APPENDIX D

VERIFICATION PLAN FOR GARDEN SOILS

Generic Verification Plan for Subsoil and Topsoil to be Used in Cover Layers

INTRODUCTION

The placement of clean topsoil and subsoil is often required on former brownfield sites where Made Ground is found, and the concentrations of certain compounds exceed designated appropriate levels. On greenfield sites, topsoil is frequently stripped off and stockpiled at the beginning of construction, being replaced during the final stages. In some cases, validation of the 'replacement' of this material is required. Frequently, verification for the placement of 'clean' material is requested by the Local Authority and NHBC.

This document outlines the steps involved in determining the suitability of various materials for use as a subsoil and topsoil and outlines the proposed testing schedule and suites involved in ensuring an appropriate material is used. It also outlines the requirements for gathering data/evidence to demonstrate that the soil meets the necessary criteria. This includes the requirements for monitoring, sampling and testing and outlines what is required in the way of field records, surveys and laboratory testing.

This Verification Plan specifically relates to the requirements for a residential site, where private gardens and landscaping are proposed and where there is a potential for the consumption of produce raised on this land.

This document should form part of a series of documents, which would include a remediation strategy, to address the design of the proposed cover layer, and a material management plan that documents how the materials are to be excavated and dealt with on-site.

ORIGIN OF MATERIAL

The ultimate aim is for a sustainable and cost-effective solution, which where possible should be achieved by making use of site won material. This could be achieved either through the re-use of existing suitable topsoil and subsoil or via improvement of existing material to generate a suitable material e.g. through the re-use of suitable materials from construction activities e.g. sand/clay from service trenches, gravel/sand from foundation trenches, organic rich strata, etc. All manufactured/improved soil should achieve the same criteria as that outlined below for imported topsoil to ensure it is suitable to support plant growth.

Prior to re-use of such material on-site is it usually necessary to produce a Material Management Plan (ref CL:AIRE Definition of Waste CoP) to ensure that the materials to be re-used are not classified as waste and that re-use is lawful. In addition careful handling and processing of this material will be required to ensure it is suitable for re-use and remains suitable for use in the proposed development.

Imported – When it is not possible to re-use on-site materials, is will be necessary to source topsoil from off-site. It is important that an appropriate material is acquired and it is suitable for the intended purpose. There are three main types of topsoil available.

- NATURAL TOPSOIL – originates from greenfield sites and sometimes undisturbed and uncontaminated brownfield sites.
- MANUFACTURED SOIL – this is a soil that is formed when two or more components are mixed e.g. sand and natural topsoil, or subsoil with green compost.
- SKIP WASTE SOIL – this is often the 'fines' element generated from the processing of 'skip waste'. This can be referred to as 'general purpose topsoil' or 'turfing soil' or 'screened topsoil'. This material typically has very variable content and will contain numerous building

waste materials e.g. brick, concrete, ash, clinker, glass, plastic, etc. The material is typically unsuitable for use and may contain elevated levels of chemical contaminants.

The remainder of this document will focus on the use and validation of imported natural topsoil or manufactured soil. Skip waste soil is not discussed further as typically the presence of construction wastes, and the required frequency of testing to ensure compliance would mean re-use of this material is not usually economic or practicable.

HARD TO DIG LAYERS

On occasion, a cover layer will include a hard to dig layer or capillary break layer. This is designed to prevent the intermixing of soils and the upward movement of dissolved or mobile contaminants. This may be composed of either natural aggregate or recycled materials often with geo-membrane separators. Testing and validation of this material is also important particularly where it is to remain close to surface. Should recycled aggregate be sourced from off-site, it would be advisable to check it complies with the WRAP Recycled Aggregate Quality Protocol prior to purchase.

SUITABILITY OF IMPORTED SOIL

All imported topsoil/subsoil will be assessed against a specification to ensure that a soil is suitable for its intended purpose. This will include:

- Visual examination – soil structure, consistency, foreign matter, etc.
- Particle size analysis (texture) and stone content
- pH and salinity values.
- Content of major plant nutrients
- Organic Matter content
- Maximum levels of potential contaminants (e.g. heavy meals, hydrocarbons, cyanide, phenols, etc.).

All imported subsoil and topsoil will generally comply with the specification outlined in BS8601:2013 and BS3882:2007 respectively.

The following table is taken from BS8601:2013 for subsoil for reference. Compliance with this specification will ensure that the material poses the correct characteristics to support plant growth.

Table 1 **Subsoil characteristics**

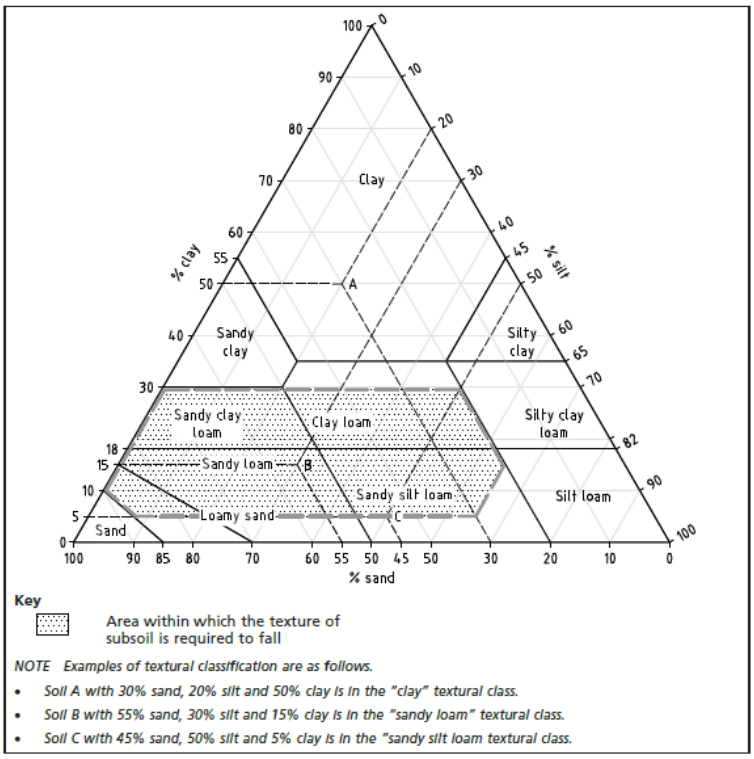
Parameter	Multipurpose subsoil	Specific purpose subsoil		Method of test
		Acidic	Calcareous	
Soil texture <2 mm fraction % *m/m*	See area of permitted soil textural classes in Figure 1			BS ISO 11277:2009
Mass loss on ignition	Maximum 2%			Annex B
Maximum coarse fragment content % *m/m* (see 3.9)				BS ISO 11277:2009
>2 mm	40			1 kg sample minimum
>20 mm	20			
>75 mm	0			
Soil pH (measured in water)	5.5 to 8.5	3.5 to 5.5	7.5 to 8.5	BS ISO 10390:2005
Carbonate % *m/m*	—	—	>1	Annex C
Exchangeable sodium percentage (ESP) % Need not measure if soil electrical conductivity <2 800 µS·cm^{-1}	<15			Annex D, Annex E and Annex F
Electrical conductivity [A), B)]	Value to be measured and recorded (see ESP)			Annex F
Potentially phytotoxic elements (by soil pH) (mg/kg dry solids)	**Multipurpose and specific purpose subsoils**			BS ISO 16729:2013
	Soil pH <6.0	**Soil pH 6.0 to 7.0**	**Soil pH >7.0**	
Zn (Nitric acid extractable)	<200	<200	<300	
Cu (Nitric acid extractable)	<100	<135	<200	
Ni (Nitric acid extractable)	<60	<75	<110	
Other contaminants % *m/m* (air-dried soil)				Annex G
>2 mm	<0.5			
of which plastics	<0.25			
sharps	zero in 1 kg air-dried soil			

[A)] The electrical conductivity is related to the concentration of soluble ionic constituents, particularly ammonium, calcium, chloride, magnesium, nitrate, phosphate, potassium, sodium and sulfate. A discussion of the importance of soil electrical conductivity, soil salinity and ESP is given in Annex H.

[B)] A high soil electrical conductivity might indicate a detrimentally high level of salinity.

BS 8601:2013 **BRITISH STANDARD**

Figure 1 **Textural classification (limiting percentages of sand, silt and clay sized particles for the mineral texture class) and the area of textures that are acceptable within BS 8601:2013**



Key

Area within which the texture of subsoil is required to fall

NOTE Examples of textural classification are as follows.

- *Soil A with 30% sand, 20% silt and 50% clay is in the "clay" textural class.*
- *Soil B with 55% sand, 30% silt and 15% clay is in the "sandy loam" textural class.*
- *Soil C with 45% sand, 50% silt and 5% clay is in the "sandy silt loam textural class.*

BS3882:2007 provides a specification of testing to generate a multipurpose topsoil suitable for most situations where topsoil is required.

Table 1 **Topsoil characteristics**

Parameter	Multipurpose topsoil	Specific purpose			Method of test
		Acidic	Low fertility	Calcareous	
Soil texture % *m/m*					BS 7755-5.4:1998
Clay content %			5–35		
Silt content %			0–65		
Sand content %			30–85		
Soil organic matter content % *m/m* (see **3.7** and Note 1)					Modified Walkley Black [1]
Clay 5–20%	3–20	3–30	1–10	3–30	
Clay 20–35%	5–20	3–30	1–10	5–30	
Maximum coarse fragment content % *m/m*					BS 7755-5.4:1998
>2 mm			0–30		
>20 mm			0–10		
>50 mm			0		
pH H_2O	5.5–8.5	3.5–5.5	3.5–9.0	7.5–9.0	BS ISO 10390:2005
Carbonate % *m/m*	–	–	–	>1	BS 7755-3.10:1995
Available plant nutrient content					
Nitrogen % *m/m*	⩾0.15	⩾0.15	<0.1	⩾0.15	BS 7755-3.7:1995
Extractable phosphorus mg/l	16–100	16–100	<15	16–100	See Annex A
Extractable potassium mg/l	121–900	121–900	<120	121–900	See Annex A
Extractable magnesium mg/l	51–600	51–600	<600	51–600	See Annex B
Carbon:Nitrogen ratio			<20:1		Modified Walkley Black [1] and BS 7755-3.7:1995
Exchangeable sodium percentage % Need not measure if soil electrical conductivity <2 800 µS cm^{-1}			<15		Annex C Annex B
Chemical contaminants (Human health and the environment) (See Notes 2 and 3)	Concentrations of contaminants (Notes 2, 3 and 4) shall not present excessive risk to human health or the environment (see Note 4)				
Phytotoxic contaminants (by soil pH) (mg/kgDS) (Note 3)	**Multipurpose and specific purpose topsoils**				
Soil pH range	**<6.0**	**6.0–7.0**		**>7**	
Zn (Nitric acid extractable)	<200	<200		<300	See Annex D
Cu (Nitric acid extractable)	<100	<135		<200	
Ni (Nitric acid extractable)	<60	<75		<110	
Visible contaminants % *m/m*					
>2 mm			<0.5		PAS 100:2005, procedure **E6.2**
…of which plastics			<0.25		
…sharps			zero in 1 kg air-dried soil		

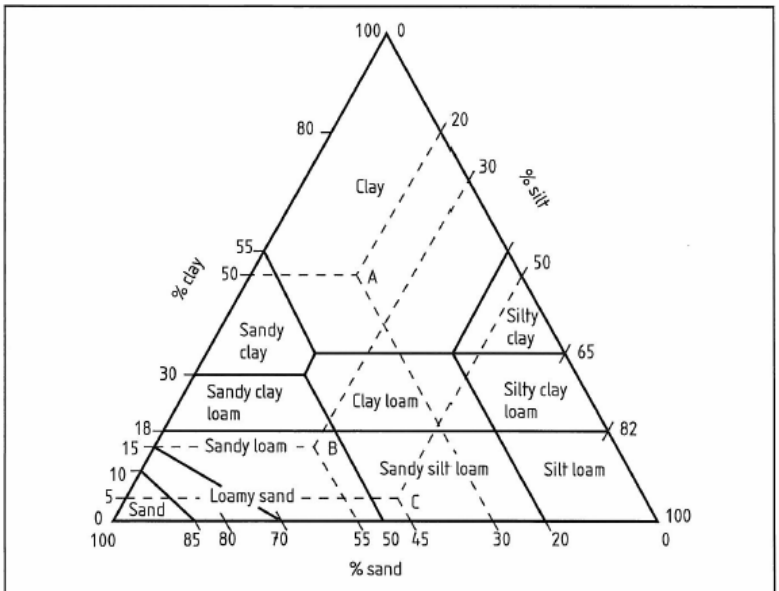
NOTE 1 For more demanding landscaping applications (e.g. ornamental shrub planting, rootballed trees), minimum soil organic matter contents 1% greater than the minima shown might be beneficial.

NOTE 2 The list of contaminants to be analysed should be based on the history of the source(s) of materials that make up the topsoil, and the intended use of the site(s) where the topsoil is to be used. The concentrations of concern depend on the end use of the topsoil. Where this information is not available, appropriate conservative assumptions should be made. The CLEA model might be a useful guide [2].

NOTE 3 The lower of the two values for chemical contaminants and phytotoxic contaminants is to be used.

NOTE 4 Attention is drawn to the need for the concentrations of contaminants not to exceed those permitted by UK legislation (current at the time when the topsoil is supplied).

Figure 1 **Textural classification (limiting percentage of sand, silt and clay sized particles for the mineral texture class)**



NOTE Examples of textural classification:

Soil A with 30% sand, 20% silt and 50% clay is in the "clay" textural class;

Soil B with 55% sand, 30% silt and 15% clay is in the "sandy loam" textural class;

Soil C with 45% sand, 50% silt and 5% clay is in the "sandy silt loam" textural class.

It is important to note that the BS is not applicable to topsoil/subsoil that is to remain in-situ and should not preclude the use of a subsoil that is already on site and suitable for its intended purpose. The BS specification above relates only to subsoil/topsoil that is to be moved or traded and is intended to support plant growth.

In addition to the above, all imported topsoil/subsoil should also conform to the following criteria:-

- Have a max stone size of 75mm (based on BS sieve)
- Be clean and free of foreign debris, building waste materials or contaminants e.g. brick, glass, asbestos, plasterboard, etc.

Characterisation testing will be undertaken at a frequency of 1 per 250m^3 from composite samples, with a minimum of three samples, assuming the material is homogenous. Ideally all imported soil will be inspected and tested at source, prior to import.

CHEMICAL TESTING SUITES

All soils will be tested to ensure they are suitable for use in a residential setting. The frequency and suite of testing will be dependent on the origin of material. Testing will be undertaken on both the topsoil and subsoil.

Site Won	The chemical testing suite is to be tailored based on the historic site use. Reference will be made to historical maps and available Desk Study information to determine an appropriate suite.
Imported	Greenfield: Soil samples will be analysed for metals, PAH, pH, SOM and asbestos. Brownfield: similar to site won above, the suite of testing will be tailored based on the historic site use of the donor site. Desk study information to be referred to where possible.
Hard to Dig Layer	Crushed Stone – testing may not be required. Recycled Stone – tested for metals, pH, Asbestos, PAHs, TPH, etc
Manufactured	The chemical testing suite will strongly depend on the origin of the components. If quarried natural stone is used, then minimal testing will be required. If this is mixed with a manufactured compost, then further testing, beyond that provided with the compost will be required e.g. to include PAHs, hydrocarbons, asbestos etc. Care will be needed with manufactured topsoil if manufactured compost or soil conditioner is used, as the current recommended limits for zinc are 400mg/kg (see PAS 100:2011), however the BS for topsoil for zinc is 200mg/kg. Test results should be obtained from the compost supplier prior to use, however independent testing is advised.

COMPLIANCE CRITERIA

All material regardless of origin needs to be 'suitable for use'. Table 1 and Table 2 below provide compliance criteria based on the risk to human health. These will ensure the material is suitable for use in a residential setting and poses either 'minimal' or 'low' risk to human health from the presence of chemical contaminants.

Both imported and site won material should be assessed against those criteria in Tables 1, 2 and 3, however, the site won material does not need to comply with the BS for physical composition if it is currently in use as a topsoil on-site.

TABLE 1 – ACCEPTABLE CONCENTRATION OF INORGANICS BASED ON HUMAN HEALTH RISK ONLY

Determinand	Human Health Derived Compliance Criteria (mg/kg)	Comments
Arsenic	37	LQM S4UL, 2015
Boron	910	LQM S4UL, 2015
Beryllium	290	LQM S4UL, 2015
Cadmium	11	LQM S4UL, 2015
Chromium VI	6	LQM S4UL, 2015
Chromium III	910	LQM S4UL, 2015
Copper	2400	LQM S4UL, 2015
Lead	200	C4SL, 2014 (modified for 1% SOM)
Inorganic Mercury	40	LQM S4UL, 2015
Nickel	180	LQM S4UL, 2015
Vanadium	410	LQM S4UL, 2015
Selenium	250	LQM S4UL, 2015
Zinc	3700	LQM S4UL, 2015
Asbestos	<0.001%	Limit of Detection
pH	>6 <8	

Criteria based on 1% SOM, but inorganics unaffected by this parameter.

TABLE 2 - ACCEPTABLE CONCENTRATION OF ORGANICS BASED ON HUMAN HEALTH RISK ONLY

Determinand	Human Health Derived Compliance Criteria (mg/kg)			Comments.
	SOM			
	1%	2.5%	6%	
Benzene	0.087	0.17	0.37	LQM S4UL, 2015
Toluene	130	290	660	LQM S4UL, 2015
Ethylbenzene	47	110	260	LQM S4UL, 2015
Xylenes	56	130	310	LQM S4UL, 2015 (based on lowest of individual xylene value)
POLYAROMATIC HYDROCARBONS				
Naphthalene	2.3	5.6	13	LQM S4UL, 2015
Acenaphthylene	210	510	1100	LQM S4UL, 2015
Acenaphthene	170	420	920	LQM S4UL, 2015
Fluorene	170	400	860	LQM S4UL, 2015
Phenanthrene	95	220	440	LQM S4UL, 2015
Anthracene	2400	5400	6000**	LQM S4UL, 2015
Fluoranthene	280	560	890	LQM S4UL, 2015
Pyrene	620	1200	2000	LQM S4UL, 2015
Benzo(a)anthracene	*	*	*	C4SL, 2014 Benzo(a)pyrene assessment criteria has been developed on the basis that benzo(a)pyrene is a surrogate marker for genotoxic PAH, therefore soil concentrations for bap only to be compared to assessment criteria.
Chrysene	*	*	*	
Benzo(b)fluoranthene	*	*	*	
Benzo(k)fluoranthene	*	*	*	
Benzo(a)pyrene	5	5	5	
Dibenzo(ah)anthracene	*	*	*	
Indeno(123cd)pyrene	*	*	*	
Benzo(ghi)perylene	*	*	*	
TPH				
EC5-6Aliphatic	42	78	160	LQM S4UL, 2015
EC6-8 Aliphatic	100	230	530	LQM S4UL, 2015
EC8-10 Aliphatic	27	65	150	LQM S4UL, 2015
EC10-12 Aliphatic	130	330	760	LQM S4UL, 2015
EC12-16 Aliphatic	1100	2400	4300	LQM S4UL, 2015
EC16-35 Aliphatic	5000	5000	5000	**
EC35-44 Aliphatic	5000	5000	5000	**
EC5-7 Aromatic	70	140	300	LQM S4UL, 2015
EC7-8 Aromatic	130	290	660	LQM S4UL, 2015
EC8-10 Aromatic	5	83	190	LQM S4UL, 2015
EC10-12 Aromatic	74	180	380	LQM S4UL, 2015
EC12-16 Aromatic	140	330	660	LQM S4UL, 2015
EC16-21 Aromatic	260	540	930	LQM S4UL, 2015
EC21-35 Aromatic	1100	1500	1700	LQM S4UL, 2015
EC35-44 Aromatic	1100	1500	1700	LQM S4UL, 2015
Phenol	120	200	380	LQM S4UL, 2015
VOCs	Below Detection Limit of Test			Any values above detection to be assessed in more detail to determine suitability for end use. Ideally VOCs to be below detection.

Notes

1) Compliance criteria based on assessment criteria for the protection of human health in a residential setting assuming that home-grown vegetables are consumed.
2) * PAH is genotoxic.
3) ** S4UL value is 10,000 mg/kg. representing 1% contamination, therefore minimal human health risk even at high concentrations. Pragmatic remediation criteria based on visual, odour and aesthetic requirements.
4) Compliance criteria are derived using CLEA V.106 using published toxicological data and generic land use parameters.
5) LQM, 2015 values sourced from the LQM/CIEH Suitable (S4UL) 2015, see references.

6) Copyright Land Quality Management Limited reproduced with permission; Publication Number S4UL3467. All rights reserved."
7) C4SL, 2014 values sourced from DEFRA Research Project. Development of Category 4 Screening Levels for Assessment of Land Affected by Contamination. FINAL. SP1010. December 2013.

Compliance with human health criteria specified above on its own is not sufficient to ensure the material is suitable for import or re-use. The presence of compounds at these limit concentrations are potentially above Hazardous Waste thresholds, and clearly importing material classified as Hazardous Waste is not suitable for re-use in a cover layer. Therefore the following additional criteria are proposed, these are based on other considerations such as aesthetic quality, odour, waste management, phytotoxicity thresholds, etc.

TABLE 3 – ADDITIONAL COMPLIANCE CRITERIA

Determinand	Compliance Criteria (mg/kg)	Objective and Comments
Copper	100-200 (pH dependent)	This is only a guideline ideal range based on phytotoxicity. Analysis to be carried out in accordance with BS. Values above this should not preclude use of the material, however certain plants may not thrive in the presence of significantly elevated concentrations. Judgement decision to be made in individual cases.
Zinc	200-300 (pH dependent)	This is only a guideline ideal range based on phytotoxicity. Analysis to be carried out in accordance with BS. Values above this should not preclude use of the material, however certain plants may not thrive in the presence of significantly elevated concentrations. Judgement decision to be made in individual cases.
Nickel	60-110 (pH dependent)	This is only a guideline ideal range based on phytotoxicity. Analysis to be carried out in accordance with BS. Values above this should not preclude use of the material, however certain plants may not thrive in the presence of significantly elevated concentrations. Judgement decision to be made in individual cases.
Boron	10	This is a guideline value based on phytotoxicity and professional judgement. Values above this should not preclude use of the material, however certain plants may not thrive in the presence of significantly elevated concentrations. Judgement decision to be made in individual cases.
Cyanide (free)	0.5	Free cyanide represents the greatest risk through short term exposure. At this current time, there is no established methodology in the UK to determine the health risk from short term exposure to elevated free cyanide concentrations. In the absence of this, the detection limit is proposed as a compliance criterion. Further, more detailed assessment is possible should concentrations exceed this value.
Total PAH	100	Based on inert waste thresholds. This limit only applies to imported material, not to in-situ soil.
Total TPH	500	Based inert waste thresholds. This limit only applies to imported material, not to in-situ soil.

GENERAL FILL MATERIAL

If it is proposed to import material to use at depth, it will not necessarily need to comply with those criteria in the Tables above, which are derived based on the assumption that the material is to remain exposed at surface. Instead, the material will need to be assessed against compliance criteria generated for that site, based on risks to groundwater, adjacent receptors, buildings and waste limits, etc.

FREQUENCY OF TESTING FOR CONTAMINATION

If testing has already been undertaken as part of a Site Investigation that should be used in combination with additional testing to ensure that frequency of testing complies with that set out in Table below.

TABLE 4 – FREQUENCY OF TESTING OF STOCKPILES

Origin	Donor Site	Material	Frequency	Type and Location
Natural Soil	Greenfield	Topsoil	1 per 50m^3	Composite following stockpiling. Assuming material is homogenous. Minimum of three samples.
		Subsoil	1 per 100m^3	
	Brownfield	Topsoil	1 per 50m^3	Minimum of three samples.
		Subsoil	1 per 50m^3	Minimum of three samples.
Manufactured	-	Animal Compost	1 per 500m^3	
	-	Green Waste compost	1 per 100m^3	Frequent testing required due to origin of material.
Hard to Dig Layer	Brownfield	Recycled Aggregate	1 per 100m^3	
	Greenfield	Natural Stone	-	Testing may not be required.

TABLE 5 – SUGGESTED TESTING FREQUENCY FOR CHEMICAL ANALYSIS OF CAPPING MATERIAL OF UNKNOWN ORIGIN (TAKEN FROM NHBC TECHNICAL GUIDANCE NOV 2012).

Site size	Nominal sampling frequency (subject to minimum totals)	Suggested minimum total number of tests per site of each material used within the capping layer
1 to 5 plots	1 test per plot	3
6 to 10 plots	1 test per 2 plots	5
11 to 20 plots	1 test per 2 plots	5
21 to 30 plots	1 test per 3 plots	7
31 to 40 plots	1 test per 4 plots	10
Over 40 plots	1 test per 4 plots	10

Notes: if the cover system consists of both subsoil and topsoil both components require testing.

The frequency outlined above is a 'typical' frequency commonly requested. It is noted that each Local Authority may have their own requirements for verification and have published their own suggestions for frequency of testing, it is therefore recommended that the EHO is consulted and agreement reached with the Local Authority and or NHBC prior to testing.

PLACED THICKNESS VALIDATION

The placed thickness of soil will either be checked using a pre and post topographical surveys or hand dug pits following placement of materials. The frequency of hand dug pits will be around 1 per plot, depending on the size of the garden. Reference will be made to the NHBC Technical Guidance when deciding on frequency of validation and agreed with the NHBC in advance. Photographs will be taken of every pit, including a levelling staff to provide visual evidence of the validation. Photographs will include the following aspects where possible:-

- Proof that sufficient depth has been excavated
- Visual proof of the quality of the material to be used as inert cover
- Proof of the method of emplacement and different layers if appropriate
- Proof of the completed project.
- Inclusion of background features which will aid locating the photograph

SOIL VERIFICATION REPORT

On completion of any works, the findings will be presented in a Verification Report, which provides a complete record of the activities undertaken as part of the verification process, and includes all data, complete surveys, lab results etc. Where capping materials are sourced from a commercial provider, all suppliers' routine chemical test certificates and the delivery tickets to site will be included in the Verification Report. In addition to the independent testing undertaken by DB Remediation.

The report will include the following:-

1) Details of the origin the subsoil/topsoil
2) Original Chemical Test Certificates
3) Photographs
4) Interpretation on the suitability of the material

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