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Guidance on characterization of excavated soil and other materials intended for re-use

Lignes directrices sur la caractérisation de la terre excavée et d'autres matériaux du sol destinés à la réutilisation

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 190, *Soil quality*, Subcommittee SC 7, *Impact assessment*.

This second edition cancels and replaces the first edition (ISO 15176:2002), which has been technically revised. The main changes compared to the previous edition are as follows:

— introduction of references to the ISO 18400 series of standards;

— updated references to international standards.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

This document is one of a series providing guidance on the assessment of soils and soil materials in relation to certain functions and uses. It should be read in conjunction with other International Standards, some of which give more specific guidance in relation to some of the uses listed in the Scope or particular aspects of assessments. For example, ISO 15800[1)] gives guidance on assessments relating to human exposure to potentially harmful substances and ISO 15175 gives guidance on characterization of contaminated soil related to groundwater protection.

Soils are the dynamic product of chemical, physical and biological processes. They are the result of interactions between the inherent nature of the parent material, the prevailing environmental conditions and human activities. They are a valuable natural and finite resource which should be conserved wherever possible. When construction, mining or other activities require soils to be excavated and moved from their natural situation, they should as far as possible be re-used in a manner consistent with their natural properties and the intended use of the target location. Soils intended for re-use are usually required to have certain chemical, leaching, geotechnical, physical, biological and radiochemical attributes consistent with this future use. Particular attention should be paid in situations where there is reason to believe that the soil might be contaminated.

Soils that are to be excavated, stripped, or otherwise removed from their original location, should be investigated to determine how they can be re-used so as to minimize the quantities to be disposed of as waste and to determine environmental impacts that might arise during re-use. Treatment of soils and soil materials to remove or destroy contaminants or to reduce their availability to the environment can alter soil properties. These properties should therefore be determined before re-use. For manufactured soils, the characteristics of both the components and of the manufactured product might need to be determined.

The purpose of characterizing soil (or other media) as suggested in this document is usually to enable judgements to be made about its suitability for a defined use (e.g. arable farming, domestic gardens). These judgements can be made by reference to published international or national guidance that sets out physical, chemical or other generic criteria, or against criteria set on a site-specific basis. When substances are present that might be harmful to human health or the environment, the judgement can also be made on the basis of a site-specific qualitative, semi-quantitative or fully quantitative risk assessment. In many jurisdictions, formal guidance on such assessments has been published. In some cases this guidance fits within a legislative framework. Guidance has also been provided by professional organizations and some standardization bodies.

When deciding whether to re-use soil material, other possibly competing or overriding objectives such as protection of soil, nature, water and air; physical planning requirements and national legislative requirements should be considered.

Assessment of soil material for re-use could require the measurement of the chemical, physical, biological, geotechnical and radiochemical characteristics of soil material and of the source and target sites. The assessor should identify those parameters that are appropriate to the task in hand.

This document identifies the functions and properties of soil materials at the source (point of origin) and also the properties of the target (target) site which could be relevant to the potential uses listed in the Scope and indicates for which parameters or procedures there are International Standards available. Radiochemical and geotechnical aspects are not covered. For guidance on the geotechnical aspects of the use of soil materials as construction material, see also other relevant International Standards (e.g. those produced by ISO/TC 182, *Geotechnics in the field of civil engineering*) or national standards.

The way the soil is handled after excavation can affect soil properties. Some suggestions regarding good practice in soil handling and related practice and monitoring after placement are provided in Annex B.

1) Under preparation. Stage at the time of publication: ISO/FDIS 15800.

Guidance on characterization of excavated soil and other materials intended for re-use

1 Scope

This document provides guidance on the range of tests that could be necessary to characterize soil and other soil materials intended to be re-used, with or without preliminary treatment (e.g. screening to remove over large material). It is intended to be of use in determining the suitability of soil materials for re-use (see 3.4.1), and the assessment of the environmental impacts that might arise from re-use. It takes into account the different requirements of topsoil, sub-soil and other soil materials such as sediments or treated soils. International Standard methods are listed that might be of use for characterization.

Soil materials include natural soils and other materials (e.g. fill, made ground) excavated, stripped, or otherwise removed from their original in-ground or above-ground location (e.g. stockpile), dredged materials, manufactured soils, and soil treated to remove or destroy contaminants. For manufactured soils, which are often made using excavated materials together with other materials such as “green waste”, the characteristics of the components and of the manufactured product might need to be determined.

NOTE The terms “excavated soil” and “excavated soil materials” are used for brevity throughout the document to embrace the range of materials covered.

An overriding principle governing the guidance provided in this document is that when there is to be no change in intended land use at the target site, imported soil materials cannot lead to a permanent reduction in performance of relevant soil functions.

The guidance provided is intended to cover a range of possible end uses, including:

— play areas for small children, including nursery schools, kindergartens, etc.;

— schools;

— gardens and other residential areas;

— allotments;

— horticulture;

— agriculture;

— forestry;

— recreational areas, e.g. parks, sport fields;

— restoration of damaged ecosystems;

— mining and industrial sites;

— construction sites;

— road and rail constructions.

It is not applicable to the placement of soil materials in an aqueous environment or to restore underground workings. It does not address geotechnical requirements when soil materials are to be used as construction material.

NOTE The sensitive end uses listed above such as play areas for small children, schools, gardens, agriculture and recreational areas require particular care, particularly when excavated soils are derived from contaminated sites.

2 Normative reference

There are no normative references in this document.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1 Types of soil and other soil materials

3.1.1
soil
upper layer of the Earth's crust transformed by weathering and physical/chemical and biological processes composed of mineral particles, organic matter, water, gases and living organisms organized in generic soil horizons

Note 1 to entry: In a broader civil engineering sense, soil includes topsoil and sub-soil; deposits such as clays, silts, sands, gravels, cobbles, boulders and organic matter and deposits such as peat; materials of human origin such as wastes; ground gas and moisture; and living organisms.

[SOURCE: ISO 11074:2015, 2.1.11, modified —"gases" replaces "air".]

3.1.2
topsoil
upper part of a natural soil that is generally dark coloured and has a higher content of organic matter and nutrients when compared to the (mineral) horizons below, excluding the humus layer

Note 1 to entry: For arable land, topsoil refers to the ploughed soil depth, while for grassland; it is the soil layer with high root content.

[SOURCE: ISO 11074:2015, 2.1.21]

3.1.3
subsoil
natural soil material below the topsoil and overlying the parent material parent rock beneath

Note 1 to entry: All or much of the original rock structure has usually been obliterated by pedogenic processes.

[SOURCE: ISO 11074:2015, 2.1.20, modified — "parent rock beneath" added.]

3.1.4
soil material
material composed of excavated soil, dredged materials, manufactured soils, treated soils and fill materials

[SOURCE: ISO 11074:2015, 7.4.16]

3.1.5
excavated soil
soil material extracted from the ground

EXAMPLE Topsoil, subsoil, altered parent rock, typically arising during construction works.

[SOURCE: ISO 11074:2015, 2.2.6]

3.1.6
manufactured soil
manufactured product intended to perform specified soil functions produced by blending combinations of natural, waste, or manufactured materials with the addition of nutrients or other additives, when necessary

[SOURCE: ISO 11074:2015, 2.2.9, modified — "manufactured materials" replaces "soil materials".]

3.1.7
treated soil
soil that has been subjected to a process-based treatment method

[SOURCE: ISO 11074:2015, 2.2.16, modified — "process-based treatment method" replaces "ex situ or in situ process".]

3.1.8
dredged material
solid material excavated or otherwise removed from waters, e.g. during maintenance, construction, reconstruction and harbour or channel extension operation

Note 1 to entry: Dredged material might consist of sediment and soil taken from below the water surface.

[SOURCE: ISO 11074:2015, 2.2.4, modified — "material excavated" changed to "solid material excavated or otherwise removed from waters" and "extension measures from waters" modified in "harbor or channel extension operation". In note 1 to entry: "subhydric soils" deleted and "soil and their parent material beneath the surface water body" changed to "soil taken from below the water surface".]

3.1.9
anthropogenic ground
deposits which have accumulated through human activity

[SOURCE: ISO 11074:2015/DAmd 1:2019[2)]]

3.1.10
fill
anthropogenic ground in which the material has been selected, placed and compacted in accordance with an engineering specification

[SOURCE: ISO 11074:2015/DAmd 1:2019]

3.1.11
made ground
anthropogenic ground comprising material placed without engineering control and/or manufactured by man in some way, such as through crushing or washing, or arising from an industrial process

[SOURCE: ISO 11074:2015/DAmd 1:2019]

2) Under preparation. Stage at the time of publication: ISO 11074:2015/DAmd 1:2019.

3.2 Soil characteristics

3.2.1
soil functions
roles performed by soil that support ecosystems, the biosphere, the water environment and human activities

EXAMPLE Control of substances and energy cycles as compartment of ecosystems, basis for life of plants, animals and humans, basis for stability of buildings and roads, basis for the yield of agriculture, horticulture, and forestry, carrier of genetic reservoir, document of natural history, archaeological and palaeological document.

[SOURCE: ISO 11074:2015, 3.3.31, modified — "roles performed by soil that support ecosystems, the biosphere, the water environment and human activities" replaces "description of the significance of soils to man and the environment".]

3.2.2
background concentration
concentration of a substance characteristic of a soil type in an area or region arising from both natural sources and anthropogenic diffuse sources such as atmospheric deposition

[SOURCE: ISO 11074:2015, 3.5.1, modified — "anthropogenic diffuse sources" replaces "non-natural diffuse sources".]

3.2.3
background value
statistical characteristics of the total (natural pedo-geochemical and anthropogenic) content of substances in soil

Note 1 to entry: It is commonly expressed in terms of an average, median, or a range of values.

[SOURCE: ISO 11074:2015, 3.5.2, modified — Note 1 to entry added.]

3.2.4
natural background concentration
concentration of a substance that is derived solely from natural sources (i.e. of geogenic origin), commonly expressed in terms of average, a range of values, or a natural-background value

[SOURCE: ISO 11074:2015, 3.5.7]

3.2.5
natural background value
statistical characteristics of the natural pedo-geochemical content of a substance in soils

[SOURCE: ISO 11074:2015, 3.5.8]

3.2.6
contaminant
substance or agent present in soil as a result of human activity

Note 1 to entry: There is no assumption in this definition that harms results from the presence of the contaminant.

[SOURCE: ISO 11074:2015, 3.4.6]

3.2.7
potentially harmful substance
substance which by its chemical form, concentration or presence, can be dangerous to humans or the environment

Note 1 to entry: It can be present naturally or as a result of human activity.

[SOURCE: ISO 11074:2015, 3.4.19]

3.2.8
residual contamination
amount or concentration of contaminants remaining in a specific medium, following remediation

[SOURCE: ISO 11074:2015, 3.4.21]

3.2.9
trace element
element present in low concentration in soil material in respect to the most commonly observed natural background level

[SOURCE: ISO 11074:2015, 3.5.12]

3.2.10
essential trace element
element essential at low concentrations for plant or animal (including human) metabolism

Note 1 to entry: An element can be essential at low concentrations but become harmful at higher concentrations.

[SOURCE: ISO 11074:2015, 3.5.5]

3.2.11
soil characterization
determination of relevant physical, chemical, and biological properties of the soil

[SOURCE: ISO 11074:2015, 2.1.12]

3.3 Land and sites

3.3.1
damaged land
degraded land
land which, due to natural processes or human activity, is no longer able to properly sustain an economic function and/or its original natural ecological function

[SOURCE: ISO 11074:2015, 2.2.2]

3.3.2
target site
site at which soil is to be re-used

[SOURCE: ISO 11074:2015, 2.3.14]

3.4 Utilization, reclamation and treatment

3.4.1
re-use of soil material
useful and harmless utilization of soil materials

Note 1 to entry: Re-use can mean transfer of soil materials to another location for use in agriculture, horticulture, forestry, gardens, recreational areas and construction sites.

[SOURCE: ISO 11074:2015, 2.2.12]

3.4.2
construction works
applications where soil materials are not required to have a direct productive use although they can support other layers intended to have a productive use

Note 1 to entry: For example, including earthworks (e.g. embankments), landscape engineering, road construction, construction of waste disposal sites, and backfilling of excavated sites or surface mines.

[SOURCE: ISO 11074:2015, 2.2.1, modified — "surface" added before "mines" in Note 1 to entry]

3.4.3
reclamation
rehabilitation
return of damaged, degraded or derelict land to beneficial use

Note 1 to entry: The term remediation is commonly restricted to the process of dealing with contaminated/polluted sites.

[SOURCE: ISO 11074:2015, 2.2.11]

3.4.4
soil rehabilitation
action taken to improve the capability of damaged or degraded soil to perform specified functions (e.g. addition of organic matter and nutrients to promote plant growth)

[SOURCE: ISO 11074:2015, 6.1.22]

3.4.5
remediation strategy
combination of remedial techniques and associated work programmes that will meet specified contamination-related remediation objectives and other objectives (e.g. engineering related), and overcome possible restraints

[SOURCE: ISO 11074:2015, 6.1.20, modified — "techniques" replaces "methods, "programmes" added, "(e.g. residual contaminant concentrations)" removed, "possible restraints" replaces "residual concentration"]

3.4.6
process-based treatment method
application of physical, chemical or biological processes either to remove or destroy contaminants, or to reduce their availability to the environment

Note 1 to entry: Different treatment methods, e.g. biotreatment, are defined in ISO 11074.

3.4.7
stockpile
temporary deposit of soil material

[SOURCE: ISO 11074:2015, 2.2.14 modified — Note 1 and Note 2 to entry deleted]

3.4.8
investigation for compliance or performance
investigation, or programme of on-going inspection, testing or monitoring, to confirm that a remediation strategy has been properly implemented and/or when a containment approach has been adopted, that this continues to perform to the specified level

EXAMPLE Testing to confirm that all contaminated material has been removed.

3.5 Assessment

3.5.1
hazard
property of a substance or material, or situation that in particular circumstances could lead to harm or pollution

[SOURCE: ISO 11074:2015, 5.2.15]

3.5.2
hazard
re-use of soil & soil materials
property of a substance or material, or any action that which might have an adverse effect on soil functions

Note 1 to entry: A hazard has the potential to cause harm.

3.5.3
risk
combination of the probability and frequency of occurrence of a defined hazard and the magnitude of the consequences of the occurrence

[SOURCE: ISO 11074:2015, 5.2.24]

3.5.4
harmlessness
<application of soil materials> condition in which the application of a soil material does not result in damage, as defined by specific criteria, to the present functions of the soil already at the target site

[SOURCE: ISO 11074:2015, 5.2.14]

3.5.5
data quality objectives
statement of the required detection limits, accuracy, reproducibility and repeatability of the required analytical and other data

Note 1 to entry: Generic data quality objectives are sometimes set at national level. Data quality objectives can also embrace the amount of data required for an area of land (or part of a site) or for a stockpile to enable a sound comparison with generic guidelines or standards or for a site-specific or material-specific estimation of risk.

[SOURCE: ISO 11074:2015, 5.1.2]

4 Characterization of soil materials and sites

4.1 General

The purpose of characterizing soil materials and sites intended for re-use of soil material is to enable judgements to be made about their suitability for a defined use (e.g. arable farming, domestic gardens, construction works). Before such judgements can be made, the right type, quantity and quality of information and data shall be available (see Clause 5). It is necessary to determine relevant site information and chemical, physical and biological soil and soil material characteristics as appropriate. This requires the development of a soil management plan which should include:

— an investigation strategy (see 4.2) and, if necessary;

— sampling strategies (see 4.3) and, if necessary;

— analytical and testing strategies (see 4.4);

— and always an assessment framework (see Clause 5);

for each site, soil and soil material that is to be assessed.

Sometimes investigations are required for the sole purpose of deciding whether soil and other soil material such as fill materials are suitable for re-use for a target site (see Figure 1) but this might be only one of a number of objectives of a more comprehensive investigation of a suspect potentially contaminated site. In this latter case, the initial task becomes to ensure that the overall sampling, analytical and testing strategies for the investigation properly address the needs of this specific objective. In practice, investigations are commonly phased for both technical and cost reasons and it could therefore be preferable to carry out at least part of the characterization, particularly for example of the nutrient and trace element status, physical and biological soil properties, through a supplementary investigation (see Figure 2).

The guidance provided in this document focuses on soil materials that are to be excavated or have already been excavated (e.g. have been placed in stockpiles). However, it also covers a number of other situations including for example dredged materials, treated soil materials and manufactured soils. Comparable investigation is required in all situations to ensure a good understanding of the source of the material and its components so that appropriate analytical and testing strategies can be developed.

NOTE 1 In some jurisdictions and some circumstances, any excavated material could be considered to be waste for regulatory purposes. There could be set procedures to go through to avoid such classification and/or enable the excavated material to be re-used. These can be accompanied by prescribed assessment procedures and testing regimes. These do not necessarily yield analytical results etc. that can be used for assessment for re-use as described in this document. Similarly, there can be regulatory procedures to follow when excavated materials are to be used for construction purposes.

Care should be taken during site investigation and subsequent handling of soil materials intended to be re-used to avoid the spread of invasive and noxious plants, infective agents, destructive organisms, and genetically modified (GM) crops outside of areas approved for their growth (see also ISO 18400-103).

NOTE Examples relevant to temperate climates include: invasive and noxious plants - Japanese Knotweed (*Fallopia japonica*), infective agents - those causing, foot/hoof and mouth disease (*Aphatae epizooticae*) and Rhizomania [*Benyvirus* – Beet Necrotic Yellow Vein Virus (BNYVV)].

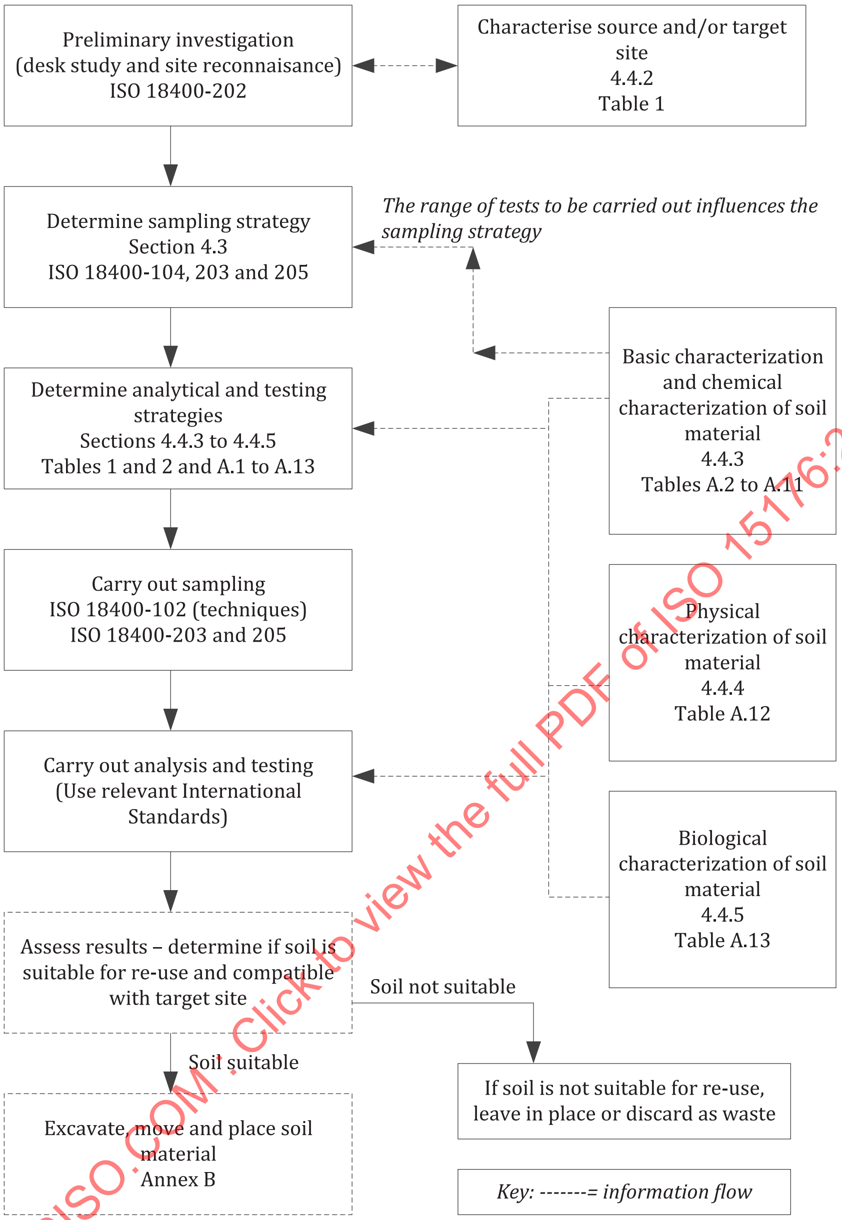

Figure 1 — Overall flow chart for characterization of soil materials for re-use

4.2 Investigation strategies

Before investigation of the soil or soil material is started, it is essential to define the objectives of the investigation.

In general, there are three likely situations:

a) the presence of elevated concentrations of potentially harmful substances (e.g. above background values) or unacceptably high nutrient status in the soil material can be excluded on the basis of the available information;

b) the soil material originates from an area with natural high concentrations of potentially harmful substances and/or organic and/or sulfidic level;

c) there are indications that anthropogenic activities have resulted in elevated concentrations of potentially harmful substances, i.e. the soil material is contaminated.

The typical overall investigation strategy for a potentially contaminated site (i.e. one where it is suspected potentially harmful substances could be present as a result of human activity) or one where there are naturally elevated concentrations of potentially harmful substances is to:

— carry out a preliminary investigation in accordance with ISO 18400-202 comprising a desk-top study and a site reconnaissance (walk over-survey) – the aim is to build up a comprehensive picture of the history of the site, its geology and hydrogeology, environmental setting, current condition;

and, on the basis of the resulting conceptual site model (see ISO 21365:2019[3)]), to:

— develop a strategy for intrusive investigation in accordance with ISO 18400-203 which properly takes into account the health and safety of the investigation team and the general public, and which avoids harm to the environment.

Often, the intrusive investigation will be phased (see Figure 2). An initial exploratory investigation (Phase 2) can be carried out first to confirm or to refute hypotheses drawn from the preliminary investigation (Phase 1) and to provide initial information to be better able to design the subsequent detailed investigation (Phase 3). In the light of the results of these early phases, it could be necessary to carry out supplementary investigations (Phase 4) to determine, for example the suitability of soil for re-use, or to gather information relevant to the application of a process-based treatment method.

It is important that the information and data required to assess excavated soil material for re-use is identified as far as possible before the investigation starts. In this way appropriate sampling, analytical and testing strategies can be developed at the outset. If this is not done, there can be significant gaps in the information available, necessitating further costly intrusive investigation. However, some aspects of characterization might often be better addressed through a supplementary investigation.

Each intrusive investigation should be accompanied by on-site observation of the site and soil material including appropriate description and documentation.

The approach outlined above should be adapted for other sources of soil materials, for example when soil material is being manufactured it would be appropriate to enquire into the source and history of each of the ingredients. In the case of soil material from a process-based treatment method, it would be appropriate to enquire into the history of the source site. Exploratory sampling programmes could then be carried out before designing and embarking on a programme for continuous monitoring of feed and output materials.

NOTE Sites sometimes contain "hotspots", i.e. areas where the concentrations of potentially harmful substances are higher than for the generality of the site. Generally, an excavation plan is needed that excludes the material from such "hot-spots" from that exported from the site for re-use. As noted in ISO 18400-104 8.2.3, a hot spot can be designated as (i) an area of contamination in an otherwise uncontaminated area, or (ii) an area of much greater contamination in a site that is generally contaminated. The size of a hotspot is not a fixed parameter and depends for example on what concentration of a particular contaminant is judged noteworthy when assessing the results of the investigation. This might be a generic assessment criterion appropriate for the intended use of the soil.

4.3 Sampling strategies

4.3.1 General considerations

Investigation could be required (as appropriate):

a) at the point of excavation;

b) of excavated material in a stockpile;

c) following treatment of excavated soil or soil material;

d) of manufactured soil;

3) Under preparation. Stage at the time of publication: ISO/DIS 21365:2019.

e) at the target site.

The sampling strategies and the measurements to be made (analytical and testing strategy) should be determined on the basis of:

f) the history of the site from which the soil material is excavated or dredged;

g) available data or results of previous investigations;

h) the nature and type of material to be characterized;

i) the quantity of soil material to be assessed;

j) the nature of any process-based treatment methods that has been applied to the soil material;

k) the intended use of the soil material;

l) the planned way of handling the soil material from excavation to target site, e.g. transport and stockpiling;

m) the history and present condition of the target site;

n) the intended use of the target site;

o) data quality objectives (see Clause 5).

NOTE Further guidance on site investigation relevant to re-use of excavated materials is provided in Annex C

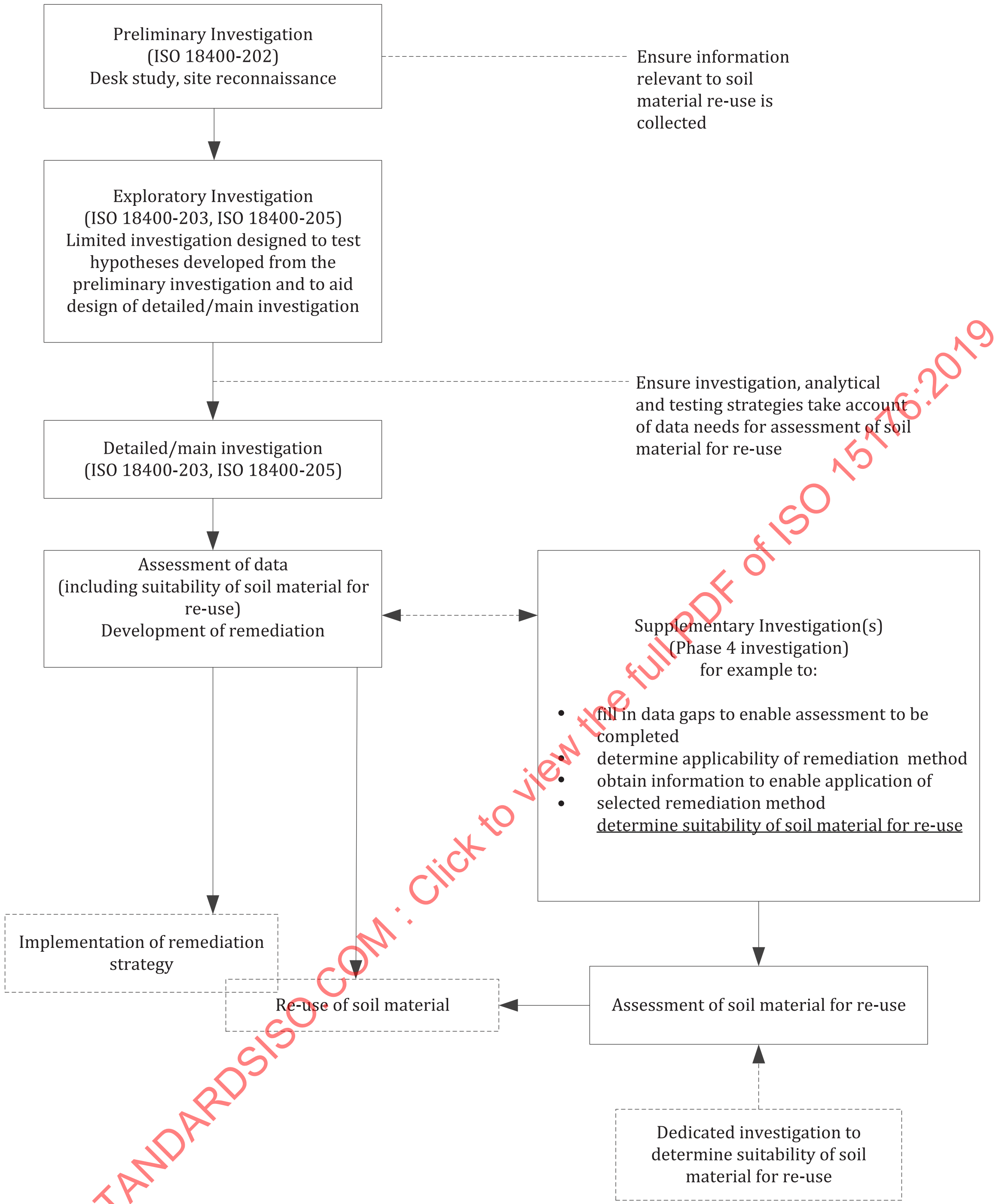

Figure 2 — Diagram showing how assessment of excavated soil material might fit into investigation of a suspect potentially contaminated site (as opposed to the alternative of a dedicated investigation with this sole objective)

When deciding on investigation, sampling, analytical and testing strategies, authoritative guidance applicable in the jurisdiction where the soil is to be excavated and/or re-used should be followed.

Reference should be made to relevant International Standards and to the guidance attached to any national guidelines or standards relating to soil quality that are to be used in the assessment of the results of the investigation. In some jurisdictions, there could be a legal requirement to follow certain procedures if published criteria are to be used as the basis of the assessment.

Within the scope of this document, sampling might be required of in situ or excavated (ex situ) soil, fill materials, dredged materials, manufactured soils and the components thereof, and treated soils. For example:

— in situ soils and other materials intended for excavation;

— in situ soils at the intended location of use;

— groundwater at the point of excavation or at the point of re-deposition or surface water in contact with sediments (see 4.3.8 and the Note below);

— sediments in situ in ponds, lakes, canals, estuaries etc.;

— stockpiles of excavated soils and other soil materials;

— stockpiles of excavated sediments;

— soil materials arising from a process-based remediation method;

— in situ soil, etc., after emplacement, to ensure conformance and performance.

NOTE Determination of groundwater levels and their fluctuation over time might be required in some circumstances, e.g. to guide decisions about how deep to excavate. Water quality in contact with sediments etc. could be important in relation to how to deal with any water draining from the sediment after extraction.

International Standards should be applied for sampling soils in various contexts; these are published as parts of ISO 18400. International Standards are also available for sampling surface water (ISO 5667-4, ISO 5667-6), groundwater (ISO 5667-11), and sediments (ISO 5667-12). In the absence of appropriate International Standards, appropriate national or equivalent standards should be used.

In general, soil materials should be sampled in situ rather than after placement in stockpiles. This enables potential environmental impacts arising from handling and storage to be determined, and potential damage to the soil that might arise during storage to be avoided (see Annex B).

Whilst the testing of soils for geotechnical properties is outside of the scope of this document, the guidance available for description, sampling and investigation design can sometimes be helpful. In particular, attention is drawn to ISO 14688-1, ISO 14688-2 and to ISO 14689. These International Standards include definitions (e.g. of soil and rock) specific to geotechnical applications.

4.3.2 Sampling in situ soil materials

If sufficient data are not already available, it will be necessary to sample soil materials at the point of excavation and/or at the target site.

On-site screening methods should be used when appropriate (see for example ISO 12404 and 13196).

Relevant International Standards on sampling soils in relation to soil quality are listed in the Bibliography. The principal guidance on sampling strategies is provided in ISO 18400-104.

NOTE On-site screening methods might for example be particularly useful where investigations to date have shown that contamination is variable across the site and that only a portion is fit to use for the intended purpose. Application of an on-site XRF method (e.g. ISO 13196) could enable the areas from which soil may be re-used to be more closely delineated, monitoring as material is removed from site, and monitoring at the target site.

4.3.3 Sampling sediments

Guidance on sampling of sediments is given in ISO 5667-12.

4.3.4 Sampling stockpiles of untreated or treated soil materials

Soil materials are sometimes stockpiled after excavation or dredging, as are treated materials. Special sampling methods are required for such stockpiles (see ISO 18400-102). Samples from different stockpiles should not be mixed.

NOTE Guidance on sampling strategies for stockpiles and other above ground deposits is provided in ISO 18400-104.

4.3.5 Sampling materials arising from a process-based remediation method

Assessment of materials arising from a process-based treatment method usually requires sampling at the time of production in a statistically sound way in order to confirm conformance with pre-determined chemical, physical or biological criteria (for example residual concentrations of contaminants). Sampling can be done from stockpiles or from the production line.

NOTE Guidance on sampling strategies for stockpiles and other above ground deposits is provided in ISO 18400-104.

4.3.6 Sampling manufactured soils

Assessment of manufactured soil materials usually requires sampling in a statistically sound way in order to confirm conformance with pre-determined chemical, physical or biological criteria. This sampling can be done from stockpiles or from the production line.

The materials used in manufacture usually require characterization before blending. Characterization may involve determination of physical, chemical and/or biological properties. The exact tests which are most appropriate to carry out on the materials used in the manufacture of soil depend on the nature of those materials and the final planned use for the manufactured soil.

NOTE Guidance on sampling strategies for stockpiles and other above ground deposits is provided in ISO 18400-104.

4.3.7 Sampling soil materials after placement at the target site

It could be necessary to sample soil materials after placement at the target site for conformance and performance assessment. This could be required shortly after placement or some years afterward, to see, for example, if a desired improvement in a soil function has been achieved. In general, sampling methods applicable to in situ soil materials are appropriate.

4.3.8 Sampling the water environment

It could sometimes be necessary to sample groundwater or surface waters at the location from which soil materials are to be excavated or dredged, or at the target site. In such cases ISO 5667-4, ISO 5667-6 and ISO 5667-11 should be followed as appropriate.

4.4 Characterization of soil materials

4.4.1 General

Characterization of soils and soil materials is a judgemental process, where prior information, on-site observations and measurements, and the results of the investigation of samples are synthesized and interpreted. As soil samples sent to the laboratory are only a very small part of the whole soil volume of interest, sound judgment of the significance and validity, especially of analytical results, is essential. Characterising soil materials requires knowledgeable transfer of the information derived from small samples to the whole volume under investigation, including identification of the uncertainties associated with this process.

NOTE 1 Although not specifically dealt with in this document, it is likely to be necessary to identify appropriate quality control and quality assurance procedures that can be applied when the actual translocation of the soil or soil materials takes place.

Depending on the intended use, characterization of soil materials requires determination of basic characteristics (for example pH, mineralogy), chemical, physical (including texture), geotechnical, biological and radiochemical properties. It is often also necessary to determine or describe certain aspects of the site from which the soil material is to be excavated from (source site) and/or at which the soil material is to be used (target site). Figure 1 indicates the broad areas in which measurement or description could be required. The figure assumes that a dedicated investigation is being carried out for the specific purpose of assessing soil material for re-use. However, as discussed in 4.1 and 4.2 and illustrated in Figure 2, investigation related to re-use of soil material could be simply one aspect of a wider investigation and assessment programme.

NOTE 2 No guidance is provided in this document about how to assess the radiochemical status of soil materials.

Certain parameters require determination in almost all situations; others only require measurement depending on the source site or the intended use of the soil material. A judgement should be made on a case-by-case basis.

Soil materials can sometimes be contaminated with substances that present a hazard to those handling the material. It is important for example, to recognise that anthropogenic deposits are often contaminated with asbestos or asbestos containing materials. This could present serious risks to human health and safety. Appropriate risk assessments should be carried out prior to any sampling followed by appropriate sampling and testing of the materials of interest[84][85].

NOTE 3 General guidance on safety during sampling is provided in ISO 18400-103.

4.4.2 Description of source and target sites

Suggestions about the characteristics of the source and target sites that might be determined are listed in Table 1. In general, the parameters to be determined at the source site are those relevant to the extraction process itself and subsequent intermediate storage and handling, and direct observations that can be made on-site (e.g. in inspection pits) that are relevant to the intended use of the excavated soil material. At the target site, the parameters of concern are primarily those that are relevant to the placement process and the properties of the existing top soil and subsoil which are relevant to determination of whether imported soil material can be used without harm (see Annex B).

Table 1 — Description of source and target sites

Parameters	Source site		Target site		International Standard
	Excavated soil to be used for natural (productive) function	Excavated soil to be used for construction (e.g. earth works)	Delivered soil to be used for natural (productive) function	Delivered soil to be used for construction (e.g. earth works)	
Land use: Vegetation, buildings, etc.	X	X	X	X	—
Topography:	X	X	X	X	ISO 25177[a]
Surface characteristic: Rock outcrops, erosion, cracks, etc.	X	X	X	X	ISO 25177

Table 1 *(continued)*

Parameters	Source site		Target site		International Standard
	Excavated soil to be used for natural (productive) function	Excavated soil to be used for construction (e.g. earth works)	Delivered soil to be used for natural (productive) function	Delivered soil to be used for construction (e.g. earth works)	
Hydrology:					
Surface water balance	—	—	X	X	—
Rainfall	—	—	X	X	—
Evapotranspiration	—	—	X	X	—
Groundwater recharge	X	X	X	X	—
Depth to groundwater table	X	X	X	X	—
Soil geometry:					
Stratigraphy	X	X	X	X	ISO 25177
Inhomogeneities	X	X	X	X	ISO 25177
Fracturing	X	X	X	X	ISO 25177
Geology:					
Type of parent material	X	X	X	X	ISO 25177
Effective soil depth	X	X	X	X	ISO 25177
Soil type/soil:					
Soil type and sequence of horizons	X	X	X	X	ISO 25177
Description:					
Thickness of horizons	X	X	X	X	ISO 25177
Colour of the horizon matrix	X	—	X	—	ISO 25177
Texture:					
Mottles	X	—	X	—	ISO 25177
Moisture status	X	—	X	—	ISO 25177
Structure	X	—	X	—	ISO 25177
Compactness	X	—	X	—	ISO 25177
Total estimated porosity	X	—	X	—	ISO 25177
Roots	X	X	X	X	ISO 25177
Worm channels, biological activity	X	—	X	—	ISO 25177
Other characteristics:					
Presence of non-soil material	X	X	X	X	—
Presence of biodegradable material	X	X	X	X	—
Presence of buildings, etc.	X	X	—	—	—

Table 1 *(continued)*

Parameters	Source site		Target site		International Standard
	Excavated soil to be used for natural (productive) function	Excavated soil to be used for construction (e.g. earth works)	Delivered soil to be used for natural (productive) function	Delivered soil to be used for construction (e.g. earth works)	
Present vegetation	X	—	X	—	—
Geotechnical properties	X	X	X	X	ISO 14688-1 ISO 14688-2 ISO 14689 ISO 17892-1 ISO 17892-2

NOTE ”X” indicates that the information or characteristic could be relevant. However, decisions about relevance should always be made on a case-by-case basis and/or on the basis of expert advice.

aUnder preparation. Stage at the time of publication: ISO/FDIS 25177:2019.

4.4.3 Chemical characterization including basic characteristics

4.4.3.1 General

It could be necessary to measure chemical parameters in the following broad groups:

— basic characteristic parameters (e.g. pH, cation exchange capacity, pedological features by texture);

— nutrients;

— trace elements;

— potentially harmful substances.

Some elements are essential trace elements at low concentrations, but at higher concentrations are potentially harmful to some biota. For example, copper is listed in Table A.3 as an essential trace element but is also included in subsequent tables dealing with potentially harmful substances.

In order to estimate the availability of inorganic substances to different environmental compartments and receptors, it can be necessary to distinguish between different fractions of an analyte, e.g. soluble in strong acid, weak extractants, or water (see Table 2). Although the extractants might differ, it is often possible to use the same methods to analyse the extractant.

Other specialist empirical methods have been developed to estimate the proportions of some substances that are bioaccessible in humans (i.e. that will enter the body if ingested.), e.g. ISO 17924.

Table 2 — Examples of extraction methods for metals and metalloids

Fraction	Examples of extraction method	Measurement method (example)
Total	Digestion with hydrofluoric and perchloric acids in accordance with ISO 14869-1	ISO 11047
Pseudo-total	Trace metals soluble in aqua regia in accordance with ISO 11466	
Weak extractants	e.g. NH_4NO_3 $NaNO_3$ $CaCl_2$	ISO 11047
Water	Batch leaching tests using various water: soil ratios (e.g. ISO 21268-1[a] or ISO 21268-2[b]) Column leaching tests (e.g. ISO 21268-3[c])	ISO 11047
Tests to simulate human bioaccessibility	Batch testing using a combination of extractants simulating digestion	ISO 17924

NOTE Extraction methods using water and weak extractants are generally empirical methods. The results obtained are often highly dependent on factors such as particle size of the test sample, the time period over which the extraction is carried out, the temperature at which the procedure is carried out and the ratio of extractant to solid. Strict adherence to the conditions stipulated in the standardised procedures is essential if consistent and comparable results are to be obtained.

[a] Under preparation. Stage at the time of publication: ISO/FDIS 21268-1:2019.

[b] Under preparation. Stage at the time of publication: ISO/FDIS 21268-2:2019.

[c] Under preparation. Stage at the time of publication: ISO/FDIS 21268-3:2019.

The organic analyst is often interested in looking for any chemical which could be present. In practice, organic analyses take two forms:

a) determination of what is present (qualitative analysis), and

b) determination of how much of a specific compound or class of compounds is present (quantitative analysis).

The detection of “adventitious” or unexpected substances, particularly when complex mixtures of organic chemical species are present, requires the use of analytical screening methods such as gas chromatography/mass spectrometry. Analytical methods (“class analyses”) are sometimes used that purport to give total concentrations of classes of compounds such as phenols, polycyclic aromatic hydrocarbons (PAHs), total petrol hydrocarbons (TPH) and chlorinated hydrocarbons. Care is required in both the use and interpretation of the results of such methods.

In some situations, qualitative analysis can be a useful precursor for quantitative analysis. Similarly, class analyses can sometimes be usefully employed in advance of more detailed analyses.

“Total” applied to organic compounds (e.g. phenols) usually means that an analytical technique has been employed that cannot distinguish between similar compounds: in the case of phenols say between monohydric, dihydric and trihydric compounds. However, the term “total” can be misleading: not all phenols might be detected by the method employed and different methods can give different results.

Analyses of soil materials for volatile organic compounds (e.g. benzene, chlorinated solvents) present particular analytical difficulties. Research suggests that even under ideal conditions of sampling, transport and sample preparation, etc., substantial losses can occur (one study suggested that 50 % retention was the best that could be achieved even under laboratory conditions). Under less than ideal conditions, almost all can be lost. Thus, use of in situ methods such as soil vapour analysis, are likely to give a more reliable indication of distribution and relative concentrations of the substances of concern. In addition, it should be noted that different laboratory methods (e.g. purge-and-trap and head-space analysis) can give substantially different results.

It is important to recognize that organic compounds can be extracted from naturally occurring organic materials (e.g. humus, decaying vegetation, peat, coal) and that non-specific analyses, in particular, can therefore give misleading results.

Guidance on the applicability of various chemical measurements in relation to the intended use of the soil material is given in Tables A.1 to A.11. Figure 3 indicates how the tables should be used.

Before any laboratory analysis, samples should be subjected to pre-treatment (e.g. ground, sub-sampled) compatible with the method(s) of analysis to be employed. Methods for pre-treatment are described in ISO 11464 (pre-treatment of samples for physico-chemical analysis) and ISO 14507 (pre-treatment for determination of organic contaminants). Some methods for extraction or analysis include their own requirements regarding pre-treatment of samples and these should always be followed unless there are sound technical reasons not to do so, in which case those reasons should be reported with the analytical results. Any pre-treatment in the field, e.g. to reduce the mass of material to be transported to the laboratory, should be carried out in accordance with ISO 18400-201.

Chemical characterization

4.4.3

Basic characteristics

4.4.3.2
Table A.1

e.g.: petrography, pH, organic matter content, cation exchange capacity, salinity

Nutrients

4.4.3.3
Table A.2

e.g.: nitrogen, phosphorus, potassium

Trace Elements

4.4.3.4
Table A.3

e.g.: cobalt, copper, magnesium, selenium, zinc

Potentially Harmful Substances

4.4.3.5
Tables A.4 to A.11

e.g.: metals and metalloids, volatile organic compounds, pesticides, dioxins, polychorinated biphenyls (PCBs), petroleum hydrocarbons, chlorinated solvents, polycyclic aromatic hydrocarbons (PAHs)

Figure 3 — Determination of basic characteristics and chemical characterization of soil materials

4.4.3.2 Basic characteristics

Basic characteristics of soil materials that it might be desirable to measure are listed in Table A.1. Assessors should decide which of the parameters listed are relevant in the particular circumstances in which the material is to be assessed. Some, such as pH, are likely to be relevant in most cases, whereas others, such as exchangeable acidity, are less frequently required.

4.4.3.3 Nutrients

Nutrient parameters that it might be desirable to measure are listed in Table A.2. These are not usually relevant when a soil material is to be used for non-productive applications such as earthworks. However, care could be required to ensure that excess nutrients do not leach into surface or ground waters when soil materials are used in construction, playing fields or other locations.

4.4.3.4 Essential trace elements

Trace elements essential for plant growth that it might be desirable to determine when soil material is to have a productive use are listed in Table A.3. Note that at concentrations above a certain level, some of these elements could be harmful to a range of biota (the level often depends on the type, species and race). Essential trace elements are by definition not relevant when the soil material is to be used for non-productive uses such as earthworks.

4.4.3.5 Potentially harmful substances

The potentially harmful substances likely to be present depend on the history of the site (e.g. current and past anthropogenic uses, parent material or pedological processes and whether the site has been subject to diffuse sources of contamination). Contaminants typically associated with a number of site types are listed in Annex C. These suggestions are not exhaustive and should be regarded as indicative only. The assessor should decide what substances might be present on a site-by-site basis. Further guidance on site use/contaminant linkages is provided in ISO 18400-202. The arrangement of the Tables referenced in this sub-clause is indicated in Figure 4. Inorganic substances are listed in Tables A.3 to A.8. Organic substances are listed in Tables A.9 to A.11.

Total concentrations of potentially harmful elements i.e. the total of the element present in all chemical forms and irrespective of its location in the soil material, including that incorporated into silicate minerals, are dealt with in Table A.4. Determination of these “true” total concentrations requires use of an instrumental technique such as X-ray fluorescence analysis or a powerful solvent combination, such as a mixture of hydrofluoric and perchloric acids. The use of this solvent presents many practical problems and for many purposes in environmental assessment, pseudo-total concentrations suffice (see Table A.5). These are determined using a strong acid or combination of acids, but they typically leave a small insoluble residue with some soil materials. Depending on the element and the matrix, these typically yield about 70 % to 90 % of the “true” total concentration (it can be lower for those elements which are present predominately bound in silicate or aluminate lattices). When comparisons with guideline values are required for particular soil uses, it is essential to determine whether “pseudo-total” or “total” concentrations are required.

Concentrations extractable with complexing agents such as diethylenetriaminepentaacetic acid (DTPA) (see Table A.6) and weak extractants (see Table A.7) such as calcium chloride solution are employed when “availability” to plants is to be assessed.

Finally, concentrations extractable in water (see Table A.8) are relevant to an assessment of potential leachability into the environment. It is important to recognize that when compounds of limited solubility are present (e.g. gypsum), the apparent amount soluble depends on the water:soil ratio employed in the tests. A detailed discussion of soil leaching and extraction tests is provided in ISO 15175. Qualitative methods for assessing potential leaching risks from non-reactive contaminants (e.g. nitrate and chloride), heavy metals (e.g. cadmium) and organic compounds are described in ISO 15175.

The range of organic chemicals that might be present is very wide. Thus only a few are listed in Tables A.9 to A.11: essentially those for which International Standard methods of analysis exist or are in preparation. For a general discussion about analyses for organic substances, see 4.4.3.1.

NOTE Guidance on the choice of petroleum hydrocarbon fractions that should be analysed is provided in ISO 11504.

4.4.3.6 Substances aggressive to construction materials

When soil materials are used on construction sites it might be necessary to determine the aggressiveness of the soil to construction materials such as cement-based materials, metals and plastics. Parameters that might be of importance include acid-soluble and water-soluble sulphate, Redox potentials and hydrocarbons depending on the material potentially at risk. Relevant guidance regarding available analytical methods can usually be found in geotechnical standards.

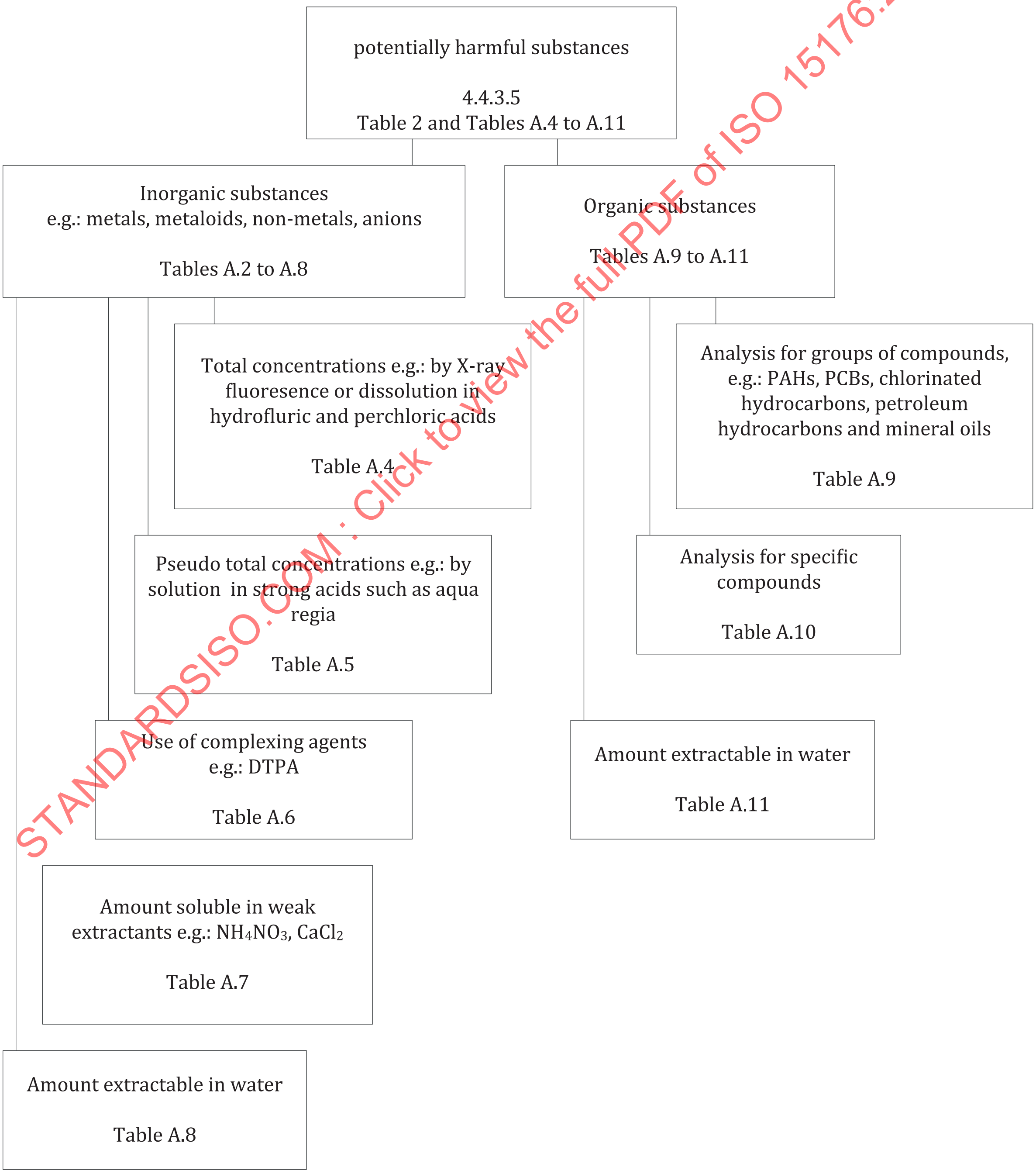

Figure 4 — Detection and measurement of potentially harmful substances

4.4.4 Physical characteristics

Physical characteristics that it might be desirable to determine when soil materials are to be re-used are listed in Table A.12. In the case of soil and other soil materials that are to be excavated, some before-placement measurements are necessarily made in situ and some on samples taken for testing in the laboratory (ex situ). In some cases, a property can be measured either in situ or ex situ.

The assessor should determine which is the more appropriate in each case. In the case of treated soil materials and manufactured soils, only ex situ measurements are possible.

Some of the characteristics to be measured influence the geotechnical and handling properties of the soil material. International Standards and guidance on geotechnics in civil engineering, e.g. ISO 14688-1 and ISO 14689, could also be of relevance.

At the target site, it could be desirable to measure some characteristics before the imported soil material is placed, in order to ensure that the application is suitable (again if the depth of soil material to be placed is particularly high, some geotechnical measurements might be desirable). Other measurements to be made concern, for example the “health” of the soil material as a growth medium. If the soil material is being used in earthworks, then appropriate geotechnical measurements on the placed soil could be required, depending on the precise function(s) it is required to perform.

4.4.5 Biological characteristics

Some biological characteristics that might be desirable to measure when soil material is to have a productive use or a use for nature protection and landscape conservation are listed in Table A.13. It is assumed that these are not relevant when soil is to be used for a non-productive use (e.g. earthworks) but note that such fill might underlie more productive layers and that some biological characteristics might then be relevant. Guidance on sampling soil for biological assessments is provided in ISO 18400-206.

It is unlikely that biological measurements will be made on a routine basis when soil materials are to be re-used. However, biological measurements which determine toxicity directly or indirectly can be particularly valuable, for example:

— when there are complex mixtures of potentially harmful substances present in soil materials and it is difficult to determine from simple analytical measurements what additive or synergistic effects there might be on living organisms;

— effects, such as the phytotoxic effects of zinc, nickel and copper, alone and in combination, can be mitigated by pH and the presence of organic matter or clay minerals, and consequently it is difficult to predict what effects there will be in practice (direct measurements of toxicity can avoid the need for costly conservative assumptions);

— treatment has resulted in the presence of residual concentrations of substances (e.g. hydrocarbons) above limiting concentrations; it might be possible to demonstrate that nevertheless there is no residual toxicity;

— treatment could have resulted in formation of difficult to identify intermediates and final products;

— it is necessary to demonstrate that mitigating measures, e.g. addition of lime or organic matter to soil, have had their desired effect.

Of course, measurements before and after any treatment or amendment of soil are often desirable in order to demonstrate any beneficial effect.

It should be noted that:

— conditions can change over time. For example, degradation of organic matter and changing pH can alter the availability of substances to biological systems and thus toxicity might increase with time. In contrast, other natural mechanisms such as biodegradation might reduce concentrations of toxic substances, leading to an overall lowering of toxicity. Thus, repeat measurements after a number of years could be desirable;

— an absence of toxicity to plants does not necessarily mean that the soil is "healthy". Toxicity to soil micro-organisms might occur at concentrations below those that affect plants directly, and this could adversely affect the overall "health" of the soil, thus lowering productivity.

5 Data quality, handling and evaluation

The purpose of characterizing soil and soil materials as described in this document is usually to enable judgements to be made about its suitability for a defined use (e.g. arable farming, domestic gardens and construction material). These judgements can be made by reference to published international or national standards that set out physical, chemical or other criteria that shall be met, or against criteria set on a site-specific basis. When contaminants are present that might be harmful to human health or the environment, it can also be made on the basis of a site-specific qualitative, semi-quantitative or fully quantitative risk assessment. In many jurisdictions, formal guidance on such assessments has been published. In some cases, this guidance fits within a legislative framework. Guidance has also been provided by professional organizations and some standardization bodies.

Before any judgement can be made about the suitability of the soil material for use, the sufficiency of data to be used should be evaluated. The data should be sufficient in terms of:

— type (e.g. if chemical: total, pseudo-total, water-soluble, as appropriate);

— quantity (e.g. number of sampling locations and number of samples from each location);

— quality of tests, analysis and assessment;

— sound sampling and analytical strategies properly implemented.

These requirements apply equally to "information" such as that obtained from desk studies and on-site observations, and to numerical data from measurement programmes. The sufficiency of the information and database on which the assessment is to be made is best guaranteed by careful planning of the necessary investigations and the use of appropriate quality control and quality assurance procedures such as, for example in the case of sampling, those in ISO 18400-106.

The assessor should bear in mind the disproportionate costs and time delays that can result if it is necessary to carry out an additional sampling exercise if, for example, a particular parameter is not determined when the opportunity is available.

Before investigation of the soil or other material is started, it is essential to:

— define the objectives of the investigation;

— establish a sampling strategy in terms of types of samples to be obtained, sampling locations, and how samples are to be handled consistent with these objectives (more detailed guidance on sampling is provided in 4.3);

— establish an analytical and testing strategy taking into account the guidance in this and other relevant International Standards;

— set data quality objectives consistent with the assessment procedure to be used.

It is essential to have sufficient data. The confidence that can be attached to any judgements made, for example through comparison with the requirements of a published standard (the requirements in such standards regarding sampling should always be followed) or a site-specific risk assessment, is no greater than the confidence there is in the representativeness of the data. This applies equally to soil that is being assessed in situ before excavation and to the stream of treated material arising from a process-based treatment method. For example, if because of the limited amount of sampling carried out, there is only 25 % confidence that a "hot spot" of contamination occupying 5 % of the volume of material has been identified, then comparisons with published criteria could be unsound. In the case of material arising from a process-based treatment method, a statistically sound basis for sampling should be agreed before treatment starts.

Care should be taken in deciding what statistical expression(s) of the data is to be used in the assessment, as this can affect the choice of sampling procedures. For example, for agricultural purposes average compositions could be appropriate, and thus a composite sampling method that gives a good estimate of this “property” is likely to be appropriate (see ISO 18400-104 and ISO 18400-205).

For human health assessments, a statistic such as the “95 % upper confidence level of the mean” or the “maximum observed value” is more likely to be required and thus a different sampling procedure will be required (see ISO 18400-104).

The quality of the data to be used can be assured by:

— setting formal data quality objectives (e.g. for accuracy, reproducibility, etc.);

— using standardized analytical and testing methods such as those listed in this document or, where International Standard methods are not available, those published by national standardization or equivalent bodies;

— using laboratories with accreditation meeting the requirements of ISO/IEC 17025;

— using laboratories that take part in relevant proficiency testing schemes;

— the commissioning agent employing its own quality assurance procedures.

Often, the reports presenting the results of assessments are scrutinized by regulators and other interested parties, including the general public. It is important, therefore, that such reports be of a high technical standard but also take account of the diverse, and often non-technical, readership. Use should therefore be made of tabular summaries, graphical and other means to present the data in ways that make the data as easy as is practicable to assimilate and assess.

6 Using this document

Some examples of assessment using the principles of this document are provided in Annex D.

Annex A
(informative)

Relevant parameters required for the chemical, physical and biological characterization of materials for re-use

The tables in this annex list parameters that might be relevant in various situations and International Standards that might be used to determine them. The guidance provided is not prescriptive. It is for the assessor to decide what to determine and how, including whether to use methods not listed here.

Table A.1 — Basic characteristics

Parameter	Use of soil material		International Standard
	Natural (productive) function	Construction (e.g. earth works)	
Petrographic characteristics	X	X	—
Mineralogy	X	X	—
Nature of parent material	X	X	—
pH	X	X	ISO 10390
Redox potential	X	X	ISO 11271
Salinity	X	X	—
Sodium	X	—	—
Total organic carbon (TOC)	X	X	ISO 10694
Organic carbon	X	—	ISO 14235
Loss on ignition at specified temperature(s)	X	X	—
Cation exchange capacity	X	—	ISO 11260 ISO 13536
Water content	X	X	ISO 11465 ISO 11461
Dry matter content	X	X	ISO 11465
Carbonate content	X	—	ISO 10693
Specific electrical conductivity	X	X	ISO 11265
Exchangeable acidity	X	—	ISO 14254
Acid soluble sulphate	—	X	ISO 11048
Water soluble sulphate (1:2 extract)	—	X	ISO 11048
Potential acidity	X	X	—
NOTE “X” indicates that the information or characteristic could be relevant, with decisions about relevance being made on a case-by-case basis on the basis of expert advice when necessary.			

Table A.2 — Nutrients

Parameters	Speciation	Use of soil material		International Standard
		Natural (productive) function	Construction (e.g. earthworks)	
Calcium	—	X	—	—
Magnesium	—	X	—	—
Sodium	—	X	—	—
Potassium	total	X	—	—
	water-soluble	X	X	—
	weak extractant	X	—	—
Nitrogen	total	X	X	ISO 11261 ISO 13878
	nitrite	X	—	ISO 14256-2
	nitrate	X	—	ISO 14256-2
	ammonium	X	—	ISO 14256-2
	water-soluble	X	X	ISO 14255
Phosphorus	total	X	—	—
	weak extractants	X	—	ISO 11263
	water-soluble	X	—	—
Sulfur	elemental	—	—	—
	total	X	X	ISO 15178
	water-soluble sulfate	X	X	ISO 11048
	dilute acid-soluble sulfate	X	X	ISO 11048

NOTE “X” indicates that the information or characteristic could be relevant, with decisions about relevance being made on a case-by-case basis on the basis of expert advice when necessary.

Table A.3 — Essential trace elements for plant nutrition

Element	Form	International Standard	
		Extraction method	Measurement method
Boron	—	[a]	—
Cobalt	weak extractant	[a]	[a]
	strong acid	ISO 11466	ISO 11047
Copper	weak extractant	[a]	—*
	strong acid	ISO 11466	ISO 11047
Iron	weak extractant	[b]	—*
	strong acid	[a]	—**
Manganese	weak extractant	[a]	—*
	strong acid	ISO 11466	ISO 11047
Molybdenum	—	[b]	—**
Selenium	—	[b]	—**
Zinc	weak extractant	[a]	—*
	strong acid	ISO 11466	ISO 11047

NOTE Essential trace elements are only relevant where the soil or other soil material is to have a productive function.

[a] Weak extractant methods for productive purpose need to be developed.

[b] Strong acid methods need to be developed.

Table A.4 — Total concentrations of potentially harmful inorganic substances

Substance group	Element/ form	Use of soil material: Natural (pro-duc-tive) function	Use of soil material: Construction (e.g. earth-works)	Extraction/preparation method		Measurement method
Metals and met-alloids	Arsenic	X	X	X-ray fluorescence HF + $HClO_4$	ISO 14869-1 ISO 14869-2	ISO 14869-1
	Barium	X	X	X-ray fluorescence HF + $HClO_4$	ISO 14869-1 ISO 14869-2	ISO 14869-1
	Cadmium	X	X	X-ray fluorescence HF + $HClO_4$	ISO 14869-1 ISO 14869-2	ISO 14869-1 ISO 11047
	Chromium	X	X	X-ray fluorescence HF + $HClO_4$	ISO 14869-1 ISO 14869-2	ISO 14869-1 ISO 11047
	Cobalt	X	X	X-ray fluorescence HF + $HClO_4$	ISO 14869-1 ISO 14869-2	ISO 14869-1 ISO 11047
	Copper	X	X	X-ray fluorescence HF + $HClO_4$	ISO 14869-1 ISO 14869-2	ISO 14869-1 ISO 11047
	Lead	X	X	X-ray fluorescence HF + $HClO_4$	ISO 14869-1 ISO 14869-2	ISO 14869-1 ISO 11047
	Manganese	X	X	X-ray fluorescence HF + $HClO_4$	ISO 14869-1 ISO 14869-2	ISO 14869-1 ISO 11047
	Mercury	X	X	X-ray fluorescence HF + $HClO_4$	ISO 14869-1 ISO 14869-2	—
	Nickel	X	X	X-ray fluorescence HF + $HClO_4$	ISO 14869-1 ISO 14869-2	—
	Selenium	X	X	X-ray fluorescence HF + $HClO_4$	ISO 14869-1 ISO 14869-2	—
	Silver	X	X	—		—
	Thallium	X	X	—		—
	Zinc	X	X	X-ray fluorescence HF + $HClO_4$	ISO 14869-1 ISO 14869-2	ISO 14869-1 ISO 11047
Non-metals	Boron	X	—	—		—
	Phosphorus	X	—	—		ISO 11263
	Sulfur	X	X	X-ray fluorescence Dry combustion	ISO 14869-1	ISO 14869-1 ISO 15178
Anions	Cyanide	X	X	—		ISO 11262 ISO 17380
	Chloride	X	X	—		—
	Sulfate	X	X	—		ISO 11048

NOTE “X” indicates that the information or characteristic could be relevant, with decisions about relevance being made on a case-by-case basis on the basis of expert advice when necessary.

Table A.5 — Pseudo-total concentrations of potentially harmful inorganic substances

Substance group	Element/form	Use of soil material		Extraction/preparation method	Measurement method
		Natural (productive) function	Construction (e.g. earthworks)		
Metals and metalloids	Arsenic	X	X	—	—
	Barium	X	X	—	—
	Boron	X	X	—	—
	Cadmium	X	X	Aqua regia ISO 11466	ISO 11047
	Chromium	X	X	Aqua regia ISO 11466	ISO 11047
	Cobalt	X	X	Aqua regia ISO 11466	ISO 11047
	Copper	X	X	Aqua regia ISO 11466	ISO 11047
	Lead	X	X	Aqua regia ISO 11466	ISO 11047
	Manganese	X	X	Aqua regia ISO 11466	ISO 11047
	Mercury	X	X	—	—
	Molybdenum	X	X	—	—
	Nickel	X	X	—	—
	Selenium	X	X	—	—
	Silver	X	X	—	—
	Thallium	X	X	—	—
	Zinc	X	X	Aqua regia ISO 11466	ISO 11047
Non-met-als'	Boron	X	X	—	—
	Carbon	—	—	—	—
	Phosphorus	X	—	—	—
Anions	Cyanide	X	X	—	—
	Sulfate	X	X	Dilute acid ISO 11048	ISO 11048

NOTE 1 "X" indicates that the information or characteristic could be relevant, with decisions about relevance being made on a case-by-case basis on the basis of expert advice when necessary.

NOTE 2 For some purposes, an alternative to extraction with aqua regia (ISO 11466) might be extraction with boiling 2 mol/l nitric acid. However, there is no International Standard for this method.

Table A.6 — Potentially harmful inorganic substances extracted with complexing agents

Substance group	Element/form	Use of soil material		Extraction/preparation method	Measurement method
		Natural (productive) function	Construction (e.g. earthworks)		
Metals and metalloids	Aluminium	X	not relevant	—	—
	Arsenic	X		—	—
	Barium	X		—	—
	Cadmium	X		DTPA ISO 14870	ISO 11047
	Chromium	X		DTPA ISO 14870	ISO 11047
	Cobalt	X		—	ISO 11047
	Copper	X		DTPA ISO 14870	ISO 11047
	Iron	X		DTPA ISO 14870	—
	Lead	X		DTPA ISO 14870	ISO 11047
	Manganese	X		DTPA ISO 14870	ISO 11047
	Mercury	X		—	—
	Nickel	X		DTPA ISO 14870	–
	Selenium	X		—	—
	Silver	X		—	—
	Thallium	X		—	—
	Zinc	X		DTPA ISO 14870	ISO 11047

NOTE “X” indicates that the information or characteristic could be relevant, with decisions about relevance being made on a case-by-case basis on the basis of expert advice when necessary.

Table A.7 — Potentially harmful inorganic substances extracted with weak extractants

Substance group	Element/form	Use of soil material		Extraction/preparation method	Measurement method
		Natural productive function	Construction (e.g. earthworks)		
Metals and metalloids	Aluminium	X	not relevant	e.g. NH_4NO_3, $NaNO_3$, $CaCl_2$, KCl	—
	Arsenic	X		e.g. NH_4NO_3, $NaNO_3$, $CaCl_2$, KCl	—
	Barium	X		e.g. NH_4NO_3, $NaNO_3$, $CaCl_2$, KCl	—
	Cadmium	X		e.g. NH_4NO_3, $NaNO_3$, $CaCl_2$, KCl	ISO 11047
	Chromium	X		e.g. NH_4NO_3, $NaNO_3$, $CaCl_2$, KCl	ISO 11047
	Cobalt	X		e.g. NH_4NO_3, $NaNO_3$, $CaCl_2$, KCl	ISO 11047
	Copper	X		e.g. NH_4NO_3, $NaNO_3$, $CaCl_2$, KCl	ISO 11047
	Iron	X		e.g. NH_4NO_3, $NaNO_3$, $CaCl_2$, KCl	—
	Lead	X		e.g. NH_4NO_3, $NaNO_3$, $CaCl_2$, KCl	ISO 11047
	Manganese	X		e.g. NH_4NO_3, $NaNO_3$, $CaCl_2$, KCl	ISO 11047
	Mercury	X		e.g. NH_4NO_3, $NaNO_3$, $CaCl_2$, KCl	—
	Nickel	X		e.g. NH_4NO_3, $NaNO_3$, $CaCl_2$, KCl	—
	Selenium	X		e.g. NH_4NO_3, $NaNO_3$, $CaCl_2$, KCl	—
	Silver	X		e.g. NH_4NO_3, $NaNO_3$, $CaCl_2$, KCl	—
	Thallium	X		e.g. NH_4NO_3, $NaNO_3$, $CaCl_2$, KCl	—
	Zinc	X		e.g. NH_4NO_3, $NaNO_3$, $CaCl_2$, KCl	ISO 11047

NOTE “X” indicates that the information or characteristic could be relevant, with decisions about relevance being made on a case-by-case basis on the basis of expert advice when necessary.

Table A.8 — Potentially harmful inorganic substances extracted with water

Substance class	Element/ species	Use of soil material		Extraction method see Notes	International Standard
		Natural (pro-ductive) function	Construction (e.g. earthworks)		
Metals and metalloids	Aluminium	X	X		—
	Arsenic	X	X		—
	Barium	X	X		—
	Cadmium	X	X		ISO 11047
	Chromium	X	X		ISO 11047
	Cobalt	X	X		ISO 11047
	Copper	X	X		ISO 11047
	Iron	X	X		—
	Lead	X	X		ISO 11047
	Manganese	X	X		ISO 11047
	Mercury	X	X		—
	Nickel	X	X		—
	Selenium	X	X		—
	Silver	X	X		—
	Thallium	X	X		—
	Zinc	X	X		ISO 11047
Non-metals'	Phosphorus	X	X		—
	Sulfur	—	—		—
	Boron	X	—		—
Anions	Cyanides	X	X	—	—
	Sulfate	X	X	ISO 11048	ISO 11048
	Chloride	X	X		

NOTE 1 "X" indicates that the information or characteristic could be relevant, with decisions about relevance being made on a case-by-case basis on the basis of expert advice when necessary.

NOTE 2 There are many different extraction methods based on batch processes (e.g. shaking with fixed amount of water, sequential extractions, or columns). For a detailed discussion of methods see ISO 15175).

NOTE 3 There are a variety of analytical methods for water available as International Standards which might be applicable. However, it is important to confirm that they will work with the extracts obtained from a particular (contaminated) soil material.

Table A.9 — Methods for groups of potentially harmful organic substances

Substance group	Use of soil material		International Standard
	Natural (productive) function	Construction (e.g. earthworks)	
Volatile aromatic hydrocarbons	X	X	ISO 15009
Petroleum hydrocarbons	X	X	ISO 16558-1 ISO TS 16558-2
Mineral oil content	X	X	—
C10 – C40 hydrocarbons	X	X	ISO 16703
Polycyclic aromatic hydrocarbons (PAHs) - "total"	X	X	ISO 13859 ISO 18287
Halogenated hydrocarbons	X	X	ISO 15009

Table A.9 *(continued)*

Substance group	Use of soil material		International Standard
	Natural (productive) function	Construction (e.g. earthworks)	
Phenols	X	X	ISO 11079 ISO TS 17182
Chlorinated phenols	X	X	ISO 14154 ISO TS 17182
Phthalates	X	X	—
Polychlorinated biphenyls (PCBs)	X	X	ISO 10382 ISO 13876
Persistent pesticides	X	X	ISO 10382
Triazines and phenyl urea herbicides	X	X	ISO 11264
NOTE “X” indicates that the information or characteristic could be relevant, with decisions about relevance being made on a case-by-case basis on the basis of expert advice when necessary.			

Table A.10 — Methods for specific potentially harmful organic substances

Substance(s)	Use of soil material		International Standard
	Natural (productive) function	Construction (e.g. earthworks)	
Benzene	X	X	—
Ethylbenzene	X	X	—
Toluene	X	X	—
Xylenes	X	X	—
Methyl *t*-butyl ether (MTBE)	X	X	—
Individual polycyclic aromatic hydrocarbons (PAHs)	X	X	—
Individual polychlorinated biphenyls	X	X	—
Pentachlorophenol	X	X	ISO 14154
NOTE “X” indicates that the information or characteristic could be relevant, with decisions about relevance being made on a case-by-case basis on the basis of expert advice when necessary.			

Table A.11 — Potentially harmful organic substances and groups of substances soluble in water

Substance group	Use of soil material		International Standard	
	Natural (productive) function	Construction (e.g. earthworks)	Extraction method	Measurement method
Groups of compounds:			see Note 2	see Note 3
Volatile aromatic hydrocarbons	X	X		
Petroleum hydrocarbons	X	X		
Mineral oil content	X	X		
Polycyclic aromatic hydrocarbons (PAHs)	X	X		
Halogenated hydrocarbons	X	X		
Phenols	X	X		
Chlorinated phenols	X	X		
Polychlorinated biphenyls (PCBs)	X	X		

Table A.11 *(continued)*

Substance group	Use of soil material		International Standard	
	Natural (productive) function	**Construction** (e.g. earthworks)	**Extraction method**	**Measurement method**
Persistent pesticides	X	X		
Triazines and phenyl urea herbicides	X	X		
Specific compounds:				
Benzene	X	X		
Ethylbenzene	X	X		
Toluene	X	X		
Xylenes	X	X		
Methyl *t*-butyl ether (MTBE)	X	X		
Individual PAHs	X	X		
Individual PCBs	X	X		
Phenol	X	X		
Pentachlorophenol	X	X		

NOTE 1 "X" indicates that the information or characteristic could be relevant, with decisions about relevance being made on a case-by-case basis on the basis of expert advice when necessary.

NOTE 2 There are many different extraction methods based on batch processes (e.g. shaking with fixed amount of water, sequential extractions, or columns). For a detailed discussion see ISO 15175.

NOTE 3 There are a variety of analytical methods for water available as International Standards which could be applicable. However, it is important to confirm that they will work with the extracts obtained from a particular (contaminated) soil material.

Table A.12 — Physical parameters

	Parameter	Source site		Target site				International Standard
		Before placement		Before placement		After placement		
		Natural (productive) function	Construction (e.g. earthworks)	Natural (productive) function	Construction (e.g. earthworks)	Natural (productive) function	Construction (e.g. earthworks)	
In situ	Soil profile description	X	X	X	X	X	X–	—
	Texture	X	—	X	—	—	—	—
	Proportion of coarse material	X	—	X	—	—	—	—
	Electrical conductivity	X	—	X	—	—	—	—
	Redox potential	X	—	X	—	X	—	ISO 11271
	Water content	X	X	X	—	X	—	ISO 10573
	Presence of roots etc.	X	X	X	—	X	—	—
	Bulk density	X	X	—	—	X	X	ISO 11272
	Hydraulic conductivity	—	—	X	—	X	—	ISO 17312
	Pore water pressure	—	—	X	—	X	—	ISO 11276
	Plasticity index	X	X	X	X	X	—	—
	Consistence	X	—	X	—	X	—	—
	Structure stability	X	—	X	—	X	—	—
	Infiltration rate	—	—	X	X	X	X	—
Ex situ	Particle size distribution	—	—	X	X	—	X	ISO 11277[a]
	Aggregate stability	—	—	X	X	X	—	ISO 10930
	Coarse material	—	—	X	X	—	X	—
	Bulk density	—	—	X	X	—	—	ISO 11272
	Water content	—	—	X	X	—	—	ISO 11461
	Particle density	—	—	X	X	—	—	ISO 11508
	Water-retention characteristics	—	—	X	X	(X)	—	ISO 11274[b]

NOTE "X" indicates that the information or characteristic could be relevant, with decisions about relevance being made on a case-by-case basis on the basis of expert advice when necessary.

[a] Under preparation. Stage at the time of publication: ISO/DIS 11277:2019.

[b] Under preparation. Stage at the time of publication: ISO/FDIS 11274:2019.

Table A.13 — Biological measurements on productive soil materials

General characteristic	Specific measurement/example	Relevant International Standard
Microbial activity	Respiration	—
	Mineralization of organic chemicals	ISO 14239
	Rate of decomposition of organic matter	—
	Soil microbial mass	ISO 14240-1, ISO 14240-2
	Biodegradation under anaerobic conditions	ISO 15473
	Biodegradation under aerobic conditions	ISO 11266

Table A.13 *(continued)*

General characteristic	Specific measurement/example	Relevant International Standard
	Nitrogen mineralization	ISO 14238
Toxicity to plants	Inhibition of root growth	ISO 11269-1
	Effects on emergence and growth of higher plants	ISO 11269-2
	Germination	—
	Field tests on higher plants	—
Toxicity to micro-organisms	Inhibition of microbial activity Change of population diversity	ISO 14238 ISO 16072 ISO 17155
Presence of pests	Nematodes	—
	Fungi	—
Microbial biomass	Induced respiration method Fumigation-extraction method	ISO 14240-1 ISO 14240-2
Toxicity to macro-fauna	Acute toxicity to earthworms (*Eisenia fetida*) Effects on reproduction of earthworms (*Eisenia fetida*) Effects on earthworms (*Eisenia fetida*) — Field testing Inhibition of reproduction of Collembola	ISO 11268-1 ISO 11268-2 ISO 11268-3 ISO 11267

Annex B
(normative)

Good practice in the re-use of soil materials

B.1 General

This annex highlights key technical factors influencing the satisfactory re-use of soils and other soil materials. Suggestions are also made regarding the requirements for continued surveillance once soil materials have been placed at the target site to ensure that the objectives of re-use are achieved over the longer term.

The guidance in this annex is applicable mainly to natural soils and soil material. It is based on practice and experience in temperate climates; however, due regard should be paid to local climatic conditions. The guidance is not exhaustive; for more details, reference should be made to authoritative guidance on the use of topsoils and the reclamation of degraded or derelict land.

In addition, it is essential that adequate site supervision be provided to ensure that all planned procedures and activities are put into place.

B.2 General guidance for re-use

B.2.1 The principles

Whenever possible, the following general principles should apply when soils and other soil materials are to be re-used:

— avoidance and/or reduction of excavation of soil or removal of soil material from site;

— avoidance of damage during handling, storage or placement;

— usefulness on the target site;

— harmlessness on the target site.

B.2.2 Avoidance and/or reduction of excavation of soil or removal from of soil material from site

Movement of soil material from the excavated site should be avoided whenever possible by, in order of priority:

— avoiding excavation;

— reducing the amount excavated;

— on-site use.

Use of excavated material within the construction site (mass balancing) reduces environmental impacts for example from waste disposal and traffic movements.

B.2.3 Avoidance of damage to soil material during handling, storage and placement

The ability of the soil structure to regenerate is limited. Detrimental structural changes, in particular of subsoil, can hence be irreversible. Therefore, soil intended to have a productive function should be handled in a way that as far as possible limits the extent and intensity of compaction.

Impairment of soil functions can be caused, for example, by:

— poor excavation practice;

— poor stockpiling practice;

— compaction by heavy machinery;

— soil erosion, when the vegetation is extinguished;

— introduction of harmful substances.

Worthwhile mitigating measures include the use of excavator mats or temporary haul roads, or storage places and vegetation cover.

B.2.4 Usefulness

Whenever possible, the use of the soil material should provide benefits at the target site. For example, restoration of degraded land, reclamation of mining areas, earthworks, soil improvement especially for agricultural use (e.g. increasing water-holding capacity, increasing depth of rooting zone, improving workability).

B.2.5 Harmlessness

When there is to be no change in intended land use at the target site, imported soil materials should not lead to a permanent reduction in performance of relevant soil functions.

When there is to be a change of use, the soil should be suitable for the new use. This can sometimes permit some change in performance of some soil functions.

The chemical, physical, biological and "basic" characteristics of the soil material should be used in evaluation of harmlessness. The concentrations of potentially harmful substances are usually decisive for harmless re-use. The concentration should not normally be adjusted by mixing with less contaminated material. Beside hazardous substances soil material rich in organic compounds or organic material such as peat also need special handling.

The concept of harmlessness is illustrated in the examples described in Annex D.

B.3 Handling and storing excavated soil and other soil materials

When soil or soil material is to be excavated, any plants growing on the area to be excavated should first be removed.

Biologically active topsoil, subsoil and other soil layers with distinct properties [for example soils belonging to different suitability classes (see Annex D)] should be excavated, stored and re-used separately. To limit compaction, the subsoil should be excavated in a single operation without intermediate trafficking.

During excavation works the consistency of the soil, which is largely governed by the moisture content, should be compatible with the planned handling, transport and placement procedures. Soil should not be handled when it is wetter than the lower plastic limit. After wet weather, neither topsoils nor sub-soils should be allowed to dry out completely.

Intermediate storage of soil material always increases the risk of quality deterioration and should be avoided if possible. If intermediate storage of soil material is required, it should be protected from compaction and waterlogging by limiting the height of the stockpile (to a maximum of 2 m in the case of humus-rich soil), adopting a profile that limits infiltration and erosion, and by limiting storage duration. In cases of prolonged storage (e.g. more than 6 months), the stack should be planted with deep rooting, frost-resistant (where relevant) and water-consuming plants and weed growth should be controlled to prevent a build-up of seeds in the stored material. The latter should be achieved by mechanical means rather than by use of herbicides, with a balance being drawn between the risks of pollution and mechanical damage to the soil.

B.4 Placement at the target site

The success of soil movement and re-use is mainly determined by the chemical and physical properties of the newly deposited soil layer. A pedologically well-founded selection of appropriate soil material to be added, and the proper handling of it and of the soil materials on the target site, are the essential keys to success.

Mechanical effects during filling can cause changes to the soil at the target site. Impairment of soil function can be caused by compaction. The soil structure stability often depends on soil texture and soil moisture. There can be a reduction in pore volume, a change in pore size distribution and an interrupted continuity of pores. The water and air balance as well as the rooting capability can be impaired, soil pores clogged and the erodability increased. Since newly deposited soils often have poor infiltration ability, there can be an increased risk of run-off and consequently increased erosion in heavy rain.

Soil material used for reclamation should usually be suitable to restore the native soil quality of the target site, at least in the long run. However, note that in some reclamations of degraded land or in creation of particular ecosystems this might not be a requirement.

Soil materials should be handled and placed in a way that avoids compaction on the target site. In addition, care should be taken to avoid introduction of unnecessary nutrient inputs that might lead to polluting run-off or promote nutrient-hungry plants at the expense of the desired, less nutrient-dependent species.

If organic material or soil material rich in organic compounds is excavated and placed elsewhere, the possibility of mineralisation and release of climate changing gases (carbon dioxide, methane, nitrous oxide) should be taken into account. Particularly, if peaty materials are removed from wet conditions to aerated conditions, a rapid decomposition takes place.

The probability of success of the re-use is generally enhanced if the following criteria are observed:

— large amelioration and recultivation areas are subdivided into sectors of a maximum of one hectare and plant cover established;

— soil material is not applied by hydraulic fill or as a suspension;

— the characteristics of the soil material to be applied are similar to those of the soil at the target site;

— reclamation works are performed only in dry weather and only when the topsoil, the subsoil and the filled soil material are dry;

— soil material is placed in layers no more than about 0,2 m thick at a time;

— if a total depth of more than about 0,2 m is to be applied, any topsoil already present is first removed (soil excavation should be carried out as a single action) and, if necessary, the subsoil broken up prior to applying the soil material;

— removed topsoil is replaced afterwards;

— care is taken when soil is placed on slopes to avoid risks of erosion and run-off;

— compaction by heavy vehicles is avoided (this can require use of large tyres, or other techniques. - crawler excavators are especially suitable);

— following soil application the area is levelled periodically, whilst taking care not to promote erosion where the soil is placed on a slope;

— if necessary, soil pH and base saturation are adjusted with either lime or gypsum, respectively.

B.5 After-care of the target site

Good and lasting productivity from the placed soil requires that appropriate pH, nutrient and trace element concentrations and physical characteristics of the soil be first established and then maintained. The structure, mechanical loading capacity, erosion resistance and pore continuity of the improved and recultivated soil can be optimized and maintained by adhering to the following principles in successive years of land utilisation:

— the soil structure is often very easily damaged during the first few years after placement (use of a special soil conserving cultivation rotation, adapted to the soil properties is thus of prime importance - for the first three years, agricultural land should be cultivated with e.g. legume or seed mixtures with a high proportion of legumes);

— adjustment of the organic matter content of the topsoil to a level appropriate to the end use via suitable crop rotations and addition of organic manures and other soil improvers (rates of manure addition should be such that the risk of nutrient leaching is minimized with the site drainage being designed to minimize the potential for pollution to occur);

— choice of plants that promote development of soil structure and drainage;

— use of legumes and other plants that promote nutrient production and retention;

— conducting land utilisation and maintenance measures only on appropriately dry soil;

— remedying soil compaction and waterlogging by mechanical loosening and/or partial appropriate draining.

Annex C
(informative)

Guidance on determination of the scope of investigation needed before excavation of soil materials

C.1 General

This annex describes a possible approach to the determination of the need for, and scope of, an investigation of soil materials which could require excavation. The materials to be excavated could be natural soils or fill comprising relocated soils and/or previously deposited waste materials.

General guidance on the investigation and assessment of soil materials that are to be excavated is given in Clause 4. Care should be taken, when following the approach suggested here, to adhere to relevant national requirements for site investigation and assessment, to make use of relevant international and national standards [for example ISO 18400 (all parts)], and to take account of any site-specific requirements of local regulatory authorities (e.g. physical planning, public health, environmental protection).

C.2 Determining the need for investigation

Before excavating soil or other soil material, it is necessary to decide whether it is likely to contain substances potentially harmful to human health or the environment. This decision should be based on a thorough review of the documentation available on the site itself and on neighbouring sites (migration of contaminants might have occurred). Based on the desk study and site reconnaissance (see ISO 18400-202), hypotheses about the probability of the presence of potentially harmful substances and their likely distribution can be developed. These hypotheses can be first tested by limited judgemental (targeted) sampling as part of an exploratory investigation and subsequently by a more detailed investigation if required, following, as appropriate, the guidance on sampling in the appropriate part of ISO 18400.

If the presence of elevated concentrations of potentially harmful substances or unacceptably high nutrient status in the soil material can be excluded on the basis of this desk study, subject to the views of local regulators and legislative requirements, investigations might not be required.

If the preliminary and exploratory investigations give reason to believe or demonstrate that potentially harmful substances are present, an investigation in accordance with ISO 18400-203 should be carried out.

Subject to the views of local regulators and legislative requirements, detailed investigations are generally not required if there is no indication of anthropogenic changes or geogenic substance accumulations, for example, when establishing building sites on areas which have not been used by industry or trade, for waste disposal or as military sites. However, it should be noted that some agricultural and horticultural sites can be contaminated (see ISO 18400-202 and ISO 18400-205) and that there is usually some contamination of surface soils in old residential areas.

In some jurisdictions it might also be unnecessary to carry out extensive assessments (subject to local regulations) if:

— soil excavated from areas with anthropogenically increased background concentrations is placed at the same depth within the soil profile and re-used on the site from which it was removed or on comparable sites in the region;

— soil excavated from areas with geogenically increased contents of potentially harmful substances is involved, provided it is used in areas where there are soils derived from the same parent rock;

— topsoil from family and house gardens is re-used within the same property;

— topsoil material from forestry areas is re-used for similar purposes.

C.3 Development of analytical strategies

Samples of soil materials should normally be analysed for their pseudo-total concentrations [e.g. metals soluble in strong acids such as aqua regia (ISO 11466)], availability to plants (concentrations soluble in weak extractants) or the environment (e.g. concentrations extractable in water) and in respect of the soil parameters that might influence their behaviour (e.g. pH value, percentage of organic material, clay content).

Guidance on potential contaminants in relation to the use(s) to which land has been subjected is provided in ISO 18400-202:2018 (Annex A). Care should be used in following all such listings, including those given here. They do not obviate the need for the assessor to think about what might be present on the site to be investigated, taking all available information into account.

It should be noted that “biological contaminants” in the form of vermin, vermin-carried pathogens [e.g. Weil’s disease (Leptospirosis)] and infected needles could be present in derelict areas (see ISO 18400-103).

When soil material is re-used for soil improvement or recultivation, the nutrients in the soil material should be considered. In some cases, use of organic soils (for example half-bog soils, low moor soils) can involve a risk of a high rate of nitrogen mineralization and of consequent leaching of nitrate into surface water or groundwaters.

In addition to the contents of potentially harmful substance, other characteristics governing the water, air and substance regime (e.g. field capacity, infiltration ability, air capacity, exchange capacity) as well as the ability of the soil to be cultivated (e.g. rock content) should be taken into account for soil material used for soil improvement or recultivation. This includes pH value, clay content (soil type), parent material and organic matter (humus) content.

Deposition of soil material containing proportions of e.g. sulphate rock (gypsum, anhydrite) or pyritic clay mineral can result in impairment of surface or groundwater quality at the target site.

Annex D
(informative)

Examples of classification and evaluation of soils and other soil materials

D.1 General

This annex provides two examples of how data obtained following the principles outlined in this document can be applied in temperate zones. D.2 to D.6 describe a particular approach and D.7 describes another approach. It should be noted that these approaches might conflict in parts with legislative requirements or codes of practice applicable in some jurisdictions.

D.2 The concept of suitability classes

Soils and other soil materials can be broadly classified in terms of their suitability for particular uses on the basis of their physical characteristics, contents of potentially harmful substances and nutrients, the type and composition of the parent material, and the conditions governing location.

D.3 Suitability classes depending on harmful substance content

D.3.1 Test criteria and suggested suitability classes

Test criteria comprise the pseudo-total contents of potentially harmful substances. For the evaluation of inorganic substances, pH values and soil type, and for organic pollutants, the organic matter content should also be determined. When the pH of the soil material is low, the mobile heavy metal contents (neutral salt extraction) should also be used in the evaluation.

It is important to recognise that soil materials never contain just one concentration value of a substance but rather a more or less wide range of concentrations. If the analytical results are to be compared to guideline values, the statistical expression (mean, median, percentile, maximum, range etc.) that is required and appropriate has to be clear (see ISO 18400-104).

Possible suitability classes are suggested in Table D.1. The scope of the suitability classes is described in D.3.2 to D.3.4 below.

Table D.1 — Suitability classes depending on the potentially harmful substance content

Suitability class		Maximum permitted concentration of potentially harmful substance
I	Unrestricted re-use	Background value (but see Note)
II	Restricted re-use	Generic requirements for potential use(s)
III	Restricted re-use subject to specified technical safety measures being employed	Generic requirements for the protection of surface or ground water resources
IV	Re-use not permitted; treat as waste	Limits applicable to waste treatment or waste disposal
NOTE In some jurisdictions, generic guideline values (to be applied with professional judgement) or legally binding limiting values might have been set somewhat above natural background values but at a level judged to pose minimal risks to defined potential human and ecological targets. In some jurisdictions these are known as soil screening values.		

D.3.2 Unrestricted re-use

Depending on the circumstances, the limiting concentrations of potentially harmful substances for unrestricted use of a soil material might be set on the basis that concentrations arising from anthropogenic sources (i.e. contaminants):

— should not exceed the substrate-specific background values for soils; or

— should not exceed the most restrictive generic guideline or standard value applicable in the jurisdiction (see Note to Table D.1).

When conforming to these values, it can be assumed that there will be no (unacceptable) impacts on the assets worthy of protection, such as humans, animals, plants or waters.

Soil materials with geogenically increased contents of potentially harmful substances constitute an exception. These materials can usually be applied to soils of the same parent material if, in view of their proposed subsequent use, precautionary values with regard to human health are not exceeded.

If there are any doubts about how "clean" the soil material is, it should not be considered suitable for unlimited use.

D.3.3 Restricted re-use

Restricted re-use of soil materials is sometimes permitted when the concentrations of potentially harmful substances exceed the background values of soils (or the generic value permitting unlimited use) but are below a specified higher value. This upper limit is typically established on the basis of the specific requirements for the potential possible uses and protected assets affected (e.g. on the basis of applicable national or regional, etc. guidelines or standards, or site-specific values).

Attention should be paid when depositing the soil material to a possible need to keep a minimum distance between the base of the deposited material and the highest groundwater level, taking into account local geology and hydrogeology and any local regulations, etc.

Soils in this class should only be used when it is proven safe to do so. They should not normally be used:

a) on soils with contents of potentially harmful substances below the background value;

b) in areas subject to flooding (e.g. flood-control reservoirs, diked areas);

c) in nature reserves;

d) in biosphere reserves;

e) on particularly sensitive areas, such as:

  — any area where there could be close contact between the material and humans, especially children, for example domestic gardens, kindergartens, school playing fields and sports fields (areas used for informal recreation, e.g. parklands, are usually less sensitive but can sometimes contain areas subject to more sensitive uses);

  — areas to be used for horticulture or agriculture;

  — established or proposed drinking water or medicinal spring protection areas.

In the case of soil material with high contents of natural humic substances, e.g. peat material, organic silt, special processes of reassembly should be used to avoid an intense mineralization. Intense mineralization can cause an inadvertent release of climate change relevant gases (carbon dioxide, methane and nitrous oxide) or of nitrate input in surface water or groundwater. Also, in the subsoil of terrestrial soils anaerobic conditions can evolve with several adverse effects.

