A REPORT ON A GROUND INVESTIGATION AT MURROW AD PLANT (FACTUAL)

CLIENT: Murrow AD Plant Limited

ENGINEER: Plandescil Limited

Date: 8 September 2021

Reference: ADB/21.237

A F Howland Associates
The Old Exchange
Newmarket Road
Cringleford
Norwich
NR4 6UF

Tel: 01603 250754
Email: admin@howland.co.uk
Web: www.howland.co.uk

A F Howland Associates

CONTENTS

APPENDICES

CLIENT: Murrow AD Plant Limited

ENGINEER: Plandescil Limited

A REPORT ON A GROUND INVESTIGATION AT MURROW AD PLANT (FACTUAL)

Reference: ADB/21.237

Date: 8 September 2021

1. INTRODUCTION

It is proposed to carry out construction work at Murrow AD Plant near Wisbech in Norfolk (Drawing 21.237/01).

At the instruction of Murrow AD Plant Limited, an investigation was carried out to provide information on the subsoil conditions and relevant geotechnical parameters associated with the proposed construction and of embankments that formed two existing lagoons.

This report provides the factual details of the fieldwork and laboratory testing undertaken during the investigation.

2. FIELDWORK

Fieldwork was carried out on 5 and 6 August 2021 and comprised three windowless dynamic sample holes and two machine excavated trial pits in the area of proposed construction. Four hand dug trial pits were also carried out in the lagoon embankments.

The exploratory hole positions were set out in general accordance with the requirements of the Client, as shown on Drawing 21.237/02. The National Grid references, and elevation of the hole locations relative to Ordnance Datum, were measured using a Hemisphere S320 VRS GPS (RTK) system. A cable avoidance tool was used to sweep the positions and the immediate surrounding area to locate any potential services with the position adjusted as necessary. A starter pit was also excavated by hand to a depth of 1.2 m at the windowless dynamic sample hole positions to provide direct inspection for services.

The **windowless dynamic sample holes**, referenced WS01 to WS03 were advanced with a tracked dynamic sampling rig and taken to a depth of 4.00 m below ground level (bgl). The sampling system utilises a 63.5 kg weight falling a distance of 750 mm to drive rods and sampling tubes into the ground, these are then extracted and the continuous samples described. During advance, sampling and *in situ* testing were carried out in general accordance with BS EN1997-2:2007 Eurocode 7 and its UK National Annex supported by BS 5930:2015+A1:2020.

Hand vane tests (HV) were carried out in cohesive material within the starter inspection pits using a Pilcon hand vane to estimate the undrained shear strength. This is achieved using a four-bladed cruciform stainless steel vane which is pushed into the ground. The torque head is attached to the 19 or 33 mm diameter vane and is rotated at the rate of one revolution per minute until the material fails. The equipment includes a direct reading scale to give the undrained shear strength

Open tube (U70) drive samples were taken in cohesive materials to allow laboratory testing of undisturbed material, as appropriate. Standard penetration tests (SPT) were carried out in cohesionless soils or materials where undisturbed samples could not be obtained, using a split barrel sampler or a solid cone as appropriate. The SPT N-value was taken as the number of blows for 300 mm of penetration, following a seating drive of 150 mm or 25 blows.

The **Hand dug trial pits,** referenced HDTP01 to HDTP04 were excavated using hand-held insulated digging tools and taken to a depth of 1.2 m within the existing lagoon embankments.

The **machine dug trial pits**, referenced TP01 and TP02 were excavated by a mechanical excavator equipped with a 1.5 m wide bucket and were taken to a maximum depth of 3.0 m. Hand vane tests (HV) were again carried out in cohesive material using the same Pilcon hand vane to estimate the undrained shear strength.

The exploratory holes were monitored for **groundwater** ingress during advance. However in this instance none was encountered

Details of the strata encountered, the sampling, *in situ* and laboratory testing are shown on records appended to this report.

3. LABORATORY TESTING

3.1 GENERAL

Subsequent to the fieldwork, a programme of laboratory testing was carried out to provide additional quantitative data on the materials encountered. The tests were completed in accordance with the procedures laid down in BS EN ISO 17892 and BS1377: 1990, unless stated otherwise, and consisted of:

- Natural moisture content
- Atterberg limits
- Particle size distribution
- Unconsolidated undrained triaxial testing
- Sulphate content and pH value
- Total sulphur content
- Loss on ignition

3.2 TEST PROCEDURES

3.2.1 NATURAL MOISTURE CONTENT

The natural moisture content (also known as water content) is determined according to BS EN ISO 17892: Part 1: 2014: clause 5.2. This represents the mass of moisture content retained by the soil in its natural state as a percentage of its dry mass. For organic soils and peats care should be taken to avoid heating the sample above 50°C to prevent irreversible physical changes to the material.

3.2.2 ATTERBERG LIMITS

The Atterberg limits are determined in the laboratory by the procedures given in BS EN ISO 17892: Part 12: 2018. The liquid limit (LL) is the moisture content of the soil at the point that its behaviour passes from that of a plastic solid to that of a liquid. The test procedure given as clause 5.3 was used based on the cone penetrometer in which the penetration of a free-fall cone into moistened and cured samples of the soil is measured. The plastic limit (PL) is the moisture content of the soil at the point that its behaviour passes from a plastic solid to a brittle solid. This point is measured according to clause 5.5 and is the point at which a thread of the soil rolled to 3 mm diameter begins to crumble.

Together the Atterberg limits can be used to define the plastic range of the soil. The plasticity index (PI) is the difference between the liquid and plastic limit and is broadly correlated to the engineering behaviour of the soil. When used with the natural moisture content of the soil they can also give an indication of its *in situ* condition.

3.2.3 PARTICLE SIZE DISTRIBUTION

A quantitative assessment of the particle size distribution of the soil down to the fine grained sand size is made according to BS EN ISO 17892: Part 4: 2016: clause 5.2. In this the percentage of certain sized fractions of the soil are found by determining the weight retained on a variety of sieve sizes through which the material is allowed to pass. The combined silt and clay fraction is determined by the difference between the sum of the retained weights and the original sample weight. Variations of the test procedure allow the silt and clay fraction to be removed from the coarser fraction by wet sieving during which the fine material is washed from the surface of the coarser material.

The quantitative determination of the particle size distribution for fine soils, from coarse silt to clay size, is made according to BS EN ISO 17892: Part 4: 2016: clause 5.3 or 5.4, using either the sedimentation by hydrometer method or pipette method. These tests are generally carried out if greater than 10% of the material passes the BS test sieve size of 63 μm. The percentages of the constituents of the fine soil can be linked to the curve obtained by sieving to provide a single curve for the whole material.

3.2.4 UNCONSOLIDATED UNDRAINED TRIAXIAL TESTING

The undrained shear strength of the soil was measured, as stated in BS EN ISO 17892: Part 8: 2018 or BS 1377: Part 7: 1990: clause 8, by axial compression of 70 mm diameter cylindrical specimens cut from the U70 undisturbed samples. The nature of the test is such that no change in moisture content of the specimen is allowed during shear.

The theory of behaviour of saturated clay materials in undrained shear failure gives that the strength will not be influenced by the confining pressure such that the measured angle of internal friction for the material will apparently be equal to zero. Experience has shown that this is true only for samples of unweathered heavily overconsolidated pure clays. Where the material is weathered or it contains a significant granular content a plastic rather than a brittle failure develops which produces a strain hardening during shear. In this

situation measurable apparent undrained angle of internal friction is produced. A similar situation develops in partially saturated materials. The test results are also influenced by sample variation, and in particular the presence of natural fissures or inclusions within the sample.

The use of large diameter specimens is preferred as this compensates for the scale effects of random features in smaller specimens. One of two tests are carried out according to the soil characteristic. Unweathered specimens of heavily overconsolidated clays which have a brittle failure in shear are tested in a single stage according to BS EN ISO 17892: Part 8: 2018. The confining pressure is taken as the total overburden pressure of the sample *in situ*. It is then failed by axial compression and the measured deviator stress reported as the apparent undrained cohesion. Specimens of weathered clay or the clays with granular contents are tested in a multistage manner according to BS 1377: Part 7: 1990: clause 9.

The test procedure is similar to the single stage but at the point that failure begins the confining pressure is increased and the specimen compressed for a further 2% of vertical strain at which point the confining pressure is again increased and held for a further 2% strain. The deviator stresses at each of the confining pressures are used to plot the Mohr envelope and the apparent undrained cohesion and if appropriate the undrained angle of internal friction.

3.2.5 SULPHATE CONTENT AND pH VALUE

In order to aid the evaluation of any aggressive tendency of the subsoil or groundwater to buried concrete, the pH, water soluble and total sulphate concentrations in a number of samples were determined using in-house procedures based on other methodologies.

The pH of a groundwater sample or a soil filtrate was established electrometrically according to BS 1377: Part 3: 1990: clause 9.5, while water soluble sulphate and groundwater sulphate were determined using procedures based on Standard Methods for the Examination of Water and Wastewater Part 3120 B – 21st Edition (AWWA & WEF, 2005). This requires the preparation of a soil extract using deionised water at a 2:1 ratio. The filtered extract of the soil, or a water sample, are then injected into an ion exchange chromatograph with a conductivity detector. The samples are compared against commercially available standards to evaluate the sulphate concentration.

The total sulphate content of a soil was measured on a filtrate following digestion of the soil by 10% hydrochloric acid, as shown by BS 1377: Part 3: 1990: clause 5.5 and TRL 447 (Reid *et al* 2005). Subsequently the soil filtrate is introduced into ICP-OES equipment to determine sulphate concentration.

3.2.6 TOTAL SULPHUR CONTENT

To aid the evaluation of aggressive tendency of the subsoil to buried concrete as a result of its pyritic potential, the total potential sulphate content can be determined from the relationship between the total (acid soluble) sulphate content and the amount of total sulphur present. The total sulphur content is determined by a laboratory in-house methodology based on Standard Methods for the Examination of Water and Wastewater Part 3120 B – 21st Edition (AWWA & WEF, 2005).

A dried portion of the soil is extracted at 115 °C for 75 minutes using 100% aqua regia. The digest solution is filtered and analysed by ICP-OES. The results are expressed as % S, and include water soluble and acid soluble sulphates and total reduced sulphur, as well as insoluble sulphates and organic sulphur.

3.2.7 LOSS ON IGNITION

The organic content of peats or organic clays containing more than about 10% organic matter or sandy soils containing only limited quantities of clay or chalk can be related to the loss in the mass of the soil on ignition. This is carried out according to a laboratory in-house method based on BS 1377: Part 3: 1990: Clause 4. The test involves a previously dried and weighed sample being burned at a temperature of 450°C, the result is then reported as the ratio (%) of mass before and after burning.

4. COPYRIGHT

A D Barks
BSc (Hons) FGS

Eur Ing Dr A F Howland
MSc PhD DIC CEng FIMMM CGeol FGS GMICE

A F HOWLAND ASSOCIATES
8 September 2021

APPENDIX A: REFERENCES

AMERICAN WATER WORKS ASSOCIATION & WATER ENVIRONMENT FEDERATION. 2005. Standard Methods for the Examination of Water and Wastewater Part 3120 B – 21st Edition. American Public Health Association, Washington D.C.

BRITISH STANDARDS INSTITUTION. 1990. BS 1377: Methods of test for Soils for engineering purposes. British Standards Institution, London.

BRITISH STANDARDS INSTITUTION. 2007. BS EN ISO 1997-2:2007 Geotechnical Design - Part 2 Ground investigation and testing. British Standards Institution, London.

BRITISH STANDARDS INSTITUTION. 2020. BS 5930:2015+A1:2020 Code of practice for ground investigations. British Standards Institution, London.

BRITISH STANDARDS INSTITUTION. BS EN ISO 17892-1:2014 Geotechnical investigation and testing - Laboratory testing of soil. Part 1: Determination of water content. British Standards Institution, London.

BRITISH STANDARDS INSTITUTION. BS EN ISO 17892-4:2016 Geotechnical investigation and testing - Laboratory testing of soil. Part 4: Determination of particle size distribution. British Standards Institution, London.

BRITISH STANDARDS INSTITUTION. BS EN ISO 17892-8:2018 Geotechnical investigation and testing - Laboratory testing of soil. Part 8: Unconsolidated undrained triaxial test. British Standards Institution, London.

BRITISH STANDARDS INSTITUTION. BS EN ISO 17892-12:2018 Geotechnical investigation and testing - Laboratory testing of soil. Part 12: Determination of liquid and plastic limits. British Standards Institution, London

REID, J. M, CZEREWKO, M. A. and CRIPPS, J.C. Sulphate specification for structural backfills. TRL Report 447, 2005. Transport Research Laboratory, Crowthorne, UK

APPENDIX B: WINDOWLESS SAMPLE HOLE RECORDS

B	Bulk disturbed sample
D	Small disturbed sample
L	Liner sample
HV	Hand shear vane
U	70 mm diameter undisturbed open tube drive sample
X blows	The associated figure 'X' is the number of blows to drive the sample tube over the given depth range
SPT(C)	Standard penetration test using a solid cone. N Value is uncorrected, but the hammer energy ratio is provided (in remarks)
SPT	Standard penetration test using a split spoon sampler. N Value is uncorrected, but the hammer energy ratio is provided (in remarks)
IP	Initial penetration of SPT equipment under its own weight
X,X/X,X,X,X	Blows per increment during the standard penetration test. The initial value relates to the seating drive (150 mm) and the remaining four to the 75 mm increments of the test length
N=X	SPT blow count 'N' given by the summation of the blows 'X' required to drive the full test length (300 mm)
X*/Y	Incomplete standard penetration test where the seating drive could not be completed. The blows 'X' represent the total blows for the given length of seating drive 'Y' (mm)
X/Z	Incomplete standard penetration test where the seating drive was achieved but the full test length was not. The blows 'X' represent the total blows for the given test length 'Z' (mm)
dd/mm/yy:1.0 **dd/mm/yy: dry**	Date, water level at the borehole depth at the end of shift and the start of the following shift

Each sample type is numbered sequentially with depth and relates to the depth range quoted

All depths and measurements are given in metres, except as noted

Strata descriptions complied by visual examination of samples obtained during boring, after BS 5930:2015+A1:2020 and modified in accordance with laboratory test results where applicable

A F Howland Associates
Geotechnical Engineers

Site Murrow AD Plant			**Number** WS01
Machine : Dando Terrier 2002 **Method :** Windowless Dynamic Sampling	**Dimensions** 102mm to 2.00m, 87mm to 3.00m, 75mm to 4.00m	**Ground Level (mOD)** -0.06	**Client** Murrow AD Plant Limited	**Job Number** 21.237
	Location 537510 E 304685 N	**Dates** 05/08/2021	**Engineer** Plandescil Limited	**Sheet** 1/1

Depth (m)	Sample / Tests	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
0.00-0.30	D1				(0.30)	TOPSOIL (Brown desiccated silty slightly sandy clay)		
				-0.36	0.30	Soft grey brown silty slightly sandy organic CLAY		
0.40-0.50	D2							
					(0.90)			
0.80-1.00	B1							
1.00	HV 27kPa		26,28,27/Av. 27.00					
1.20-1.65	SPT N=0	DRY	IP 450 Test Failed	-1.26	1.20	Very soft grey brown silty slightly sandy CLAY		
1.20-1.65	D3							
1.20-2.00	L1							
					(1.50)			
2.00-2.45	U1	DRY	0 blows					
2.00-3.00	L2							
2.50-2.60	D4							
				-2.76	2.70	Very soft dark grey silty slightly sandy organic CLAY with occasional pockets of semi-decayed organic matter		
2.80-3.00	D5							
3.00-3.45	SPT N=0	DRY	IP 450 Test Failed					
3.00-3.45	D6							
3.00-4.00	L3							
					(1.30)			
3.80-4.00	D7							
				-4.06	4.00	Complete at 4.00m		

Remarks
1. Location CAT scanned prior to excavation
2. Hand dug inspection pit to 1.20 m
3. No groundwater encountered
4. SPT Hammer Energy Ratio = 63%
5. Hand vane serial number = 2032

Scale (approx)	Logged By
1:25	SW

Figure No. 21.237.WS01

A F Howland Associates
Geotechnical Engineers

Site Murrow AD Plant			**Number** WS02
Machine : Dando Terrier 2002 **Method :** Windowless Dynamic Sampling	**Dimensions** 102mm to 2.00m 87mm to 3.00m 75mm to 4.00m	**Ground Level (mOD)** -0.53	**Client** Murrow AD Plant Limited	**Job Number** 21.237
	Location 537649 E 304667 N	**Dates** 05/08/2021	**Engineer** Plandescil Limited	**Sheet** 1/1

Depth (m)	Sample / Tests	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
0.00-0.30	D1				(0.40)	TOPSOIL (brown desiccated silty slightly sandy clay)		
				-0.93	0.40	Soft brown silty slightly sandy organic CLAY		
0.60-0.80	D2							
0.90	HV 44.33kPa		36,48,49/Av. 44.33					
1.00-1.20	D3				(1.30)			
1.20-1.65 1.20-2.00	U1 L1	DRY	0 blows			... becoming very soft		
1.70-1.90	D4			-2.23	1.70	Very soft grey silty organic CLAY with wood fragments and pockets of black semi decayed organic matter		
2.00-2.45 2.00-2.45 2.00-3.00	SPT N=0 D5 L2	DRY	IP 450 Test Failed					
						.... pockets of brown peat from 1.70 m		
2.80-3.00	D6				(2.30)			
3.00-3.45 3.00-4.00	U2 L3	DRY	0 blows					
3.20-3.40	D7							
						.... shell fragments (Bivalves) from 3.70 m		
3.80-4.00	D8							
				-4.53	4.00	Complete at 4.00m		

Remarks
1. Location CAT scanned prior to excavation
2. Hand dug inspection pit to 1.20 m
3. No groundwater encountered
4. SPT Hammer Energy Ratio = 63%
5. Hand vane serial number = 2032

Scale (approx)	Logged By
1:25	SW

Figure No. 21.237.WS01

A F Howland Associates
Geotechnical Engineers

Site Murrow AD Plant			**Number** WS03
Machine : Dando Terrier 2002 **Method :** Windowless Dynamic Sampling	**Dimensions** 102mm to 2.00m, 87mm to 3.00m, 75mm to 4.00m	**Ground Level (mOD)** -0.34	**Client** Murrow AD Plant Limited	**Job Number** 21.237
	Location 537788 E 304631 N	**Dates** 05/08/2021	**Engineer** Plandescil Limited	**Sheet** 1/1

Depth (m)	Sample / Tests	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
0.00-0.30	D1					TOPSOIL (Brown desiccated silty slightly sandy clay with rare angular to subrounded fine to coarse limestone gravel)		
					(0.50)			
0.40-0.50	D2			-0.84	0.50	Soft brown, orange and grey mottled silty CLAY with occasional pockets of black organic matter		
0.80-1.00	D3							
0.90	HV 95.33kPa		99,91,96/Av. 95.33			.... desiccated layer		
					(1.10)			
1.20-1.65	SPT N=0	DRY	IP 450 Test Failed					
1.20-1.50	D4							
1.20-2.00	L1							
				-1.94	1.60	Very soft grey silty organic CLAY with frequent pockets of black organic matter		
1.80-2.00	D5							
2.00-2.45	U1	DRY	0 blows					
2.00-3.00	L2							
2.45-2.95	D6							
2.50-2.95	SPT N=0	DRY	IP 450 Test Failed					
					(2.40)			
3.00-3.45	SPT N=0	DRY	IP 450 Test Failed					
3.00-3.45	D7							
3.00-4.00	L3					.... band of peat from 3.50 m to 3.60 m		
3.80-4.00	D8							
				-4.34	4.00	Complete at 4.00m		

Remarks
1. Location CAT scanned prior to excavation
2. Hand dug inspection pit to 1.20 m
3. No groundwater encountered
4. SPT Hammer Energy Ratio = 63%
5. Hand vane serial number = 2032

Scale (approx)	Logged By
1:25	SW

Figure No. 21.237.WS01

APPENDIX C: TRIAL PIT RECORDS

B	Bulk disturbed sample
D	Small disturbed sample
HV	Hand shear vane
dd/mm/yy:1.0 **dd/mm/yy: dry**	Date, water level at the borehole depth at the end of shift and the start of the following shift

Each sample type is numbered sequentially with depth and relates to the depth range quoted

All depths and measurements are given in metres, except as noted

Strata descriptions complied by visual examination of samples obtained during boring, after BS 5930:2015+A1:2020 and modified in accordance with laboratory test results where applicable

A F Howland Associates
Geotechnical Engineers

Site Murrow AD Plant			**Trial Pit Number** HDTP01
Excavation Method Hand dug	**Dimensions** 0.3 L x 0.3 W x 1.2 D	**Ground Level (mOD)** 1.61	**Client** Murrow AD Plant Limited	**Job Number** 21.237
	Location (dGPS) 537467 E 304563 N	**Dates** 06/08/2021	**Engineer** Plandescil Limited	**Sheet** 1/1

Depth (m)	Sample / Tests	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
						EMBANKMENT (Stiff brown silty clay)		
						... frequent rootlets		
					(1.20)			
						... becoming light brown		
0.80	D1							
				0.41	1.20	Complete at 1.20m		

Remarks

1. Location CAT scanned prior to excavation
2. No groundwater encountered
3. Trial pit remained open and sidewalls stable during excavation.
4. Trial pit backfilled with arisings upon completion.

Scale (approx)	Logged By	Figure No.
1:10	ZRH	21.237.HDTP01

A F Howland Associates
Geotechnical Engineers

Site Murrow AD Plant			**Trial Pit Number** HDTP02
Excavation Method Hand dug	**Dimensions** 0.3 L x 0.3 W x 1.2 D	**Ground Level (mOD)** 1.01	**Client** Murrow AD Plant Limited	**Job Number** 21.237
	Location (dGPS) 537575 E 304646 N	**Dates** 06/08/2021	**Engineer** Plandescil Limited	**Sheet** 1/1

Depth (m)	Sample / Tests	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
					(1.20)	EMBANKMENT (Stiff light brown silty clay) ... frequent rootlets		
0.80	D1							
				-0.19	1.20	Complete at 1.20m		

Remarks

1. Location CAT scanned prior to excavation
2. No groundwater encountered
3. Trial pit remained open and sidewalls stable during excavation.
4. Trial pit backfilled with arisings upon completion.

Scale (approx)	Logged By	Figure No.
1:10	ZRH	21.237.HDTP02

A F Howland Associates
Geotechnical Engineers

Site Murrow AD Plant			**Trial Pit Number** HDTP03
Excavation Method Hand dug	**Dimensions** 0.3 L x 0.3 W x 1.2 D	**Ground Level (mOD)** 2.62	**Client** Murrow AD Plant Limited	**Job Number** 21.237
	Location (dGPS) 537754 E 304518 N	**Dates** 06/08/2021	**Engineer** Plandescil Limited	**Sheet** 1/1

Depth (m)	Sample / Tests	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
					(1.20)	EMBANKMENT (Soft brown greyish mottled silty clay) ... occasional rootlets		
0.80	D1							
				1.42	1.20	Complete at 1.20m		

Remarks

1. Location CAT scanned prior to excavation
2. No groundwater encountered
3. Trial pit remained open and sidewalls stable during excavation.
4. Trial pit backfilled with arisings upon completion.

Scale (approx)	Logged By	Figure No.
1:10	ZRH	21.237.HDTP03

A F Howland Associates
Geotechnical Engineers

Site Murrow AD Plant			**Trial Pit Number** HDTP04
Excavation Method Hand dug	**Dimensions** 0.3 L x 0.3 W x 1.2 D	**Ground Level (mOD)** 0.93	**Client** Murrow AD Plant Limited	**Job Number** 21.237
	Location (dGPS) 537822 E 304564 N	**Dates** 06/08/2021	**Engineer** Plandescil Limited	**Sheet** 1/1

Depth (m)	Sample / Tests	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
					(1.20)	EMBANKMENT (Stiff light brown silty clay) ... frequent rootlets		
0.80	D1							
				-0.27	1.20	Complete at 1.20m		

Remarks

1. Location CAT scanned prior to excavation
2. No groundwater encountered
3. Trial pit remained open and sidewalls stable during excavation.
4. Trial pit backfilled with arisings upon completion.

Scale (approx)	Logged By	Figure No.
1:10	ZRH	21.237.HDTP04

A F Howland Associates
Geotechnical Engineers

Site	Trial Pit Number
Murrow AD Plant	TP01

Excavation Method	Dimensions	Ground Level (mOD)	Client	Job Number
Machine Excavated	3.40 m x 1.50 x 3.00 m	0.01	Murrow AD Plant Limited	21.237
	Location	**Dates**	**Engineer**	**Sheet**
	537496 E 304686 N	06/08/2021	Plandescil Limited	1/1

Depth (m)	Sample / Tests	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
0.00-0.30	D1				(0.30)	TOPSOIL (Brown desiccated very slightly slightly sandy clay)		
0.30-0.70	D2			-0.29	0.30	Soft to firm occasionally desiccated grey brown very silty slightly sandy organic CLAY with rare shell fragments.		
0.60	HV 74.33kPa		69,83,71/Av. 74.33		(0.40)			
1.10	HV 32.33kPa		34,38,25/Av. 32.33	-0.69	0.70	Soft brown, grey and orange mottled very silty slightly peaty CLAY with occasional black organic matter and rare shell fragments		
1.10	D3				(1.40)			
1.60	D4							
2.00	HV 15.67kPa		18,15,14/Av. 15.67					
2.10	D5			-2.09	2.10	Very soft dark grey very silty slightly sandy CLAY with occasional organic matter		
2.50	D6				(0.90)			
3.00	HV 10kPa		12,8,10/Av. 10.00	-2.99	3.00	Complete at 3.00m		
3.00	D7							

No image available

Remarks

1. Location CAT scanned prior to excavation
2. No groundwater encountered
3. Trial pit remained open and sidewalls stable during excavation.
4. Trial pit backfilled with arisings upon completion.
5. Hand vane serial number = 2032

Scale (approx)	Logged By	Figure No.
1:20	SW	21.237.TP01

A F Howland Associates
Geotechnical Engineers

Site	Trial Pit Number
Murrow AD Plant	TP02

Excavation Method	Dimensions	Ground Level (mOD)	Client	Job Number
Machine Excavated	3.40 m x 1.50 x 3.00 m	-0.56	Murrow AD Plant Limited	21.237
	Location	**Dates**	**Engineer**	**Sheet**
	537776 E 304635 N	06/08/2021	Plandescil Limited	1/1

Depth (m)	Sample / Tests	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
0.00-0.40	D1				(0.40)	TOPSOIL (Brown desiccated very silty slightly sandy clay)		
				-0.96	0.40			
0.50	D2					Soft grey brown with occasional orange mottling very silty slightly sandy organic CLAY		
0.60	HV 54kPa		55,49,58/Av. 54.00			.... dessicated 0.60 m to 0.90 m		
1.00	HV 24kPa		22,26,24/Av. 24.00		(1.20)			
1.00	D3							
1.50	D4							
				-2.16	1.60	Very soft grey very silty organic peaty CLAY with frequent fragments of wood, reeds and black organic matter		
2.00	HV 7.67kPa		8,6,9/Av. 7.67					
2.00	D5				(1.40)			
2.50	D6							
2.80	D7					.... 2.70 m to 2.80 m band of fibrous peat and plant matter with a strong organic odour		
				-3.56	3.00			
3.00	HV 9.33kPa		9,9,10/Av. 9.33			Complete at 3.00m		
3.00	D8							

No image available

Remarks

1. Location CAT scanned prior to excavation
2. No groundwater encountered
3. Trial pit remained open and sidewalls stable during excavation.
4. Trial pit backfilled with arisings upon completion.
5. Hand vane serial number = 2032

Scale (approx)	Logged By	Figure No.
1:20	SW	21.237.TP02

APPENDIX D: LABORATORY TESTING

Natural moisture content

Atterberg limits

Particle size distribution

Unconsolidated undrained triaxial testing

Sulphate, sulphur and pH values

Loss on ignition

A F Howland Associates
Geotechnical Engineers

Laboratory Test Results

Site : Murrow AD Plant

Client : Murrow AD Plant Limited

Engineer : Plandescil Limited

Job Number 21.237

Sheet 1 / 1

DETERMINATION OF MOISTURE CONTENT, LIQUID LIMIT AND PLASTIC LIMIT AND DERIVATION OF PLASTICITY AND LIQUIDITY INDEX

Borehole/ Trial Pit	Depth (m)	Sample	Natural Moisture Content %	Sample Passing 425µm Sieve		Liquid Limit %	Plastic Limit %	Plasticity Index %	Liquidity Index	Group Symbol	Laboratory Description
				Percentage %	Moisture Content %						
TP02	2.50	D6	53.8	100	53.8	67	27	40	0.68	CH	Grey mottled black CLAY.
WS01	0.80	B1	28.1	100	28.1	41	20	21	0.38	CI	Dark brown sandy CLAY. Sand is fine.
WS03	1.80	D5	70.7	100	70.7	95	34	61	0.61	CE	Dark brown and dark grey CLAY.

Method of Preparation : BS EN ISO 17892:PART 1:2014:5.1 Test specimen preparation (moisture content). BS EN ISO 17892:PART 1:2018:5.2 Preparation of samples for classification tests

Method of Test : BS EN ISO 17892:PART 1:2014:5.2 Test execution (moisture content) BS EN ISO 17892: PART 12:5.3 & 6.2 Determination of the liquid limit BS EN ISO 17892:PART 5.5, 6.4 & 6.5 Determination of the plastic limit and plasticity index

Remarks :

A F Howland Associates
Geotechnical Engineers

Laboratory Test Results

Site : Murrow AD Plant

Client : Murrow AD Plant Limited

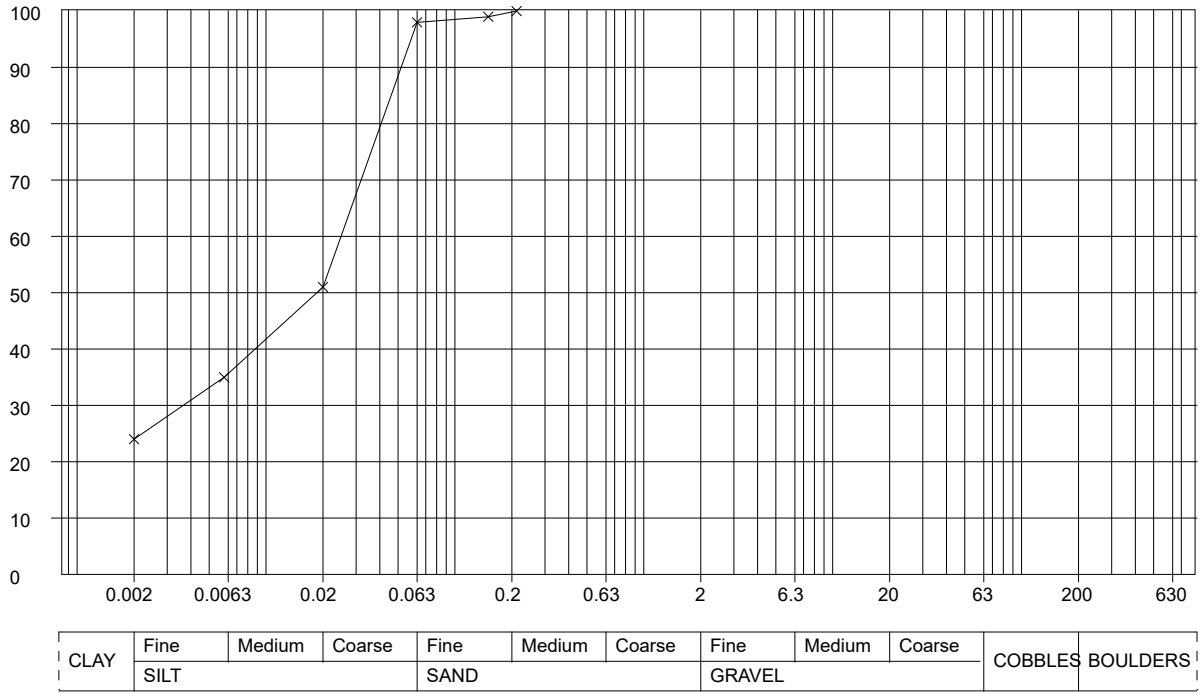
Engineer : Plandescil Limited

Job Number 21.237

Sheet 1/2

DETERMINATION OF PARTICLE SIZE DISTRIBUTION

Borehole / Trial Pit	Depth (m)	Sample	Laboratory Description
TP02	1.00	D3	Dark brown clayey SILT.



Sieve / Particle Size	% Passing
212 µm	100.0
150 µm	99.0
63 µm	98.0
20 µm	51.0
6 µm	35.0
2 µm	24.0

Grading Analysis	
D85	51.1 µm
D60	28.2 µm
D10	<2.0 µm
Uniformity Coefficient	-

Particle Proportions	
Cobbles + Boulders	-
Gravel	-
Sand	4.0%
Silt	72.0%
Clay	24.0%

Method of Preparation : BS EN ISO 17892:2016 Part 4. Determination of particle size distribution

Method of Test : BS EN ISO 17892: Part 4: 2016: Clause 5.2 Wet or dry sieve. Clause 5.4 Sedimentation by pipette

Remarks :

A F Howland Associates
Geotechnical Engineers

Laboratory Test Results

Site : Murrow AD Plant

Client : Murrow AD Plant Limited

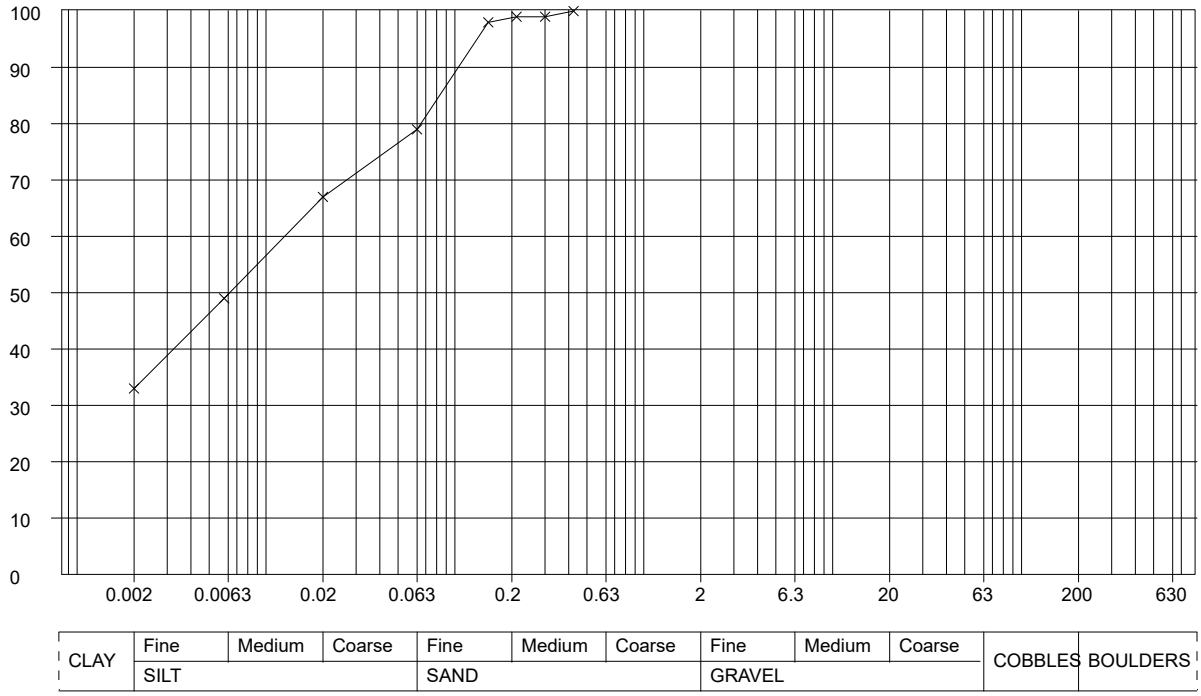
Engineer : Plandescil Limited

Job Number 21.237

Sheet 2/2

DETERMINATION OF PARTICLE SIZE DISTRIBUTION

Borehole / Trial Pit	Depth (m)	Sample	Laboratory Description
WS01	2.50	D4	Brownish grey slightly sandy silty CLAY.



Sieve / Particle Size	% Passing
425 µm	100.0
300 µm	99.0
212 µm	99.0
150 µm	98.0
63 µm	79.0
20 µm	67.0
6 µm	49.0
2 µm	33.0

Grading Analysis	
D85	90.5 µm
D60	14.6 µm
D10	<2.0 µm
Uniformity Coefficient	-

Particle Proportions	
Cobbles + Boulders	-
Gravel	-
Sand	21.5%
Silt	45.5%
Clay	33.0%

Method of Preparation : BS EN ISO 17892:2016 Part 4. Determination of particle size distribution

Method of Test : BS EN ISO 17892: Part 4: 2016: Clause 5.2 Wet or dry sieve. Clause 5.4 Sedimentation by pipette

Remarks :

A F Howland Associates
Geotechnical Engineers

Laboratory Test Results

Site : Murrow AD Plant

Client : Murrow AD Plant Limited

Engineer : Plandescil Limited

Job Number 21.237

Sheet 1 / 1

DETERMINATION OF DENSITY, MOISTURE CONTENT AND UNDRAINED SHEAR STRENGTH IN TRIAXIAL COMPRESSION WITHOUT MEASUREMENT OF PORE PRESSURE

Borehole/ Trial Pit	Depth (m)	Sample	Moisture Content %	Bulk Density (Mg/m^3)	Dry Density (Mg/m^3)	Cell Pressure (kN/m^2)	Deviator Stress (kN/m^2)	Apparent Cohesion (kN/m^2)	Angle of Shearing Resistance (degrees)	Laboratory Description
WS01	2.00	U1	37.7	1.69	1.23	40	47	23		Firm brown sandy CLAY.
WS02	1.20	U1	57.4	1.62	1.03	24	30	15		Soft to firm brownish grey CLAY.
WS02	3.00	U2	77.9	1.39	0.78	60	14	7		Very soft dark grey CLAY.

Method of Preparation : BS EN ISO 17892:PART 1:2014:5.1 Test specimen preparation (moisture content). BS EN ISO 17892:PART 8:2018: 6.2 Preparation of undisturbed samples for testing

Method of Test : BS EN ISO 17892:PART 1:2014:5.2 Test execution (moisture content) and PART 2:2014 Determination of density. BS EN ISO 17892: PART 8: 2018: 6,7 + 8 Undrained shear strength (Single stage). BS 1377:PART 7:1990:9 Multistage loading

Remarks :

A F Howland Associates
Geotechnical Engineers

Laboratory Test Results

Site : Murrow AD Plant

Client : Murrow AD Plant Limited

Engineer : Plandescil Limited

Job Number 21.237

Sheet 1 / 1

DETERMINATION OF pH, SULPHATE CONTENT AND TOTAL SULPHUR OF SOIL AND GROUNDWATER

Borehole/ Trial Pit	Depth (m)	Sample	Concentration of Soluble Sulphate			Total Sulphur %	Percentage of sample passing 2mm Sieve %	pH	Laboratory Description
			Soil		Groundwater g /l				
			Total S04 %	S03 in 2:1 water:soil g /l					
WS01	0.40	D2	0.64	1.48		1.13		7.7	Grey loamy clay
WS01	2.80	D5	0.08	0.12		0.08		7.9	Brown sandy clay
WS03	2.50	D6	0.31	0.58		0.55		7.7	Grey loamy clay

Method of Preparation : BS 1377:PART 1:1990:7.5 Preparation of soil for chemical tests

Method of Test : Laboratory in-house methods based on BS1377: Part 3 for ph and total sulphate and TRL 447 (2005) for total sulphate, Standard Methods for the Examination of Water and Wastewater Part 3120 B – 21st Edition (2005) for water soluble sulphate and total sulphur.

Remarks :

A F Howland Associates
Geotechnical Engineers

Laboratory Test Results

Site : Murrow AD Plant

Client : Murrow AD Plant Limited

Engineer : Plandescil Limited

Job Number 21.237

Sheet 1 / 1

DETERMINATION OF CHLORIDE CONTENT, ORGANIC MATTER CONTENT AND LOSS ON IGNITION

Borehole/ Trial Pit	Depth (m)	Sample	Concentration of Chloride			Percentage of sample passing 2mm Sieve %	Organic Matter Content %	Mass Loss on Ignition %	Laboratory Description
			Soil		Groundwater mg/l				
			Acid Soluble %	Water Soluble mg/l					
WS03	2.50	D6						6.80	Grey loamy clay

Method of Preparation : BS 1377:PART 1:1990:7.5 Preparation of soil for chemical tests

Method of Test : Lab in-house method based on Standard Methods for the Examination of Water and Wastewater Part 3120 B – 21st Edition (2005) for Determination of chloride content, BS 1377:PART 3:1990:4 for Determination of loss on ignition

Remarks :

APPENDIX E: DRAWINGS

Drawing 21.237/01 Site Location Plan

Drawing 21.237/02 Exploratory Hole Location Plan

North

Circle indicates approximate location of site

Scale 1: 50,000 @ A4

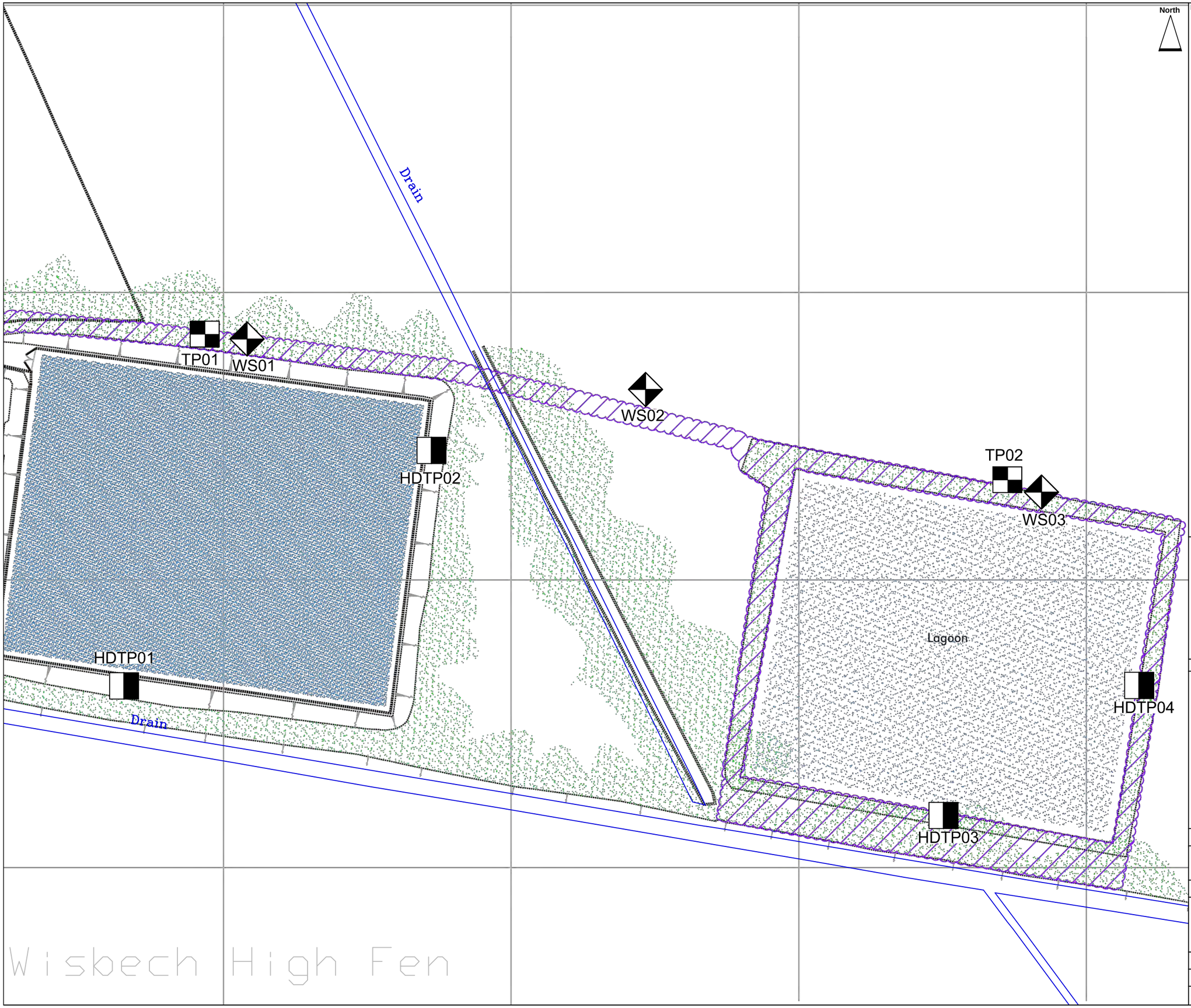
A F Howland Associates
Geotechnical Engineers

Site: Murrow AD Plant

SITE LOCATION PLAN

Client : Murrow AD Plant Limited

Date : September 2021 **Dwg :** 21.237/01



Key:

- Windowless dynamic sampling location and reference
- Trial pit location and reference
- Hand dug trial pit location and reference

Rev	Date	Revision Description	Drwn	Chkd

A F Howland Associates
Geotechnical Engineers

A F Howland Associates Ltd
The Old Exchange
Newmarket Road
Cringleford
Norwich
NR4 6UF

Tel: 01603 250754 Fax: 01603 250749

web: www.howland.co.uk
mail: admin@howland.co.uk

Client: Murrow AD Plant Limited

Site:
Murrow AD Plant

Job No.: 21.237

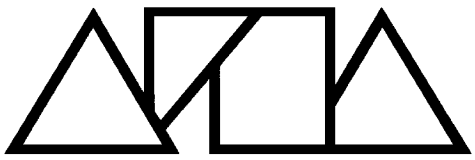
Drawing Title:

EXPLORATORY HOLE LOCATION PLAN

Date: September 2021

Drawing No: 21.237/02

Scale: 1:1250 @ A3



A F Howland Associates
The Old Exchange
Newmarket Road
Cringleford
Norwich
NR4 6UF

Tel: 01603 250754
Fax: 01603 250749
Email: admin@howland.co.uk
www: http://www.howland.co.uk