



**METRO NORTH
ORAL HEARING**

**SD-2.6Ai Geotechnical Data Report
RevA**

Mater Stop

Geotechnical Data Report

M000384/243231/SD-2.6Ai/A



RPA
PG2 Parkgate Business Centre
Parkgate Street
Dublin 9

Mater Stop

Geotechnical Data

Report

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April 2009

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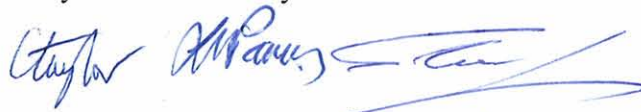
Mater Stop

Geotechnical Data Report

M000384/243231/SD-2.6Ai/A

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Executive Summary

It is proposed to construct the Mater Stop of the Dublin North Metro as an advance element of the project to enable integration with construction at the adjacent Mater Hospital. This is necessary because the proposed Mater Hospital works are at a more advanced stage of development than Metro North and require the stop box to be in place before they can be completed.

The proposed stop will require the construction of a box measuring some 165m by 30m, and approximately between 25m to 27m below ground level, in close proximity to existing housing, infrastructure and the existing and proposed Mater Hospitals. Current proposals are to form the box within diaphragm walls extending slightly beyond the full depth of the excavation.

To date there have been three phases of ground investigation (Preliminary, Main and Additional Ground Investigations) for Metro North which has been supplemented with information available from a number of investigations for the adjacent Mater Hospital developments.

This report summarises the factual information from available geotechnical investigations in the vicinity of the proposed Mater Stop. A full review of all available information is presented within the Geotechnical Basis of Design, (April 2009), SD-2.6A(ii), (Ref. 1). The report represents RPA deliverable SD-2.6A under the Contract.

1 Introduction

1.1 Objectives

The Geotechnical Data Report for the proposed Mater Stop has been prepared to meet deliverable SD-2.6A.

The Geotechnical Data Report is a factual report and summarises the geotechnical data available in the vicinity of the proposed Mater Stop from both the Metro North Ground Investigation and those from adjacent development.

1.2 Sources of Information

The following factual sources of information form the basis of this report:

- Irish Geotechnical Services Ltd (IGSL). (March 2007). Dublin Metro North Ground Investigation, Factual Ground Investigation Report (Volume 1). RPA Contract M7081. Report No. 03/11826/March 07.
- Norwest Holst Soil Engineering Ltd. (January 2008). Report on a Ground Investigation at Dublin Metro North, Main Ground Investigation – Sections 6 & 7. Report Ref: F14824/F01.
- Norwest Holst Soil Engineering Ltd (March 2009) Report on a Ground Investigation for Mater Stop – Additional GI, Dublin. Report Ref F15404/F01
- Site Investigation Ltd. (1979). Report on Site Investigation for Mater Hospital Project.
- Irish Geotechnical Services Ltd (IGSL). (June 1999). Site Investigation at Mater Hospital, Dublin. Report No. 5650.
- Irish Geotechnical Services Ltd (IGSL). (September 2002). Mater & Children's Hospital Ground Investigation Report. Report No. 7737.
- Irish Geotechnical Services Ltd (IGSL). (April 2008). Ground Investigation, Mater Hospital Dublin, Swords Co. Dublin. Report No. 13227.
- Glover Site Investigations Ltd. (May 2008). Mater Hospital, Dublin. Report No. 08-0168.

1.3 Proposed Works

As part of the proposed Dublin Metro North scheme, linking Dublin city centre with the Airport to the north, a new metro stop is to be located on the site of the car park for the existing Mater Misericordiae Hospital. The local area is predominantly residential. Due to the advanced plans for a redeveloped Mater Hospital at the site location, Mater Stop is required to be constructed in advance of the main Dublin Metro North works.

Mater Stop will comprise a cut and cover box, which will contain the platforms and all required accommodation rooms. There will be three main surface penetrations, one for the entrance off North Circular Road, and two for ventilation shafts. The structure will be designed so that at a later date the TBM can transit through the box.

The Stop box will be constructed from diaphragm walls toed into the underlying bedrock, and tension piles will be required beneath the base slab to prevent uplift. In the central area of the box, the design comprises of a concourse and platform level. In the back-of-house areas, additional floor levels are included to provide sufficient space for the M&E requirements. The majority of the internal structure will be constructed from reinforced concrete, with both the roof and concourse slabs being from a beam/slab arrangement. At this stage it is envisaged that the box will be constructed using a top-down methodology.

2 Ground Investigation Field Works

Three investigations have been undertaken for the Dublin Metro North in the Mater area plus several phases of investigation for the adjacent hospital developments. Several exploratory holes undertaken for the later are relatively shallow but within the Mater area as a whole there are a total of 31 boreholes extending to depths of 7m or greater. A location plan for all available exploratory holes extending to greater than 7m in depth is presented in Drawing No. D MN 0791 GI 6001 in Appendix A. Details of all boreholes within the vicinity of the proposed Mater Stop are detailed in the following sections of the report.

2.1 RPA Investigations

2.1.1 Preliminary Ground Investigation

Irish Geotechnical Services Ltd (IGSL) carried out a Preliminary Ground Investigation (PGI) for the proposed Dublin Metro North, (Ref. 2). The ground investigation was performed under the direction of Parsons Brinckerhoff (PB) Consulting Engineers to the Railway Procurement Agency (RPA) for the project. The purpose for the PGI was to provide geotechnical information on ground conditions and the groundwater regime for use in preliminary design, optioneering, route selection and in particular the Emerging Preferred Route. The results of the PGI are presented in the Geotechnical Interpretative Report prepared by Parsons Brinckerhoff (Ref. 3).

Fieldwork was carried out between May and November 2006 and comprised of 58 cable percussion boreholes, and 58 rotary core boreholes located along the alignment of the proposed Dublin Metro North. Rotary boreholes were completed using a combination of open hole drilling, rotary core drilling and Geobore-S wireline drilling methods. All boreholes were cored vertically to depths ranging from 12m to 54.6m. Downhole and surface geophysical surveying and in-situ testing were performed in select boreholes. Soil and rock laboratory testing was carried out on schedules prepared by the Engineer.

Only two of the PGI boreholes (IGSLRC15 and IGSLRC77; see Table 2.1) were undertaken in the vicinity of the proposed Mater Stop. Neither of these boreholes are located within the footprint of the proposed Mater Stop, with IGSLRC77 being 60m to the east of the site and IGSLRC15 being 15m to the west of the site. Slotted standpipes with gravel response zones located within the rock were installed in both boreholes. Steel headwork covers were concreted in place to protect the installations. No trial pits were carried out as part of the Preliminary Ground Investigation.

Table 2.1: Summary of RPA PGI Boreholes (nr. Mater Stop)

BH No.	Type	Co-Ordinates		Ground Level (mOD)	Depth	Comments	Instrumentation
		Easting	Northing				
RC15	RC	315554.27	235696.45	16.68	47.1	70% Recovery*	SP
RC77	RC	315641.88	235613.44	15.77	45.6	80% Recovery*	SP

*Approximate overall recovery in overburden materials SP = Standpipe

Standpipes were installed and monitored in both of the PGI boreholes within the vicinity of the proposed Mater Stop. Long term monitoring of these boreholes was also undertaken as part of the Additional Ground Investigation (AGI) (see Section 2.1.3). A summary of installation details is presented in Table 2.2.

Table 2.2: Summary of Installations RPA PGI Boreholes (nr. Mater Stop)

BH No.	Ground Level (mOD)	Instrument Type	Depth to top of response zone (mbgl)	Depth to bottom of response zone (mbgl)	Top of response zone (mOD)	Bottom of response zone (mOD)	Response zone material
RC15	16.68	SP	26	47.1	-9.32	-30.42	Limestone
RC77	15.77	SP	27.6	45.6	-11.84	-29.84	Limestone

SP = Standpipe

Standard Penetration Tests (SPT's) were not undertaken in either of the two PGI boreholes in the vicinity of the proposed Mater Stop.

Variable Head permeability tests were not undertaken in either of the two PGI boreholes in the vicinity of the proposed Mater Stop.

Packer (Lugeon) permeability tests were undertaken in both PGI boreholes located in the vicinity of the site. A summary of tests is presented in Table 2.3.

Table 2.3: Summary of RPA PGI Packer Tests (nr. Mater Stop)

BH No.	Test Number	Reduced level of top of test section (mOD)	Reduced level of bottom of test section (mOD)	Material Tested
RC15	1	-20.32	-21.32	Calcsiltite, limestone, shale
RC15	2	-12.32	-13.32	Calcsiltite, limestone
RC77	1	-23.23	-26.23	Calcsiltite, limestone
RC77	2	-16.23	-19.23	Limestone, shale
RC77	3	-12.23	-15.23	Limestone, calcsiltite, shale

Downhole geophysical testing was undertaken in both PGI boreholes in the vicinity of the proposed Mater Stop. A summary of this testing is presented in Table 2.4.

Table 2.4: Summary of RPA PGI Downhole Geophysical Tests (nr. Mater Stop)

BH No.	Ground Level (mOD)	Optical Televiwer		Acoustic Televiwer		4-Arm Dipmeter	
		Start (mbgl)	Finish (mbgl)	Start (mbgl)	Finish (mbgl)	Start (mbgl)	Finish (mbgl)
RC15	16.68	27.00	43.00	25.15	45.94	-	-
RC77	15.77	-	-	26.29	43.56	28.00	28.00

Three surface geophysical surveys were carried out within Metro North Area 6 (see Section 2.1.2) at 2km north of the site at Griffith Avenue, 0.6km north-east of the site at Drumconda Road and the closest at Dorset Street 0.25km to the east of the proposed Mater Stop. Surface geophysical surveys were carried out by IGSL Ltd's specialist subcontractor Apex Geophysics Ltd as part of the PGI. The objectives of the surveys were to provide information on the stiffness of the glacial deposits, map the bedrock profile and indicate rock quality, map variations in bedrock velocity and help assess the excavatability of rock. P-wave seismic refraction profiling was carried out to map overburden thickness, depth to bedrock and indicate overburden stiffness and bedrock quality, whilst multichannel analysis of surface wave (MASW) profiling was used to provide information regarding the small shear modulus, shear wave velocity and stiffness at each site. Details and results of the surveys are described in IGSL Ltd's PGI Factual Report (Ref. 2).

2.1.2 Main Ground Investigation

Prior to the Main Ground Investigation (MGI), a Desk Study was carried out by Jacobs on behalf of RPA. This was first issued as a working paper in June 2007, with a full report issued in April 2008, (Ref. 4). The original objectives of the Desk Study Review were to identify previous site use along the proposed alignment, to inform planning and design of the MGI and to inform the ongoing Reference Design of the Metro North.

The desk study reviewed the following sources:

- Ordnance Survey of Ireland (OSI) Historical Maps
- Aerial photography
- Results from enquires of Geological Survey of Ireland's (GSI) well and karst databases
- Trinity College Library and RPA's Archaeological Assessment Report (Ref. 8)

The Main Ground Investigation (MGI) for Metro North was carried out under the supervision and direction of Jacobs. The purpose of the MGI was to provide sufficient geotechnical information on the ground conditions and groundwater regimes to inform the Reference Design and Railway Order Stages, particularly for use in the design and construction planning process. The works were carried out under three separate contracts. Ground investigations for Group A and Group B were carried out by IGSL Ltd whilst ground investigations for Group C were undertaken by Norwest Holst Soil Engineering Ltd.

The areas covered by the three separate contracts are as follows.

- Group A: (Metro North Areas 1 to 3) from Belinstown to Dublin Airport southern boundary;
- Group B: (Metro North Areas 4 and 5) from Dublin Airport southern boundary to north of Dublin City University;
- Group C: (Metro North Areas 6 and 7) from north of Dublin City University to St. Stephen's Green.

Fieldwork for Group C, which includes the proposed Mater Stop, was carried out by Norwest Holst Soil Engineering Ltd between 16th April and 26th October 2007. In total 42 cable-percussion boreholes were bored to depths of between 0.3m and 27.1m using conventional light cable percussion techniques. A total of 21 of these boreholes were extended using rotary drilling techniques.

A further 25 vertical holes and 3 inclined holes were cored from the surface using rotary drilling techniques down to a maximum depth of 40m for the vertical holes and 60.25m for the inclined holes.

A total of 7 boreholes from Group C MGI are in the vicinity of Mater Stop, (Table 2.5).

Full details of all boreholes data from Group C, including test data are presented within Norwest Holst Soil Engineering Ltd 'Report on a Ground Investigation at Dublin Metro North, Main Ground Investigation – Sections 6 & 7' issued January 2008, (Ref. 9).

Table 2.5: Summary of RPA MGI Boreholes (nr. Mater Stop)

BH No.	Type	Co-Ordinates		Ground Level (m)	Depth	Comments	Instrumentation
		Easting	Northing				
MGI/BH/637	RC	315520.34	235603.1	17.31	35.2	40% Recovery*	PZ + VW
MGI/BH/638	CP	315592.2	235801.96	14.38	8.2	Cable percussion boring complete at 8.2m	None
MGI/BH/639	RC	315619.38	235786.15	13.51	29.9	45% Recovery*	VW
MGI/BH/640	CP	315580.98	235710.77	15.43	20.6	Stopped on obstruction: Possible rockhead	None
MGI/BH/641	RC	315553.45	235763.79	15.57	35	20% Recovery*	None
MGI/BH/642	CP	315575.11	235657.7	16.49	0.3	Terminated at 0.3m due to tunnel walkway encountered	None
MGI/BH/642A	CP	315529.36	235773.3	14.94	12.8	Cable percussion boring complete at 12.8m	None

*Approximate overall recovery in overburden materials

PZ = Piezometer; VW = Vibrating Wireline Piezometer

A 19mm diameter piezometer was installed in MGI/BH/637 with a tip depth of 24.5m. Vibrating wireline piezometers were installed in MGI/BH/637 and MGI/BH/639 with tip depths of 34.5m and 29.5m respectively. Long term monitored of these boreholes was also undertaken as part of the Additional Ground Investigation (AGI) (see Section 2.1.3). 50mm diameter gas monitoring standpipes were installed in boreholes MGI/BH/638, MGI/BH/639 and MGI/BH/642A. A summary of installation details is presented in Table 2.6.

Table 2.6: Summary of Installations RPA MGI Boreholes (nr. Mater Stop)

BH No.	Ground Level (mOD)	Instrument Type	Depth to top of response zone (mbgl)	Depth to bottom of response zone (mbgl)	Tip Depth (mbgl)	Top of response zone (mOD)	Bottom of response zone (mOD)	Tip Depth (mOD)	Response zone material
MGI/BH/637	17.31	PZ	24	25	24.5	-6.69	-7.69	-7.19	Glacial Till
MGI/BH/637	17.31	VW	-	-	32.5	-	-	-15.2	Limestone
MGI/BH/638	14.38	Gas SP	5	8	-	9.38	6.38	-	Glacial Till
MGI/BH/639	13.51	Gas SP	16	22	-	-2.49	-8.49	-	Glacial Till
MGI/BH/639	13.51	VW	-	-	29.5	-	-	-15.1	Limestone
MGI/BH/642A	15.57	Gas SP	9.8	11.4	-	5.77	4.17	-	Glacial Sand & Gravel

PZ = Piezometer; VW = Vibrating Wireline Piezometer; Gas SP = Gas Standpipe; - = Not Applicable

Standard Penetration Tests (SPT's) were undertaken in all MGI boreholes in the vicinity of the proposed Mater Stop.

Variable Head permeability tests were undertaken in MGI/BH/637, MGI/BH/641 and MGI/BH/642A. A summary of these tests is presented in Table 2.7

Table 2.7: Summary of RPA MGI Variable Head Tests (nr. Mater Stop)

BH No.	Ground Level (mOD)	Test Type	Top of test section (mbgl)	Bottom of test section (mbgl)	Top of test section (mOD)	Bottom of test section (mOD)	Response zone material
MGI/BH/637	17.31	Rising	27.6	35.2	-9.59	-17.19	Limestone
MGI/BH/641	16.49	Rising	27.5	35	-11.02	-18.52	Limestone
MGI/BH/642A	15.57	Rising	9.8	9.8	5.77	5.77	Glacial Sand & Gravel

Packer (Lugeon) permeability tests were undertaken in MGI boreholes MGI/BH/637 and MGI/BH/639. A summary of tests is presented in Table 2.8.

Table 2.8: Summary of RPA MGI Packer Tests (nr. Mater Stop)

BH No.	Test Number	Reduced level of top of test section (mOD)	Reduced level of bottom of test section (mOD)	Material Tested
MGI/BH/637	1	-11.69	-13.19	Limestone
MGI/BH/637	2	-15.19	-16.69	Limestone
MGI/BH/639	1	-11.39	-12.89	Limestone
MGI/BH/639	2	-13.39	-14.89	Limestone

Downhole geophysical testing was not undertaken in any MGI boreholes in the vicinity of the proposed Mater Stop.

Jacobs 'Dublin Metro North, Geotechnical Data Report' (issued April 2008), (Ref. 4) and 'Dublin Metro North Reference Ground Conditions for Information' (issued May 2008) (Ref. 6) are based on information provided by the Preliminary Geotechnical Investigation, (Ref. 1). Due to time constraints, very little data from the Main Ground Investigation, (Ref. 9) was included.

No surface geophysical surveys were carried out as part of the Main Ground Investigation for Mater Stop.

2.1.3 Additional Ground Investigation

Norwest Holst Soil Engineering Ltd (NWH) carried out an Additional Ground Investigation (AGI) for the proposed Dublin Metro North (Ref. 10). The Ground Investigation was carried out under the supervision and direction of Mott MacDonald Design Consultant to the Railway Procurement Agency (RPA) for the project. The Additional Ground Investigation was undertaken at the site between 17th November and 19th December 2008. The Additional Ground Investigation was scheduled with the aim of determining bedrock levels across site, determining ground water levels across site and further understanding of the glacial material present on site.

The works were carried out by between November and December 2008 and comprised 8 rotary core boreholes. Rotary boreholes were advanced using open hole drilling and Geobore-S wireline drilling methods. All boreholes were cored vertically to depths ranging from 20m to 50.1m. Downhole geophysical surveying and in-situ testing were performed in select boreholes. Soil and rock laboratory testing was carried out on schedules prepared by the Engineer.

All AGI boreholes were undertaken in the vicinity of the proposed Mater Stop, (Table 2.9) and of these six are located within the footprint of the proposed Mater Stop. Boreholes AGI/BH/A1 and AGI/BH/BHA2 are located respectively 20m and 23m to the Northwest of the box.

Full details of all boreholes data, including test data are presented within Norwest Holst Soil Engineering Ltd 'Report on a Ground Investigation for Mater Stop – Additional GI, Dublin' (March 2009), (Ref. 10).

Table 2.9: Summary of RPA AGI BH's (nr Mater Stop)

BH No.	Type	Co-Ordinates		Ground Level (m)	Depth	Comments	Instrumentation
		Easting	Northing				
AGI/BH/A1	RC	315544	235800.6	14.81	50.1	47.2% Recovery in glacial material	PZ
AGI/BH/A2	OH	315540.3	235799.7	14.94	20	Open Hole	PZ
AGI/BH/B1	RC	315582.6	235754.3	15.09	40	73.4% Recovery in glacial material	PZ
AGI/BH/C	RC	315581.8	235708.8	15.45	30	61.9% Recovery in glacial material	Gas SP & PZ
AGI/BH/D	RC	315557.6	235665.1	16.91	40.05	48.4% Recovery in glacial material	PZ
AGI/BH/E1	RC	315583.9	235647	16.29	45.1	68.1% Recovery in Glacial Material	x2 PZ
AGI/BH/E2	OH	315579.5	235648.7	16.41	26	Open Hole	Gas SP & PZ
AGI/BH/F	OH/RC	315581.3	235681.7	16.18	26.5	OH to 20m then RC.	None

PZ = Piezometer; Gas SP = Gas Standpipe; - = Not Applicable

A 19mm diameter casagrande piezometer was installed in each of boreholes AGI/BH/A1, AGI/BH/A2, AGI/BH/B1, AGI/BH/C, AGI/BH/D, AGI/BH/E2 and two 19mm piezometers in AGI/BH/E1. Gas monitoring standpipes (50mm diameter) were installed in boreholes AGI/BH/C and AGI/BH/E2. A summary of installation details is presented in Table 2.10.

Table 2.10: Summary of Installations RPA AGI Boreholes (nr. Mater Stop)

BH No.	Ground Level (mOD)	Instrument Type	Depth to top of response zone (mbgl)	Depth to bottom of response zone (mbgl)	Tip Depth (mbgl)	Top of response zone (mOD)	Bottom of response zone (mOD)	Tip Depth (mOD)	Response zone material
AGI/BH/A1	14.81	PZ	26	30	28	-11.19	-15.19	-13.2	Limestone
AGI/BH/A2	14.94	PZ	17	18.5	17.7	-2.06	-3.56	-2.76	Sand
AGI/BH/B1	15.09	PZ	26.5	28.5	27.5	-11.41	-13.41	-12.4	Limestone
AGI/BH/C	15.45	PZ	24	26	25	-8.545	-10.55	-9.55	Limestone
AGI/BH/C	15.45	Gas SP	0.8	1.8	-	14.65	13.65	-	Made Ground
AGI/BH/D	16.91	PZ	14	15.5	15	2.908	1.408	1.908	Sand and Gravel
AGI/BH/E1	16.29	PZ	30	34	32	-13.71	-17.71	-15.7	Limestone
AGI/BH/E1	16.29	PZ	12	13.5	12.7	4.29	2.79	3.59	Sand
AGI/BH/E2	16.41	PZ	24	26	25	-7.587	-9.587	-8.59	Glacial Till
AGI/BH/E2	16.41	Gas SP	0.9	2	-	15.51	14.41	-	Made Ground

PZ = Piezometer; Gas SP = Gas Standpipe; - = Not Applicable

Standard Penetration Tests (SPT's) were undertaken in AGI boreholes in AGI/BH/B1 and AGI/BH/E1.

Variable Head permeability tests were undertaken in AGI/BH/A1, AGI/BH/A2 and AGI/BH/D. A summary of these tests is presented in Table 2.11.

Table 2.11: Summary of RPA AGI Variable Head Tests (nr. Mater Stop)

BH No.	Ground Level (mOD)	Test Type	Top of test section (mbgl)	Bottom of test section (mbgl)	Top of test section (mOD)	Bottom of test section (mOD)	Response zone material
AGI/BH/A1	14.81	Rising	10	10	4.81	4.81	No Recovery – Driller’s Description “Sand and Gravel”
AGI/BH/A1	14.81	Falling	10	10	4.81	4.81	No Recovery – Driller’s Description “Sand and Gravel”
AGI/BH/A1	14.81	Falling	22	22	-7.19	-17.19	Glacial Till
BHA2	14.94	Falling	17	18.5	-2.06	-3.56	Open Hole – Driller’s Description “Claybound Gravel/Sand and Gravel”
BHA2	14.94	Falling	17	18.5	-2.06	-3.56	Open Hole – Driller’s Description “Claybound Gravel/Sand and Gravel”
BHD	16.91	Rising	11.2	11.2	5.708	5.708	No Recovery – Driller’s Description “Sand and Gravel”
BHD	16.91	Falling	11.2	11.2	5.708	5.708	No Recovery – Driller’s Description “Sand and Gravel”
BHD	22.1	Rising	22.1	22.1	-5.192	-5.192	Glacial Till
BHD	22.1	Falling	22.1	22.1	-5.192	-5.192	Glacial Till

Packer (Lugeon) permeability tests were undertaken in AGI boreholes AGI/BH/A1, AGI/BH/B1, AGI/BHC and AGI/BH/E1. A summary of tests is presented in Table 2.12.

Table 2.12: Summary of RPA AGI Packer Tests (nr. Mater Stop)

BH No.	Test Number	Reduced level of top of test section (mOD)	Reduced level of bottom of test section (mOD)	Material Tested
AGI/BH/A1	1	-21.39	-25.69	Limestone
AGI/BH/A1	2	-11.094	-35.294	Limestone
AGI/BH/B1	1	-11.212	-17.412	Limestone
AGI/BH/B1	2	-19.912	-24.912	Limestone
AGI/BH/C	1	-11.545	-13.245	Limestone
AGI/BH/C	2	-8.545	-10.245	Limestone
AGI/BH/E1	1	-14.01	-18.21	Limestone
AGI/BH/E1	2	-17.91	-22.16	Limestone

In-situ geophysical logging of rock was undertaken in RPA AGI boreholes AGI/BH/A1, AGI/BH/B1, AGI/BH/C and AGI/BH/E1 by specialist subcontractor Borehole Logging Solutions Ltd (BLS). Water temperature, conductivity and natural gamma profiling was undertaken in boreholes AGI/BH/A1 and AGI/BH/C. Rock resistivity (induction) measurements were undertaken in boreholes AGI/BH/B1 and AGI/BH/E1. A summary of downhole geophysical testing is presented in Table 2.13.

BH No.	Ground Level (mOD)	Water Temperature		Conductivity		Natural Gamma		Resistivity (Induction)	
		Start (mbgl)	Finish (mbgl)	Start (mbgl)	Finish (mbgl)	Start (mbgl)	Finish (mbgl)	Start (mbgl)	Finish (mbgl)
AGI/BH/A1	14.81	0	49.2	0	49.2	0	49.2	-	-
AGI/BH/B1	15.09	-	-	-	-	-	-	22.59	41.39
AGI/BH/C	15.45	0	30.3	0	30.3	0	30.3	-	-
AGI/BH/E1	16.29	-	-	-	-	-	-	22.59	41.39

Table 2.13: Summary of RPA AGI Downhole Geophysical Tests (nr. Mater Stop)

No surface geophysical surveys were carried out as part of the Additional Ground Investigation for Mater Stop.

2.2 Mater Hospital Ground Investigations

Five ground investigations have been undertaken at the adjacent Mater Hospital Development as detailed below:

- Site Investigations Ltd. (1979). Report on Site Investigation for Mater Hospital Project, (Ref. 11).
- IGSL. (June 1999). Report on a Site Investigation at the Mater Hospital, Dublin. Report No. 5650 (Ref. 12).
- IGSL. (September 2002). Mater & Children's Hospital (Phase II) – Main Site. Ground Investigation Report No. 7737, (Ref. 13)
- IGSL. (April 2008). Ground Investigation Mater Hospital, Dublin, Swords Co. Dublin. Project No. 13227, (Ref. 14).
- Glover Site Investigations Limited. (May 2008). Mater Hospital, Dublin. Report No. 08-0168, (Ref. 16)

The above investigations included a large number of exploratory holes, many of which are either within or adjacent to the footprint of the proposed Mater Stop box. Many of these holes will be of relevance to the Mater Stop design, although, as the hospital development is to a relatively shallow depth compared to the Metro, the holes are often shallow.

2.2.1 IGSL. (June 1999). Site Investigation at the Mater Hospital, Dublin

The investigation comprised of 10 cable percussion boreholes, 2 rotary core boreholes, 5 trial pits as well as *in-situ* monitoring and laboratory testing. The site is located in an existing car park situated between the Mater Private and Mater Public hospitals. All boreholes are located within 130m of the proposed stop, however there are no boreholes located on the footprint of the stop itself. The work was carried out using a DANDO 150 cable tool boring rig with 200mm equipment and a Casagrande C60 rotary drilling rig.

Boreholes were sunk to a maximum depth of 8.7m for cable tool boreholes and 25m for rotary core boreholes. Groundwater monitoring standpipes (50mm diameter) were installed in half of the cable tool boreholes.

Table 2.14: Summary of Mater Hospital BHs (nr. Mater Stop) – IGSL (June 1999)

* Ground level and co-ordinates not provided within factual report

BH No.	Type	Co-Ordinates		Ground Level (m)*	Start Date	End Date	Depth	Comments	Instrumentation
		Easting*	Northing*						
1	CP	-	-	-	15/04/1999	16/04/1999	8.1m		SP
2	CP	-	-	-	16/04/1999	19/04/1999	7.6m		None
3	CP	-	-	-	20/04/1999	20/04/1999	1.4m	Borehole terminated by Mater Hospital maintenance staff due to presence of EXB back up cable in area. Moved 5m and rebored (see 3-R)	None
3-R	CP	-	-	-	21/04/1999	12/04/1999	7m		SP
4	CP	-	-	-	14/04/1999	14/04/1999	8.7m		None
5	CP	-	-	-	30/04/1999	30/04/1999	7.1m		SP
6	CP	-	-	-	13/04/1999	13/04/1999	7.7m		None
8	CP	-	-	-	28/04/1999	28/04/1999	5.6m		None
9	CP	-	-	-	22/04/1999	22/04/1999	5.8m		SP
10	CP	-	-	-	23/04/1999	13/04/1999	8.2m		SP
RC1	RC	-	-	-	June-1999 [†]	June-1999 [†]	15m		None
RC2	RC	-	-	-	June-1999 [†]	June 1999 [†]	25m		None

[†] Precise start and end dates not listed within factual report

Groundwater monitoring standpipes (50mm diameter) were installed in boreholes BH1, BH3-R, BH5, BH9 and BH10. No further details regarding the installations and no groundwater readings were included within the factual report.

Standard Penetration Tests (SPT's) were undertaken in all boreholes for this investigation.

Variable Head permeability tests were undertaken in boreholes 1, 3-R and 5. A summary of these tests is presented in Table 2.16

Table 2.15: Summary of Mater Hospital BHs Variable Head Tests – IGSL (June 1999)

BH No.	Ground Level (mOD)*	Test Type	Top of test section (mbgl)	Bottom of test section (mbgl)	Top of test section (mOD)	Bottom of test section (mOD)	Response zone material
1	-	Rising	1	8.1	-	-	Made Ground/ Glacial Till/ Gravel
3-R	-	Falling	1	7	-	-	Made Ground/ Glacial Till
5	-	Falling	1	7	-	-	Made Ground/ Glacial Till

* Ground level and co-ordinates not provided within factual report; - = Not Applicable

Packer (Lugeon) permeability tests were not undertaken as part of this investigation.

In-situ geophysical logging of rock was not undertaken as part of this investigation.

No surface geophysical surveys were carried out as part of this investigation.

2.2.2 IGSL. (September 2002). Mater & Children's Hospital (Phase II)

The investigation comprised of 11 cable percussion boreholes, 2 rotary core boreholes and 13 trial pits as well as *in-situ* testing and monitoring. The vast majority of boreholes are located within an existing car park situated between the Mater Private and Mater Public hospitals. All boreholes are located within 150m of the proposed stop with boreholes M-BHE, M-BHF and M-RCB all located within the stop footprint.

Rotary holes were produced using Geobore S rotary core drilling using a Knebel top drive rotary rig, producing 102mm diameter cores. Triple tube coring techniques together with a semi-rigid plastic core liner and polymer gel flush were used, providing excellent recovery in 'cohesive' gravely clays, however granular soils proved difficult to recover.

The 'Shell and Auger' technique of soft ground boring was used in cable percussion holes. Cable percussion boreholes were bored to a maximum depth of 14.2m with rotary boreholes cored to a maximum depth of 19.8m.

Table 2.16: Summary of Mater Hospital BHs (nr. Mater Stop) – IGSL (September 2002)

BH No.	Type	Co-Ordinates		Ground Level (m)	Start Date	End Date	Depth	Comments	Instrumentation
		Easting	Northing						
M/BH/A	CP	N/A*	N/A*	17.25	14/02/2002	14/02/2002	1		None
M/BH/A1	CP	N/A*	N/A*	17.25	18/04/2002	20/04/2002	14.2		SP
M/BH/B	CP	N/A*	N/A*	17.02	20/04/2002	20/04/2002	3.8		None
M/BH/B1	CP	315507	235611	17	20/04/2002	21/04/2002	9		SP
M/BH/C	CP	315440	235698	17.6	01/05/2002	01/05/2002	8		SP
M/BH/D	CP	315517	235814	14.96	02/05/2002	02/05/2002	8		SP
M/BH/E	CP	315570	235644	17.28	21/04/2002	22/04/2002	7.9		SP
M/BH/F	CP	315587	235757	14.74	30/04/2002	20/04/2002	8		SP
M/BH/G	CP	315488	235774	15.82	11/05/2002	11/05/2002	2.1		None
M/BH/H	CP	315427	235637	18.33	25/05/2002	26/05/2002	8		SP
M/BH/I	CP	315517	235767	15.78	15/06/2002	15/06/2002	7		SP
M/RC/A	RC	315453	235637	17.24	09/04/2002	10/04/2002	19.8	65% Recovery	PZ
M/RC/B	RC	315507	235611	16.64	12/04/2002	13/04/2002	15	46% Recovery	PZ

* Precise co-ordinate not provided for borehole

UPVC standpipes (50mm diameter) were installed in 8 out of 10 of the cable percussion boreholes to monitor both groundwater and ground gas. Casagrande piezometers (19mm diameter) were installed in both rotary boreholes. A summary of instrumentation data is presented in Table 2.17.

Table 2.17: Summary of Mater Hospital BHs Instrumentation – IGSL (September 2002)

BH No.	Ground Level (mOD)	Instrument Type	Depth to top of response zone (mbgl)	Depth to bottom of response zone (mbgl)	Tip Depth (mbgl)	Top of response zone (mOD)	Bottom of response zone (mOD)	Tip Depth (mOD)	Response zone material
M/BH/A1	17.25	SP*	5	8	-	12.25	9.25	-	Glacial Till/ Gravel
M/BH/B1	17	SP*	5	8	-	12	9	-	Gravel
M/BH/C	17.6	SP*	1.8	8	-	15.8	9.6	-	Glacial Till
M/BH/D	14.96	SP*	4	8	-	10.96	6.96	-	Glacial Till
M/BH/E	17.28	SP*	2	7	-	15.28	10.28	-	Glacial Till
M/BH/F	14.74	SP*	2	8	-	12.74	6.74	-	Glacial Till
M/BH/H	18.33	SP*	3	6	-	15.33	12.33	-	Glacial Till
M/BH/I	15.78	SP*	3	7	-	12.78	8.78	-	Glacial Till
M/RC/A	17.24	PZ	5	13.5	8	12.24	3.74	11.24	Gravel
M/RC/B	16.64	PZ	2	5	4.5	14.64	11.64	12.14	Made Ground/ Gravel

* Standpipes used to monitor both gas and groundwater levels:

PZ = Piezometer; SP = Standpipe; - = Not Applicable

Standard Penetration Tests (SPT's) were undertaken in all boreholes as part of this investigation.

Variable Head permeability tests were undertaken in boreholes M/BH/A1, M/BH/B1, M/BH/D, M/BH/E, M/BH/F, M/RC/A and M/RC/B. A summary of these tests is presented in Table 2.18.

Table 2.18: Summary of RPA AGI Variable Head Tests (nr. Mater Stop)

BH No.	Ground Level (mOD)	Test Type	Top of test section (mbgl)	Bottom of test section (mbgl)	Top of test section (mOD)	Bottom of test section (mOD)	Response zone material
BHA1	17.25	Falling	5	8	12.25	9.25	Glacial Till/ Gravel
BHB1	17	Falling	5	8	12	9	Mostly Gravel
BHD	14.96	Falling	5	8	9.96	6.96	Glacial Till
BHE	17.28	Falling	4	8	13.28	9.28	Glacial Till
BHF	14.74	Falling	2	8	12.74	6.74	Glacial Till
RCA	17.24	Falling	5	13.5	12.24	3.74	No Recovery – Driller's Description "Gravel"
RCB	16.64	Falling	2	5	14.64	11.64	Made Ground/ Glacial Till/ Gravel

Packer (Lugeon) permeability tests were not undertaken as part of this investigation.

Downhole geophysical logging was not undertaken as part of this investigation.

No surface geophysical surveys were carried out as part of this investigation

2.2.3 IGSL. (April 2008). Ground Investigation Mater Hospital, Dublin

The investigation comprised of 4 cable percussion boreholes, 3 rotary core boreholes monitoring and *in-situ* testing and laboratory testing. All seven boreholes are located within an existing car park situated between the Mater Private and Mater Public hospitals. All boreholes are located within 90m of the proposed stop, however there are no boreholes located on the footprint of the box itself.

Rotary holes were produced using Geobore S rotary core drilling using a Puntel drilling rig, producing 102mm diameter cores. During the drilling a polymer gel drill fluid was used to minimise core degradation and a core liner was also used to protect the core, particularly with glacial till cores.

The 'Shell and Auger' technique of soft ground boring was used in cable percussion holes.

A maximum depth of 12m was achieved for cable percussion boreholes with a maximum depth of 30.2m for rotary cored boreholes.

Table 2.19: Summary of Mater Hospital BHs (nr. Mater Stop) – IGSL (April 2008)

BH No.	Type	Co-Ordinates		Ground Level (m)	Start Date	End Date	Depth	Comments	Instrumentation
		Easting	Northing						
IGSL/BH/X	CP	N/A*	N/A*	N/A*	20/12/2007	21/12/2007	5.1		None
IGSL/BH/X1	CP	N/A*	N/A*	N/A*	03/01/2008	08/01/2008	12		SP
IGSL/BH/Y	CP	315499.96	235726.97	18.94	11/01/2008	11/01/2008	8.2		SP
IGSL/BH/Z	CP	315523.25	235679.54	19.43	17/12/2007	19/12/2007	8		SP
IGSL/RC/X	RC	315532.58	235755.3	18.11	23/01/2008	24/01/2008	24.7	95% Recovery in Glacial Material	SP
IGSL/RC/Y	RC	315501.32	235727.11	18.93	19/01/2008	19/01/2008	24.7	60% Recovery in Glacial Material	SP
IGSL/RC/Z	RC	315516.68	235681.63	19.08	21/01/2008	22/01/2008	30.2	87% Recovery in Glacial Material	SP

* Co-ordinates and ground levels not recorded at IGSL/BH/X and IGSL/BH/X1 as location covered by construction works during survey

Groundwater monitoring standpipes (50mm diameter) were installed in 3 out of 4 cable percussion boreholes and all three rotary boreholes. A summary of instrumentation is presented in Table 2.20.

Table 2.20: Summary of Mater Hospital BHs Instrumentation – IGSL (April 2008)

BH No.	Ground Level (mOD)	Instrument Type	Depth to top of response zone (mbgl)	Depth to bottom of response zone (mbgl)	Tip Depth (mbgl)	Top of response zone (mOD)	Bottom of response zone (mOD)	Tip Depth (mOD)	Response zone material
IGSL/BH/X1	-*	SP	9	11.5	-	-	-	-	Gravel
IGSL/BH/Y	18.94	SP	2	8.2	-	18.43	11.43	-	Glacial Till
IGSL/BH/Z	19.43	SP	1	8	-	3.11	-6.59	-	Glacial Till
IGSL/RC/X	18.11	SP	15	24.7	-	3.93	-5.77	-	Glacial Till
IGSL/RC/Y	18.93	SP	15	24.7	-	4.88	-11.12	-	Glacial Till
IGSL/RC/Z	19.08	SP	14.2	30.2	-	16.94	10.74	-	Glacial Till/ Limestone

* Co-ordinates and ground levels not recorded at IGSL/BH/X and IGSL/BH/X1 as location covered by construction works during survey

SP = Standpipe; - = Not Applicable

Surface geophysical surveying was carried out as part of this investigation. Minerex Geophysics Ltd. (MGX) carried out a Ground Penetrating Radar Survey and Probing for the proposed extension of the Mater Hospital, Dublin. The work was undertaken to check for possible obstructions in the subsurface prior to piling a secant piling wall and excavating a basement. The survey consisted of 2D and 3D Ground Penetrating Radar (GPR) measurements with two different antennas (100 and 400MHz) along the secant piling wall and within the proposed basement area. The probing was done to a maximum depth of 4m along the secant piling wall at nominal 5 m centres. The survey was commissioned by Arup Consulting Engineers acting for the Mater Hospital Development Company. Full details and results can be found in the “Mater Hospital, Dublin Proposed Extension Ground Penetrating Radar Survey and Probing Report (April 2008)”, (Ref. 15)

Standard Penetration Tests (SPT’s) were undertaken in all boreholes for this investigation.

Two falling head permeability tests were undertaken in boreholes IGSL/BH/X1. A summary of these tests is presented in Table 2.21.

Table 2.21: Summary of Mater Hospital BHs Variable Head Tests – IGSL (April 2008)

BH No.	Ground Level (mOD)*	Test Type	Top of test section (mbgl)	Bottom of test section (mbgl)	Top of test section (mOD)	Bottom of test section (mOD)	Response zone material
IGSL/BH/X1	-	Falling	6.8	7.5	-	-	Glacial Till
IGSL/BH/X1	-	Falling	6.8	8.5	-	-	Gravel

* Ground level and co-ordinates not provided within factual report; - = Not Applicable

Packer (Lugeon) permeability tests were not undertaken as part of this investigation.

Downhole geophysical logging was not undertaken as part of this investigation.

2.2.4 Glover Site Investigations Limited. (May 2008). Mater Hospital, Dublin

The investigation comprised 46 window sampler holes and 9 trial pits as well as laboratory testing. The site is located in an existing car park situated between the Mater Private and Mater Public hospitals. All boreholes are located within 115m of the proposed stop with 16 window sampler holes and 2 trial pits located directly within the stop footprint. Window sampler holes within the footprint are BH3, BH4, BH10, BH16, BH20, BH21, BH22, BH27, BH28, BH30, BH31, BH32, BH37, BH38, BH41, BH42 and trial pits TP5 and TP7.

The 46 window sampler holes were bored using the sleeved windowless sampler boring methods with tracked Dando Terrier percussion boring rigs. Boreholes were bored to a maximum depth of 4m. Nine trial pits were excavated to a maximum depth of 2.5m, using a Volvo EC25 tracked excavator.

The depth of exploratory holes is relatively shallow and it is understood that the objective was to investigate near surface materials for evidence of contamination.

No *in-situ* testing or monitoring was undertaken as part of this investigation.

Table 2.22: Summary of Mater Hospital BHs (nr. Mater Stop) – IGSL (May 2008)

BH No.	Type	Co-Ordinates		Ground Level (m)	Start Date	End Date	Depth	Comments	Instrumentation
		Easting	Northing						
M/BH/01	WS	315518.8	235814.1	15.14	19/03/2008	19/03/2008	3		None
M/BH/02	WS	315543.3	235799.9	14.91	08/04/2008	08/04/2008	2.4		None
M/BH/02A	WS	315543.3	235799.9	14.91	19/03/2008	19/03/2008	3.7		None
M/BH/03	WS	315584.1	235791.3	14.55	04/04/2008	04/04/2008	2.9		None
M/BH/04	WS	315586.3	235783	14.56	04/04/2008	04/04/2008	3.5		None
M/BH/05	WS	315447	235819.4	16.19	18/03/2008	18/03/2008	2.7		None
M/BH/06	WS	315496.5	235802.9	15.56	19/03/2008	19/03/2008	3		None
M/BH/07	WS	315514.2	235801	15.83	19/03/2008	19/03/2008	2.9		None
M/BH/08	WS	315541	235785.6	15.53	19/03/2008	19/03/2008	4		None
M/BH/09	WS	315549.1	235771.9	14.67	04/04/2008	04/04/2008	0.5		None
M/BH/10	WS	315588.8	235753.1	15.01	01/04/2008	01/04/2008	3		None
M/BH/11	WS	315462.8	235801.2	16.72	19/03/2008	19/03/2008	2.7		None
M/BH/11B	WS	315477.2	235803.2	15.53	04/04/2008	04/04/2008	3.4		None
M/BH/11C	WS	315471.8	235785.9	16.37	04/04/2008	04/04/2008	3		None
M/BH/11D	WS	315461.4	235793	16.47	04/04/2008	04/04/2008	2.5		None
M/BH/12	WS	315481.7	235779	16.1	03/04/2008	03/04/2008	3		None
M/BH/13	WS	315513.1	235763.6	15.91	01/04/2008	01/04/2008	3.3		None
M/BH/14	WS	315524.7	235759	15.86	25/03/2008	25/03/2008	3.7		None
M/BH/15	WS	315543.3	235754.4	15.49	25/03/2008	25/03/2008	3.8		None
M/BH/16	WS	315567.5	235758.9	14.83	25/03/2008	25/03/2008	3		None
M/BH/17	WS	315501.5	235743	16.39	01/04/2008	01/04/2008	3.5		None
M/BH/18	WS	315510.8	235737.2	16.31	26/03/2008	26/03/2008	4		None
M/BH/19	WS	315533.6	235727	15.69	26/03/2008	26/03/2008	3		None
M/BH/20	WS	315563.6	235720.6	15.61	25/03/2008	25/03/2008	3		None
M/BH/21	WS	315585.6	235718.8	15.46	31/03/2008	31/03/2008	3		None
M/BH/22	WS	315582.2	235706.6	15.37	27/03/2008	27/03/2008	3.7		None
M/BH/23	WS	315494.8	235729.6	15.57	01/04/2008	01/04/2008	3		None
M/BH/24	WS	315504.8	235724.2	16.65	26/03/2008	26/03/2008	4		None
M/BH/25	WS	315531.1	235709.1	16.3	02/04/2008	02/04/2008	3		None
M/BH/26	WS	315552.5	235705.2	16.01	25/03/2008	25/03/2008	3		None
M/BH/27	WS	315560.8	235697.9	16.13	31/03/2008	31/03/2008	3		None
M/BH/28	WS	315574.8	235699.5	15.67	26/03/2008	26/03/2008	2.3		None
M/BH/29	WS	315546.4	235691.2	16.84	25/03/2008	25/03/2008	4		None
M/BH/30	WS	315560.2	235691.2	16.33	25/03/2008	25/03/2008	3		None
M/BH/31	WS	315570.1	235689	16.2	26/03/2008	26/03/2008	4		None
M/BH/32	WS	315581.5	235684.9	16.18	27/03/2008	27/03/2008	3.7		None
M/BH/33	WS	315496.6	235694.8	17.24	01/04/2008	01/04/2008	3.1		None
M/BH/34	WS	315516.8	235686.6	17.14	02/04/2008	02/04/2008	3		None
M/BH/35	WS	315541.2	235678.7	16.98	28/03/2008	28/03/2008	3.7		None
M/BH/36	WS	315557.6	235647	16.94	31/03/2008	31/03/2008	4		None
M/BH/37	WS	315567.7	235678.7	16.56	31/03/2008	31/03/2008	3.6		None
M/BH/38	WS	315580.5	235671.2	16.52	27/03/2008	27/03/2008	3		None
M/BH/39	WS	315530.5	235671.5	17.14	02/04/2008	02/04/2008	3.6		None
M/BH/40	WS	315551.4	235666.6	16.96	03/04/2008	03/04/2008	3.5		None
M/BH/41	WS	315559.8	235660.1	16.77	03/04/2008	03/04/2008	4		None
M/BH/42	WS	315576.4	23565627	16.62	02/04/2008	02/04/2008	1.4		None

3 Ground Investigation Laboratory Testing

Laboratory test data from all investigations described in Section 2 have been collated and are reviewed in the Geotechnical Basis of Design Report, MM Report No. SD-2.6A(ii).

Laboratory tests carried out on soil samples include index and classification tests, triaxial tests, small strain triaxial tests, compaction tests, chemical tests and contamination tests.

Laboratory tests carried out on water samples include chemical tests and contamination tests.

Laboratory tests carried out on rock include classification tests, uniaxial compressive tests, point load strength index tests, tensile strength tests, slake durability tests, direct shear tests on rock joints, Schmidt rebound hardness, cuttability tests and abrasivity tests.

Results of contamination testing can be found in the Project Construction Waste Management Plan, (April 2009), SD-2.4A, (Ref.21) and the Environmental Description, (April 2009), SD-2.3, (Ref. 22)

3.1 RPA Investigations

3.1.1 Preliminary Ground Investigation

Table 3.1 details all soil laboratory tests results obtained from RPA Preliminary Ground Investigation (PGI) boreholes located in the vicinity of the proposed Mater Stop, i.e. boreholes IGSLRC15 and IGSLRC77 only (see Section 2.1.1)

Table 3.1: Summary of Soil Laboratory Tests RPA PGI (nr. Mater)

Soil laboratory test description	Number of test results obtained
Moisture Content	17
Liquid Limit	18
Plastic Limit	18
Bulk Density	4
Dry Density	1
Particle Size Distribution	17
Unconsolidated Undrained Triaxial (UU)	8
Consolidated Undrained Triaxial (CU)	1

Table 3.2 details all chemical test results obtained from RPA PGI boreholes located in the vicinity of the proposed Mater Stop, i.e. boreholes IGSLRC15 and IGSLRC77 only (see Section 2.1.1)

Table 3.2: Summary of Chemical Laboratory Tests RPA PGI (nr. Mater)

Chemical laboratory test description	Number of test results obtained
PH	3
Water Soluble Sulphate Content of Soil	3
Chloride Content of Soil	3
Organic Mater Content of Soil	3

Table 3.3 details all rock test results obtained from RPA PGI boreholes located in the vicinity of the proposed Mater Stop, i.e. boreholes IGSLRC15 and IGSLRC77 only (see Section 2.1.1)

Table 3.3: Summary of Rock Laboratory Tests RPA PGI (nr. Mater)

Rock laboratory test description	Number of test results obtained
Moisture Content	5
Bulk Density	9
Dry Density	11
Porosity	28
Point Load Strength Index	10
Uniaxial Compressive Strength	9
Brazilian Tensile Strength	4
Direct Shear on saw cut rock samples	1
Slake Durability	4
Cherchar Abrasivity	4
Cuttability	2

All test results are presented within the Irish Geotechnical Services Ltd (IGSL), Dublin Metro North Ground Investigation, Factual Ground Investigation Report (March 2007), (Ref. 2)

3.1.2 Main Ground Investigation

Table 3.4 details all soil laboratory tests results obtained from RPA Main Ground Investigation (MGI) boreholes located in the vicinity of the proposed Mater Stop, i.e. boreholes MGI/BH/637, MGI/BH/638, MGI/BH/639, MGI/BH/640, MGI/BH/641, MGI/BH/642 and MGI/BH/642A only (see Section 2.1.2)

Table 3.4: Summary of Soil Laboratory Tests RPA MGI (nr. Mater)

Soil laboratory test description	Number of test results obtained
Moisture Content	26
Moisture Condition Value	4
Optimum Moisture Content	3
Maximum Dry Density	3
Liquid Limit	23
Plastic Limit	23
Bulk Density	4
Dry Density	1
Particle Size Distribution	16
Unconsolidated Undrained Triaxial (UU)	1
Consolidated Undrained Triaxial (CU)	2

Table 3.5 details all chemical test results obtained from RPA MGI boreholes located in the vicinity of the proposed Mater Stop, i.e. boreholes MGI/BH/637, MGI/BH/638, MGI/BH/639, MGI/BH/640, MGI/BH/641, MGI/BH/642 and MGI/BH/642A only (see Section 2.1.2)

Table 3.5: Summary of Chemical Laboratory Tests RPA MGI (nr. Mater)

Chemical laboratory test description	Number of test results obtained
PH	3
Water Soluble Sulphate Content of Soil	3
Water Soluble Chloride Content of Soil	3
Suphide	3
Carbonate	3
Organic Mater Content of Soil	3

Table 3.6 details all rock test results obtained from RPA MGI boreholes located in the vicinity of the proposed Mater Stop, i.e. boreholes MGI/BH/637, MGI/BH/638, MGI/BH/639, MGI/BH/640, MGI/BH/641, MGI/BH/642 and MGI/BH/642A only (see Section 2.1.2).

Table 3.6: Summary of Rock Laboratory Tests RPA MGI (nr. Mater)

Rock laboratory test description	Number of test results obtained
Moisture Content	9
Bulk Density	9
Dry Density	9
Porosity	7
Point Load Strength Index	35
Uniaxial Compressive Strength	5
Schmidt Rebound Hardness	5

All test results are presented within the Norwest Holst Soil Engineering Ltd, Report on a Ground Investigation at Dublin Metro North, Main Ground Investigation – Sections 6 & 7, (January 2008), (Ref. 9)

3.1.3 Additional Ground Investigation

Table 3.7 details all soil laboratory tests results obtained from all RPA Additional Ground Investigation (AGI) boreholes, (see Section 2.1.3)

Table 3.7: Summary of Soil Laboratory Tests RPA AGI (nr. Mater)

Soil laboratory test description	Number of test results obtained
Moisture Content	47
Liquid Limit	40
Plastic Limit	40
Bulk Density	7
Dry Density	7
Particle Size Distribution	32
Consolidated Undrained Triaxial (CIU)	4
Small Strain Triaxial (CAUC)	3

Table 3.8 details all chemical test results obtained from all RPA AGI boreholes, (see Section 2.1.3)

Table 3.8: Summary of Chemical Laboratory Tests RPA AGI (nr. Mater)

Chemical laboratory test description	Number of test results obtained
PH	18
Water Soluble Sulphate Content of Soil	18
Acid Soluble Chloride Content of Soil	18
Total Sulphur	18
Organic Mater Content of Soil	18

Table 3.9 details all rock test results obtained from all RPA AGI boreholes, (see Section 2.1.3)

Table 3.9: Summary of Rock Laboratory Tests RPA AGI (nr. Mater)

Rock laboratory test description	Number of test results obtained
Moisture Content	18
Bulk Density	18
Dry Density	18
Point Load Strength Index	76
Uniaxial Compressive Strength	18

All test results are presented within the Norwest Holst Soil Engineering Ltd, Report on a Ground Investigation for Mater Stop – Additional GI, Dublin, (March 2009), (Ref. 10)

3.2 Mater Hospital Ground Investigations

3.2.1 IGSL. (June 1999). Site Investigation at the Mater Hospital, Dublin

Table 3.10 details all soil laboratory tests results obtained from the IGSL (1999) Ground Investigation for the proposed Mater Hospital Investigation, (see Section 2.2.1)

Table 3.10: Summary of Soil Laboratory Tests Mater Hospital BHs – IGSL (1999)

Soil laboratory test description	Number of test results obtained
Moisture Content	11
Liquid Limit	11
Plastic Limit	11
Bulk Density	2
Particle Size Distribution	2
Triaxial Compression Test (U67)	2

Table 3.11 details all chemical tests results obtained from the IGSL (1999) Ground Investigation for the proposed Mater Hospital Investigation, (see Section 2.2.1)

Table 3.11: Summary of Chemical Laboratory Tests Mater Hospital BHs – IGSL (1999)

Chemical laboratory test description	Number of test results obtained
PH	7
Total Sulphur in Groundwater	2
Total Sulphur in Soil	5

No rock testing was completed as part of this investigation.

All test results are presented within the Irish Geotechnical Services Ltd (IGSL), Investigation at Mater Hospital, Dublin. (June 1999), (Ref. 12)

3.2.2 IGSL. (September 2002). Mater & Children's Hospital (Phase II)

Table 3.12 details all soil laboratory tests results obtained from the IGSL (2002) Mater & Children's Hospital (Phase II), Ground Investigation for the proposed Mater Hospital Investigation, (see Section 2.2.2)

Table 3.12: Summary of Soil Laboratory Tests Mater Hospital BHs – IGSL (2002)

Soil laboratory test description	Number of test results obtained
Moisture Content	10
Liquid Limit	10
Plastic Limit	10
Particle Size Distribution	15
Small Stain Stiffness Triaxial	2

Table 3.13 details all chemical tests results obtained from the IGSL (2002) Mater & Children's Hospital (Phase II), Ground Investigation for the proposed Mater Hospital Investigation, (see Section 2.2.2)

Table 3.13: Summary of Chemical Laboratory Tests Mater Hospital BHs – IGSL (2002)

Chemical laboratory test description	Number of test results obtained
PH	6
Total Sulphur in Soil	6

No rock testing was undertaken for the IGSL (2002) Mater & Children's Hospital (Phase II), Ground Investigation for the proposed Mater Hospital Investigation.

All test results are presented within the Irish Geotechnical Services Ltd (IGSL), Mater & Children's Hospital Ground Investigation Report, (September 2002), (Ref. 13)

3.2.3 IGSL. (April 2008). Ground Investigation Mater Hospital, Dublin

Table 3.14 details all soil laboratory tests results obtained from the IGSL (2008) Ground Investigation for the proposed Mater Hospital Investigation, (see Section 2.2.3)

Table 3.14: Summary of Soil Laboratory Tests Mater Hospital BHs – IGSL (2008)

Soil laboratory test description	Number of test results obtained
Moisture Content	7
Liquid Limit	7
Plastic Limit	7
Particle Size Distribution	4
Unconsolidated Undrained Triaxial	2
Consolidated Undrained Triaxial	1

No chemical testing was undertaken for the IGSL (2008) Ground Investigation for the proposed Mater Hospital Investigation.

No rock testing was undertaken for the IGSL (2008) Ground Investigation for the proposed Mater Hospital Investigation

All test results are presented within the Irish Geotechnical Services Ltd (IGSL), Ground Investigation, Mater Hospital Dublin, Swords Co. Dublin, (April 2008), (Ref. 14)

3.2.4 Glover Site Investigations Limited. (May 2008). Mater Hospital, Dublin

The Glover Site Investigation (May 2008) for the proposed Mater Hospital Investigation, (see Section 2.2.4) was undertaken to determine levels of contamination within the upper 4m only. Consequently no chemical testing, rock testing or soil classification or index testing was undertaken as part of this investigation.

4 Reference

1. Mott MacDonald for RPA. (April 2009). Geotechnical Basis of Design Report. Report No. M000384/243231/SD-2.6A(ii).
2. Irish Geotechnical Services Ltd (IGSL). (March 2007). Dublin Metro North Ground Investigation, Factual Ground Investigation Report (Volume 1). RPA Contract M7081. Report No. 03/11826/March 07.
3. Parsons Brinckerhoff (Ireland) Ltd. (April 2007). Geotechnical Interpretative Report (Sections 1 to 6). Working Paper No. 60.
4. Jacobs. (April 2008). Dublin Metro North, Geotechnical Data Report. Report No. B0307000-010/GEO.28/006/1.
5. Skipper, J., Follet, B., Menkiti, C.O., Long, M. & Clark-Hughes, J. (March 2005). The engineering geology and characterization of Dublin Boulder Clay. *Quarterly Journal of Engineering Geology and Hydrogeology*, **38**, 171-187.
6. Jacobs. (May 2008). Dublin Metro North Reference Ground Conditions for Information. Report No. B0307000-010/GEO.28/007/1.
7. Jacobs. (April 2008). Dublin Metro North, Desk Study Review. Technical Note 023. Report No. B0307000-010/GEO.360/002/1.
8. Railway Procurement Agency (RPA). (June 2008). Archaeological Strategy for Metro North. Draft Report. Report No. RPAMNACHr:01.
9. Norwest Holst Soil Engineering Ltd. (January 2008). Report on a Ground Investigation at Dublin Metro North, Main Ground Investigation – Sections 6 & 7. Report Ref: F14824/F01.
10. Norwest Holst Soil Engineering Ltd (March 2009) Report on a Ground Investigation for Mater Stop – Additional GI, Dublin. Report Ref F15404/F01
11. Site Investigation Ltd. (1979). Report on Site Investigation for Mater Hospital Project.
12. Irish Geotechnical Services Ltd (IGSL). (June 1999). Site Investigation at Mater Hospital, Dublin. Report No. 5650.
13. Irish Geotechnical Services Ltd (IGSL). (September 2002). Mater & Children's Hospital Ground Investigation Report. Report No. 7737.
14. Irish Geotechnical Services Ltd (IGSL). (April 2008). Ground Investigation, Mater Hospital Dublin, Swords Co. Dublin. Report No. 13227.
15. Minarex. (April 2008). Mater Hospital, Dublin Proposed Extension Ground Penetrating Radar Survey and Probing. Report No. 5234f_005.
16. Glover Site Investigations Ltd. (May 2008). Mater Hospital, Dublin. Report No. 08-0168.
17. Jacobs. (October 2007). Temporary Excavation and Lateral Support Design Input Statement for Mater Stop, Revision A. Report No. B0307000-260/PCT.024/002

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18. Long, M. & Menkiti, C.O. (2007). Geotechnical Properties of Dublin Boulder Clay. *Geotechnique* 57, No. 7, 595-611.
 19. Stroud. M., (1989), The Standard Penetration. Test – Its Application and Interpretation
 20. British Standards. (1994). Code of Practice for Earth Retaining Structures. BS 8002:1994.
 21. Mott MacDonald for RPA. (April 2009). The Construction Waste Management Plan. Report No. M000384/243231/SD-2.4A
 22. Mott MacDonadl for RPA. (April 2009). Environmental Description. Report No. M000384/243231/SD-2.3/A.

Appendix A Borehole Location Plan



NOTES:

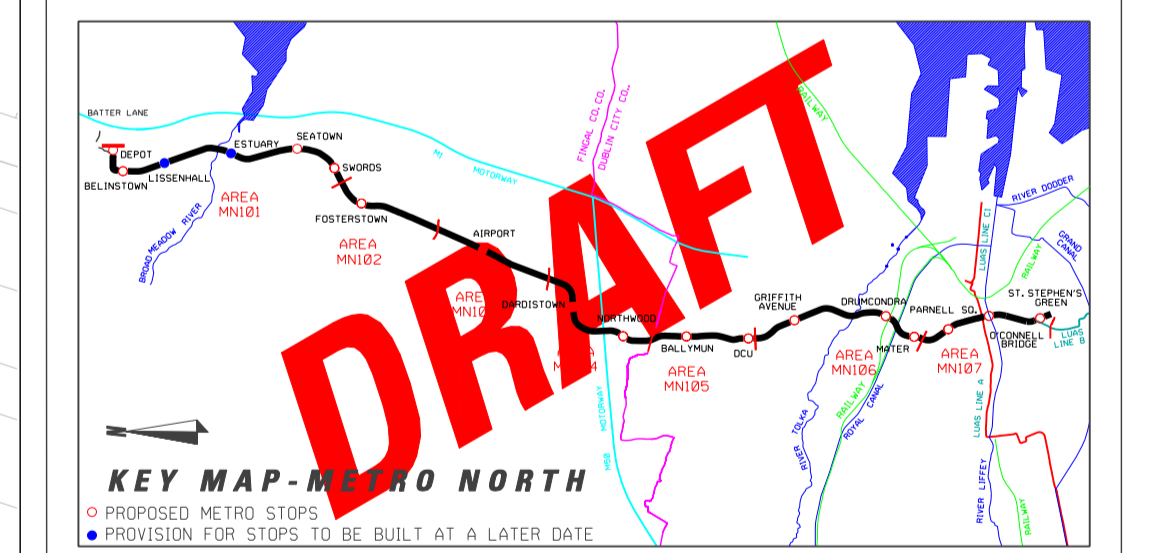
- 1. ORDNANCE SURVEY MAPPING BASE USED AS RPA MAPPING DOES NOT COVER A SUFFICIENTLY LARGE AREA.

LEGEND

- RC-RPA RPA BOREHOLES - ROTARY CORE
- RC-M THIRD PARTY MATER HOSPITAL BOREHOLES - ROTARY CORE
- ⊕ CP-RPA RPA BOREHOLES - CABLE PERCUSSION
- ⊕ CP-M THIRD PARTY MATER HOSPITAL BOREHOLES - CABLE PERCUSSION

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METRO



Mott
MacDonald

CONTRACT NO. MN - 7091	AREA MN_106	CHANGING
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LOCATION
MATER STOP

DRAWING TITLE
**GROUND INVESTIGATION
EXISTING EXPLORATORY HOLE LOCATIONS**

PREPARED: K. E. TIBBS	DESIGNED BY: C. E. TAYLOR	APPROVED BY: M. S. ANBAR
CHECKED: C. E. TAYLOR	CHECKED: L. N. PARRY	AS BUILT BY:
DATE: 09.04.09	SCALE: 1:500 @ A1	SHEET SIZE: A1

STAGE	LINE	CONTRACT	ELEMENT	DRW. NO.	DRW. REV.
D	MN	7091	GI	6001	D01

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