HYDROGEOLOGICAL ASSESSMENT OF SUBSOILS FOR PROPOSED NEW BURIAL GROUND AT LOGANSTOWN, TRIM, COUNTY MEATH

FINAL REPORT

Prepared for:

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SCOPE OF THIS REPORT

The findings of this report are the result of a desk study and geological field interpretation. Interpretations and conclusions included in the report are based on knowledge of the ground conditions following detailed investigations, as well as the regional soils, subsoils and bedrock geology, and the experience of the author. Dr. Robert Meehan has prepared this report in line with best current practice and with all reasonable skill, care and diligence in consideration of the limits imposed by the survey techniques used and the resources devoted to it by agreement with the client. The interpretative basis of the conclusions contained in this report should be taken into account in any future use of this report.

Dr. Robert Meehan accepts no responsibility for any matters arising if any recommendations contained in this document are not carried out, or are partially carried out, without further advice being obtained from Dr. Robert Meehan.

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EXECUTIVE SUMMARY

EurGeol. Dr. Robert Meehan PGeo. was retained by Meath County Council to undertake a hydrogeological desk study, subsoils investigation and modelling exercise as part of an investigation into the subsoils of the locality around the proposed cemetery site at Loganstown, east of the town of Trim.

This report provides a description of the geological character of the site and details the nature, extent and complexity of the geological material from the surface downwards through the mineral subsoil. No detailed quantitative geological or hydrogeological field investigations were undertaken; however, trial pits were dug across the site, field mapping as completed, and samples were taken from the subsoil for textural analyses using British Standard BS: 5930. The results of the desk study, walkover survey and trial pitting exercise were collated to assess the drainage characteristics of the subsoil on the site.

The bedrock under the site is expected to be over 5m deep, and is proven to be >3.0 m deep across the majority of the site, and >2.5 m deep over the entire site. This bedrock at depth is of shale and sandstone of the 'Namurian Undifferentiated' unit, which is a 'poor' aquifer. The locality has a high groundwater vulnerability rating, owing to the depth and permeability of the subsoil, and the depth to the water table. Groundwater flow under the site is towards the northeast in the northern section of the site, and towards the south in the southern section, downslope from the groundwater divide running through the site and 'through' the proposed cemetery. This groundwater is at a relatively deep depth under the site, proven to be >3.0 m across the majority of the site, and >2.45 m over the entire site.

The topsoil encountered in the trial pits on-site was seen to be generally well drained sandy loam to loam with pockets of deeper sandy SILT with occasional gravels, which shows a similar drainage class to that suggested by the regional scale soils mapping of the area by An Foras Taluintais (Finch *et al.*, 1983). The subsoil under the site is dominated by a unit of sandy SILT with occasional to abundant gravels and occasional cobbles and boulders between approx. 0.6 m and 3.2 m depth, interspersed with beds and pods of SAND-dominated material.

With the observation of the majority of the material within the trial pits across the site as being 'well drained', and in some localities sorted and bedded, with rounded to subrounded clasts, the BS 5930 descriptions and the lack of mottling in the major subsoil units in each profile, this would definitively place the sediments within the 'moderate' permeability class. As well as this, there occurred no infiltrating water in the uppermost 2.35 m of subsoil on the site. This means that the proposed burial ground site is suitable for burials.

As a precautionary measure and in order to ensure no groundwater contamination under the site, no burials should take place at a depth below 2.1 m depth, and no deeper than 1.45 m below current ground level in the southern extreme of the site. This will maintain at least 0.9m depth of unsaturated subsoil between all burials and the water table. As well as this, an area in the northwestern corner of the site should not be used for burials, in order to maintain a separation distance of 60 m with the well at the adjacent house there.

1.0 INTRODUCTION

EurGeol. Dr. Robert Meehan, PGeo. was retained by Meath County Council to undertake a hydrogeological desk study, subsoils investigation and drainage potential examination as part of a scoping exercise for the proposed new burial ground at Loganstown, Trim, County Meath (*Irish National Grid Reference 282150 257300)*. The site is located approximately 2.0 km east-northeast of the centre of the town of Trim, on the southern upper to mid-backslope of a low ridge feature, at an elevation of approximately 59 m - 63 m AOD. The site is approached by a third class road (formerly the National N1 route, Figure 1).

The closest surface watercourse as seen on the Discovery Series Map is approximately 295 m to the northeast, with the River Boyne also approximately 300 m south-southwest of the site. A spring is also shown to emerge approximately 135 m northeast of the site, and join the stream there, on the six-inch to one mile sheets of the locality. Drainage ditches do not seem common in the general area on these maps, and there are no drains marked within 300 m of the proposed burial ground site.

Figure 1 Location of site at Loganstown, Trim, illustrating surrounding topography and surface water stream and river features (OS Licence EN 0057921). Grid squares are 1 km distance.

This report provides a description of the geological character of the site and details the nature, extent and complexity of the geological material from the surface downwards through the mineral subsoil. A

comprehensive desk study was completed, and trial pits and a visual assessment of the site were completed in the field. The results of the desk study, walkover survey, trial pitting exercise and subsoil sample analysis were collated to assess the potential for installation of the burial ground on-site, and in particular to examine if there may be issues with either bedrock or a shallow water table in the locality.

2.0 SOILS, SUBSOILS, GEOLOGICAL & HYDROGEOLOGICAL CHARACTERISTATION

2.1 Topography.

The site is situated at the central portion of the 'Plains of Meath' topographic unit in southwestern County Meath, at the edge of the valley of the River Boyne (Meehan, 2012; Figure 1).

The site rests on the southern upper to mid- backslope of a low elevation ridge which rises a number of metres above the surrounding, gently undulating landscape of the area. The land in the area is generally relatively well drained upon first impression, although it is noted that this is an area of low effective rainfall. Elevations within the area rise to a high of 63 m AOD in the eastern extreme of the site itself, with the remainder of the site situated at between *c.* 59 m and 63 m AOD.

2.2 Soils

The site and the area surrounding it is mapped as being underlain by deep mineral soils of good drainage status, and derived mainly from calcareous parent materials (Teagasc/EPA, 2006a).

Previously, this area of County Meath was mapped by An Foras Talúntais as being characterised by soils of the Rathowen Series. Rathowen Series soils are grey brown podzolics, which are well drained, and of silt to silty clay loam texture. The development of the Rathowen Series soils is primarily associated with a leaching process; the principal constituent in the 'B' horizon is a finely divided clay fraction. The' B' horizon therefore has a much greater percentage of clay than the 'A' horizon. The water table is usually at depth within the areas occupied by these soils.

The area of the proposed burial ground site, being part of the upper to mid-backslope of a low ridge, has the potential to have soils of very good drainage class throughout it's area. As well as this, the likelihood a water table at a deeper depth than in the surrounding landscape is quite high, as the ridge itself may have subsoil materials different in texture to those around in the lowerlying areas of the landscape.

2.3 Subsoil (Quaternary) Geology

The Quaternary period extended from 1.6 M.A to present day. During this period great Ice Ages took hold in Ireland, the last of these extending from 73,000 years BP until 10,000 years BP. There were several phases of ice flow affecting County Meath. Within these phases, ice flowed from a number of different centres. Ice moving from the northwest to the southeast would have been the last ice to cross over the site, as the existing glacial landforms indicate that ice flow direction during the Last Glacial Maximum was approximately southeasterly across southwestern Meath (Clark and Meehan, 2001). Following this there was a period of deglaciation, when waterlain glaciofluvial sediments were deposited. Since deglaciation ended, a period of post-glacial geological processes has continued until the present day, where natural landscape processes in Ireland are dominated by the action of water.

Glacial deposits in this region are often deep, with bedrock found several metres below the land surface. For example, a borehole drilled in the landholding south of the subject site at Loganstown, during

exploration work for Ambassador Oil in 1961, was bored to 7.6 m below ground level, and did not meet bedrock (GSI, 2021).

Glacial deposits in this region generally consist of glaciofluvial sands and gravels, which were formed by glacial meltwater as the ice sheets of the last Ice Age melted. These are mapped as occurring under the site at Loganstown (Teagasc/EPA, 2006b). Sands and gravels, being deposited by glacial meltwater, are usually sorted and well bedded, and comprise well washed and rounded clasts. They are usually unconsolidated, and relatively 'loose' and often prone to collapse when dug in pits. In general, sands and gravels are highly permeable, as they are dominated by gravel clasts and sand, with little silt or clay. From Figure 2 it would appear that the site is located within an area of sands and gravels derived chiefly from limestones, which extends outwards in all directions from the site. The permeability of this sand and gravel subsoil, as mapped for the County Meath Groundwater Protection Scheme (1995), is 'high'. This is owing to the sorting and bedding, and lack of fine sediment within the material.

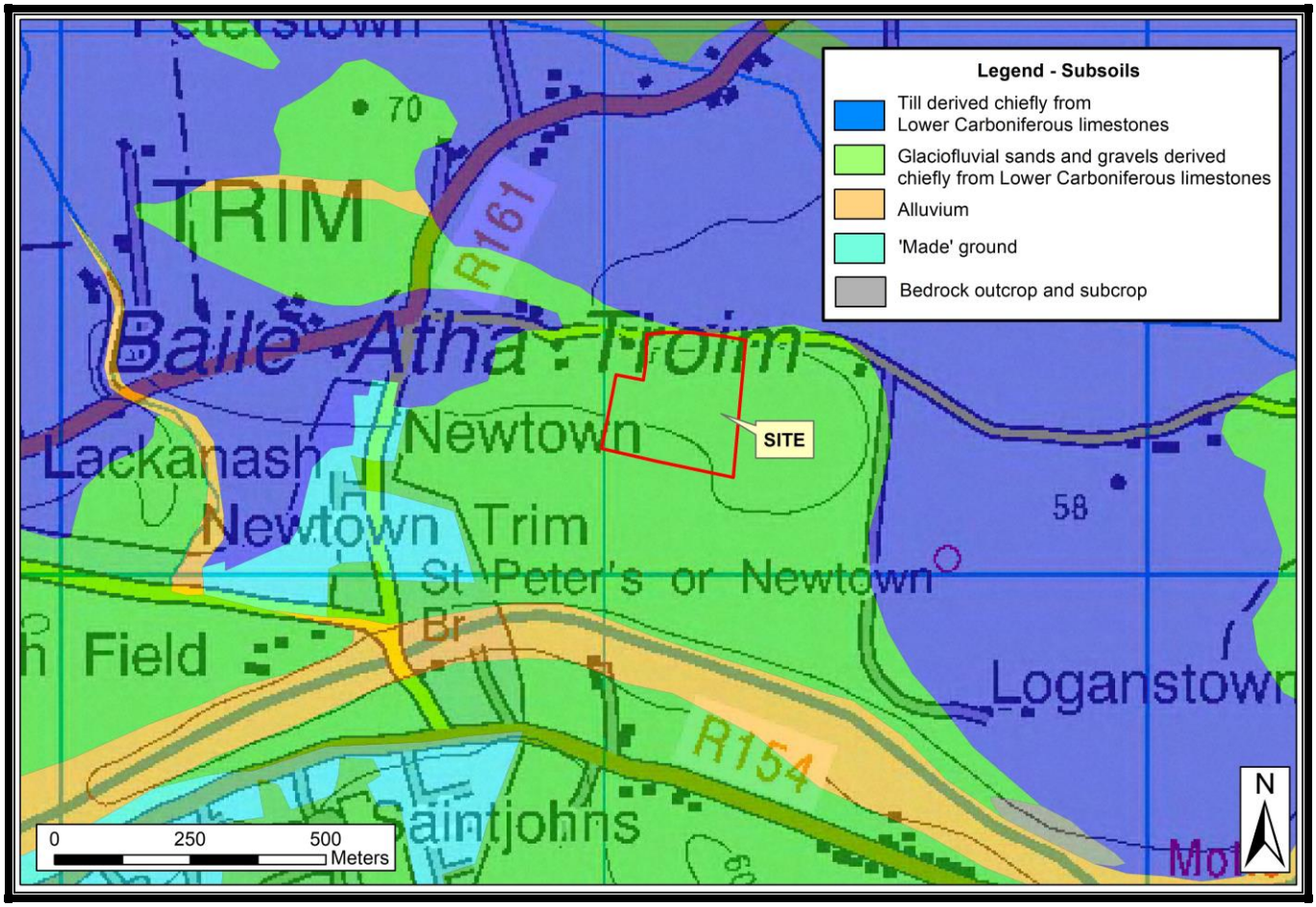

Figure 2: Subsoils geology of the site and its environs. The green depicts 'glaciofluvial sands and gravels', the blue till derived from limestones, the orange alluvium, and the cyan 'Made' ground (OS Licence EN 0057921).

During glaciation across Meath, till (boulder clay) was deposited on top of the pre-existing bedrock at the base of the moving ice sheet. During the advancement of the glaciers, the weight and pressure of the ice broke the bedrock upon which the glaciers moved and ground it down to particle sizes ranging from boulders to clay. This material was smeared by the advancing ice on top of the pre-existing bedrock, leaving the mixture of debris material comprising till. Tills are often over-consolidated, or tightly packed, unsorted, unbedded, possessing many different particle and clast (stone) sizes, and commonly contain sharp, angular clasts. These materials are also common glacially-deposited subsoils across the county and dominate the area immediately north, northwest and northeast of the Loganstown locality.

On the subsoil map both tills and sands and gravels are categorised according to their dominant lithological component (Figure 2). Grain size of the matrix, or the texture of the till, is also important, as this determines the permeabilityof these subsoils, which is important for soil development processes and for infiltration potential. Thus, tills may be described as gravelly, sandy, silty or clayey.

Post-glacial alluvium is also common in the lowlying river channel areas along streams and rivers around the site (Teagasc/EPA, 2006b). Where the areas around Trom |Town have had ground disturbed and covered by concrete and/or tarmacadam over the last few centuries, 'Made' ground has been mapped as a subsoil class in itself. Examining Figure 2, the subsoil geometry in the region therefore seems quite complex, but the site itself lies within an extensive area mapped as sands and gravels.

Information from the County Meath depth-to-bedrock map, which was mapped by the Geological Survey of Ireland (GSI, County Meath Groundwater Protection Scheme, 1995) suggests that depth-to-bedrock in the vicinity of the proposed site is between 5 m and 10 m.

2.4 Bedrock Geology

The 1:100,000-scale bedrock geology map of the area (Geology of Meath, Sheet 13; GSI, 1994) indicates that the site is underlain by rocks of the Namurian Undifferentiated class (NAM). These were deposited during the Upper Carboniferous Period (324 to 299 million years ago) and comprise sandstones and shales (Figure 3). Approximately 100 m southeast and 450 m northwest of the site, bedrock of the Lucan Formation have been mapped as the bedrock. These rocks were deposited earlier, during the Lower Carboniferous Period (359 to 324 million years ago), and comprise dark limestones and shales (Figure 3).

The County Meath Groundwater Protection Scheme vulnerability map suggests that bedrock is present at depths of between 5 m and 10 m below ground level around the proposed burial ground site, and closest bedrock outcrop/subcrop is over 775 m to the southeast, in the southeastern portion of Loganstown Townland (see greyed locality on Figure 2).

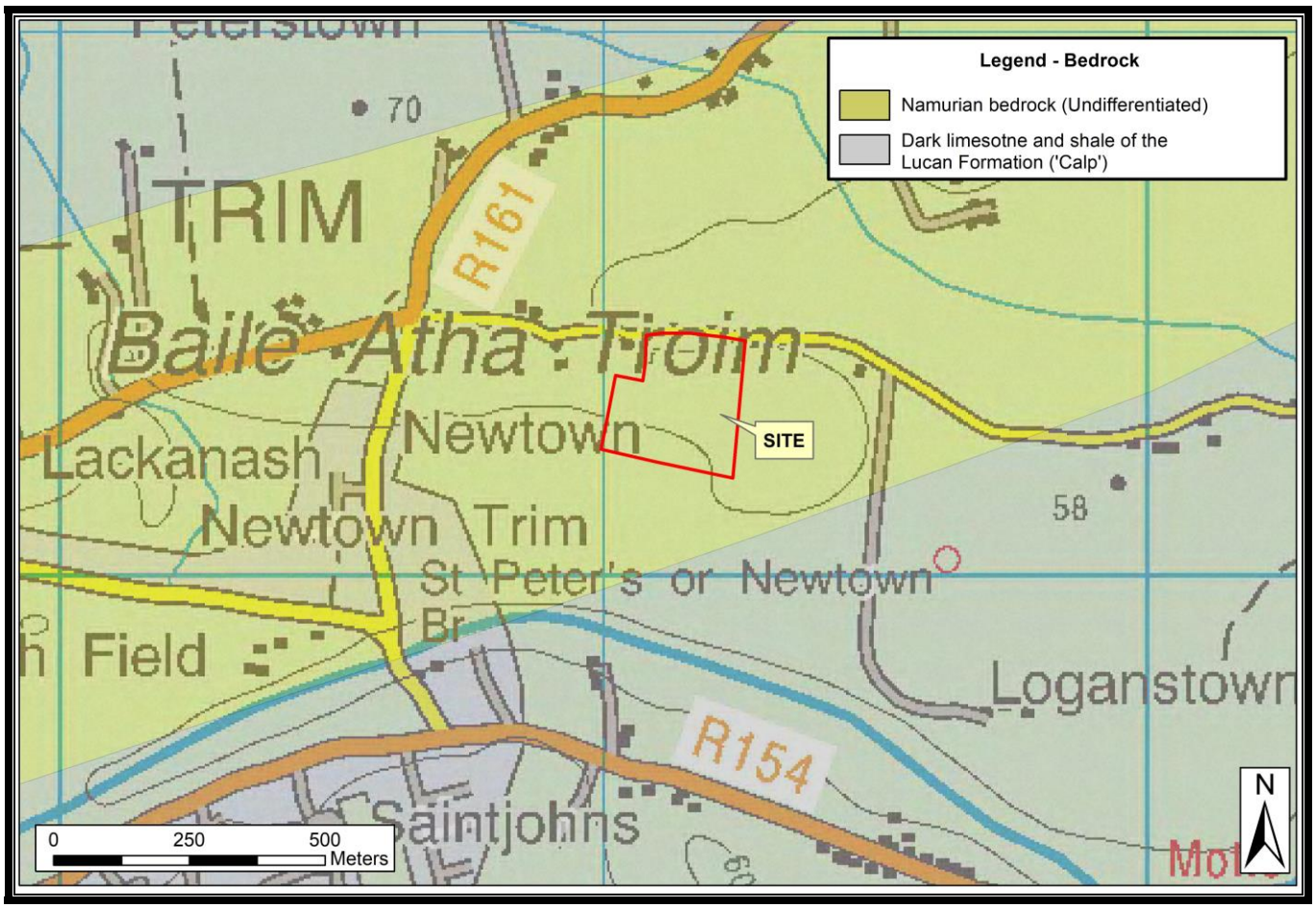

Figure 3: Bedrock geology of the site and its environs (OS Licence EN 0057921).

2.5 Hydrogeology

2.5.1 Groundwater Flow Direction

Groundwater is defined as water that moves through and is stored within sub-terrain geological strata and flow direction generally follows topography.

Groundwater underlying the site is therefore assumed to flow from southwest to northeast, downslope towards the stream at the northeast, in the northern section of the site (Figure 4). Flow is to the south towards the River Boyne in the southern section. This means that any contamination arising from burials will also move along those planes, when mixed with and diluted by groundwater.

Figure 4: Interpreted groundwater flow directions under the land at Loganstown, using contours from the O.S. 1:50,000 Discovery Series map, levels measured on-site, and surface water stream flow directions. Flow should generally be towards the lower land to the northeast (in the northern section of the site) and towards the south (in the southern section, OS Licence EN 0057921).

2.5.2 Aquifer Classification

The aquifer potential of a bedrock unit is determined by the groundwater productivity and the productivity is based on hydraulic characteristics compiled from borehole data throughout the country. The national aquifer map of Ireland produced by the Geological Survey of Ireland has classified the Namurian Undifferentiated bedrock as a poor aquifer (Pl) – bedrock which is generally moderately productive only in local zones, with few and poorly connected fractures, fissures and joints. This low fissure permeability tends to decrease further with depth. A shallow zone of slightly higher permeability may exist within the top few metres of more fractured/weathered rock, and higher permeability may rarely occur along large fault zones. In general, the poor fissure network results in poor aquifer storage, short flow paths (tens of metres) and low 'recharge acceptance'. Groundwater discharge to streams ('baseflow') is very limited.

The national aquifer map has classified the bedrock of the Lucan Formation to the southeast and northwest of the site as a locally important aquifer (Lm) – bedrock which is generally moderately

productive. In these rocks, the permeability, storage capacity, recharge acceptance, length of flow path and baseflow are higher than in Pl aquifers.

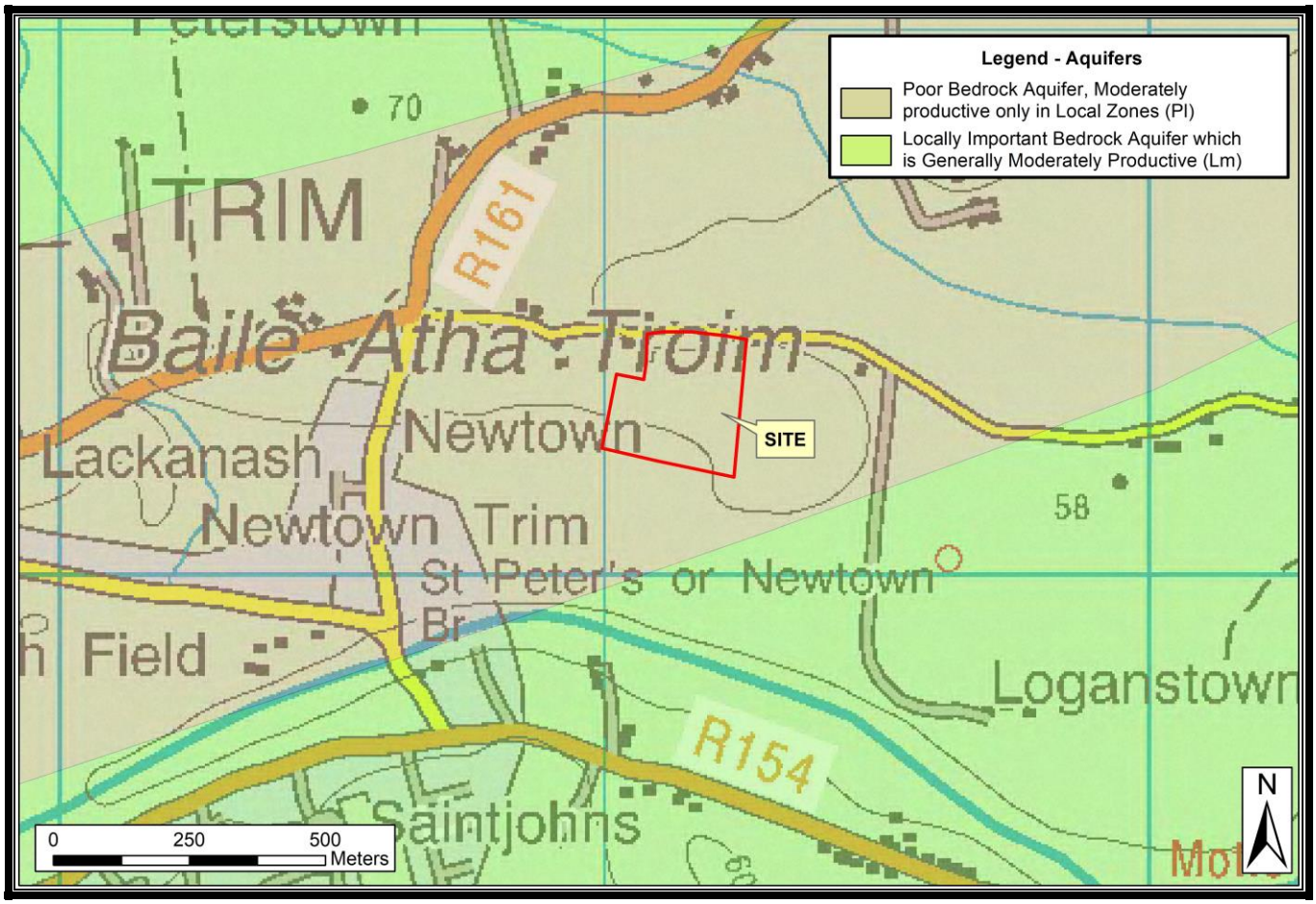

Figure 5: Aquifer map of the site at Loganstown and its environs (OS Licence EN 0057921).

There is a general scarcity of hydrogeological data for the Namurian Undifferentiated rocks of the within the Trim Groundwater Body, of which the Loganstown locality forms part. Groundwater flow in these Upper Carboniferous rocks is considered to take place in the upper weathered zone of the aquifer. Flow paths are not considered to extend further than the nearest surface water features and will generally not be greater than 500 m. The flow is usually in relatively localised systems with little continuity between them.

According to the Groundwater Body Summary sheet of the GSI for the Trim Groundwater Body, it is impossible to quote specific, single figures with respect to permeability, transmissivity and storativity of the aquifer.

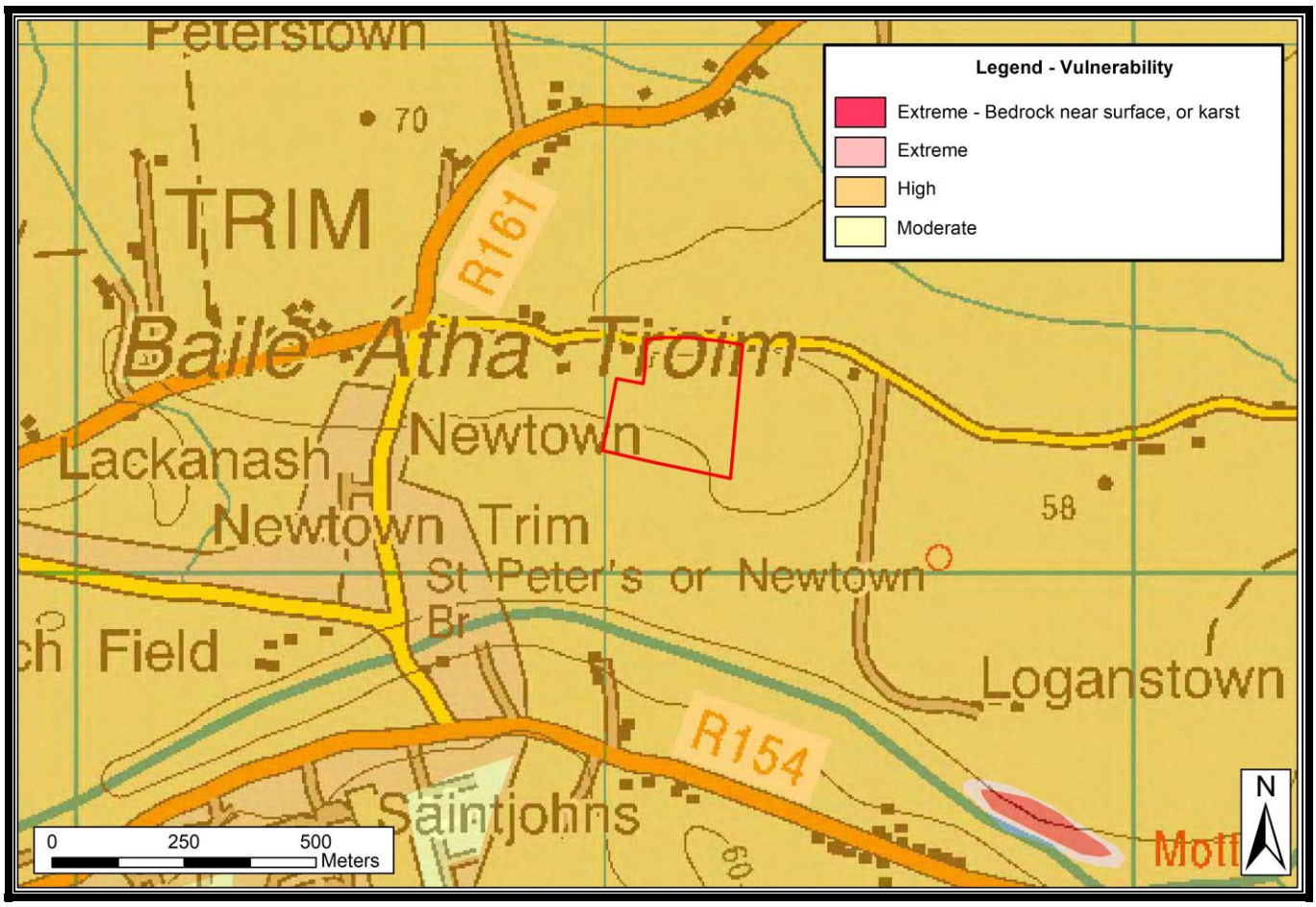

Figure 6: Groundwater vulnerability zonings for the proposed burial ground at Loganstown and its' surrounding areas (OS Licence EN 0057921).

2.5.3 Groundwater Vulnerability

Groundwater vulnerability is a term used to represent the intrinsic geological and hydrogeological characteristics that determine the ease with which groundwater may be contaminated by human activities. The vulnerability of an aquifer is defined as the ease with which infiltrating water and potential contaminants may reach groundwater in a vertical or sub-vertical direction. It is dependent on permeability and thickness of the subsoil.

A groundwater vulnerability map for the area has been completed for County Meath by the GSI and from consultation of the map the locality is ranked as being of 'high' groundwater vulnerability.

2.5.4 Recharge

The term 'recharge' refers to the amount of water replenishing the groundwater flow system. Recharge is generally estimated on an annual basis, and is assumed to consist of an input (*i.e.* annual rainfall) less water losses (*i.e.* annual evapotranspiration and runoff). In areas where point recharge from sinking streams etc. is discounted, the main parameters involved in recharge rate estimation are annual rainfall, annual evapotranspiration, and annual runoff.

Diffuse recharge will occur *via* rainfall percolating through the subsoil or through areas of outcropping rock. The proportion of the effective rainfall that will recharge the aquifer is determined by the permeability of the soil and subsoil, and by the slope. The generally deep 'high' permeability subsoil of the Loganstown locality will in no sense restrict percolation of recharge to the aquifer.

The National Recharge Map produced by the Geological Survey of Ireland (GSI, 2013) has classified the subject site as having a recharge rate of 100 mm per year, owing more to limited recharge acceptance in the 'poor' aquifer under the site, rather than the high permeability of the subsoils in the locality.

2.5.5 Utilisation of Groundwater Resources in the vicinity of the Proposed Development

Twenty-one houses occur within 500 m of the site, and a well audit of the surrounding area identified 8 no. water supply boreholes in the immediate vicinity of the site.

The first of these is at the house at the northwestern corner of the site, and will be exactly. 15 m from the site's northwestern boundary. This well is interpreted as alongside with respect to groundwater flow, but **in order to ensure no contamination from burials, and as the site is situated in highly permeable sands and gravels, the well should be considered as down-gradient and a 60 m buffer between it and any burials should be maintained**.

All of the other wells are to the east of the site, with the closest approximately 75m from the proposed burial ground site, and alongside with respect to groundwater flow. Given the distance between it and the site, burials can take place up to the site's eastern boundary without having an impact on this well.

There are no other down-gradient wells between the proposed burial ground and the nearest receptors, which are the stream to the northeast and the River Boyne to the south.

3.0 HYDROGEOLOGICAL INVESTIGATIONS INTO THE SUBSOIL

Intrusive site investigations, comprising trial pitting and walkover survey, were therefore carried out by Robert Meehan in association with Meath County Council at the subject site on 4th September 2018.

3.1 Walkover survey

Initially, a walk-over survey was conducted across the entire site to examine the ground conditions and salient features on-site. The area of the proposed burial ground is covered with good quality grassland, which is not intensively managed. Though pasture also covers the field immediately to the south, east and north, arable crops are grown in the majority of the fields west and northwest of the site.

From this walkover, it was seen one deep drainage ditch has been dug along the sites western boundary. This seems to have been dug to drain a relatively lowlying locality at the north of the site, across the road, and to conduct water from it towards the River Boyne at the south. Shallow, roadside drainage ditches have also been dug along each side of the road along the site's northern boundary, and are for excess road surface water, rather than for drainage the land there. The closest stream, as on the Discovery Series Map, is approximately 125 m to the northeast, where the spring emerges, and the majority of the other hedgerows around the site comprise fences and/or dry banks.

None of the land across the site or the surrounding locality hosts rushes and the low ridge forming the site, as well as the land around it, is firm and dry.

3.2 Trenching programme

From the walkover survey, sites were selected for excavation and 12 no. trenches were excavated throughout the site (Figure 7).

Trenches were dug using a JCB 4CX Backhoe Excavator. The holes were left open for up to 2 hours to see if there were water inflows and if the water table stabilised following initial examination. Based on the materials logged from the 12 no. trial pits dug within the proposed burial ground site, the subsoil material across the site is relatively consistent and is at least 2.5 m deep throughout the site (in all probability this depth is >3.2 m, as seen from trial pit no. 5).

The pits allow a detailed hydrogeological conceptual model of the subsoils under the site be drawn up. The geological logs showing descriptions of the subsoils encountered in the pits are presented in Appendix A. All subsoils encountered were described in accordance with the British Standards Institution Code of Practice for Site Investigations (BS 5930, 1999) which gives a geotechnical classification of the materials encountered, in particular bulk density, structure and textural characteristics. Bulk samples were collected and retained for analysis, should this be required. A summary of the conditions encountered under each of the localities on-site follows.

The land on the site has a gently undulating to hummocky topography, with varying slope directions and slope angles generally between 2^{o} and 4^{o}, but up to 8^{o} across some of the hollows on the site.

Figure 7: Location of trial trial pits excavated within the proposed Loganstown burial ground site area.

The topsoil encountered in these pits was generally very dark brown to dark brown, sandy loam to loam, underlain in places by sandy SILT with occasional gravels, which was between 0.35 m and 1.06 m deep. This was compact to very soft and was of crumb to subangular blocky structure, with abundant grass roots and rootlets.

The soils sequence, including both the 'A' and 'B' horizons, is of either an acid brown earth or a grey brown podzolic, which corroborates with the regional Soil Survey Mapping of An Foras Taluintais (Finch *et al.,* 1983), and suggests that the subsoil is well drained in the general locality.

Within the trial pits, a number of subsoil units were encountered in some of the pits. The major subsoil layer extends from approx. 0.6 m to approx. 3.15 m+ depth, and is a very soft to firm, well aerated, sandy SILT with occasional to abundant gravels and occasional cobbles and boulders (as per BS5930, 1999). The layer is the major unit in which burial will take place, and is unmottled and dark grey in colour. From this, the unit seems permeable and suitable for burial.

Groundwater was not met in three of the trial pits, number 1, 2 and 4 at the southernmost portion of the proposed burial ground site, where seepages were seen also. Trial hole 4 showed mottled material throughout it's profile, suggesting intermittent waterlogging in this locality.

None of the other trial holes met seepages or water table, and were dry throughout.

Bedrock was not met in any of the pits dug in the proposed burial ground, at up to 3.2 m below ground level. As the depth to bedrock under the site is expected to be in the order of 5 m-10 m (section 2.4) this means that encountering bedrock will not be an issue on the site.

The subsoil under the site is therefore dominated by a unit of sandy SILT with occasional to abundant gravels, and occasional cobbles and boulders.

3.3 Permeability of subsoil sediments under the site

The permeability of subsoil is largely a function of (a) the grain size distribution, (b) the amount (and sometimes type) of clay size particles present, and (c) how the grains are packed together. It can also be influenced by other factors such as discontinuities (fissures/cracks, plant roots, pores formed by soil fauna, isolated higher permeability beds or lenses, voids created by weathering of limestone clasts) and density/compactness of the deposit.

In poorly sorted sediments such as glacial tills, these characteristics describe the engineering behaviour of the materials as detailed in the subsoil description and classification method derived from BS 5930:1999 (Swartz, 1999). This method is used to assess the subsoil permeability at each trial pit, and is combined with recharge and drainage observations in the surrounding area for a regional, three-dimensional classification. Each approach used in assessing the permeability is discussed briefly here. Some are described in more detail in the research theses of Lee (1999) and Swartz (1999):

Subsoil Description and Classification Method *(derived from BS 5930:1999).* Using this method, subsoils described as gravelly CLAY or CLAY has been shown to behave as low permeability materials. Subsoils classed as sandy SILT and gravelly sandy SILT, on the other hand, are found to have a moderate permeability (Swartz, 1999).

Particle Size Analyses*.* The particle size distribution of sediments describes the relationships between the different grain sizes present. Well-sorted sediments such as water-lain gravels (high permeability, such as under the site at Loganstown) or lacustrine clays (low permeability) will, on analysis, show a predominance of grain sizes at just one end of the scale. Glacial tills, on the other hand, are more variable and tend to have similar proportions of all grain sizes. Despite their complexity, evaluations of the grain size analyses for a range of tills in Ireland have established the following relationships (Swartz, 1999):

i. Samples described as 'moderate permeability', based on observations of recharge indicators (vegetation, drainage density); typically have less than 35% fines (silt plus clay).

ii. These 'moderate permeability' samples also tend to have less than 12% clay.
iii. Samples described as 'low permeability' frequently have more than 50% fines.
iv. These 'low permeability' samples also tend to have more than 14% clay.
v. 'High permeability' sand/gravel deposits tend to be sorted and have less than 7.5% fines (O Suilleabhain, 2000).

Quantitative Analysis. From a limited number of national field permeability measurements, the boundary between moderate and low permeability is estimated as about 10^{-8}-10^{-9} m/s. While the moderate to high boundary has not yet been examined in detail, one study suggests this boundary may be in the region of 10^{-4} m/s (O'Suilleabhain, 2000). However, permeability measurements are highly scale dependent: laboratory values are often up to two orders of magnitude lower than field measurements, which in turn tend to be lower than regional assessments based on large scale pumping tests. Thus, for regional permeability mapping, qualitative assessments of the recharge characteristics and engineering behaviour of the subsoils are more appropriate than specific permeability measurements.

None of these methods can be used in isolation: a holistic approach is necessary to gain an overall assessment of each site and thereby build up a three dimensional picture of the permeability. In a given area, as many factors as possible are considered together in order to obtain a balanced, defensible permeability decision.

The observations of the majority of the material within the trial pits across the site as being 'well drained', the unsorted and fine to coarse grained nature of the sediments, the BS 5930 descriptions and the lack of mottling in the major subsoil units in almost all profiles would definitively place the sediments under the site within the 'moderate' permeability class.

3.4 Conceptual model of the site

The desk study, walkover survey and intrusive trial pitting programme allow the following conceptual model for the site to be drawn up.

- The bedrock under the site is expected to be over 5m deep, and is proven to be >3.2 m in portions of the site, and >2.5 m over the entire site.
- This bedrock is of shale and/or sandstone, which is a poor aquifer.
- The locality has a 'high' groundwater vulnerability rating, owing to the depth and permeability of the subsoil and the general presence of the water table at a depth greater than 3m.
- Recharge in the area (the amount of rainfall seeping through the soil and subsoil to groundwater in the bedrock aquifer) is expected to be approximately 100 mm per year, owing more to the limited recharge acceptance properties of the bedrock aquifer under the site, than to the 'high' permeability of the sands and gravels subsoils.
- Groundwater flow under the site is towards the northeast in the northern portion of the site, and to the south in the southern portion., downslope 'through' the burial ground.

- This groundwater is at a relatively deep depth under the site, and was only met in three of the twelve trial holes excavated, in the southern extreme of the site (and is therefore at least 2.35 m – 2.72m from surface in this portion of the site)
- The soil under the site is hosted at the top of a well drained, unmottled, sandy SILT unit of subsoil, which has occasional to abundant gravels and occasional cobbles and boulders within, and dominates the subsoil across the site to 3.2 m+ depth.
- Analysis of the subsoil units under the site (as per BS 5930: 1999) would suggest that it is of 'moderate' permeability status, meaning that infiltration is generally rapid and the subsoil material across the majority of the site remains unsaturated throughout the year.

3.5 Discussion.

The trial pitting on-site proves that the subsoil under the site is variable in its internal geometry with a dominant, unmottled and unsaturated SILT-dominated layer interspersed with unmottled and unsaturated SAND-dominated pods and beds. Some mottled material occurs in the southeastern corner of the site.

The general characteristics around the site at Loganstown are as follows:

- The land use in the area is of dry grassland and arable crops, and wetland indicators such as rushes and willow are absent on and around the low ridge hosting the site. This suggests high to moderate permeability subsoil.
- The artificial drainage density around the site is low, with few field drains within 250 m, and only one deep ditch around the site. This suggests generally moderate permeability.
- The natural drainage density around the site is also low (<1 km per km^2), also suggesting moderate permeability.

With the topsoil encountered in the trial pits on the site:

- The topsoil units on the site, in the uppermost 0.35 m-1.06 m, are well drained and unmottled, suggesting high to moderate permeability.

The major subsoil unit under the site, within which burials would take place:

- Results in a BS 5930 description of sandy SILT with occasional to abundant gravels and occasional cobbles and boulders, which would suggest a moderate permeability and ready infiltration;
- Generally has a colour of dark brown to brown to yellowish brown, which is unmottled and which also suggests moderate permeability.
- Has pods and beds of unmottled, unsaturated SAND-dominated material within, which would suggest localised pockets of high permeability.

Given the overall unmottled and SILT-dominated characteristics of the major subsoil unit, and the absence of infiltrating water in the uppermost 3.0 m of subsoil across the majority of the area of the site, it is considered that the locality is suitable for burials.

As a precautionary measure and in order to ensure no groundwater contamination under the site, no burials should take place at a depth below 2.1 m below current ground level across the entirety of the site. This will maintain at least 0.9m depth of unsaturated subsoil between all burials and the water table.

In the southernmost portion of the site, where groundwater was met at depths between 2.35 m and 2.72 m below current ground level, no burials should take place here at depths below 1.45m below ground level.

4.0 CONCLUSIONS AND RECOMMENDATIONS

- The soil under the site is well drained.
- The soil under the site is hosted at the top of a well drained, unmottled, sandy SILT unit of subsoil, with occasional to abundant gravels and occasional cobbles and boulders, which dominates the subsoil across the site to 3.2 m+ depth.
- The bedrock under the site is expected to be over 5 m deep, and is proven to be at a depth >3.0 m across the majority of the site, and >2.5 m over the entire site.
- This bedrock at depth is of shale and / or sandstone, which is a poor aquifer.
- The locality has a high groundwater vulnerability rating, owing to the depth and permeability of the subsoil, as well as the depth of the water table.
- Groundwater flow under the site is towards the northeast in the northern portion of the site, and to the south in the southern portion., downslope 'through' the burial ground.
- This groundwater is at a relatively deep depth under the site, proven to be >3.0 m across the majority of the site, and >2.35 m over the entire site.
- Recharge in the area (the amount of rainfall seeping through the soil and subsoil to groundwater in the bedrock aquifer) is expected to be approximately 100 mm per year.

- **Given the overall unmottled and SILT-dominated characteristics of the major subsoil unit, and the absence of infilltrating water in the uppermost 3.0 m of subsoil across the majority of the area of the site, it is considered that the locality is suitable for burials, especially given the well drained nature of the surrounding land and the general absence of drains adjacent to the site.**
- **As a precautionary measure and in order to ensure no groundwater contamination under the site, no burials should take place at a depth below 2.1 m. This will maintain at least 0.9 m depth of unsaturated subsoil between all burials and the water table.**
- **In the southernmost portion of the site, where groundwater was met at depths between 2.35 m and 2.72 m below current ground level, no burials should take place here at depths below 1.45m below current ground level.**
- **As well as this, an area in the northwestern corner of the site should not be used for burials, in order to maintain a separation distance of 60 m with the well at the adjacent house there (see Figure 8 following for a map showing 60 m buffers around wells, and the locality in the southeast where no burials can take place below 1.45 m below current ground level).**

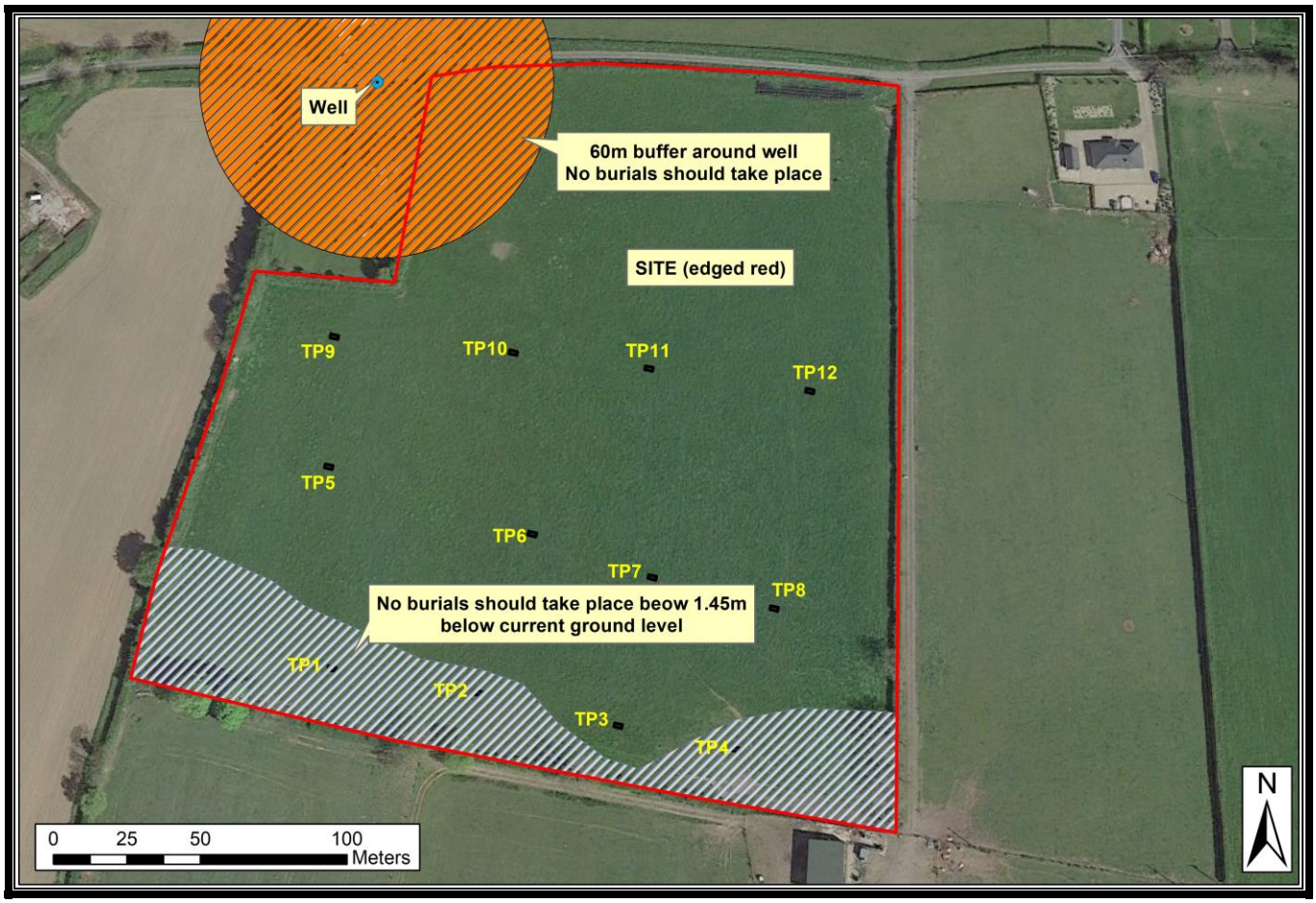

Figure 8: Plot showing wells around the site and the required 60 m buffer zones around these, given that the subsoil contains units of highly permeable sand and gravel. The only locality where burials can not take place on the site is within the stippled area at the northwestern corner.

NOTES:

Neither the whole nor any part of this report or any reference thereto may be included in any document, circular or submission, without our prior written consent as to the form and context in which it appears. This report is for the use solely of the party to whom it is addressed and no responsibility is accepted to any third party.

All information supplied by the Client, the Client's staff and professional advisers, local authorities, other statutory bodies, investigation agencies and other stated sources is accepted as being correct unless otherwise specified.

This report is not a design specification for surface water or foul water drainage systems and as such should not be used as one.

All data and methods of analysis presented are, to the best of my knowledge, valid at the time of report generation.

Areas presented, off site distances and elevations are sometimes computed from Ordnance Survey maps and not from physical surveys. They are approximate unless otherwise stated.

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Appendix A
Trial pit logs

Robert Meehan
Consultant Geologist

TRIAL PIT RECORD TP1

Project: Hydrogeology of proposed cemetery at Loganstown

Site: Loganstown
Client: Meath County Council
Project No.: 26/031

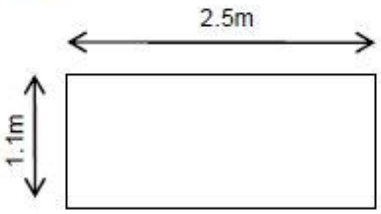
All dimensions on this sheet are in metres unless otherwise stated

Method and Equipment:: JCB 4CX Backhoe Excavator
Logged by: R. Meehan Date: 04/09/2018
Easting: 282052 Northing: 257234
Ground level OD: 59.5m

Samples & in-situ tests			Result Peak (Residual)	Water	Strata details			
Depth taken	Type	No			O.D. Level	Legend	Depth	Description
0.1-0.18					59.3			TOPSOIL 'A' horizon: compact, crumb, dark brown (3/3, 10YR) sandy loam with occasional gravels and occasional grass roots and rootlets.
0.39-0.44					59.1			TOPSOIL/SUBSOIL 'B_1' horizon: soft to firm, subangular blocky, dark brown (3/3 10YR), sandy SILT with occasional gravels and occasional grass rootlets.
0.82-0.89								TOPSOIL/SUBSOIL 'B_2t horizon: soft, massive, dark brown (3/3 10YR), sandy SILT with occasional gravels.
								'C' horizon (SUBSOIL): very soft, massive, yet fissile, dark yellowish brown (3/4, 10YR), very silty gravelly SAND with occasional cobbles and boulders.
								Pods of SAND up to 0.4m thick and 0.5m long.
2.6					56.9			**Trial pit completed at 2.6m on dark yellowish brown, massive, yet fissile, very soft, very silty gravelly SAND with occasional cobbles and boulders (glacial TILL subsoil).**

0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0

Plan



Bearing : 102° (E-W)

Stability :

Trial pit walls consolidated, and little collapse in side walls following excavation.

General remarks :

Dug in southwestern portion of the proposed burial ground site, into a dry locality, at one of the lowest points in the landholding. Dug on a 1° slope, falling southwestwards.

Groundwater :

Groundwater ingress at 2.5m, but rises to 2.35m after 2 hours.

Sequence summary:
Well drained topsoil over a permeable subsoil to 2.6m+ depth.
No bedrock.

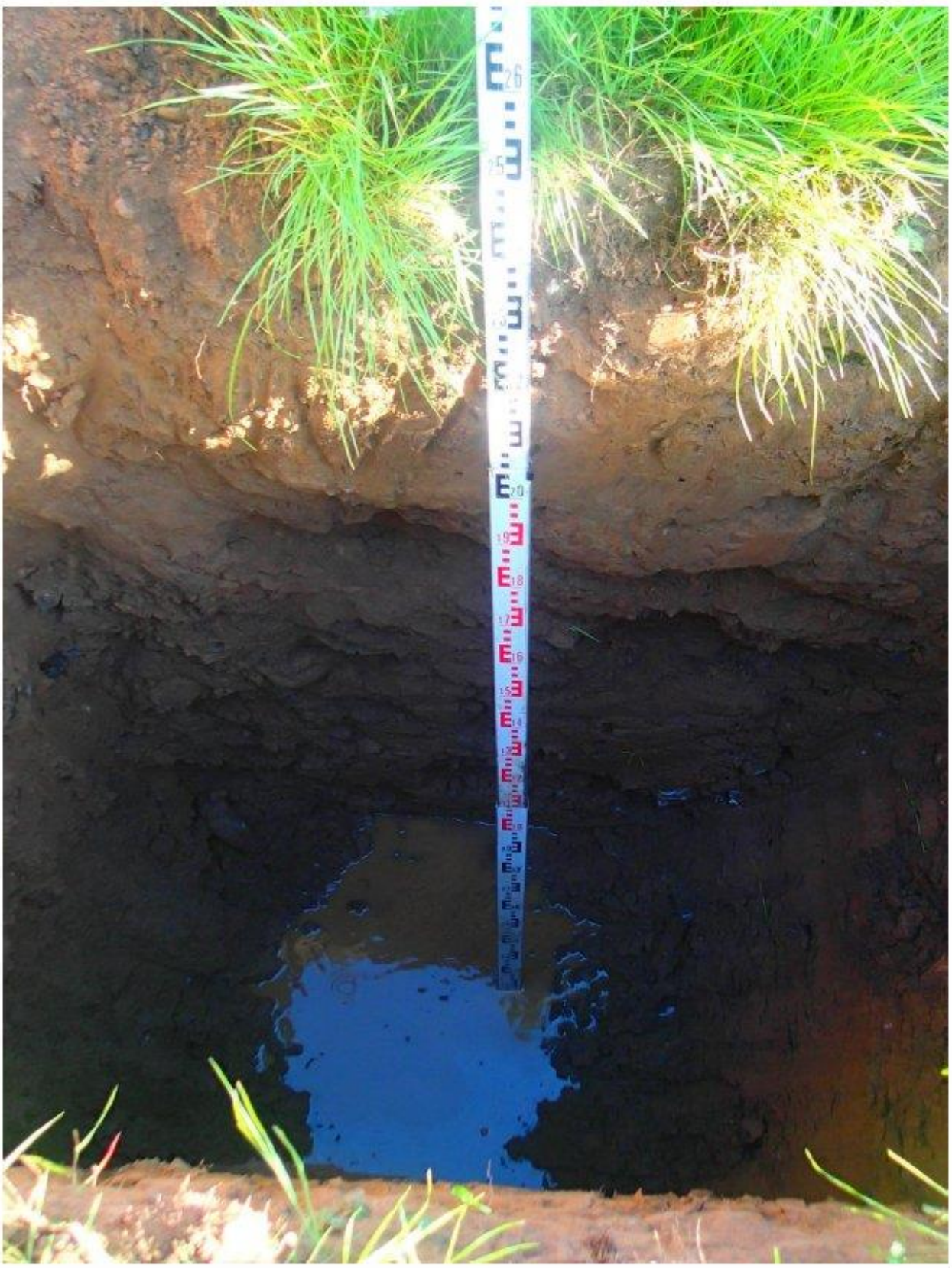


Plate A1: Profile of well drained topsoil overlying unmottled very silty gravelly SAND with occasional cobbles and boulders to 2.6m depth, in trial hole TP1. See the presence of the water table at the base of the hole.

Robert Meehan
Consultant Geologist

TRIAL PIT RECORD TP2

Project: Hydrogeology of proposed cemetery at Loganstown

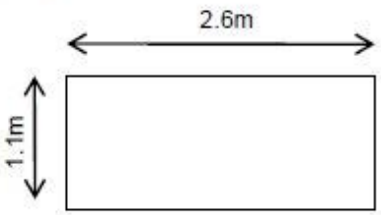
Site: Loganstown
Client: Meath County Council
Project No.: 26/031

All dimensions on this sheet are in metres unless otherwise stated

Method and Equipment:: JCB 4CX Backhoe Excavator
Logged by: R. Meehan Date: 04/09/2018
Easting: 282104 Northing: 257225
Ground level OD: 59.8m

Samples & in-situ tests			Result Peak (Residual)	Water	Strata details			
Depth taken	Type	No			O.D. Level	Legend	Depth	Description
0.11-0.16					59.6			TOPSOIL 'A' horizon: compact, crumb, dark brown (3/3, 10YR) sandy loam with occasional gravels and occasional grass roots and rootlets.
0.34-0.42					59.4			TOPSOIL/SUBSOIL 'B$_1$' horizon: firm to stiff, subangular blocky, dark brown (3/3 10YR), sandy SILT with occasional gravels and occasional grass rootlets.
0.5								TOPSOIL/SUBSOIL 'B$_2$t' horizon: firm, massive, dark yellowish brown (4/6 10YR), sandy SILT with occasional gravels.
1.0								
0.91-1.06								'C' horizon (SUBSOIL): very soft to soft, massive, yet fissile, dark brown (3/3, 10YR), very silty gravelly SAND with occasional cobbles and boulders.
1.5								Pods of SAND up to 0.3m thick and 0.3m long.
2.0								
2.5								
3.0					56.8			**Trial pit completed at 3.0m on dark brown, massive, yet fissile, very soft to soft, very silty gravelly SAND with occasional cobbles and boulders (glacial TILL subsoil).**
3.5								
4.0								
4.5								
5.0								

Plan



Bearing : 96° (E-W)

Stability :

Trial pit walls consolidated, and little collapse in side walls following excavation.

General remarks :

Dug in southern portion of the proposed burial ground site, into a dry locality, at one of the lowest points in the landholding. Dug on a 1° slope, falling southwards.

Groundwater :

Groundwater ingress at 2.8m, but rises to 2.67m after 2 hours.

Sequence summary:
Well drained topsoil over a permeable subsoil to 3.0m+ depth.
No bedrock.

Plate A2: Profile of well drained topsoil overlying unmottled very silty gravelly SAND with occasional cobbles and boulders to 3.0m depth, in trial hole TP2. See the presence of the water table at the base of the hole.

Robert Meehan
Consultant Geologist

TRIAL PIT RECORD TP3

Project: Hydrogeology of proposed cemetery at Loganstown

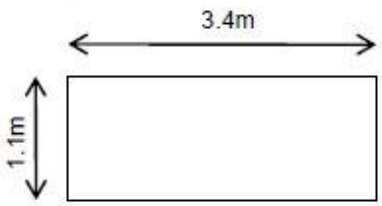
Site: Loganstown
Client: Meath County Council
Project No.: 26/031

All dimensions on this sheet are in metres unless otherwise stated

Method and Equipment:: JCB 4CX Backhoe Excavator
Logged by: R. Meehan Date: 04/09/2018
Easting: 282152 Northing: 257214
Ground level OD: 59.8m

Samples & in-situ tests			Result Peak (Residual)	Water	Strata details			
Depth taken	Type	No			O.D. Level	Legend	Depth	Description
0.1-0.17					59.6			TOPSOIL 'A' horizon: compact, crumb, dark brown (3/3, 10YR) sandy loam with occasional gravels and abundant grass roots and rootlets.
0.34-0.42					59.4			TOPSOIL/SUBSOIL 'B,' horizon: firm, subangular blocky, dark yellowish brown (3/4 10YR), sandy SILT with occasional gravels and occasional grass rootlets.
0.5					59.1			TOPSOIL/SUBSOIL 'B_2t' horizon: firm, massive, dark yellowish brown (4/6 10YR), sandy SILT with abundant gravels.
0.66-0.74								
1.0								'C' horizon (SUBSOIL): very soft to soft, massive, yet fissile, very dark greyish brown (3/2, 10YR), very sandy gravelly SILT with occasional cobbles and boulders.
1.5								
2.0								Pods of SAND up to 0.1m thick and 0.3m long.
2.5								
3.0								
3.05					56.75			**Trial pit completed at 3.05m on very dark greyish brown, massive, yet fissile, very soft to soft, very sandy gravelly SILT with occasional cobbles and boulders (glacial TILL subsoil).**
3.5								
4.0								
4.5								
5.0								

Plan



Bearing : 98° (E-W)

Stability :

Trial pit walls consolidated, and little collapse in side walls following excavation.

General remarks :

Dug in southern portion of the proposed burial ground site, into a dry locality, at one of the lowest points in the landholding. Dug on a 1° slope, falling southwards.

Groundwater :

Dry.

Sequence summary:
Well drained topsoil over a permeable subsoil to 3.05m+ depth.
No bedrock.

Plate A3: Profile of well drained topsoil overlying unmottled very sandy gravelly SILT with occasional cobbles and boulders to 3.05m depth, in trial hole TP3. See the absence of the water table and bedrock at the base of the hole.

Robert Meehan
Consultant Geologist

TRIAL PIT RECORD TP4

Project: Hydrogeology of proposed cemetery at Loganstown

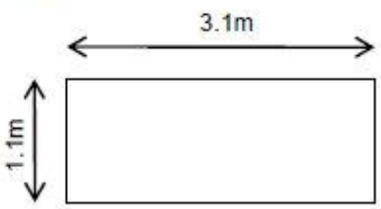
Site: Loganstown
Client: Meath County Council
Project No.: 26/031

All dimensions on this sheet are in metres unless otherwise stated

Method and Equipment:: JCB 4CX Backhoe Excavator
Logged by: R. Meehan Date: 04/09/2018
Easting: 282188 Northing: 257206
Ground level OD: 59.8m

Samples & in-situ tests			Result Peak (Residual)	Water	Strata details			
Depth taken	Type	No			O.D. Level	Legend	Depth	Description
0.1-0.14					59.7			TOPSOIL 'A' horizon: compact, crumb, dark brown (3/3, 10YR) sandy loam with occasional gravels and abundant grass roots and rootlets.
0.5					59.4			TOPSOIL/SUBSOIL 'B_2g horizon: soft to firm, massive, **mottled** yellowish brown (5/6 10YR) and light bluish grey (8/1, GLEY 2). SAND.
0.73-0.89					59.1			
1.0								'Cg' horizon (SUBSOIL): very soft to firm, massive, yet fissile, **mottled** yellowish brown (5/6, 10YR), very dark greyish brown (3/2, 10YR) and light bluish grey (6/1, 10YR), very sandy gravelly SILT with occasional cobbles and boulders.
1.5								
2.0								Pods of silty SAND with abundant gravels up to 0.3m thick and 2.3m long.
2.5								
2.9					56.9			
3.0								**Trial pit completed at 2.9m on mottled yellowish brown, very dark greyish brown and light bluish grey, massive, yet fissile, very soft to firm, very sandy gravelly SILT with occasional cobbles and boulders (glacial TILL subsoil).**
3.5								
4.0								
4.5								
5.0								

Plan



Bearing : 86° (E-W)

Stability :

Trial pit walls consolidated, but some collapse in side walls following excavation.

General remarks :

Dug in southeastern portion of the proposed burial ground site, into a dry locality, at one of the lowest points in the landholding. Dug on a 1° slope, falling southwestwards.

Groundwater :

Seep in basal 0.05m of holes means groundwater ingress to 2.72m bgl, 2 house after excavation.

Sequence summary:
Poorly drained topsoil over a permeable subsoil to 2.9m+ depth.
No bedrock.

Plate A4: Profile of poorly drained topsoil overlying mottled very sandy gravelly SILT with occasional cobbles and boulders to 2.9m depth, in trial hole TP4. See the presence of the water table at the base of the hole.

Robert Meehan
Consultant Geologist

TRIAL PIT RECORD TP5

Project: Hydrogeology of proposed cemetery at Loganstown

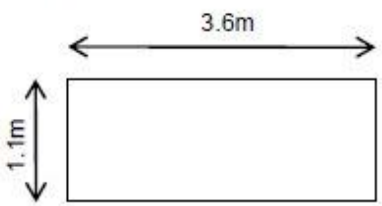
Site: Loganstown
Client: Meath County Council
Project No.: 26/031

All dimensions on this sheet are in metres unless otherwise stated

Method and Equipment:: JCB 4CX Backhoe Excavator
Logged by: R. Meehan Date: 04/09/2018
Easting: 282205 Northing: 257253
Ground level OD: 61.2m

Samples & in-situ tests			Result Peak (Residual)	Water	Strata details			
Depth taken	Type	No			O.D. Level	Legend	Depth	Description
0.1-0.15					61.1			TOPSOIL'A' horizon: compact, crumb, very dark brown (2/2, 10YR) organic sandy loam with abundant grass roots and rootlets.
0.38-0.41								TOPSOIL/SUBSOIL 'B$_1$' horizon: firm to stiff, subangular blocky, yellowish brown (4/5 10YR), slightly sandy SILT with occasional grass rootlets.
0.5					60.8			TOPSOIL/SUBSOIL 'B$_2$t horizon: stiff, massive, light brown (6/4 10YR), SILT with occasional gravels.
0.71-0.85								
1.0								'C' horizon (SUBSOIL): very soft to soft, massive, yet fissile, dark brown (3/3, 10YR), gravelly silty SAND with occasional cobbles and boulders.
1.5								
2.0								Pods of silty SAND up to 0.15m thick and 0.6m long.
2.5								
3.0								
3.2					58.0			**Trial pit completed at 3.2m on dark brown, massive, yet fissile, very soft to soft, gravelly silty SAND with occasional cobbles and boulders (glacial TILL subsoil).**
3.5								
4.0								
4.5								
5.0								

Plan



Bearing : 342º (NNW-SSE)

Stability :

Trial pit walls consolidated, and little collapse in side walls following excavation.

General remarks :

Dug in southeastern portion of the proposed burial ground site, into a dry locality, on relatively high ground within the landholding. Dug on a 3º slope, falling southwestwards.

Groundwater :

Dry.

Sequence summary:
Well drained topsoil over a permeable subsoil to 3.2m+ depth.
No bedrock.

Plate A5: Profile of well drained topsoil overlying unmottled gravelly silty SAND with occasional cobbles and boulders to 3.2m depth, in trial hole TP5. See the absence of the water table and bedrock at the base of the hole.

Robert Meehan
Consultant Geologist

TRIAL PIT RECORD TP6

Project: Hydrogeology of proposed cemetery at Loganstown

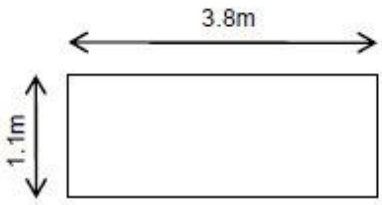
Site: Loganstown
Client: Meath County Council
Project No.: 26/031

All dimensions on this sheet are in metres unless otherwise stated

Method and Equipment:: JCB 4CX Backhoe Excavator
Logged by: R. Meehan Date: 04/09/2018
Easting: 282164 Northing: 257264
Ground level OD: 60.8m

Samples & in-situ tests			Result Peak (Residual)	Water	Strata details			
Depth taken	Type	No			O.D. Level	Legend	Depth	Description
0.12-0.18					60.6			TOPSOIL'A' horizon: compact, crumb, very dark brown (2/2, 10YR) loam with abundant grass roots and rootlets.
0.35-0.38								TOPSOIL/SUBSOIL 'B,' horizon: soft to firm, subangular blocky, very dark brown (2/2, 10YR), sandy SILT with abundant gravels, and occasional grass rootlets.
0.5					60.4			TOPSOIL/SUBSOIL 'B_2t' horizon: firm, massive, dark yellowish brown (4/6 10YR), sandy SILT with abundant gravels.
0.56-0.74					60.1			
1.0								'C' horizon (SUBSOIL): very soft to soft, massive, yet fissile, dark brown (3/3, 10YR), sandy SILT with abundant gravels and occasional cobbles and boulders.
1.5								
2.0								Pods of SAND up to 0.3m across.
2.5								
3.0								
3.15					57.65			**Trial pit completed at 3.15m on dark brown, massive, yet fissile, very soft to soft, sandy SILT with abundant gravels and occasional cobbles and boulders (glacial TILL subsoil).**
3.5								
4.0								
4.5								
5.0								

Plan



Bearing : 74° (W-E)

Stability :

Trial pit walls consolidated, and little collapse in side walls following excavation.

General remarks :

Dug in south central portion of the proposed burial ground site, into a dry locality, on relatively high ground within the landholding. Dug on a 3° slope, falling southwestwards.

Groundwater :

Dry.

Sequence summary:
Well drained topsoil over a permeable subsoil to 3.15m+ depth.
No bedrock.

Plate A6: Profile of well drained topsoil overlying unmottled sandy SILT with abundant gravels and occasional cobbles and boulders to 3.15m depth, in trial hole TP6. See the absence of the water table and bedrock at the base of the hole.

Robert Meehan
Consultant Geologist

TRIAL PIT RECORD TP7

Project: Hydrogeology of proposed cemetery at Loganstown

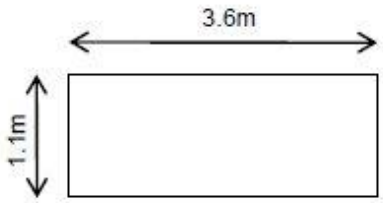
Site: Loganstown
Client: Meath County Council
Project No.: 26/031

All dimensions on this sheet are in metres unless otherwise stated

Method and Equipment:: JCB 4CX Backhoe Excavator
Logged by: R. Meehan Date: 04/09/2018
Easting: 282120 Northing: 257281
Ground level OD: 60.4m

Samples & in-situ tests			Result Peak (Residual)	Water	Strata details			
Depth taken	Type	No			O.D. Level	Legend	Depth	Description
0.11-0.13					60.3			TOPSOIL 'A' horizon: compact, crumb, dark brown (3/3, 10YR) organic loam with abundant grass roots and rootlets.
0.5 0.5-0.55					59.9			TOPSOIL/SUBSOIL 'B' horizon: firm to stiff, subangular blocky, dark brown (3/3, 10YR), sandy SILT with occasional gravels, and occasional grass rootlets.
1.0								
1.5								'C' horizon (SUBSOIL): very soft, massive, yet fissile, dark brown (3/3, 10YR), sandy gravelly SILT with occasional cobbles and boulders.
2.0								Wide, long beds of gravelly SAND up to 0.3m across at 2.0m-2.6m depth.
2.5								
3.0					57.4			**Trial pit completed at 3.0m on dark brown, massive, yet fissile, very soft, sandy gravelly SILT with occasional cobbles and boulders (glacial TILL subsoil).**
3.5								
4.0								
4.5								
5.0								

Plan



Bearing : 74° (W-E)

Stability :

Trial pit walls consolidated, and little collapse in side walls following excavation.

General remarks :

Dug in south central portion of the proposed burial ground site, into a dry locality, on relatively high ground within the landholding. Dug on a 2° slope, falling southwards.

Groundwater :

Dry.

Sequence summary:
Well drained topsoil over a permeable subsoil to 3.0m+ depth.
No bedrock.

Plate A7: Profile of well drained topsoil overlying unmottled sandy gravelly SILT with occasional cobbles and boulders to 3.0m depth, in trial hole TP7. See the absence of the water table and bedrock at the base of the hole.

Robert Meehan
Consultant Geologist

TRIAL PIT RECORD TP8

Project: Hydrogeology of proposed cemetery at Loganstown

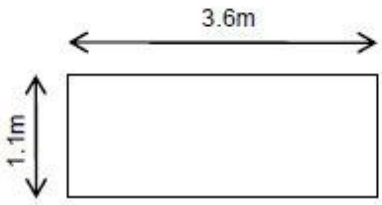
Site: Loganstown
Client: Meath County Council
Project No.: 26/031

All dimensions on this sheet are in metres unless otherwise stated

Method and Equipment:: JCB 4CX Backhoe Excavator
Logged by: R. Meehan Date: 04/09/2018
Easting: 282054 Northing: 257302
Ground level OD: 60.6m

Samples & in-situ tests			Result Peak (Residual)	Water	Strata details			
Depth taken	Type	No			O.D. Level	Legend	Depth	Description
0.11-0.16					60.5			TOPSOIL 'A' horizon: compact, crumb, dark brown (3/3, 10YR) loam with abundant grass roots and rootlets.
0.36-0.45					60.2			TOPSOIL/SUBSOIL 'B$_1$' horizon: firm to stiff, subangular blocky, dark yellowish brown (4/5, 10YR), SILT with occasional gravels, and occasional grass rootlets.
0.5								TOPSOIL/SUBSOIL 'B$_2$t' horizon: firm, massive, light brown (6/8, 10YR) sandy SILT with occasional gravels.
1.0 1.03-1.12								
1.5								'C' horizon (SUBSOIL): very soft to soft, massive, yet fissile, dark brown (3/3, 10YR), gravelly silty SAND with occasional cobbles and boulders.
2.0								Pods of SAND up to 0.1m across.
2.5								
3.0					57.6			**Trial pit completed at 3.0m on dark brown, massive, yet fissile, very soft to soft, gravelly silty SAND with occasional cobbles and boulders (glacial TILL subsoil).**
3.5								
4.0								
4.5								
5.0								

Plan



Bearing : 106º (WNW-ESE)

Stability :

Trial pit walls consolidated, and little collapse in side walls following excavation.

General remarks :

Dug in southwestern portion of the proposed burial ground site, into a dry locality, on relatively high ground within the landholding. Dug on a 2º slope, falling southwards.

Groundwater :

Dry.

Sequence summary:
Well drained topsoil over a permeable subsoil to 3.0m+ depth.
No bedrock.

Plate A8: Profile of well drained topsoil overlying unmottled gravelly silty SAND with occasional cobbles and boulders to 3.0m depth, in trial hole TP8. See the absence of the water table and bedrock at the base of the hole.

Robert Meehan
Consultant Geologist

TRIAL PIT RECORD TP9

Project: Hydrogeology of proposed cemetery at Loganstown

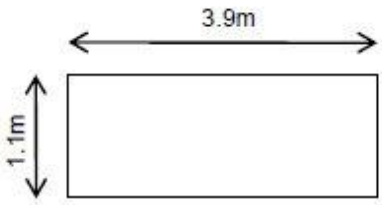
Site: Loganstown
Client: Meath County Council
Project No.: 26/031

All dimensions on this sheet are in metres unless otherwise stated

Method and Equipment:: JCB 4CX Backhoe Excavator
Logged by: R. Meehan Date: 04/09/2018
Easting: 282052 Northing: 257346
Ground level OD: 61.4m

Samples & in-situ tests			Result Peak (Residual)	Water	Strata details			
Depth taken	Type	No			O.D. Level	Legend	Depth	Description
0.1-0.16					61.3			TOPSOIL'A' horizon: compact, crumb, dark brown (3/3, 10YR) loam with abundant grass roots and rootlets.
0.4-0.43					61.0			TOPSOIL/SUBSOIL 'B$_1$' horizon: firm to stiff, subangular blocky, yellowish brown (5/5, 10YR), sandy SILT with occasional gravels, and occasional grass rootlets.
0.5								TOPSOIL/SUBSOIL 'B$_2$t' horizon: stiff, massive, dark brown (3/3, 10YR) slightly sandy SILT/CLAY with occasional gravels.
0.77-0.84								
1.0								'C' horizon (SUBSOIL): very soft to soft, massive, yet fissile, dark brown (3/3, 10YR), very sandy gravelly SILT with occasional cobbles and boulders.
1.5								Pods of silty SAND up to 0.3m across.
2.0								
2.5								
3.0					58.4			**Trial pit completed at 3.0m on dark brown, massive, yet fissile, very soft to soft, very sandy gravelly SILT with occasional cobbles and boulders (glacial TILL subsoil).**
3.5								
4.0								
4.5								
5.0								

Plan



Bearing : 86° (W-E)

Stability :

Trial pit walls consolidated, and little collapse in side walls following excavation.

General remarks :

Dug in western portion of the proposed burial ground site, into a dry locality, on relatively high ground within the landholding. Dug on a 1° slope, falling southwards.

Groundwater :

Dry.

Sequence summary:
Well drained topsoil over a permeable subsoil to 3.0m+ depth.
No bedrock.

Plate A9: Profile of well drained topsoil overlying unmottled very sandy gravelly SILT with occasional cobbles and boulders to 3.0m depth, in trial hole TP9. See the absence of the water table and bedrock at the base of the hole.

Robert Meehan
Consultant Geologist

TRIAL PIT RECORD TP10

Project: Hydrogeology of proposed cemetery at Loganstown

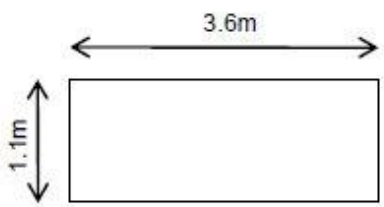
Site: Loganstown
Client: Meath County Council
Project No.: 26/031

All dimensions on this sheet are in metres unless otherwise stated

Method and Equipment:: JCB 4CX Backhoe Excavator
Logged by: R. Meehan Date: 04/09/2018
Easting: 282113 Northing: 257342
Ground level OD: 61.5m

Samples & in-situ tests			Result Peak (Residual)	Water	Strata details			
Depth taken	Type	No			O.D. Level	Legend	Depth	Description
0.1-0.15					61.4			TOPSOIL'A' horizon: compact, crumb, dark brown (3/3, 10YR) sandy loam with abundant grass roots and rootlets.
0.4-0.5					61.0			TOPSOIL/SUBSOIL 'B' horizon: firm to stiff, subangular blocky, brown (4/3, 10YR) sandy gravelly SILT with occasional grass rootlets.
1.0								'C' horizon (SUBSOIL): very soft to soft, massive, yet fissile, dark brown (3/3, 10YR), very sandy gravelly SILT with occasional cobbles and boulders.
1.5								Pods of silty SAND up to 0.3m across.
2.0								
2.5								
3.0					58.4			**Trial pit completed at 3.0m on dark brown, massive, yet fissile, very soft to soft, very sandy gravelly SILT with occasional cobbles and boulders (glacial TILL subsoil).**
3.5								
4.0								
4.5								
5.0								

Plan



Bearing : 94° (W-E)

Stability :

Trial pit walls consolidated, and little collapse in side walls following excavation.

General remarks :

Dug in eastern edge of a marked hollow in the proposed burial ground site, into a dry locality, still on relatively high ground within the landholding. Dug on a 2° slope, falling westwards.

Groundwater :

Dry.

Sequence summary:
Well drained topsoil over a permeable subsoil to 3.0m+ depth.
No bedrock.

Plate A10: Profile of well drained topsoil overlying unmottled very sandy gravelly SILT with occasional cobbles and boulders to 3.0m depth, in trial hole TP10. See the absence of the water table and bedrock at the base of the hole.

Robert Meehan
Consultant Geologist

TRIAL PIT RECORD TP11

Project: Hydrogeology of proposed cemetery at Loganstown

Site: Loganstown
Client: Meath County Council
Project No.: 26/031

All dimensions on this sheet are in metres unless otherwise stated

Method and Equipment:: JCB 4CX Backhoe Excavator

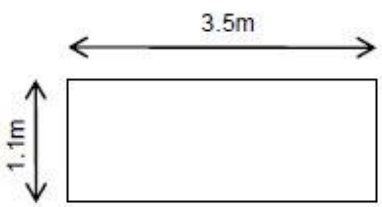
Logged by: R. Meehan Date: 04/09/2018

Easting: 282162 Northing: 257335

Ground level OD: 62.2m

Samples & in-situ tests			Result Peak (Residual)	Water	Strata details			
Depth taken	Type	No			O.D. Level	Legend	Depth	Description
0.13-0.16					62.1			TOPSOIL'A' horizon: compact, crumb, brown (4/3, 10YR) loam with abundant grass roots and rootlets.
0.31-0.35					61.9			TOPSOIL/SUBSOIL 'B' horizon: firm, subangular blocky, brown (4/3, 10YR) sandy SILT with abundant gravels and abundant grass rootlets.
0.5								
1.0								
1.5								'C' horizon (SUBSOIL): very soft, granular, very dark greyish brown (3/2, 10YR), SAND with occasional gravels.
2.0								Pods of sandy GRAVEL in places, up to 0.25m across.
2.5								
3.0					59.2			**Trial pit completed at 3.0m on very dark greyish brown, massive, yet fissile, very soft, SAND with occasional gravels (glaciofluvial SAND subsoil).**
3.5								
4.0								
4.5								
5.0								

Plan



Bearing : 78° (W-E)

Stability :

Trial pit walls consolidated, and little collapse in side walls following excavation.

General remarks :

Dug in western edge of a marked hillock in the proposed burial ground site, into a dry locality, on relatively high ground within the landholding. Dug on a 1° slope, falling westwards.

Groundwater :

Dry.

Sequence summary:
Well drained topsoil over a permeable subsoil to 3.0m+ depth.
No bedrock.

Plate A11: Profile of well drained topsoil overlying unmottled SAND with occasional gravels to 3.0m depth, in trial hole TP11. See the absence of the water table and bedrock at the base of the hole.

Robert Meehan
Consultant Geologist

TRIAL PIT RECORD TP12

Project: Hydrogeology of proposed cemetery at Loganstown

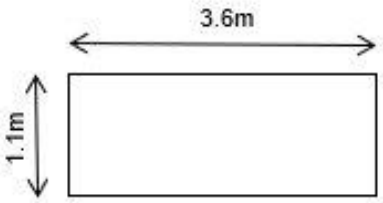
Site: Loganstown
Client: Meath County Council
Project No.: 26/031

All dimensions on this sheet are in metres unless otherwise stated

Method and Equipment:: JCB 4CX Backhoe Excavator
Logged by: R. Meehan Date: 04/09/2018
Easting: 282162 Northing: 257335
Ground level OD: 62.6m

Samples & in-situ tests			Result Peak (Residual)	Water	Strata details			
Depth taken	Type	No			O.D. Level	Legend	Depth	Description
0.13-0.16					62.5			TOPSOIL/'A' horizon: compact, crumb, brown (4/3, 10YR) loam with abundant grass roots and rootlets.
0.31-0.35					62.3			TOPSOIL/subSOIL 'B' horizon: firm, subangular blocky, brown (4/3, 10YR) sandy SILT with abundant gravels and abundant grass rootlets.
0.5								
1.0								
1.5								'C' horizon (SUBSOIL): very soft, granular, very dark greyish brown (3/2, 10YR), SAND with occasional gravels.
2.0								Pods of sandy GRAVEL in places, up to 0.4m across.
2.5								
3.0					59.6			**Trial pit completed at 3.0m on very dark greyish brown, massive, yet fissile, very soft, SAND with occasional gravels (glaciofluvial SAND subsoil).**
3.5								
4.0								
4.5								
5.0								

Plan



Bearing : 84° (W-E)

Stability :

Trial pit walls consolidated, and little collapse in side walls following excavation.

General remarks :

Dug in western shoulder of a marked hillock in the proposed burial ground site, into a dry locality, on relatively high ground within the landholding. Dug on a 1° slope, falling westwards.

Groundwater :

Dry.

Sequence summary:
Well drained topsoil over a permeable subsoil to 3.0m+ depth.
No bedrock.

Plate A12: Profile of well drained topsoil overlying unmottled SAND with occasional gravels to 3.0m depth, in trial hole TP12. See the absence of the water table and bedrock at the base of the hole.

Appendix B
Methodology for Burial Ground Risk Assessment

In Ireland, there has been little attention given to the risk assessment of cemeteries. A preliminary study was conducted for Cork County Council in 1998 by David Ball, Consultant Hydrogeologist, for a proposed burial ground development at Killeen in County Cork, which gives an excellent basis for risk assessment under Irish conditions and was referred to in this current study. As well as this, the author has prepared a risk assessment for a proposed cemetery extension at Dalgan Park, Navan, County Meath (Meehan, 2008), the existing cemetery at Robinrath, Navan (January 2009), and a proposed cemetery extension at Rush, Dunboyne (December 2013). In order to outline a complete risk assessment framework, consultation with documents from Britain was also required.

The Environment Agency Guidance Document (2004) provides much of the material required to structure a risk assessment under Irish conditions. A three-tiered approach to assessing the risk from cemeteries is recommended. Each tier of the risk assessment involves the same series of stages, namely:

- hazard identification;
- identification of consequences;
- magnitude of consequences;
- probability of consequences;
- significance of risk.

The three tiers are the risk screening tier (desk study), the preliminary quantitative risk assessment tier (detailed desk study and preliminary site investigation), and a detailed quantitative risk assessment. Sites are ranked as having low, intermediate (moderate) or high risk. Only sites which comes up as intermediate risk or higher in tier 1 qualify for tiers 2 and 3, and only those sites considered high/uncertain risk in tier 2 qualify for tier 3 assessment.

It is notable that these recommendations do not take into account the flow direction of groundwater. Risk assessments in Ireland, for example that for On-Site Wastewater Treatment Systems and for Landfills, use the Source-Pathway-Receptor Model for Risk Assessment, which always takes into account groundwater flow direction. This means a more knowledge-based (and, eventually, less restrictive) approach to the screening of sites at risk. From this, a combination of the relevant portions of the Environment Agency report, as well as utilising some of the methodology of Irish Site Characterisation and Assessment, were used in this study at Loganstown. The three tier assessment procedure was employed, involving desk study, site characterisation and risk quantitative assessment, and buffers were considered using an assessment of groundwater flow direction as for assessments for installations such as On-Site Wastewater Treatment Systems and Landfills.

Appendix C
Quantification of contaminant loading in proposed burial ground at Loganstown

Data are supplied by the British Environment Agency in their Guidance Document (2004) on the composition rate of corpses and potential pollution releases, reproduced in Table 1.

Composition	*Percentage Weight*
Water	64
Protein	20
Carbohydrate	1
Mineral salts	5
Fat	10
Elemental Component	*Mass (g)*
Oxygen	43000
Carbon	16000
Hydrogen	7000
Nitrogen	1800
Calcium	1100
Phosphorous	500
Sulphur	140
Potassium	140
Sodium	100
Chlorine	95
Magnesium	19
Iron	4.2
Copper	0.07
Lead	0.12
Cadmium	0.05
Nickel	0.01
Uranium	0.00009
Total body mass	**70000**

Table 1: Composition and elemental components of an average human body (70kg).

These pollutants derived from bodies are found as dissolved and gaseous organic compounds and dissolved nitrogenous forms (particularly ammoniacal nitrogen).

When examining bodies in terms of their rate of degradation, it is seen that 60% of the material is readily degradable, 15% is moderately degradable, 20% is slowly degradable and 5% is non-degradable. Those proportions that are non-degradable, as well as much that is slowly degradable, may be considered inert (ashes forming final stable residue, and bones).

The primary process governing the production, release and potential migration of pollutants from a buried corpse is microbial decay. The rate of decay depends on the extent of microbial growth and activity, which is in turn affected by the availability of nutrients and moisture, climate, soil lithology and burial practice. Therefore, in Irelands' wet, temperate climate, the vast majority of the mass of a human body is readily degradable, given that a well drained, porous subsoil medium forms the receiving environment.

The die off of pathogens will occur naturally and will rapidly decrease in concentration with increasing distance from the grave.

A human corpse normally decays within 10 to 12 years. It is estimated that over half of the pollutant load leaches within the first year and halves year on year (Environment Agency, 2004). Less that 0.1% of the original loading may remain after 10 years.

Year	*TOC*	*NH_4*	*Ca*	*Mg*	*Na*	*K*	*P*	*SO_4*	*Cl*	*Fe*
1	6.00	0.87	0.56	0.010	0.050	0.070	0.250	0.210	0.048	0.020
2	3.00	0.44	0.28	0.005	0.025	0.035	0.125	0.110	0.024	0.010
3	1.50	0.22	0.14	0.003	0.013	0.018	0.063	0.054	0.012	0.005
4	0.75	0.11	0.07	0.001	0.006	0.009	0.032	0.027	0.006	0.003
5	0.37	0.05	0.03	<0.001	0.003	0.004	0.016	0.012	0.003	0.001
6	0.19	0.03	0.02	<0.001	0.002	0.002	0.008	0.006	0.002	<0.001
7	0.10	0.01	0.01	<0.001	0.001	0.001	0.004	0.003	<0.001	<0.001
8	0.05	<0.01	<0.01	<0.001	<0.001	<0.001	0.002	0.001	<0.001	<0.001
9	0.02	<0.01	<0.01	<0.001	<0.001	<0.001	0.001	<0.001	<0.001	<0.001
10	0.01	<0.01	<0.01	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

Table 2: Potential contaminant release (kg) from a single 70kg human burial.