Geo-Environmental

GROUND INVESTIGATION REPORT

for the land at

WOODCROFT FARM PHASE 3,

LOVEDEAN, HAMPSHIRE

PO9 9WN

on behalf of

GRAINGER PLC

Report:	**GROUND INVESTIGATION REPORT**
Site:	**WOODCROFT FARM PHASE 3, LOVEDEAN, HAMPSHIRE, PO9 9WN**
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EXECUTIVE SUMMARY		
Site Details	Site Address	Woodcroft Farm Phase 3, Lovedean, Hampshire, PO9 9WN
	National Grid Reference	468186, 112255
	Site Area	6.91Ha (approx.)
	Form of Development	The proposed development is understood to comprise the construction of residential dwellings with associated private gardens, areas of soft landscaping, car parking, access road and other associated development infrastructure.
Encountered Conditions	Scope of works	A series of surface anomalies were present on site which were identified by a previous phase of site assessment as likely to comprise surface expression of sub-surface chalk solution features. The Master Plan prepared following the third-party assessment (2015) sought to avoid development within the features. An intrusive investigation was required by the Client to inform a review and update to the emerging Master Plan ahead of an Outline Planning Application. The scope of investigation comprised targeting the features and their peripheries to clarify ground conditions and identify surface and/or sub-surface constraints which may need to be accounted for in the Master Plan. The investigation would also serve to provide initial assessment of the ground around these features to inform technical design.
	Ground Conditions	The ground conditions encountered comprised a variable depth of interbedded clay, sandy/gravelly clay, clay, sand and gravel considered likely to be Lambeth Group strata (as mapped by BGS) with highly weathered Chalk encountered at depth within some of the exploratory holes. The investigation targeted areas identified as sinkholes and a palaeo-valley. Zones of potentially weak and/or voided ground were identified within some exploratory holes. Whilst some potentially weak or voided zones at shallow depth were indicated from probing around the northern end of the palaeo-valley and within the eastern field, proximal exploratory holes encountered firm or stiff clay such that shallow 'low blow counts' in these areas were not considered as clear indicators of weak or voided ground. However, probing and in-situ testing in boreholes within and proximal to the sinkholes also identified zones and pockets of weak ground or potentially voided ground at depth and were considered likely to be associated with Chalk dissolution. In addition to probe/SPT results, drill strings were observed to sink under their own weight (no blows applied) during borehole construction, e.g. WS02 in Sinkhole 1. It is anticipated from published mapping that the strata of the Lambeth Group increase in thickness towards the north and north-east. In addition, mapping showed a tract of Head Deposits located in the vicinity of Sinkhole 4 and the southern end of the portion of the palaeo-valley located within the site. The strata encountered in exploratory holes within this portion of the site were similar in composition to soils in exploratory holes elsewhere within the site and thus are reported as Lambeth Group. It is noted that investigation undertaken for Grainger by Geo-Environmental on land immediately to the south of the site demonstrated that the palaeo-valley feature extended towards the south and south-west and that superficial strata over Lambeth Group or Chalk became more evident around that off-site portion of the palaeo-valley. Whilst the Master Plan has evolved to avoid development (houses) within the sinkholes and palaeo-valley, some development such as access road, cycleway, amenity landscaping and the like is proposed in areas of these features. The presence of the sinkholes is not considered to preclude development on the wider site, but the variation in ground conditions and implications for detailed design, construction and end use will need to be considered further in due course.
	Groundwater	Groundwater was not encountered within any of the exploratory holes during the intrusive investigation, nor is it expected to be present at shallow depth based on publicly available groundwater records for the area within which the site is located.

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Geotechnical Considerations	Foundations	It is anticipated based on the ground conditions encountered, that conventional foundations may be suitable for many of the plots proposed within the site. However, piled foundations, or alternative foundations are likely to be require for some plots due to factors such as tree influence on clay strata, proximity to sinkholes and presence of weak or voided ground beneath or close to plot foundations. The soils of the Lambeth Group should be considered as High Volume Change Potential as defined in NHBC Standards thereby requiring a minimum founding depth of 1m bgl. Foundations must pass through Topsoil, Made Ground, earthworks fill, root zones, disturbed/reworked ground or the like and terminate in competent strata, e.g. stiff clay of the Lambeth Group or Chalk. A preliminary net allowable bearing capacity of 125kPa is recommended for the stiff clay soils of the Lambeth Group. Whilst a higher bearing capacity might be achievable for Chalk, this is not recommended at this stage due to the likelihood that foundation bases could span differing strata and using a higher bearing capacity could overstress clay soils. Reinforcement will be required for all foundations as discussed in the main text. It is expected that where conventional foundations are to be constructed, the building warranty provider will require excavations to be inspected by a Geotechnical Engineer at the time of excavation in order to check for the presence of previously undetected solution features, karstic weathering and other factors which might influence foundation performance.
	Floor Slabs	Suspended floor slabs will be required due to the presence of shrinkable strata.
	Excavations	It is anticipated that shallow excavations would be stable in the short term providing they remain dry and are not surcharged. Long and/or deep excavations, excavations left open for extended periods of time, or excavations which intercept weak, voided or granular ground are likely to be prone to collapse. Long and/or deep excavations across sloping ground should be avoided due to their potential to initiate instability of the ground upslope of the excavation and possible catastrophic collapse. The need for entry into excavations should, where possible, be designed out. However, where this cannot be achieved a robust risk assessment must be undertaken and entry of any personnel only permitted in accordance with an approved risk assessment, method statement and safe system of work.
	Drainage	Soakage testing undertaken as part of the investigation was unsuccessful and it is considered that conventional soakaways will not perform satisfactorily on this site. Given the presence of known/identified sinkholes on the site, a minimum offset of 20m is required between any foundation and soakaway or component of a storm water drainage scheme where any infiltration is likely. Whilst the sinkholes might provide topographically good locations for storm water basins, if these features are used to store water, the basins, inlets and outfalls, must be lined such that infiltration to the ground is not possible. This will be necessary to mitigate the risk of infiltration induced collapse of the ground, which could be sudden and locally catastrophic, i.e. formation of crown holes/collapse and open holes at ground surface.

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	Pavements	Based on the results of testing to date, a preliminary design CBR of 2% is recommended for the shallow soils across the site. The shallow soils should be assumed to be frost susceptible thus requiring a minimum pavement thickness of 450mm. Any hard or soft spots in the formation level may induce reflective cracking in the pavement and allowance should be made for removing hard or soft spots that may be present. The master Plan shows an access road entering the southern central portion of the site, i.e. into the southern end of the palaeo-valley and Sinkhole 4 with the road then turning westward over Sinkhole 3 and into the western portion of the site. Specific ground engineering will be required to mitigate the potential for road deformation where it crosses Sinkholes 3 and 4.
	Buried Concrete	The results of the water soluble sulphate and pH analyses indicate that buried concrete should be designed in accordance with Class DS-1 of BRE Special Digest 1, with an ACEC class of AC-1s. The advice of this publication should be taken for the design and specification of all sub surface concrete.
Environmental Considerations	Human Health	No soil contamination was identified from the investigation and testing undertaken. As such, at this stage, it is anticipated that no specific remediation measures would be required.
	Groundwater	No pollutant linkages for groundwater have been identified in relation to the existing site condition or in the context of the proposed development. It is therefore considered that no risk mitigation measures are required.
	Radon	Radon protection measures are not anticipated to be required.
	Built Environment	In the absence of any identified contamination, it is anticipated that standard pipe materials could be suitable for potable water supply. This would be subject to consultation with the water supply company.
	Waste soils	Where possible, soils should be retained and re-used on site, subject to a certainty of requirement and physical, geotechnical and geochemical suitability. Assessment of laboratory results has not identified soils tested as having hazardous properties from a waste classification perspective.
Further Action: The findings of this investigation should be used to inform any further evolution of the Master Plan and interaction with other technical disciplines in the master planning process. Further ground investigation of the main development areas will be required in due course to inform design. A foundation works risk assessment may be required if piled foundations are proposed to be constructed in Chalk strata beneath the site due to its location within SPZ I. Preparation of an Earthworks Specification, to reflect the findings of this phase of investigation works. A discovery strategy must be maintained during development such that any abnormal conditions (geotechnical or potential contamination) are identified, the discovery strategy should be enacted and their potential impact on the proposed development assessed prior to determining any potential mitigation measures. Allowance for a Geotechnical Engineer to attend site to inspect and record ground conditions exposed in foundation excavations. This is anticipated to form a building warranty provider condition for plots on conventional foundations due to the presence of geohazards on/beneath the site.		
This Executive Summary is intended to provide a brief summary of the main findings and conclusions of the investigation. For detailed information, the reader is referred to the main report ref. GE20772-GIR-DEC23.		

1.0 INTRODUCTION

1.1 General

Geo-Environmental Services Limited (Geo-Environmental) was instructed by Grainger plc (the Client), to undertake an investigation of the geotechnical and geo-environmental factors pertaining to land within the Woodcroft Farm Phase 3 development area at Woodcroft Farm, Lovedean, Hampshire, PO9 9WN (see Figure 1). The area to be investigated included a series of surface depressions, including six sinkholes and a palaeo-valley, as identified by previous third party assessment within the site and from investigation on the adjacent 'Phase 2' development.

1.2 Form of Development

The proposed development is understood to comprise the construction of residential dwellings with associated private gardens, areas of soft landscaping, car parking, access road and other associated development infrastructure. At the time of the investigation, the Master Plan was going through a review and revision process, with findings from the investigation and other technical disciplines informing the process.

It is understood from the Client's Planning Consultants that "Outline planning application [has been] sought for the development of up to 200 dwellings, with associated vehicular access and landscaping (all matters reserved except access)".

The development layout incorporates retention of the six main sinkholes (Sinkholes 1-6) and palaeo-valley, identified in the 2015 third-party report.

1.3 Objectives

The investigation was undertaken to target the land around Sinkholes 1-6 and a palaeo-valley, where development is proposed with an aim of clarifying the ground conditions in terms of composition, condition and variation across the development area and from this to identify potential development constraints and associated technical solutions. The objective of the investigation was to gather geological and geotechnical information to inform geohazard and constraints assessment with respect to progression of the development master plan ahead of an outline planning application for development of the site.

1.4 Standards and References

Where practicable, the ground investigation and subsequent geotechnical and environmental assessments were undertaken in accordance with the following documents and guidance.

National Planning Policy Framework, September 2023;
Land Contamination Risk Management (LCRM), updated July 2023;
Model Procedures for the Management of Contaminated Land, CLR11, DEFRA and Environment Agency 2004; (withdrawn);
Environment Agency Guidance on Requirements for Land Contamination Reports, Version 1 dated July 2005;
BS10175:2011+A2:2017 - Investigation of Potentially Contaminated Sites - Code of Practice, BSI 2017;
BS5930:2015+A1:2020 - Code of Practice for Site Investigations, BSI 2020;
EN ISO 14688 Geotechnical Investigation and Testing Part 1-2002 and Part 2-2004;
BS1377: 1990 - Soils for Civil Engineering Purposes, BSI1990;
EN 1990: Eurocode – Basis of Structural Design;
BS EN 1997-1. Eurocode 7: Geotechnical Design – General Rules 1997-1:2004, BSI;
British Standards Institute - Eurocode 7 – Geotechnical Design - Parts 1 & 2 (BS EN1997-1:2004 & BS EN1997-2:2007);

National Annex to BS EN 1997-1. UK National Annex to Eurocode 7: Geotechnical Design – General Rules 1997-1:2004, BSI;
CIRIA C574 – Engineering in Chalk (2002);
The nature, formation and engineering significance of sinkholes related to dissolution of chalk in SE Hampshire, England. P W McDowell, J Coulton, C N Edmonds and A J Poulsom. Quarterly Journal of Engineering Geology and Hydrogeology, Volume 41, Part 3, August 2008, pp 279-290;
NHBC Standards Chapter 4.1 Land Quality - Managing Ground Conditions;
NHBC Standards Chapter 4.2 Building Near Trees;
BRE BR240 Low-rise buildings on shrinkable clay soils: Part 1, 1993.

1.5 Conditions

This report does not purport to be a "Geotechnical Design Report" as defined in Clause 2.8 of Eurocode 7 (Geotechnical Design BS EN 1997-1:2004) and some of the data used to support this preliminary geotechnical assessment may not be fully compliant with that design code. It is considered possible that further detailed ground investigations could be required to facilitate the detailed geotechnical design process and should be carried out on a structure specific basis if necessary.

The desk study data where reviewed for the site as part of third-party reports is assumed to be factually correct and up to date at the point of review. No liability is taken for any omissions or inaccuracies in the data presented. It must also be noted that changes to the desk study data may occur following the production of this report, Geo-Environmental accepts no liability where this subsequently affects the assessment presented herein.

The data collected from the investigations have been used to provide an interpretation of the geotechnical and/or environmental conditions pertaining to the site. The recommendations and opinions expressed in this report are based on the data obtained. Geo-Environmental takes no responsibility for conditions that either have not been revealed in the available records, or that occur between or under points of physical investigation, or that result from updates to desk-based data/third party investigations utilised subsequent to that presented herein or reviewed at the time of writing which may in turn alter the presented assessment. Whilst every effort has been made to interpret the conditions, such information is only indicative, and liability cannot be accepted for its accuracy.

It must be noted that the findings and assessment presented herein are based on the ground and groundwater conditions as encountered at the time of investigation within the investigation positions undertaken and any associated testing and monitoring. The ground by its very nature is variable and the engineering properties of soils can vary over time, such as due to changes in soil moisture content, disturbance and similar factors. Similarly, groundwater conditions can and do vary over time. As such, if conditions are encountered which differ from those described herein, the Client or their appointed representative, e.g. contractor, must seek advice from a Geotechnical Engineer at the earliest practicable opportunity. It is possible that this could result in changes to the assessment presented herein.

It should be noted that in particular the concentrations and levels of mobile liquid and gaseous materials are likely to vary with time. The results obtained may therefore only be representative of the conditions at the time of sampling. The absence of asbestos noted during the site walkover or within any soil samples analysed does not guarantee the absence of asbestos within buildings, within or bonded to concrete, as discrete burials, or within the soils mass elsewhere within a site. This report should not be taken as any guarantee that a site is free of hazardous or potentially contaminative materials.

Information contained in this report is intended for the use of the Client and Geo-Environmental can take no responsibility for the use of this information by any party for uses other than that described in this report. Geo-Environmental makes no warranty or representation whatsoever express or implied with respect to the use of this information by any third party. Geo-Environmental does not indemnify the Client or any third parties against any dispute or claim arising from any finding or other result of this investigation report or any consequential losses.

Assessment criteria or other parameters developed for the evaluation of contamination on this site are based on a number of assumptions regarding exposure and toxicology. Exposure to contaminants and levels of adverse effects may therefore vary. Whilst reasonable care and expertise has been employed in the development of such criteria, no liability is accepted in this respect. Other criteria or guidance on the development of assessment criteria may be published in the future and no liability is accepted in this respect.

This report remains the property of Geo-Environmental and the Client has no rights to, or reliance upon this document or supporting documents until such time as payment has been received in full for all invoices for works undertaken in connection with this report.

2.0 SITE CONTEXT

2.1 Previous Report

The site has been the subject of a Phase I Ground Condition Assessment undertaken by Peter Brett Associates (now Stantec) ref. 21834, dated January 2015.

A brief summary of the findings deemed relevant to this phase of investigation are presented below. It is assumed that the third-party information is factually correct, and that Grainger plc has reliance on the data included within the report.

Geo-Environmental accepts no liability for errors or omissions within the third-party report, nor for implications of any updates in the background datasets since the third-party desk study was undertaken. For further information reference should be made to the Phase I Ground Condition Assessment, January 2015.

A desk study was undertaken as part of the third-party report for the site, which included a review of historical maps, an environmental database search, a site walkover and production of a preliminary conceptual site model.

The desk study data identified the site's anticipated underlying geology to comprise bedrock geology of the Lambeth Group described as, mottled locally sandy clay and overlying the Tarrant Chalk Member at depth. The Chalk was mapped at surface in the northwestern corner of the site. The bedrock geology was reportedly overlain by Head Deposits comprising sandy silty clay, locally gravelly chalk and flint, at the southern boundary of the site within the minor valley feature. It was considered possible by the 2015 report's authors that, due to site topography, Head Deposits derived from reworking of the Lambeth Group and the Chalk by natural processes may be present in other areas of the site.

The desk study stated that the potential for the occurrence of the majority of geological hazards at the site was negligible or very low with the exception of hazards arising from shrinking and swelling of clays of the Lambeth Group which was considered a Moderate Hazard. The potential for occurrence of solution features was considered to be a High Hazard.

During the site visit undertaken as part of the third-party 2015 investigation six possible solution features were identified at the site. Two of these features were recorded on the PBA Natural Cavities Database as sinkholes or swallow holes. Furthermore, an area of karstic underdrainage was identified in the base of the minor valley feature to cross the site. The soils within and in the immediate vicinity of the sinkholes were expected to be weak, with infilled or even voided zones posing a ground instability hazard.

Overall, the potential hazard for ground subsidence over karstic features formed by dissolution weathering of chalk at the site was assessed to be High.

The superficial Head Deposits and bedrock geology of the Lambeth Group were classified as Secondary A Aquifers, which are formations of variable permeability that, although seldom producing large quantities of water for abstractions, may be important for local supplies and in supplying base flow to rivers. The Chalk was classified as a Principal Aquifer, which is defined as layers of rock or drift deposits that have high intergranular and/or fracture permeability, meaning they usually provide a high level of water storage. They may support water supply and/or river base flow on a strategic scale.

Groundwater vulnerability mapping showed that the soils on the majority of the site have low leaching potential, whereas the soils in the southwestern corner of the site were shown to have intermediate leaching potential.

The site was shown to be located within an Inner Source Protection Zone (Zone 1) for a groundwater abstraction. According to the Envirocheck Report there are two recorded groundwater abstractions located within a 2km radius of the site. The closest abstraction license is registered to Portsmouth Water Ltd located approximately 1km to the

north of the site and used for potable water supply. It is understood that the Inner Source Protection Zone (Zone 1) that underlies the site is in-place to safeguard this abstraction point.

There are no records of any significant surface watercourses within 1km of the site.

The site was recorded as being within an area where Radon protection measures are not required. Current radon mapping (updated December 2022) indicates the site is located in an area where 1-3% of homes are above the Action Level for radon. This is not anticipated to change the assessment presented in the 2015 assessment.

The desk study stated that the site had been in agricultural use (horse grazing) with no identified sources of contamination on the site. The site was surrounded by agricultural land. Limited potential contamination was identified at Woodcroft Farm (formerly located to the south of the site) within a small, infilled pit and dismantling yard. It should be noted that Woodcroft Farm has been redeveloped as residential housing since the production of the 2015 third-party report. Based on the contemporary and historical land uses, both on and offsite, the potential for significant widespread ground contamination was considered to be very low.

The 2015 report stated that, it is expected that any structures, roads and services within and immediately adjacent to the sinkholes and the karstic underdrainage area may suffer from significant settlement and structural damage with time. It was therefore recommended that a development exclusion buffer zone of 10m from the identified edge of any untreated sinkhole or karstic underdrainage zone is applied. This would include any structure in the vicinity such as buildings, services or roads. Alternatively, consideration could be given to carrying out ground treatment to stabilise the sinkholes or karstic underdrainage zone to permit future development. Appropriate remedial works include the removal of loose soil infill, compaction grouting of the weathered karstic chalk, and backfilling of the depression with engineered fill to create a building platform. The process would require an engineering specification and validation testing, also the use of materials that do not cause any deleterious effect upon the underlying aquifer.

In terms of foundations, the 2015 report stated that due to the expected presence of sinkholes and associated disturbed ground linked to the underlying karstic weathering of chalk there is a risk that hitherto undiscovered solution features that can lead to sinkhole formation might be present elsewhere on the site even without surface expressions such as a depression. Consequently, future subsidence and settlement of near surface soils into such features would occur beneath conventional foundation types and lead to a risk of structural damage. Such instability could be triggered by extremes of climate, changes to infiltration and drainage due to development, soakaways or leakages etc.

Suggested foundation options included reinforced conventional spread or strip foundations and reinforced raft foundations following the proving of ground conditions using dynamic probing techniques to confirm span conditions. It was also recommended that all bearing surfaces be inspected by a qualified geotechnical engineer prior to constructing foundations to ensure that the design criteria are achieved. Any soft or loose soil encountered at foundation level was recommended to be removed and replaced with well compacted granular fill or foundation concrete.

The 2015 report considered that soils of the Lambeth Group and Head Deposits are likely to be classified as shrinkable. A minimum founding depth of 0.9m bgl was recommended but it was noted that this depth may need to be increased where foundations are located close to existing or new trees, hedgerows or shrubs that may cause significant changes in moisture content resulting in ground movement. In addition, suspended floors were stated as possibly being required due to potential volume change resulting in ground movement.

Surface water drainage using shallow infiltration (soakaways) was considered unlikely due to low permeability of near surface soils over large areas of the site. It was noted that surface water drainage should not be discharged into the sinkhole features to avoid triggering instability and avoiding the potential to discharge pollutants directly into the underlying chalk aquifer.

It was recommended that ground investigation and laboratory testing should be undertaken in order to ascertain the Design Sulphate Class required to design concrete that is in contact with the ground.

In terms of environmental risks to the site the 2015 report concluded - Based on the known current and historical land uses at the site (farmland) the potential for contamination to be present as a result of on-site activities is considered to be Very Low. Given the level of risk and the proposed end use it is anticipated that a ground investigation is not likely to be required to support the planning application for redevelopment of the site owing to contamination. Notwithstanding the above, it is recommended that any future ground investigation at the site will incorporate some basic contamination testing to support the conclusions of this study.

In relation to geotechnical risks the 2015 report concluded - The presence of ground dissolution hazards is potentially a major constraint for the proposed development. A ground investigation will be required to confirm the ground conditions, in particular, the presence, extent and nature of the solution features (sinkholes and karstic underdrainage). The potential presence of unstable solution features will have a potential impact on foundations, infiltration drainage, infrastructure and services. Notwithstanding the above, it is possible to undertake safe development of such sites provided that the geotechnical characteristics are fully understood, the risks adequately managed and appropriate engineering solutions are adopted to mitigate the hazards. A ground investigation will be required to inform a mitigation strategy. It is possible that remedial ground treatment of an area will be required to facilitate the development as currently proposed.

2.2 Site Description

The site comprised an irregularly shaped parcel of land located at NGR 468186, 112255 which extended to c. 6.91ha. Six distinct depressions were present within the investigation area and these correlated with Sinkholes 1 – 6 as described in the 2015 report.

At the time of the intrusive investigation works, September 2023, the site comprised two separate agricultural fields divided by a public footpath. This footpath/track divided the two fields running in a north-south direction. The track was lined with dense vegetation and trees along the eastern side, with a radio mast located in the northeastern corner of the western field and adjacent to the track.

Both the western and eastern fields were bounded by a mix of mature trees, hedgerows and fencing around all site boundaries. Public footpaths and bridleways were noted to be present to the north of the site and the west of the western field.

The site was surrounded by agricultural land to the north and west and residential uses to the south and east.

Western Field

The western field was being utilised for the grazing of horses from the adjacent stables and was accessed via a gateway located in the northwestern corner of the field.

The ground surface on the western field generally fell from north to south. Four depressions/sinkholes were noted within the field (Sinkhole 1, 2a, 2b and 3). Sinkhole 1 was located within the north west of the western field and comprised a surface depression that was wholly within the grassed field. Sinkholes 2a and 2b were located in the south west of the western field and comprised two adjacent depressions that were also part of the grass field but extended to the field boundaries. Sinkhole 2a correlated with Sinkhole 2 as described in the 2015 report. Sinkhole 3 was located in the south eastern portion of the western field and comprised a grassed depression which extended to the southern and eastern boundaries of the field. In addition, the ground around and between sinkholes 1, 2a, 2b and 3 was observed to undulate and slope away in a general southeasterly direction. Figure 4 shows the locations of these identified geohazards.

In addition, a sub-linear break in slope was located towards the eastern side of the western field such that ground

levels fell from within the field towards the track which bisected the site. The linear feature was oriented approximately north-north-east to south-south-west (sub-parallel to the footpath/track bisecting the site), with a change in ground level from west to east but also with a general topographic fall in ground level towards the south. The linear feature appeared to continue around the northern margin of Sinkhole 3 and turn to a westerly orientation to run to the north of Sinkhole 2b and petering out towards Sinkhole 2a.

Eastern Field

The eastern field was an open field within long uncut grass and a series of footpaths running across the field and utilised by local dog walkers as informal footpaths. The southwestern portion of the eastern field was densely vegetated and overgrown. The eastern field was accessed via an open gateway located in the northeastern corner of the field adjacent to the newly developed houses.

Whilst the eastern portion of the eastern field was generally level, ground levels on the western portion of the eastern field were variable. A shallow valley-like feature was evident transecting the western portion of the eastern field from north-north-east to south-south-west. The northern and southern ends of this valley-like feature were grassed, but the central portion was heavily vegetated such that detailed site walkover of this central section was not possible. Nonetheless, observations into the more heavily vegetated area appeared to indicate that ground level fell quite sharply with steepening of the valley sides into this area.

In addition to the valley features, three sinkholes (Sinkhole 4, 5 and 6) were noted to be located within the western portion of the eastern field. Sinkhole 4 was located in the far southwestern corner of the eastern field and comprised a grassed depression. Sinkhole 5 was located to the north of Sinkhole 4, i.e. in the more densely vegetated portion of the valley-like feature. Sinkhole 6 was located to the east of Sinkhole 4 along the southern boundary of the eastern field. This sinkhole was also densely vegetated with mature trees, shrubs and undergrowth. Ground levels varied significantly between Sinkhole 4 and Sinkhole 6, the latter being at a higher elevation, i.e. on the shoulder of the valley-like feature and two step changes in slope level and profile were observed between Sinkhole 4 and Sinkhole 6. Figure 4 shows the locations of these identified geohazards.

Whilst not identified previously, an additional potential geohazard was observed in the hedgerow along the eastern side of the track bisecting the site. This feature was observed as an approximately circular hole at ground surface, tentatively identified as a crown hole, and located in the central third of the path alignment. Access to the feature was not possible due to the presence of undergrowth, but is likely to be required in due course to ensure that the feature can be treated and de-risked prior to development of the wider site.

November site visit

The site was revisited in late November 2023 such that Sinkhole 5 and a potential feature on the eastern side of the central footpath could be re-examined once leaves had started to fall and visibility into the features was better.

At the time of the re-visit, the feature in the eastern side of the footpath (c. 50m north from the southern end of the path) was evident as an open hole extending to unknown depth into the ground. The ground surface to the north, east and south appeared to have suffered some additional collapse such that the feature comprised an open hole with an estimated 1-2m diameter with a notable depression around its edge to the north, east and south. The hole appeared to have regressed towards the footpath albeit that no surface depression was observed in the footpath. An abandoned car (rusted shell) was located over the northern portion of the feature (located within the hedgerow). The open hole was considered consistent with the morphology of a crown hole (see Section 2.3 for description). It was not possible to examine this feature in greater detail due to its location within the hedgerow alignment and also due to safety concerns of approaching or working adjacent to foundered strata and a hole of unknown depth.

An area of disturbed ground was also observed on the eastern side of the footpath c. 20m north of the southern end of the path. Whilst this disturbed ground included several holes c. 0.3-0.5m diameter and exposed soils, it was

considered likely to be associated with badger activity or similar and not a geohazard. It is understood that the Client's Ecological Consultant had also identified this area of disturbed ground as being likely burrowing activity.

Sinkhole 5 was also revisited and whilst trees had shed some of their leaves, the density of vegetation within the feature hindered visibility. Nonetheless, the base of the Sinkhole appeared to fall towards the south and water was observed to be located in the bottom of the Sinkhole. The revisit was undertaken following a period of prolonged heavy rainfall and thus it was considered possible that the water in the Sinkhole might have been pooling of storm water run-off from the field areas to the west, north and east, or storm water exfiltrating the ground on the upper portion of the Sinkhole. The palaeo-valley feature extended to the north, rising gently from Sinkhole 5 towards the woodland beyond the northern boundary. Storm water was also observed to be pooling and flowing over the ground in the track and wooded area to the north, i.e. as overland flow.

2.3 Geomorphology

With regards to the description of geomorphological features and sub-surface cavities, the following terms are used and comply with general UK and international terminology. As can be seen there is a degree of cross over between the various terms:

Doline – commonly a circular or oval shaped depression at ground level caused by dissolution of sub-surface strata, e.g. Chalk.
Sinkhole – a depression at ground level caused due to the subsidence or collapse of surface strata into sub-surface cavities.
Solution Feature – a cavity, or infilled former cavity extending into underlying strata, e.g. Chalk. The infill is derived from overlying strata but there may be no evidence of the feature at ground level.
Solution Pipe – a solution feature which is typically cylindrical in section.
Crown Hole – typically a circular feature where a sub-surface void has migrated to ground level. Foundered strata are present within the crown hole often at shallow depth below ground level.
Swallow Hole – a sink hole into which surface water flows.
Denehole – man made shaft or cavity extending into the Chalk. Deneholes date from the Neolithic period (Stone Age) to recent past. CIRIA C574 describes deneholes as typically formed of a vertical shaft approximately 1m in diameter. The cavities were created often to recover chalk for use as lime although occasionally also as a source of flint or for storage. Deneholes were excavated using hand tools and were typically unsupported and unlined. The shafts were often backfilled with mined spoil and/or overburden placed on top of vegetation (trees, branches or bushes) dropped into the shaft. Decomposition of the organic material and settlement of the soil backfill can result in unstable ground and the regression of the void back to ground level.
Ice wedge – a conical depression in the upper portion of a stratum created by localised freezing of the ground which resulted in degradation of the frozen soil/ground and subsequent infilling with overlying soils. These can be very similar in appearance to solution features but may be more uniform in section.
Suffusion and dropout sinkholes form in superficial deposits overlying the soluble rock, typically limestone. Suffusion sinkholes occur where sediment is gradually washed down into fissures in underlying limestone which have been enlarged by 'solution' activity, causing gradual subsidence. Dropout failures form similarly, but in more cohesive soils which are able to bridge voids until they become unsupportable, resulting in sudden failure and collapse. Where the Chalk is covered by a thin cover of clay or sand, acidic drainage can gradually dissolve out the Chalk beneath, creating dissolution pipes up to 10m deep. Normally they gradually become infilled with sediment as they form, so rarely contain voids and are generally stable where surface conditions remain constant although changes in loading, compaction and drainage can reduce this stability.

As noted in Sections 2.1 and 2.2, six oval to circular depressions had previously been identified and referenced as Sinkholes 1 to 6. In addition, an area of karstic underdrainage in the form of a palaeo-valley was identified within the centre of the site trending in a general north-north-east to south-south-west direction. A crown hole was also tentatively identified in the hedgerow on the eastern side of the footpath which bisected the site.

Prior to redevelopment, the land immediately adjacent to the south of the site was found to include sinkholes, depressions and undulating ground. As such, the features located within the site appeared to be associated with a more extensive zone of undulating ground and geomorphological features.

In addition, with reference to McDowell et al (2008) the position of the depressions on the side of a shallow post Ice Age valley and the general orientation of these depressions appeared to correlate well with solution features elsewhere within the Lovedean, Clanfield and Horndean area.

2.4 Geology

British Geological Survey mapping indicated the subject site to be underlain by Head Deposits, Lambeth Group and Tarrant Chalk Member. The area indicated to be underlain by Head Deposits appeared to correlate with the general orientation of the valley to the west of the site and to extend through the site towards the north-east.

Head Deposits are drifts produced by solifluction, the downslope movement of debris outwash during the periglacial period, and characteristically vary from silt and clay to poorly sorted sand, gravel and chalk of local derivation.

The Lambeth Group is a sedimentary complex characterised by red, orange, yellow and grey mottled clay and sandy clay with a basal bed (the Bottom Bed) composed of clayey glauconitic sand. A bed of green-coated flints is also commonly present.

Tarrant Chalk is a soft white friable microporous limestone composed of coccolith biomicrites with a varying proportion of larger shell fragments. Flint occurs as nodular courses, tabular beds and linings to fractures.

At various levels clay sized material occurs as marl seams and partings. Close to the surface the upper few metres are invariably discoloured brown, due to leaching from the overlying strata. The interface with any overlying stratum is invariably extremely irregular as a result of localised weathering and general dissolution of the chalk. Weathering by frost action may extend to a depth of several metres.

Occasional solution features, such as pipes, swallow holes and solution cavities, usually in-filled with drift deposits, are found in the chalk, sometimes manifesting themselves at the surface as shallow circular depressions. Solution features may be reactivated by the concentrated ingress of water from leaking drains or soakaways. Reactivation may lead to surface collapse.

With reference to McDowell et al (2008), the occurrence of solution features in the general Lovedean and Horndean area (encompassing/bordering the subject site) is significantly higher than elsewhere within south-east Hampshire, with approximately 55 features per km^2, the average being 15 per km^2. The solution features reported by McDowell et al are predominantly associated with a shallow cover of drift deposits and palaeo-valley features. The majority of these features have been identified from shallow depressions (dolines) at ground level rather than collapse at ground level and the formation of sinkholes. The document reports that given the frequency of solution features in this area surprisingly few collapses at ground level have been recorded. Whilst the primary focus of McDowell et al's study was approximately 2km to the east of the subject site, the ground conditions on the subject site and located close to the head of a palaeo-valley form a similar ground model for the occurrence of solution features within the Chalk, this being further supported by the geomorphological evidence as described in Sections 2.2 and 2.3 above.

2.5 Hydrology

No surface water features were located on or in close proximity to the subject site.

2.6 Hydrogeology

With reference to Environment Agency records and the Groundwater Vulnerability Map No. 52 entitled South Hampshire, the site is indicated to overlie a Secondary Aquifer (undifferentiated); a Secondary 'A' Aquifer; over a Principal Aquifer (assumed to be the Head Deposits, Lambeth Group and Chalk respectively).

The 'Secondary (undifferentiated)' Aquifer classification has been assigned in cases where the stratum in question has previously been designated as both minor and non-aquifer in different locations due to the variable characteristics of the strata.

Secondary 'A' Aquifers are defined as fractured or potentially fractured rocks which do not normally have a high primary permeability. Although these formations will seldom produce large quantities of water for abstraction, they are important both for local supplies and in supplying base flow to rivers.

Principal Aquifers are layers of rock or drift deposits that have high intergranular and/or fracture permeability, meaning that they usually provide a high level of water storage. They may support water supply and/or river base flow on a strategic scale.

The soil cover across the site varies from low to intermediate vulnerability classification. Intermediate leaching potential soils have some ability to attenuate diffuse source pollutants and in which non-absorbed diffuse source pollutants and liquid discharges have the potential to move rapidly to underlying strata or to shallow groundwater.

The site is located within the Inner zone of a Source Protection Zone (SPZ I) which is associated with a potable water abstraction located approximately 1km to the north of the site.

With reference to previous phases of assessment on the recently developed site immediately to the south of the site, groundwater is anticipated to be present at depth, possibly in excess of 25m below site ground level.

Reference to Defra's Hydrology Data Explorer (most recently accessed 09/11/2023) identified several groundwater monitoring wells within c. 5km of the site as summarised in Table 2.1.

Name	Bleak Cottage	Hinton Daubney Farm	Catherington	Pyle Farm Cottages	Sheepwash Lane
Grid Reference	SU6625912744	SU6800914243	SU69451435	SU7119512374	SU65511059
Distance from site (km)	1.7	1.85	2.15	2.85	2.95
Direction from site	W	N	NE	E	SW
Station ID	143302750	143301026	143301106	143701558	143302945
Aquifer	Tarrant Chalk Member	Tarrant Chalk Member	Chalk Group (undivided)	Tarrant Chalk Member	Chalk Group (undivided)
BH depth (m)	23.8	75.5	89.9	34.7	150
Datum (m AOD)	58.23	109.76	115.64	56.36	40.40
Shallowest groundwater level (m AOD)	43.81	51.83	55.60	33.64	38.39
Shallowest groundwater level date	25/03/2021	30/03/2021	02/03/2020	17/04/2018	25/03/2021
Deepest groundwater level (m AOD)	35.24	39.93	28.67	22.06	29.39
Deepest groundwater level date	22/10/2019	04/11/2022	16/11/2022	04/11/2022	08/11/2022

NOTE: Records relate to the most recent 5 years' of data as accessed on 09/11/2023; ground level on site is c. 72m AOD to 61m AOD

Table 2.1 Summary of nearby groundwater monitoring station records

3.0 GROUND INVESTIGATION

3.1 Scope of Works

The scope of the investigation incorporated the following elements to assess the sinkhole and solution feature areas and establish the underlying ground conditions:

Attendance of a specialist surveyor to undertake a buried utilities survey at proposed investigation positions using radiodetection and ground penetrating radar techniques.
Attendance of a Geo-Environmental Engineer to set out and supervise the intrusive investigation, undertake sampling, in-situ testing and logging of recovered soils from exploratory holes.
Attendance of a JCB and operator to excavate 27No. trial pits to depths of between 3.0m and 3.5m bgl. The trial pits were to be excavated on the periphery of each solution feature (subject to access and constraints such as trees), along the shoulder of the valley feature and also located remote from the solution features to provide some additional preliminary information on general ground conditions.
Undertake trial pit soakage tests in general accordance with BRE Digest 365 within 4No. trial pits to a depth of c. 1m bgl. 2No. trial pits were to be located within the western field and 2No. trial pits within the eastern field, remote from solution features.
Construction of 5No. cable percussion boreholes to depths of between 6m and 15m bgl together with in-situ testing and sampling at regular intervals. The boreholes were to be located, where possible, within the footprint of the solution features. Once on site, it became apparent that Sinkholes 4, 5 and 6 could not be accessed by the drilling rig and thus some revision of proposed investigation locations was required.
Attendance of a dynamic sampling rig to construct 12No. small diameter dynamic sampler boreholes within the solution features to depths of c. 5m bgl, coupled with in-situ SPTs.
Attendance of a dynamic sampler rig to undertake Super Heavy Dynamic Probing at 40No. locations within the solution features and valley feature, to depths of between 8-10m bgl, or refusal if obstructions were present at shallower depth.
Geochemical and geotechnical laboratory testing of selected recovered samples.

3.2 Investigation Strategy

The positioning of exploratory holes was determined on site to target specific areas whilst working within access restrictions associated with the presence of services, access constraints and current site uses. Table 3.1 sets out the investigation strategy adopted.

Area of Concern	Investigation	Positions
General ground conditions	Exploratory holes located across the site, coupled with sampling and laboratory analysis.	All
Potential contamination of near surface soils	Exploratory holes located to provide coverage of the site, coupled with sampling and laboratory analysis.	All
Permeability of underlying soils	Trial pit soakage tests in general accordance with BRE Digest 365.	TP102, TP107, TP118 and TP125
Sinkhole 1	Exploratory holes located on the shoulder and within the footprint of the solution feature.	BH01, DP34-DP40, TP122-TP124 and WS01-WS04
Sinkhole 2a & 2b	Exploratory holes located on the shoulder and within the footprint of the solution feature.	BH02, DP31-DP33, TP119-TP121 and WS05-WS07
Sinkhole 3	Exploratory holes located on the shoulder and within the footprint of the solution feature.	DP24-DP30, TP111-TP113, TP117-TP118 and WS08-WS11
Sinkhole 4	Exploratory holes located on the shoulder and within the footprint of the solution feature.	DP16-DP18, TP110, WS12-WS14 and WS16

Area of Concern	Investigation	Positions
Sinkhole 5	Exploratory holes located on the shoulder of the solution feature.	BH03, BH05, DP06-DP07, DP13-DP15, and TP104-TP15
Sinkhole 6	Exploratory holes located on the shoulder of the solution feature.	DP09, TP103 and TP109
Palaeo-valley	Exploratory holes located along the shoulder and within the valley feature.	BH04, DP10-DP12, DP20-DP22, TP108 and TP114-TP115

Table 3.1 Summary of the Investigation Strategy

Soil samples were collected and placed into amber jars and cool boxes on site for transit to the office, where they were stored under chilled conditions (<4ºC) prior to final transportation in cool boxes to the laboratory by their in-house courier. Both the geotechnical and contamination testing were undertaken by UKAS accredited laboratories (where appropriate). Contamination testing of soil samples was also undertaken in accordance with accredited MCERTS protocols. Samples were stored in temperature controlled conditions from sampling until receipt at the laboratory from which time sample preparation and storage was determined by testing requirements and in line with laboratory's protocols.

4.0 ENCOUNTERED CONDITIONS

A factual record of the conditions encountered during the physical investigation of the site is presented in the following sections.

For further details of the ground conditions, reference should be made to the exploratory hole logs and in situ testing presented in Appendix A, the super heavy dynamic probe results presented within Appendix B, the soakage test results presented in Appendix C, geotechnical testing results presented in Appendix D and geochemical testing results presented in Appendix E.

The physical ground investigation works were undertaken on from 25th September to 29th September 2023.

Unless stated otherwise, all depths are reported as metres below ground level (m bgl).

4.1 Soils

With reference to British Geological Survey (BGS) mapping and the previous third-party report provided for review by the client, the geology of the site was anticipated to comprise a thickness of Topsoil over Head Deposits overlying cohesive soil of the Lambeth Group and/or chalk of the Tarrant Chalk.

The ground conditions encountered were consistent with those anticipated based on published geological mapping and previous phases of intrusive investigation on the Phase 1 and Phase 2 development parcels to the immediate south of the site. However, the observed shallow soils varied in compositions, with depth and laterally within individual investigation locations making it difficult to distinguish between soils of the Head Deposits and soils of the Lambeth Group. Reference has been made to published geological mapping to assist in assigning soils to specific strata. In general, shallow soils across the site have been assigned to the Lambeth Group however, it is possible that some shallow soils are derived from reworking of the Lambeth Group and Chalk by natural processes.

A generalised summary of the encountered shallow ground conditions within investigation positions is presented in Table 4.1.

Top (m bgl)	Base (m bgl)	Geology	Positions
0.00	0.10 – 0.30	TOPSOIL: Grass over dark brown CLAY with varying proportions of silt, sand and gravelly and frequent roots and rootlets.	All
0.10 – 0.30	1.45 – 7.00	LAMBETH GROUP: Firm to very stiff brown, orange brown, orange and grey mottled CLAY with varying proportions of silt, sand and gravel; Stiff to very stiff grey, purplish grey, red and orange mottled CLAY; Orange, brown and grey mottled fine to medium SAND; Brown and off white cobbly CLAY.	All
1.45 – 7.00	15.00 (base of hole)	TARRANT CHALK: Structureless off white CHALK recovered as fine gravel sized clasts of very weak to weak chalk with a silt chalk matrix and occasional flint gravel, CIRIA grade Dm; Structureless off white CHALK comprising weak to moderately strong chalk clasts with a silt chalk matrix, estimated CIRIA Grade Dc.	BH01 – BH05, TP121 – TP124, WS01, WS04, WS06, WS07, WS11, WS12, WS13, WS16

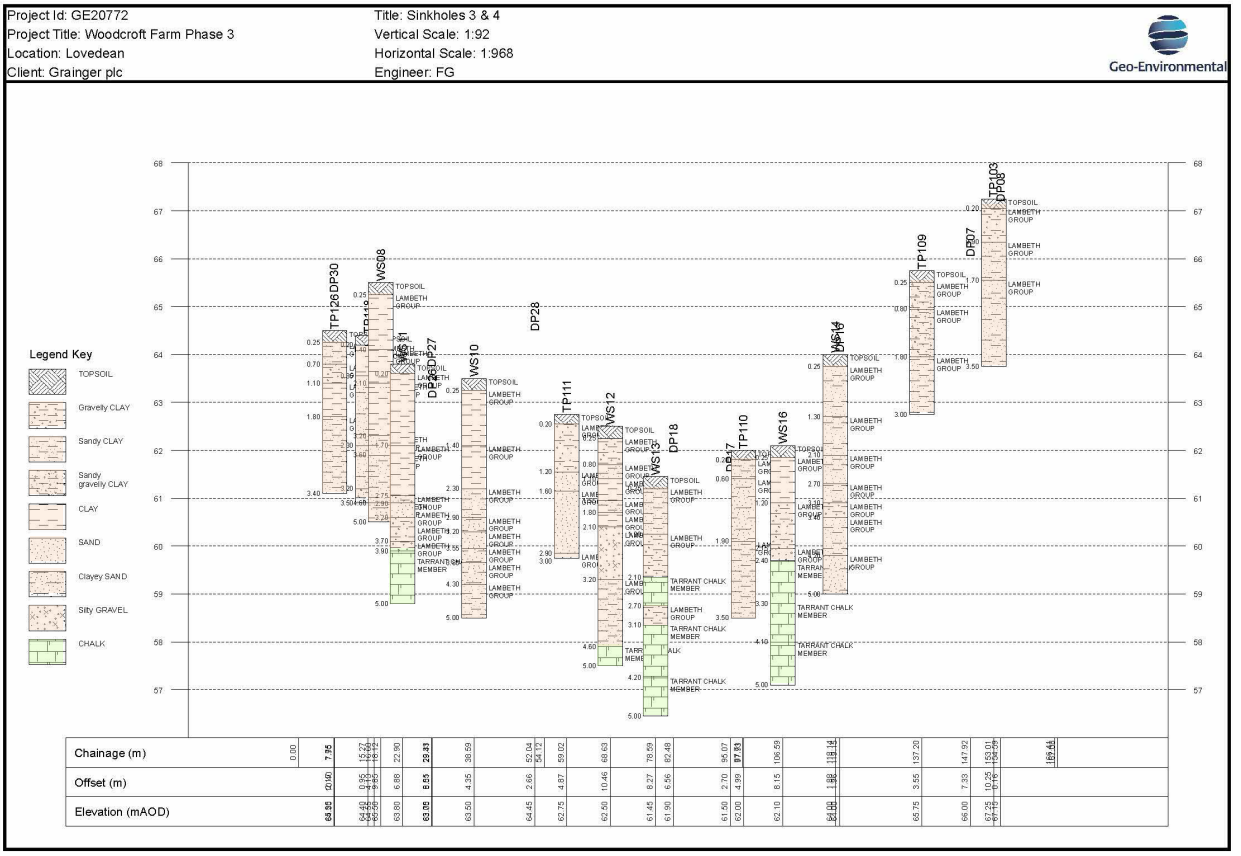
Table 4.1 Summary of Ground Conditions

Whilst the soils encountered overlying the Chalk have, at this stage, been reported as Lambeth Group, it is considered likely that some of these soils represent disturbed, potentially reworked strata. Published geological mapping indicates the presence of Head Deposits proximal to the southern central portion of the site and to the south of the wooded area of Sinkhole 5. This appears to correlate with Sinkhole 4 and the southern portion of the palaeo-valley feature within the site. As noted above, clear differentiation between potential Head Deposits

(reworked, locally derived soils) and in-situ strata was not possible due to similarity of composition, condition and the like. It is possible that further investigation might be able to inform differentiation of strata in this portion of the site. The presence of more granular soils in some of the exploratory holes within or proximal to the southern portion of the palaeo-valley/Sinkhole 4 showed some possible correlation with superficial deposits encountered in exploratory holes located on the eastern shoulder of the southern continuation of the palaeo-valley on the development immediately to the south of Phase 3 (ground investigation undertaken by Geo-Environmental for Grainger as part of assessment of the Phase 2 site). These superficial strata and their associated geomorphology comprised a sequence of layered deposits and terrace steps/shoulders and undulating ground on the eastern side of the palaeo-valley within the Phase 2 area. This was similar to the geomorphology around Sinkhole 4 and the area between Sinkholes 4 and 6.

As noted above, the ground conditions were observed to vary over relatively short distances, i.e. within the extent of some of the exploratory holes. In addition, the depth to the Chalk was observed to vary significantly such that whilst Chalk was encountered at relatively shallow depth in some of the exploratory holes, it was not encountered in others. These variations in depth to the Chalk are considered characteristic of karstic weathering, but also reflect the site's location on the 'feather edge' of the junction between the Lambeth Group and underlying Chalk, with the thickness of Lambeth Group cover increasing towards the north and north-east.

A ground model section from west to east through Sinkholes 3 and 4 is presented below and presents a graphical illustration of the variation in topography and underlying ground conditions.



Plot 1 Ground model section through Sinkholes 3 and 4

In-situ testing, both in-situ SPTs and super heavy dynamic probing identified potential loose and voided zones at varying depths within a number of the identified features across the site (Sinkholes 1-6 and the palaeo-valley). Figures 4-7 present the depth and locations were potential loose or voided zones have been identified.

As shown in Figures 4-7, the depth of loose and/or potentially voided zones varied within location even within specific sinkholes. This variation was spatial across a sinkhole area and also variation in depth at which the loose or voided ground was encountered. Table 4.2 summarises the exploratory holes where loose or voided ground was indicated by investigation undertaken.

	DPSH N value <3		SPT N = 0	
Feature	Exploratory hole	Depth range (m bgl)	Exploratory hole	Depth range (m bgl)
Sinkhole 1	WS04 DP37, DP38	2.0-3.0 <2.0	DP37, DP38	<2.0
			DP39	2.0-3.0
	WS02, DP34, DP35	3.0-5.0	WS02, DP34, DP35 DP36	3.0-5.0 <2.0
Sinkhole 2	WS05	3.0-5.0	WS05	3.0-5.0
	DP31	2.0-3.0	DP21	<2.0
			DP33	<2.0
Sinkhole 3	DP30	3.0-5.0	DP30	3.0-5.0
	DP28	3.0-5.0	DP28	3.0-5.0
	DP26, DP27	>7.5	DP26, DP27	>7.5
	DP23, DP25	5.0-7.5	DP23, DP25	5.0-7.5
Sinkhole 4	WS12	3.0-5.0	WS12	3.0-5.0
	DP14 DP15	5.0-7.5 <2.0	DP14	5.0-7.5
	DP17	5.0-7.5	DP17	5.0-7.5
Palaeo-valley west	DP19 – DP22	2.0-3.0	DP20, DP22 DP21	2.0-3.0 <2.0
Palaeo-valley east	DP02	<2.0	DP02, DP04, DP06	<2.0
	DP03, DP04, DP11, DP12	2.0-3.0	DP11, DP12	2.0-3.0

NOTES: m bgl – metres below ground level at the time of investigation; Palaeo-valley West and East refer to the western and eastern sides of the palaeo-valley; results are grouped where they form a spatial cluster in plan

Table 4.2 Summary of loose and/or voided ground as identified from exploratory holes

No probing or SPTs were undertaken in Sinkhole 2a, as this feature was investigated only by means of a trial pit. No intrusive investigations were undertaken within Sinkholes 5 or 6, due to their relatively heavily vegetated condition and no safe means of access/egress being identified for the investigation plant or personnel.

Whilst low and zero blow counts were recorded in numerous exploratory holes, as summarised in Table 4.2 and Figures 4-7, cross reference to boreholes and trial pits adjacent to some of these locations did not identify the presence of loose or voided ground and it is considered possible that in some cases, sporadic low or zero blow counts might have been associated with clay strata and possible punching through gravel or the like. As such, the results of the probing must be considered in conjunction with visual descriptions soils proximal to the probe locations and not in isolation.

It is noted that the proposed development is based on retention of Sinkholes 1-6 and the palaeo-valley as landscape features with development around their periphery and beyond. The purpose of this investigation was to ascertain ground conditions within and around the features, to determine their implications with regards to evolution of the Master Plan and identify potential geohazard constraints which need further consideration in the planning and design process. Evolution of the Master Plan was supported by workshops and input from a collaborative design team, such that the Master Plan as used in this report accounts for investigation and assessment of geo-hazards prior to reporting.

The exploratory hole logs are presented within Appendix A with the super heavy dynamic probing results presented within Appendix B.

4.2 Groundwater

Groundwater was not encountered within any of the exploratory holes during the intrusive investigation. Additionally, no monitoring wells were installed as part of this phase of investigation. However, previous intrusive investigation works undertaken across the adjoining site to the south (now developed) indicated that groundwater is present at depth within the Chalk, possibly c. 25m bgl or deeper. This is supported by groundwater monitoring records from off-site monitoring stations as summarised in Tabe 2.1 above.

It should be noted that changes in groundwater levels do occur for a number of reasons including seasonal effects and variations in drainage. Such fluctuations may only be recorded by the measurement of the groundwater level within a standpipe or piezometer installed within appropriate response zones. Changes in groundwater level can have a direct effect on the stability of excavations and slopes, and the presence of water (groundwater, perched water or run-off) in granular or interbedded strata can result in rapid loss of stability.

4.3 Obstructions

Refusals were recorded within three of the cable percussion boreholes prior to achieving their target depth. BH03 refused at 7.30m bgl, BH04 refused at 6.70m bgl and BH05 refused at 6.0m bgl. In addition, a number of refusals were noted with the super heavy dynamic probes as summarise in Table 4.3 below. Each of the refusals was considered likely either to be on a harder band of chalk, or flint within the Chalk.

Probe Location	Depth of Refusal (m bgl)
DP2	7.3
DP4	6.8
DP6	6.4
DP8	6.8
DP10	7.6
DP11	6.3
DP12	6.8
DP13	4.0
DP16	3.9
DP19	5.7
DP20	5.9
DP21	5.0
DP22	4.0
DP32	5.8
DP34	6.8
DP35	7.1
DP36	2.9
DP37	5.0
DP38	7.4
DP40	4.3

Table 4.3 Summary of depths of super heavy dynamic probe refusals

4.4 Geotechnical Testing

The results of geotechnical testing undertaken as part of the ground investigation are summarised in Table 4.4, with test results presented in Appendix C.

Parameter	Lambeth Group	Tarrant Chalk
Natural Moisture Content (%)	12 – 44	7.0 – 27
Liquid Limit (%)	36 – 76	-
Plastic Limit (%)	14 – 22	-
Plasticity Index Ip (%)	22 – 55	-
Modified Plasticity Index Ip' (%)	23 – 53	-
Saturation Moisture Content (%)	-	7.7 – 27
Bulk Density (mg/m³)	-	1.97 – 2.39
Dry Density (mg/m³)	-	1.56 – 2.23
pH	4.7 – 7.3	-
Water Soluble Sulphate (mg/l)	14.1 – 81	-

NOTE: Modified plasticity index is defined in NHBC Standards Chapter 4.2

Table 4.4 Summary of Geotechnical Test Results

The Modified Plasticity Indices showed the cohesive soils of the Lambeth Group to be of Medium to High Volume Change Potential as defined in NHBC guidance. Based on the results of Saturation Moisture Content and Dry Density, the samples of chalk tested were considered to vary from medium to very high density as defined in CIRIA C574.

4.5 Chemical Analysis

In order to assess the general chemical quality of the strata encountered, samples of soils recovered from the exploratory holes were submitted for analysis for a range of potential contaminants selected on the basis of the findings of the third-party desk study. The intrusive investigation did not encounter conditions that required a revision of the preliminary risk assessment presented within the previous third party desk study for the site.

The testing rationale included sampling and analysis to provide a general coverage of the subject site. Testing was undertaken for a broad range of commonly occurring contaminants including metals, metalloids, inorganic compounds, speciated TPH, PAH and asbestos.

5.0 ENGINEERING CONSIDERATIONS

Subsequent to intrusive investigation of the site and receipt of the laboratory test results, the following geotechnical assessments have been made.

5.1 Ground Model and Master Plan Evolution

As described previously, the site's topography was variable, with a general fall in ground level from north to south, but also with a shallow north to south plunging valley transecting the central portion of the site and a series of distinct depressions also evident. In line with previous third party reporting, the depressions are referenced Sinkhole 1 to Sinkhole 6 and the shallow valley is referred to as a palaeo-valley. Sinkholes 1, 2 (incl. 2a) and 3 were located in the western field and Sinkholes 4, 5 and 6 were located in the western portion of the eastern field and associated with the alignment of the palaeo-valley. It was not possible to undertake intrusive investigation within Sinkholes 5 or 6 due to the density of vegetation and no clear safe access/egress at the time of the fieldwork, but these features lie outside of the proposed development footprint, i.e. shown as amenity open space areas on the Master Plan. Ground investigations undertaken by Geo-Environmental on land immediately to the south (now developed) demonstrated that the palaeo-valley continued on a southerly trend before turning towards the south-west.

It is noted that some other undulations and localised changes in ground surface were observed in addition to the features previously identified as sinkholes and palaeo-valley. One of these features was targeted as Sinkhole 2a and several other features formed part of the undulating profile of the western and eastern flanks of the palaeo-valley and were targeted as part of this ground investigation. Other features, including one in the western field where a water trough was located were not targeted for investigation and would require further assessment in due course to inform detailed design of the proposed scheme.

The ground conditions encountered within Sinkholes 1, 2, 2a, 3 and 4 were similar and comprised sandy and/or gravelly clay overlying structureless weathered Chalk. The depth of cover of the clay strata varied within each sinkhole as is common with karstic weathering and where chalk dissolution has occurred. The variation was even notable with the extent of some trial pits, i.e. marked as a plunging interface between the clay strata and underlying Chalk.

As discussed in Section 4.1 above, whilst the depth to the chalk varied both within the Sinkholes and between different areas of the site, the investigation also identified the presence of weak or possibly voided ground in some exploratory holes, with the depths of these zones varying from <2.0m bgl to >7.5m bgl. The deepest of these zones appeared to be associated with positions within the Sinkholes and thus likely to reflect a high degree of weathering and karstic erosion in the Chalk at depth. With regards to the shallower occurrences of weak/voided ground, the ground conditions observed in trial pits and boreholes proximal to these locations generally comprised firm or stiff clay and as such, some of the shallow weak zones such as those along the flanks of the palaeo-valley might be a function of the probing method in sandy/gravelly clay deriving 'false positives' rather than identifying voided ground. It is noted that with the exception of Sinkhole 1, the Master Plan has evolved to avoid development within geohazard areas such as the sinkholes and flanks of the palaeo-valley. With regards to Sinkhole 1, whilst the proposed development is located around the northern, eastern and southern margins of the Sinkhole, investigation around its northern periphery indicated the presence of weak and/or voided ground beneath proposed development footprint which was not considered to require significant change to the Master Plan layout but will require a ground engineering solution to deliver the proposed layout (house foundations and road construction).

The Master Plan includes two access points into the site, one into the eastern field from the north-eastern corner and the second access road entering the central portion of the southern boundary, i.e. into Sinkhole 4, before turning west to access the western field. The road alignments proposed at the time of writing changed slightly from those on a previous iteration of the Master Plan. Whilst the north-eastern access has remained relatively unchanged, the central southern access was changed from an alignment swinging into the eastern field and connector road crossing the palaeo-valley (to access the western field), to an alignment which turns west upon

entering the site. Amongst other factors, these changes reflected geotechnical concerns regarding proximity of the former alignment to Sinkhole 5 and a significant change in level between the site access point on the southern boundary and ground level in the western field which would have been likely to require relatively significant earthworks on the margins of Sinkholes 4, 5 and 6 to form cut slopes and some road embankment to create an acceptable gradient. The revised layout dispensed with the east-west link road close to the northern fringe of Sinkhole 5 and the western portion of the site is shown to be accessed from the southern boundary. Whilst the revised western field access still requires a road to be constructed over Sinkhole 4 (as was the case with the previous interaction) and across a portion of Sinkhole 3, the ground profile was less significant thereby reducing or negating a requirement for significant cutting. It is considered that specific ground engineering will be required to deliver the southern access road due to its positioning over sinkholes and areas of deeper seated weak strata.

Based on the findings of the intrusive investigation it is anticipated that substantial variation in ground conditions is likely to be encountered within foundation trenches and should be accounted for in foundation design and construction.

5.2 Foundations

The intrusive investigation has confirmed the presence of highly variable strata in terms of both composition and depth across this portion of the site. The three key strata comprise sand, clay and Chalk. Sand and clay were attributed to the Lambeth Group but may also be attributable to the Head Deposits in places.

On the basis of the ground conditions encountered, it is considered that conventional foundations could be used for the proposed development, with strip foundations extending through any Made Ground, disturbed, reworked, desiccated ground or root zones and terminating within the soils of the Lambeth Group or Chalk.

Laboratory testing has shown the more cohesive soils to vary from Medium to High Volume Change Potential as defined in NHBC Standards. The sand and Chalk would be considered non-shrinkable. Given the high degree of variability in ground conditions over short distances, it is not considered feasible currently to zone the site and thus foundation design should account for the presence of clay soils of high volume change potential and thus a minimum founding depth of 1m bgl is recommended.

It should be noted that near surface soils (<1m bgl) were visually assessed to be desiccated and this should be accounted for in foundation design. In addition, the junction between Lambeth Group and the underlying Chalk was found to be highly variable and solution features (infilled with gravelly clay) were encountered within several pits as summarised above. Localised deepening to terminate on a single soil type is not considered feasible and thus, it is recommended that reinforcement is incorporated within all foundations. Such reinforcement typically comprises an upper and lower layer of steel mesh laid within the foundation during construction. The specification of the mesh, construction requirements and placement positions within the foundation should be confirmed by the structural engineer responsible for designing foundations on this site. Given that that sinkholes and solution pipes have been identified at various locations across the site, it is recommended that the inclusion of reinforcement in foundations is maintained throughout the development of the site. Reinforcement should be designed to be sufficient to enable a foundation to span a void of c.3m diameter in plan.

On the basis of ground conditions encountered, a net allowable bearing capacity of 125kPa for the high strength soils of the Lambeth Group is recommended, this could be increased to 150kPa for the Chalk. However, it is considered that unless whole foundation footprints extend into Chalk, the lower allowable bearing capacity must be used in order to avoid overstressing soils overlying the Chalk.

Given the potential for foundations to be constructed within the zone of influence of trees in some portions of the site, it is possible that foundation bases would require to be stepped and as such, it is recommended that steps do not exceed the limit stated in NHBC Standards at any point and are at least 1.0m (lateral distance) away from any corner or node point on the foundations. Where this cannot be accommodated, the foundation should be formed at the greater depth.

Initial modelling using the NHBC Foundation Depth Calculator indicates that deepened foundations could be required in proximity to trees. This is dependent on the species, condition, water demand of the tree(s) and their distance from the proposed foundation.

It is possible that piled foundations may be required for some plots due to tree influence, or proximity to geohazards such as solution features, e.g. plots on the northern side of Sinkhole 1, and localised zones of weak ground.

Where foundations extend to depths in excess of 1.5m bgl, heave precaution measures should be included to the face of foundations in accordance with NHBC Standards Chapter 4.2.

It is recommended that foundation excavations be concreted or blinded as soon after excavation as possible. Where concreting could take place the following day it is recommended that excavations are not taken to full depth overnight and that the final 0.5m of cover is only removed immediately prior to concreting.

Where conventional foundations (e.g. trench fill, strip, pad or the like) are constructed, each excavation should be inspected by a Geotechnical Engineer to record the conditions exposed in the excavation, including presence/absence of visible indicators of chalk dissolution. It is anticipated that this could form an engineering condition applied to construction and copies of inspection records should be submitted to the developer and the building warranty provider.

5.3 Floor Slabs

Suspended floor slabs will be required on all plots due to the presence of shrinkable soils at shallow depth.

5.4 Excavations

Shallow excavations on level ground should remain stable in the short term assuming an absence of water ingress and surcharging, although may require battering to a safe angle if open in the medium to long term. It is anticipated that all excavations would become unstable where water ingress occurs without measures to control water and support excavation faces. Long and/or deep excavations, excavations left open for extended periods of time, or excavations which intercept weak, voided or granular ground are likely to be prone to collapse. In addition, excavations across the slope should be kept to as short a distance as possible to avoid stability issues and associated collapse.

Ground works should be designed in such a manner to avoid man entry into excavations.

5.5 Pavements

With reference to Table C1 of TRRL LR1132, a CBR value of between 2% and 6% would be recommended depending on construction conditions. Based on the laboratory test results, a preliminary CBR of 2% is recommended for the shallow soils across the site. This also accords with Table A, Appendix A of HCC's Companion Document to Manual for Streets.

In addition, if roads cross alignments of hedgerows, trees or the like which are to be removed as part of the development, or where trees or hedges are to remain close to roads, consideration should be given to the inclusion of geogrid reinforcement with the road construction as set out in HCC's Companion Document to Manual for Streets.

The Master Plan has evolved during the period in which the ground investigation and geotechnical assessment have been undertaken. One of the revisions relates to the road alignment in the central southern portion of the site. Ground levels change significantly between Sinkhole 4 and Sinkhole 6, with the current topography marked by a stepped/terraced profile with a relatively steep gradient. The road alignment was revised to avoid needing to form locally extensive earthworks to form an engineered cut slope at suitable gradient to accommodate development

traffic and a second cut-through road either through Sinkhole 5 or to its north to connect the eastern and western parcels. The current road alignment (at the time of reporting) enters the central southern boundary into Sinkhole 4 and turns west towards and across the periphery of Sinkhole 3. This provides access to the western parcel, whilst access to the eastern parcel would remain in the north-eastern corner of the eastern field as per previous iterations of the Master Plan.

The access road into the western parcel will require ground engineering as part of the road construction as it will cross over portions of Sinkholes 3 and 4. Such engineering might require the construction of a basal load transfer platform (LTP), e.g. geogrid reinforcement granular fill blanket beneath the 'standard' road construction, to reduce or mitigate potential deformation at road surface due to potential settlement of soils within the sinkholes upon loading. In addition, the revised western access would require a reduced quantum of earthworks, possibly including more placement of fill rather than cut to achieve the required road gradient. It is possible, subject to more detailed assessment in due course, that site won soils might be suitable as general bulk fill.

If any sections of estate road cross areas of known, or suspected chalk dissolution, geogrid reinforcement is likely to be required in/on the sub-grade formation to provide additional tensile reinforcement to the road. It is possible that this might also require localised cut along the road alignment (over the geohazard and onto stable ground either side) and localised sections of LTP to be constructed.

The shallow soils should be assumed to be frost susceptible thus requiring a minimum pavement thickness of 450mm. Any hard or soft spots in the formation level may induce reflective cracking in the pavement and allowance should be made for removing hard or soft spots that may be present.

5.6 Sulphates

The results of the water soluble sulphate and pH analyses indicate that buried concrete should be designed in accordance with Class DS-1 of BRE Special Digest 1, with an ACEC class of AC-1s. The advice of this publication should be taken for the design and specification of all sub surface concrete.

5.7 Soakaways

Soakage testing was undertaken within 4No. trial pits at 1.00m bgl in TP102, TP105, TP116 and TP125. The soakage testing was undertaken in general accordance with BRE Digest 365.

There was an insufficient fall in head to calculate an infiltration rate for any of the tests undertaken and, as such, the tests were deemed to have failed.

The results of the soakage testing indicate that the use of soakaways within the cohesive Lambeth Group would not be suitable and therefore an alternative drainage solution will need to be considered. The results from the soakage testing are presented within Appendix E.

The intrusive investigation has identified the presence of sinkholes and suffusion/solution features extending into the Chalk with high variability in overlying soils. The area of the site where Sinkholes 1-6 and the palaeo-valley were located are considered high risk in terms of solution feature activation and thus a minimum offset of 20m is recommended between any soakaway and foundation (i.e. in line with CIRIA C574). However, if soakaways could be constructed at depths remote from the solution features, i.e. discharging into blocky chalk with negligible potential for chalk dissolution, then there would be a negligible risk of water discharging through a solution feature, or infill and thus collapse risk is markedly reduced. However, the use of deeper soakaways would be subject to the agreement of the Environment Agency given the site's location in SPZ I for a potable water abstraction.

CIRIA C574 also states the following "For drainage systems, flexible jointed pipes should be used wherever possible; particular care should be taken for the avoidance of leaks in both water supply and drainage pipework." This must form part of the design and construction of water pipes (potable, storm and foul) on this site due to the potential

for leaks to cause reactivation, or creation of solution cavities in the Chalk, or collapse of overlying strata and resultant migration of voids to ground surface, e.g. crown holes or other collapse features.

Given the positional constraints associated with a 20m offset rule for soakaways and the results of trial pit soakage testing undertaken to date, it is considered that conventional soakaways are not suitable on this site. There may be potential to utilise permeable paving as shallow storage for storm water as part of a tiered drainage strategy to store and attenuate peak storm water flow.

As discussed previously, the sinkholes present landforms which might appear suitable for positioning of storm water basins. However, given that these features are sinkholes and investigation within the features identified zones of weak and/or voided ground at depth, any such storm water storage basins (including inlets and outfalls) must be lined to hold water and prevent concentrated infiltration of storm water to the ground.

5.8 Abnormal Conditions

In the event that abnormal, or unexpected ground conditions are encountered during construction, the advice of a Geotechnical Engineer familiar with the ground conditions and geohazards present on this site must be sought at the earliest practicable opportunity.

6.0 ENVIRONMENTAL CONSIDERATIONS

A Generic Quantitative Risk Assessment (GQRA) has been undertaken incorporating the results of the third-party desk study and Geo-Environmental ground investigation, the findings of which are presented in the following sections.

Site workers involved in the preparation and construction of the development have not been considered further in this assessment as the Principal Contractor is duty bound under the current CDM Regulations to undertake their own risk assessments with respect to their employees.

6.1 Outline Risk Assessment

Soil samples were also collected from across the site and included analysis of Topsoil and natural soils. The samples were submitted for analysis for a suite of commonly occurring contaminants including metals, metalloids, inorganic compounds, speciated TPH, PAH and asbestos.

The intrusive investigation did not encounter conditions that required a revision of the preliminary risk assessment presented within the previous third-party desk study for the site.

6.2 Soil Contamination vs. End Users

The presence of a possible contaminant does not necessarily imply that a site or area is contaminated or that there is any unacceptable risk to human health. A Preliminary Quantitative Risk Assessment has been undertaken in order to evaluate any unacceptable risks posed to human health with respect to the proposed redevelopment. It should be noted that this assessment is protective of the chronic long-term effects of contaminants, which is also likely to be protective of any possible immediate acute effects.

A quantitative risk assessment has been undertaken by comparing the results of the laboratory chemical testing of shallow soils against Tier 1 screening criteria in the first instance. These criteria comprise the Atkins ATRISK soil screening values (SSVs), the Suitable for Use Levels (S4ULs) published by LQM (Copyright Land Quality Management Limited reproduced with permission; Publication Number S4UL3453. All rights reserved) and the Category 4 Screening Levels (C4SLs) published by DEFRA. Although the C4SLs were released for Part 2A use, the associated policy companion document for the C4SLs indicated that they may also be used for planning. Although the C4SLs represent a marginally higher risk level than the SSACs (low risk rather than minimal risk) it is considered that the risk levels remain very low. Therefore, the final C4SLs are considered to be suitable to assess soils under the planning regime.

In the first instance the results of the sample analysis were compared to the Tier 1 screening criteria, for a residential end use with plant uptake, where available. All of the results were noted to be below the respective assessment criteria, therefore further assessment was not considered necessary.

In addition, samples submitted for laboratory testing were also screened for asbestos. Geochemical testing of the shallow soils across the site has not returned any positive identification for asbestos. Nonetheless, the absence of asbestos in samples analysed does not mean that asbestos might not be present at locations remote from exploratory holes. If/where any such materials are encountered, or suspected, further assessment will be required in accordance with the Discovery Strategy presented in Section 7 of this report.

As such, it is considered that remedial action would not be warranted to protect end users of the proposed residential development. However, it should be noted that this intrusive investigation was focussed in and around identified sinkholes and solutions features. As such, once a development layout has been fixed it may be considered prudent to undertake some additional shallow soil sampling to demonstrate that soils within proposed garden areas and areas of soft landscaping are compliant with relevant screening criteria and suitable for use.

6.3 Soil Contamination vs. Adjacent land Users

Surrounding land uses were identified to comprise residential properties to the south and east of the site. On the basis of the testing undertaken to date, it is considered that no significant risks to adjacent land users exist.

However, short term risks to adjacent land users may arise in relation to the generation of soil derived dust and particles as fugitive emissions from the site during the construction phase. Therefore, it is recommended that dust suppression techniques, e.g. damping down exposed soils, are employed during the ground works and construction phases on site in order to minimise and manage potential nuisance issues for adjacent land users.

6.4 Soil Contamination vs. Soft Landscaping

British Standard BS3882:2015 Specification for topsoil and requirements for use provides assessment criteria for a number of potentially phytotoxic contaminants in terms of new planting.

The results of the chemical analysis for determinands known to pose a potential phytotoxic risk to plant growth are summarised in Table 6.1, together with the respective adopted Generic Assessment Criteria (GAC) for plant growth. The compliance criteria set out in BS3882:2015 are pH dependent and thus the GAC used relate to the pH range measured on samples recovered from the site.

Determinand	Phytotoxicity GAC (mg/kg)			GAC Exceedances
	pH <6.0	pH 6.0-7.0	pH >7.0	
Zinc	200	200	300	No
Copper	100	135	200	No
Nickel	60	75	110	No

Table 6.1 Summary of Plant Phytotoxicity Assessment

The phytotoxicity assessment did not identify any exceedance against the relevant phytotoxicity criteria. As such, it is considered that no specific measures are required in this respect.

6.5 Soil Contamination vs. Built Environment

Recommendations with respect to pH and sulphate in relation to buried concrete are made in Section 5.6.

The current guidance on the selection of materials for water supply pipes to be laid in contaminated land is contained in UK Water Industry Research's (UKWIR) report reference 10/WM/03/21 (re-issued 2010). However, the guidance is not mandatory and there has been concerns raised by various industry technical associations regarding the document and the methodologies proposed.

As such, the utility company should be consulted in order to confirm their specific requirements in this respect, at this time subject to further confirmation it is considered that specific protection measures are unlikely to be required for potable water supply. As a matter of good practice and to maximise the protection to maintenance workers, it is recommended that clean, granular backfill is used in service runs and that marker tapes are used for all buried services.

6.6 Soil Contamination vs. Groundwater

The investigation did not identify any mobile contamination and thus in the absence of a pollutant linkage, no further action is warranted.

6.7 Groundwater vs Human Health

The desk study did not identify any potential sources of highly mobile contamination on the site and the intrusive investigation works have not identified any mobile contamination within the soils analysed on the site.

Due diligence should be undertaken as a part of the site clearance and development works and if any currently unidentified potential sources of mobile contamination are identified these should then be further assessed in line with the discovery strategy for the site.

End users would not come in to contact with groundwater and thus in the absence of a plausible pollutant linkage between groundwater and end-users, no specific protection measures are considered likely to be required in this respect.

6.8 Groundwater vs Soft Landscaping

Shallow continuous groundwater has not been identified beneath the site to date. As such, it is considered that no specific action is warranted with respect to soft landscaping.

6.9 Groundwater vs Built Environment

Protection measures for the Built Environment as discussed in Section 6.5 are considered appropriate.

6.10 Waste Disposal

The soil analyses from the site were assessed using HazWasteOnline software. None of the samples assessed were indicated to comprise properties attributable to hazardous waste. The HazWasteOnline results are included within Appendix F.

Any soils identified as containing asbestos or mobile contaminants e.g. hydrocarbon may be classified as Hazardous waste.

It must be noted that any waste classification assessment is indicative only and actual classification would depend on permit status of the final disposal facility. Once soils for disposal have been identified it is recommended that further testing of these specific soils be undertaken in order to confirm the above assessment.

In accordance with the CL:AIRE Definition of Waste Code of Practice (2011) materials are only considered waste if 'they are discarded, intended to be discarded or required to be discarded by the holder'.

The Code of Practice therefore allows soils to be reused on site where the following criteria are met:

- The re-use of the soils will not present an unacceptable or increased risk to controlled waters, the environment and human health;
- The soils are suitable both in terms of chemical and geotechnical properties for the intended use without prior treatment;
- Only the required volume is used and no more;
- There is a required use and a certainty of use not just a possibility.

In order to comply with the Code of Practice, a Materials Management Plan (MMP) that confirms the above criteria are met must be prepared. The MMP must be reviewed by a 'Qualified Person' who then issues a declaration to the Environment Agency. The MMP and declaration must be in place before soils are excavated and it cannot be applied retrospectively. Geo-Environmental can provide this service should it be required.

Where materials do not meet the required criteria, it may be possible to treat them under an environmental permit so that they may be re-used on site. In addition, where material is discarded as waste, it may still be possible to reuse the waste on site under a standard rules environmental permit or a U1 waste exemption. However, strict limits on the volumes that can be reused apply in these cases.

Under current legislation, where wastes are to be disposed of to landfill, they may, depending on their classification, require pre-treatment. Pre-treatment shall comprise a chemical, physical (including sorting), thermal or biological process. The pre-treatment is required to change the characteristics of the waste, reduce its volume, reduce its hazardous nature, and facilitate its handling and enhance its recovery.

Other materials disposed of from site as part of the development of the site may require disposal separately. All materials containing dangerous substances e.g. tar or bitumen, asbestos, mercury, hydrocarbons, PCBs and asbestos are likely to be classified as Hazardous Waste and therefore susceptible to the relevant legislative controls.

7.0 DISCOVERY STRATEGY

Whilst an intrusive investigation has been undertaken on the site, it remains possible that unexpected ground and/or groundwater conditions may be encountered during the process of construction.

Should previously undiscovered contamination or unforeseen ground conditions be encountered during construction by the ground workers, this must be reported to the Site Manager immediately in order that the Consultant is notified. Abnormal ground conditions could include sudden changes in ground composition, presence of loose or voided ground, sudden changes in interface between strata or the like.

Where deemed necessary, the Consultant shall attend the site to inspect the discovery and provide recommendations on the further actions required, if any. Where necessary the regulatory authority shall be informed. Post any additional investigation or laboratory testing the results and any proposed remedial measures shall be reported to the regulatory authority or other appropriate organisation for consent, before proceeding or implementing the remedial measures.

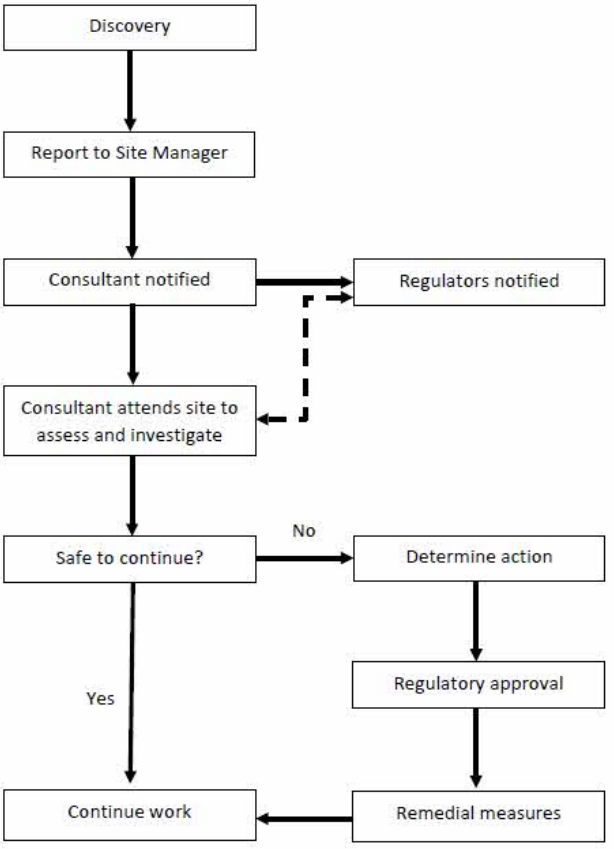
A copy of the discovery strategy must be lodged on site, and provisions made to ensure that all workers are made aware of their responsibility to observe, report, and act on any potentially suspicious, abnormal, unforeseen or contaminated ground and/or groundwater conditions they may encounter.

Depending on the type, nature and extent of any such 'discovery', it may be necessary to halt works in that location until such time as the assessment has been completed. This shall be reviewed on a 'discovery' specific basis and in conjunction with consultation with the client, other technical personnel and/or regulatory/approval organisations.

As a general guide, where such unexpected conditions are encountered the following approach is required as a minimum:

All discoveries are to be reported to the Site Manager immediately and works at that location are to halt until further notice;
The Site Manager is to report any such discoveries to the Client and the Consultant;
Following notification from the Site Manager, the Consultant shall discuss the discovery with the Local Authority and/or other relevant parties and if considered necessary, arrange to meet on site to view the discovery;
The Consultant shall attend the site to record the location, extent and nature of the discovery and implement an appropriate sampling and analysis regime, taking due account of the type and nature of the discovery, known and probable land uses in that area of the site;
Where remedial action is required, regulatory consultation and approval will be sought;
A record will be produced by the Consultant and held on site (with copies held by the Consultant, Client and Local Authority/other relevant organisation), detailing the discovery, assessment works undertaken, findings thereof, confirmation either of no action required or detailing the remedial action taken and validation thereof.

The process is summarised overleaf:

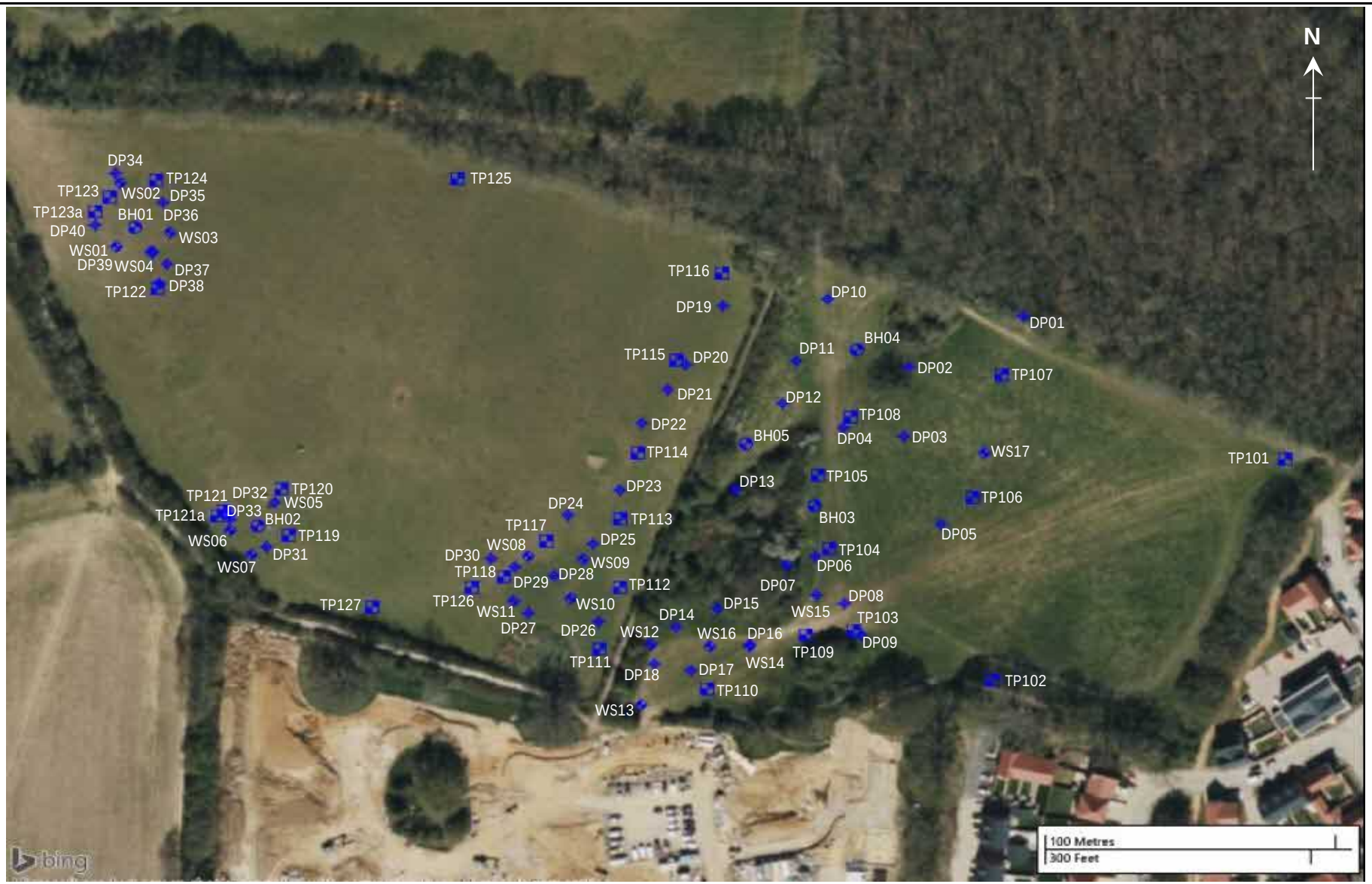


Discovery Strategy Process

Geo-Environmental

FIGURES

Project:	Woodcroft Phase 3, Lovedean			Title	Site Location Plan
Client:	Grainger plc			Geo-Environmental Services Ltd Unit 7 Danworth Farm, Cuckfield Road Hurstpierpoint, West Sussex BN6 9GL +44(0)1273 832972 www.gesl.net	Geo-Environmental
Ref No:	GE20772	Version:	1		
Drawn:	GR	Date:	19/10/2023		
Figure:	1	Scale:	Not To Scale		



Project:	Woodcroft Phase 3, Lovedean			Title	Exploratory Hole Location Plan
Client:	Grainger plc			Geo-Environmental Services Ltd Unit 7 Danworth Farm, Cuckfield Road Hurstpierpoint, West Sussex BN6 9GL +44(0)1273 832972 www.gesl.net	Geo-Environmental
Ref No:	GE20772	Version:	1		
Drawn:	FG	Date:	19/10/2023		
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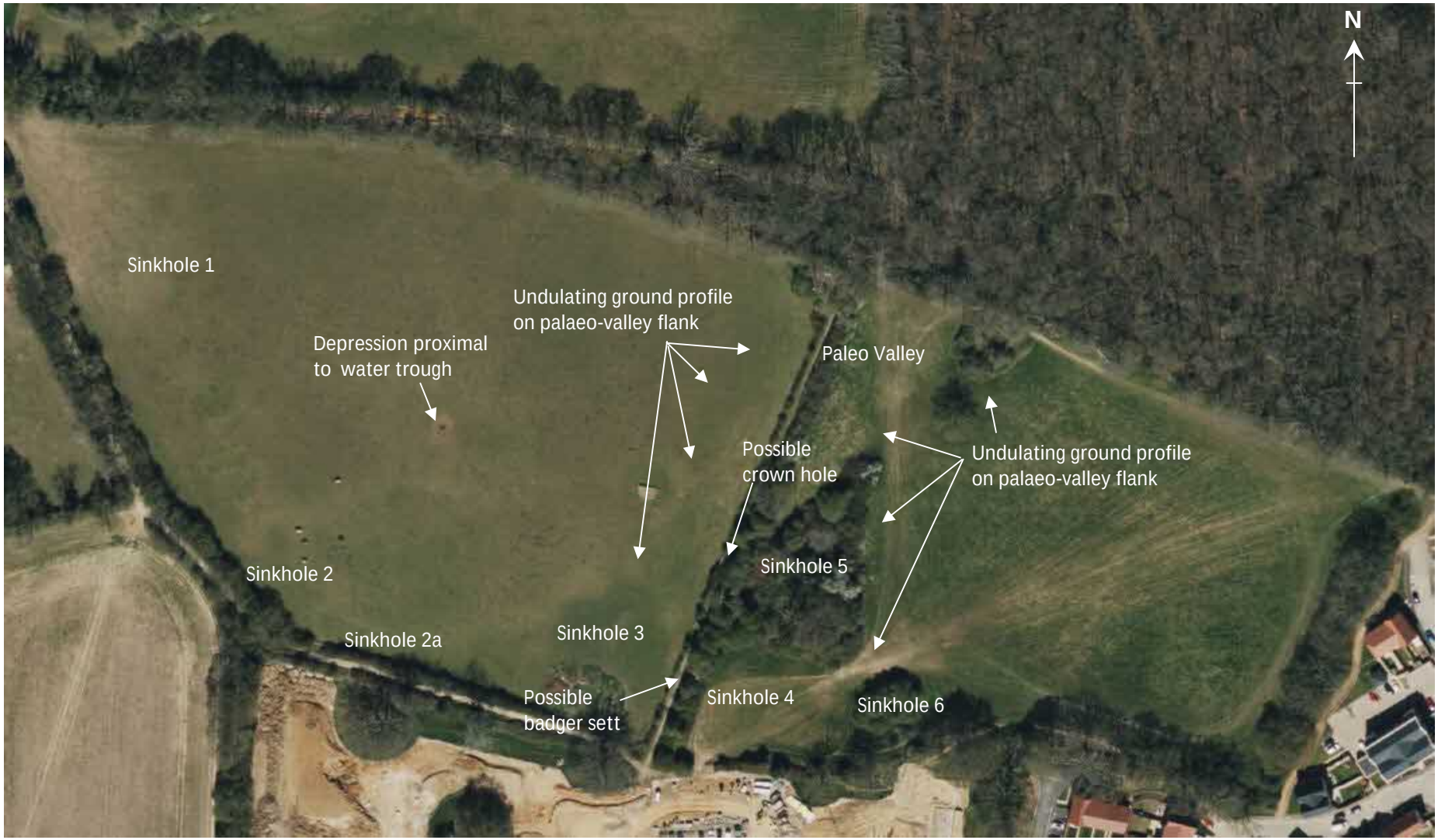

Project:	Woodcroft Phase 3, Lovedean			Title	Geohazrd Features Plan
Client:	Grainger plc			Geo-Environmental Services Ltd Unit 7 Danworth Farm, Cuckfield Road Hurstpierpoint, West Sussex BN6 9GL +44(0)1273 832972 www.gesl.net	Geo-Environmental
Ref No:	GE20772	Version:	2		
Drawn:	FG/GR	Date:	05/12/2023		
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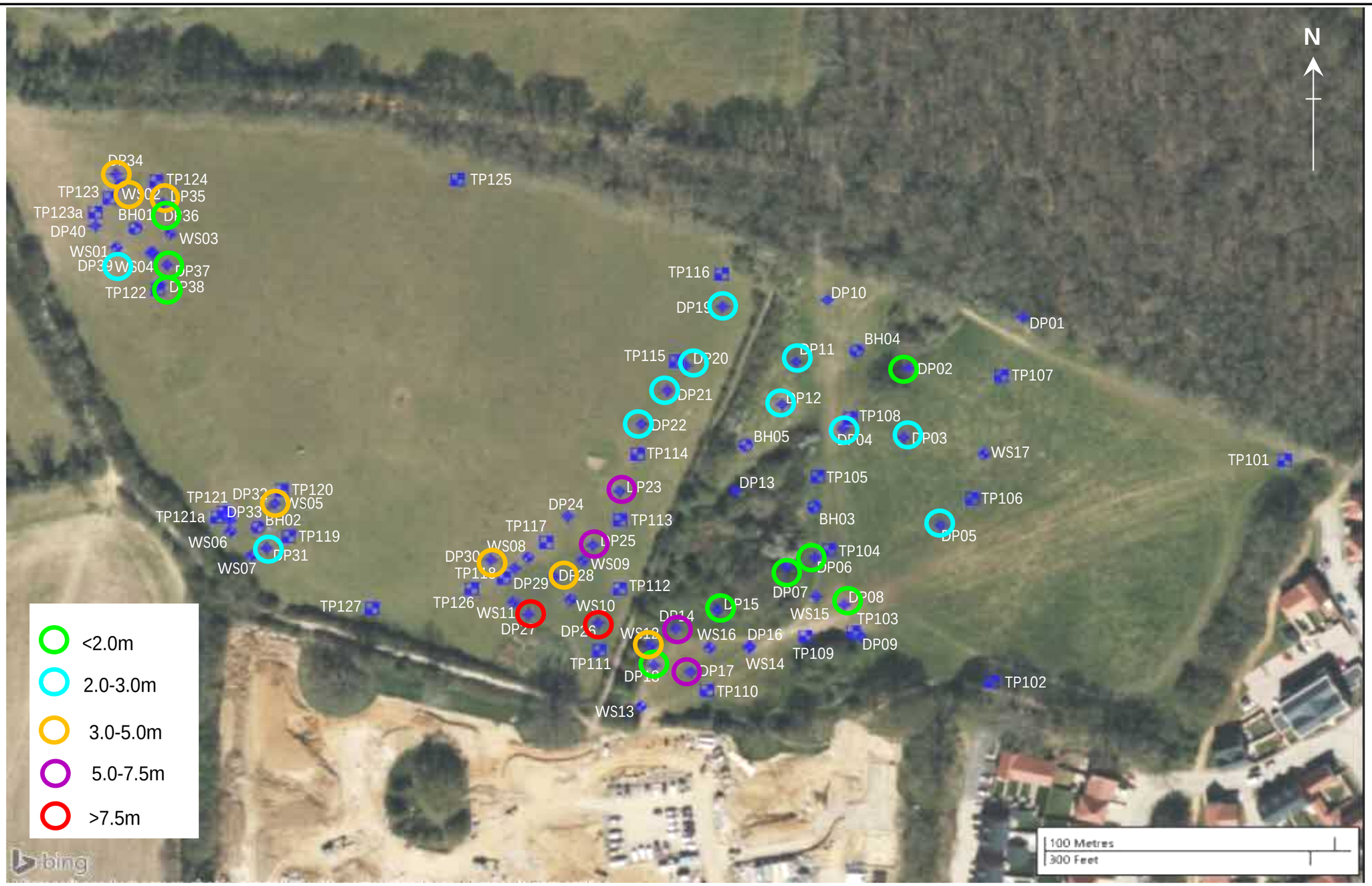

Project:	Woodcroft Phase 3, Lovedean			Title	Locations where DPSH N values of <3 were recorded (incl SPT N=0) 4
Client:	Grainger plc			Geo-Environmental Services Ltd Unit 7 Danworth Farm, Cuckfield Road Hurstpierpoint, West Sussex BN6 9GL +44(0)1273 832972 www.gesl.net	Geo-Environmental
Ref No:	GE20772	Version:	1		
Drawn:	GR	Date:	19/10/2023		
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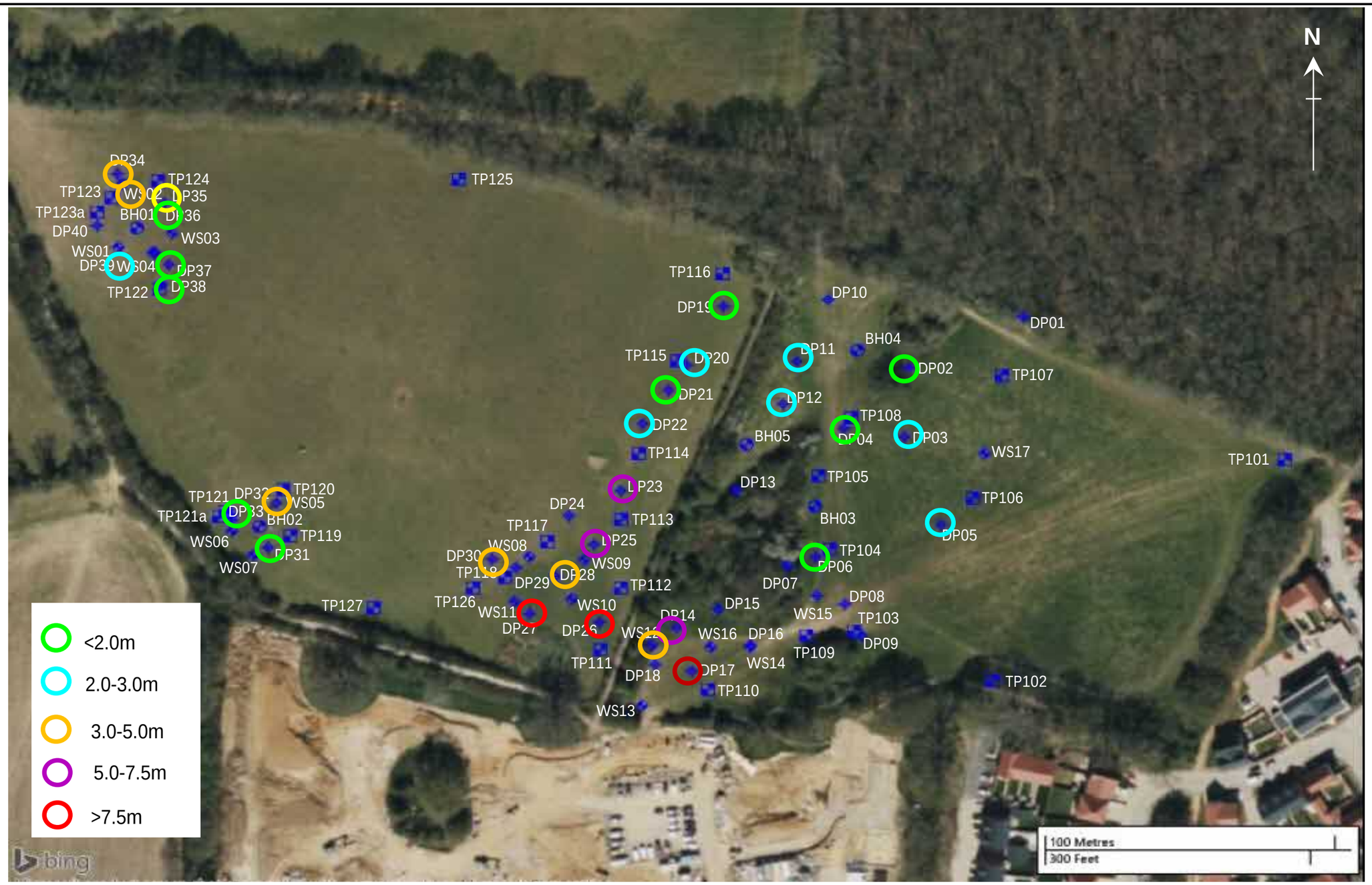

Project:	Woodcroft Phase 3, Lovedean			Title	Locations where DP values of 0 (zero) were recorded (incl SPT N=0)
Client:	Grainger plc			Geo-Environmental Services Ltd Unit 7 Danworth Farm, Cuckfield Road Hurstpierpoint, West Sussex BN6 9GL +44(0)1273 832972 www.gesl.net	Geo-Environmental
Ref No:	GE20772	Version:	1		
Drawn:	GR	Date:	19/10/2023		
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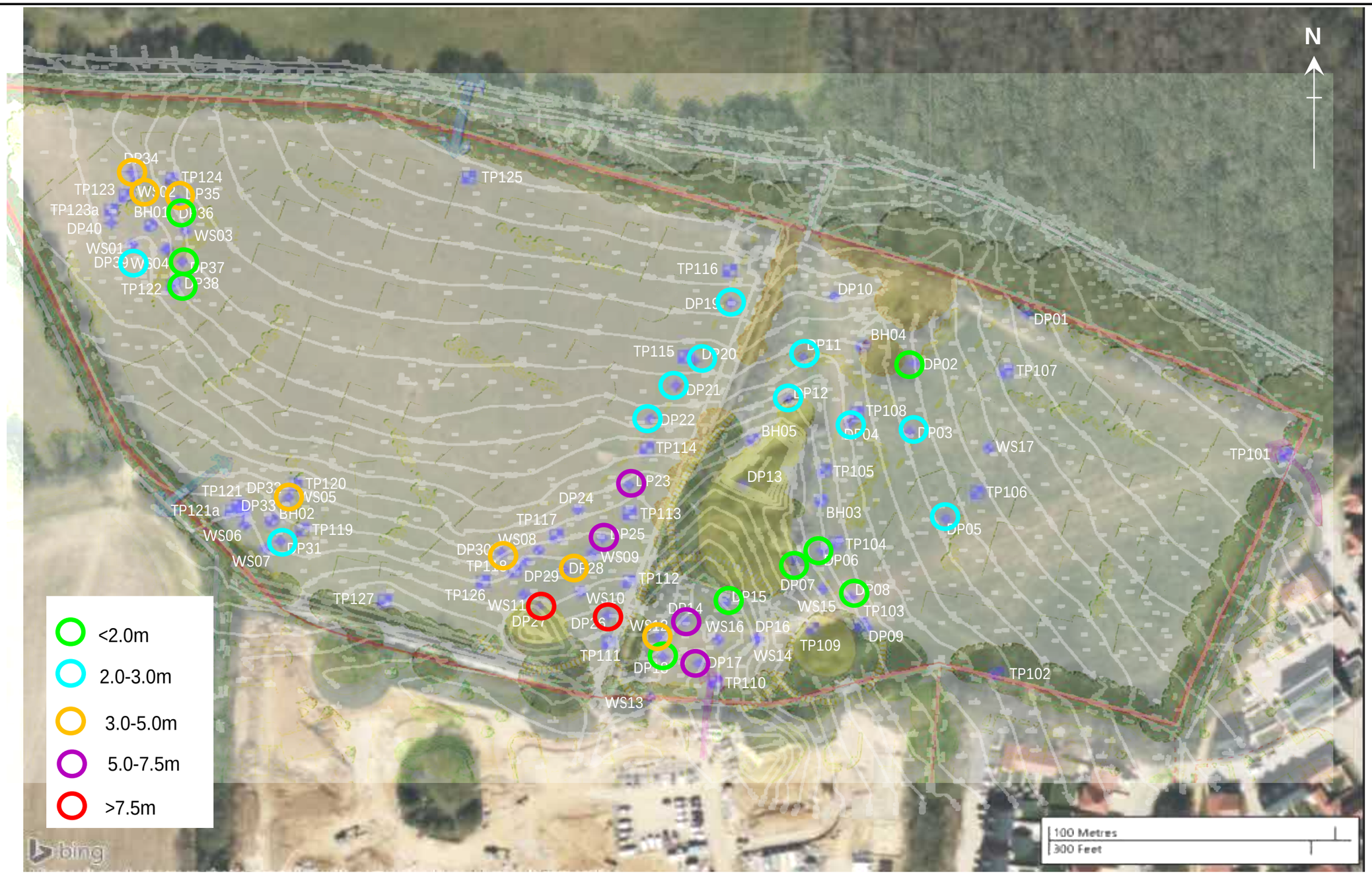
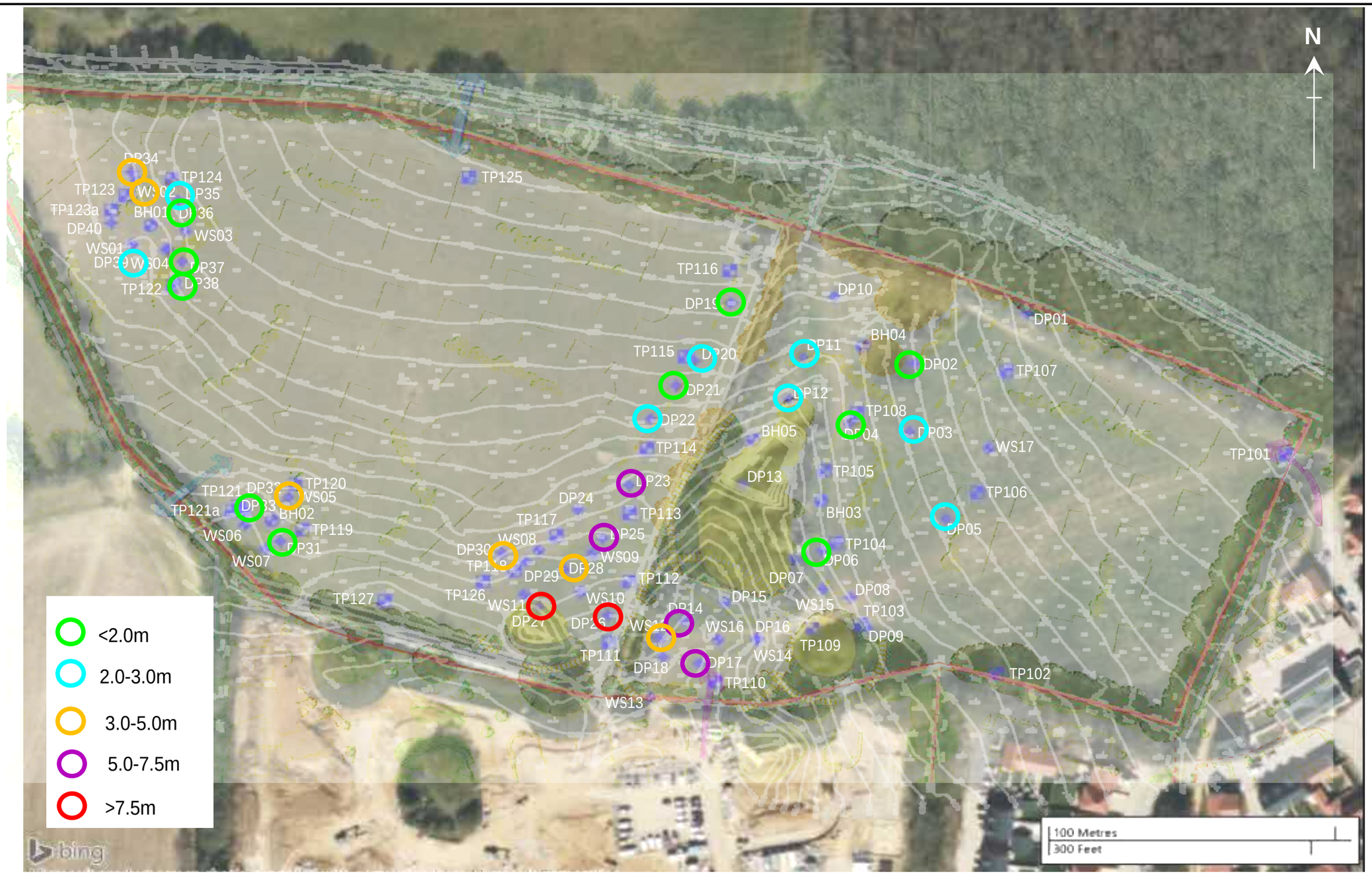


Project:	Woodcroft Phase 3, Lovedean			Title	Locations where DPSH N values of <3 were recorded (incl SPT N=0) on layout
Client:	Grainger plc			Geo-Environmental Services Ltd Unit 7 Danworth Farm, Cuckfield Road Hurstpierpoint, West Sussex BN6 9GL +44(0)1273 832972 www.gesl.net	Geo-Environmental
Ref No:	GE20772	Version:	1		
Drawn:	GR	Date:	19/10/2023		
Figure:	6	Scale:	Not To Scale		



Project:	Woodcroft Phase 3, Lovedean			Title	Locations where DP values of 0 (zero) were recorded (incl SPT N=0) on layout
Client:	Grainger plc			Geo-Environmental Services Ltd Unit 7 Danworth Farm, Cuckfield Road Hurstpierpoint, West Sussex BN6 9GL +44(0)1273 832972 www.gesl.net	Geo-Environmental
Ref No:	GE20772	Version:	1		
Drawn:	GR	Date:	19/10/2023		
Figure:	7	Scale:	Not To Scale		

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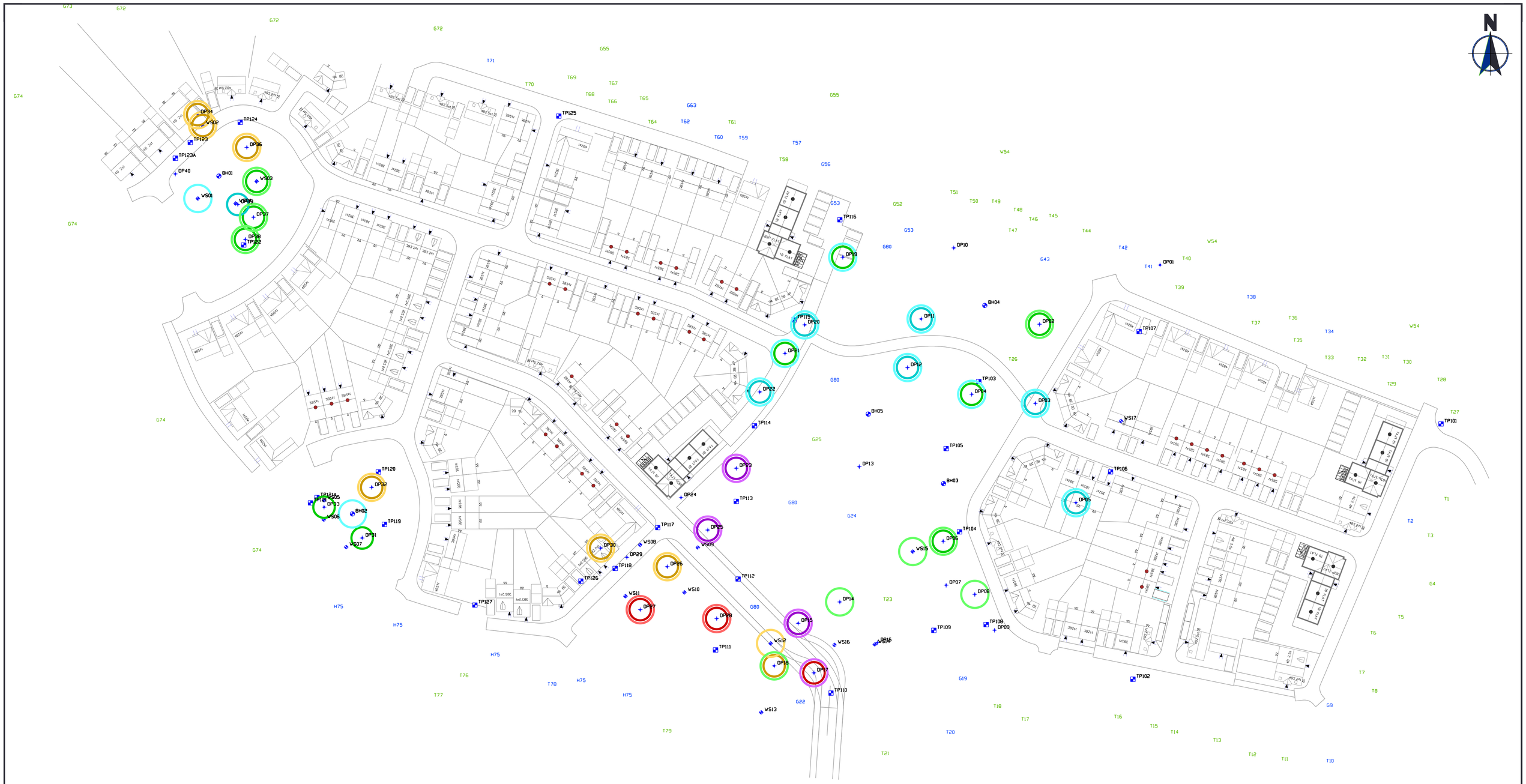
DRAWINGS



Grid

The survey grid is Ordnance Survey National Grid, computed using Lecia Smartnet RTK Network.

Datum

All levels are orthometric heights related to OSGM02 GPS datum, computed using Leica Smartnet RTK Network.

Notes

Add notes here

Legend

Locations Where DP Values of 0 (zero) Were Recorded (incl SPT N=0)

- <2.0m
- 2.0 - 3.0m
- 3.0 - 5.0m
- 5.0 - 7.5m
- >7.5m

Locations where DPSH N values of <3 were recorded (incl SPT N=0)

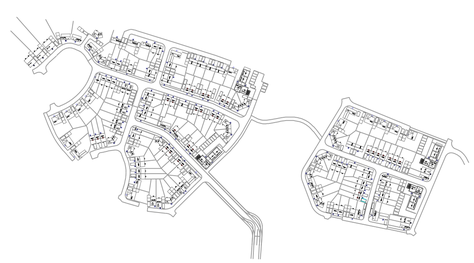
- <2.0m
- 2.0 - 3.0m
- 3.0 - 5.0m
- 5.0 - 7.5m
- >7.5m

- Cable Percussive Borehole (BH)
- Dynamic Probe - Super Heavy (DP)
- Trial Pit (TP)
- Windowless Sampler Borehole (WS)

Model / References List

Description	Drawing Number/Name	Revision	Status
Base Mapping	44515 - Masterplan - October Revision	A	Final/Working
Geo-Env Map	GE20772-DR-V01	A	Final/Working

Sheet Layout



Client
Grainger PLC

Site
Woodcroft Phase 3
Lovedean

Drawing Title
Woodcroft Phase 3, Lovedean

Project Number	Scale	Drawn Date
GE20772	1:600	21/11/2023
Field Work By	**Drawn By**	**Checked By**
N/A	JC	GR
Status	**Sheet**	**Revision**
Final	1 OF 1	V01

Drawing Number

GE20772-DR-V01

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APPENDIX A

Exploratory Hole Logs and Sections