4 Doolittle Mill
Froghall Road
Ampthill
Bedfordshire
MK45 2ND

Tel: 01525 307060

Email: richard.earl@tgms.co.uk
Web: www.tgms.co.uk

EAST STAFFORDSHIRE BOROUGH COUNCIL

A report on a Tier 2 hydrological risk assessment of the viability of extending Stapenhill Cemetery.

24th May 2021

TGMS1163.3

TGMS and PSD Agronomy are trading names of Professional Sportsturf Design (North West) Ltd.
Company number: 01957538.
Registered Office: Wigan Road, Leyland, Lancashire, PR25 5XW.
Director: Charles Henderson

REVISION RECORD					
Rev	**Date**	**Description**	**Prepared**	**Checked**	**Approved**
0	24/05/21	Document Creation	RE	MY	MY

Please note: The aim of this report is to appraise the current conditions on site at the site specified in 'Physical Site Survey' below only. This is not a design document and does not include detailed design or design information and should not be used for this purpose. TGMS accepts no design liability or responsibility for subsequent works based on the information contained within this report.

TABLE OF CONTENTS

1 EXECUTIVE SUMMARY STAPENHILL CEMETERY

KEY: **No action required** **Action may be required** **Action required**

1.1 Site information

	1	**Objective:** To undertake a Tier 2 hydrological risk assessment for the proposed conversion of existing allotment land into a new extension to Stapenhill Cemetery, Stapenhill Road, DE15 9AE.
	2	**Site Visits:** A detailed site investigation was conducted on the 2nd February 2021.
	3	**Site location and access:** The site comprises a rectangular plot of allotments which is located immediately adjacent to the north-eastern corner of the existing cemetery and can be accessed via a track at the end of Claverhouse Road off Scalpcliffe Road.
	4	**Current land use:** The plot comprises disused allotments and is bounded by residential properties to the north, pasture land to the east, and the existing cemetery to the south and west.
	5	**Hydrology:** The River Trent is located approximately 500 m north-west of the site, but no watercourses abut or cross the site.
	6	**Climate:** Climate data obtained from the Flood Estimation Handbook (FEH) indicate that the standard-period average annual rainfall (SAAR) = 657 mm for this location; significantly lower than the national average of 885 mm/year.
	7	**Drainage catchment:** Catchment data obtained from the Flood Estimation Handbook (FEH) Web Service indicate that the site forms part of a 3,103 km^2 catchment with an outlet into the River Trent near the cemetery entrance approximately 500 m to the west of the site.
	8	**Predicted land drainage rates:** The predicted drainage rates for the site are generally close to the Greenfield runoff rates and so installation of a new drainage scheme, should one be required, would not cause significantly faster or greater flow than the Greenfield condition. Drainage design should account for at least the 1:30 return period outfall rate of 5.2 l/s/ha for the site over a 24-hour period.
	9	**Risk of flooding from rivers and seas:** Based on information obtained from Gov.uk, the site has a very low risk of flooding from rivers and seas with a probability of flooding of less than 1 in 1000 (<0.1%).
	10	**Risk of flooding from surface water:** Based on information obtained from Gov.uk, the site has a very low risk of flooding from surface water with a probability of flooding of less than 1 in 1000 aside from some minor flow down Claverhouse Road.
	11	**Groundwater vulnerability:** Based on information obtained from magic.defra.gov.uk, the site is not located within a Groundwater Source Protection Zone.
	12	**Landfill:** Based on information from data.gov.uk, the site is not located in an area of historic or permitted landfill.
	13	**Soil map:** According to Sheet 3 of the Soil Survey of England and Wales (SSEW) 1:250,000 soil map (1983), the indigenous soil in this area forms part of the HODNET Association. The geological origin of this Soil Association is Permo-Triassic and Carboniferous reddish mudstone, siltstone and sandstone and it is characterised by reddish fine and coarse loamy soils with slowly permeable subsoils and slight seasonal waterlogging. Some similar well drained reddish fine loamy soils, slight risk of water erosion.
	14	**Geology:** Data from the British Geological Survey indicate that the site is underlain by the Tarporley Siltstone Formation of the Mercia Mudstone Group. This unit comprises reddish brown to green-grey, laminated and micaceous siltstones interbedded with thin beds of mudstone (containing sporadic gypsum nodules) or sandstone. The thickness of this unit is not known with any certainty but estimated to be several metres. This is underlain by the Helsby Sandstone Formation which consists of beds of red-brown, buff or greenish grey, fine- to medium-grained sandstone, with interbeds of red-brown mudstone. The full thickness of the Helsby Sandstone Formation unit beneath the site is not known due to a paucity of adjacent borehole information coupled with the regional structural complexity. Examination of the elevation range that the unit crops-out to in the west indicates that the unit is at least 25 m thick beneath the site.
	15	**Hydrogeology:** The proposed development area is underlain by the Tarporley Siltstone Formation (of the Mercia Mudstone Group) which consists predominantly of siltstones interbedded with low permeability mudstones and more permeable sandstones which may contain and transmit groundwater predominantly through fracture flow. Therefore, small amounts of groundwater may be encountered where recharge is slowed by low permeability mudstones, and forms a perched water table in the sandstone and siltstone horizons above.
	16	**Water well records:** With reference to the Environment Agency's stipulation that no interments shall occur within 250 metres of any spring, well or borehole used as a source of drinking water, data from the British Geological Survey indicate that there is only one borehole / well in the vicinity

		of the cemetery extension area which was drilled in 1884 and so there is a need to establish whether this is no longer operational in order to meet the Environment Agency's criterion. It is unlikely to still be operational as it appears to be located in the adjacent field.
	17	**Topography:** The highest part of the site (74.50 m above ordnance datum (AOD)) occurs at the south-eastern corner. The land falls from east to west with the lowest elevated land located in the north-western corner at approximately 68.50 m AOD, which equates to a gradient of circa. 4%.
	18	**Soils:** The site typically comprises 0.25 m of CLAY LOAM topsoil (aside from the car park area) over red CLAY LOAM or SANDY SILT LOAM subsoil to between 1.5 to 1.8 m over argillaceous micaceous fine-grained SANDSTONE.
	19	**Dipwell monitoring:** Dipwell monitoring results indicate that the site does not meet the Environment Agency's minimum criterion of one metre of unsaturated soil beneath maximum interment depth.
	20	**Revised risk assessment:** A desk-based risk assessment of the site conducted by TGMS (September 2020) has been revised following the input of information emanating from this detailed site investigation. The site Vulnerability Ranking is confirmed as 'Moderate', and the level of risk just falls from 'High' to 'Moderate'. It is concluded that although the level of risk is 'Moderate', given that the proposed extension area abuts the existing cemetery and that there have been no historic pollution incidents, then the risk to the environment can be considered to be 'Low' provided that the surface levels are increased by; ~1.33 m in the south-east, ~1.18 m towards the centre, and 1.03 m in the north-west.
	21	**Potential grave numbers:** TGMS has previously produced a conceptual layout for the proposed cemetery extension. This arrangement provides 2,314 adult grave plots, and so at the anticipated rate of demand of 30 new graves per year, this new extension site potentially offers capacity for new adult graves for approximately 77 years.

1.2 Recommendations

In summary, the site typically comprises 0.25 m of CLAY LOAM topsoil (aside from the car park area) over red CLAY LOAM or SANDY SILT LOAM subsoil to between 1.5 to 1.8 m over argillaceous micaceous fine-grained SANDSTONE.

Dipwell monitoring results indicate that the site does not meet the Environment Agency's minimum criterion of one metre of unsaturated soil beneath maximum interment depth. Moreover, given the presence of shallow sandstone encountered in TP1, TP2 and TP3 at 1.5 m, 1.7 m and 1.8 m respectively, the site does not meet two further criteria:

1. 1 m of subsoil below the base of the burial pit.

2. Graves should not be dug in unaltered or unweathered bedrock. This is solid rock which can be buried or exposed at the earth's surface, and which has not been altered by physical or chemical reactions (or both), such as exposure to the weather.

In order to meet the three criteria discussed above, it is therefore proposed that the surface level of the cemetery extension is raised through the importation of inert subsoil and topsoil to achieve at least 2.83 m of unsaturated soil above the sandstone bedrock. This equates to raising levels by a minimum of 1.33 m, 1.18 m and 1.03 m at TP1, TP2 and TP3 respectively.

Dr Richard Earl – May 2021

2 INTRODUCTION AND OBJECTIVES

TGMS has been commissioned by East Staffordshire Borough Council to undertake a Tier 2 hydrological risk assessment for the proposed conversion of existing allotment land into a new extension to Stapenhill Cemetery, Stapenhill Road, DE15 9AE.

2.1 Tier 1 risk assessment

A desk-based Tier 1 hydrogeological risk assessment conducted by TGMS (September 2020) concluded that the proposed development of this site as a cemetery would constitute a 'High' risk to groundwater. Although the site Vulnerability Ranking derived in that assessment was 'Moderate', the overall risk to groundwater was adjusted up to 'High' mainly as a result of:

- The absence of Drift covering the site.
- The shallow depth to the water table (5 to 10 m).
- The site's location over a secondary aquifer.
- The mix of Intergranular / fissure flow through the underlying Tarporley Siltstone Formation
- The number of anticipated interments per year (50).

2.2 Objectives

The proposed extension area is conveniently located near the existing cemetery however as the level of risk of water contamination is considered to be 'High', it is recommended that the following detailed site investigations are conducted in order to gain a better understanding of the degree of risk and potential for mitigating it:

1. Using the existing levels survey to provide a basis for establishing the most appropriate locations for excavating test pits down to a maximum depth of 3.5 m and installing a minimum of three dip wells to monitor groundwater levels.
2. An assessment of the soil profile pits, and to 'window sample' material removed during the boring of the dip wells, in terms of the type, condition and physical properties of the soil exposed. The results would be used to determine factors that may influence the appropriateness of the site for burial purposes and the vulnerability of the environment to contamination from the proposed development.
3. Monitor the groundwater levels in the dip wells over a winter period, i.e. during the period of highest rainfall.
4. Confirmation that the well / borehole sunk in 1884 in land to the east of the site is no longer operational.

If observations from the proposed detailed site investigation, and/or mitigation measures, can be used to reduce the risk of water contamination from 'High' to 'Moderate', the Environment Agency would still require the adoption of the following safeguards / criteria for graves:

- >50 m away from any well, spring or borehole, irrespective of its current use.
- >250 m away from any spring, well or borehole where the water is intended for human consumption or used in food production.
- >30 m away from any other spring or water course.
- >10 m from any field drain.
- 1 m of subsoil below the base of the burial pit.
- When first dug, the bottom of the hole must be free of standing water.

3 PHYSICAL SITE SURVEY

TGMS has previously conducted a detailed levels survey of the site and this information has been used to produce topographic data to provide a basis for identifying appropriate locations for more detailed investigations to be conducted. Dr Richard Earl of TGMS conducted a detailed site investigation on the 2nd February 2021. Dr Richard Earl, who will act as Lead Consultant for the project, is a Chartered Engineer specialising in soil and water engineering, with over 30 years of relevant professional experience.

3.1 Site location and access

Stapenhill Cemetery	Grid reference (site centre);
38 Stapenhill Road	OS X (Eastings) 426133
Burton-on-Trent	OS Y (Northings) 322832
DE15 9AE	Nearest Post Code DE15 9AD

The site comprises a rectangular plot of allotments which is located immediately adjacent to the north-eastern corner of the existing cemetery and is outlined in red on the aerial view below. The site can be accessed via a track at the end of Claverhouse Road off Scalpcliffe Road (Figure 1).

Figure 1. Site location (within red-dashed line – courtesy of Google Earth Pro). The existing cemetery is outlined in blue. TP1 to TP3 mark the approximate locations of the test pits

The plot is bounded by residential properties to the north, pasture land to the east, and the existing cemetery to the south and west (Figures 2 to 7).

Figure 2. Access track from Claverhouse Road.

Figure 3. General view towards the west.

Figure 4. General view towards the south-east.

Figure 5. General view towards the south.

Figure 6. General view towards the west.

Figure 7. General view towards the north-west.

3.2 Hydrology, climate, geology and hydrogeology

3.2.1 Hydrology

TGMS has previously conducted a levels survey of the development area (Figure 8). The site has a ground elevation of between 67.5 and 74.5 m above ordnance datum (AOD) with the ground surface sloping towards the north-west. This fall of 7 m over 158 m equates to a mean gradient of 4.4%

Figure 8. Levels survey results (0.50 m contours).

The River Trent is located approximately 500 m north-west of the site (Figures 9 and 10), but no watercourses abut or cross the site.

Figure 9. The River Trent.

Figure 10. The River Trent.

3.2.2 Rainfall

Climate data obtained from the Flood Estimation Handbook (FEH) indicate that the standard-period average annual rainfall (SAAR) = 657 mm for this location; significantly lower than the national average of 885 mm/year.

3.2.3 Drainage catchment

Catchment data obtained from the Flood Estimation Handbook (FEH) Web Service indicate that the site forms part of a 3,103 km^2 catchment with an outlet into the River Trent near the cemetery entrance approximately 500 m to the west of the site (Figure 11).

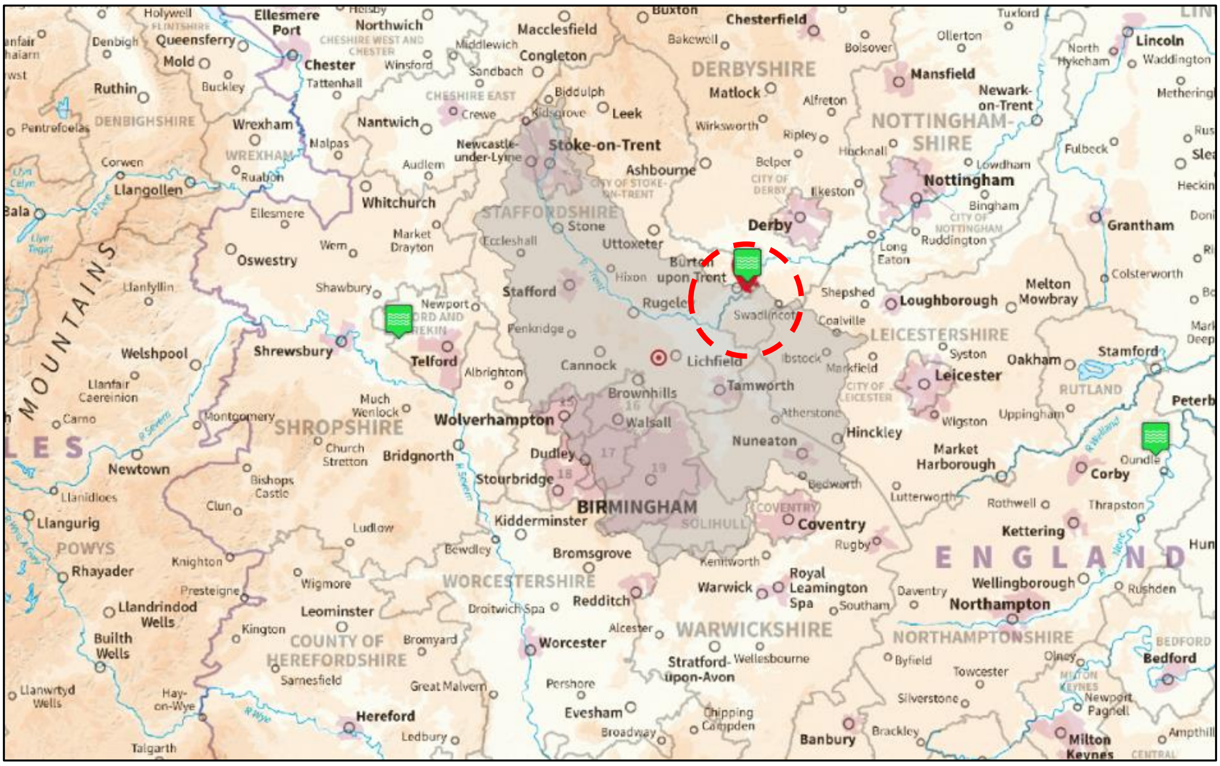


Figure 11. Land drainage catchment (grey polygon) for the site (red circle) and catchment outlet (green marker).

The predicted drainage rates for the site are generally close to the Greenfield runoff rates (Table 1), and so installation of a new drainage scheme, should one be required, would not cause significantly faster or greater flow than the Greenfield condition. Drainage design should account for at least the 1:30 return period outfall rate of 5.2 l/s/ha for the site over a 24-hour period.

Table 1. Greenfield run off rate (FEH method) and drainage outfall rates (ADAS 345 Method) for the proposed extension area for 6 hr and 24 hr duration events for the return periods shown.

Return period	Greenfield Runoff Rate (FEH method) (l/s/ha)	Drainage Outfall Rate (6 hr FEH rainfall event) l/s/ha)	Drainage Outfall Rate (24 hr FEH rainfall event) (l/s/ha)
1:1	2.21	1.5	2.5
1:30	5.32	3.6	5.2
1:100	6.83	4.8	6.6

3.2.4 Risk of flooding from rivers and seas

Based on information obtained from Gov.uk (Figure 12), the site has a very low risk of flooding from rivers and seas with a probability of flooding of less than 1 in 1000 (<0.1%).

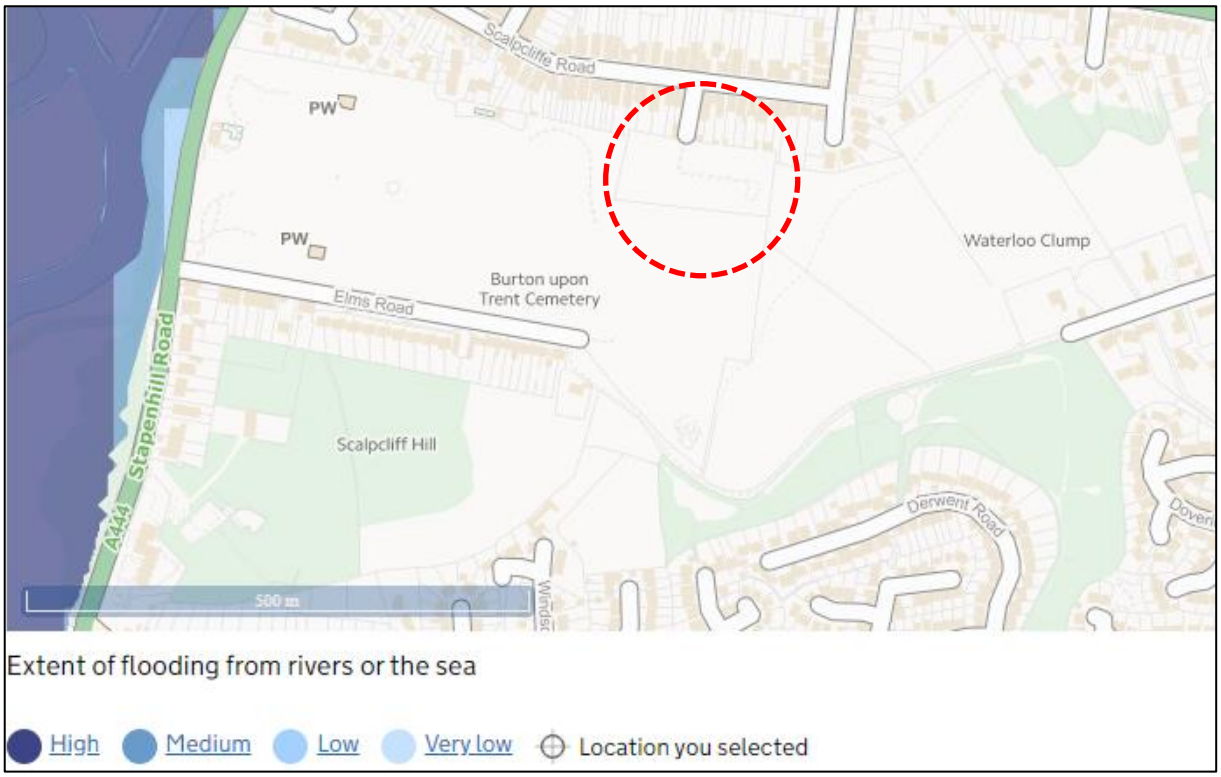


Figure 12. Risk of flooding from rivers or the sea, image courtesy of Gov.uk.

3.2.5 Risk of flooding from surface water

Based on information obtained from Gov.uk (Figure 13), the site has a very low risk of flooding from surface water with a probability of flooding of less than 1 in 1000 aside from some minor flow down Claverhouse Road.

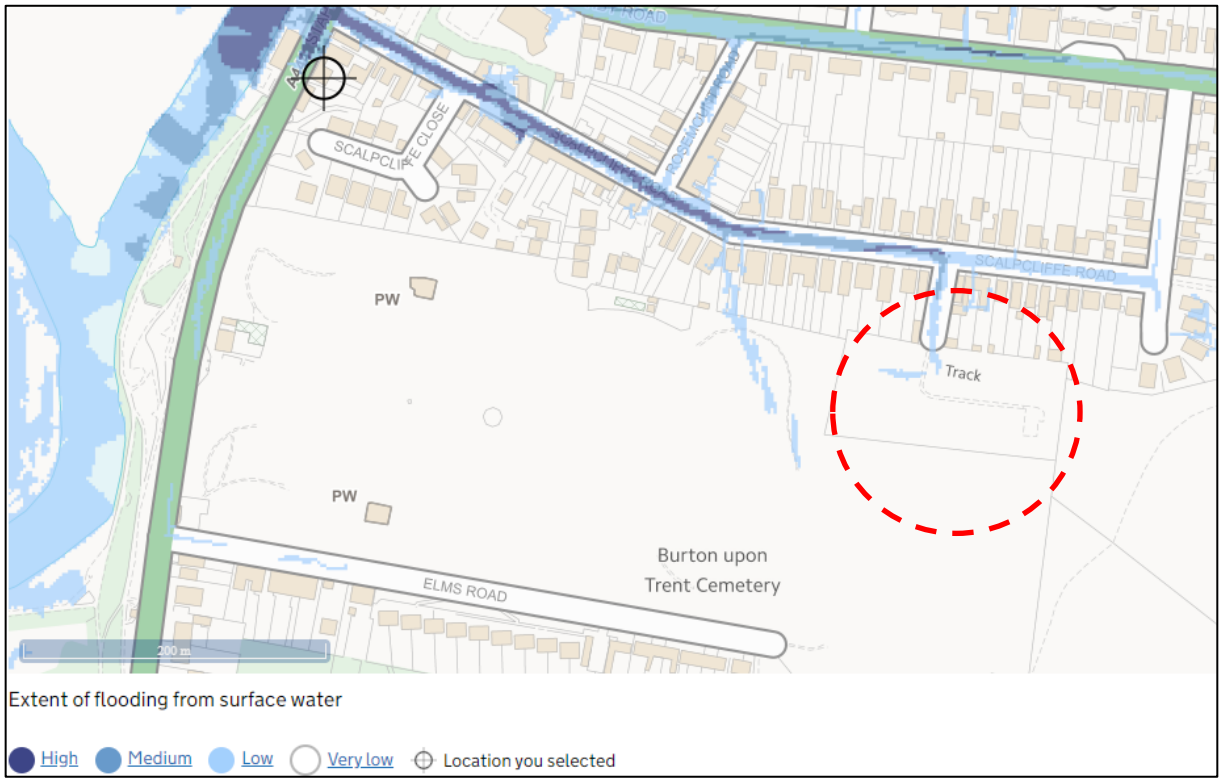


Figure 13. Risk of flooding from surface water. Image courtesy of Gov.uk

3.2.6 Groundwater vulnerability

Based on information obtained from magic.defra.gov.uk, the site is not located within a Groundwater Source Protection Zone (Figure 14).

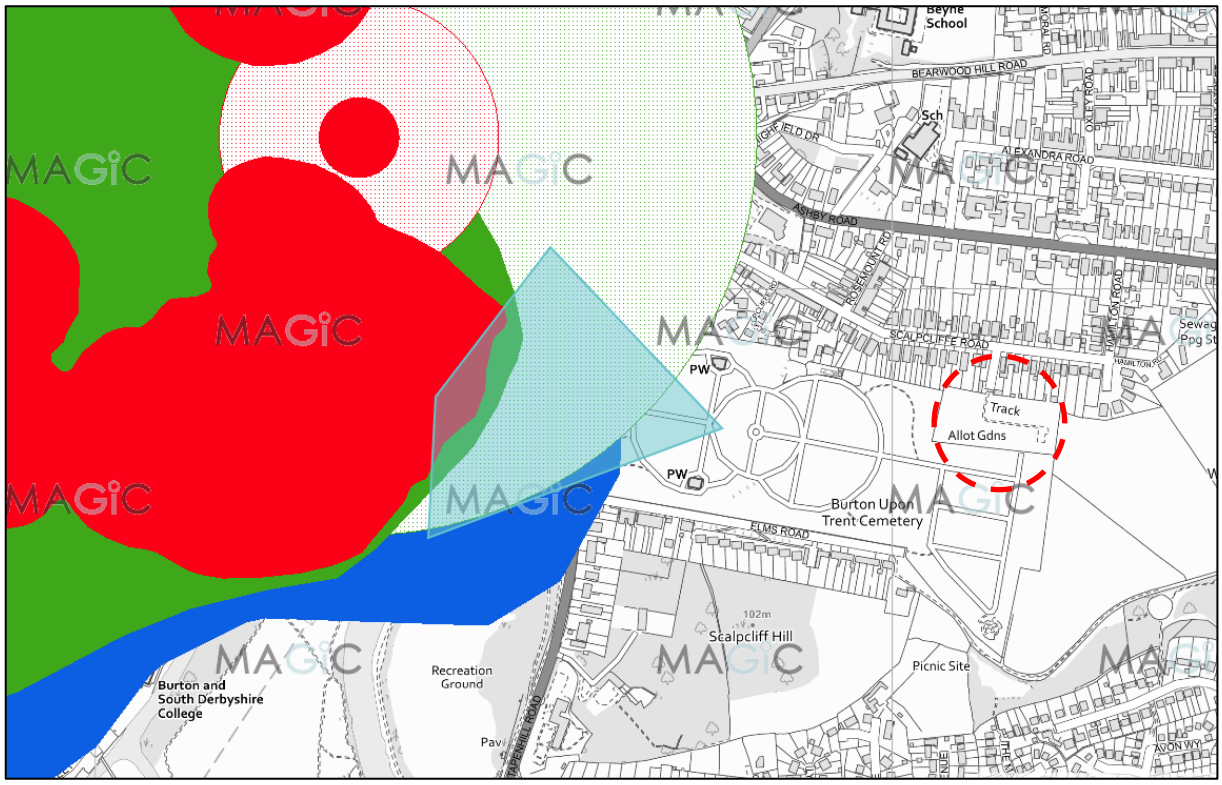


Figure 14. Groundwater source protection zones.

Key: = *Inner Zone*
= *Outer Zone*
= *Total Catchment*

Given this information, it may be permissible to conduct site remodelling works without affecting the volume or dynamics of a flood plain, and also to construct a deep-bored soakaway for the discharge of surface water (if required) should a more convenient method of outfall not be available.

3.3 Soils and geology

3.3.1 Soil map

According to Sheet 3 of the Soil Survey of England and Wales (SSEW) 1:250,000 soil map (1983), the indigenous soil in this area forms part of the HODNET Association. The geological origin of this Soil Association is Permo-Triassic and Carboniferous reddish mudstone, siltstone and sandstone and it is characterised by reddish fine and coarse loamy soils with slowly permeable subsoils and slight seasonal waterlogging. Some similar well drained reddish fine loamy soils, slight risk of water erosion.

3.3.2 Landfill

According to data.gov.uk, the site is not located in an area of historic landfill (Figure 15) or permitted landfill (Figure 16).

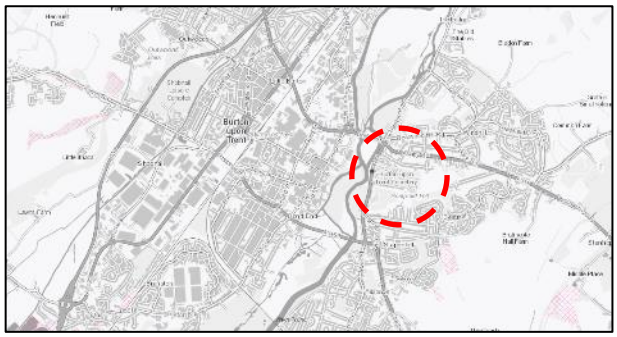


Figure 15. Historic landfill.

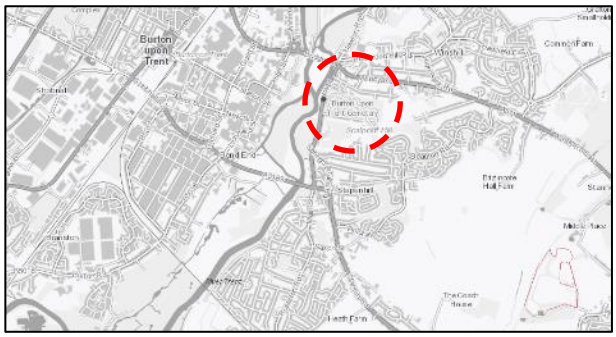


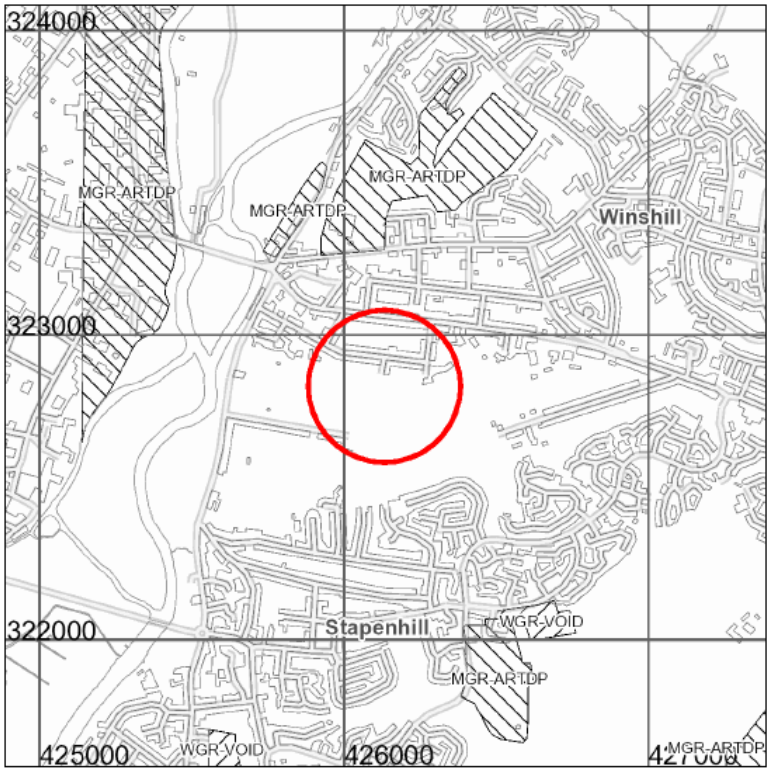
Figure 16. Permitted landfill.

3.3.3 Geology

With reference to BGS Report Nº BGS_310663/13829 (August 2020), the site comprises the following:

Artificial ground

This is ground at or near the surface that has been modified by man. It includes ground that has been deposited (Made Ground) or excavated (Worked Ground), or some combination of these: Landscaped Ground or Disturbed Ground. The map extract below shows the presence and extent of the artificial ground on the site (Figure 17):



Contains OS data © Crown Copyright and database right 2020
Scale: 1:25 000 (1cm = 250 m)
Search area indicated in red

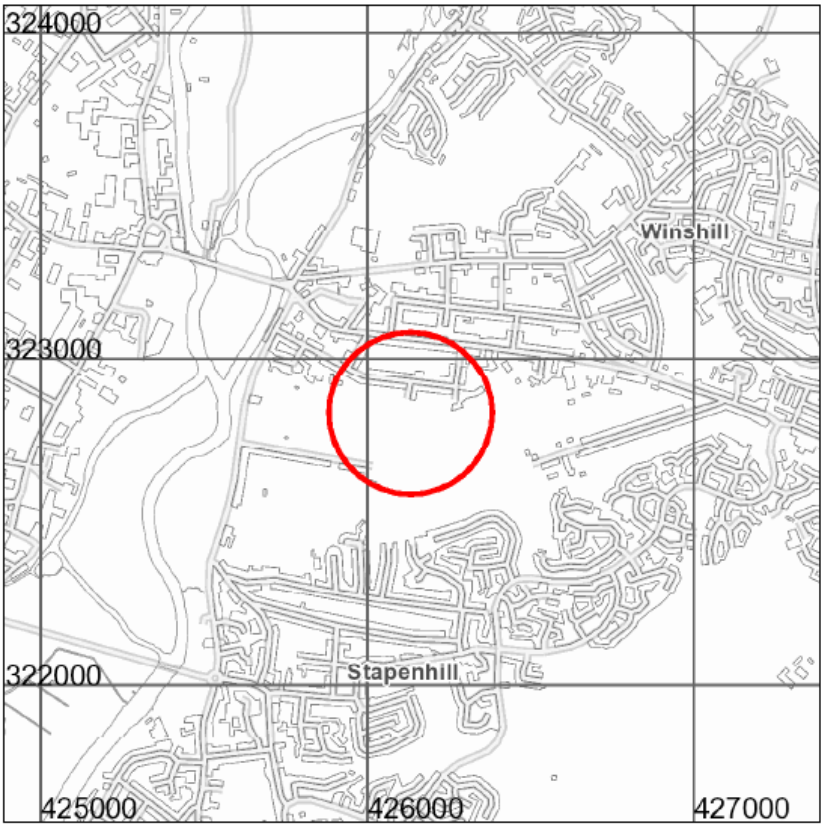
Key to Artificial ground:

Map colour	Computer Code	Name of geological unit	Composition
	MGR-ARTDP	MADE GROUND (UNDIVIDED)	ARTIFICIAL DEPOSIT
	WGR-VOID	WORKED GROUND (UNDIVIDED)	VOID

Figure 17. Presence and extent of artificial ground.
(Source; BGS Report Nº BGS_310663/13829 (August 2020), not to scale)

With reference to Figure 17, no artificial ground is recorded on the map, however artificial ground of generally limited thickness and extent is often present in many urban, built-over and landscaped areas. The site appears to be in an allotment gardens and there is unlikely to be any significant thickness of made ground beneath that site.

Landslide deposits
These are deposits formed by localised mass-movement of soils and rocks on slopes under the action of gravity. Landslides may occur within the bedrock, superficial deposits or artificial ground; and the landslide deposits may themselves be artificially modified. The map extract below shows the presence and extent of the landslide deposits on the site (Figure 18):



Contains OS data © Crown Copyright and database right 2020
Scale: 1:25 000 (1cm = 250 m)
Search area indicated in red

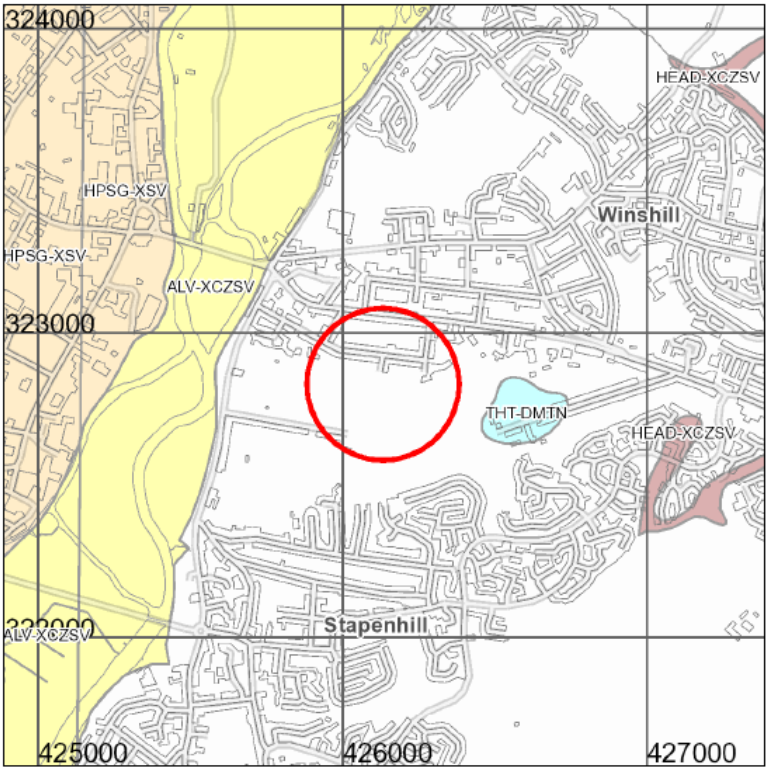
Key to Landslide deposits:

No deposits found in the search area

Figure 18. Presence and extent of landslide deposits.
(Source; BGS Report N^{o} BGS_310663/13829 (August 2020), not to scale)

Superficial Deposits (Drift)
These are relatively young geological deposits, formerly known as 'Drift', which lie on the bedrock in many areas. They include deposits such as unconsolidated sands and gravels formed by rivers, and clayey tills formed by glacial action. They may be overlain by landslide deposits or by artificial deposits, or both. Superficial deposits, particularly if they have low permeability, are helpful for cemetery developments in slowing the downward migration of any contaminants that may be released from the decomposition of burials into the underlying bedrock.

The map extract below shows the presence and extent of the superficial deposits on the site (Figure 19):



Contains OS data © Crown Copyright and database right 2020
Scale: 1:25 000 (1cm = 250 m)
Search area indicated in red

Key to Superficial deposits:

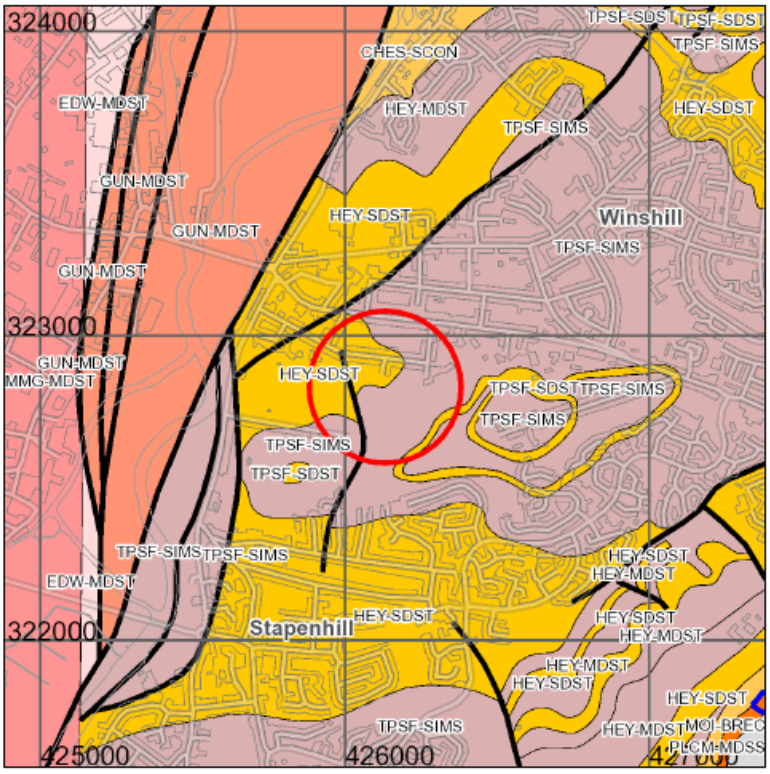
Map colour	Computer Code	Name of geological unit	Composition
	ALV-XCZSV	ALLUVIUM	CLAY, SILT, SAND AND GRAVEL
	THT-DMTN	THRUSSINGTON MEMBER	DIAMICTON
	HPSG-XSV	HOLME PIERREPONT SAND AND GRAVEL MEMBER	SAND AND GRAVEL
	HEAD-XCZSV	HEAD	CLAY, SILT, SAND AND GRAVEL

Figure 19. Presence and extent of superficial deposits
(Source; BGS Report N^{o} BGS_310663/13829 (August 2020), not to scale)

With reference to Figure 19, there are no superficial deposits recorded at that site, although there may be a thin veneer of head and slope-wash deposits up to 1 m thick in the area. If present, these superficial deposits would consist of weathered bedrock material (poorly-sorted sandy silt) that have been remobilised down slope.

Bedrock Geology
Bedrock forms the ground underlying the whole of an area, commonly overlain by superficial deposits, landslide deposits or artificial deposits, in any combination. The bedrock formations were formerly known as the 'Solid Geology'.

A diagram showing the bedrock geology in the area is presented in Figure 20:



Search area indicated in red

Fault

Coal, ironstone or mineral vein

Note: Faults are shown for illustration and to aid interpretation of the map. Because these maps are generalised from more detailed versions not all such features are shown and their absence on the map face does not necessarily mean that none are present. Coals, ironstone beds and mineral veins occur only in certain rock types and regions of the UK; if present here, they will be described under 'bedrock' below.

Scale: 1:25 000 (1cm = 250 m)

Key to Bedrock geology:

Map colour	Computer Code	Name of geological unit	Rock type
	EDW-MDST	EDWALTON MEMBER	MUDSTONE
	GUN-MDST	GUNTHORPE MEMBER	MUDSTONE
	HEY-MDST	HELSBY SANDSTONE FORMATION	MUDSTONE
	HEY-SDST	HELSBY SANDSTONE FORMATION	SANDSTONE
	CHES-SCON	CHESTER FORMATION	SANDSTONE AND CONGLOMERATE, INTERBEDDED
	TPSF-SIMS	TARPORLEY SILTSTONE FORMATION	SILTSTONE, MUDSTONE AND SANDSTONE
	TPSF-SDST	TARPORLEY SILTSTONE FORMATION	SANDSTONE
	MMG-MDST	MERCIA MUDSTONE GROUP	MUDSTONE
	MOI-BREC	MOIRA FORMATION	BRECCIA
	PLCM-MDSS	PENNINE LOWER COAL MEASURES FORMATION	MUDSTONE, SILTSTONE AND SANDSTONE

Figure 20. Bedrock geology.
(Source; BGS Report N^{o} BGS_310663/13829 (August 2020), not to scale)

With reference to Figure 20, the eastern corner of the search site is underlain by the Tarporley Siltstone Formation of the Mercia Mudstone Group. This unit comprises reddish brown to green-grey, laminated and micaceous siltstones interbedded with thin beds of mudstone (containing sporadic gypsum nodules) or sandstone. Occasional mudstone clasts may be present, concentrated at the base of the sandstone beds. The thickness of this unit is not known with any certainty. However, it can be estimated to be several metres thick based upon adjacent outcrops of the siltstone and underlying Helsby Sandstone Formation which provide an indication of thicknesses.

The Tarporley Siltstone Formation overlies the Helsby Sandstone Formation (Sherwood Sandstone Group) but thins progressively, pinching-out westwards across the site where the latter unit crops-out. The Helsby Sandstone Formation consists of beds of red-brown, buff or greenish grey, fine- to

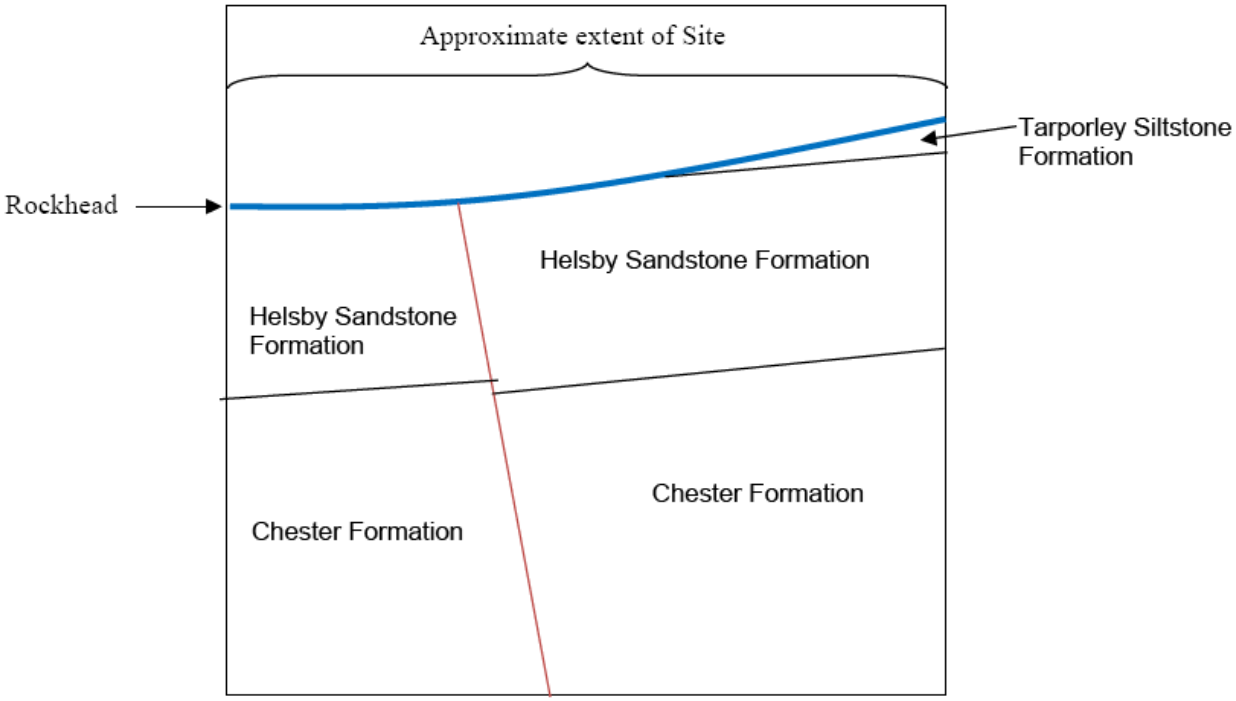
medium-grained sandstone, with interbeds of red-brown mudstone. The full thickness of the Helsby Sandstone Formation unit beneath the site is not known due to a paucity of adjacent borehole information coupled with the regional structural complexity. Examination of the elevation range that the unit crops-out to the west site demonstrates that the unit is at least 25 m thick beneath the site. However, regionally the average thickness of the unit varies between 30-50 m but can be considerably thicker (up to 110 m) in localised fault-controlled basins. Underlying the Helsby Sandstone Formation and likely occurring at depth beneath the site is the Chester Formation (Sherwood Sandstone Group). This unit consists of poorly-cemented, medium- to coarse- grained, pebbly sandstones or conglomerates. Based on regional thicknesses, this unit is estimated to be around 90 m thickness

The geological map shows a small fault running almost north-south by the site and terminating in the residential street to the north of the area. Faults are planes of movement around which the blocks of rock have moved relative to each other. They commonly consist of disturbed zones, tens of metres wide, containing several fracture zones. The portrayal of faults as a single line on the geological map is therefore a generalisation.

Rockhead depth
Bedrock is mapped at outcrop, so rockhead is expected to be close-to, or at the ground surface. A schematic diagram of the underlying geology is presented in Figure 21:

Not to scale

National grid references for site	
West 425811, 322876	East 426369, 322920



This sketch represents an interpretation of the geometrical relationships of the main rock units described in the text. It is not to scale.
The blue line indicates 'rockhead'; that is the base of superficial deposits. This is the 'geological rockhead', as distinct from the 'engineering rockhead', which is the base of 'engineering soil' (in the sense of BS5930:1999).

Figure 21. Schematic diagram of geology relating to the proposed Cemetery development. (BGS Report N^{o} BGS_310663/13829 (August 2020), not to scale)

3.3.4 Hydrogeology

The Tarporley Siltstone Formation (of the Mercia Mudstone Group) consists predominantly of siltstones interbedded with low permeability mudstones and more permeable sandstones which may contain and transmit groundwater predominantly through fracture flow. Therefore, small amounts of groundwater may be encountered where recharge is slowed by low permeability mudstones, and forms a perched water table in the sandstone and siltstone horizons above. The presence of gypsum in the rock, can lead to high calcium and sulphate concentrations in the groundwater.

Stratification within the Helsby Sandstone, due to the interbedded mudstones can cause perched water tables to exist in the sandstone; water levels may also rise above where first struck. However, the mudstone horizons are not always continuous and therefore unlikely to form a barrier to flow at the regional scale.

Regional groundwater levels in the unconfined Helsby Sandstone Formation will lie within 30 m of the surface at the proposed site; and could be much shallower, although probably more than 5 to10 m below the surface. However, some shallower perched water may be encountered above this. Seasonal variations in level are likely to be less than 2 m. Water levels under Burton-upon-Trent, west of the River Trent and the other side of the major Hint Fault, were lowered locally to below sea level, due to abstraction exceeding recharge, but have been recovering since the late 1950s. East of the Trent, a nearby borehole at Winshill West (Record SK22SE590 at [SK 2597 2348]) intercepted 50 m of Helsby Sandstone Formation and recorded a rest water level of 35.2 m above OD on 20/04/2001. A borehole at Winshill (Record SK22SE589 at [SK 2707 2317]) intercepted 29.5 m of Mercia Mudstone Group and 18.5 m of underlying Helsby Sandstone. The borehole was cased into the Helsby Sandstone and the rest water level was 76 m above OD in April 2001, just under a metre above the top of the sandstone. The closest borehole at Waterloo Mount, Winshill (Record SK22SE43 at [c. SK 262 227]) does not record the water level, but it produced water and was only 21 m deep, so the water level must have been above 60 m above OD when drilled in 1884.

The groundwater flow direction is likely to follow the local topography, draining down over the Tarporley Siltstone Formation where it may infiltrate into sandier horizons of the Sherwood Sandstone Group and then draining towards the River Trent, located ~500 m to the north-west of the proposed site.

A summary of hydrogeological considerations is presented in Table 2

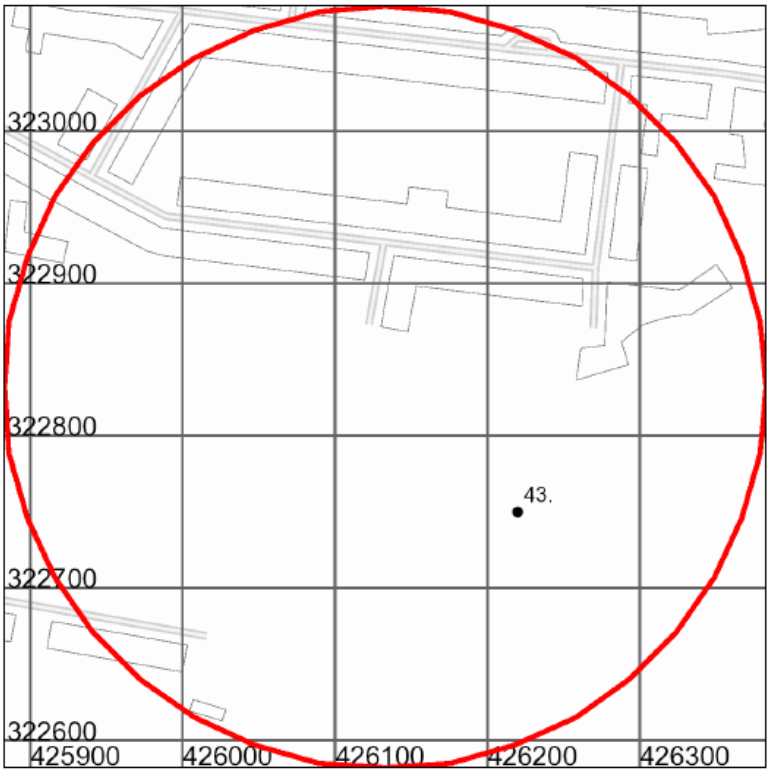
Table 2 Summary of hydrogeological considerations.

Geological unit	Groundwater potential	Water level and strikes	Quality	Environment Agency Groundwater vulnerability classification
Tarporley Siltstone Formation	Mainly fracture flow, multi-layered aquifer with low permeability	Multi-layered aquifer where water may be perched in the siltstone and sandstone horizons interbedded with low permeability mudstones.	Shallow water quality is generally good, but can be very hard with total hardness exceeding 500 mg/l (as $CaCO_3$) and high calcium and sulphate concentrations of over 250 mg/l due to the presence of gypsum.	High vulnerability, secondary aquifer
Helsby Sandstone Formation	Mixed intergranular and fracture flow, multi-layered aquifer	Water stored in sandier horizons, and may be confined by overlying low permeability mudstone horizons. So water may rise above level where first struck	Water is likely to have a total dissolved solids content of up to 1000 mg/l and total hardness around 350-400 mg/l (as $CaCO_3$), but sulphate concentrations exceeding 150 mg/l and chloride over 200 mg/l possible. Iron concentrations may locally exceed 0.5 mg/l below Mercia Mudstone.	High vulnerability, principal aquifer
Chester Formation	Mainly intergranular flow aquifer	Water may rise above level where first struck		Principal aquifer

(BGS Report N^{o} BGS_310663/13829 (August 2020))

3.3.5 Borehole locations

A map extract showing the location of boreholes within the search area is presented in Figure 22.



Scale: 1:5 000 (1cm = 50 m)

Borehole records

Number of records in map area: 1

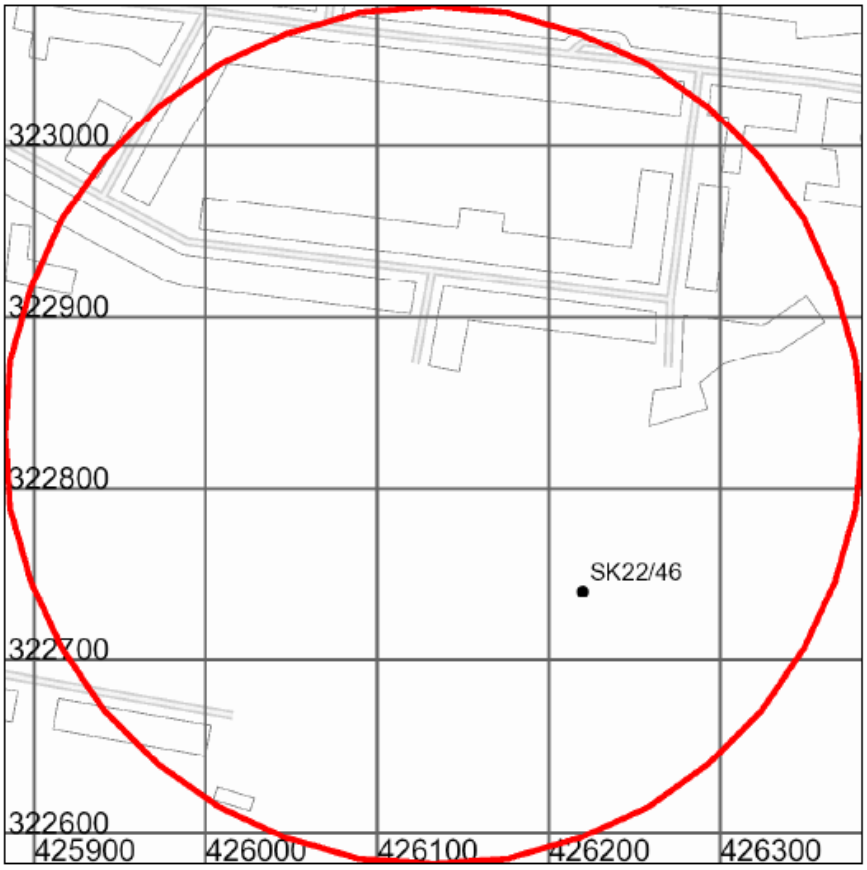
In the following table a blank 'Length' field indicates that the borehole is confidential or that no depth has been recorded digitally.
Enquiry staff may be able to provide you with contact details for the originator if you wish to seek release of confidential information.

Borehole registered no	Grid reference	Borehole name	Length (m)
SK22SE43	SK 26220 22750	WATERLOO MOUNT	21.33

Figure 22. Borehole location map.
(BGS Report N^{o} BGS_310663/13829 (August 2020))

3.3.6 Water well locations

A map extract showing the location of the water wells is presented in Figure 23.



Contains OS data © Crown Copyright and database right 2020
Scale: 1:5 000 (1cm = 50 m)

Water Well records

Number of records in map area: 1

Figure 23. Water well location map.
(BGS Report N^{o} BGS_310663/13829 (August 2020))

With reference to Figures 22 and 23, and the Environment Agency's stipulation that no interments shall occur within 250 metres of any spring, well or borehole used as a source of drinking water. There is only one borehole / well in the vicinity of the cemetery extension area which was drilled in 1884 and so there is a need to establish whether this is no longer operational in order to meet the Environment Agency's criterion. It is unlikely to still be operational as it appears to be located in the adjacent field.

3.4 Soil profile examination and soil sampling

3.4.1 Trial Pit Profile Description

In order to explore the underlying soil type and structure further, three profile pits were excavated at the locations indicated on Figure 1. A summary of the soil characteristics prevailing in each of these pits is presented in the following section.

Figure 24. Digger used to excavate soil profile pits.

In order to facilitate the excavation of pits down to at least 1 m below maximum anticipated burial depth, a JCB 3CXeco excavator was used for the assessment (Figure 24).

Pits were excavated in ~1 m stages to enable soil to be sampled for subsequent laboratory analysis and to allow the suitability of the soil encountered to be assessed. Following excavation, the pits were allowed to remain open for up to an hour to provide sufficient time for any subsurface water present to percolate into the pits.

TP1 was located in an area of high elevation (74.50 m Above Ordnance Datum (AOD)) on an area previously used for car parking in the south-eastern corner of the site (Figure 1). The excavation at TP1 revealed a profile that comprised 0.30 m of DOT Type 1 stone sub-base over red SANDY SILT LOAM subsoil (mudstone) to 1.50 m over hard red SANDSTONE which extended beyond the maximum sampling depth of 2.00 m (Figure 25). No Groundwater was encountered in the test pit.

Figure 25. DOT Type 1 stone over SANDY SILT LOAM subsoil – TP1

Figure 26. Competitor Dart 130 percussion rig

The composition of the underlying geology was also assessed through window sampling using a Competitor Dart 130 percussion rig (Figure 26), however this was aborted at 1.60 m below ground level (bgl) due to the hard sandstone.

Samples extracted from 0.10 m, 1.00 m and 2.00 m are presented in Figure 27 and window sampling cores are presented in Figure 28.

Figure 27. Soil samples from 0.1 m to 2.0 m – TP1.

Figure 28. Window sampling cores from TP1.

In order to facilitate ongoing monitoring of the groundwater, a dipwell comprising a piezometer tip and solid pipe was installed and back-filled in the TP1 to a depth of 2.00 m (Figures 29 and 30).

Borehole logs are appended. The dipwell will be monitored over the spring period to establish the presence of any perched groundwater, and whether it rises to less than 1 m below maximum anticipated burial depth.

Figure 29. Installation of a dipwell – TP1.

Figure 30. Piezometer for dipwell installation.

TP2 was located in an area of mid elevation (69.50 m AOD) towards the centre of the site (Figure 1). The excavation at TP2 revealed a profile that comprised 0.25 m of brown CLAY LOAM topsoil over red CLAY LOAM subsoil (mudstone) to 1.70 m (Figure 31) over red SANDSTONE to 2.10 m over grey SANDSTONE to 2.40 m over hard red SANDSTONE which extended beyond the maximum sampling depth of 2.90 m (Figure 32). No Groundwater was encountered in the test pit.

Samples extracted from 0.1 m, 1.0 m, 2.0 m, 2.4 m and 2.90 m are presented in Figure 33 and window sampling cores are presented in Figure 34.

In order to facilitate ongoing monitoring of the groundwater, a dipwell comprising a piezometer tip and solid pipe was installed and back-filled in TP2 to a depth of 2.90 m (Figures 35 and 36). The dipwell will be monitored over the spring period to establish whether ground water rises to less than 1 m below maximum burial depth.

Figure 31. CLAY LOAM topsoil over red CLAY LOAM subsoil (mudstone) – TP2.

Figure 32. Red SANDSTONE to 2.10 m over grey SANDSTONE to 2.40 m over hard red SANDSTONE – TP2.

Figure 33. Soil samples from 0.1 m to 2.9 m – TP2.

Figure 34. Window sampling cores from TP2.

Figure 35. Dipwell installed TP2.

Figure 36. Dipwell installed TP2.

TP3 was excavated in an area of low elevation (68.00 m AOD) towards the north-western corner of the site (Figure 1). The excavation at TP3 revealed a profile that comprised 0.25 m of brown CLAY LOAM topsoil over red CLAY LOAM subsoil (mudstone) to 1.80 m (Figure 37) over grey SANDSTONE to 2.00 m over hard red SANDSTONE which extended beyond the maximum sampling depth of 2.20 m (Figure 38). No Groundwater was encountered in the test pit.

Due to the presence of hard sandstone, the test pit was aborted at 2.20 m (bgl), and the window sampling was aborted at 2.30 m (bgl) (Figure 39).

Samples extracted from 0.1 m, 1.0, m, 2.0 m and 2.2 m are presented in Figure 40.

In order to facilitate ongoing monitoring of the groundwater, a dipwell was installed to a depth of 2.30 m immediately adjacent to TP3 comprising a piezometer tip and solid pipe. Borehole logs are appended. The dipwell will be monitored over the spring period to establish whether ground water rises to less than 1 m below maximum burial depth.

Figure 37. 0.25 m of brown CLAY LOAM topsoil over red CLAY LOAM subsoil (mudstone) to 1.80 m – TP3.

Figure 38. Grey SANDSTONE to 2.00 m over hard red SANDSTONE – TP3.

Figure 39. Window sampling cores from TP3.

Figure 40. Soil samples from 0.1 m to 2.2 m – TP3.

3.4.2 Soil Texture

The results from a soil textural analysis are presented in Table 3. The results generally concur with observations made during the site investigation.

Table 3. Soil Texture (Sand 2.00 – 0.063 mm; Silt 0.063 mm – 0.002 mm; Clay < 0.002 mm)

TP	Depth (m)	Sand (%)	Silt (%)	Clay (%)	Classification
1	0.10	-	-	-	DOT Type 1 stone
	1.00	38.2	45.1	16.7	SANDY SILT LOAM
	2.00	34.5	45.7	19.8	CLAY LOAM
	5.00	87.9	6.4	5.7	SAND
2	0.10	28.6	44.5	26.9	CLAY LOAM
3	0.10	34.8	4.6	20.6	CLAY LOAM
	1.00	38.8	41.2	20.0	CLAY LOAM

3.4.3 Topsoil Nutrient Status

Samples of topsoil were sent to a contract laboratory for analysis of nutrient status (Table 3).

Table 3. Topsoil nutrient and pH status.

TP	Depth	pH	Phosphorus (ppm)	Index	Potassium (ppm)	Index	Magnesium (ppm)	Index
2	0.00 – 0.25	7.2	77	5.2	219	2.8	279	5.3

Indices of 2 and above indicate that there is sufficient supply of a particular nutrient. With reference to Table 3, the nutrient status of the topsoil is in good order. Soil pH of 7.2 is within the acceptable range for supporting most grasses likely to be growing in a cemetery environment. Note that for reasons of soil chemistry, this analysis does not include nitrogen which is often limiting to grass plant growth.

3.4.4 Dipwell monitoring

Dipwells have been installed at depths of 2.0 m, 2.9 m and 2.3 m at locations TP1, TP2 and TP3 respectively. On the day of installation (2nd February 2021), no groundwater was observed in any of the three dipwells. Dipwell monitoring is ongoing and the results to-date are presented in Table 4.

Table 4. Stapenhill cemetery extension dipwell monitoring log.

Stapenhill Cemetery Extension Dipwells - depth to water below surface level (m)			
Date	DW1	DW2	DW3
Dipwell depth	2.00	2.90	2.30
02/02/2021	Dry	Dry	Dry
10/03/2021	Dry	2.63	Dry
17/03/2021	Dry	1.65	Dry
24/03/2021	Dry	2.33	Dry
31/03/2021	Dry	2.89	Dry
07/04/2021	Dry	2.83	Dry
05/05/2021	Dry	2.81	Dry
12/05/2021	Dry	2.65	Dry
19/05/2021	Dry	2.68	Dry

With reference to Table 4, groundwater has only been encountered in Dipwell 2 which is located towards the centre of the site at mid-elevation. It is concluded that water is perching above the excavated surface of the Helsby Sandstone Formation.

Dipwell 2 was backfilled in Test Pit 2 (as the window sampling rig refused at 2 m). The shallowest measurement to-date is 1.65 m bgl which was observed on the 17th March 2021 during a period of very wet weather.

If the grave depth required for a double burial is 1.83 m (6 feet), then an unsaturated zone of at least 2.83 m below ground level will be required in order to meet the Environment Agency's minimum criterion of one metre of unsaturated soil beneath maximum interment depth. The site does not meet this criterion.

3.4.5 Soil and water summary

In summary, the site typically comprises 0.25 m of CLAY LOAM topsoil (aside from the car park area) over red CLAY LOAM or SANDY SILT LOAM subsoil to between 1.5 to 1.8 m over argillaceous micaceous fine-grained SANDSTONE.

Dipwell monitoring results indicate that the site does not meet the Environment Agency's minimum criterion of one metre of unsaturated soil beneath maximum interment depth. Moreover, given the presence of shallow sandstone encountered in TP1, TP2 and TP3 at 1.5 m, 1.7 m and 1.8 m respectively, the site does not meet two further criteria:

1. 1 m of subsoil below the base of the burial pit.
2. Graves should not be dug in unaltered or unweathered bedrock. This is solid rock which can be buried or exposed at the earth's surface, and which has not been altered by physical or chemical reactions (or both), such as exposure to the weather.

In order to meet the three criteria discussed above, it is therefore proposed that the surface level of the cemetery extension is raised through the importation of inert subsoil and topsoil to achieve at least 2.83 m of unsaturated soil above the sandstone bedrock. This equates to raising levels by a minimum of 1.33 m, 1.18 m and 1.03 m at TP1, TP2 and TP3 respectively.

4 RISK ASSESSMENT

A desk-based risk assessment of the site was conducted by TGMS (September 2020) using the methodology presented in the Environment Agency R & D Technical Report P223, ISBN 1 85705 0215 (1999) and subsequent guidance on groundwater protection and controlling the risks posed by cemeteries published on www.gov.uk. A summary of the findings, and revisions to this assessment based on observations made during the detailed site investigations (in red type), are presented below. Please note, the revisions in red type below are made on the assumption that the ground level is raised as proposed in Section 3.4.5.

4.1 Site Vulnerability Assessment

Pertinent criteria, associated comment and assigned score are presented in Tables 5, 6 and 7.

Table 5. Site vulnerability criteria and comment

Criteria	Comment
Drift Type	Absent. CLAY LOAM topsoil over CLAY LOAM or SANDY SILT LOAM subsoil present to between 1.5 to 1.8 m.
Drift Thickness	N/A. 1.5 to 1.8 m.
Depth to Water Table	< 5 m. 1.65 m.
Flow Mechanism	Intergranular / fissure flow. Intergranular.
Aquifer	The Tarporley Siltstone Formation is designated 'secondary aquifer with high vulnerability'. The underlying Helsby Sandstone Formation is designated 'principal aquifer' with high vulnerability. Agreed.
Abstraction and SPZ	The site lies outside Zone III. It is assumed that the well borehole sunk in 1884 on land to the east is no longer functional. Agreed.
Watercourses & springs	The River Trent is located approximately 500 m north-west of the site. Agreed, no watercourses abut or abound the site.
Drains	None known. None observed.

Table 6. Site vulnerability assessment score sheet

Factor	Site Characteristics	Ranking	Score		
Drift type	Absent. CLAY LOAM topsoil over CLAY LOAM or SANDY SILT LOAM subsoil present to between 1.5 to 1.8 m.	Very High Low	10 4	- -	9 3
Drift thickness	N/A. 1.5 to 1.8 m.	Very High High	10 8	- -	9 7
Depth to water table	5 to 10 m. 1.65 m.	High Very High	8 10	- -	7 9
Flow mechanism	Intergranular / fissure flow. Intergranular.	Moderate Very Low	6 2	- -	5 1
Aquifer	Secondary aquifer over principal aquifer. Agreed.	High High	8 8	- -	7 7
Abstraction and Source Protection Zone	Outside Zone III. Agreed.	Very Low Very Low	2 2	- -	1 1
Watercourses & springs	The River Trent is located about 500 m to the north-west of the site. Agreed.	Very Low Very Low	2 2	- -	1 1
Land Drains	None. Agreed.	Very Low Very Low	2 2	- -	1 1
Total (range)			48 38	- -	40 30

Table 7. Site vulnerability assessment

Vulnerability	Range	Actual
Low vulnerability	8 – 32	
Moderate vulnerability	32 – 56	**XX**
High Vulnerability	56 – 80	

4.2 Vulnerability Class

Based upon the total ranking score indicated, the site may be classified with a vulnerability class of:

Low: [ ] Moderate: [X] High: [ ]

4.3 Scale of Development

Estimates provided by East Staffordshire Borough Council indicate that the number of full earth burials anticipated in the cemetery extension is likely to be around 30 new graves and 20 re-openers.

4.4 Level of Risk

The EA determine the appropriate level of risk assessment required by considering a combination of the scale of development (i.e. number of burials) and the vulnerability class of the site using a nomograph reproduced in Figure 41.

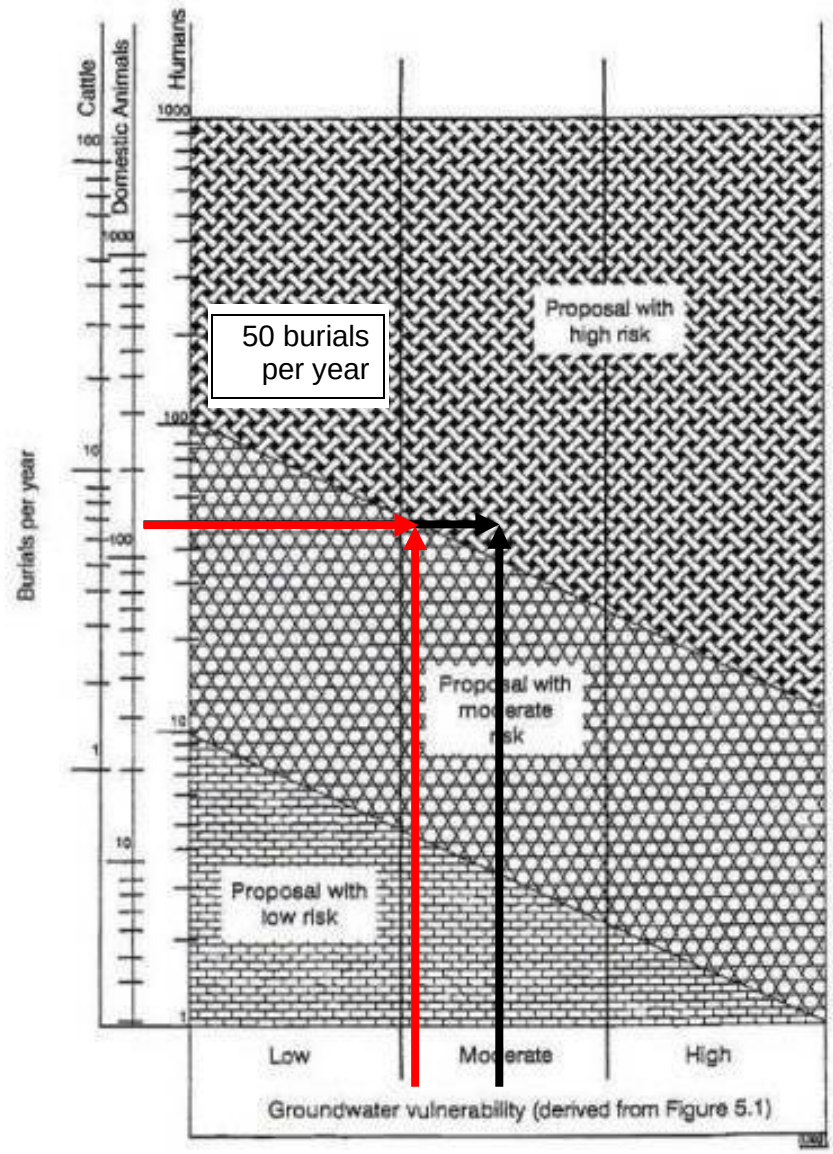


Figure 5.2 Schematic relationship between burial rates, vulnerability class and level of risk

R&D Technical Report P223 37

Figure 41. Schematic relationship between burial rates, vulnerability class and level of risk (from EA R & D Technical Report P223 (1999).

With reference to Figure 41, following the detailed site investigation, the site Vulnerability Ranking is confirmed as 'Moderate', and the level of risk just falls into 'Moderate'. It is concluded that although the level of risk is 'Moderate', given that the proposed extension area abuts the existing cemetery and that there have been no historic pollution incidents, then the risk to the environment can be considered to be 'Low' provided that the surface levels are increased by ~1.33 m in the south-east, ~1.18 m towards the centre, and 1.03 m in the north-west.

5 POTENTIAL GRAVE NUMBERS

TGMS has previously produced a conceptual layout for the proposed cemetery extension (Drawing Tgms1163.1-2) which is part reproduced in Figure 42.

Figure 42. Conceptual design for the layout of the proposed cemetery extension. (Extract from drawing Tgms1163.1-2).

A standard adult grave space size in a cemetery usually measures 2.74 m x 1.22 m (9ft x 4ft). This space permits graves to be excavated to receive typical coffins measuring 1.96 m x 0.6 m (6ft 5in x 2ft) and still leave sufficient virgin ground between each excavated grave.

With reference to Figure 42, this arrangement provides 2,314 adult grave plots.

At the anticipated rate of demand of 30 new graves per year, this new extension site potentially offers capacity for new adult graves for approximately 77 years.

6 SUMMARY AND RECOMMENDATIONS

6.1 Summary

1. **Objective:** To undertake a Tier 2 hydrological risk assessment for the proposed conversion of existing allotment land into a new extension to Stapenhill Cemetery, Stapenhill Road, DE15 9AE.

2. **Site Visits:** A detailed site investigation was conducted on the 2nd February 2021.

3. **Site location and access:** The site comprises a rectangular plot of allotments which is located immediately adjacent to the north-eastern corner of the existing cemetery and can be accessed via a track at the end of Claverhouse Road off Scalpcliffe Road.

4. **Current land use:** The plot comprises disused allotments and is bounded by residential properties to the north, pasture land to the east, and the existing cemetery to the south and west.

5. **Hydrology:** The River Trent is located approximately 500 m north-west of the site, but no watercourses abut or cross the site.

6. **Climate:** Climate data obtained from the Flood Estimation Handbook (FEH) indicate that the standard-period average annual rainfall (SAAR) = 657 mm for this location; significantly lower than the national average of 885 mm/year.

7. **Drainage catchment:** Catchment data obtained from the Flood Estimation Handbook (FEH) Web Service indicate that the site forms part of a 3,103 km^2 catchment with an outlet into the River Trent near the cemetery entrance approximately 500 m to the west of the site.

8. **Predicted land drainage rates:** The predicted drainage rates for the site are generally close to the Greenfield runoff rates and so installation of a new drainage scheme, should one be required, would not cause significantly faster or greater flow than the Greenfield condition. Drainage design should account for at least the 1:30 return period outfall rate of 5.2 l/s/ha for the site over a 24-hour period.

9. **Risk of flooding from rivers and seas:** Based on information obtained from Gov.uk, the site has a very low risk of flooding from rivers and seas with a probability of flooding of less than 1 in 1000 (<0.1%).

10. **Risk of flooding from surface water:** Based on information obtained from Gov.uk, the site has a very low risk of flooding from surface water with a probability of flooding of less than 1 in 1000 aside from some minor flow down Claverhouse Road.

11. **Groundwater vulnerability:** Based on information obtained from magic.defra.gov.uk, the site is not located within a Groundwater Source Protection Zone.

12. **Landfill:** Based on information from data.gov.uk, the site is not located in an area of historic or permitted landfill.

13. **Soil map:** According to Sheet 3 of the Soil Survey of England and Wales (SSEW) 1:250,000 soil map (1983), the indigenous soil in this area forms part of the HODNET Association. The geological origin of this Soil Association is Permo-Triassic and Carboniferous reddish mudstone, siltstone and sandstone and it is characterised by reddish fine and coarse loamy soils with slowly permeable subsoils and slight seasonal waterlogging. Some similar well drained reddish fine loamy soils, slight risk of water erosion.

14. **Geology:** Data from the British Geological Survey indicate that the site is underlain by the Tarporley Siltstone Formation of the Mercia Mudstone Group. This unit comprises reddish brown to green-grey, laminated and micaceous siltstones interbedded with thin beds of mudstone (containing sporadic gypsum nodules) or sandstone. The thickness of this unit is not known with any certainty but estimated to be several metres. This is underlain by the Helsby Sandstone Formation which consists of beds of red-brown, buff or greenish grey, fine- to medium-grained sandstone, with interbeds of red-brown mudstone. The full thickness of the Helsby Sandstone Formation unit beneath the site is not known due to a paucity of adjacent borehole information coupled with the regional structural complexity. Examination

of the elevation range that the unit crops-out to in the west indicates that the unit is at least 25 m thick beneath the site.

15. **Hydrogeology:** The proposed development area is underlain by the Tarporley Siltstone Formation (of the Mercia Mudstone Group) which consists predominantly of siltstones interbedded with low permeability mudstones and more permeable sandstones which may contain and transmit groundwater predominantly through fracture flow. Therefore, small amounts of groundwater may be encountered where recharge is slowed by low permeability mudstones, and forms a perched water table in the sandstone and siltstone horizons above.

16. **Water well records:** With reference to the Environment Agency's stipulation that no interments shall occur within 250 metres of any spring, well or borehole used as a source of drinking water, data from the British Geological Survey indicate that there is only one borehole / well in the vicinity of the cemetery extension area which was drilled in 1884 and so there is a need to establish whether this is no longer operational in order to meet the Environment Agency's criterion. It is unlikely to still be operational as it appears to be located in the adjacent field.

17. **Topography:** The highest part of the site (74.50 m above ordnance datum (AOD)) occurs at the south-eastern corner. The land falls from east to west with the lowest elevated land located in the north-western corner at approximately 68.50 m AOD, which equates to a gradient of circa. 4%.

18. **Soils:** The site typically comprises 0.25 m of CLAY LOAM topsoil (aside from the car park area) over red CLAY LOAM or SANDY SILT LOAM subsoil to between 1.5 to 1.8 m over argillaceous micaceous fine-grained SANDSTONE.

19. **Dipwell monitoring:** Dipwell monitoring results indicate that the site does not meet the Environment Agency's minimum criterion of one metre of unsaturated soil beneath maximum interment depth.

20. **Revised risk assessment:** A desk-based risk assessment of the site conducted by TGMS (September 2020) has been revised following the input of information emanating from this detailed site investigation. The site Vulnerability Ranking is confirmed as 'Moderate', and the level of risk just falls from 'High' to 'Moderate'. It is concluded that although the level of risk is 'Moderate', given that the proposed extension area abuts the existing cemetery and that there have been no historic pollution incidents, then the risk to the environment can be considered to be 'Low' provided that the surface levels are increased by; ~1.33 m in the south-east, ~1.18 m towards the centre, and 1.03 m in the north-west.

21. **Potential grave numbers:** TGMS has previously produced a conceptual layout for the proposed cemetery extension. This arrangement provides 2,314 adult grave plots, and so at the anticipated rate of demand of 30 new graves per year, this new extension site potentially offers capacity for new adult graves for approximately 77 years.

6.2 Recommendations and development options

In summary, the site typically comprises 0.25 m of CLAY LOAM topsoil (aside from the car park area) over red CLAY LOAM or SANDY SILT LOAM subsoil to between 1.5 to 1.8 m over argillaceous micaceous fine-grained SANDSTONE.

Dipwell monitoring results indicate that the site does not meet the Environment Agency's minimum criterion of one metre of unsaturated soil beneath maximum interment depth. Moreover, given the presence of shallow sandstone encountered in TP1, TP2 and TP3 at 1.5 m, 1.7 m and 1.8 m respectively, the site does not meet two further criteria:

1. 1 m of subsoil below the base of the burial pit.
2. Graves should not be dug in unaltered or unweathered bedrock. This is solid rock which can be buried or exposed at the earth's surface, and which has not been altered by physical or chemical reactions (or both), such as exposure to the weather.

In order to meet the three criteria discussed above, it is therefore proposed that the surface level of the cemetery extension is raised through the importation of inert subsoil and topsoil to achieve at least 2.83 m of unsaturated soil above the sandstone bedrock. This equates to raising levels by a minimum of 1.33 m, 1.18 m and 1.03 m at TP1, TP2 and TP3 respectively.

7 OTHER ITEMS

Issues for consideration that can arise from the construction of cemeteries and cemetery extensions can be summarised as follows:

- **Services** – It is recommended that the client obtains up to date service plans of the site prior to any development works. It is important to note that the presence of services may inhibit the scope of works.
- **Planning permission** – Where soil importation and re-grading earthworks are required resulting in a change of levels, it may be prudent to obtain guidance from the local planning department as to whether planning permission is necessary.
- **Land drainage outfall** – When discharging into existing drainage infrastructure or natural watercourses, it may be necessary to obtain the relevant permissions including discharge consents and/or land drainage consent from the Environment Agency, landowner or local authority. These procedures can significantly delay proceedings and prior investigation may be necessary at the feasibility stage. It is the responsibility of the Client to obtain the appropriate consents.
- **Cut and fill** – Cut and fill involves significant earthmoving using large plant machinery e.g. dozers, excavators and dumper trucks. The nature of the works invariably changes the soil structure which can become compacted and, as a consequence, create very low surface water infiltration rates. Settlement of levels is also not uncommon as Contractors try to achieve a balance between avoiding over-consolidation, reducing the risk of settlement whilst maintaining infiltration rates.
- **Settlement of drain lines** – Land drains can be prone to differential settlement (i.e. there can be some sinkage over the drain lines) as the soil surrounding the drain pipe dries out and shrinks; this is perfectly normal in new constructions. Whilst topping up drain lines is usually covered by the Contractor during the first 12-months following construction, it is possible that drains may continue to sink to some extent after this time. Therefore, there should be some allowance within the maintenance programme to ensure that drains are kept topped up.

8 CONFIDENTIALITY

This presentation is confidential and is only for the use of Officers of East Staffordshire Borough Council. Without the specific consent in writing of TGMS, no copies of this presentation are to be made and information contained herein should not be communicated to any third party. At the request of TGMS all copies of this document, in whatever form, are to be returned.

9 CONTACT DETAILS

Dr Richard Earl
TGMS
4 Doolittle Mill
Froghall Road
Ampthill
Bedfordshire
MK45 2ND

Tel: 01525 307060

Email: richard.earl@tgms.co.uk

ADVANCED INVESTIGATION SYSTEMS LTD
Tel: 07970 460 427
Email: enquiries@windowsampling.com
Web: www.windowsampling.com

BOREHOLE RECORD
(Window Sampling)

Borehole Number
BH01

Site:	Engineer:	Drilling Equipment:
Stapenhill Cemetery Extension, Burton-on-Trent	TGMS	Competitor 130

Client:	Elevation mAOD:	Easting:	Northing:	Start:	Finish:	Scale:
	74.500	426187.73	322820.84	02/02/2021	02/02/2021	1:20

Sheet 1 of 1

GROUND WATER			SAMPLING & IN SITU TESTING			STRATA RECORD			
Strike	Well	Depth (m)	Depth/Type (m)	Standard Penetration Testing	Sampler / Recovery	Depth mBGL	Depth mAOD	Key	Description
							74.0		MADE GROUND: (dense) brown grey silty sandy GRAVEL of limestone brick concrete quartzite.
									Stiff red brown locally light brown variegated slightly sandy silty CLAY.
					101mm WLS: 90%	1			Stiff to very stiff red brown sandy silty CLAY with mudstone and siltstone lithorelics becoming increasingly abundant with depth.
							73.0		Moderately weak to moderately strong thinly bedded & laminated red brown argillaceous micaceous fine grained SANDSTONE.
					101mm WLS: 100%				
						2			
							72.0		
						3			
							71.0		
						4			

Remarks / Well Installation / Casing Details

1.60m BGL: refusal. Dry hole. Backfilled with arisings. 19mm standpipe piezometer installed within adjacent trial pit to 2.0m BGL.

AGS

ES ES Sample
● □ Disturbed Sample
W Water Sample
Φ Bulk Sample
U Undisturbed Sample

WLS Windowless Sampler
WS Window Sampler
▽ Depth to water strike
▼ Standing water depth

Job No. AA0113

ADVANCED INVESTIGATION SYSTEMS LTD
Tel: 07970 460 427
Email: enquiries@windowsampling.com
Web: www.windowsampling.com

BOREHOLE RECORD
(Window Sampling)

Borehole Number
BH02

Site:	Engineer:	Drilling Equipment:
Stapenhill Cemetery Extension, Burton-on-Trent	TGMS	Competitor 130

Client:	Elevation mAOD:	Easting:	Northing:	Start:	Finish:	Scale:
	69.500	426124.56	322837.23	02/02/2021	02/02/2021	1:20

GROUND WATER | **SAMPLING & IN SITU TESTING** | **STRATA RECORD** | Sheet 1 of 1

Strike	Well	Depth (m)	Depth/Type (m)	Standard Penetration Testing	Sampler / Recovery	Depth mBGL	Depth mAOD	Key	Description
									TOPSOIL: dark brown grey slightly sandy silty organic CLAY.
							69.0		Stiff red brown slightly sandy silty CLAY.
					101mm WLS: 100%	1			Very weak locally weak red brown thinly & thickly laminated sandy silty micaceous MUDSTONE.
				N=107 (12,19/22,25,28,32)	92mm WLS: 100%		68.0		Moderately weak to moderately strong thinly bedded & laminated red brown argillaceous micaceous fine grained SANDSTONE.
					SPT	2			
							67.0		
						3			
							66.0		
						4			

Remarks / Well Installation / Casing Details

2.0m BGL: refusal. Dry hole. Backfilled with arisings. 19mm standpipe piezometer installed within adjacent trial pit to 2.9m BGL.

AGS

ES ES Sample
● □ Disturbed Sample
W Water Sample
Φ Bulk Sample
U Undisturbed Sample

WLS Windowless Sampler
WS Window Sampler
▽ Depth to water strike
▼ Standing water depth

Job No. AA0113

ADVANCED INVESTIGATION SYSTEMS LTD
Tel: 07970 460 427
Email: enquiries@windowsampling.com
Web: www.windowsampling.com

BOREHOLE RECORD
(Window Sampling)

Borehole Number
BH03

Site:	Engineer:	Drilling Equipment:
Stapenhill Cemetery Extension, Burton-on-Trent	TGMS	Competitor 130

Client:	Elevation mAOD:	Easting:	Northing:	Start:	Finish:	Scale:
	68.000	426080.25	322873.13	02/02/2021	02/02/2021	1:20

GROUND WATER | **SAMPLING & IN SITU TESTING** | **STRATA RECORD** | Sheet 1 of 1

Strike	Well	Depth (m)	Depth/Type (m)	Standard Penetration Testing	Sampler / Recovery	Depth mBGL	Depth mAOD	Key	Description
									TOPSOIL: dark brown grey slightly sandy organic SILT.
					101mm WLS: 90%	1	67.0		Stiff red brown locally light brown variegated slightly sandy slightly gravelly silty CLAY. Gravel is fine medium coarse angular mudstone siltstone & sandstone. Occasional carbonaceous fragments.
				0 (22,35/,,,)	101mm WLS: 100%	2	66.0		Very weak locally weak red brown thinly & thickly laminated sandy silty micaceous MUDSTONE. Locally with green grey & light yellow reduction thin interbeds.
					79mm WLS: 100%				Moderately weak to moderately strong thinly bedded & laminated red brown / light green grey & light yellow reduced argillaceous micaceous fine grained SANDSTONE.
						3	65.0		
						4	64.0		

Remarks / Well Installation / Casing Details

2.3m BGL: refusal. Dry hole. 19mm standpipe piezometer installed to 2.3m BGL.

AGS

ES ES Sample
● □ Disturbed Sample
W Water Sample
Φ Bulk Sample
U Undisturbed Sample

WLS Windowless Sampler
WS Window Sampler
▽ Depth to water strike
▼ Standing water depth

Job No. AA0113

EUROPEAN TURFGRASS LABORATORIES
GEOTECHNICAL (PUTTING GREEN MATERIALS) CERTIFICATE NO. 903-01
ACCREDITED

Unit 6, Millar Court
Alloa Business Park
Alloa, FK10 3SA, Scotland
Tel: +44 (0) 1259 725060
Fax: +44 (0) 1259 722289
europeanturf@etl-ltd.com
www.etl-ltd.com

16684/1				**PARTICLE SIZE DISTRIBUTION** **SAND / SILT / CLAY** Test Report Number 16684/A Page 1 of 2
100%				Stapenhill: TP1, 1.0M
				*** Stones present > 8mm *****
08/02/21				Sample Received Date & Sample Test Date
moist				Sample Moisture (very wet, wet, moist, dry, n/a)
friable				Sample Consistency (hard, friable, plastic, n/a)
high				Sample Homogeniety (high, medium, low, n/a)
				Particle Size Distribution – ASTM F1632-03 (Reapproved 2018)
38.2				% Sand 0.05 to 2.00 mm
45.1				% Silt 0.002 to 0.05 mm
16.7				% Clay less than 0.002 mm
Sandy Silt Loam				Soil Classification

ASTM Method: F1632-03 (Reapproved 2018)
"Particle Size Analysis and Sand Shape Grading of Golf Course Putting Green and Sports Field Root Zone Mixes"

Professional Sportsturf Design (NW) Ltd, trading as TGMS
Wigan Road, Leyland, Lancashire, PR25 5XW

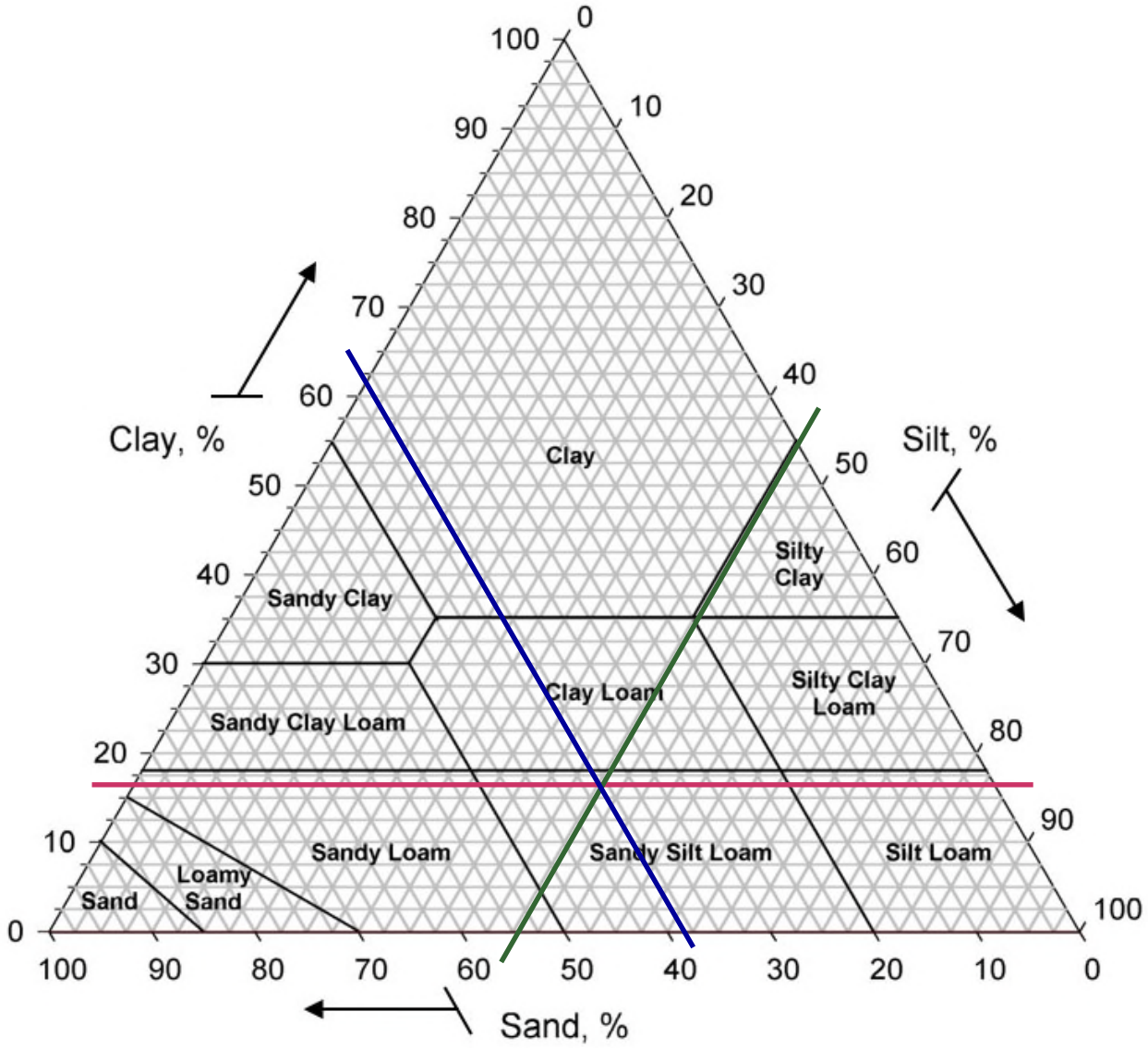
Approved by: Sara Singleton-Price **Date: 11th February 2021**

Managing Director, for European Turfgrass Laboratories Ltd

EUROPEAN TURFGRASS LABORATORIES

Triangle of Texture : Soil Classification

Date of Issue: Sept 2019, Revision 1,
Issuing Authority: Sharon Singleton-Bruce



Soil Sample: TGMS

Test Report 16684/A

			After removal of gravel			
Sample	**% Gravel**		**% Sand**	**% Silt**	**% Clay**	**Soil Texture Classification**
Stapenhill: TP1, 1.0M	1.2		38.2	45.1	16.7	**Sandy Silt Loam**

Signed: Sharon Singleton-Bruce

Date: **11th February 2021** **for European Turfgrass Laboratories Ltd**

EUROPEAN TURFGRASS LABORATORIES
GEOTECHNICAL (PUTTING GREEN MATERIALS) CERTIFICATE NO. 903-01
ACCREDITED

Unit 6, Millar Court
Alloa Business Park
Alloa, FK10 3SA, Scotland
Tel: +44 (0) 1259 725060
Fax: +44 (0) 1259 722289
europeanturf@etl-ltd.com
www.etl-ltd.com

16684/2				**PARTICLE SIZE DISTRIBUTION** **SAND / SILT / CLAY** Test Report Number 16684/B Page 1 of 2
100%				Stapenhill: TP2, 0.1M
				*** Stones present > 8mm **
08/02/21				Sample Received Date & Sample Test Date
moist				Sample Moisture (very wet, wet, moist, dry, n/a)
fria-plast				Sample Consistency (hard, friable, plastic, n/a)
high				Sample Homogeniety (high, medium, low, n/a)
				Particle Size Distribution – ASTM F1632-03 (Reapproved 2018)
34.5				% Sand 0.05 to 2.00 mm
45.7				% Silt 0.002 to 0.05 mm
19.8				% Clay less than 0.002 mm
Clay Loam				Soil Classification

ASTM Method: F1632-03 (Reapproved 2018)
"Particle Size Analysis and Sand Shape Grading of Golf Course Putting Green and Sports Field Root Zone Mixes"

Professional Sportsturf Design (NW) Ltd, trading as TGMS
Wigan Road, Leyland, Lancashire, PR25 5XW

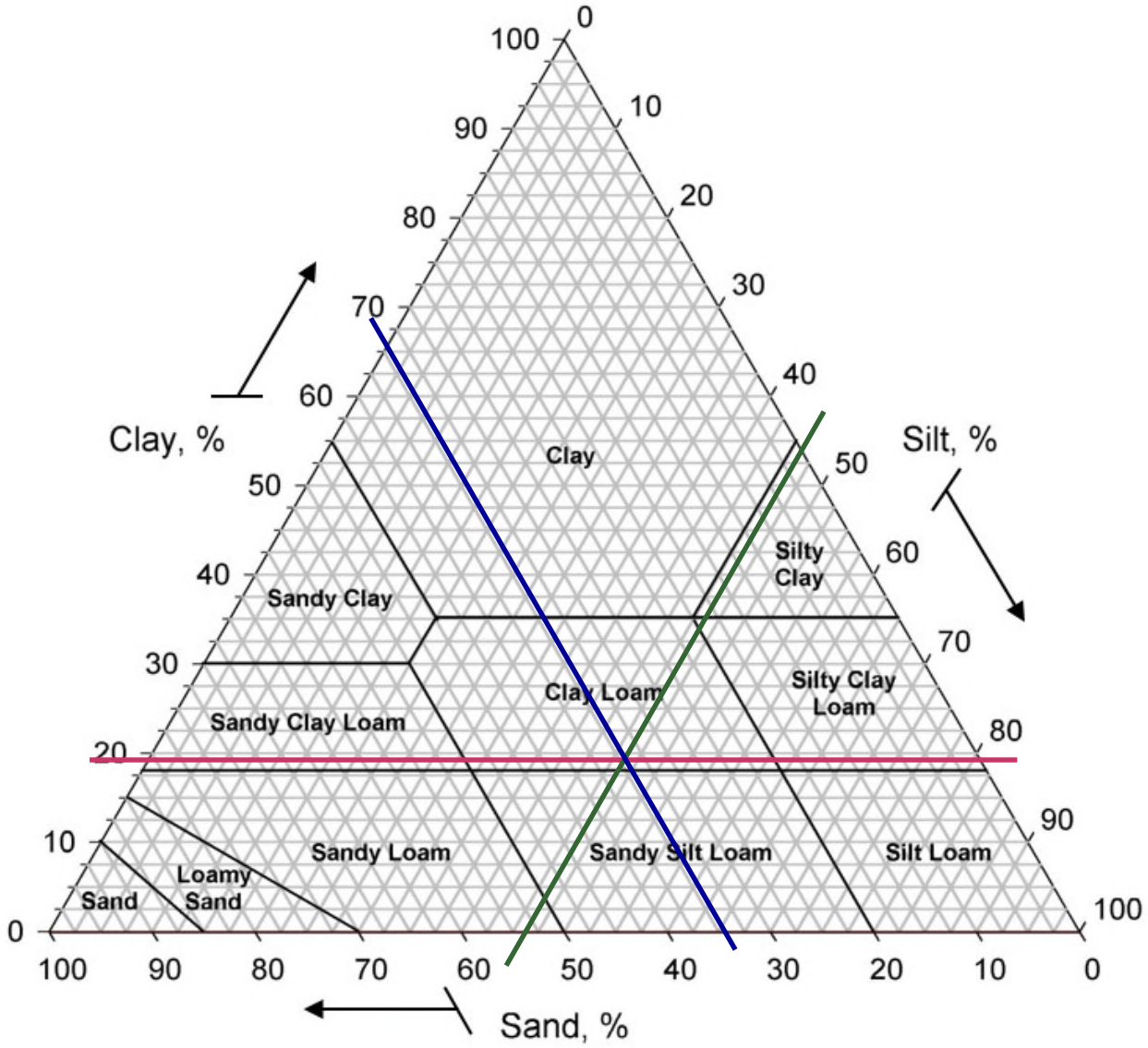
Approved by: Sara Singleton-Price **Date: 11th February 2021**

Managing Director, for European Turfgrass Laboratories Ltd

EUROPEAN TURFGRASS LABORATORIES

Triangle of Texture : Soil Classification

Date of Issue: Sept 2019, Revision 1,
Issuing Authority: Sharon Singleton-Bruce



Soil Sample: TGMS

Test Report 16684/B

			After removal of gravel			
Sample	**% Gravel**		**% Sand**	**% Silt**	**% Clay**	**Soil Texture Classification**
Stapenhill: TP2, 0.1M	2.4		34.5	45.7	19.8	**Clay Loam**

Signed: Sharon Singleton-Bruce

Date: **11th February 2021** **for European Turfgrass Laboratories Ltd**

EUROPEAN TURFGRASS LABORATORIES
GEOTECHNICAL (PUTTING GREEN MATERIALS) CERTIFICATE NO. 903-01
ACCREDITED

Unit 6, Millar Court
Alloa Business Park
Alloa, FK10 3SA, Scotland
Tel: +44 (0) 1259 725060
Fax: +44 (0) 1259 722289
europeanturf@etl-ltd.com
www.etl-ltd.com

16684/3				**PARTICLE SIZE DISTRIBUTION** **SAND / SILT / CLAY** Test Report Number 16684/C Page 1 of 2
100%				Stapenhill: TP2, 1.0M
				*** Stones present > 2mm *****
08/02/21				Sample Received Date & Sample Test Date
moist				Sample Moisture (very wet, wet, moist, dry, n/a)
fria-plast				Sample Consistency (hard, friable, plastic, n/a)
high				Sample Homogeniety (high, medium, low, n/a)
				Particle Size Distribution – ASTM F1632-03 (Reapproved 2018)
28.6				% Sand 0.05 to 2.00 mm
44.5				% Silt 0.002 to 0.05 mm
26.9				% Clay less than 0.002 mm
Clay Loam				Soil Classification

ASTM Method: F1632-03 (Reapproved 2018)
"Particle Size Analysis and Sand Shape Grading of Golf Course Putting Green and Sports Field Root Zone Mixes"

Professional Sportsturf Design (NW) Ltd, trading as TGMS
Wigan Road, Leyland, Lancashire, PR25 5XW

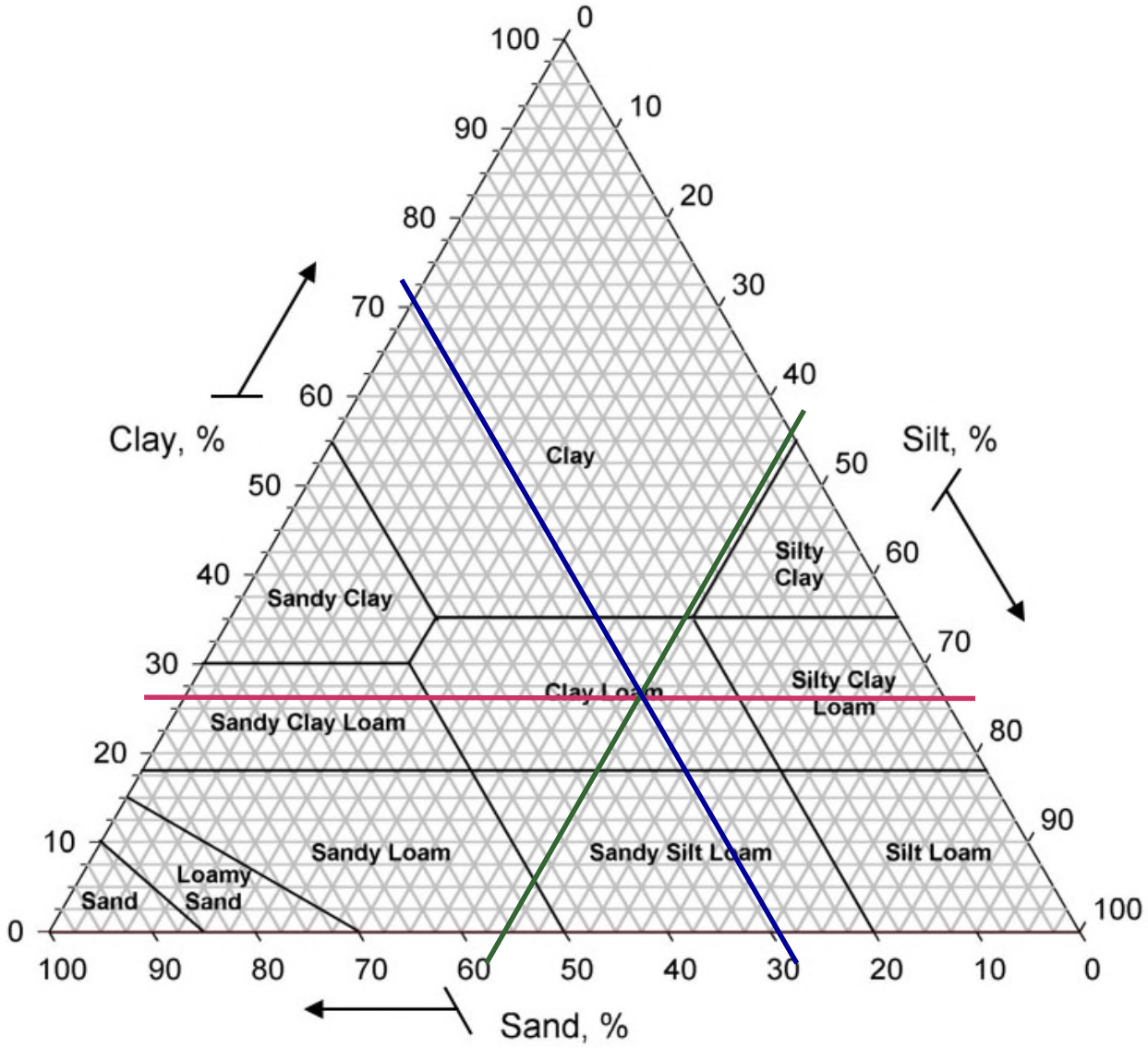
Approved by: Sara Singleton-Price **Date: 11th February 2021**

Managing Director, for European Turfgrass Laboratories Ltd

EUROPEAN TURFGRASS LABORATORIES

Triangle of Texture : Soil Classification

Date of Issue: Sept 2019, Revision 1,
Issuing Authority: Sharon Singleton-Bruce



Soil Sample: TGMS

Test Report 16684/C

			After removal of gravel			
Sample	**% Gravel**		**% Sand**	**% Silt**	**% Clay**	**Soil Texture Classification**
Stapenhill: TP2, 1.0M	-		28.6	44.5	26.9	**Clay Loam**

Signed: Sharon Singleton-Bruce

Date: **11th February 2021** **for European Turfgrass Laboratories Ltd**

EUROPEAN TURFGRASS LABORATORIES
GEOTECHNICAL (PUTTING GREEN MATERIALS) CERTIFICATE NO. 903-01
ACCREDITED

Unit 6, Millar Court
Alloa Business Park
Alloa, FK10 3SA, Scotland
Tel: +44 (0) 1259 725060
Fax: +44 (0) 1259 722289
europeanturf@etl-ltd.com
www.etl-ltd.com

16684/4				**PARTICLE SIZE DISTRIBUTION** **SAND / SILT / CLAY** Test Report Number 16684/D Page 1 of 2
100%				Stapenhill: TP3, 0.1M
				*** Stones present > 8mm **
08/02/21				Sample Received Date & Sample Test Date
moist				Sample Moisture (very wet, wet, moist, dry, n/a)
friable				Sample Consistency (hard, friable, plastic, n/a)
high				Sample Homogeniety (high, medium, low, n/a)
				Particle Size Distribution – ASTM F1632-03 (Reapproved 2018)
34.8				% Sand 0.05 to 2.00 mm
44.6				% Silt 0.002 to 0.05 mm
20.6				% Clay less than 0.002 mm
Clay Loam				Soil Classification

ASTM Method: F1632-03 (Reapproved 2018)
"Particle Size Analysis and Sand Shape Grading of Golf Course Putting Green and Sports Field Root Zone Mixes"

Professional Sportsturf Design (NW) Ltd, trading as TGMS
Wigan Road, Leyland, Lancashire, PR25 5XW

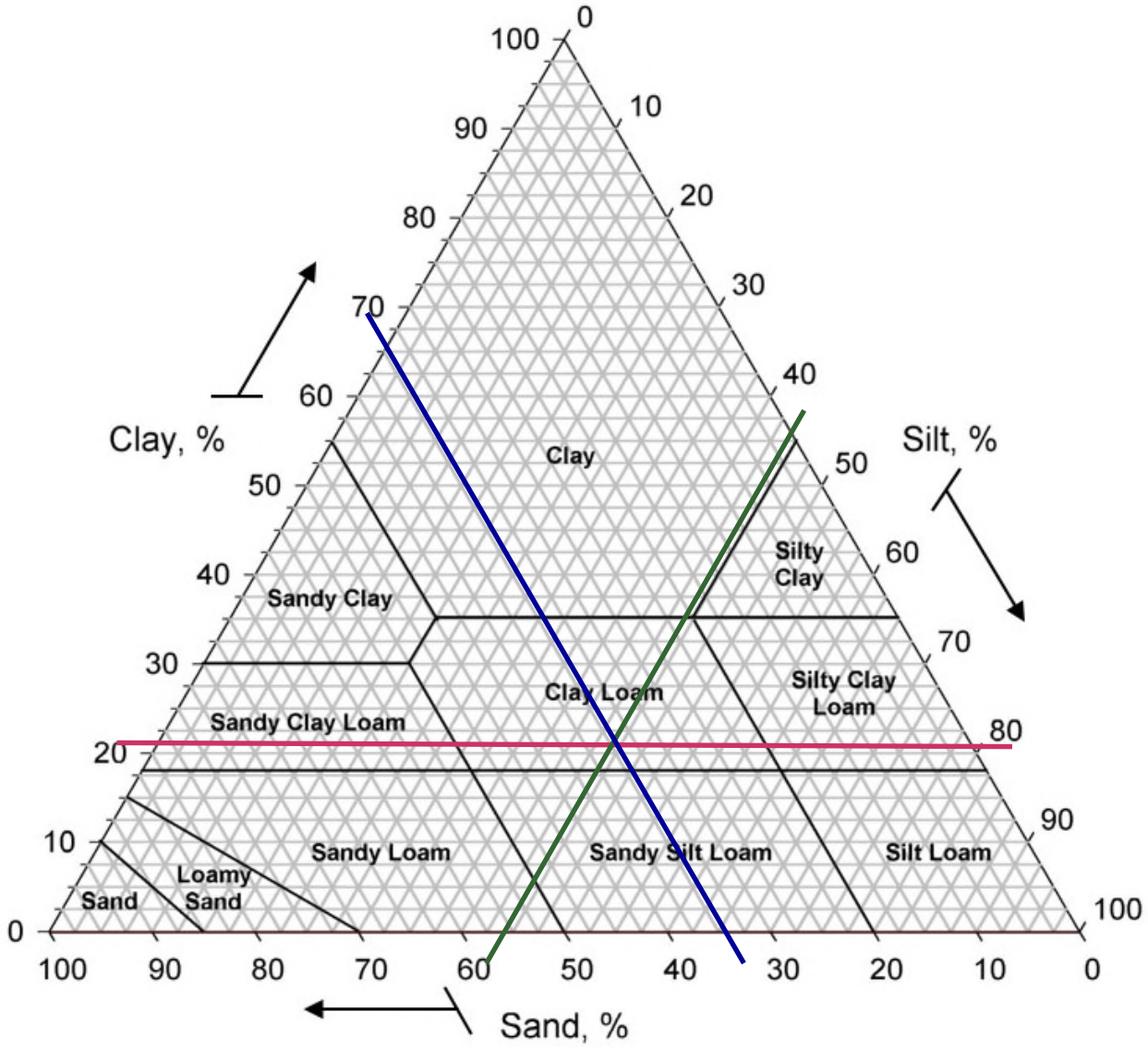
Approved by: Sara Singleton-Price **Date: 11th February 2021**

Managing Director, for European Turfgrass Laboratories Ltd

EUROPEAN TURFGRASS LABORATORIES

Triangle of Texture : Soil Classification

Date of Issue: Sept 2019, Revision 1,
Issuing Authority: Sharon Singleton-Bruce



Soil Sample: TGMS

Test Report 16684/D

			After removal of gravel			
Sample	**% Gravel**		**% Sand**	**% Silt**	**% Clay**	**Soil Texture Classification**
Stapenhill: TP3, 0.1M	4.7		34.8	44.6	20.6	**Clay Loam**

Signed: Sharon Singleton-Bruce

Date: **11th February 2021** **for European Turfgrass Laboratories Ltd**

EUROPEAN TURFGRASS LABORATORIES
GEOTECHNICAL (PUTTING GREEN MATERIALS) CERTIFICATE NO. 903-01
ACCREDITED

Unit 6, Millar Court
Alloa Business Park
Alloa, FK10 3SA, Scotland
Tel: +44 (0) 1259 725060
Fax: +44 (0) 1259 722289
europeanturf@etl-ltd.com
www.etl-ltd.com

16684/5				**PARTICLE SIZE DISTRIBUTION** **SAND / SILT / CLAY** Test Report Number 16684/E Page 1 of 2
100%				Stapenhill: TP3, 1.0M
				*** Stones present > 6mm *****
08/02/21				Sample Received Date & Sample Test Date
moist				Sample Moisture (very wet, wet, moist, dry, n/a)
plastic				Sample Consistency (hard, friable, plastic, n/a)
high				Sample Homogeniety (high, medium, low, n/a)
				Particle Size Distribution – ASTM F1632-03 (Reapproved 2018)
38.8				% Sand 0.05 to 2.00 mm
41.2				% Silt 0.002 to 0.05 mm
20.0				% Clay less than 0.002 mm
Clay Loam				Soil Classification

ASTM Method: F1632-03 (Reapproved 2018)
"Particle Size Analysis and Sand Shape Grading of Golf Course Putting Green and Sports Field Root Zone Mixes"

Professional Sportsturf Design (NW) Ltd, trading as TGMS
Wigan Road, Leyland, Lancashire, PR25 5XW

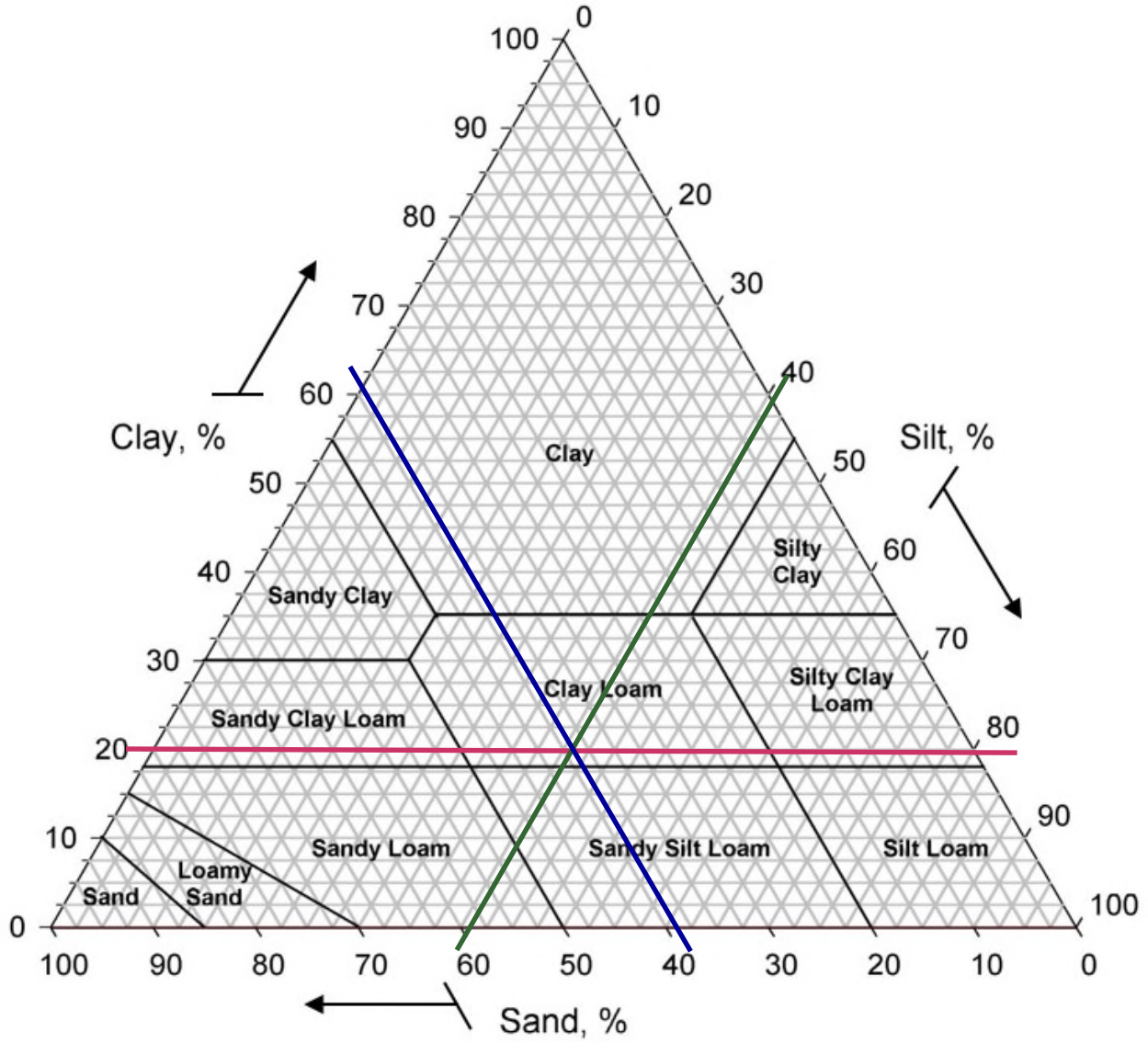
Approved by: Sara Singleton-Price **Date: 11th February 2021**

Managing Director, for European Turfgrass Laboratories Ltd

EUROPEAN TURFGRASS LABORATORIES

Triangle of Texture : Soil Classification

Date of Issue: Sept 2019, Revision 1,
Issuing Authority: Sharon Singleton-Bruce



Soil Sample: TGMS

Test Report 16684/E

			After removal of gravel			
Sample	**% Gravel**		**% Sand**	**% Silt**	**% Clay**	**Soil Texture Classification**
Stapenhill: TP3, 1.0M	6.0		38.8	41.2	20.0	**Clay Loam**

Signed: Sharon Singleton-Bruce

Date: **11th February 2021** **for European Turfgrass Laboratories Ltd**

EUROPEAN TURFGRASS LABORATORIES

Routine Nutrient Analysis Summary Report

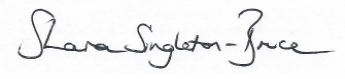
Client: **TGMS**

Date: **12/02/2021**

Order: **16684**

Sample: **Stapenhill: TP2, 0.1M**

Analysis	Result	Guideline	Interpretation	Comments
pH	7.2	6.0	Normal	Maintain pH to ensure optimum nutrient availability and ideal conditions for an active soil biology
Phosphorus (ppm)	77	16	Very High	(Index 5.2) Possible interference on availability of Fe, Cu & Zn
Potassium (ppm)	219	121	Normal	(Index 2.8) Apply 40 kg/ha K_2O
Magnesium (ppm)	279	51	Very High	(Index 5.3) Possible interference on availability of Potassium

Signed:  **Date: 12th February 2021**

Position: **Sharon Singleton-Bruce, Managing Director, European Turfgrass Laboratories Ltd**

This is a Sub-Contracted Test – this sample has not been tested by ETL
This statement is a direct interpretation of the sample tested

EUROPEAN TURFGRASS LABORATORIES

Routine Nutrient Analysis Summary Report

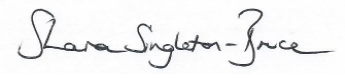
Client: **TGMS**

Date: **12/02/2021**

Order: **16684**

Sample: **Stapenhill: TP3, 0.1M**

Analysis	Result	Guideline	Interpretation	Comments
pH	7.3	6.0	Normal	Maintain pH to ensure optimum nutrient availability and ideal conditions for an active soil biology
Phosphorus (ppm)	103	16	Very High	(Index 6.1) Possible interference on availability of Fe, Cu & Zn
Potassium (ppm)	397	121	High	(Index 3.9) Adequate level
Magnesium (ppm)	550	51	Very High	(Index 6.8) Possible interference on availability of Potassium

Signed:  **Date: 12th February 2021**

Position: **Sharon Singleton-Bruce, Managing Director, European Turfgrass Laboratories Ltd**

This is a Sub-Contracted Test – this sample has not been tested by ETL
This statement is a direct interpretation of the sample tested