

## Ground Investigation Report

Please note that this survey was completed in 2018 and has been reassessed. There have been no alterations to site which will impact on the content or outcomes of the surveys since they were completed.



**Oxford Health  
NHS  
Foundation Trust**

**Ground Investigation Report**

**Warneford Hospital  
Warneford Lane  
Oxford  
Oxfordshire  
OX3 7JX**

**Report No: 18-04-04  
June 2018**



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## EXECUTIVE SUMMARY

<b>Site Location</b>	Warneford Hospital, Oxford, OX3 7JX
<b>OS Grid Reference</b>	SP 53870 05970
<b>Development Proposals</b>	It is proposed to develop an existing open soft-landscaped area of the hospital grounds, to accommodate a new extension comprising a new single story secure unit. The extension is to be adopted as an adolescent Mental Health Inpatient Unit.
<b>Published Geology</b>	The site is directly underlain by Jurassic bedrock geology of the Corralian Group, which comprises the Beckley Sand Member and underlying the Temple Cowley Member. In this area the Corallian Group overlies the West Walton Formation.
<b>Topography</b>	The general topography of the investigation area, slopes gently down to the southeast.
<b>Vegetation</b>	The southern site boundary comprises mature shrubs and trees.
<b>Site History</b>	The earliest maps dated 1876, record the site within an open undeveloped field southeast of the Warneford Asylum. Expansion of the Asylum in the 1890s records the site to be located within the grounds of the Asylum, retaining its undeveloped characteristics to date.
<b>Ground Conditions Encountered</b>	The site is underlain by Topsoil from ground level to a depth of between 0.10m and 0.50m below ground level, overlying localised Made Ground from beneath the topsoil at 0.10m, down to a depth of between 0.40m and 0.75m depth, overlying the Beckley Sand Member down to the base of the exploratory holes at 5m depth.
<b>Groundwater Encountered</b>	Groundwater was encountered within the exploratory holes during the fieldwork initially at a depth of between 3.20m to 4.00m, rising to a depth as shallow as 2.90m bgl over the course of the testing. Additionally a monitoring visit carried out as part of the project also revealed that the standpipe installed within borehole CT1 had a standing groundwater level at 2.76m depth below the existing ground level.
<b>Ground &amp; Groundwater Contamination</b>	There is no significant risk of significant harm to human health or environmental receptors at the site.
<b>Foundations</b>	The Beckley Sand Member is considered to be a suitable bearing stratum for conventional shallow foundations at not less than 1.00m below existing ground level or 0.20m into the top of the formation, whichever is the deeper. At this depth a net allowable bearing pressure of 110kPa may be adopted for foundations not exceeding 1.0m in width. This allows for a factor of safety of three against shear failure and for settlements generally not to exceed 25mm.
<b>Floor Slabs</b>	Floor slabs at the site can be ground bearing, provided the Made Ground is stripped and removed and is based on a blanket of good quality, free draining, well compacted granular material, placed prior to the construction of the floor slab.
<b>Gas Protection</b>	Based on the conditions measured during the monitoring visits carried out to date, In accordance with BS8485:2015 and CIRIA C665, 2007 the site is classified as a Characteristic Situation 1 (CS1). Therefore it is currently considered that no gas protection is necessary with regard to methane or carbon dioxide gas.
<b>Chemical Attack On Buried Concrete</b>	Design Sulphate Class: DS-1 Aggressive Chemical Environment Classification (ACEC) Class: AC-1 <sup>d</sup> .
<b>Waste Soil Classification</b>	From the results of the HazWasteOnline spreadsheets and the WAC testing, currently, the waste soil on this site is classified Inert.
<b>Recommendations</b>	We recommend a watching brief should be undertaken during the construction phase, and if during development any previously undiscovered contamination (including visual or olfactory evidence) is found then site management should be immediately informed and inspection by a suitably qualified person should be undertaken.

**This executive summary must be read in conjunction with this report and the previous site reports.**

## GROUND INVESTIGATION REPORT

### INTRODUCTION









Geo-Integrity Ltd were commissioned by the Warneford Hospital, Oxford, OX3 7JX, via a purchase order dated the 11<sup>th</sup> April 2018, order number AA04218, to undertake a site investigation at Warneford Hospital, Oxford, OX3 7JX. This Phase I desk study and Phase II intrusive investigation has been completed to gather geotechnical and geo-environmental data.

This report describes desk based searches of geological, environmental and historical information, the fieldwork and laboratory testing undertaken and provides an interpretative section of the geotechnical and geo-environmental data from this investigation to inform the proposed development.

The site is located at National Grid Reference SP 53870 05970.

The report is likely to be reviewed by the Local Authority with reference to the NPPG. Once the development is completed, and as a minimum, land must not be capable of being determined as 'contaminated land' under the terms of Part IIA of the Environmental Protection Act 1990. However, it also states that "Where a site is affected by contamination or land stability issues, responsibility for securing a safe development rests with the developer and/or landowner." As such the desk study in this report is the first stage in investigating whether the site is likely to be considered "contaminated", in accordance with clause 121.






The objectives of this phase I and phase II interpretative report are:-

-  To undertake a site walkover to identify any potential pollution sources or geotechnical hazards on the site.
-  To gather historical, geological and environmental information.
-  To complete a preliminary site conceptual model so that potential pollutant linkages can be established and investigated further.
-  Briefly summarise the site development proposals and site setting.
-  To describe and report the fieldwork undertaken at the site.
-  To describe and report the chemical laboratory work undertaken on selected samples.
-  To describe and report the geotechnical laboratory work undertaken on selected samples.
-  To provide an interpretation of the results of this investigation with regards to the geo-environmental and waste disposal implications for the proposed development.

The investigation was performed in accordance with the general requirements of BS 5930:2015, BS EN 1997-2 (2007), BS EN ISO 22475-1 (2006) and other relevant related standards identified below. The fieldwork took place on the 4<sup>th</sup> May 2018.

## **SOURCES OF INFORMATION**

The following sources of information have been used to compile this report:-

-  Extracts of available historical Ordnance Survey (OS) maps covering the period from 1876 to 2014, which are presented in the Appendices.
-  Groundsure Report Ref GS 5058760 and 5058761 included in the Appendices.
-  The British Geological Survey (BGS) and Environment Agency (EA) websites.
-  A site reconnaissance visit undertaken on 4<sup>th</sup> May 2018.
-  Information from various internet sites on site history and environmental setting.

It should be noted that the information provided in the desk study is obtained from independent third party sources. It is provided in good faith, but no guarantee can be provided as to its accuracy. The desk study information is not necessarily exhaustive and further information relevant to the site may be available from other sources.

## **DEVELOPMENT PROPOSALS**

It is proposed to develop an existing open soft-landscaped area of the hospital grounds, to accommodate a new extension comprising a new single story secure unit. The extension is to be adopted as an adolescent Mental Health Inpatient Unit.



## **PHASE I DESK STUDY**

### **WALKOVER SURVEY**

A site walkover survey was undertaken on the 4<sup>th</sup> March 2018. Site location and layout plans are included in the Appendices, along with a selection of photographs taken during the survey.

The investigation area consists of a parcel of open undeveloped soft-landscaped ground to the immediate east of the existing hospital building, centred at national grid reference SP 53870 05970. The area extends an area of approximately 30m by 90m, equating to 0.27 hectares.

The general topography of the investigation area, slopes gently down to the southeast with a drop of approximately 1.0m to 2.0m across the site area (1.1° to 2.1°).

The investigation area is bordered by an existing hospital building to the immediate west, open undeveloped soft landscaped area to the north and east and a large public open space meadow area to the south of the site.

The investigation areas comprised entirely soft landscaped lawn and flower bedded areas, the southern site boundary with the meadow comprised mature shrubs and trees.

During the site walkover there were no significant potential point sources of contamination encountered, however to the immediate west of the site, alongside the parking area of the adjacent hospital building an electrical substation was located.

The substation is internal and is located within a concrete floored single-storey structure, constructed in 2012 and therefore it is unlikely that this feature would provide any significant risk to human health.

## **GEOLOGY**

### *Published Geology*

Reference to the British Geological Survey website and Sheet 237; Thame; 1994; indicates that the site is directly underlain by Jurassic bedrock geology of the Corralian Group, which comprises the Beckley Sand Member and underlying Temple Cowley Member. In this area the Corallian Group overlies the West Walton Formation.

The Beckley Sand Member is described as “A grey, weathering brown to yellow, quartzose, fine- to medium-grained Sand in the east, becoming coarser in the west, with calcareous sandstone beds and doggers, and thin, sandy, shelly bioclastic limestone beds” It is known for being a medium dense medium grained sand with localised sandstone bands that are difficult to drill through. In this area the Beckley Sand Formation is encountered up to 25m in thickness.

The Temple Cowley Member is described as “Fine-grained silty sands, calcareous sandstones and clayey silts and siltstones, commonly thinly or ripple bedded, may show pronounced bioturbation.” In this area the Temple Cowley Member is encountered up to 12m in thickness.

The West Walton Formation is described as “Calcareous mudstone, silty mudstone and siltstone, with subordinate fine-grained sandstones and argillaceous limestone (cementstone) or siltstone nodules; typically rhythmic alternations of dark grey, silty mudstone (rich in fine-grained shell and plant material) with pale grey mudstone; ooidal, and in some cases coralline marls and limestones developed locally”. In this area the West Walton Formation is encountered up to 45m in thickness.

## **HISTORY OF THE SITE**

The history of the site has been established by the review of old Ordnance Survey maps going back to 1876 and freely available aerial/satellite imagery. The maps and any other relevant information are included in the Appendices and indicated the following.

### *Ordnance Survey*

The earliest maps dated 1876, record the site within an open undeveloped field southeast of the Warneford Asylum. Expansion of the Asylum in the 1890s records the site to be located within the grounds of the Asylum, retaining however its undeveloped characteristic, excluding a row of trees along the southeastern site boundary. No significant changes are recorded at the site to 2014 (the most recent map).

Development within the surrounding hospital area and Oxford itself has of course occurred, although no significant industrial land uses are identified within close proximity and the open area of the site/surroundings area, now recorded as sports fields, bowling greens and cricket fields.

### *Satellite and Aerial Imagery*

Freely available imagery of the site and surrounding area identifies that in 2012 the adjacent hospital building was under construction, and the site itself has been stripped of topsoil, with a stockpile located to the east of the site. The site compound for the construction of the adjacent building is also recorded on the northern section of the site area.

## **UNEXPLODED ORDNANCE AND BOMB SITES**

Reference to the site specific unexploded bomb risk map (UXO) produced by Zetica indicates that the site is located in an area where there is a low risk of unexploded ordnance. Low-risk regions are those with a bombing density of up to 15 bombs per 1000 acres or less.

Care is however required when assessing the risk for specific sites where the risk may be higher because of local wartime activity, such as munitions factories, pivotal infrastructure, airfields and dummy airfields, many of which were removed from historical maps in the interest of national security.



## HYDROLOGY

The nearest surface watercourse is recorded as the Boundary Brook, located 222m east of the site. In this area the Boundary Brook has not been classified with a chemical quality grade by the Environment agency.

There are no current surface water abstraction license located within 1000m of the site.

## HYDROGEOLOGY

Desk Study information indicates that the site is located on the following aquifers and aquicludes;

-  Secondary A Aquifer– associated with the Corallian Group strata beneath the site (Beckley Sand Member and underlying the Temple Cowley Member).
-  Unproductive Strata - associated with the underlying West Walton Formation.

The aquifer designation data is based on geological mapping provided by the British Geological Survey. The maps are divided into two different types of aquifer designation:

**Superficial (Drift)** - permeable unconsolidated (loose) deposits. For example, sands and gravels.

**Bedrock** - solid permeable formations e.g. sandstone, chalk and limestone.

For each type there are four designations:-Principal, Secondary A, Secondary B and Unproductive Strata, ranked by importance.

The site is recorded to be located outside of any Source Protection Zones.

A Source Protection Zone (SPZ) is a designated area around a well or abstraction borehole. An SPZ is generally divided into three zones (but can be a fourth) defined as follows:

There are no recorded groundwater abstraction license located within 1000m of the site.

There have been no significant pollution incidents to controlled waters recorded within the surrounding area, in the last 10 years, or any incidents older than that likely to have caused an elevated risk to the site itself.

## **WASTE TREATMENT AND LANDFILL SITES**

### *Landfills*

There are no records of operational or historical landfill sites within vicinity to the site area.

### *Other Waste Treatment Sites*

There are no records of other waste treatment sites in close vicinity to the site area.

## **INDUSTRIAL USAGE SITES**

Potentially contaminative activities have been identified within the vicinity of the site, which relate to the historical usage of the surrounding area as an infirmary/hospital.

Records indicated that there are no active or inactive fuel filling station is identified within 500m of the site.

## **WORKED OUT GROUND/MADE GROUND**

The desk study information records no significant areas of worked out ground within the surrounding area.

## **GROUND GASES**

### *Radon*

Information obtained from the BGS and the National Geoscience Information Service indicates that the site lies within an area where less than 1% of homes exceed the action level for radon gas. Therefore, no radon protection measures are necessary in the construction of new dwellings or extensions, on this site.

However should development proposals change to include a basement, radon levels may be higher in this underground room and in accordance with BRE Quick Guide 7, Reducing Radon, Underground Rooms – Cellars and Basements, 2015, mitigation measures should be included in the basement design.

### *Landfill Gasses*

In accordance with BS8576:2013 the site has provisionally assessed for the risk of ground gases. This has been done with reference to “A pragmatic approach to ground gas risk assessment for the 21<sup>st</sup> Century” Card and Wilson, 2011.

- No credible sources or pathways for landfill gas migration from an offsite landfill have been identified.
- The site has not been a registered landfill
- The Made Ground is not expected to be 5m deep or an average of 3m in thickness.
- The site is not located on a carbonate rich rock that can produce carbon dioxide.
- Radon protection measures are not recommended for this site.
- The site does not lie on a potential naturally organic soil or humic or degradable Made Ground soil.

Therefore it is considered that the site is unlikely to be at risk from ground gases.

### **POTENTIAL GEOTECHNICAL HAZARDS**

The desk study information identified that the site does not lie within an area likely to be affected by coal mining or non-coal mining activities.

The risk of naturally occurring geotechnical hazards at the site is recorded in the Groundsure report to be as follows:

<b>Ground Stability Hazard</b>	<b>Maximum Hazard Potential Rating</b>
Collapsible deposits	Very Low
Compressible deposits	Negligible
Ground dissolution of soluble rocks	Negligible
Shrinking and swelling clays	Negligible
Landslides	Very Low
Running sand	Negligible

It should be noted that the underlying Gault formation is attributed as a moderate risk of shrinking and swelling clays. Dependant on the thickness of the overlying Greensand Formation, and zone of influence imparted by the proposed structure, this higher risk may be attributed to the site itself.

### **POTENTIALLY SENSITIVE LAND USES**

The site is located within a Nitrate Vulnerable Zone.

## INITIAL CONCEPTUAL SITE MODEL

In accord with the Environment Agency CLR11 “Model Procedures for the Management of Contaminated Land” 2004, this desk study and site reconnaissance report constitutes a preliminary risk assessment in order to establish the potential presence of pollutant linkages. The diagram below illustrates the potential linkages.

Reference to the desk study and walkover survey indicates there were no significant potential point sources of contamination at the site and that the site has never had a potentially contaminative land usage, therefore, it is considered unlikely that human health or Controlled Waters receptors will be at an elevated risk from the proposed development.

However satellite imagery did identify that the site was stripped of topsoil and partially used as a site compound, during the construction of the adjacent hospital building. Therefore it is plausible that some Made Ground may be present from this historical activity on the site, and therefore the following potential source/pathway/receptors may be present at and around the site.

Potential Source	Potential Pathway	Potential Receptor	Considered Risk
Historic metals within the ground from long human history	Ingestion, inhalation or absorption from direct contact with soil.	End Users	Low/Medium risk
	Leaching through the ground	Controlled Waters	Low risk
	Possible contact during work phase	Construction Workers	Low/Medium risk
Historic hydrocarbons within the ground from long human history	Volatile vapours possible	End Users	Low risk
	Leaching through the ground	Controlled Waters	Low risk
Historic hydrocarbons within the ground from long human history	Possible contact during work phase	Construction Workers	Low risk
	Possible contact	Underground services	Low risk
Historic asbestos within the made ground from long human history	Ingestion, inhalation or absorption from direct contact with soil.	End Users	Low risk
	Possible contact during work phase	Construction Workers	Low
Ground gas from organic soil and made ground	Inhalation in buildings if present	End Users	Low risk

## **PHASE II INTRUSIVE INVESTIGATION**

### **SITE WORK AND SAMPLING STRATEGY**

The fieldwork was undertaken in accordance with BS 5930:2015, BS EN 1997-2 (2007) and BS EN ISO 22475-1 (2006), with the exploratory locations being selected by Geo-Integrity Ltd. The exploratory hole locations can be seen in the Appendices.

The fieldwork was undertaken on the 4<sup>th</sup> May 2018 and consisted of four continuous tube sampling boreholes to 5.00m depth, three Insitu TRL DCP CBR tests and two 'BRE 365' soakaway tests located within machine excavated pits.

Disturbed samples were taken at selected depths down to the base of the holes for subsequent laboratory testing and inspection. On completion, all trial pits were carefully backfilled with arisings in thin layers, ensuring that excavated material was replaced in the same order as it had been removed.

### **GROUND CONDITIONS**

#### *Summary*

The site and laboratory test work revealed that the general succession of strata can be represented by Topsoil overlying localised Made Ground, overlying the Beckley Sand Member. The downward succession was generally consistent across the site, and was in accordance with published geology. Descriptions of the strata encountered are given on the exploratory hole records, and are summarised below. Further information is provided on the exploratory hole logs within the appendices.

#### *Topsoil*

Encountered in each of the exploratory holes from ground level to a depth of between 0.10m and 0.50m below ground level. The material generally consisted of a soft, dark-brown, organic very-sandy, clay.

#### *Made Ground*

Encountered at four of the test locations, from beneath the topsoil at 0.10m, down to a depth of between 0.40m and 0.75m depth. The material was variable but generally consisted of brown and dark brown gravelly SAND. The gravel component comprised fine to medium, angular of pottery brick and clinker.



### *Beckley Sand Member*

Encountered at each of the test locations from depths of between 0.40m 0.75m below ground level, down to the base of the exploratory holes at 5m depth. Represented in general as a loose becoming medium dense brown silty slightly clayey sand. Three of the four boreholes encountered a very weak brownish grey calcareous sandstone bed across the site at a depth of 3m to 3.5m bgl.

Laboratory tests undertaken on representative samples revealed that although a high silt and clay content is present that the material is a granular soil, and therefore is therefore non-shrinkable.

SPT 'N' values undertaken within the boreholes ranged from 5 to 17 (a reading of 41 was recorded however this is located within the thin band of sandstone), the penetration resistance of the strata generally increased with depth and the results are interpreted to indicate generally loose becoming medium dense granular soils.

The super heavy dynamic probe undertaken within CT3 revealed N100 values ranging from 1 to 8, within the sand deposits, and 16 to 52 within the sandstone beds, with no voids or extended weak zones. The probe results correlate to the SPT 'N' values, and generally increase with depth over the length of the boreholes.

### *Groundwater*

Groundwater was encountered within the exploratory holes during the fieldwork initially at a depth of between 3.20m to 4.00m, rising to a depth as shallow as 2.90m bgl over the course of the testing.

A monitoring visit carried out as part of the project also revealed that the standpipe installed within borehole CT1 had a standing groundwater level at 2.76m depth below the existing ground level.

### *Sulphate and pH Tests*

Soluble sulphate and pH tests were carried out on two representative soil samples recovered from the exploratory holes. These recorded values as shown in the table below:

<b>Parameter</b>	<b>Range</b>
Soluble Sulphate (g/l)	<0.010
pH units	7.4 – 7.8

### *Ground Gas*

Ground gas monitoring was undertaken within the borehole standpipe at CT1 as a part of this investigation, on the 10<sup>th</sup> May 2018, using a calibrated Gas Data GFM Series gas analyser.

The results revealed an oxygen level of 13.6% by volume, a carbon dioxide level of 4.8% by volume, and a methane level below detectable limits. Peak ground gas flow rates were recorded at 0l/hr.





### *Evidence of Contamination*

No obvious or significant contamination was identified within the natural or Made Ground soils encountered during the field work. However some man-made materials were encountered within the Made Ground such as clinker brick and tarmac and ash, which may contain elevated levels of possible contaminants.

## **GEOENVIRONMENTAL TESTING**

Geo-environmental laboratory testing was scheduled by Geo-Integrity on four soil samples recovered during the fieldwork. The testing was carried out at a MCERTS and UKAS accredited laboratory. The results are presented in the Appendices.

Soil samples were tested for a varied suite containing the following

-  Metals and inorganic substances
-  Speciated Polyaromatic Hydrocarbons (PAH)
-  Benzene, Toluene, Ethylbenzene and Xylene (BTEX)
-  Total Petroleum Hydrocarbons (TPH), with eight band split

Two of which were tested of the presence or absence of Asbestos.

Furthermore a single sample of representative Made Ground was tested for a single stage inert WAC test for final waste classification.

## **GEOTECHNICAL INTERPRETATIVE SECTION**

### **GENERAL GROUND CONDITIONS INTERPRETATION**

The exploratory field work undertaken during this investigation has identified that the site is underlain by Topsoil from ground level to a depth of between 0.10m and 0.50m below ground level, overlying localised Made Ground from beneath the topsoil at 0.10m, down to a depth of between 0.40m and 0.75m depth, overlying the Beckley Sand Member down to the base of the exploratory holes at 5m depth. The downward succession was generally consistent across the site, and was in accordance with published geology.

Groundwater was encountered within the exploratory holes during the fieldwork initially at a depth of between 3.20m to 4.00m, rising to a depth as shallow as 2.90m bgl over the course of the testing. Additionally a monitoring visit carried out as part of the project also revealed that the standpipe installed within borehole CT1 had a standing groundwater level at 2.76m depth below the existing ground level.

The desk study recorded the site at negligible risk from shrinking and swelling clays. Laboratory tests have confirmed that the underlying granular soils are non-shrinkable.

## **EXCAVATIONS**

Normal excavating plant should be sufficient within the underlying soils encountered on site, however should excavations be undertaken in excess of 3m bgl then breaking out of sandstone beds may be required.

Furthermore precautions in line with CDM 2015, should be taken with excavations on site. Additionally it is considered likely that shallow excavations should remain dry in the short term.

## **FOUNDATIONS**

### *Shallow Foundations*

The Made Ground is considered unsuitable as a bearing stratum due to its variability, and potential for unacceptable total and differential settlement under applied foundation loadings.

The Beckley Sand Member is considered to be a suitable bearing stratum for conventional shallow foundations at not less than 1.00m below existing ground level or 0.20m into the top of the formation, whichever is the deeper.

At this depth a net allowable bearing pressure of 110kPa may be adopted for foundations not exceeding 1.0m in width. This allows for a factor of safety of three against shear failure and for settlements generally not to exceed 25mm. The soils should be considered as non-shrinkable.

## **FLOOR SLAB DESIGN**

Floor slabs at the site can be ground bearing, provided the Made Ground is stripped and removed and is based on a blanket of good quality, free draining, well compacted granular material, placed prior to the construction of the floor slab, in order to make up the level.

Alternatively in areas of thicker Made Ground >600mm, suspended ground floors should be used.

## **GAS PROTECTION**

The risk of ground gases impacting the site was assessed by reference to the paper "A pragmatic approach to ground gas risk assessment for the 21<sup>st</sup> Century" Card and Wilson, 2011. And determined that there was no significant source of ground gas, or an amenable pathway for any gas to significantly affect the proposed development.

A confirmatory monitoring visit was undertaken at the site on the 10<sup>th</sup> May 2018, in conjunction with groundwater level monitoring, which recorded no carbon dioxide levels above 5% and no methane gas above detectable limits. A flow rate of 0l/h was also recorded.

Furthermore no radon protection measures are necessary in the construction of new dwellings or extensions, on this site. However should development proposals change to include a basement, radon levels may be higher in this underground room and in accordance with BRE Quick Guide 7, Reducing Radon, Underground Rooms – Cellars and Basements, 2015, mitigation measures should be included in the basement design.

Based on the conditions measured during the monitoring visits carried out to date, In accordance with BS8485:2015 and CIRIA C665, 2007 the site is classified as a Characteristic Situation 1 (CS1). Therefore it is currently considered that no gas protection is necessary with regard to methane or carbon dioxide gas.

### **SULPHATE ATTACK ON UNDERGROUND CONCRETE**

Three soil samples from this investigation were scheduled for the measurement of water soluble sulphate, pH, Total Sulphur and Acid Soluble Sulphate (to investigate the potential for sulphate ions/pyrite) to give an indication of the aggressivity of the ground in relation to buried concrete, as set out in the Building Research Establishment (BRE) Special Digest 1 (2005) Concrete in Aggressive Ground, Part 1: Assessing the aggressive chemical environment. The samples were recovered from depths ranging from 0.1m to 2.0m.

In accordance with the BRE Special Digest, these results would indicate a Design Sulphate Class of **DS-1** and a site Aggressive Chemical Environment Classification (ACEC) **Class AC-1<sup>d</sup>**.

The recommendations given in the above digest, with respect to suitable concrete design and other associated precautions against sulphate attack, should be followed for all below ground level concrete.

## **GEO-ENVIRONMENTAL INTERPRETATION SECTION**

### **RISKS TO HUMAN HEALTH**




#### *Introduction*

Environment Agency guidance CLR 11, *Model Procedures for the Management of Land Contamination*, (EA, 2004), states that human health risk assessment should be undertaken by a tiered approach using the source-pathway-receptor principle. A desk study constitutes the first tier and this has been undertaken as part of this investigation. The conclusions of this phase were that:-





“There were no significant potential point sources of contamination at the site and that the site has never had a potentially contaminative land usage, therefore, it is considered unlikely that human health or Controlled Waters receptors will be at an elevated risk from the proposed development”.



However as part of the investigation confirmatory chemical testing was undertaken at the site. Results are analysed under the second tier, known as a Generic Quantitative Risk Assessment (GQRA), which uses generic guideline values to compare site chemical data against, and the final tier would be a Detailed Quantitative Risk Assessment (DQRA), which use data derived from the ground investigation to assess risks to identified receptors.

The assessment included in this report comprises a GQRA, which is undertaken by comparing soil contaminant concentrations from this investigation with conservative Generic Assessment Criteria (GAC). GAC for various land use and exposure scenarios have been selected from the following sources:

-  CL:AIRE Category 4 Screening Levels (C4SL);
-  LQM Suitable for Use Levels (S4UL);
-  CL:AIRE/EIC/AGS GAC

The GAC have been derived using the Environment Agency Contaminated Land Exposure Assessment (CLEA) model, for a range of land uses and exposure scenarios, including:

-  Residential with the consumption of home-grown produce;
-  Residential without the consumption of home-grown produce;
-  Commercial;
-  Allotments;

-  Public Open Space near residential housing (POS<sub>resi</sub>); and
-  Public Open Space public park scenario (POS<sub>park</sub>)

Given the proposed setting as a new single story secure unit as part of the existing hospital building extension. It is considered that a “Commercial” land use scenario is the most applicable as the receptor/end users at most exposure risk would be staff members i.e. nurse/doctor present at the site throughout their working life (approximately 40 years).

### *Results of Chemical Testing*

Of the four soil samples screened as part of this investigation, screened against the relevant GAC for a ‘commercial’ land use scenario as described above, none have exceeded the relevant GACs.

Additionally it is worth noting that background levels were so insignificant that the site also passes in respect to a “Residential with the consumption of home-grown produce” scenario, the most stringent scenario.

### Asbestos

Screening for the presence of asbestos did not reveal any asbestos containing material (ACM) or fibres in the two samples of soils tested.

Given the results of the desk study, intrusive investigation and laboratory testing, no significant source-pathway-receptor linkage exists at the site and consequently no additional human health risk assessment is considered necessary. However, this should be confirmed by the relevant Regulatory Authority as soon as possible prior to development.

### **RISK TO CONTROLLED WATERS**





None of the metal and inorganic contaminants tested for within the total soil chemical tests recorded significantly elevated values. Therefore it is considered that, there is no elevated risk of Controlled Waters pollution from development at this site.

The Environment Agency is the regulatory body charged with protection of controlled waters and may be a consultee in the planning process. We recommend that the conclusions of this report are agreed with the relevant Local Authority at the earliest stage, to reduce potential delays to the development.

## WASTE DISPOSAL CLASSIFICATION

### INTRODUCTION

Excavation for foundations or services will produce waste soil and possibly other waste streams. As a waste producer you have a duty of care under section 34 of the Environmental Protection Act 1990 to ensure, amongst other things that these wastes are:-

-  Correctly stored
-  Correctly classify
-  Handed only to an authorised person
-  Disposed of properly.

To aid with these obligations we have used HazWasteOnline to undertake the Hazard Assessment Screen as part of this investigation, to establish whether the sampled soils should be considered as either hazardous or non-hazardous waste. This classification process is in line with the Environment Agency's guidance WM3 "Guidance on the classification and assessment of waste", 1st edition May 2015.

### RESULTS OF HAZARD ASSESSMENT

The full results of the HazWasteOnline analyses can be seen in the Appendices.

The HazWasteOnline classification summary sheet from this investigation provides a waste classification of non-hazardous waste for all samples tested.

Also no visible pieces of asbestos were detected (by the naked eye) in any of the exploratory holes and the asbestos identification tests also recorded no asbestos within the soil. Therefore, asbestos was not considered further from a waste perspective.

#### *Waste Acceptance Criteria (WAC) Testing Results*

To further classify the waste soil for landfill disposal, Waste Acceptance Criteria (WAC) testing has been carried out on a sample of the Made Ground collected from 0.10m to 0.40m depth in CT4.

The results show that this Made Ground soil passes the inert waste criteria. The full laboratory testing results are presented in Appendices.

Uncontaminated soil can be classified as inert without testing, in accordance with EU Council Decision 2003/33/EC para. 2.1.1. As such currently the underlying soils from the site can be disposed of at an Inert Landfill site.



From the results of the HazWasteOnline spreadsheets and the WAC testing, currently, the waste soil on this site is classified Inert.

Analytical results relevant to the materials being disposed of should be provided to the landfill operators or waste management contractors to confirm whether it meets their license agreements and to confirm tipping costs.

All wastes removed from site should be consigned, transported and disposed of in full accordance with all relevant UK legislation.

### **RE-USE OF MATERIAL ON SITE**

Currently, if surplus arisings are 'fit for re-use' on the site and have not been treated, its re-use is allowed within the planning law. If it needs treating prior to re-use, exemptions can be sought from the Environment Agency to allow this activity.

Based upon the human health and groundwater risk assessments, the soil at the site is considered to be suitability for re-use on site. This analysis is however, dependent on the agreement of the Local Authority.

### **RECOMMENDATIONS**

We recommend a watching brief should be undertaken during the construction phase, and if during development any previously undiscovered contamination (including visual or olfactory evidence) is found then site management should be immediately informed and inspection by a suitably qualified person should be undertaken.

## REFERENCES

Building Research Establishment (BRE) BR 211, Radon: guidance on protective measures for new buildings. 2007.

National House Building Council (NHBC) Standards, Chapter 4.2 Building Near Trees. 2011.

National House Building Council (NHBC) Standards, Chapter 4.1 Land Quality – Managing Ground Conditions. 2011.

Environment Agency, 'The Model Procedures for the Management of Land Contamination', CLR 11, 2004.

Health and Safety Executive (HSE), "Protection of Workers and the General Public during Development of Contaminated Land" HS(G) 66. HMSO London 1991.

Environment Agency, 'Human Health Toxicological Assessment of Contaminants in Soil', August 2008.

BGS Geology of Britain Viewer : 2016. [www.bgs.ac.uk](http://www.bgs.ac.uk). British Geological Survey.

BRE Special Digest 1 : 2005 : Concrete in aggressive ground. Building Research Establishment.

BS 1377 : 1990 : Methods of test for soils for civil engineering purposes. British Standards Institution.

BS 5930 : 2015 : Code of practice for ground investigations. British Standards Institution.

BS EN 1997-2 : 2007 : Eurocode 7 - Geotechnical design - Part 2 Ground investigation and testing. British Standards Institution.

BS EN ISO 14688-1:2002+A1 : 2013 : Geotechnical investigation and testing - Identification and classification of soil - Part 1 Identification and description. British Standards Institution.

BS EN ISO 14688-2:2004+A1 : 2013 : Geotechnical investigation and testing - Identification and classification of soil - Part 2 Principles for a classification. British Standards Institution.  
Investigation of Potentially Contaminated Sites – Code of Practice, BS10175, 2011.

Environment Agency, "Waste Sampling and Testing for Disposal to Landfill" March 2013

G Card and S Wilson, An Alternative Approach for Ground Gas Risk Assessment, 2011.



## APPENDIX A



**Key**

Continuous Tube Borehole

CBR test Location

Trial Pit



4 Church Street  
Maids Moreton  
MK18 1QE

Tel:- 01280 816409  
Mob:- 07858 367 125  
www. geo-integrity.co.uk

**Exploratory Hole  
Location Plan**

**SITE:- Warneford  
Hospital**

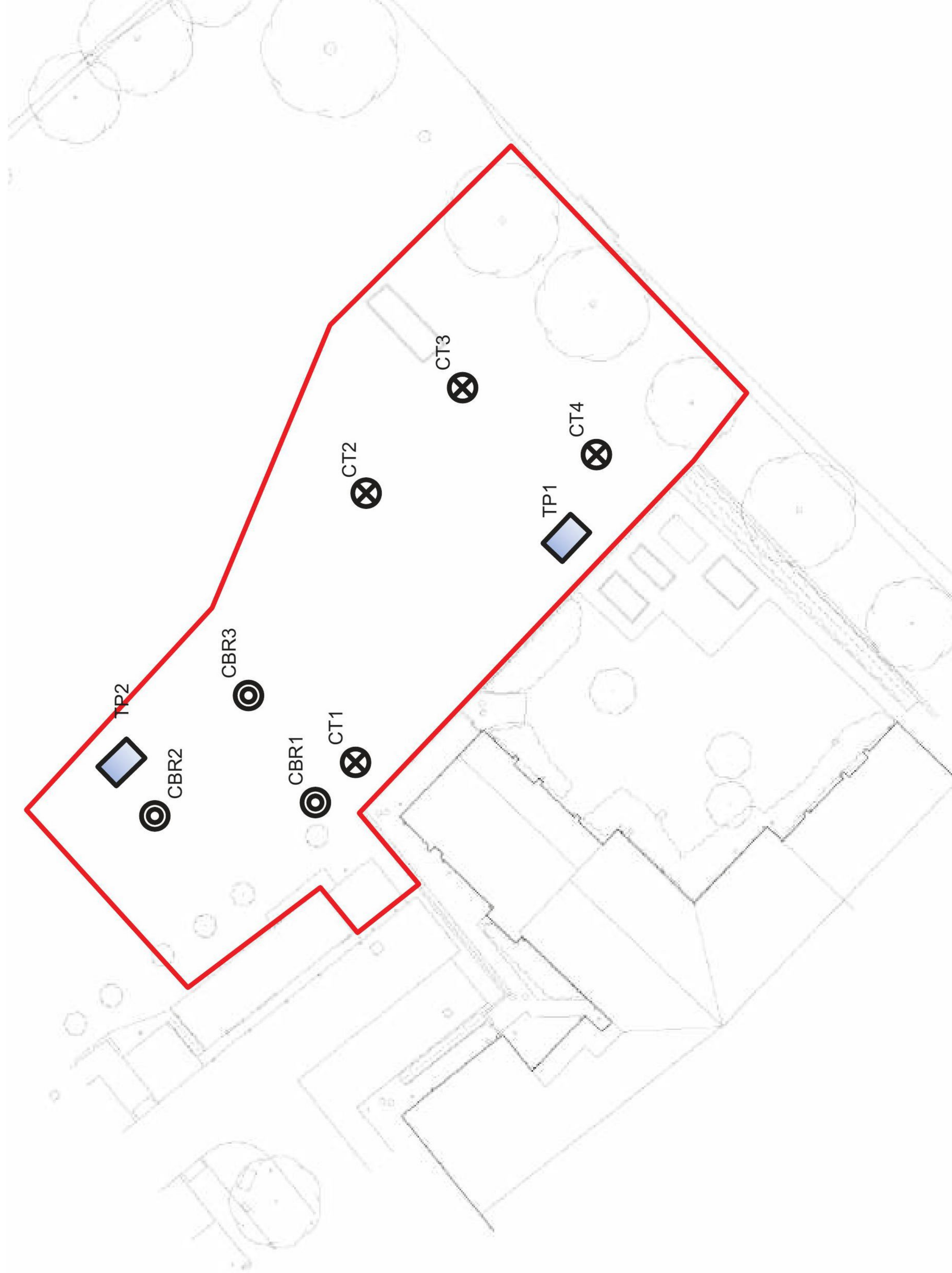
**JOB NO.:- 18-04-04**

**CLIENT:- OHF NHS  
Trust**

**Drawn  
DL**

**Checked  
MB**

**Scale: Not To Scale, for  
indicative purposes only**





Site location looking southwards



Site area from east

## APPENDIX B



# CONTINUOUS TUBE CT 1

**INTEGRITY**

<b>PROJECT NUMBER</b> 18-04-04	<b>DRILLING DATE</b> 04/05/2018	<b>EASTINGS</b> 453866
<b>PROJECT NAME</b> WARNERFORD HOSPITAL	<b>TOTAL DEPTH</b> 5m	<b>NORTHINGS</b> 205972
<b>CLIENT</b> OXFORD HEALTH NHS TRUST	<b>DIAMETER</b> 100mm-60mm	<b>SURFACE ELEVATION</b> 92.10m AOD
	<b>GROUNDWATER</b> Inflow recorded at 4.00m rising to 2.90m at completion of borehole	

<b>COMMENTS</b> Logged to BS14688:2013	<b>LOGGED BY</b> DL
	<b>CHECKED BY</b> MB

Samples	Groundwater	Depth (m)	Graphic Log	Material Description	Well Diagram	Elevation (m)
D				TOPSOIL Soft brown very sandy organic CLAY.		92
D		0.5		BECKLEY SAND MEMBER Loose brown silty slightly clayey SAND.		91.5
D		1				91
D		1.5		BECKLEY SAND MEMBER Loose becoming medium dense brown silty clayey SAND.		90.5
D		2				90
D		2.5				89.5
	∇ 2	3				89
D		3.5		BECKLEY SAND MEMBER Very Weak brownish grey calcareous SANDSTONE.		88.5
D		4		BECKLEY SAND MEMBER Medium dense becoming dense orange brown slightly clayey SAND. With occasional light grey silt inclusions.		88
D		4.5				87.5
		5		Borehole collapsed into 4m		87
		5.5				86.5





# CONTINUOUS TUBE CT 2

## INTEGRITY

<b>PROJECT NUMBER</b> 18-04-04	<b>DRILLING DATE</b> 04/05/2018	<b>EASTINGS</b> 453882
<b>PROJECT NAME</b> WARNERFORD HOSPITAL	<b>TOTAL DEPTH</b> 5m	<b>NORTHINGS</b> 205973
<b>CLIENT</b> OXFORD HEALTH NHS TRUST	<b>DIAMETER</b> 100mm-60mm	
	<b>GROUNDWATER</b> Inflow recorded at 3.20m depth Groundwater at 3.40m upon completion	<b>SURFACE ELEVATION</b> 91.50m AOD

<b>COMMENTS</b> Logged to BS14688:2013	<b>LOGGED BY</b> DL <b>CHECKED BY</b> MB
----------------------------------------	---------------------------------------------

Samples	Groundwater	Depth (m)	Graphic Log	Material Description	SPT/kN/m <sup>2</sup> (HV)	Elevation (m)
D				TOPSOIL Soft brown very sandy organic CLAY.		
D		0.5		BECKLEY SAND MEMBER Loose brown silty slightly clayey gravelly SAND. Gravel is fine to coarse sub angular of sandstone.		91
D		1			N = 4	90.5
D		1.5		BECKLEY SAND MEMBER Loose becoming medium dense brown silty clayey SAND.		90
D		2			N = 9	89.5
D		2.5				89
D		3			N = 41	88.5
D	1			BECKLEY SAND MEMBER Very Weak brownish grey calcareous SANDSTONE.		
D	2			BECKLEY SAND MEMBER Medium dense orange brown slightly clayey SAND. With occasional light grey silt inclusions.		88
D		4			N = 17	87.5
D		4.5				87
		5		Borehole collapsed into 3.9m		86.5
		5.5				86



# CONTINUOUS TUBE CT 3

## INTEGRITY

<b>PROJECT NUMBER</b> 18-04-04	<b>DRILLING DATE</b> 04/05/2018	<b>EASTINGS</b> 453892
<b>PROJECT NAME</b> WARNERFORD HOSPITAL	<b>TOTAL DEPTH</b> 4.3m	<b>NORTHINGS</b> 205961
<b>CLIENT</b> OXFORD HEALTH NHS TRUST	<b>DIAMETER</b> 100mm-60mm	<b>SURFACE ELEVATION</b> 91.50m AOD
	<b>GROUNDWATER</b> Inflow recorded at 4.00m Groundwater at 3.20m upon completion	

<b>COMMENTS</b> Logged to BS14688:2013	<b>LOGGED BY</b> DL <b>CHECKED BY</b> MB
----------------------------------------	---------------------------------------------

Samples	Groundwater	Depth (m)	Graphic Log	Material Description	Elevation (m)
D				TOPSOIL Soft brown very sandy organic CLAY.	
D		0.5		MADE GROUND (Loose) Brown and dark brown slightly gravelly SAND with occasional pottery pieces. Gravel is medium to angular of clinker.	91
D		1		BECKLEY SAND MEMBER Loose becoming medium dense brown silty clayey SAND.	90.5
D		1.5			90
D		2			89.5
D		2.5			89
D		3			88.5
D	2	3.5		BECKLEY SAND MEMBER Very Weak brownish grey calcareous SANDSTONE.	88
D		4		BECKLEY SAND MEMBER Medium dense orange brown slightly clayey SAND.	87.5
D	1	4.5		No penetration past 4.30m. Subsequent borehole collapsed into 3.8m	87
		5			86.5
		5.5			86



# CONTINUOUS TUBE CT 4

## INTEGRITY

<b>PROJECT NUMBER</b> 18-04-04	<b>DRILLING DATE</b> 04/05/2018	<b>EASTINGS</b> 453892
<b>PROJECT NAME</b> WARNERFORD HOSPITAL	<b>TOTAL DEPTH</b> 5m	<b>NORTHINGS</b> 205953
<b>CLIENT</b> OXFORD HEALTH NHS TRUST	<b>DIAMETER</b> 100mm-60mm	<b>SURFACE ELEVATION</b> 91.55m AOD
	<b>GROUNDWATER</b> Inflow recorded at 3.50m Groundwater at 2.90m upon completion	

<b>COMMENTS</b> Logged to BS14688:2013	<b>LOGGED BY</b> DL <b>CHECKED BY</b> MB
----------------------------------------	---------------------------------------------

Samples	Groundwater	Depth (m)	Graphic Log	Material Description	SPT/kN/m <sup>2</sup> (HV)	Elevation (m)
D				TOPSOIL Soft brown very sandy organic CLAY.		91.5
D		0.5		MADE GROUND (Loose) brown and dark brown ashy gravelly SAND. Gravel is fine to medium angular of pottery and clinker.		91
D		1		BECKLEY SAND MEMBER Loose becoming medium dense brown silty clayey SAND.	N = 5	90.5
D		1.5				90
D		2			N = 6	89.5
D		2.5				89
D	2	3			N = 16	88.5
D		3.5		BECKLEY SAND MEMBER Medium dense orange brown slightly clayey SAND. With occasional light grey silt inclusions.		88
D	1	4		BECKLEY SAND MEMBER Medium dense orange brown slightly clayey SAND.	N = 15	87.5
D		4.5				87
		5		Borehole collapsed into 2.90m.		86.5
		5.5				86



# TRIAL PIT LOG TP 1

**INTEGRITY**

<b>PROJECT NUMBER</b> 18-04-04	<b>EXCAVATION DATE</b> 04/05/2018	<b>EASTINGS</b> 453885
<b>PROJECT NAME</b> WARNERFORD	<b>TOTAL DEPTH</b> 2.0m	<b>NORTHINGS</b> 205952
<b>CLIENT</b> OXFORD HEALTH NHS TRUST	<b>EXCAVATION METHOD</b> MINI DIGGER	<b>SURFACE ELEVATION</b> 91.60m AOD
	<b>GROUNDWATER</b> DRY	
	<b>DIMENSIONS (W X L)</b> 0.3m x 1.50m	

<b>COMMENTS</b> Logged to BS14688:2013	<b>LOGGED BY</b> DL
	<b>CHECKED BY</b> MB

Hand Vane (kN/m <sup>2</sup> )	Samples	Groundwater	Depth (m)	Graphic Log	Material Description	Elevation (m)
			0.1		TOPSOIL Soft brown very sandy organic CLAY.	91.5
	D		0.2		MADE GROUND Light brown very sandy slightly gravelly CLAY. Gravel is fine to coarse angular of concrete and flint.	
			0.3			
			0.4			
	B		0.5		BECKLEY SAND MEMBER (Loose) Brown silty slightly clayey SAND.	91
			0.6			
			0.7			
			0.8			
			0.9			
	B		1			
			1.1			90.5
			1.2			
			1.3			
			1.4			
			1.5			
			1.6			90
			1.7			
			1.8			
			1.9			
			2			
			2.1		Soil densities have been assumed by ease of excavation.	89.5
			2.2			
			2.3			
			2.4			



# TRIAL PIT LOG TP 2

**INTEGRITY**

<b>PROJECT NUMBER</b> 18-04-04	<b>EXCAVATION DATE</b> 04/05/2018	<b>EASTINGS</b> 453859
<b>PROJECT NAME</b> WARNERFORD	<b>TOTAL DEPTH</b> 1m	<b>NORTHINGS</b> 205989
<b>CLIENT</b> OXFORD HEALTH NHS TRUST	<b>EXCAVATION METHOD</b> MINI DIGGER	<b>SURFACE ELEVATION</b> 92.0m AOD
	<b>GROUNDWATER</b> DRY	
	<b>DIMENSIONS (W X L)</b> 0.3m x 1.30m x 1.00m	

<b>COMMENTS</b> Logged to BS14688:2013	<b>LOGGED BY</b> DL
	<b>CHECKED BY</b> MB

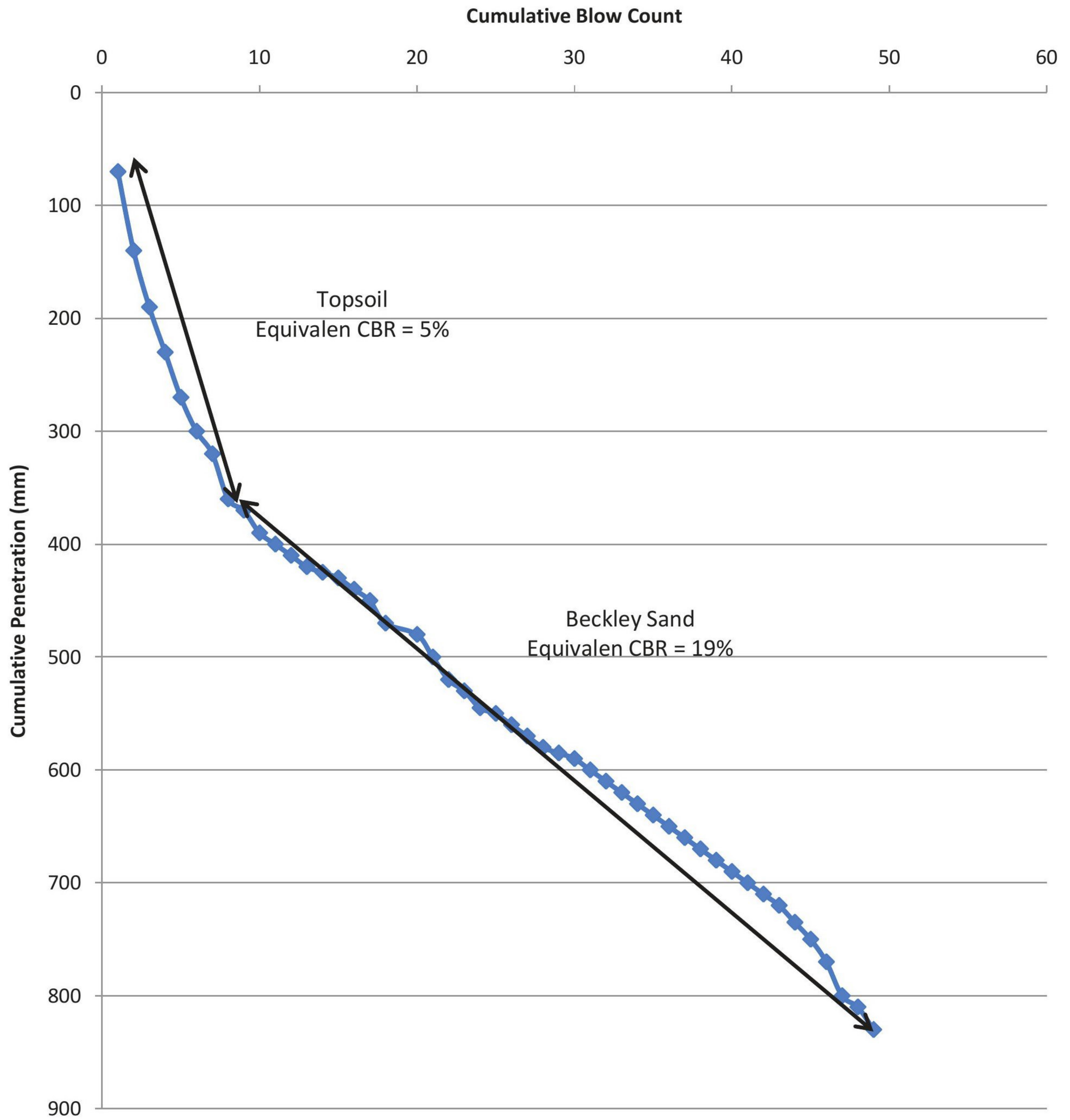
Hand Vane (kN/m <sup>2</sup> )	Samples	Groundwater	Depth (m)	Graphic Log	Material Description	Elevation (m)
			0.1		TOPSOIL Soft brown very sandy organic CLAY.	91.9
	D		0.2		MADE GROUND Soft to firm light brown very sandy slightly gravelly CLAY. Gravel is fine to coarse angular of concrete and flint with rare cobbles of brick and tarmac.	91.8
			0.3			91.7
			0.4			91.6
	B		0.5		BECKLEY SAND MEMBER (Loose) Brown silty slightly clayey SAND.	91.5
			0.6			91.4
			0.7			91.3
			0.8			91.2
			0.9			91.1
			1		Soil densities have been assumed by ease of excavation.	91
			1.1			90.9
			1.2			90.8
			1.3			90.7
			1.4			90.6
			1.5			90.5
			1.6			90.4
			1.7			90.3
			1.8			90.2
			1.9			90.1



# TRL DYNAMIC CONE PENETROMETER RECORD

Job No:- 18-04-04  
Job Name:- Warnerford Hospital  
Position:- CBR1

## Cumulative Blows Vs Penetration (mm)

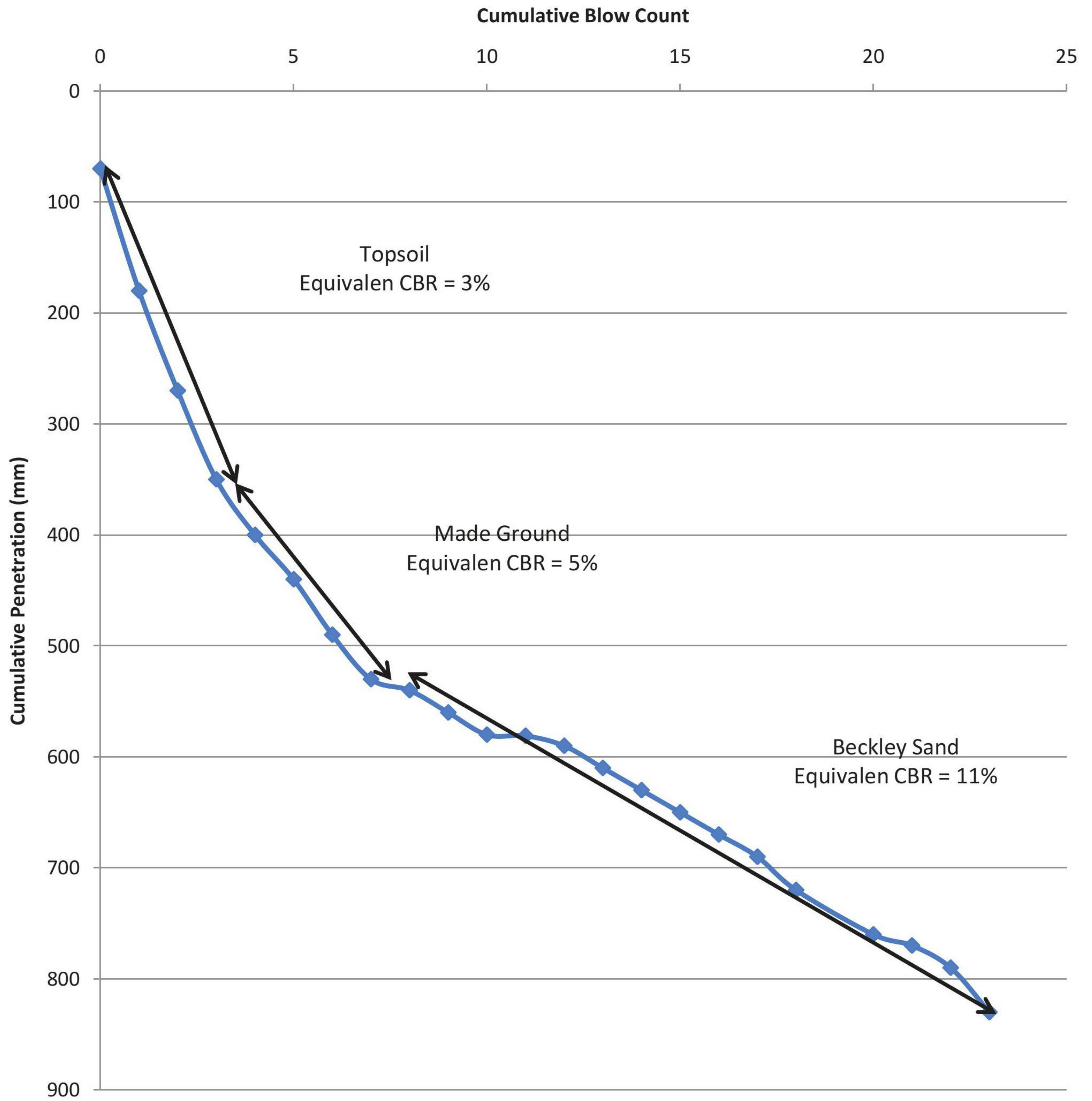




## TRL DYNAMIC CONE PENETROMETER RECORD

Job No:- 18-04-04  
Job Name:- Warnerford Hospital  
Position:- CBR2

### Cumulative Blows Vs Penetration (mm)

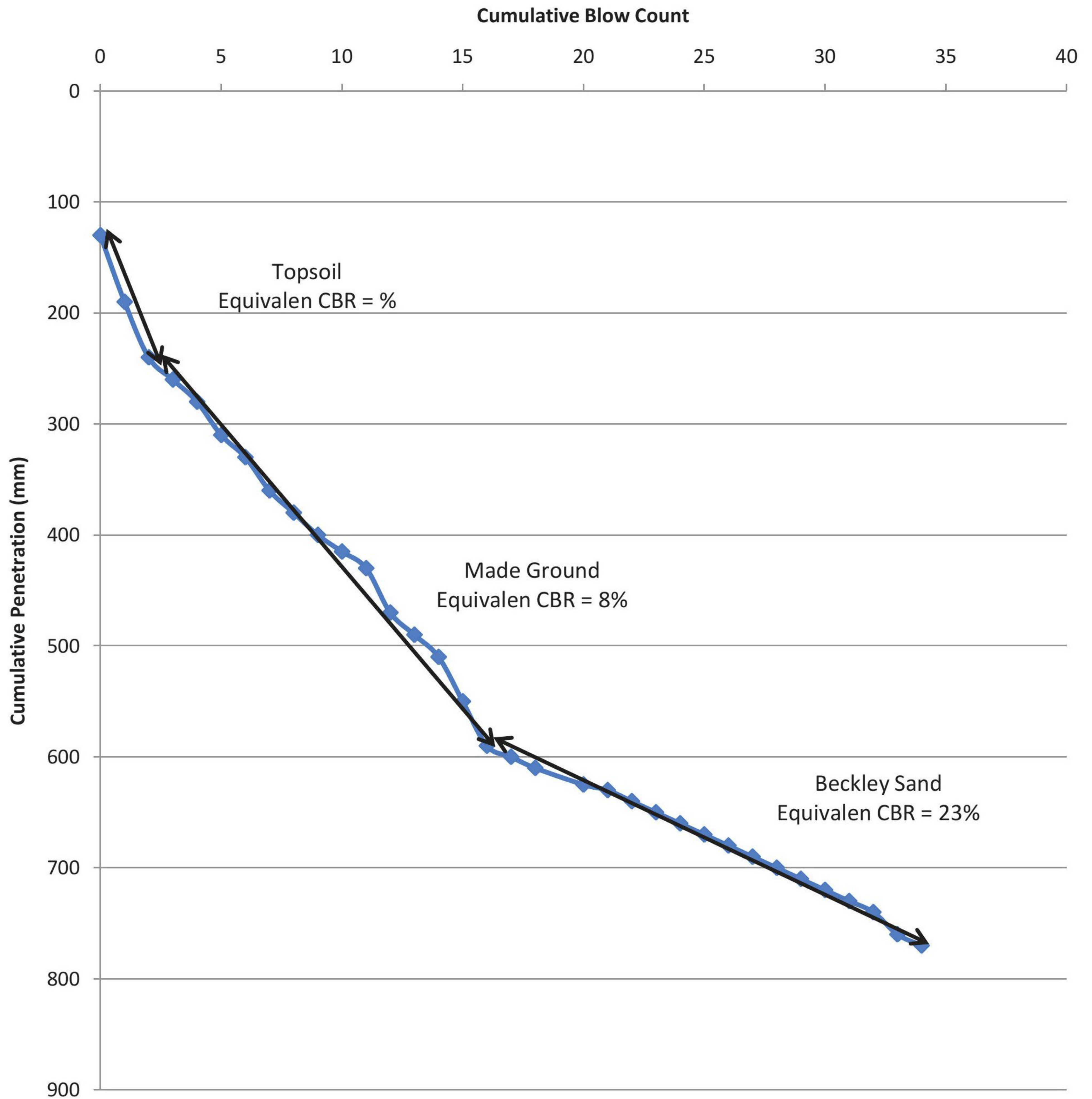




## TRL DYNAMIC CONE PENETROMETER RECORD

Job No:- 18-04-04  
Job Name:- Warnerford Hospital  
Position:- CBR3

### Cumulative Blows Vs Penetration (mm)







Geo-Integrity Ltd.  
www.geo-integrity.co.uk  
murraybateman@geo-integrity.co.uk  
07858 367 125  
01280 816409



### Trial Pit Infiltration Testing to BRE Digest 365

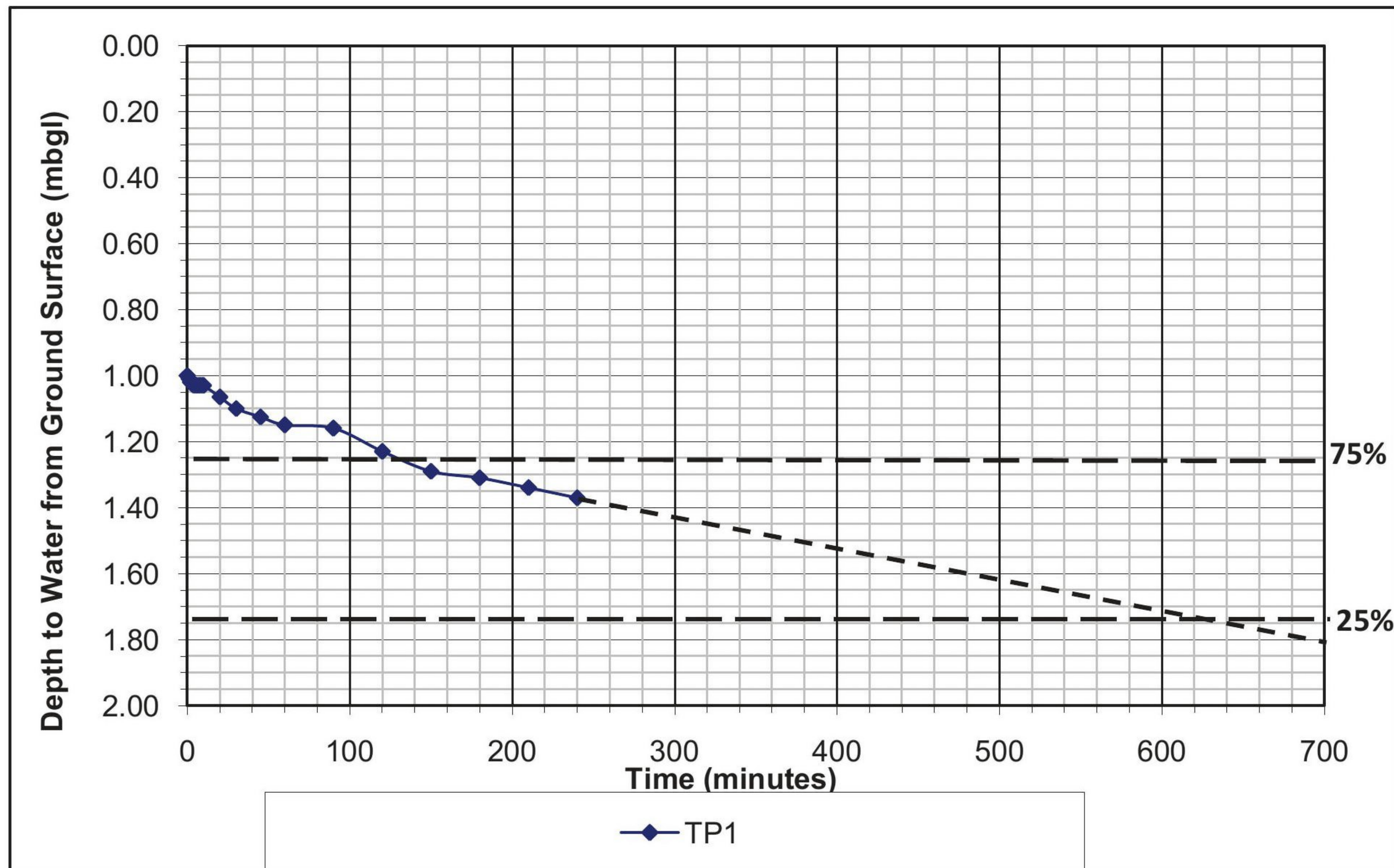
**Client:** Oxford Health NHS Trust  
**Site:** Warnerford Hospital  
**Dimensions:** 0.30m x 1.50m x 2.00m  
(width x length x depth)

**Report No:** 18-04-04  
**Date Tested:** 18/04/18  
**Test Location:** TP1

#### Test Response Zone Description - : Beckley Sand

Time	Depth BGL	Time	Depth BGL	Time	Depth BGL
0	1.00	7	1.03	60	1.15
1	1.01	8	1.03	90	1.16
2	1.02	9	1.03	120	1.23
3	1.03	10	1.03	150	1.29
4	1.03	20	1.07	180	1.31
5	1.03	30	1.10	210	1.34
6	1.03	45	1.13	240	1.37

**Average Soil Infiltration Rate =  $3.40 \times 10^{-6}$  m/s**  
**Comments : Caution Results Extrapolated**





Geo-Integrity Ltd.  
www.geo-integrity.co.uk  
murraybateman@geo-integrity.co.uk  
07858 367 125  
01280 816409



### Trial Pit Infiltration Testing to BRE Digest 365

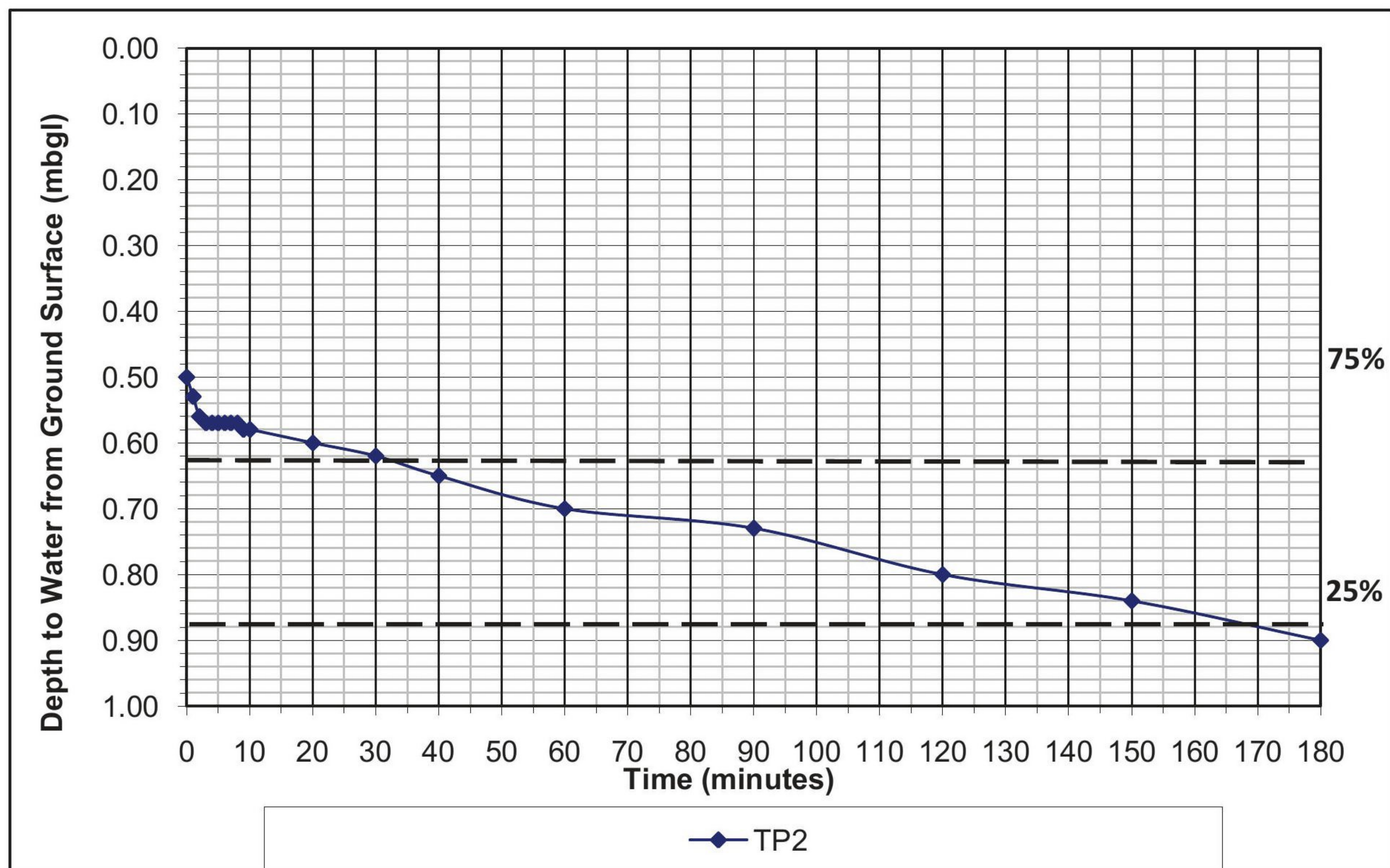
**Client:** Oxford Health NHS Trust  
**Site:** Warnerford Hospital  
**Dimensions:** 0.30m x 1.30m x 1.00m  
(width x length x depth)

**Report No:** 18-04-04  
**Date Tested:** 18/04/18  
**Test Location:** TP2

#### Test Response Zone Description - : Beckley Sand

Time	Depth BGL	Time	Depth BGL	Time	Depth BGL
0	0.50	7	7.00	60	0.70
1	0.53	8	8.00	90	0.73
2	0.56	9	9.00	120	0.80
3	0.57	10	10.00	150	0.84
4	0.57	20	20.00	180	0.90
5	0.57	30	30.00		
6	0.57	40	40.00		

**Average Soil Infiltration Rate =  $9.9 \times 10^{-6}$  m/s**





Date	Job No.	BH	CH4(%)	LEL(%)	CO2(%)	O2(%)	H2S (ppm)	CO (ppm)	Hex(%)	PIDCf()	PkFlw (lh)	AP (mbar)	GW (m bgl)	Pmp (s)	Bal(%)
10/05/18	18-04-04	CT1	0	0	4.8	13.6	0	0	0.003	1	0	1007	2.76	62	81.6