BS ISO 18400-205:2018

INTERNATIONAL STANDARD

ISO 18400-205

First edition
2018-10

Soil quality — Sampling —

Part 205: Guidance on the procedure for investigation of natural, near-natural and cultivated sites

Qualité du sol — Échantillonnage —

Partie 205: Recommandations relatives aux modes opératoires d'investigation des sites naturels, quasi naturels et cultivés

Reference number
ISO 18400-205:2018(E)

ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Fax: +41 22 749 09 47
Email: copyright@iso.org
Website: www.iso.org

Published in Switzerland

Contents

Page

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 2, *Sampling*.

This first edition of ISO 18400-205, together with ISO 18400-104 and ISO 18400-202, cancels and replaces the first edition of ISO 10381-4:2003, which has been technically and structurally revised. The new ISO 18400 series is based on a modular structure and cannot be compared to ISO 10381-1 clause by clause.

A list of all parts in the ISO 18400 series can be found on the ISO website.

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 group of standards providing guidance on site investigation in general, and sampling in particular, for the principal purpose of determining soil quality. It is intended to be used in conjunction with the other parts of the ISO 18400 series. The role/position of the standards within the total investigation programme is shown in Figure 1.

This document describes investigation and sampling procedures for determination of soil quality on natural, near natural and cultivated sites. Its structure is generally similar to that of ISO 18400-203 which provides guidance on the investigation of potentially contaminated sites. In accordance with ISO 18400-104, it recommends that investigations should be undertaken in three phases:

— preliminary investigation (desk study and site reconnaissance) in accordance with ISO 18400-202;

— exploratory investigation (this document);

— detailed site investigation (this document).

It is recognized that:

— the preliminary investigation needs to be no more detailed than required by the task in hand (objectives of the investigation), but some basic information is always required for reasons of legality, safety of those carrying out site work including site reconnaissance, and protection of the environment;

— the preliminary investigation might show that no intrusive investigation is required;

— an exploratory investigation might suffice in some cases with no requirement for a detailed investigation;

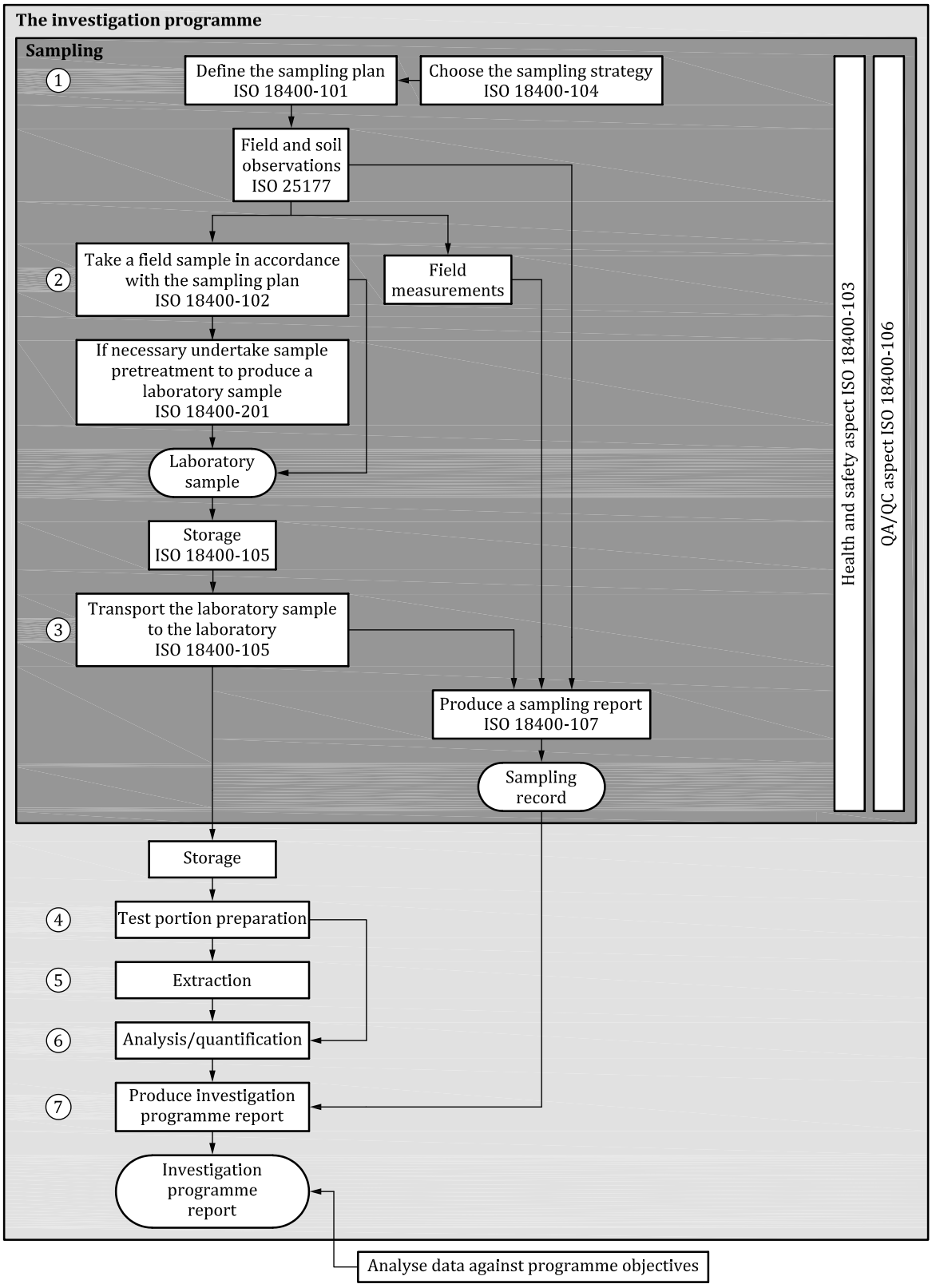
— an exploratory investigation is not always needed in advance of a detailed investigation;

— it might be desirable to carry out each phase of an investigation in stages;

— during any phase of an investigation it might become apparent that the site should be treated as a potentially contaminated site — decisions will then be required whether to proceed as planned, to delay the investigation, and/or carry out an investigation in accordance with ISO 18400-203.

The guidance also calls for the formulation of a conceptual site model as described in ISO 18400-202. This synthesis and interpretation of the available information needs to be no more detailed than required by the task in hand but helps in the design of intrusive phases of investigation. In practice, the investigator will always have a mental image of the site and formal development of the conceptual site model helps to reveal what could be serious flaws in this mental image.

NOTE Clauses 4, 5 and 6 provide guidance applicable to sampling on the generality of natural, near-natural and cultivated sites. Clause 7 provides additional guidance in relation to sampling for particular purposes (e.g. determination of mobile nitrogen) and soil types (e.g. peat soils).



NOTE 1 Numbers in circles define the key elements (1 to 7) of the investigation programme.

NOTE 2 Figure 1 displays a generic process which can be amended when necessary.

Figure 1 — Links between the essential elements of an investigation programme

INTERNATIONAL STANDARD **ISO 18400-205:2018(E)**

Soil quality — Sampling —

Part 205: Guidance on the procedure for investigation of natural, near-natural and cultivated sites

1 Scope

This document provides guidance on the sampling of soils of

— natural and near-natural sites,

— natural arboreal areas including forests and woods,

— areas used for agriculture (arable and pasture sites),

— areas used for horticulture (including domestic gardens, allotments), and

— areas used for special crop-cultivation, orchards, vineyards, commercial plantations and forests, etc.

It is applicable to

— soil investigations and evaluations in the field, and

— collection of samples for chemical, geochemical, physical, and biological characterization of soil and soil materials in the laboratory.

This document sets out appropriate strategies for the design of sampling programmes, field procedures and subsequent treatment of samples for transport and storage prior to sample pretreatment (e.g. drying, milling). It is intended to be used in conjunction with the other parts of the ISO 18400 series. Attention is, in particular, drawn to the requirements concerning collection, handling and storage of soil for assessment of biological functions in ISO 18400-206.

NOTE 1 Groundwater and surface water can be adversely impacted by agricultural and related activities, such as nitrates and pesticides, and by translocation of soil particles. In turn, knowledge about water quality can provide information about possible sources of groundwater contamination or contaminating run-off. Investigation of groundwater and surface water quality is outside of the scope of this document; relevant guidance is given in the ISO 5667 series of standards. ISO 15175 provides guidance on the relationship between soil properties and groundwater quality.

NOTE 2 It could also be appropriate to investigate ambient air, vegetation, potable water supplies and a variety of other media depending on the findings of the preliminary investigation.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 11074, *Soil quality — Vocabulary*

ISO 18400-103, *Soil quality — Sampling — Part 103: Safety*

ISO 18400-104:2018, *Soil quality — Sampling — Part 104: Strategies*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 11074 and ISO 18400-104 apply.

NOTE When the definitions in these two documents differ, those in ISO 18400-104 take precedence.

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 https://www.electropedia.org/

4 Objectives of sampling

The investigation, sampling and analytical strategies are determined mainly by

— the objective of the investigation, and

— current and previous soil/land use.

The objective of investigations can be various but might be:

— collection of information on general soil quality with regard to preservation and improvement of ecological soil functions;

— collection of information for evaluation of soil quality and nutrient supply or nutrient demand with regard to preservation and improvement of the productivity of soils;

— collection of information to manage and evaluate the effects of the addition of soil amendments materials such as sewage sludge;

— collection of information for soil mapping, classification and taxation;

— collection of information on the quality of forest and woodland (arboreal) soils in connection with study of damaged trees or other vegetation;

— collection of information for establishment and maintenance of soil monitoring areas;

— collection of information for replicate samples used for soil specimen banks or environmental specimen banks.

Further guidance about the setting of objectives for soil sampling is given in ISO 18400-104.

5 Principles, requirements and general considerations for soil sampling

5.1 General

This document should be used in conjunction with ISO 18400-104 which gives general guidance on the development of site investigation strategies and detailed guidance on sampling strategies.

This clause summarizes general principles, requirements and considerations for soil sampling which should be taken into account for natural, near-natural and cultivated sites.

The aspects in 5.3 to 5.16 should be considered when developing a sampling strategy and preparing the sampling plan in accordance with ISO 18400-101.

NOTE 1 Clause 5 and 6 provide guidance applicable to sampling on the generality of natural, near-natural and cultivated sites. Clause 7 provides additional guidance in relation to sampling for particular purposes (e.g. determination of mobile nitrogen) and soil types (e.g. peat soils).

NOTE 2 A supposed natural site or near-natural site (e.g. an agricultural site or a wooded site) could be a potentially contaminated site, not only because of activities carried out on the site, but because they were developed in the past on potentially contaminated land, for example an old refuse disposal site (landfill) or mining waste. This could have significance for agricultural performance of a site and the health and safety of the investigator; hence the need for a good site history to be developed as part of the preliminary investigation.

5.2 General strategy of site investigation

5.2.1 General

The principal site investigation phases are

— preliminary investigation (see 5.2.3),

— exploratory investigation (see 5.2.5), and

— detailed (main) site investigation (see 5.2.6).

The relationship between these phases is illustrated in Figure 2.

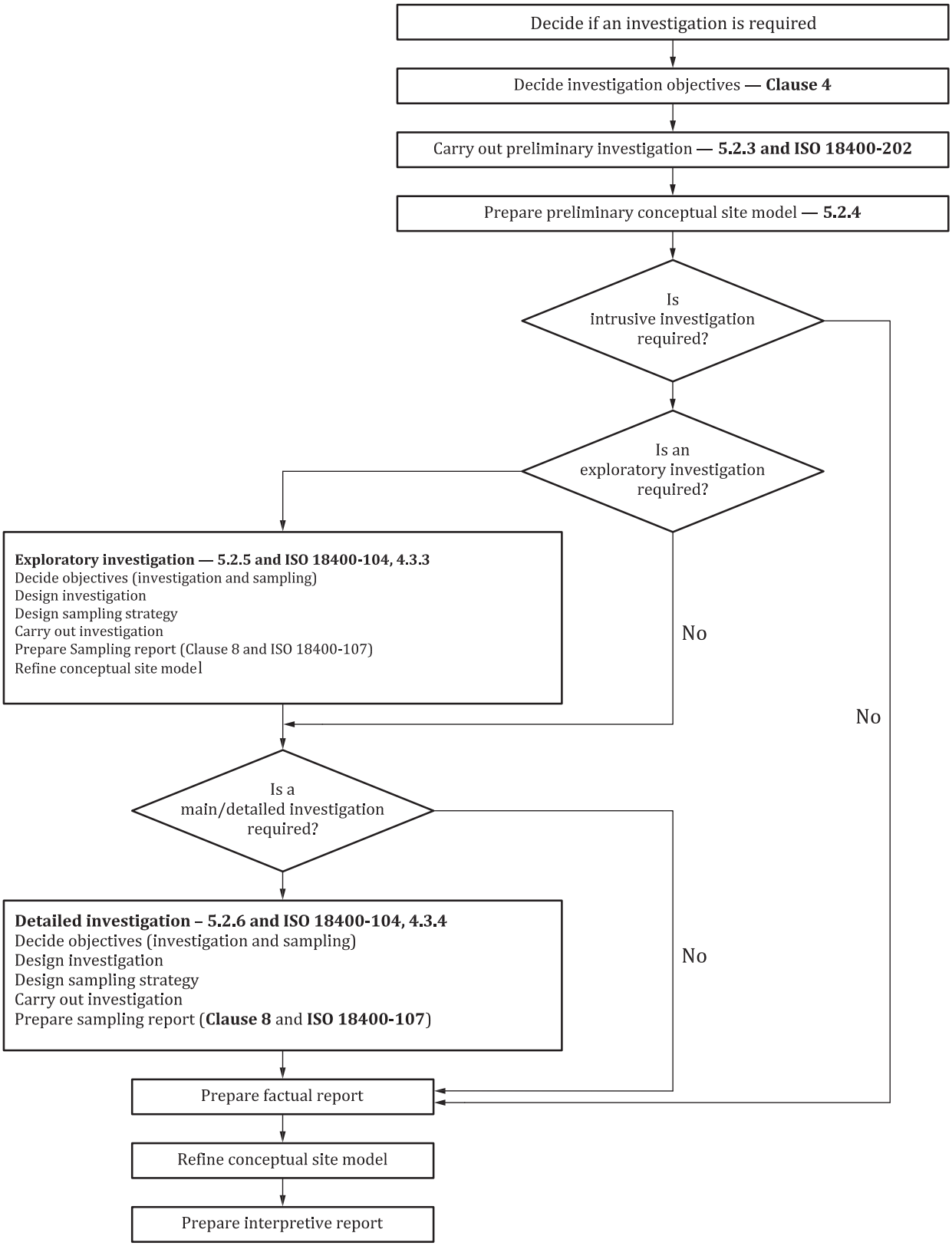
On completion of soil sampling activities during any phase or stage of investigation, a sampling report should be prepared in accordance with ISO 18400-107 (see Clause 8).

Following completion of the investigation, a report giving its results should be prepared.

The strategy for the investigation (whether preliminary, exploratory or detailed) will be determined by the objectives (see Clause 4).

Before embarking on any phase or stage of investigation, it is important to set data quality objectives in terms of the type, quantity and quality (e.g. analytical quality) of the data and other information that is to be collected. These data quality objectives will depend in part on the nature of the decisions to be made on the basis of the investigation, and the confidence required in those decisions.

When deciding on the strategy, consideration should be given to the applicability and use of on-site analysis and/or *in situ* measurement techniques (e.g. see ISO 12404 and ISO 13196).



NOTE This is an example of a site investigation process for agricultural sites.

Figure 2 — Site investigation process

5.2.2 Conceptual site model

A conceptual site model should be developed and refined as the investigation proceeds in accordance with the guidance in ISO 18400-104. It should be presented in narrative, tabular or graphical form, or a combination of forms. It needs to be no more complex than the objectives of the investigation require.

NOTE 1 A conceptual site model is a synthesis of all that is known about a site and its surroundings that is relevant to the task. Preparation of the conceptual site model requires some interpretation of the information available and explicit recognition of the uncertainties in the information. Even when a formal conceptual site model is not prepared, investigators will have a conceptual site model of the site in their mind. This could be dangerously misleading if a proper preliminary investigation has not been carried out and, for example, the presence of an animal burial pit in the corner of a field is not known about.

NOTE 2 Although the conceptual site model is usually first formally prepared following a preliminary investigation, it first comes into existence the moment the question is asked whether the site needs to be investigated. At that stage, for example, it might be recognized that the site is agricultural land used for keeping livestock and the investigator will immediately form an initial picture about what the site might be like and act accordingly. Thus, it is this initial conceptual site model and the purpose of the overall investigation that guide decisions about the scope and depth of preliminary investigation required.

5.2.3 Preliminary investigation

A preliminary investigation in accordance with ISO 18400-202 should be carried out prior to any intrusive investigation. The depth and detail of the preliminary investigation should be tailored to the objectives of the investigation. The preliminary investigation should lead to the development of a preliminary conceptual site model and possibly to hypotheses that can be tested during the subsequent investigation.

NOTE 1 The preliminary investigation needs only to be as detailed as required by the task in hand, but there will usually be a requirement for a minimum information set relating for example to site location and setting, site ownership, site access, safety and protection of the environment.

NOTE 2 Detailed guidance on preliminary investigations is provided in ISO 18400-202, including the type of information that could be required in relation to particular types of site, such as agricultural and near-natural sites, wooded sites and potentially contaminated sites. ISO 18400-202 includes reference to activities other than normal farming activities that might give rise to contamination of farmland. Land used for horticulture, orchards, etc. can also be contaminated.

NOTE 3 The preliminary investigation might provide information that suggests that the site, or part of the site, is “a potentially contaminated site” requiring investigation in accordance with ISO 18400-203. A decision might be required as to whether to proceed with an investigation in accordance with this document, to delay the investigation, or to constrain the area to be investigated, until the results of the investigation for contamination are available.

5.2.4 Preliminary conceptual site model

A preliminary conceptual site model should be developed from the results of the preliminary investigation. It needs to be no more complex than the objectives of the investigation require.

Formal hypotheses about the site that can be tested during an on-site investigation should be developed when appropriate.

NOTE During the site reconnaissance, areas of poor plant growth within an otherwise healthy looking crop might be seen. Ideas (hypotheses) about possible causes can be postulated and tested during the subsequent on-site investigation.

5.2.5 Scope of exploratory investigation

The exploratory investigation involves a limited on-site investigation. The data and information produced are assessed to determine if the hypotheses from the preliminary investigation are correct, and, where appropriate, to test other aspects of the conceptual site model. In some cases where the

hypotheses are indicated as being correct, no further investigation might be needed. However, when this is not the case, it will be necessary to either

— carry out a further stage of exploratory investigation before proceeding to the design and execution of a detailed investigation, or

— carry out a detailed site investigation to produce sufficient information to achieve the objectives of the investigation.

NOTE 1 Exploratory investigations typically comprise one or more judgmental (targeted) sampling exercises although systematic sampling or composite sampling might also sometimes be carried out.

NOTE 2 In the case of an agricultural site, an exploratory investigation could be used to confirm conclusions from the preliminary investigation about the soil type(s) present or to test a hypothesis, for example, that poor growth of vegetation is due to compaction and/or waterlogging. With this information available, the investigator can decide whether more detailed investigation is required, or that sufficient information is available to advise the client (e.g. the farmer).

5.2.6 Scope of detailed site investigation

The amount and nature of the information required from a detailed site investigation (or any particular stage of it) will vary depending on the nature of the site, and the objectives of the investigation. The implications of the decisions on what actions should be implemented on a site will vary from site to site.

5.3 Types of sample

The type(s) of samples to be taken should be chosen according to ISO 18400-104 regarding their applicability for particular purposes. It should be decided whether to take

— single samples (which can be disturbed or undisturbed – see Note) (see ISO 18400-104:2018, 6.4.2),

— cluster samples (see ISO 18400-104:2018, 6.4.3), or

— spatial composite samples (see ISO 18400-104:2018, 6.4.4).

Spatial composite samples are commonly used for the investigation of natural, near-natural and cultivated sites.

NOTE Types of sample, include (see ISO 18400-104:2018, 6.4.1):

— disturbed samples (mass-proportional sampling, samples obtained without any attempt to preserve the soil structure);

— undisturbed samples (volume-proportional sampling, samples obtained using a method designed to preserve the soil structure).

5.4 Selection of sampling locations

Sampling locations in aggregate should be representative of the total area to be sampled. Considerations when selecting sampling locations include

— the objectives of the investigation,

— the (expected) uniformity of soil quality,

— land use, and

— type of cultivation or natural vegetation.

Sampling patterns can be based on statistical models, numerical random distributions or systematic patterns as described in ISO 18400-104:2018, 6.2.3 and Annex B.

A sampling pattern can be the basis for taking either single samples or incremental samples to be mixed to provide a composite sample.

Locations such as dead patches, field margins, peat bogs, rocky sites, damp areas and other areas which obviously deviate from the average should generally be avoided unless these are of specific interest.

NOTE For further guidance, see ISO 18400-104.

5.5 Number of samples — General

The total number of samples required in any sampling exercise will depend on a number of factors. In the case of an investigation in which spot or cluster samples are to be taken, it will depend on the number of sampling locations, the depths from which samples are taken at each location (see 5.6) and whether one or more sample is taken from each sampling point (see 5.7).

When composite sampling is to be carried out, the total number of samples will depend on the number of zones into which the site is divided and whether one or more sample is taken from each zone (see 5.8).

The number of sampling locations required when systematic sampling is employed will depend on sampling pattern used and the spacing between sampling locations (sampling density). There are a variety of factors governing the density of sampling required including the number of samples required to enable a statistically sound estimate, for example, of average properties. Whether geostatistics are to be used will also have an influence (for detailed guidance, see ISO 18400-104:2018, 6.5).

5.6 Sampling depths

The guidance about sampling depths for different applications provided in ISO 18400-104:2018, 8.4 should be followed as appropriate.

Sampling should be directed towards sampling:

— soil horizons (preferably for agricultural, arboreal areas and natural land use);

— soil layers (e.g. artificial urban sites, mixed soils or forced by the objectives of the investigation).

The past, current and planned uses of the site should be taken into account.

NOTE 1 See Clause 7 for detailed guidance about sampling in relation to mobile nitrogen (7.1) and other specific situations.

NOTE 2 Sampling depths vary in national standards. For example, depths of 0 mm to 50 mm, 50 mm to 100 mm and 100 mm to 200 mm or 250 mm are sometimes used for pasture and grassland.

5.7 Number of samples to be taken at discrete sampling points

It might be necessary to take more than one sample from a discrete sampling point (see ISO 18400-104:2018, 6.5.2) to:

— aid estimation of measurement uncertainty, and its sources (see ISO 184000-104:2018, 5.8 and Annex C);

— provide samples of more than one type to satisfy testing requirements (e.g. disturbed and undisturbed samples);

— provide samples of different size for test purposes;

— provide samples for different analytical and test regimes as required by the laboratories;

— provide duplicate samples for quality assurance purposes (see ISO 18400-106).

The practicality of providing near-equivalent samples will be constrained by the technique used to obtain them (see ISO 18400-102), the particle sizes (maximum and distribution), and the nature of the soil (e.g. clayey, granular, organic-rich).

5.8 Number of samples in relation to determination of average properties

Average properties can be derived using composite samples or by averaging the results of investigations to determine spatial distributions. In both cases, it is essential to carefully define the area/zone/volume that is to be sampled and to understand what is being sampled. When composite sampling is employed, taking a number of independent samples and averaging the results can reduce uncertainty in the estimated mean value and enable estimation of variability.

If average concentrations and variability parameters are to be derived from sampling used to determine spatial distributions, it is essential to define the volume of soil for which the average is being calculated very carefully. While an average is always a valid parameter, its practical and theoretical usefulness will be limited if, for example, it includes different soil types, sampling horizons, or zones with different contamination histories (see also ISO 18400-104:2018, 6.3).

In the case of uniform land use, soil quality and soil management when average properties of the soil within an area is of interest, the number of composite samples taken should be in accordance with the guidance in ISO 18400-104:2018, 6.5.4 and 7.3.2.

Considering the case of a field in which soil quality is to be determined decisions should be made about:

— whether to divide the site into zones on the basis of some attribute (e.g. soil type, perceived plant health);

— whether to sub-divide the field or zones into sub-areas (subpopulations) for the purposes of sampling (the assumption is that soil in each sub-area will have similar characteristics although this might not prove to be the case);

— whether to take one or more composite samples from the field or zone (the population) or from each sub-area if the field or zone has been divided in this way;

— how many increments should be taken to form each composite sample.

A further reason for sub-dividing a field or other site is that it is simply too large for it to be considered reasonable that a single (or even a few) composite sample taken across the whole area could properly portray the soil quality for the whole area. In such circumstances, the site should be divided into a number of zones (preferably of similar size) as shown in ISO 18400-104:2018, Table 4. A separate decision should then be taken as to how many composite samples to take from each zone.

If average properties are to be determined using spot samples, this should be done following the guidance in ISO 18400-104:2018, 7.3.3.

5.9 Sample sizes

The size of samples required depends mainly on the type and extent of intended field and laboratory investigations, including, when required determination of particle size distribution and bulk density (see ISO 18400-104:2018, 6.6). The following amounts are recommended for investigations covered by this document, but should be adjusted to meet the needs of the investigation as necessary:

— in the case of sandy, loamy and clay soils (i.e. fine soils): up to 1,0 kg (see Note 1);

— in the case of peat soils and organic horizons from forest or woodland (arboreal) soils: up to 0,75 kg (or 0,5 kg of fine soil) — see below.

In the case of soils with increasing fractions of gravel, cobbles and stones, greater masses are required (see ISO 18400-104:2018, 6.6).

Additional soil material is needed for preparation of replicate samples.

NOTE There could be occasions when it is easier to specify required sample sizes in terms of a volume.

5.10 Sampling techniques and application

Appropriate sampling techniques should be selected and applied following the guidance in ISO 18400-102 (see also Clause 6).

5.11 Time and frequency of sampling

In some circumstances, it can be necessary to restrict sampling to specific periods of the year. For example, if the characteristic or substance to be determined is likely to be affected by seasonal factors or human activities (weather, soil conditioning/fertilization, use of plant-protective agents). Factors to be taken into account include

— the objective of sampling,

— use of land (e.g. periodic sampling for soil fertility analysis), and

— soil quality.

NOTE 1 This is particularly important where monitoring lasts several months or years, or is continued periodically and therefore requires similar preconditions every time sampling is carried out.

NOTE 2 Guidance in respect of the timing of measurements of mobile nitrogen is provided in 7.1.

5.12 Sample containers

Sample containers should be selected and used in accordance with the guidance in ISO 18400-105 and ISO 18400-206 as appropriate.

5.13 Sample transport

Samples should be transported in accordance with the guidance in ISO 18400-105.

5.14 Sample storage

Samples should be stored and handled in accordance with ISO 18400-201, ISO 18400-105 and ISO 18512 as appropriate, and in accordance with any special requirements set out in later clauses of this document (see 7.1 for example). ISO 18400-206 should be followed when samples are required for the assessment of biological function and structural end points in the laboratory.

When there is a delay before pretreatment and analysis or when a long storage period is foreseen, soil samples required for chemical analysis should be stored under suitable conditions, in accordance with ISO 18512. It should be decided whether, in special cases, they should remain in the sampling container or not. Chemical, physicochemical or biological changes in the soil samples caused by contamination, and losses or chemical reactions, should be avoided by adoption of appropriate procedures.

NOTE Drying, cooling or freezing of the original samples are the most common treatments; chemical or UV treatment is used in special cases. However, depending on the purpose of the laboratory test, there could be a need for samples to be stored at the same temperature and moisture state as they were when taken at the site.

5.15 Safety

In respect of health and safety, ISO 18400-103 shall be followed.

5.16 Quality assurance and control

Sampling should be carried out by personnel with knowledge and experience in soil science, geological and hydrological aspects as appropriate, including, with respect to

— application of suitable sampling equipment to avoid cross-contamination, losses, etc.,

— application of reproducible sampling systems and procedures, and

— off-site estimation of sampling variance.

NOTE Detailed guidance on quality assurance and quality control is given in ISO 18400-106.

6 Taking soil samples

Disturbed or undisturbed samples should be taken from top-soil or at greater depths as required following the procedures described in ISO 18400-102.

Roots (living and dead), other plant or animal parts, macrofauna (e.g. worms, beetles, grubs) and stones should be removed in the field following an agreed procedure especially in relation to the size of the material to be removed and whether an estimate of the proportion/number, etc. is required. In some circumstances, the material/items removed might need to be retained for separate analysis/ examination.

NOTE ISO 18400-102 provides detailed guidance on the selection and application of sampling techniques including how to take undisturbed samples of top-soil and other near surface materials (ISO 18400-102:2017, 8.1), such as using cutting cylinders (ISO 18400-102:2017, 8.1.2). It also describes how to take disturbed samples from agricultural and forest sites (ISO 18400-102:2017, 8.2.2) and procedures for taking undisturbed (ISO 18400-102:2017, 9.1) and disturbed samples (ISO 18400-102:2017, 9.2) at greater depths including from trial pits (ISO 18400-102:2017, A.1) and using small hand-operated augers (ISO 18400-102:2017, A.2). ISO 18400-102:2017, Figure A.1 provides a schematic description of soil sampling in a trial pit formed to sample natural ground. Drawings of a wide range of sampling devices are included in ISO 18400-102:2017, Annex C.

7 Sampling for particular purposes

7.1 Sampling for the determination of mobile nitrogen

The determination of the mobile (bioavailable and readily leachable) part of the total soil nitrogen provides important baseline data when making recommendations for nitrogen fertilization. In agriculture and horticulture, data on the nitrogen residuals after the vegetation period are also important in order to minimize leaching to groundwater. Sampling procedures require special attention in order to obtain reliable results.

Usually samples from two soil horizons are taken:

— arable soil, topsoil/ploughed layer (max. 300 mm) and subsoil 300 mm to 600 mm;

— grassland, 0 mm to 200 mm (upper turf layer is removed/upper root zone is removed) and 200 mm to 400 mm;

— hop-garden, 100 mm to 400 mm and 400 mm to 700 mm;

— orchards and vineyards, 0 mm to 300 mm and 300 mm to 600 mm.

The depths indicated above are indicative only and should be adjusted as necessary to take into account on-site observations and the objectives of the investigation. There could be occasions where specific horizons of smaller size (<300 mm) have to be investigated. In these cases, a representative sample of the horizons should be obtained.

Sometimes it could be desirable to take samples from more than two layers. For example, the maximum root depths of plants should be taken into account in order to increase or decrease the number of layers to be sampled.

Sampling can be carried out manually or by use of machinery. A spatial composite sample should be formed compromising at least 25 incremental samples taken from the layers of interest, using one of the sampling patterns described in ISO 18400-104:2018, B.2. Incremental samples are laid out equally on the sampling site. To avoid losses of mobile nitrogen, the composite samples should be stored in plastic bags in a refrigerated box at 4 °C in darkness and transferred to the laboratory. It is strongly recommended that sampling, transport, pretreatment and analysis be carried out in as short a time as possible. In case of storage of the samples before analysis, freezing of the samples is strongly recommended.

Samples should be taken in autumn once agro-technical operations with the soil are completed and before soil profile freezing begins to occur. Important conditions for the initiation of sampling are: at least two weeks after the last operation with soil and three to four weeks after fertilization with manure.

NOTE In the Northern Hemisphere, depending on altitude and climate conditions, especially in the Central Europe, sampling can start on October 15th and be terminated by December 15th.

7.2 Forest and woodland soils

For the investigation of forest and woodland soils, a special approach is required for the selection of sampling points. Within a forest or other wooded area, for example, at least 10 sampling circles should be selected in a pattern so that each of the circles encloses approximately the same number of trees. From these sampling circles, near-trunk zones (approximately 1,0 m distance from trunks), areas in between, and canopy areas can be sampled. Incremental samples obtained in this way may be used to form horizon-related composite samples per unit area.

When organic horizons of forest or woodland soils are being sampled, cluster samples should be taken from the whole volume within an area 250 mm × 250 mm (e.g. as delineated by a sampling frame). If the amount of soil present is limited, the sampling area should be increased to 500 mm × 500 mm.

Roots (living and dead), other plant or animal parts, and stones should be removed in the field.

7.3 Peat soils

In the case of peat soil layers close to the surface and peat soils for agricultural use, the top soil can be sampled using hand augers. Peat probes are suitable for sampling at greater depth or at groundwater level. In addition, special boring tools with a working edge in the form of saw teeth (serrated edges) can be used.

Preparation of trial pits is appropriate in some cases. Sampling is then usually carried out at a number of depths, e.g. 0,10 m, 0,30 m, 0,50 m, 1,0 m and 1,50 m.

7.4 Saturated-zone soils

Special procedures are required for sampling water-saturated soil (influenced by groundwater) in order to avoid negative influences on structure and physical properties as well as loss or displacement of substances of interest (see ISO 18400-102).

7.5 Special types of land use

Careful thought should be given to the best way of taking samples having regard to the distribution of plants and the cultivation regime. A combination of sampling approaches might be required.

Options available include:

— composite samples compromising at least 25 increments taken symmetrically around the trunk(s) should be formed for example using a circular grid as illustrated in ISO 18400-104:2018, B.4;

— sampling carried out between rows using an appropriate pattern(s), possibly with additional sampling between plants in a row depending on the spacing;

— sampling between two rows of trees at one or more points at different depths (in some circumstances this might be more informative than taking several samples from the same horizon).

At least 15 incremental samples should be taken for a composite sample. Sampling between two rows of trees at one point at different depths can be as useful as taking samples at several points between trees. This also applies to soft fruit cultivation. Sampling between rows of plants is preferred here if drilling fertilization has not been used. Sampling in vineyards is affected primarily by slope and depth of soils. Sampling two soil layers could be necessary (see also 5.5).

8 Sampling report

On completion of sampling, a sampling report in accordance with ISO 18400-107 should be prepared. It should, as appropriate

— facilitate comparison of soil characteristics in soil inventories, land evaluation, etc.,

— include information on the site (location and utilization of the area, soil conditions, conditions of cultivation and climate, etc.),

— provide information on the condition of the sampled area at the time of sampling (e.g. crop type), and

— be supplemented by location map(s), field maps, photographs, etc.

The sampling report prepared by the field staff should contain the following information:

— sample designation and number (identical to the marking on the sample container);

— date of sampling;

— information on the site (e.g. location, land use, textural class, weather conditions);

— description of soil profile in special cases;

— information on the procedures used to obtain the samples (field pattern, sampling equipment, depth of sampling, number of increments or composite samples etc.);

— information on storage and transport;

— information on the time and place of delivery to the laboratory;

— identification of sampler;

— counter-signature of customer or programme supervisor;

— confirmation of receipt by laboratory.

In addition to the reporting recommendations above, the identity numbers of any soil sample rings used (usually engraved) and arrangement of rows should be reported.

Sketches should be made, and photographs taken of the sampling sites (i.e. the ground around where the samples were taken).

9 Investigation report

The report of the site investigation (exploratory or detailed) generally should include as appropriate:

— the objectives of the site investigation;

— the state of knowledge about the site previous to the beginning of the investigation, and presentation of any formal hypotheses formulated using the results of the preliminary investigation and verified by any earlier phases of investigation, including statements concerning the reliability of the hypotheses;

— the planning and justification of the strategy and design of the investigation (if necessary in consecutive stages);

— a description of the methodologies used for the investigation;

— a description of the works performed and sampling techniques used;

— the documentation of the results of all field observations (including any differences and irregularities during the practical application of the proposed methodology);

— the justification of the sample selection for analysis and documentation of all relevant details relating to sample preservation, storage, transportation, pre-treatment as well as performance and evaluation of analyses;

— a description of the analytical results including information on variation and error boundaries and limitations of the analytical methods used;

— an evaluation of the results of the investigation;

— a “plain language” summary;

— a review of uncertainties and limitations of the investigation;

— recommendations for future measures including when appropriate prioritization on the basis of, for example, urgency.

Other aspects may be added.

The wording used in the report should supply decision makers and those who ordered the investigation with an appropriate overview and a reliable basis for making decisions. Facts should be clearly distinguishable from interpretations and hypotheses.

The production of separate factual and interpretative reports (two separate volumes) might be advantageous. Evaluation and interpretation of the results should be done involving the investigator who planned and performed the investigation to avoid information losses.

Bibliography

[1] ISO 5667, *Water quality — Sampling*

[2] ISO 11277, *Soil quality — Determination of particle size distribution in mineral soil material — Method by sieving and sedimentation*

[3] ISO 11464, *Soil quality — Pretreatment of samples for physico-chemical analysis*

[4] ISO 12404, *Soil quality — Guidance on the selection and application of screening methods*

[5] ISO 13196, *Soil quality — Screening soils for selected elements by energy-dispersive X- ray fluorescence spectrometry using a handheld or portable instrument*

[6] ISO 15175, *Soil quality — Characterization of soil related to groundwater protection*

[7] ISO 18400-101, *Soil quality — Sampling — Part 101: Framework for the preparation and application of a sampling plan*

[8] ISO 18400-102, *Soil quality — Sampling — Part 102: Selection and application of sampling techniques*

[9] ISO 18400-105, *Soil quality — Sampling — Part 105: Packaging, transport, storage and preservation of samples*

[10] ISO 18400-107, *Soil quality — Sampling — Part 107: Recording and reporting*

[11] ISO 18400-201, *Soil quality — Sampling — Part 201: Physical pretreatment in the field*

[12] ISO 18400-202, *Soil quality — Sampling — Part 202: Preliminary investigations*

[13] ISO 18400-203, *Soil quality — Sampling — Part 203: Investigation of potentially contaminated sites*

[14] ISO 18400-206, *Soil quality — Sampling — Part 206: Guidance on the collection, handling and storage of soil for the assessment of biological functional and structural endpoints in the laboratory*

[15] ISO 18512, *Soil quality — Guidance on long and short term storage of soil samples*

[16] Boden A.G. (1994): *Bodenkundliche Kartieranleitung*, 4th ed., 392 pp., Hannover. In Kommission: E. Schweizerbart"sche Verlagsbuchhandlung (Nägel u. Obermiller), Stuttgart

[17] Anonymous. (1993). 2. Verwaltungsvorschrift des Umweltministeriums Baden-Württemberg zum Bodenschutzgesetz über die Probenahme und -aufbereitung (VwV Bodenproben) v. 24.8.1993; Umweltministerium Baden-Württemberg, Deutschland

[18] BMELF. *Bundesweite Bodenzustandserhebung im Wald (BZE), Arbeitsanleitung Bundesministerium Ernährung, Landwirtschaft, Forsten.* BMELF, Bonn, 1990

[19] FAC. (1989): *Methoden für Bodenuntersuchungen/Méthodes pour l"Analyse des sols.* Schriftenreihe Nr. 5. Eidgenössische Forschungsanstalt für Agrikulturchemie und Umwelthygiene 3097 Liebefeld-Bern, Schweiz

[20] *Guidelines for soil description*, 3rd ed., Soil Resources, Management and Conservation. Service Land and Water Development Division, UN Food and Agriculture Organization, 1990, Rome

[21] Hartge K.H., & Horn R *Die physikalische Untersuchung von Böden.* Enke Verlag, Stuttgart, Second Edition, 1989

[22] Jennische P. (1987): *Handledning i provtagning för lantbrukskemisk analys*. SLL Rapport nr. 48, Uppsala

[23] Lundmark J.-E., & Odell G. (1984): *Fältinstruktion för Standortskartering av permanenta provytor vid riksskogstaxeringen*. Sveriges lantbruksuniversitet, Uppsala

[24] Melcher R.G. Peters Th.L., Emmel H.W. Sampling and environmental material. *Top. Curr. Chem.* 1985, **134** pp. 61–109

[25] Öster. Bodenkundliche Gesellschaft (1986): *Waldbodenuntersuchung — Geländeaufnahme, Probenahme, Analyse*. Empfehlungen zur Vereinheitlichung der Vorgangsweise in Österreich; Öster. Bodenkdl. Ges., Wien

[26] VDLUFA. *Die Untersuchung von Böden, Methodenbuch.* VDLUFA-Verlag, Darmstadt, **Vol. 1**, 1991

[27] Lessells W J Unpublished Agricultural Development Advisory Service (ADAS), Paper SS/SAF/7, Rothamsted Experimental Station 1973 quoted in: Ministry of Agriculture Fisheries and Food, *Booklet 2082 — Sampling of soils, soilless growing media, crop plants and miscellaneous substances for chemical analysis*, MAFF, London, 1979