the nature and scale of the development.
P13 617 PWWP Development Ltd	BALLYKINAVA/CUILLMORE, CLAREMORRIS, CO MAYO (2 km to the southeast of proposed solar farm)	10 YEAR PLANNING PERMISSION FOR A WIND FARM DEVELOPMENT. WIND FARM COMPRISES OF A TOTAL OF 7 WIND TURBINES, WITH A MAXIMUM OVERALL BLADE TIP HEIGHT OF UP TO 156.5M, UPGRADE OF EXISTING AND PROVISION OF NEW INTERNAL ACCESS ROADS INCLUDING THE UPGRADING OF SITE ACCESS JUNCTION AND PROVISION OF A NEW SITE ACCESS JUNCTION, PROVISION OF ANEMOMETRY MAST UP TO 100M, PEAT DISPOSAL AREAS, UNDERGROUND ELECTRICITY CONNECTION CABLING, TEMPORARY CONSTRUCTION COMPOUND AND ALL ANCILLARY SITE WORKS.	Permission granted in Oct 14 by Mayo Co Co and modified by ABP	NIS submitted with mitigation measures. Construction completed in 2018 under the supervision of Ecological Consultancy. Status of Robe_020 unaffected by development. In combination effects unlikely to occur during operational phase of development.

2.6 ASSESSMENT OF THE SIGNIFICANCE OF POTENTIAL EFFECTS ON THE SITES WITHIN THE ZONE OF INFLUENCE

Table 2-6 below provides an assessment of the significance of any potential effects on the conservation objectives of the Natura 2000 sites considered to be in the zone of influence.

Table 2-3 Screening Matrix for Assessment of Significance of Potential Impacts

Screening Matrix for Assessment of Significance of Potential Impacts on Conservation Objectives	
Describe the individual elements of the project (either alone or in combination with other plans or projects) likely to give rise to impacts on the Natura 2000 sites	Due to the separation distances involved between the site and the Natura 2000 sites it is considered that no elements of the project are likely to give rise to effects on the conservation objectives of the Natura 2000 sites in the zone of influence. The construction of internal access roads and control cabins will result in limited excavation works but the installation of solar panels themselves is minimally invasive. Any potential effects will be limited to the local environmental receptors. Operational effects are not likely to occur as maintenance requirements are limited and the landscape management will be in the form of grazing livestock (most likely sheep)
Assessment of the likelihood of direct, indirect or secondary impacts of the project (either alone or in combination with other plans or projects) on the Natura 2000 sites	**Size and Scale** The project involves the installation of a 5 mW Solar Farm on 9 hectare site close to Claremorris town. The size and scale of the proposed project is relatively small in comparison to the N17 upgrade works which were carried out in the area during the early 2000s. **Land take** There will be no land take from any of the Natura 2000 sites within the zone of influence. **Distance from the Natura 2000 site or key feature of the site** The closest Natura 2000 site (Carrowkeel Tourlough SAC) is 7km south east of the project to which it has a tenuous theoretical indirect groundwater connection. Lough Carra/Mask SAC is over 40 km distant from the project location via 4 waterbodies (Robe _020, Robe_30, Robe_40 and Robe_50) **Resource requirements (water abstraction etc.,)** No resources associated with the Natura 2000 site considered will be required for the works. **Emissions (disposal to land, water, air etc.,)** The area to the east of the N17 (approximately 5 hectares) is a historical landfill site under the ownership of Mayo County Council. The EPA Code of

Practice Environmental Risk Assessment for Unregulated Waste Disposal Sites (2007)[15] sets out a risk prioritisation protocol using the Source Pathway Receptor model. During the Tier I Qualitative Risk Assessment (Risk Screening and Prioritisation) the Claremorris landfill site was classified as a medium risk site on the basis of the score obtained (61.25%) for risk of leachate migration to the aquifer through the groundwater pathway.

As part of the same assessment, the risk score for leachate migration to Natura 2000 sites through groundwater and surface water pathways was calculated to be 0 %.[16] Based on this, it is considered that any potential emission from the development to land, surface water, groundwater or air will not cause any effects on the Natura 2000 sites due to the separation distance involved.

Excavation requirements

The excavation requirements will be limited in nature as the site is relatively uniform in topography (no cut and fill requirements). Excavation depths for internal access roads will be based on ground conditions. Minimally invasion techniques will be used for panel installation (metal frame penetrating 1.7m into ground). The alternative of precast concrete pads as ballast for the Solar panels will be employed where ground conditions are deemed unsuitable for installation of the metal frame.

Transportation requirements

Raw material required for the construction of the internal access roads, PV panel, cables, hard standing for the control cabins and security fencing will be transported by road with no expected effects on any SACs.

Duration of construction, operation, decommissioning

It is anticipated that construction activity will last for approximately 12 months. There is no set lifespan for the project, but efficiency of the solar panels does decrease over time.

Noise Emission, Light Pollution & Glint and Glare

Any noise or light pollution due to construction activity may impact the local environment but will not have any effects on the SACs within the zone of influence.

[15] https://www.epa.ie/pubs/advice/waste/waste/EPA_CoP_waste_disposal_sites.pdf

[16] (EPA 2009) Risk Ranking Report for Claremorris Closed Landfill S22-02588 Mayo County Council

	Potential in-combination impacts As stated in Section 3.6.2 above the construction schedule for the proposed project does not overlap with other developments identified in the vicinity. It is considered that the proposed works are of such a limited size, scale and duration that the potential for in combination effects with the projects identified in Table 2-2 is negligible.
Likely changes to the Natura 2000 sites arising from the development as a result of ;	**Reduction of habitat area** The proposed project will not result in the loss of any qualifying habitats associated with the qualifying interests of the SACs in the zone of influence. **Disturbance to key species** Considering the separation distance involved no disturbance of Annex II species is expected. **Habitat or species fragmentation** The project will not result in any habitat or species fragmentation. **Reduction in species density** Due to the small scale short duration of the works and the separation distances involved Annex II species density will not be reduced. **Changes in key indicators or conversation value (water quality etc.)** Based on 2013 to 2018 data the Robe_020 waterbody is at high ecological status. A small tributary of the Robe_020 which runs through the eastern subsite will require a buffer zone and potentially sediment control measures to ensure that the development does not reduce this high status of this waterbody. These measures will be required for the purposes of achieving the objectives of the Water Framework Directive and not to prevent any negative effects on the conservation objectives of the SACs within the zone of influence. While the groundwater resource underlying the Solar Farm is a Regionally Important Karstified aquifer, there are no karstic features in the immediate vicinity of the project (nearest feature identified is 3.7 km to the south).The nearest groundwater dependant Natura 2000 site to the proposed development is 7km to the southwest and is considered to be beyond any potential for impact on the basis of the separation distance involved and the overlying quaternary deposits at the project site. There is therefore no risk of the development affecting the hydrological status of any of the Natura 2000 sites of which Carrowkeel Turlough is the closest.

	The presence of invasive alien plant species Japanese Knotweed and Winter Heliotrope will trigger the need for an invasive species management plan to be drafted prior to construction to ensure that further dispersal of these species does not occur. The measures included as part of this management plan are required to comply with SI No 477/20011 EC (Birds and Habitats) Regulations 2011 and not for the direct protection of any of the Natura 2000 sites in the zone of influence.
Describe the likely impacts on the Natura 2000 sites as a whole in terms of interference with key relationships that define the structure and function of the site	Due to the nature, scale and short duration of the works no significant interference with key relationships that define the structure and function of the site is predicted.
Describe from the above the elements of the project or plan or combination of elements where the above impacts are likely to be significant or where the scale of the magnitude of the impact is not known	None. There are no such elements of the project where the above impacts are likely to be significant or where the scale or magnitude of impacts is not known

3 SCREENING CONCLUSION

The Appropriate Assessment screening process considered all potential impacts which may arise during the construction and operational phases of the proposed Solar PV Farm at Clare, Claremorris Co. Mayo.

Through an assessment of the pathways for effects and an evaluation of the project, it has been evaluated that there are no likely significant adverse effects on the qualifying interests or the conservation objectives of any designated European Site.

Consequently, the proposed works do not need to proceed to Stage 2 - Natura Impact Statement.

Leo Brogan

Environmental Scientist

FEHILY TIMONEY
30 YEARS

CONSULTANTS IN ENGINEERING,
ENVIRONMENTAL SCIENCE & PLANNING

APPENDIX 5

European Site Synopses

SITE SYNOPSIS

Site Name: Ardkill Turlough SAC

Site Code: 000461

Ardkill turlough is situated about 7 km east of Ballinrobe in Co. Mayo, and is one of a group of five turloughs that occupy hollows in rolling countryside. It is set amongst low limestone knolls with drift around the south and east. Exposed limestone extends out across the northern part forming a central island with low cliffs. The basin has steep western sides but slopes more evenly to the east. There is much loose rock in the north-eastern part.

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

[3180] Turloughs*

At Ardkill turlough there is a deep pond at the western end of the basin which is of the order of 6 m below flood level. A shallower pond occurs in the south-eastern sector. In the south-west corner there is a swallow hole at the base of the slope just above floor level. Water also rises at the edge of the northern rock outcrop as a spring. There is no above-ground inflow to the basin. Peat has accumulated in the lower-lying parts of the site, with some accumulation of marl (calcium carbonate) on the rocks and other surfaces where the water is more permanent.

The vegetation is highly diverse for such a small area because of the great range of water level fluctuations and occurrence of bare rock. Characteristic turlough plant communities occur in distinct bands at various levels in the basin. At the topmost level there is a narrow fringe of limestone grassland. The sloping ground below this supports sedge-heath with Mat-grass (*Nardus stricta*). Midslopes are dominated by Creeping Cinquefoil (*Potentilla reptans*) communities. The turlough floor is occupied by wet Common Sedge (*Carex nigra*) vegetation. The main lake supports abundant Amphibious Bistort (*Polygonum amphibium*) and Great Yellow-cress (*Rorippa amphibia*).

The shallower pond also has much Amphibious Bistort along with Common Club-rush (*Scirpus lacustris*) and Water Horsetail (*Equisetum fluviatile*). This pond has a soft marly bed with abundant Spiked Water-milfoil (*Myriophyllum spicatum*), Unbranched Bur-reed (*Sparganium emersum*) and Ivy-leaved Duckweed (*Lemna trisulca*). The stone walls in this area are draped with a spectacular abundance of the moss *Fontinalis antipyretica* and Great Yellow-cress (*Rorippa amphibia*). The central parts of the island are not flooded and contain scrub with Burnet Rose (*Rosa pimpinellifolia*), Ground Ivy (*Glechoma hederacea*) and other species. At the flood line there is Bramble (*Rubus*

caesius), Downy Rose (*Rosa tomentosa*), Buckthorn (*Rhamnus catharticus*) and Common Meadow-rue (*Thalictrum flavum*).

Several pairs of Lapwing breed at the site, and Snipe and Common Sandpiper probably breed. The site is likely to attract wintering waterfowl.

The basin floods regularly to a considerable depth and has some water for many months of the year. No drainage attempts are apparent at present. Much of the area is closely grazed by cattle but the vegetation has not suffered unduly from this.

Ardkill is unusual in Mayo for having such a large fluctuation in water depth (8-10 m), a long-lasting pond and exposed limestone on its shore. The variation in topography creates a good diversity of vegetation types within a small area. The site contains Common Meadow-rue (*Thalictrum flavum*), a species known only from this site in Co. Mayo, as well as a number of other uncommon species. A species of parasitic wasp (*Mesoleptus hibernica*) has been described as new to science from Ardkill Turlough. Taken together, all these features combine to make it a site of high conservation value.

SITE SYNOPSIS

Site Name: Towerhill House SAC

Site Code: 002179

Towerhill House is situated 10 km north of Ballinrobe in Co. Mayo. The site comprises the ruins of Towerhill House, the surrounding woodlands, Lough Beg and its associated swamp vegetation.

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

[1303] Lesser Horseshoe Bat (*Rhinolophus hipposideros*)

At this site the Lesser Horseshoe Bats use a man-made, stone underground passage which runs around the ruin of Towerhill House. This offers ideal winter hibernation conditions as it is humid and remains at a constant temperature. The entrance to the passage is extremely narrow and there is little or no disturbance by visitors.

Up to 56 bats have been recorded at Towerhill House in recent years, making it a site of international importance. It is also notable for being along the northern limit of the distribution of the species in Europe.

At the south of the site, a series of drains and a stream flow into Lough Beg, a small lake which is surrounded by swamp vegetation and wet woodland. The lake system is of some interest, with extensive reed beds (*Phragmites australis*) and fine stands of Greater Tussock-sedge (*Carex paniculata*). The wet woodland is mainly Downy Birch (*Betula pubescens*), Rusty Willow (*Salix cinerea* subsp. *oleifolia*) and Alder (*Alnus glutinosa*). The uncommon Greater Spearwort (*Ranunculus lingua*) occurs within the swamp vegetation. The remainder of the site is mainly composed of commercial coniferous forestry, though in places this is of mixed composition. The woodland and watercourses provide ideal foraging and shelter conditions for the bats, which are often active in hibernacula in autumn and spring.

The macro-invertebrate community of the wetland area is also interesting, containing elements characteristic of littoral lacustrine and slow flowing riverine habitats. There is also a high diversity of aquatic beetle species at this site.

At present there is little disturbance to the bats though the erection of a grille at the roost entrance would be useful. Any commercial felling of timber near the roost site would negatively impact on the bats.

Overall this site is of conservation importance due to the habitats and species it supports, and in particular the Annex II listed Lesser Horseshoe Bat.

SITE SYNOPSIS

Site Name: River Moy SAC

Site Code: 002298

This site comprises almost the entire freshwater element of the River Moy and its tributaries including both Loughs Conn and Cullin. The system drains a catchment area of 805 sq. km. Most of the site is in Co. Mayo, though parts are in west Sligo and north Roscommon. Apart from the Moy itself, other rivers included within the site are the Deel, Bar Deela, Castlehill, Addergoole, Clydagh and Manulla on the west side, and the Glenree, Yellow, Strade, Gweestion, Trimogue, Sonnagh, Mullaghanoe, Owengarve, Eighnagh and Owenaher on the east side. The underlying geology is Carboniferous Limestone for the most part, though Carboniferous Sandstone is present at the extreme west of the site, with Dalradian Quartzites and schists at the south-west. Some of the tributaries at the east, the south of Lough Conn and all of Lough Cullin are underlain by granite. There are many towns adjacent to but not within the site. These include Ballina, Crossmolina, Foxford, Swinford, Kiltimagh and Charlestown.

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

[7110] Raised Bog (Active)*
[7120] Degraded Raised Bog
[7150] Rhynchosporion Vegetation
[7230] Alkaline Fens
[91A0] Old Oak Woodlands
[91E0] Alluvial Forests*

[1092] White-clawed Crayfish (*Austropotamobius pallipes*)
[1095] Sea Lamprey (*Petromyzon marinus*)
[1096] Brook Lamprey (*Lampetra planeri*)
[1106] Atlantic Salmon (*Salmo salar*)
[1355] Otter (*Lutra lutra*)

On the slopes and rising ground around the southern shores of Loughs Conn and Cullin, oak woodlands are found. Sessile Oak (*Quercus petraea*) is the dominant tree species, with an understorey of Holly (*Ilex aquifolium*), Hazel (*Corylus avellana*) and Downy Birch (*Betula pubescens*), with some Ash (*Fraxinus excelsior*). Additional species are associated with the lakeshore such as Rock Whitebeam (*Sorbus rupicola*), Aspen (*Populus tremula*), Silver Birch (*B. pendula*) and the shrubs Guelder-rose

(*Viburnum opulus*), Buckthorn (*Rhamnus catharticus*) and Spindle (*Euonymus europaeus*). The ground flora is usually composed of Bilberry (*Vaccinium myrtillus*), Great Wood-rush (*Luzula sylvatica*), Wood-sorrel (*Oxalis acetosella*), buckler-ferns (*Dryopteris aemula* and *D. dilatata*), Hard Fern (*Blechnum spicant*), Common Cow-wheat (*Melampyrum pratense*) and Bracken (*Pteridium aquilinum*). The rare Narrow-leaved Helleborine (*Cephalanthera longifolia*), protected under the Flora (Protection) Order, 1999, occurs in association with the woodlands. Also found in these woodlands is the snail *Spermodea lamellata*, a species associated with old natural woodlands.

Alluvial woodland occurs at several locations along the shores of the lakes but is particularly well developed along the river at Coryosla Bridge. Principal tree species are willows (including *Salix cinerea* subsp. *oleifolia*) and Alder (*Alnus glutinosa*). Herbaceous species include Royal Fern (*Osmunda regalis*), Meadowsweet (*Filipendula ulmaria*) and Reed Canary-grass (*Phalaris arundinacea*). The woods are flooded by seasonal fluctuations in lake level.

On higher ground adjacent to the woodlands is blanket bog with scattered shrubs and trees on the drier areas. The rocky knolls often bear Juniper (*Juniperus communis*) or Gorse (*Ulex europaeus*), with some unusual rare herb species such as Intermediate Wintergreen (*Pyrola media*) and Lesser Twayblade (*Listera cordata*).

Within the site are a number of raised bogs including those at Kilgarriff, Gowlaun, Derrynabrock, Tawnaghbeg and Cloongoonagh. These are examples of raised bogs at the north-western edge of the spectrum and possess many of the species typical of such in Ireland, including an abundance of Bog Asphodel (*Narthecium ossifragum*), Carnation Sedge (*Carex panicea*) and the moss *Campylopus atrovirens*. Some of the bogs include significant areas of active raised bog habitat. Well developed pool and hummock systems with quaking mats of bog mosses (*Sphagnum* spp.), Bog Asphodel and White Beaked-sedge (*Rhynchospora alba*) are present. Many of the pools contain a diversity of plant species, including Bogbean (*Menyanthes trifoliata*), the bog moss *Sphagnum cuspidatum*, *Campylopus atrovirens*, Common Cottongrass (*Eriophorum angustifolium*), Great Sundew (*Drosera anglica*) and occasional Lesser Bladderwort (*Utricularia minor*). Several of the hummock-forming mosses (*Sphagnum fuscum* and *S. imbricatum*) which occur here are quite rare in this region and add to the scientific interest of the bogs within the overall site.

Depressions on the bogs, pool edges and erosion channels, where the vegetation is dominated by White Beaked-sedge comprise the habitat 'Rhynchosporion vegetation'. Associated species in this habitat at the site include Bog Asphodel, sundews, Deergrass (*Scirpus cespitosus*) and Carnation Sedge.

Degraded raised bog is present where the hydrology of the uncut bogs has been affected by peat cutting and other land use activities in the surrounding area, such as afforestation and associated drainage, and also the Moy arterial drainage. Species typical of the active raised bog habitat may still be present but the relative abundances differ. A typical example of the degraded habitat, where drying has

occurred at the edge of the high bog, contains an abundance and more uniform cover of Heather (*Calluna vulgaris*), Carnation Sedge, Deergrass and sometimes Bog-myrtle (*Myrica gale*). Occurring in association with the uncut high bog are areas of wet regenerating cutover bog with species such as Common Cottongrass, bog mosses and sundew, while on the drier areas, the vegetation is mostly dominated by Purple Moor-grass (*Molinia caerulea*). Natural regeneration with peat-forming capability will be possible over time with some restorative measures.

Alkaline fen is considered to be well developed within the site. An extensive stand occurs as part of a wetland complex at Mannin and Island Lakes on the Glore River. Key diagnostic species of the *Schoenus* association characteristic of rich fens include the bryophytes *Campylium stellatum*, *Aneura pinguis* and *Scorpidium scorpioides*, and the herbaceous species Long-stalked Yellow-sedge (*Carex lepidocarpa*), Grass-of-parnassus (*Parnassia palustris*) and Common Butterwort (*Pinguicula vulgaris*). Other fen species include Black Bog-rush (*Schoenus nigricans*), Purple Moor-grass, Marsh Helleborine (*Epipactis palustris*), Meadow Thistle (*Cirsium dissectum*) and Blunt-flowered Rush (*Juncus subnodulosus*). The rare moss *Bryum uliginosum* occurs on exposed marl at a ditch to the east of Island Lake.

The open water of Loughs Conn and Cullin is moderately hard with relatively low colour and good transparency. The phytpoplankton of the lake is dominated by diatoms and blue-green algae and there is evidence that the latter group is more common now than in former years. This indicates that nutrient inflow is occurring. The changes in Lough Conn appear to represent an early phase in the eutrophication process. Stoneworts still present include *Chara aspera, C. delicatula* and *Nitella* cf. *opaca*. Other plants found in the shallower portions include pondweed species (*Potamogeton* spp.). Where there is a peat influence Intermediate Bladderwort (*Utricularia intermedia*) is characteristic, while Water Lobelia (*Lobelia dortmanna*) often grows in sand. Narrow reedbeds and patches of Yellow Water-lily (*Nuphar lutea*) occur in some of the bays.

Drainage of the Moy in the 1960s lowered the level of the lakes, exposing wide areas of stony shoreline and wet grassland, which are liable to flooding in winter. This increased the habitat diversity of the shoreline and created a number of marginal wetlands, including fens and marshes. Plant species of note in the lake-margin include Heath Cudweed (*Omalotheca sylvatica*), Great Burnet (*Sanguisorba officinalis*) and Irish Lady's-tresses (*Spiranthes romanzoffiana*). These three species are listed on the Irish Red Data list and are protected under the Flora (Protection) Order, 1999.

Other habitats present within the site include wet grassland dominated by rushes (*Juncus* spp.) grading into species-rich marsh in which sedges are common. Among the other species found in this habitat are Yellow Iris (*Iris pseudacorus*), Water Mint (*Mentha aquatica*), Purple Loosestrife (*Lythrum salicaria*) and Soft Rush (*Juncus effusus*).

Rusty Willow (*Salix cinerea* subsp. *oleifolia*) scrub and pockets of wet woodland dominated by Alder (*Alnus glutinosa*) have become established in places throughout the site. Ash (*Fraxinus excelsior*) and Downy Birch (*Betula pubescens*) are common in

the latter and the ground flora is typical of wet woodland with Meadowsweet (*Filipendula ulmaria*), Wild Angelica (*Angelica sylvestris*), Yellow Iris, horsetails (*Equisetum* spp.) and occasional tussocks of Greater Tussock-sedge (*Carex paniculata*).

Small pockets of conifer plantation, close to the lakes and along the strip both sides of the rivers, are included in the site.

The Moy system is one of Ireland's premier salmon waters and it also encompasses two of Ireland's best lake trout fisheries in Loughs Conn and Cullin. Although the Atlantic Salmon (*Salmo salar*) is still fished commercially in Ireland, it is considered to be endangered or locally threatened elsewhere in Europe and is listed on Annex II of the E.U. Habitats Directive. The Moy is a most productive catchment in salmon terms and this can be attributed to its being a fingered system with a multiplicity of 1st to 5th order tributaries which are large enough to support salmonids < 2 years of age while at the same time being too small to support significant adult trout numbers and are therefore highly productive in salmonid nursery terms.

Salmon run the Moy every month of the year. Both multi-sea-winter fish and grilse are present. The salmon fishing season is 1st February to 30th September. The peak of the spring fishing is in April and the grilse begin running in early May. The average weight of the spring fish is 9 lb and the grilse range from about 3-7 lb. In general spring fish are found more frequently in the rivers at the western extent of the Moy system.

The Arctic Char (*Salvelinus alpinus*), an interesting relict species from the last ice age, which is listed as threatened in the Irish Red Data Book has been recorded from Lough Conn and in only a few other lakes in Ireland. The latest reports suggest that it may now have disappeared from the site.

The site is also important for the presence of four other species listed on Annex II of the E.U. Habitats Directive, namely Sea Lamprey, Brook Lamprey, Otter and White-clawed Crayfish. The Sea Lamprey is regularly encountered in the lower stretches of the river around Ballina, while the Otter and White-clawed Crayfish are widespread throughout the system. In addition, the site also supports many of the mammal species occurring in Ireland. Those which are listed in the Irish Red Data Book include Pine Marten, Badger, Irish Hare and Daubenton's Bat. Common Frog, another Red Data Book species, also occurs within the site.

Loughs Conn and Cullin support important concentrations of wintering waterfowl and both are designated Special Protection Areas (SPAs). A nationally important population of the Annex I species Greenland White-fronted Goose (average 113 over 6 winters 1994/95 to 1999/00) is centred on Lough Conn. Whooper Swans also occur (numbers range between 25 to 50), along with nationally important populations of Tufted Duck 635, Goldeneye 189 and Coot 464. A range of other species occur on the lakes in regionally important concentrations, notably Wigeon 303, Teal 154, Mallard 225, Pochard 182, Lapwing >1,000 and Curlew 464. Golden Plover also frequent the lakes, with numbers ranging between 700 and 1,000.

Loughs Conn and Cullin are one of the few breeding sites for Common Scoter in Ireland. Breeding has occurred on Lough Conn since about the 1940s when about 20-30 pairs were known. A census in 1983 recorded 29 pairs. Breeding was first proved on Lough Cullin in 1983 when 24 pairs were recorded. In 1995, 24-26 pairs were recorded at Lough Conn and 5 pairs at Lough Cullin. The latest survey in 1999 gives a total of 30 birds for both lakes, comprising only 5 pairs, 18 unpaired males and 2 unpaired females. The reason for the decline is not known but may be due to predation by mink, possible changes in food supply and/or redistribution to other sites. The Common Scoter is a Red Listed species.

Agriculture, with particular emphasis on grazing, is the main land use along the Moy. Much of the grassland is unimproved but improved grassland and silage fields are also present. The spreading of slurry and fertiliser poses a threat to the water quality of this salmonid river and to the large lakes. Fishing is the main tourist attraction on the Moy and there are a large number of Angler Associations, some with a number of beats. Fishing stands and styles have been erected in places. The North Western Regional Fishery Board have erected fencing along selected stretches of the river as part of their salmonid enhancement programme. Other aspects of tourism are concentrated around Loughs Conn and Cullin.

Afforestation has occurred in the past around the shores of Loughs Conn and Cullin. The coniferous trees are due for harvesting shortly. It is proposed to replant with native tree species in this area. Forestry is also present along many of the tributaries and in particular along the headwaters of the Deel. Forestry poses a threat in that sedimentation and acidification can occur. Sedimentation can cover the gravel beds resulting in a loss of suitable spawning grounds. The Moy was arterially dredged in the 1960s. Water levels have been reduced since that time. This is particularly evident along the shores of Loughs Conn and Cullin and in the canal-like appearance of some river stretches. Ongoing maintenance dredging is carried out along stretches of the river system where the gradient is low. This is extremely destructive to salmonid habitat in the area.

The site supports populations of several species listed on Annex II of the E.U. Habitats Directive, and habitats listed on Annex I of this Directive, as well as examples of other important habitats. The presence of a fine example of broadleaved woodland in this part of the country increases the overall habitat diversity and adds to the ecological value of the site, as does the presence of the range of nationally rare and Red Data Book plant and animal species.

SITE SYNOPSIS

Site Name: Lough Corrib SAC

Site Code: 000297

Lough Corrib is situated to the north of Galway city and is the second largest lake in Ireland, with an area of approximately 18,240 ha (the entire site is 20,556 ha). The lake can be divided into two parts: a relatively shallow basin, underlain by Carboniferous limestone, in the south, and a larger, deeper basin, underlain by more acidic granite, schists, shales and sandstones to the north. The surrounding lands to the south and east are mostly pastoral farmland, while bog and heath predominate to the west and north. A number of rivers are included within the cSAC as they are important for Atlantic Salmon. These rivers include the Clare, Grange, Abbert, Sinking, Dalgan and Black to the east, as well as the Cong, Bealanabrack, Failmore, Cornamona, Drimneen and Owenriff to the west. In addition to the rivers and lake basin, adjoining areas of conservation interest, including raised bog, woodland, grassland and limestone pavement, have been incorporated into the site.

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

[3110] Oligotrophic Waters containing very few minerals
[3130] Oligotrophic to Mesotrophic Standing Waters
[3140] Hard Water Lakes
[3260] Floating River Vegetation
[6210] Orchid-rich Calcareous Grassland*
[6410] *Molinia* Meadows
[7110] Raised Bog (Active)*
[7120] Degraded Raised Bog
[7150] Rhynchosporion Vegetation
[7210] *Cladium* Fens*
[7220] Petrifying Springs*
[7230] Alkaline Fens
[8240] Limestone Pavement*
[91A0] Old Oak Woodlands
[91D0] Bog Woodland*

[1029] Freshwater Pearl Mussel (*Margaritifera margaritifera*)
[1092] White-clawed Crayfish (*Austropotamobius pallipes*)
[1095] Sea Lamprey (*Petromyzon marinus*)

[1096] Brook Lamprey (*Lampetra planeri*)
[1106] Atlantic Salmon (*Salmo salar*)
[1303] Lesser Horseshoe Bat (*Rhinolophus hipposideros*)
[1355] Otter (*Lutra lutra*)
[1393] Slender Green Feather-moss (*Drepanocladus vernicosus*)
[1833] Slender Naiad (*Najas flexilis*)

The shallow, lime-rich waters of the southern basin of Lough Corrib support one of the most extensive beds of stoneworts (Charophytes) in Ireland, with species such as *Chara aspera*, *C. hispida*, *C. delicatula*, *C. contraria* and *C. desmacantha* mixed with submerged pondweeds (*Potamogeton perfoliatus*, *P. gramineus* and *P. lucens*), Shoreweed (*Littorella uniflora*) and Water Lobelia (*Lobelia dortmanna*). These *Chara* beds are an important source of food for waterfowl. In contrast, the northern basin contains more oligotrophic and acidic waters, without *Chara* species, but with Shoreweed, Water Lobelia, Pipewort (*Eriocaulon aquaticum*), Quillwort (*Isoetes lacustris*), Alternate Water-milfoil (*Myriophyllum alternifolium*) and Slender Naiad (*Najas flexilis*). The last-named is listed under the Flora (Protection) Order, 2015, and is an Annex II species under the E.U. Habitats Directive.

Large areas of reedswamp vegetation, dominated by varying mixtures of Common Reed (*Phragmites australis*) and Common Club-rush (*Scirpus lacustris*), occur around the margins of the lake. Reedswamp usually grades into species-rich marsh vegetation characterised by Slender Sedge (*Carex lasiocarpa*), Water Mint (*Mentha aquatica*), Water Horsetail (*Equisetum fluviatile*) and Bogbean (*Menyanthes trifoliata*). Of particular note are the extensive beds of Great Fen-sedge (*Cladium mariscus*) that have developed over the marly peat deposits in sheltered bays, particularly in the south-east corner of the lake. Alkaline fen vegetation is more widespread around the lake margins and includes, amongst the typically diverse range of plants, the Slender Cottongrass (*Eriophorum gracile*), a species protected under the Flora (Protection) Order, 2015. Wet meadows dominated by Purple Moor-grass (*Molinia caerulea*) occur in seasonally flooded areas close to the lake shore. These support species such as Sharp-flowered Rush (*Juncus acutiflorus*), Jointed Rush (*J. articulatus*), Carnation Sedge (*Carex panicea*), Devil's-bit Scabious (*Succisa pratensis*), Creeping Bent (*Agrostis stolonifera*) and Tormentil (*Potentilla erecta*), amongst others.

This large site contains four discrete raised bog areas and is selected for active raised bog, degraded raised bog, Rhynchosporion and bog woodland. Active raised bog comprises areas of high bog that are wet and actively peat-forming, where the percentage cover of bog mosses (*Sphagnum* spp.) is high, and where some or all of the following features occur: hummocks, pools, wet flats, *Sphagnum* lawns, flushes and soaks. Degraded raised bog corresponds to those areas of high bog whose hydrology has been adversely affected by peat cutting, drainage and other land use activities, but which are capable of regeneration. The Rhynchosporion habitat occurs in wet depressions, pool edges and erosion channels where the vegetation includes White Beak-sedge (*Rhynchospora alba*) and/or Brown Beak-sedge (*R. fusca*), and at least some

of the following associated species, Bog Asphodel (*Narthecium ossifragum*), sundews (*Drosera* spp.), Deergrass (*Scirpus cespitosus*) and Carnation Sedge.

At Addergoole, on the eastern shores of Lough Corrib, there is an important area of western raised bog. This bog area is one of the most westerly, relatively intact raised bogs in the country. There are also other substantial areas of raised bog along various tributaries of the Corrib in east Co. Galway, namely Slieve Bog, Lough Tee Bog and Killaclogher bog. The active parts of these bogs mostly correspond to the wettest areas, where there are well-developed surface features with hummocks, lawns and pools. It is in such areas that Rhynchosporion vegetation is best represented. The dominant species is the aquatic bog moss *Sphagnum cuspidatum,* which is usually accompanied by Bogbean, White Beak-sedge, Bog Asphodel, Common Cottongrass (*Eriophorum angustifolium*), Bog Sedge (*Carex limosa*) and Great Sundew (*Drosera anglica*). Brown Beak-sedge, a locally rare plant of wet bog pools, has been recorded from a number of the bog areas within the site. At Addergoole a substantial bog lake or soak occurs and this is infilling with large rafts of Rhynchosporion vegetation at present. This area is associated with an important area of wet bog woodland dominated by Downy Birch (*Betula pubescens*).

The largest part of the uncut high bog comprises degraded raised bog. Degraded bog is dominated by a raised bog flora which tends to be rather species-poor because of disturbance and/or drying-out. The most conspicuous vascular plant species are usually Carnation Sedge, Heather (*Calluna vulgaris*), Cottongrasses, Cross-leaved Heath (*Erica tetralix*), Bog Asphodel and Deergrass. Bog-rosemary (*Andromeda polifolia*) and Cranberry (*Vaccinium oxycoccos*), two species indicative of raised bog habitat, are frequent on both degraded and active areas of raised bog. *Sphagnum* cover is generally low within degraded areas due to a combination of drying-out and frequent burning.

Limestone pavement occurs along much of the shoreline in the lower Corrib basin, and supports a rich and diverse flora, including Herb-Robert (*Geranium robertianum*), Bloody Crane's-bill (*G. sanguineum*), Carline Thistle (*Carlina vulgaris*), Spring Gentian (*Gentiana verna*), Wild Thyme (*Thymus praecox*), Rustyback (*Ceterach officinarum*), Wood Sage (*Teucrium scorodonia*), Slender St. John's-wort (*Hypericum pulchrum*), Quaking-grass (*Briza media*) and Blue Moor-grass (*Sesleria albicans*). Areas of Hazel (*Corylus avellana*) scrub occur in association with exposed limestone pavement and these include species such as Hawthorn (*Crataegus monogyna*), Buckthorn (*Rhamnus catharticus*), Spindle (*Euonymus europaeus*), with occasional Juniper (*Juniperus communis*). Three Red Data Book species are also found in association with limestone scrub - Alder Buckthorn (*Frangula alnus*), Shrubby Cinquefoil (*Potentilla fruticosa*) and Wood Bitter-vetch (*Vicia orobus*), the latter is also protected under the Flora (Protection) Order, 2015.

Open areas of orchid-rich calcareous grassland are also found in association with the limestone exposures. These can support a typically rich vegetation, including many orchids such as Pyramidal Orchid (*Anacamptis pyramidalis*), Common Spotted-orchid (*Dactylorhiza fuchsii*), Early-purple Orchid (*Orchis mascula*), Frog Orchid (*Coeloglossum*

viride), Fragrant Orchid (*Gymnadenia conopsea*), Marsh Helleborine (*Epipactis palustris*), Greater Butterfly-orchid (*Platanthera chlorantha*) and Irish Lady's-tresses (*Spiranthes romanzoffiana*). The latter is protected under the Flora (Protection) Order, 2015.

The Hill of Doon, located in the north-western corner of the lake, is a fine example of a Sessile Oak (*Quercus petraea*) woodland. The understorey is dominated by Sessile Oak, Holly (*Ilex aquifolium*) and occasional Juniper. There are occasional Yew (*Taxus baccata*) and Ash (*Fraxinus excelsior*), and a well-developed ground layer dominated by Bilberry (*Vaccinium myrtillus*), Hard Fern (*Blechnum spicant*) and Wood Rush (*Luzula sylvatica*). Woodland also occurs on some of the islands in the lake.

A number of the rivers in the site support submerged and floating vegetation of the Ranunculion fluitantis and Callitricho-Batrachion, including mosses. For example, in the River Corrib species such as Shining Pondweed (*Potamogeton lucens*), Perfoliate Pondweed (*Potamogeton perfoliatus*), Small Pondweed (*P. berchtoldii*), Yellow Water-lily (*Nuphar lutea*), White Water-lily (*Nymphaea alba*) and stoneworts (*Chara* spp.) occur.

The rare and Annex II-listed Slender Green Feather-moss (*Drepanocladus* [*Hamatocaulis*] *vernicosus*) is found at the fen at Gortachalla, north-east of Moycullen. Here it is widespread around the margins, and this constitutes a large and significant population in the national context. A very large population of another rare moss, *Pseudocalliergon trifarium,* is also found in this area.

The lake is rated as an internationally important site for waterfowl. Counts from 1984 to 1987 revealed a mean annual peak total of 19,994 birds. In the past a maximum peak of 38,281 birds was recorded. The lake supports internationally important numbers of Pochard (average peak 8,600) and nationally important numbers of the following species: Coot (average peak 6,756), Mute Swan (average peak 176), Tufted Duck (average peak 1,317), Cormorant (average peak 110) and Greenland White-fronted Goose (average peak 83). The latter species is listed on Annex I of the E.U. Birds Directive. The Coot population is the largest in the country and populations of Tufted Duck and Pochard are second only to Lough Neagh. Breeding pairs of Common Scoter on the lake number 30-41 (1995 data), as well as breeding populations of Arctic Tern and Common Tern. Other bird species of note recorded from or close to the lake recently include Hen Harrier, Whooper Swan, Golden Plover and Kingfisher. All of these species are listed on Annex I of the E.U. Birds Directive.

Otter and Irish Hare have been recorded regularly within this site. Both of these species are listed in the Red Data Book and are legally protected by the Wildlife Act, 1976. Otter is also listed on Annex II of the E.U. Habitats Directive. Lough Corrib is considered one of the best sites in the country for Otter, due to the sheer size of the lake and associated rivers and streams, and also the generally high quality of the habitats. Atlantic Salmon (*Salmo salar*) use the lake and rivers as spawning grounds. Although this species is still fished commercially in Ireland, it is considered to be

endangered or locally threatened elsewhere in Europe and is listed on Annex II of the E.U. Habitats Directive. Lough Corrib is also a well-known fishing lake with a very good Trout (*Salmo trutta*) fishery. The lake has a population of Sea Lamprey (*Petromyzon marinus*), a scarce, though probably under-recorded species listed on Annex II of the E.U. Habitats Directive. Brook Lamprey (*Lampetra planeri*), also listed on Annex II, are also known from a number of areas within the site.

A population of Freshwater Pearl Mussel (*Margaritifera margaritifera*), a species listed on Annex II of the E.U. Habitats Directive, occurs within the site. White-clawed Crayfish (*Austropotamobius pallipes*), also listed on Annex II, is well distributed throughout Lough Corrib and its in-flowing rivers over limestone. A summer roost of Lesser Horseshoe Bat, another Annex II species, occurs within the site - approximately 100 animals were recorded here in 1999.

The main threats to the quality of this site are from water polluting activities resulting from intensification of agricultural activities on the eastern side of the lake, uncontrolled discharge of sewage which is causing localised eutrophication of the lake, and housing and boating development, which is causing the loss of native lakeshore vegetation. The raised bog habitats are susceptible to further degradation and drying out due to drainage and peat cutting and, on occasions, burning. Peat cutting threatens Addergoole Bog and already a substantial area of it has been cut away. Fishing and shooting occur in and around the lake. Introduction of exotic crayfish species or the crayfish fungal plague (*Aphanomyces astaci*) could have a serious impact on the native crayfish population. The bat roost is susceptible to disturbance or development.

Despite these ongoing issues, however, Lough Corrib is one the best examples of a large lacustrine catchment system in Ireland, with a range of habitats and species still well represented. These include 15 habitats which are listed on Annex I of the E.U. Habitats Directive, six of which are priority habitats, and nine species which are listed on Annex II. The lake is also internationally important for birds and is designated as a Special Protection Area.

SITE SYNOPSIS

Site Name: Lough Carra/Mask Complex SAC

Site Code: 001774

This site is dominated by two large lakes, Lough Mask and Lough Carra, and includes the smaller Cloon Lough. Most of the site is in Co. Mayo, with a small portion in Co. Galway. On the western side, the site is overlooked by the Partry Mountains, while to the east the landscape is largely low-lying agricultural land. The nearest large town is Ballinrobe which is about 4 km east of Lough Mask. The general geological character of the area is Carboniferous limestones, with some shales and sandstones on the western side of Lough Mask. The underlying geology results in a great diversity of habitats, which support many scarce and rare plants and animals.

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

[3110] Oligotrophic Waters containing very few minerals
[3130] Oligotrophic to Mesotrophic Standing Waters
[3140] Hard Water Lakes
[4030] Dry Heath
[6210] Orchid-rich Calcareous Grassland*
[7210] *Cladium* Fens*
[7230] Alkaline Fens
[8240] Limestone Pavement*
[91E0] Alluvial Forests*

[1303] Lesser Horseshoe Bat (*Rhinolophus hipposideros*)
[1355] Otter (*Lutra lutra*)
[1393] Slender Green Feather-moss (*Drepanocladus vernicosus*)

Lough Mask, at over 8,000 ha, is the sixth largest lake in the country and with a maximum depth of 58 m it is one of the deepest. It is an excellent example of an oligotrophic lake. Aquatic and wetland plant species present which are characteristic of this habitat include several pondweed species (*Potamogeton* spp.), Water Lobelia (*Lobelia dortmanna*) and Shoreweed (*Littorella uniflora*). The eastern part of the lake is shallow and is edged by a lowlying shoreline which is subject to winter flooding. An intricate mixture of plant communities has developed on the limestone, with bare pavement, scrub-dominated pavement, dry grassland and heath. A variety of wetland habitats are also present, along with significant amounts of deciduous woodland along the eastern and southern shores. The western shoreline is less

diverse and lacks the limestone communities. However, the fast flowing Owenbrin River has created at its mouth an interesting delta of coarse sandy sediment.

Lough Carra, which is hydrologically linked to Mask, is one of the best examples in Ireland of a hard water marl lake. It is a shallow (mostly less than 2 m), predominantly spring fed, lake with only a few streams flowing into it. Its well-known pellucid green colour is due to calcareous encrustations. It has well developed stonewort communities in the submerged zones, with *Chara curta, C. desmacantha, C. rudis* and *C. contraria* recorded. Lough Carra, like the eastern and southern shores of Mask, is fringed by a diverse complex of limestone and wetland habitats.

The limestone pavement within this site represents the northern limit of the limestones of Clare and Galway. The limestone is variable in character, from open bare pavement to areas covered with dense scrub. Associated with the pavement are areas of dry calcareous grassland and dry heath. Characteristic species of the rocky, limestone formations where soil may only occur in pockets include Bloody Crane's-bill (*Geranium sanguineum*), Yellow-wort (*Blackstonia perfoliata*), Blue Fleabane (*Erigeron acer*), Wild Madder (*Rubia peregrina*) and Rustyback (*Ceterach officinarum*).

Areas of calcareous grassland, often orchid-rich, occur interspersed amongst the limestone. These grasslands support species such as Carline Thistle (*Carlina vulgaris*), Quaking-grass (*Briza media*), Blue Moor-grass (*Sesleria albicans*), Sweet Vernal-grass (*Anthoxanthum odoratum*), Cowslip (*Primula veris*), Common Knapweed (*Centaurea nigra*), Fairy Flax (*Linum catharticum*), Lady's Bedstraw (*Galium verum*) and Wild Thyme (*Thymus praecox*). A good diversity of orchid species have been recorded from these grasslands, including Pyramidal Orchid (*Anacamptis pyramidalis*), Early-purple Orchid (*Orchis mascula*), Bee Orchid (*Ophrys apifera*), Fragrant Orchid (*Gymnodenia conopsea*) and Dense-flowered Orchid (*Neotinea maculata*). Several of these species, notably Dense-flowered Orchid and Spring Gentian (*Gentiana verna*), are typical Burren species and occur here towards the northern end of their distribution.

The scrub vegetation is variable in character, with extensive areas dominated by Hazel (*Corylus avellana*) and Hawthorn (*Crataegus monogyna*), with Buckthorn (*Rhamnus catharticus*), Alder Buckthorn (*Frangula alnus*), Spindle (*Euonymus europaeus*) and Ash (*Fraxinus excelsior*).

The dry heath is well developed in places and is characterised by Gorse (*Ulex europaeus*), Bell Heather (*Erica cinerea*), Heather (*Calluna vulgaris*) and St. Dabeoc's Heath (*Dabeocia cantabrica*). The diminutive orchid Lesser Twayblade (*Listera cordata*) occurs within the heath communities.

A wide range of wetland habitats occur around Lough Carra and along parts of the eastern and southern shores of Lough Mask, including *Cladium* fen and alkaline fen. Great Fen-sedge (*Cladium mariscus*) occurs as pure stands in places but also grades into areas of alkaline fen, where it is intermixed with Black Bog-rush (*Schoenus nigricans*), Common Club-rush (*Scirpus lacustris*), Common Reed (*Phragmites australis*)

and a number of sedge species (*Carex* spp.). The areas of alkaline fen are more extensive than the *Cladium* fens, and here Black Bog-rush is generally the dominant species. A rich diversity of flowering plant occurs in the fen communities. In addition to the fen habitats, there are sparse but widespread reed swamps, wet grassland and some freshwater marsh communities around the lake shores.

Broadleaved deciduous woodland occurs fairly frequently around much of the shores of the lakes and on some of the islands. This is often scrub-type woodland, which may be either dry (dominated by Hazel, Hawthorn and Ash) or wet. In the case of the latter, dominant species include birches (*Betula* spp.), willows (*Salix* spp.) and Alder (*Alnus glutinosa*). The wet areas of woodland flood seasonally and represent alluvial woodland, a habitat that is listed with priority status on Annex I of the E.U. Habitats Directive. These are particularly well developed in the Ballykine and Clonbur areas of Lough Mask. In some places the woodlands contain Sessile Oak (*Quercus petraea*), Holly (*Ilex aquifolium*) and Rowan (*Sorbus aucuparia*).

A high concentration of rare plants is found at this site. Five species protected under the Flora (Protection) Order, 2015, occur: Irish St. John's-wort (*Hypericum canadense*), Chives (*Allium schoenoprasum*), Pillwort (*Pilularia globulifera*), Irish Lady's-tresses (*Spiranthes romanzoffiana*), and Small Cudweed (*Logfia minima*). Two other Red Data Book plants, Alder Buckthorn and Bird's-nest Orchid (*Neottia nidus-avis*), also occur, along with two Red Data Book stonewort species, *Chara curta* and *C. rudis*.

The Owenbrin area of the site supports a population of the rare bryophyte *Drepanocladus vernicosus*, a species listed on Annex II of the E.U. Habitats Directive. This is the only known lake shore site for the species, which is usually found in upland flushes in association with blanket bog.

A large loft in the stable block of Curramore House provides a summer breeding site of the Lesser Horseshoe Bat, a species listed on Annex II of the E.U. Habitats Directive. The bats gain access to the loft through windows that extend from the ground floor to the loft area. The building is surrounded by mixed woods and is close to the shores of Lough Mask; both of these habitats provide ideal foraging habitat for the bats. In 1993 more than 100 bats were counted at this site, which makes it of international importance. A second internationally important summer roost of Lesser Horseshoe Bats occurs within the site at Ballykyne, near Clonbur. Over 150 bats have been counted at this site in recent years.

The site provide excellent habitat for Otter, also an Annex II species, and the area has Pine Marten (*Martes martes*), a species listed in the Irish Red Data Book.

The site has important bird interests, both in winter and summer. It provides feeding areas for part of the Erriff/Derrycraff population of Greenland White-fronted Goose. This flock has declined somewhat in recent years but is still of national importance, with an average spring peak from 1989-94 of 124 birds. The following count figures are the averages from surveys in January 1995 and January 1996: Wigeon 167, Mallard 397, Shoveler 57, Pochard 91, Tufted Duck 757, Goldeneye 158, Lapwing 233

and Curlew 118. Also, 68 Whooper Swan and 25 Gadwall were recorded in January 1996. The Shoveler, Tufted Duck and Goldeneye populations are of national importance. Both lakes are traditional sites for breeding gulls and terns. In 1995, 44 pairs of Common Tern nested at Lough Mask, while in 1992 a census of gulls at both lakes resulted in the following counts: Black-headed Gull 1,451 pairs, Common Gull 407 pairs and Lesser Black-backed Gull 361 pairs. The Common Gull colony represents 11.3% of the national total, and the Lesser Black-backed Gull colony is 6.9% of the total.

The deep waters of Lough Mask are home to a population of the glacial relict fish species Arctic Char (*Salvelinus alpinus*), and a rare shrimp (*Niphargus* spp.) is also found in these waters. Lough Mask is a very important Brown Trout fishery. White-clawed Crayfish (*Austropotamobius pallipes*), a species listed on Annex II of the E.U. Habitats Directive, has been recorded from Lough Carra.

This site is of considerable conservation importance as it has good examples of nine habitats listed on Annex I of the E.U. Habitats Directive, four of which are listed with priority status. Some of these habitats are amongst the best examples of their kind in the country. It is also selected for two Annex II mammal species and an Annex II moss. The site is of ornithological importance for both wintering and breeding birds. A relatively large number of rare or localised plant and animal species occur, including the glacial relict Arctic Char.

SITE SYNOPSIS

SITE NAME: LOUGH CARRA SPA

SITE CODE: 004051

Lough Carra, which extends for over 9 km along its long axis, lies to the north-east of Lough Mask, in the Corrib catchment in Co. Mayo. It is one of the best examples in Ireland of a hard water marl lake. It is a shallow (mean depth 1.5 m, maximum depth 18 m), predominantly spring-fed lake with only a few inflowing streams. It is connected to Lough Mask via the Keel River. The water has an alkaline pH and negligible amounts of iron and manganese. Sodium and chloride are present in relatively high concentrations. Lough Carra is classified as a mesotrophic system.

Lough Carra has well-developed stonewort communities in the submerged zones, and includes such species as *Chara curta*, *C. desmacantha*, *C. rudis* and *C. contraria*. The lake has a highly indented shoreline (over 69 km in length) and includes many small islands. It is fringed by a diverse complex of limestone and wetland habitats. The wetland habitats include both Great Fen-sedge (*Cladium mariscus*) fen and alkaline fen. In addition to the fen habitats, there are widespread reed swamps, wet grassland and some freshwater marsh communities around the lakeshores.

The site is a Special Protection Area (SPA) under the E.U. Birds Directive, of special conservation interest for the following species: Common Gull.

The islands in Lough Carra have traditionally supported nesting gulls. A survey in 1993 recorded Common Gull (72 individuals) and Black-headed Gull (252 individuals). The site was surveyed in 1999 as part of the Seabird 2000 Survey and 65 pairs of Common Gull and 100 pairs of Black-headed Gull were recorded.

The site also supports wintering populations of a number of species including Wigeon (67), Gadwall (26), Teal (63), Mallard (140), Shoveler (38), Pochard (33), Tufted Duck (133), Goldeneye (64), Little Grebe (14) Great Crested Grebe (12) and Lapwing (243) - all figures are mean peaks for 4 of the 5 winters in the period 1995/96-1999/2000. In the past, Lough Carra supported a population of Mallard of national importance.

Lough Carra SPA is of considerable ornithological importance for breeding gulls including a nationally important population of Common Gull. Part of Lough Carra SPA is a Wildfowl Sanctuary.

8.7.2014

SITE SYNOPSIS

Site Name: Kilglassan/Caheravoostia Turlough Complex SAC

Site Code: 000504

This site is situated about 7 km east of Ballinrobe in Co. Mayo. It comprises two turloughs separated by a rise of land which includes a pond and a small floating fen. The surrounding topography is gently rolling, with limestone outcrop at the northern end of Kilglassan. Both turloughs occupy relatively flat basins that remain wet even in summer and have accumulated peat. Peat depth is up to 2 m at one point in the southern section of Kilglassan and has not been cut for over 20 years.

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

[3180] Turloughs*

The large size of this site allows good development of the wetter turlough vegetation types. There are substantial areas of Amphibious Bistort (*Polygonum amphibium*) and Common Sedge (*Carex nigra*) at lower levels, with some Canary Reed-grass (*Phalaris arundinacea*), Bladder Sedge (*Carex vesicaria*) and Bogbean (*Menyanthes trifoliata*). Purple Moor-grass (*Molinia caerulea*) and Marsh Pennywort (*Hydrocotyle vulgaris*) are frequent on the peat surfaces, while Carnation Sedge (*Carex panicea*), Northern Bedstraw (*Galium boreale*) and a little Mat-grass (*Nardus stricta*) occupy the shallow soils on the sides of the basin. Several ponds occur where Great Yellow-cress (*Rorippa amphibia*), Unbranched Bur-reed (*Sparganium emersum*) and Hemlock Water-dropwort (*Oenanthe aquatica*) are characteristic.

At Caheravoostia there is some Tubular Water-dropwort (*Oenanthe fistulosa*) present, an unusual plant for a turlough, and scarce west of the River Shannon. The high level pond between the two basins provides a good contrast of vegetation, with species such as Lesser Tussock-sedge (*Carex diandra*), Knotted Pearlwort (*Sagina nodosa*) and Small Sweet-grass (*Glyceria declinata*).

Other habitats which are included in the site are wet and dry grassland, and some improved grassland at the southern section of Kilglassan. These grasslands may flood at times of high water. Some scrub occurs at the margins of Kilglassan.

The wetness of the site and the lack of grazing in the central parts provides good habitat for breeding waders, with several pairs each of Lapwing, Snipe and Redshank present in 1990. The site is likely to attract wintering waterfowl but no data are available.

The turloughs lie only 1 km from the (drained) River Robe and their flooding pattern seems likely to have been affected to some degree by this drainage. There is no internal drainage apart from some ditches marking boundaries. Grazing occurs in both basins and some agricultural improvements have taken place around the margins of the site.

This site is of interest as it is a relatively large turlough complex with considerable habitat diversity. The extensive area of wetland vegetation that occurs in the turlough basins is notable.

SITE SYNOPSIS

Site Name: Greaghans Turlough SAC

Site Code: 000503

Greaghans Turlough is the most easterly of a group of five turloughs located near to Ballinrobe in Co. Mayo. It has a flattish, oval basin, which is deepest along the northern edge. For the most part it is surrounded by grazing land and is itself moderately grazed, least intensively at the eastern end. Two small clumps of trees occur on spurs on the northern edge. Two streams enter the turlough, one from the north-east which appears to be permanent, and one from the south which is ephemeral. A channel in the north-western corner may represent attempted drainage but it would appear to have had little overall effect on the hydrology of the site.

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

[3180] Turloughs*

The vegetation in the turlough basin is clearly related to the contours, with Amphibious Bistort (*Polygonum amphibium*) occurring in most of the deepest parts, and Common Sedge (*Carex nigra*), Jointed Rush (*Juncus articulatus*) and Lesser Spearwort (*Ranunculus flammula*) above this. At the edges, this grades into grassland, which is nutrient-enriched and species-poor at the western end but more species-rich to the east.

In places, the floor of the turlough is trampled where cattle gather. These areas support a vegetation community which is particularly rich in annual or short-lived perennial species such as Water-pepper (*Polygonum hydropiper*), Redshank (*Polygonum persicaria*), Common Chickweed (*Stellaria media*), Thread-leaved Water-crowfoot (*Ranunculus trichophyllus*), Marsh Foxtail (*Alopecurus geniculatus*) and the rare, Red Data Book species, Northern Yellow-cress (*Rorippa islandica*).

Low, tree-covered spurs are found on the northern side of the turlough. Here Ash (*Fraxinus excelsior*), Hawthorn (*Crataegus monogyna*) and Spindle (*Euonymus europaeus*) occur, above a fringe of Reed Canary-grass (*Phalaris arundinacea*) and Meadowsweet (*Filipendula ulmaria*), through which grow Creeping Cinquefoil (*Potentilla reptans*) and Creeping-Jenny (*Lysimachia nummularia*).

Greaghans Turlough is notable for its use in winter by swans - 40 Whooper Swan, a species listed on Annex I of the E.U. Birds Directive, were recorded in 1986 on the site.

Greaghans Turlough is somewhat uniform because of its topography, but is valuable as an undrained turlough with a variety of well-developed vegetation communities. The site is notable for the occurrence of a large area of vegetation dominated by annual plant species. Turloughs are rare and threatened habitats that are listed on Annex I of the E.U. Habitats Directive and, as such, are of conservation significance. The presence of the rare Northern Yellow-cress and of a large flock of wintering Whooper Swan add significantly to the importance of the site.

SITE SYNOPSIS

Site Name: Carrowkeel Turlough SAC

Site Code: 000475

Carrowkeel turlough lies between Ballinrobe and Claremorris, Co. Mayo, about 2 km from the Robe River. It is contained within a linear basin which is orientated north-east to south-west. There are no obvious signs of successful external drainage, though some surplus water may be taken away at the south-west corner. At the southern end of the turlough, which is generally deeper than the rest of the basin, there is a long-lasting lake (Poll Oilean na gCorr).

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

[3180] Turloughs*

For its size, Carrowkeel turlough has a high diversity of vegetation types. This is partly due to the presence of permanent water in at least part of the turlough basin. Consequently, the turlough offers an excellent series of communities which are linked to water depth and quality. The vegetation in the lake consists of a stand of Common Club-rush (*Scirpus lacustris*), with abundant Fine-leaved Water-dropwort (*Oenanthe aquatica*), Amphibious Bistort (*Polygonum amphibium*), Water Horsetail (*Equisetum fluviatile*) and the mosses *Drepanocladus revolvens* and *Calliergon giganteum*. Areas of open water have Thread-leaved Water-crowfoot (*Ranunculus trichophyllus*), Lesser Marshwort (*Apium inundatum*) and Broad-leaved Pondweed (*Potamogeton natans*).

At the north-east end of the turlough basin a small scraw includes Floating Sweet-grass (*Glyceria fluitans*), Water Horsetail, Bladder-sedge (*Carex vesicaria*), Fine-leaved Water-dropwort, Bogbean (*Menyanthes trifoliata*) and Greater Spearwort (*Ranunculus lingua*). There is also a distinct zone of Common Spike-rush (*Eleocharis palustris*), Unbranched Bur-reed (*Sparganium emersum*) and Creeping Bent (*Agrostis stolonifera*), on which both Water-plantain (*Alisma plantago-aquatica*) and Narrow-leaved Water-plantain (*A. lanceolatum*) grow. This vegetation type is generally rare in turloughs.

Also of note is the occurrence of the scarce Marsh Stitchwort (*Stellaria palustris*), which is found scattered throughout several different communities in the turlough.

There is low grazing pressure throughout most of the site, though some of the fields in the north-east are closely grazed by sheep.

The catchment is very small and therefore the turlough is relatively oligotrophic (nutrient-poor) in character, at least at its northern end. A more eutrophic (nutrient-rich) band occurs across the centre of the basin, perhaps linked to the presence of a farm at the north-east corner. Despite this possible enrichment, the range of vegetation types, the presence of some uncommon plant species and the relatively natural state of the turlough itself, makes this site of conservation interest.

SITE SYNOPSIS

Site Name: Balla Turlough SAC

Site Code: 000463

This turlough lies in a north-south hollow just east of the village of Balla, Co. Mayo. Along each side of its basin there are smooth, low ridges of glacial deposition, while to the east the land rises more steeply. The floor of the basin is probably flat but there is a considerable accumulation of peat in the basin, which forms a raised platform. This process of peat build-up is taking the central dome above the level of frequent flooding, and the period of inundation here may be reduced as a result. Marl deposits are also present, and marl deposition is actively occurring in places. Water seems to rise mostly on the western side of the site and from the depression at the southern end, where there are more permanent bodies of water.

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

[3180] Turloughs*

The peat dome has a uniform vegetation of Purple Moor-grass (*Molinia caerulea*) and sedges (*Carex panicea* and *C. hostiana*), with scattered Meadowsweet (*Filipendula ulmaria*) and Meadow Thistle (*Cirsium dissectum*). This vegetation type is extensive at Balla, compared to other Irish turloughs. In damper places, Marsh Cinquefoil (*Potentilla palustris*) and Brown Sedge (*Carex disticha*) become abundant, and here the scarce plant Marsh Stitchwort (*Stellaria palustris*) occurs, with Yellow Loosestrife (*Lysimachia vulgaris*) and Bogbean (*Menyanthes trifoliata*). Marsh Stitchwort is a relatively rare species in the central lowlands of Ireland, and occurs in few turloughs.

Around the peat dome, the vegetation consists of dry and wet mesotrophic grassland, which is more typical of turlough habitats. Amphibious Bistort (*Polygonum amphibium*) and sedges (*Carex nigra* and *C. vesicaria*) are frequent in wet grassland, while Mat-grass (*Nardus stricta*) and Quaking-grass (*Briza media*) occur in drier areas.

Standing water supports an emergent community with Common Club-rush (*Scirpus lacustris*) and sedges (*Carex rostrata* and *C. elata*), with aquatic plants such as Shoreweed (*Littorella uniflora*) and Fen Pondweed (*Potamogeton coloratus*). Marl ponds also contain oligotrophic communities with Bulbous Rush (*Juncus bulbosus*) and Floating Club-rush (*Scirpus fluitans*). This community is more a feature of the Burren turloughs, and its occurrence here is unusual for the region.

Most of the turlough is open to cattle but grazing is light. Peat-cutting took place in the past but ceased a long time ago. The main threats to turloughs are drainage and agricultural reclamation. Balla Turlough lies in the Moy (Manulla) catchment, which was drained in the 1960's-70's. Due to local catchment conditions, the turlough still floods regularly and retains its habitat quality. The site remains oligotrophic, but this would be threatened in the event of nutrient input into its system.

The turlough and surrounding grasslands attract significant numbers of waders in winter. Counts made in one season from 1984/85 to 1986/87 indicate locally/regionally important numbers of Golden Plover (380), Lapwing (190) and Curlew (110). Swans also use the area in winter.

Balla Turlough occurs at the northern edge of the main range of turloughs in Mayo and Roscommon, and is one of very few within the Moy catchment. Overall, the turlough is of high ecological value for its range of unusual topographical features and vegetation communities. The amount and physical shape of the peat present here is of interest in offering a comparison with other northern turloughs where peat-cutting has been widespread. Turloughs are an increasingly rare habitat in Europe and Ireland, and Balla is important as an excellent example of an unusual turlough in a very natural condition.

SITE SYNOPSIS

SITE NAME: LOUGH CORRIB SPA

SITE CODE: 004042

Lough Corrib is the largest lake in the country and is located, for the most part, in County Galway, with a small section in the north extending into County Mayo. The lake can be divided into two parts: a relatively shallow basin in the south, which is underlain by Carboniferous limestone, and a larger, deeper basin to the north, which is underlain by more acidic granite, schists, shales and sandstones. The main inflowing rivers are the Black, Clare, Dooghta, Cregg, Owenriff and the channel from Lough Mask. The main outflowing river is the Corrib, which reaches the sea at Galway City.

The shallow, lime-rich waters of the southern basin of the lake support one of the most extensive beds of Stoneworts (Charophytes) in Ireland. These *Chara* beds are a very important source of food for waterfowl. In contrast, the northern basin contains more oligotrophic and acidic waters. Large areas of reedswamp vegetation, dominated by varying mixtures of Common Reed (*Phragmites australis*) and Common Club-rush (*Scirpus lacustris*) occur around the margins of the lake. The lake has numerous islands, which range from relatively bare rocky islets to larger islands with grassland or woodland.

The site is a Special Protection Area (SPA) under the E.U. Birds Directive, of special conservation interest for the following species: Greenland White-fronted Goose, Gadwall, Shoveler, Pochard, Tufted Duck, Common Scoter, Hen Harrier, Coot, Golden Plover, Black-Headed Gull, Common Gull, Common Tern and Arctic Tern. The site is also of special conservation interest for holding an assemblage of over 20,000 wintering waterbirds. The E.U. 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 Wetlands & Waterbirds.

Lough Corrib is an internationally important site that regularly supports in excess of 20,000 wintering waterbirds including an internationally important population of wintering Pochard (10,107) – except where indicated all figures are five year mean peaks for the period 1995/96 to 1999/2000. The site also supports nationally important populations of wintering Greenland White-fronted Goose (160 - five year mean peak for the period 1994/95 to 1998/99), Gadwall (48), Shoveler (90), Tufted Duck (5,486), Coot (14,426) and Golden Plover (1,727). Other species which occur include Mute Swan (182), Whooper Swan (35), Wigeon (528), Teal (74), Mallard (155), Goldeneye (74), Lapwing (2,424) and Curlew (114).

In winter nationally important numbers of Hen Harrier (8 - four year mean peak count between 2006 and 2009) also utilise the site as a communal roost.

Lough Corrib is also a traditional breeding site for gulls and terns, with various islands being used for nesting each year. There are important colonies of Common Tern (37 pairs in 1995) and Arctic Tern (60 pairs in 1995). The site supports substantial colonies of Black-headed Gull (431 pairs in 2000) and Common Gull (186 pairs in 2000), these representing 3% and 11% of the respective all-Ireland totals. Small numbers of Lesser Black-backed Gull, Great Black-backed Gull and Herring Gull have also been recorded breeding within the site.

The site supports approximately half of the national population of nesting Common Scoter (30 pairs in 1995); Lough Corrib was colonised by this rare, Red Data Book species only as recently as the late1970s/early1980s.

Lough Corrib SPA is an internationally important site which supports in excess of 20,000 wintering waterbirds, including a population of Pochard that is, itself, of international importance. A further six species of wintering waterfowl have populations of national importance. The site also contains a nationally important communal roost site for Hen Harrier. Lough Corrib is the most important site in the country for breeding Common Scoter. Its populations of breeding gulls and terns are also notable, with nationally important numbers of Black-headed Gull, Common Gull, Common Tern and Arctic Tern occurring. It is of note that several species which regularly occur are listed on Annex I of the E.U. Birds Directive, i.e. Whooper Swan, Greenland White-fronted Goose, Hen Harrier, Golden Plover, Common Tern and Arctic Tern. Lough Corrib is a Ramsar Convention site.

7.7.2014

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