Statutory Consultation 2022

Preliminary Environmental Information Report

Volume 3: Appendix 6.3

Land at Luton Airport Soil Resource Survey
June 2016

LAND AT LUTON AIRPORT

SOIL RESOURCE SURVEY

Prepared on behalf of:

CAPITA PROPERTY AND INFRASTRUCTURE LIMITED

TOHA Document Ref:	TOHA/16/3010/TW
Document Revision:	01
Document Status	Issue 1
Current Issue Date:	15th June 2016
Original Issue Date:	15th June 2016

Prepared by: Tim O'Hare Associates LLP

Howbery Park, Wallingford
Oxfordshire, OX10 8BA

Tel: 01491 822653
Email: info@toha.co.uk
Web: www.toha.co.uk

TIM O'HARE ASSOCIATES
SOIL & LANDSCAPE CONSULTANCY

CONTENTS

1.0 INTRODUCTION

Tim O'Hare Associates LLP was commissioned by Capita Property and Infrastructure Limited to undertake a soil resource survey at the 'Land at Luton Airport' site.

The authority to carry out the work is contained in an email message from Capita Property and Infrastructure Limited dated 7th April 2016, with an official purchase order dated 24th May 2016.

1.1 Purpose

It is understood that Capita Property and Infrastructure Limited ('Capita') has been appointed to provide high level consultancy services in the development of a Strategic Masterplan for a new country park, as well as employment allocated land and associated infrastructure. Capita has also been appointed to provide consultancy services for the country park element through to implementation.

It is intended for the country park to be linked to the existing Wigmore Park via an access corridor. Wigmore Park itself is to be updated with a number of landscape improvements.

The majority of the existing site is in use as agricultural land (arable), with the remainder comprising a public park and limited areas of woodland. As such, the site contains large reserves of topsoil and subsoil, however, there is currently no information available on the horticultural quality, variability and suitability of the soils for landscape purposes for this development.

A scheme of this size will require soils to support the required landscape planting / seeding and the creation of species-rich habitats. Soil provides the foundation to all new landscape and habitat schemes. Its quality, composition and function are intrinsically linked to the health, vigour and establishment of the plants that rely on it for water, mineral and organic reserves, and structural support. Not all soils are suitable for landscape and habitat creation purposes.

The purpose of this work was to assess the existing site soils to provide information on their pertinent chemical and physical properties for horticultural re-use. This Soil Resource Survey is intended to guide on-going design and cost analysis by providing information on the existing site soil resources and their potential for re-use for the new development. Subsequently it will inform future soil management activities and support the required Landscape Specifications for this site /soils.

1.2 Actions

Tim O'Hare Associates LLP (TOHA) has evaluated the quality and suitability of the soils by assessing a number of key chemical and physical soil properties, through desk study review, on-site investigation and laboratory analysis.

This report issues the findings of the desk study review and soil investigation, including site observations and soil descriptions, results and interpretation of all analyses, discussion on soil quality and implications for landscape construction and habitat creation on this site.

The brief for this appointment does not include the extreme western part of Wigmore Park which is built over a restored landfill.

2.0 DESK STUDY REVIEW

2.1 Document Reviewed

Prior to commencing the site investigation work, the following documents were reviewed as part of a Desk Study Review:

- *Capita Property and Infrastructure site plan : Landform Option Proposal Option 1;*
- *Capita Design Statement – Land at Luton Airport;*
- *Soil Map of England and Wales (Scale: 1:250,000 – Sheet 6);*
- *British Geological Survey website (Geology of Britain – 1:50,000 Scale);*

The findings of this review are presented below.

2.2 Topography

The western part of the site (existing Wigmore Park and future access corridor) has an elongated shape and is oriented roughly east / west. This part of the site approximately follows the site contours (reasonably level) and is located partway down a wider, off-site slope formation.

The eastern portion of the site is of an irregular shape and features two low valleys extending into the site from the east, with gentle to moderately steep slopes.

2.3 Soils

The Soil Map of England and Wales (1:250,000 scale) Sheet 6 indicates the site soils to comprise *Brown Soils*, with some variations represented. The majority of the site falls under the following:

Major Group	*Brown Soils*
Group	*Paleo-argillic brown earths*
Subgroup	*Stagnogleyic paleo-argillic brown earths*

Brown soils have dominantly brownish or reddish subsurface horizons with no prominent mottling or greyish colours above 400mm depth. Paleo-argillic brown earths are loamy or clayey soils with a reddish or reddish mottled, clay-enriched subsoil. Further definition places these soils within the following Soil Associations:

BATCOMBE Soil Association, which is described as 'Fine silty over clayey and fine loamy over clayey soils with slowly permeable subsoils and slight seasonal waterlogging. Some well-drained clayey soils over chalk. Variably flinty'.

HORNBEAM 2 Soil Association – 'Deep, fine loamy over clayey soils with slowly permeable subsoils and slight seasonal waterlogging. Some well-drained fine loamy and fine silty over clayey and clayey soils. Some soils very flinty'.

Limited parts of the site may also comprise *Brown calcareous earths* – 'Non-alluvial loamy or clayey soils with a weathered calcareous subsoil', which fall into the following Soil Association.

SWAFFHAM PRIOR Soil Association – 'Well-drained, calcareous coarse and fine loamy soils over chalk rubble. Some similar shallow soils. Deep non-calcareous loamy soils in places. Striped and polygonal soil patterns locally'.

2.4 Geology

The *British Geological Survey* website (*Geology of Britain – 1:50,000 Solid and Drift*) describes the geology (Bedrock and Superficial Deposits) as follows with some differences indicated between the *slopes* and *valley bases* on this site:

Slopes

The bedrock for the sloping parts of the site comprise '*Lewes Nodular Chalk Formation and Seaford Formation (undifferentiated) – chalk'*. This consists of Sedimentary Bedrock formed 84 to 94 million years ago in the Cretaceous Period. These rocks were formed in warm chalk seas with little sediment input from land.

Superficial deposits for the sloping portions of the site consist of '*Clay-with-flints Formation - Clay, Silt, Sand and Gravel'*. Superficial Deposits formed up to 5 million years ago in the Quaternary and Neogene Periods. Local environment previously dominated by weathering processes.

Valley bases

At the base of valleys, the bedrock consisted of '*Holywell Nodular Chalk Formation and New Pit Chalk Formation (undifferentiated) – chalk'*. This is a Sedimentary Bedrock formed approximately 89 to 100 million years ago in the Cretaceous Period. Local environment previously dominated by warm chalk seas.

Superficial deposits at the base of the valleys are shown as '*Head - Clay, Silt, Sand and Gravel'*, formed up to 3 million years ago in the Quaternary Period. Local environment previously dominated by subaerial slopes.

2.5 Landscape Proposals

The landscape design is at an early stage, but is to focus on habitat creation landscape types, including species-rich wildflower grasslands, with native woodland and hedge planting. There may also be limited areas of tree and shrub planting.

As part of the development strategy, it is anticipated that the majority of the site soils will remain in-situ, with earthworks limited to localised soil stripping / remodelling only.

3.0 SITE INVESTIGATION

3.1 Site Visit

The site work was conducted on the 27th and 29th April 2016 during a period of changeable, showery weather.

3.2 The Site

The site was located to the north east of Luton Airport, on the outskirts of Luton, Bedfordshire and was accessed Eaton Green Road / Darley Road.

The survey area was made up of several distinct zones / land-uses. The western portion of the site (Wigmore Park) was relatively narrow in shape and was mainly in use as amenity grassland, with some established tree lines / wooded areas and allotment gardens. An earth bank planted with mature trees / scrub was located on the eastern boundary of Wigmore.

The extreme western end of the site was part of a restored landfill and was not included in this scope of works. Also, please note it was not possible to access the allotment gardens at the time of the site visit.

The central part of the survey site (access corridor) was also linear and included a variety of land uses, including agricultural land (arable), areas of woodland / pine plantation and rough grassland. A number of derelict / un-used structures were located at the old Winch Hill Farm site, including farm houses, barns and areas of hard standing (not included in this survey).

The main part of the new country park was located east of the old Winch Hill Farm and was comprised entirely of existing agricultural land (arable).

Plate 1 : Wigmore Park (amenity grass)

Plate 2 : Wigmore Park (amenity grass)

Plate 3 : Earth bank on eastern boundary to Wigmore Park

Plate 4 : Access corridor pocket of rough grass and scrub

Plate 5 : Access corridor – Pine plantation

Plate 6 : Access corridor – derelict farm buildings

Plate 7 : Access corridor – area of old hard standing

Plate 8 : New country park southern section, looking north (agricultural land)

Plate 9 : New country park – southern section, looking east (agricultural land)

Plate 10 : New country park – soil surface (agricultural land)

3.3 Soil Conditions

We examined the soils by constructing a total of 38 no. hand-dug trial holes (TH) at representative locations within the survey areas. Trial holes were dug to a maximum depth of 1000mm where possible. The locations of our trial holes are indicated on the site plan in Appendix 1.

At each trial hole, the soils were examined with reference to the Soil Survey Field Handbook. Important physical soil characteristics were recorded, including texture, structure, compaction, waterlogging, anaerobism, topsoil depths, stone content and the presence of deleterious materials. At the same time, representative soil samples were taken for laboratory analysis.

3.4 Soil Descriptions

A total of 4 No. distinct soil profiles / types were encountered during the site visit, including:

Soil Profile 1 - Agricultural Soil
Soil Profile 2 - Agricultural Soil (calcareous)
Soil Profile 3 - Parkland Soil
Soil Profile 4 - Woodland Soil

The distribution of these soil profiles is indicated on the site plan in Appendix 2 and each of them are described below:

Soil Profile 1 - Agricultural Soil

Soil Profile 1 was observed within areas of agricultural land at the new country park and access corridor at TH1 to TH7, TH9, TH10, TH13 to TH16, TH18 to TH21, TH29 to TH31, TH33 and TH34.

Topsoil 1 GL – 230/360mm Average depth : 280mm	Very dark greyish brown (Munsell Colour 10YR 3/2), moist, plastic, slightly compacted, non-calcareous HEAVY CLAY LOAM to CLAY, with a moderate to poorly developed, subrounded to sub-angular blocky and common blocky structures. Moderate to very stony, comprising common medium to large subrounded to angular flints up to 140mm in size and no observable deleterious materials.
Subsoil 230/360 – 1000mm	Strong brown (Munsell Colour 7.5YR 5/6) slightly moist to moist, plastic, non-calcareous CLAY to SILTY CLAY LOAM, with a moderately developed, subangular blocky structure. Slight to moderately stony with occasional large subangular flints up to 105mm diameter. No observable deleterious materials. Ochreous mottling and manganese concretions recorded throughout the subsoil, becoming stronger with depth.

Plate 11 : Soil Profile 1 at TH1 (agricultural soil)

Plate 12 : Soil Profile 1 at TH19 (agricultural soil)

Plate 13 : Topsoil 1 showing plastic consistency

Plate 14 : Subsoil arisings

Plate 15 : Soil Profile 1 - subrounded flints

Plate 16 : Soil Profile 1 – large subangular flint

Soil Profile 2 - Agricultural Soil (Calcareous)

Soil Profile 2 was observed at locations within the central / eastern part of the new country park site at TH8, TH11, TH12, TH17 and TH22.

Topsoil 2 GL – 260/320mm Average depth : 300mm	Greyish brown (Munsell Colour 10YR 5/2), dry to slightly moist, very calcareous CLAY with a well developed, medium to coarse granular and subrounded blocky structure. Slightly stony (chalk fragments) and no observable deleterious materials.
Calcareous Subsoil 260/320 – 310/420mm	Strong brown to very pale brown (Munsell Colour 7.5YR 5/6 to 10YR 7/3) slightly moist, slightly plastic, very calcareous CLAY, with a moderate to well developed, medium to coarse granular and subrounded blocky structure. Slight to moderately stony (chalk fragments).
Chalk 310/420 - 600mm	Very pale brown (Munsell Colour 10YR 8/3) dry fractured CHALK.

Plate 17 : Soil Profile 2 at TH8 - agricultural soil (calcareous)

Plate 18 : Topsoil 2 arisings - agricultural soil (calcareous)

Plate 19 : Soil Profile 2 – Chalk

Soil Profile 3 - Parkland Soils

Soil Profile 3 was observed at locations within Wigmore Park at TH23 to TH28 and TH37.

Topsoil 3 GL – 240/270mm Average depth : 260mm	Dark greyish brown (Munsell Colour 10YR 4/2), moist, plastic, non calcareous MEDIUM CLAY LOAM with a moderate to well developed, granular to subrounded blocky structure. The upper 90/120mm topsoil was slightly stony and the remaining topsoil was moderately stony including subangular flints up to 65mm in size. A compaction pan was typically identified at a depth of 90-150mm below surface level. At TH37 the topsoil contained frequent brick fragments up to 85m in size. A 'no-dig' marker layer (open mesh type) was encountered at TH23 at 70mm below ground level.
Subsoil 240/270 – 1000mm	Subsoil described as Soil Profile 1 Subsoil

Plate 20 : Topsoil 3 showing stone layer at 90mm below surface level (TH24)

Plate 21 : Soil Profile 3 (Parkland Soil) at TH25

Plate 22 : Soil Profile 3 showing 'no dig' marker layer at TH23 (70mm below surface level)

Plate 23 : Soil Profile 3 showing brick fragments at TH37

Soil Profile 4 - Woodland Soils

Soil Profile 4 was observed at locations within Access Corridor at TH32, TH33 and TH35.

Litter Layer GL – 70/120mm Average depth : 95mm	Distinguishable plant remains (mainly leaves or needles with small twigs) overlying unrecognisable plant matter. Described as very dark greyish brown, slightly moist to moist, loose PEATY SAND with a weakly developed granular structure.
Topsoil 4 70/120 – 290/320mm Average thickness : 210mm	Brown (Munsell Colour 10YR 4/2), slightly moist, slightly plastic non-calcareous MEDIUM CLAY LOAM with a well developed, granular structure. Moderately high stone contents, with subangular flints up to 85mm in size. No observable deleterious materials.
Subsoil 290/320mm – 1000mm	Subsoil described as Soil Profile 1 Subsoil

Plate 24 : Soil Profile 4 showing litter layer at TH32 (Woodland Soil)

3.5 Topsoil Depths

The following topsoil depths (mm) were recorded during our survey

TH1 – 250
TH2 – 230
TH3 – 250
TH4 – 250
TH5 – 360
TH6 – 250
TH7 – 320
TH8 – 300
TH9 – 290
TH10 – 280
TH11 – 320
TH12 – 260
TH13 –260
TH14 – 230
TH15 – 330
TH16 – 290
TH17 – 310
TH18 – 270
TH19 – 320
TH20 – 360
TH21 – 270
TH22 – 300
TH23 – 70 (over 'no-dig' marker layer)
TH24 – 240
TH25 – 240
TH26 – 250
TH27 – 290
TH28 – 270
TH29 – 280
TH30 – 270
TH31 – 240
TH32 – 290
TH33 – 320
TH34 – 290
TH35 – 350
TH36 – 310
TH37 – 270
TH38 – 280

4.0 LABORATORY ANALYSIS

4.1 Analytical Schedule

A total of 21 no. representative samples of topsoil (16 No.) and subsoil (5 No.) were submitted to the laboratory for analysis.

The samples were analysed in accordance with the following schedule:

- particle size analysis;
- stone content;
- pH and electrical conductivity values;
- major plant nutrients - N, P, K, Mg;
- organic matter content.

The results for topsoil and subsoil are presented on the Certificates of Analyses in Appendix 3, and Appendix 4 respectively and our interpretation of the results is given below.

4.2 Results of Analysis – Topsoils

Particle Size Analysis

Topsoil 1 (Agricultural Soils)

The samples of Topsoil 1 fell into the HEAVY CLAY LOAM to CLAY texture class, and are described as 'heavy' in texture. Such soils usually have good water and nutrient retention capacities, but they are slow-draining and can suffer from seasonal waterlogging following periods of prolonged or heavy rainfall. They are also prone to structural degradation and compaction during handling, and especially when plastic in consistency. Given the high clay content of these topsoils, they will tend to form strong structures when completely dry that may be difficult to break down by mechanical cultivation.

Heavy textured topsoil such as this would be suited to less demanding landscape types only, including for example native hedgerows and woodland, marginal and shallow water planting, species-rich wildflower grassland and amenity grass establishment (low foot traffic areas), provided species tolerant of heavy moisture retentive soils are selected and provided the soils' physical condition is adequate at planting / seeding. These soils would only be considered acceptable for more demanding landscape types such as tree and shrub planting provided they are at their *optimum* physical condition at planting. Additional measures may be needed to offset other adverse properties of these soils for less robust hardy types (see Section 5.3).

Topsoil 2 (Agricultural Soils – Calcareous), Topsoil 3 (Parkland Soils) and *Topsoil 4 (Woodland Soils)*

The sample of Topsoil 2 was classified as a calcareous CLAY and the samples of Topsoil 3 and Topsoil 4 fell into the MEDIUM CLAY LOAM texture class and would be described as 'medium' in texture. The highly calcareous nature of Topsoil 2 helps to mitigate its otherwise clay dominated characteristics, which aids soil structural development and improves its handling properties.

Soils such as these usually have adequate water and nutrient retention capacities, with good drainage and aeration properties. They can be degraded by compaction during soil handling, vehicle tracking or trampling. Once their structure is damaged, these soils are likely to suffer from reduced aeration and drainage rates and once damaged could be prone to waterlogging after periods of prolonged or heavy rainfall.

Topsoils such as these, are typically suitable for many landscape types, including tree and shrub planting, native hedgerows and woodland, species-rich wildflower grassland and amenity grass establishment (low foot traffic areas), provided the structural condition of the soil is satisfactory.

Stone Content

The stone contents recorded within samples of Topsoil 1 and Topsoil 4 were moderately high to high and included large stones >50mm in size. Stony soils, such as these contain a lower proportion of fine earth (material less than 2mm) from which water and nutrients may be obtained, and they can be more prone to drought in dry weather. Furthermore, the high proportions of stones observed may affect the establishment, use and maintenance of seeded areas (e.g. amenity grass, species-rich wildflower grasslands). It would therefore be necessary to remove/treat the larger stones by raking, picking, burying or screening, should the soil be used for seeded landscape types. A combination of treatments may be needed to deal with the stones in this instance.

The stone contents of Topsoil 2 and Topsoil 3 were moderate and, as such, stones are unlikely to constitute a significant limitation for general landscape purposes. However, it may be prudent to reduce a proportion of the larger stones, should the soil be used for seeded landscape types.

pH and Electrical Conductivity

The samples of Topsoil 1 and Topsoil 3 were slightly acid to alkaline in reaction (pH 6.0 – 7.8) with a pH range that would be suitable for a wide range of plant species commonly used for general landscape purposes, provided they have a broad pH tolerance.

The sample of Topsoil 2 was strongly alkaline in reaction (pH 8.2) with a pH value which would be suitable for species and landscape types which prefer or demand alkaline and chalky soils only. The pH value recorded is in keeping with the highly calcareous nature of this soil type.

Samples of Topsoil 4 were strongly acid in reaction (pH 4.3 to 4.6), with pH values that would be suitable for general landscape purposes and in particular acid-loving species (calcifuges). These pH values would not be suitable for species known to specifically require or prefer alkaline soil.

The electrical conductivity (salinity) values were all low, indicating that soluble salts were not present at levels that would be harmful to plants.

Organic Matter and Nutrient Status

All of the topsoil types displayed moderate to moderately high levels of organic matter and all major plant nutrients.

For landscape types which require fertile soils (e.g. tree and shrub planting, native woodland planting and amenity grass) there are no apparent deficiencies which would warrant amendment. Certain, demanding landscape types may benefit from a routine fertiliser application at planting or seeding to aid establishment.

With respect to habitat creation purposes, including the establishment of species-rich wildflower grassland, the site topsoils are considered to be *fertile* (typically phosphorus MAFF index 3 to 4) and therefore generally have a low potential for this purpose. Such landscape types require a low fertility soil, particularly in relation to levels of phosphorus to reduce competition form aggressive broad-leaved species and grasses. Phosphorus is relatively immobile in soils and it would therefore be difficult to remove it from the topsoil to reduce the level to a more acceptable level.

4.3 Results of Analysis – Subsoils

Particle Size Analysis

The samples of subsoil form all parts of the site into the CLAY and SILTY CLAY LOAM texture classes, and are described as heavy in texture.

These soils are typically slow-draining and often suffer from seasonal waterlogging following periods of prolonged or heavy rainfall. They are also prone to structural degradation and compaction during handling, and especially when plastic in consistency. As such, they are restricted in terms of their potential for re-use for landscape purposes.

The subsoil at Soil Profile 1, Soil Profile 3 and Soil Profile 4 would be suitable for less-demanding planting, including native hedgerows and woodland, amenity grass establishment (low foot traffic areas) and species-rich wildflower grassland and provided the structural condition of the soil is satisfactory and provided species tolerant of water retentive soils are selected. These subsoils are unsuitable for plant species or landscape environments that require or prefer light or free-draining soils. Furthermore, there is likely to be a need for improvements to promote a healthy rooting environment, particularly for tree planting and other key locations such as the base of slopes.

At Soil Profile 2, the calcareous nature of the subsoil will help to improve its structural development and assist drainage. As such, this subsoil type has potential for re-use for more demanding planting types provided its physical condition is maintained.

Stone Content

The stone contents of the subsoil samples were low to moderate and, as such, stones are unlikely to constitute a significant limitation for general landscape purposes. However, where the subsoil is used for seeding purposes, it may be prudent to reduce a proportion of the larger stones by raking, picking or burying.

pH and Electrical Conductivity

The subsoil samples were alkaline to strongly alkaline in reaction (pH 7.5 – 8.1) with a pH range that is suitable for landscape purposes, provided species selected have a broad pH tolerance.

The electrical conductivity (salinity) values were all low, indicating that soluble salts were not present at levels that would be harmful to plants.

Organic Matter Content and Fertility Status

Samples of subsoil displayed elevated organic matter and total nitrogen contents and low to moderate levels of extractable phosphorus, extractable potassium and extractable magnesium.

The organic matter contents of these soils are higher than are normally found in subsoils and increase the risk of the formation anaerobic conditions (oxygen depleted) should they become degraded (compacted).

The fertility status of the subsoil may be classified as *infertile* to *intermediate* (phosphorus MAFF index 0 to 2) and would be considered acceptable for re-use as a low nutrient soil for species-rich wildflower meadows. The elevated organic matter content of these soils would provide good cultural conditions for this purpose and should encourage establishment, without encouraging colonisation by aggressive species and grasses.

5.0 DISCUSSION

The majority of the survey site is to be used to construct a new country park, with an associated access corridor and improvements to the existing Wigmore Park.

As part of the development strategy, it is anticipated that the majority of the site soils will remain in-situ, with earthworks limited to localised soil stripping / remodelling only. The purpose of this work was to assess the existing site soils to provide information on their pertinent chemical and physical properties for horticultural re-use.

The landscape design is at an early stage and is likely to include the following landscape types:

- Tree planting
- Shrub beds
- Native woodland and hedge planting
- Amenity grass
- Species-rich wildflower grassland

There is currently little or no information on the horticultural quality, variability and suitability of the site soils for habitat creation and landscape purposes, so the purpose of the investigation was to assess the existing soil conditions, and advise on their potential for re-use. The information collected will be used to support the preparation of the landscape design and a Landscape Specification for this site / soils.

5.1 Summary of Findings

From our investigation, the site contained significant reserves of undisturbed topsoil and subsoil. A total of 4 No. soil profiles were identified, comprising:

Soil Profile 1 - Agricultural Soil
Soil Profile 2 - Agricultural Soil (calcareous)
Soil Profile 3 - Parkland Soil
Soil Profile 4 - Woodland Soil

The depths of topsoil over the site were reasonably consistent (230 to 360mm) , with an overall site average of 275mm.

Soil Profile 1, Soil Profile 3 and Soil Profile 4

From our site survey and subsequent laboratory analysis, Soil Profile 1, Soil Profile 3 and Soil Profile 4 comprised a respective Topsoil type over Subsoil. The main characteristics of these soils are summarised below:

Topsoil 1
heavy clay loam to clay
blocky to cloddy structure
moderate to high stone contents with common large sized stones
slightly acid to slightly alkaline (non-calcareous)
moderately high levels of organic matter and all major nutrients
fertile with respect to habitat creation purposes

Topsoil 3 and Topsoil 4
medium clay loam
granular to subrounded blocky structures (Topsoil 3 compacted at 90-150mm bgl)
low to moderate stone contents
slightly acid to neutral (non-calcareous) - Topsoil 3
strongly acid (non-calcareous) – Topsoil 4
moderately high levels of organic matter and all major plant nutrients
fertile with respect to habitat creation purposes

Subsoil
clay to silty clay loam
blocky structures
low to moderate stone contents, including occasional large stones
alkaline to strongly alkaline (non-calcareous)
elevated levels of organic matter
infertile to *intermediate* with respect to habitat creation purposes)

Soil Profile 2

From our site survey and subsequent laboratory analysis, *Soil Profile 2* comprised Topsoil 2 over Calcareous Subsoil and Chalk

Topsoil 2	**Calcareous Subsoil**
calcareous clay	calcareous clay
granular to blocky structure	blocky structure
low to moderate stone contents	low to moderate stone contents
strongly alkaline (high carbonate content)	strongly alkaline (high carbonate content)
moderately high levels of organic matter and all major plant nutrients	moderately high levels of organic matter and total nitrogen
Fertile with respect to habitat creation purposes	*infertile* with respect to habitat creation purposes

5.2 Re-use of the Site Soils and Outline Recommendations

The soils encountered varied in terms of their physical composition in terms of soil texture, carbonate content, pH value and stone contents. The condition of the topsoils also varied, with Topsoil 1 and Topsoil 3 displaying structural degradation (compaction). The fertility status of the topsoil was moderate to moderately high and there are no apparent deficiencies which would warrant amendment. The topsoils were '*fertile*' with respect to species-rich habitat creation and the subsoils were of '*infertile'* to '*intermediate'* fertility status with respect to habitat creation purposes.

The following sections consider the potential to re-use each of the soils identified for the proposed landscape purposes. The moisture retentive nature of Soil Profile 1, Soil Profile 3 and Soil Profile 4 limits the potential to re-use these soil types to non-demanding, hardy species and planting types.

The development strategy to retain the majority of the topsoils will assist the management of these soils and help to preserve their physical condition to maximise their potential for re-use. For all future uses, it is important that following all landscape construction activities, soil preparation, planting and seeding works that all soils are left in an uncompacted condition with adequate soil structures.

Certain landscape types may benefit from a routine fertiliser application at planting or seeding to aid plant establishment. In this instance a slow release, compound type fertiliser could be applied at a moderate rate at planting to aid establishment. There would be no need for further amelioration (e.g. with compost or lime) for general landscape purposes. Fertiliser should not be applied to locations to be used for species-rich habitat establishment.

The site soils are all vulnerable to physical degradation (compaction) by intense uses, resulting in a loss of soil aeration and reduced infiltration and drainage and therefore would not be suitable for amenity grass which is expected to support high rates of foot traffic.

Soil Profile 1

Soil Profile 1 is characterised by its heavy soil textures (non-calcareous) with restricted permeability (drainage) characteristics and high stone contents (subrounded to angular flints) including *large stones* up to 140mm in size.

In their current condition, these soils would be described as 'Imperfectly Drained' and prone to seasonal waterlogging through the year.

This type of topsoil has inherent physical properties (e.g. low sand content, clayey nature, moisture retentive, with reduced aeration and drainage performances) which can make it particularly problematic for demanding landscape construction purposes. Topsoil 1 often displayed reduced structural development and compaction as a result of current agricultural practices. Unless rectified, damage to soil structure in clay soils typically results in a loss of drainage and aeration, and subsequent adverse growing conditions, including extended periods of waterlogging, inadequate aeration (oxygen depletion) and can lead to plant stress and an increased risk of failures. As such, it would be sensible to improve the physical condition of this soil by appropriate cultivation prior to planting and seeding.

Additional specific problems envisaged with the use of this type of topsoil could include limited responses to tillage following degradation and a need for multiple cultivations to prepare a suitable tilth. This soil type can be subject to extensive surface cracking.

The moderately high to high stone contents recorded within Soil Profile 1 can be problematic for landscape purposes. For seeding purposes, specific action(s) would be warranted to reduce the overall stone content to a suitable level and to remove medium to large stones from the surface (and near surface) soil horizon as part of seed bed preparation.

Soil Profile 1 would be best suited to non-demanding landscape environments only, including native woodland and hedgerow planting, amenity grass establishment (low foot traffic areas) provided the soils are suitably prepared for planting/seeding (including stone treatment) and the plants selected are tolerant of heavy, moisture retentive soils. Species selected should have a broad pH tolerance.

It may be possible to increase the re-use potential of these soils (e.g. shrub planting) providing its physical condition is at its optimum and by improving the overall functioning of the soil profile (see section 5.3).

Soil Profile 2

Soil Profile 2 is characterised by its calcareous nature, relatively shallow soil depth over fractured chalk (310/420mm). In its current condition, this soil should be free draining and, as such, is unlikely to become waterlogged for prolonged periods after rainfall. Following disturbance (e.g. topsoil stripping), this topsoil type may demonstrate reduced drainage characteristics in the short term, until its physical condition has been restored.

Based on our findings, Soil Profile 2 is anticipated to provide adequate drainage for demanding planting types such as tree and shrub planting, however the soils at this location are strongly alkaline and highly calcareous and this must be factored into planting selections made for this soil profile. Furthermore, the moderately shallow soil depth observed at Soil Profile 2 (<500mm topsoil/subsoil over fractured chalk) may be a limiting factor for certain species demanding on their root morphology. Soil Profile 2 is not appropriate for landscape types which prefer or demand moisture retentive and/or non-calcareous soils.

Soil Profile 3 and Soil Profile 4

Soil Profile 3 and Soil Profile 4 are characterised by its medium soil textures.

In its current condition Soil Profile 3 and Soil Profile 4 would be described as 'Moderately Well Drained' to 'Imperfectly Drained' and, as such, the topsoils may be subject to seasonal waterlogging during the wettest periods of the year.

Provided these soils remain undisturbed they should provide the required cultural conditions for a wide range of landscape types, including tree and shrub planting, native woodland and hedges and amenity grass establishment (low foot traffic areas) provided species selected are tolerant of moisture retentive soils. Species selected should have a broad pH tolerance and Soil Profile 4 may be suitable for species which prefer or demand strongly acid soils.

Subsoil Organic Matter Contents

The organic matter contents of the subsoil samples (3.0 – 5.7%) were higher than that typically observed in subsoil material (<2%). In this instance, this is likely to be associated with a diffuse boundary between the topsoil and subsoil. Following excavation and reinstatement, the presence of organic matter within subsoil at higher levels may lead to the formation of anaerobic conditions. In this instance, no evidence of anaerobism was observed in these subsoils during our examinations. At present the structure is adequate to allow sufficient drainage of water and gaseous exchange to allow the oxygen demand on the soil to be met. Particular care and good soil management practices should be taken to maintain the physical condition of these subsoils.

Tree Pits for Semi-Mature Trees

Topsoil 2, Topsoil 3 and Topsoil 4 may be suitable for tree planting provided its physical condition is maintained. Alternatively for tree planting within Soil Profile 1 the upper portion of the tree pits should be back-filled with a suitable imported, fertile, free draining sandy topsoil.

Where tree pits for semi-mature trees are to be constructed in areas of *Soil Profile 1, Soil Profile 3* or *Soil Profile 4,* it would be important that appropriate modifications are incorporated into their design so that they do not act as sumps for surface draining water. The level of modification required would depend on the extent of any disturbance and degradation caused to the soil structures and the level of soakage following landscape construction. For any locations subject to significant disturbance, consideration should be given to the provision of an appropriate gravel soakaway layer at the base of the tree pits.

The subsoil will be prone to self-compaction if placed below the weight of a tree root ball and so these subsoils are not considered suitable for use as backfill in tree pits for semi-mature trees. It is recommended that an appropriate free-draining sand or sandy subsoil is used as subsoil in all tree pits. Topsoil 'mounding' should also be considered in order to improve soil aeration and exposure of the rootball to waterlogging.

The drainage properties of Soil Profile 2 would suit species which prefer or demand free draining soils, however this soil profile may not be ideally suited to planting semi-mature trees due to its moderately shallow soil depth.

Species-rich Wildflower Grasslands

The site topsoils all have a low potential for species-rich wildflower grassland establishment due to their elevated fertility status and existing weed seed bank, and, as such, would be expected to be particularly prone to colonisation by aggressive species and grasses. If desired, it would be possible to re-use the site subsoil (all soil profiles) for species-rich grassland. The balance of organic matter and nutrients is acceptable for this purpose and should not require amelioration to improve fertility, to encourage effective establishment.

The non-calcareous character of the subsoil found at Soil Profile 1 and Soil Profile 3, makes it suitable for a wide range of species-rich wildflower grasslands, provided the seed mix(es) selected have a broad pH range. The subsoil at Soil Profile 2 is strongly alkaline and highly calcareous and would be ideal for the establishment of a *calcareous* grassland type habitat.

There are various methods by which subsoil can relocated at the surface of a soil profile, including:

1. Removal of the overlying topsoil to expose the subsoil;
2. Respread subsoil arisings generated from elsewhere on the site over the topsoil.
3. Inversion of the soil profile to bury the topsoil and leave the subsoil at the surface;

Option 1 and option 2 may be conducted using non-specialist earthworks machinery (e.g. excavator / dozer / dump truck), whereas option 3 would require specialist equipment to effect a suitable soil inversion. Once the surface subsoil layer has been achieved, the soil would need to be cultivated to a suitable tilth and prepared for seeding.

Summary of Soil Suitability

The suitability of the site soils for re-use for landscape purposes and habitat creation are summarised in the table below:

Landscape Type	*Topsoil 1*	*Topsoil 2*	*Topsoil 3*	*Topsoil 4*	*Subsoil (as Subsoil)*	*Subsoil (as Infertile Topsoil)*
Semi-mature tree planting	X	O^	O	O*	O^{s}	NA
Native woodland	✓	✓^	✓	✓*	✓	NA
Native hedges	✓	✓^	✓	✓*	✓	NA
Shrub beds	O	✓^	✓	✓*	✓	NA
Amenity grass (low foot traffic)	✓	✓^	✓	✓*	✓	NA
Amenity grass (Intense foot traffic)	X	X	X	X	$✓^{d}$	NA
Species-rich wildflower grassland	X	X	X	X	✓	✓

✓ Suitable for this purpose provided the physical condition of the soil is adequate at planting / seeding and species selected are tolerant of moisture retentive soils (with the exception of calcareous subsoils) and have a broad pH tolerance.

O Possibly suitable for this purpose provided the physical condition of the soil is at its optimum. Species selected must be tolerant of moisture retentive soils. Improvement to aeration and drainage functions of the soil profile may also be necessary.

✓^ Suitable for this purpose provided the physical condition of the soil is adequate at planting / seeding and species selected are suited to strongly alkaline, chalky soils with a shallow total soil depth.

O^ Not ideally suited to this purpose due to moderately shallow total soil depth (over chalk). Species selected must be tolerant of strongly alkaline, chalky soils.

✓* Suitable for this purpose provided the physical condition of the soil is adequate at planting / seeding and species selected are suited to strongly acid soils.

O* Possibly suitable for this purpose provided the physical condition of the soil is at its optimum. Species selected must be tolerant of strongly acid soils.

O^{s} Potentially suitable for this purpose, provided the physical condition of the subsoil is maintained and used in conjunction with a shallow layer of sand to support the rootball. Species selected must tolerant of moisture retentive soils, with the exception of calcareous subsoils.

X Not suitable for this purpose due to inappropriate drainage characteristics or fertility status.

NA Not applicable to this purpose.

$✓^{d}$ May be acceptable for this purpose provided assistance is given to the drainage properties (e.g. by installation of an artificial drainage system).

5.3 Improvement options for poorly draining soils

The restricted drainage properties of the site subsoil will limit the re-use potential of Soil Profile 1, Soil Profile 3 and Soil Profile 4 to the more hardy planting types only. Any damage caused to the soils during landscape works and any intense handling is likely to reduce its quality. For more demanding purposes, such as tree and shrub planting, it would be necessary to improve the physical aspects of these soils in order to broaden their re-use potential, including:

Installation of artificial drainage. Drainage may be installed at key locations or specifically for particularly vulnerable planting types. The type, design and depth of the drainage should be suitable to the proposed application. Drainage can be expensive and is reliant on the availability of a suitable outfall / discharge point.

Localised mounding of topsoil. The topsoil may be mounded locally for vulnerable species. This effectively 'lifts' the plants, and reduces the risk of harm from waterlogging and improves aeration within the rooting zone. This approach can be extremely cost effective and is not reliant on an outfall. Mounding can be done on an individual tree basis or larger mounds provided for clusters of trees.

Species-selection. There may be scope to revise the species selection and stock sizes for this landscape scheme to those which are tolerant of heavy moisture retentive soils.

It is likely that a combination of the measures above would be needed to ensure suitable soil conditions are provided for successful landscape construction on this site.

It is likely that tree pits and shrub beds within this area will require positive drainage, or at least a soakaway, to remove accumulating water from low points and prevent the tree pits from acting as sumps.

5.4 Soil Structure & Physical Degradation

It is essential to provide a structured, uncompacted topsoil for the successful establishment and subsequent growth of plants and grass. Adequate soil structure is a key element for healthy plant growth to ensure aeration and drainage within the rooting zone.

Topsoil 1 typically displayed damage to its structure and a sub-surface compaction pan was encountered at Topsoil 3 (90/120mm below ground level). The compaction damage identified is likely to reduce the drainage rate and aeration of these topsoils. In this situation, the larger (air containing) soil pores are destroyed and replaced by smaller (water retentive) pores. This will restrict gaseous exchange with the atmosphere and cause the topsoil to become anaerobic (oxygen depleted). In addition, the lack of larger pores prevents effective drainage and results in an increased risk of waterlogging. Waterlogged and anaerobic conditions, if they persist, can be severely detrimental to plants and therefore, the physical condition of these soils should be improved as part of the soil preparation works at these locations.

Landscape construction and soil preparation works themselves can be damaging to the structures of heavy, clay based soil such as these, therefore all soil handling operations should ideally be programmed for periods when the soils are friable and non-plastic in consistency.

We would like to thank Capita Property and Infrastructure Limited for entrusting our practice with this commission. We trust this report meets with your approval and provides the necessary information. Please do not hesitate to contact the undersigned if we can be of further assistance.

Tim White
BSc MSc MISoilSci CSci
Senior Associate

For and on behalf of Tim O'Hare Associates LLP

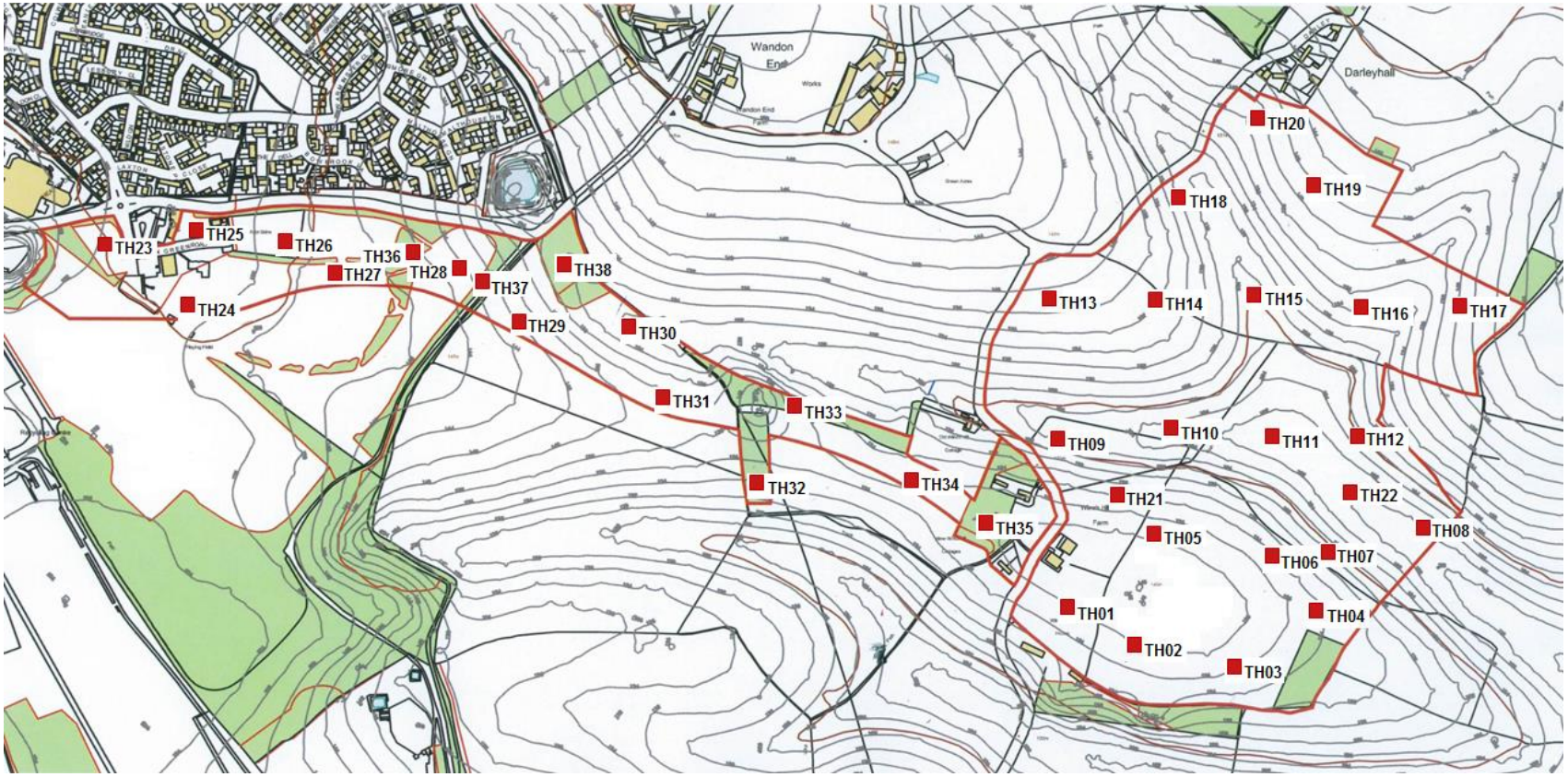
Report Qualifications

Our interpretation of the soil conditions is based on observations made during our site investigation and the results of laboratory tests. This report presents our site observations and test results and our interpretation of those observations and results. On any site there may be variations in soil conditions between these exploratory positions. We can therefore not accept any responsibility for soil conditions that have not been exposed by this investigation.

This investigation considers the re-use of the soils for landscaping works within the Land at Luton Airport site. It should not therefore be relied on for alternative end-uses or for other schemes. This report has been prepared solely for the benefit of our client Capita Property and Infrastructure Limited. No warranty is provided to any third party and no responsibility or liability will be accepted for any loss or damage in the event that this report is relied upon by a third party or is used in circumstances for which it was not originally intended.

Appendix 1

Site Plan Showing
Trial Hole Locations



THx

Approximate Trial Hole location

Site Boundary

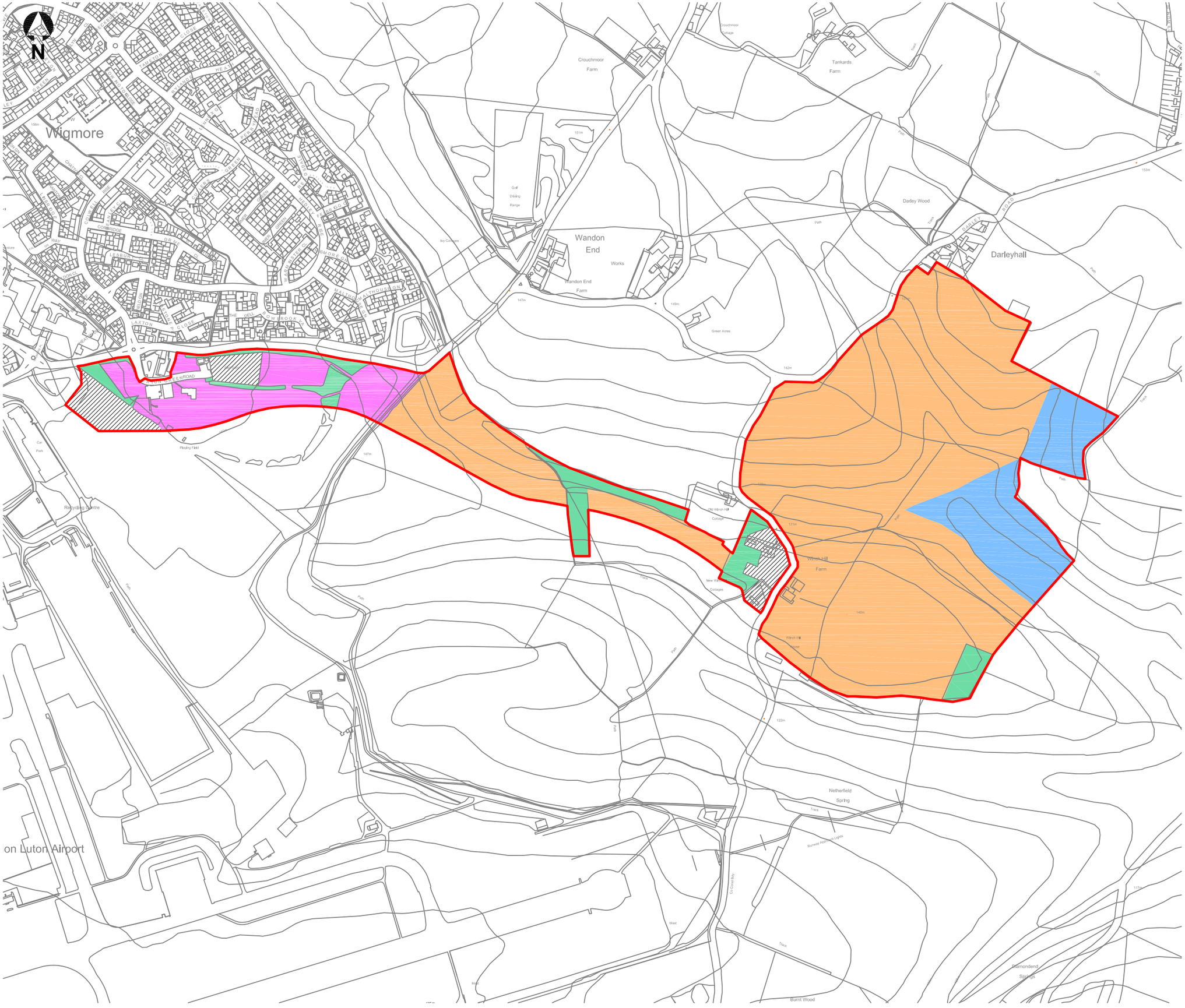
TIM O'HARE ASSOCIATES
SOIL & LANDSCAPE CONSULTANCY

Client:	Capita Property and Infrastructure Limited		
Project:	Land at Luton Airport		
Job ref no.:	TOHA/16/3007/TW		
Drawing no.:	3007/1		
Drawing title	Soil Resource Survey		
Date:	June '16	Scale:	NTS
Drawn by:	RH	Checked by:	TW

Tim O'Hare Associates LLP
Howbery Park Wallingford Oxfordshire OX10 8BA
T: 01491 822653 E:info@toha.co.uk
www.toha.co.uk

Appendix 2

Site Plan Showing Distribution of Soil Profile Types



LEGEND

- Soil Type 1 (Agricultural Soils)
- Soil Type 2 Agricultural Soils (Calcareous)
- Soil Type 3 (Parkland Soils)
- Soil Type 4 (Woodland Soils)
- Not surveyed

Revision	Date	Notes
-	-	-

Client	Capita Property and Infrastructure Limited
Site	Land at Luton Airport
Drawing Title	Soil Map
Job ref.	TOHA/16/3007/TW
Drawing No.	3007/2
Scale	NTS @ A3
Date	June 2016

TIM O'HARE ASSOCIATES
SOIL & LANDSCAPE CONSULTANCY

Tim O'Hare Associates LLP
Howbery Park, Wallingford,
Oxfordshire OX10 8BA
Tel: +44 (0)1491 822653
Fax: +44 (0)1491 822644
E-mail: info@toha.co.uk

Appendix 3

Laboratory Analysis Results

Topsoils

TIM O'HARE ASSOCIATES
SOIL & LANDSCAPE CONSULTANCY

Client:	**Capita Property and Infrastructure Limited**
Project:	**Land at Luton Airport**
Job:	**Topsoil and Subsoil Analysis**
Date:	**June 2016**
Job Ref No:	**TOHA/16/3007/TW**

Sample Reference			**TH1**	**TH2**	**TH4**	**TH6**	**TH8**	**TH10**	**TH20**
Soil Type			**Topsoil 1**	**Topsoil 1**	**Topsoil 1**	**Topsoil 1**	**Topsoil 2**	**Topsoil 1**	**Topsoil 1**
Development Area			**Country Park**	**Country Park**	**Country Park**	**Country Park**	**Country Park**	**Country Park**	**Country Park**
Land Use			**Agriculture**	**Agriculture**	**Agriculture**	**Agriculture**	**Agriculture**	**Agriculture**	**Agriculture**
		Accreditation							
Clay (<0.002mm)	%	UKAS	36	34	42	38	48	40	39
Silt (0.002-0.063mm)	%	UKAS	41	41	38	43	34	42	41
Sand (0.063-2.00mm)	%	UKAS	23	25	20	19	18	18	20
Texture Class (UK Classification)	--	UKAS	C	HCL	C	C	C	C	C
Stones (2-20mm)	% DW	GLP	5	3	6	6	5	6	8
Stones (20-50mm)	% DW	GLP	8	13	6	7	6	5	5
Stones (>50mm)	% DW	GLP	13	30	10	13	5	14	8
pH Value (1:2.5 water extract)	units	UKAS	6.4	6.0	7.1	7.4	8.2	7.8	7.5
Electrical Conductivity (1:2.5 water extract)	uS/cm	UKAS	84	62	119	141	178	213	130
Electrical Conductivity (1:2 $CaSO_4$ extract)	uS/cm	UKAS	1990	1980	1919	1980	2001	2010	1960
Exchangeable Sodium Percentage	%	UKAS	0.2	0.2	0.2	0.2	0.2	0.2	0.4
Organic Matter (LOI)	%	UKAS	8.6	6.6	6.9	6.5	4.8	6.8	6.6
Total Nitrogen (Dumas)	%	UKAS	0.42	0.29	0.30	0.26	0.22	0.31	0.27
C : N Ratio	ratio	UKAS	12	13	13	15	13	13	14
Extractable Phosphorus	mg/l	UKAS	48	45	54	24	34	48	18
Extractable Potassium	mg/l	UKAS	271	301	216	160	77	143	126
Extractable Magnesium	mg/l	UKAS	143	214	116	81	30	103	81

HCL = HEAVY CLAY LOAM
C = CLAY

Results of analysis should be read in conjunction with the report they were issued with

TIM O'HARE ASSOCIATES
SOIL & LANDSCAPE CONSULTANCY

Client:	**Capita Property and Infrastructure Limited**
Project:	**Land at Luton Airport**
Job:	**Topsoil and Subsoil Analysis**
Date:	**June 2016**
Job Ref No:	**TOHA/16/3007/TW**

Sample Reference			**TH21**	**TH19**	**TH24**	**TH29**	**TH32**	**TH33**	**TH37**
Soil Type			**Topsoil 1**	**Topsoil 1**	**Topsoil 3**	**Topsoil 1**	**Topsoil 4**	**Topsoil 4**	**Topsoil 3**
Development Area			**Country Park**	**Country Park**	**Wigmore Park**	**Access Corridor**	**Access Corridor**	**Access Corridor**	**Acess Corridor**
Land Use			**Agriculture**	**Agriculture**	**Park**	**Agriculture**	**Woodland**	**Woodland**	**Park**
		Accreditation							
Clay (<0.002mm)	%	UKAS	36	41	27	30	26	21	22
Silt (0.002-0.063mm)	%	UKAS	44	44	47	42	36	36	37
Sand (0.063-2.00mm)	%	UKAS	20	15	26	28	38	43	41
Texture Class (UK Classification)	--	UKAS	C	C	MCL	CL	MCL	MCL	MCL
Stones (2-20mm)	% DW	GLP	4	6	8	5	6	6	6
Stones (20-50mm)	% DW	GLP	8	12	6	5	8	12	15
Stones (>50mm)	% DW	GLP	12	25	0	16	13	11	25
pH Value (1:2.5 water extract)	units	UKAS	7.1	7.8	6.7	7.0	4.3	4.6	6.7
Electrical Conductivity (1:2.5 water extract)	uS/cm	UKAS	157	220	84	61	235	108	131
Electrical Conductivity (1:2 $CaSO_4$ extract)	uS/cm	UKAS	2013	2035	1950	1960	2018	1998	1990
Exchangeable Sodium Percentage	%	UKAS	0.2	0.4	0.7	0.3	1.5	3.4	0.8
Organic Matter (LOI)	%	UKAS	8.5	6.3	7.0	5.3	9.3	7.9	4.3
Total Nitrogen (Dumas)	%	UKAS	0.41	0.28	0.31	0.22	0.38	0.26	0.14
C : N Ratio	ratio	UKAS	12	13	13	14	14	18	18
Extractable Phosphorus	mg/l	UKAS	42	35	17	23	49	21	19
Extractable Potassium	mg/l	UKAS	180	147	129	113	110	82	113
Extractable Magnesium	mg/l	UKAS	115	59	82	46	157	89	74

MCL = MEDIUM CLAY LOAM
C = CLAY

Results of analysis should be read in conjunction with the report they were issued with

Appendix 4

Laboratory Analysis Results

Subsoils

TIM O'HARE ASSOCIATES
SOIL & LANDSCAPE CONSULTANCY

Client:	**Capita Property and Infrastructure Limited**
Project:	**Land at Luton Airport**
Job:	**Topsoil and Subsoil Analysis**
Date:	**June 2016**
Job Ref No:	**TOHA/16/3007/TW**

Sample Reference			**TH1**	**TH7**	**TH19**	**TH22**	**TH27**
Soil Type			**Subsoil**	**Subsoil**	**Subsoil**	**Calc' Subsoil**	**Subsoil**
Development Area			**Country Park**	**Country Park**	**Country Park**	**Country Park**	**Wigmore Park**
Land Use			**Agriculture**	**Agriculture**	**Agriculture**	**Agriculture**	**Park**
		Accreditation					
Clay (<0.002mm)	%	UKAS	49	31	49	31	36
Silt (0.002-0.063mm)	%	UKAS	40	49	36	38	49
Sand (0.063-2.00mm)	%	UKAS	11	20	15	31	15
Texture Class (UK Classification)	--	UKAS	C	ZCL	C	C	C
Stones (2-20mm)	% DW	GLP	4	4	2	2	2
Stones (20-50mm)	% DW	GLP	2	0	1	0	1
Stones (>50mm)	% DW	GLP	2	0	0	0	0
pH Value (1:2.5 water extract)	units	UKAS	7.7	8.1	7.7	8.2	7.8
Electrical Conductivity (1:2.5 water extract)	uS/cm	UKAS	140	117	130	77	173
Organic Matter (LOI)	%	UKAS	5.7	3.0	4.4	4.1	4.4
Extractable Phosphorus	mg/l	UKAS	8	13	16	8	17
Extractable Potassium	mg/l	UKAS	186	48	147	121	135
Extractable Magnesium	mg/l	UKAS	180	22	49	85	47

ZCL = SILTY CLAY LOAM
C = CLAY

Results of analysis should be read in conjunction with the report they were issued with