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Water quality — Sampling —

Part 6: Guidance on sampling of rivers and streams

Qualité de l'eau — Échantillonnage —

Partie 6: Lignes directrices pour l'échantillonnage des rivières et des cours d'eau

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Contents

Page

Foreword

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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).

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For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is ISO/TC 147, *Water Quality*, Subcommittee SC 6, *Sampling*.

This third edition cancels and replaces the second edition (ISO 5667-6:2005), which has been technically revised.

ISO 5667 consists of the following parts, under the general title *Water quality — Sampling*:

— *Part 1: Guidance on the design of sampling programmes and sampling techniques*

— *Part 3: Preservation and handling of water samples*

— *Part 4: Guidance on sampling from lakes, natural and man-made*

— *Part 5: Guidance on sampling of drinking water from treatment works and piped distribution systems*

— *Part 6: Guidance on sampling of rivers and streams*

— *Part 7: Guidance on sampling of water and steam in boiler plants*

— *Part 8: Guidance on the sampling of wet deposition*

— *Part 9: Guidance on sampling from marine waters*

— *Part 10: Guidance on sampling of waste waters*

— *Part 11: Guidance on sampling of groundwaters*

— *Part 12: Guidance on sampling of bottom sediments*

— *Part 13: Guidance on sampling of sludges*

— *Part 14: Guidance on quality assurance and quality control of environmental water sampling and handling*

— *Part 15: Guidance on the preservation and handling of sludge and sediment samples*

— *Part 16: Guidance on biotesting of samples*

— *Part 17: Guidance on sampling of bulk suspended solids*

— *Part 19: Guidance on sampling of marine sediments*

— *Part 20: Guidance on the use of sampling data for decision making — Compliance with thresholds and classification systems*

— *Part 21: Guidance on sampling of drinking water distributed by tankers or means other than distribution pipes*

— *Part 22: Guidance on the design and installation of groundwater monitoring points*

— *Part 23: Guidance on passive sampling in surface water*

Introduction

An understanding of the purpose of sampling is an essential prerequisite to identifying the principles to be applied to a particular sampling problem. Examples of the purposes of sampling programmes commonly devised for rivers and streams are as follows:

a) to determine the suitability of the water quality of a river or stream within a river basin for a particular use, such as

   1) a source of drinking water,

   2) for agricultural use (e.g. all types of irrigation, live-stock watering),

   3) for the maintenance or development of fisheries,

   4) for amenity use (e.g. aquatic sports and swimming), and

   5) for conservation and protection of aquatic life;

b) to assess the impact of human activities on the quality of water, such as

   1) study of the effects of waste discharge or accidental spillages on a receiving water,

   2) assessment of the impact of land use on river or stream quality,

   3) assessment of the effect of the accumulation and release of substances including contaminants from bottom deposits on aquatic biota within the water mass, or on bottom deposits,

   4) study of the effects of abstraction, river regulation, and river-to-river water transfers on the chemical quality of rivers and their aquatic biota, and

   5) study of the effects of river engineering works on the water quality (e.g. addition or removal of weirs, changes to channel or bed structure).

Water quality — Sampling —

Part 6: Guidance on sampling of rivers and streams

WARNING — The focus of this part of ISO 5667 is the collection and integrity of water samples. The collection of these samples can be hazardous and attention is therefore drawn to the existence in some countries of legislative requirements for the safety of personnel. It is essential that all sampling personnel have had thorough health and safety training for the conditions they are likely to encounter.

1 Scope

This part of ISO 5667 sets out the principles to be applied to the design of sampling programmes, sampling techniques, and the handling of water samples from rivers and streams for physical and chemical assessment.

It is not applicable to the sampling of estuarine or coastal waters nor for microbiological sampling.

NOTE 1 Procedures for microbiological sampling are given in ISO 19458.[10]

This part of ISO 5667 is neither applicable to the examination of sediment, suspended solids or biota, nor to dammed stretches of rivers or streams. Also, it is not applicable to passive sampling of surface waters (see ISO 5667-23).

NOTE 2 In cases where naturally occurring or artificially constructed dams result in the retention or storage of water for several days or more, the stretch of the river or stream should be considered as a standing water body. For sampling purposes, see ISO 5667-4.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 5667-1, *Water quality — Sampling — Part 1: Guidance on the design of sampling programmes and sampling techniques*

ISO 5667-3, *Water quality — Sampling — Part 3: Preservation and handling of water samples*

ISO 5667-11, *Water quality — Sampling — Part 11: Guidance on sampling of groundwaters*

ISO 5667-14, *Water quality — Sampling — Part 14: Guidance on quality assurance and quality control of environmental water sampling and handling*

ISO 6107-2:2006, *Water quality — Vocabulary — Part 2*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 5667-11, ISO 6107-2, and the following apply.

3.1
automatic sampling
process whereby samples are taken either discretely or continuously, independently of human intervention, and according to a predetermined programme

[SOURCE: ISO 6107-2:2006, 9]

3.2
composite sample
two or more samples or sub-samples, mixed together in appropriate known proportions (either discretely or continuously), from which the average value of a desired characteristic can be obtained

Note 1 to entry: The proportions are usually based on time or flow measurements.

[SOURCE: ISO 6107-2:2006, 29]

3.3
continuous sampling
process whereby a sample is taken continuously from a body of water

[SOURCE: ISO 6107-2:2006, 32]

3.4
discrete sampling
process whereby single samples are taken from a body of water

[SOURCE: ISO 6107-2:2006, 40]

3.5
incremental sampling
technique in which small samples are taken because of a low flow rate (with the possibility of contamination by bottom deposits) or because of restricted access (e.g. where a sample is obtained through a small aperture), these small samples then being aggregated to form a composite sample

Note 1 to entry: All the liquid contained in the small samples is used, unlike blending of aliquots used to make a flow-proportional sample (see 9.4).

3.6
isokinetic sampling
technique in which the sample from a water stream passes into the orifice of a sampling probe with a velocity equal to that of the stream in the immediate vicinity of the probe

[SOURCE: ISO 6107-2:2006, 56]

3.7
light non-aqueous-phase liquid
LNAPL
organic compound that has low water solubility and a density less than that of water

EXAMPLE Petroleum products.

[SOURCE: ISO 5667-11:2009, 3.15, modified — Singular forms replace plural forms.]

3.8
random sampling
form of sampling whereby the chances of obtaining different concentration values of a determinand are precisely those defined by the probability distribution of the determinand in question

3.9
river
natural body of water flowing continuously or intermittently along a well-defined course into an ocean, sea, lake, inland depression, marsh, or other watercourse

[SOURCE: ISO 6107-2:2006, 109]

3.10
sampling site
general area or location from which samples are taken

3.11
sampling point
precise position within a sampling location from which samples are taken

[SOURCE: ISO 6107-2:2006, 117]

3.12
stream
water flowing continuously or intermittently along a well-defined course as for a river, but generally on a smaller scale

[SOURCE: ISO 6107-2:2006, 137]

3.13
sub-sample
portion removed from a sample and intended to be representative of that sample

3.14
systematic sampling
sampling whereby the samples are taken at predetermined intervals, often equally spaced in time

4 Design of sampling programme

Sampling is usually the first step in carrying out an investigation and largely determines the quality of the whole investigation. It is therefore recommended that a detailed sampling strategy be drawn up, often based upon a preliminary investigation in which an assessment has identified the important aspects. Both the purpose and the ambient situation determine the way in which the sampling is carried out. Consideration of time-of-travel data can influence choice of sampling locations depending on the objective of the survey. General aspects for sampling programme design can be found in ISO 5667-1.

The sampling plan should give consideration to at least the following aspects.

General aspects:

a) purpose of the investigation;

b) parameters to be analysed for each sampling point;

c) the measurements to be carried out at the sampling point (with specification of the methods to be used) such as temperature, dissolved oxygen, degree of acidity, or discharge;

d) frequency and times of sampling and the type of sample;

e) sampling site and the number and locations of sampling points (also see 5.1);

f) sampling equipment;

g) quality assurance procedures to be followed;

h) transport, preservation, and storage of samples.

Aspects relating to the ambient situation of the sampling point:

a) safety aspects;

b) hydrodynamic and morphological characteristics of the water to be sampled;

c) local circumstances such as water depth, floating layers, vegetation, and accessibility of the location;

d) the sampling depth(s);

e) anticipated composition and quantity of the water to be sampled, among other things whether there are any floating and/or sludge layers present.

In addition, many characteristics can influence the behaviour of contaminants in river systems. An understanding of the nature of these characteristics is important when planning and carrying out river sampling programmes. Important factors include temperature, turbidity, depth, velocity, turbulence, slope, changes in direction and in cross-sections, and the nature of the river bed.

These factors are so interrelated that it is difficult to assign more or less importance to each one. For example, slope and roughness of the stream channel affect both depth and velocity of flow, which together control turbulence. Turbulence in turn affects rates of mixing of effluents and tributary streams, re-aeration, sedimentation or scour of solids, growths of attached biological forms and rates of natural purification. In addition, chemical and biological processes can occur, e.g. photosynthesis, respiration, and metabolic effects.

Practical sampling issues, such as accessibility, can make the ideal sampling point impractical. It is essential that any change to the designated sampling point on any grounds be discussed and agreed with the sampling programme originator. The outcome of the deliberations should be recorded in a sampling point file which contains directions to the sampling site, the detailed location of the sampling point, the method of sampling, and specific details (e.g. keys required, health, and safety issues). It can differentiate between equivalent sampling points that can be used if, for instance, river conditions change. It can also specify the type of sampling to be carried out, e.g. the depth to sample.

5 Sampling location

5.1 Sampling point selection

5.1.1 Choice of sampling site

In choosing the exact point from which samples are required, two aspects are generally involved:

a) the selection of the sampling site (i.e. the location of the sampling cross-section within the river basin, river, or stream);

b) the identification of the precise point at the sampling site.

The purpose of sampling often defines sampling sites (as in the case of the determination of the quality of an effluent discharge), but sometimes the purpose only leads to a general idea of the sampling site, as in the characterization of quality in a river basin. Where possible, sampling site locations should be defined by a grid reference in accordance with the international grid system in ISO 19112.[9]

The choice of sampling sites for single sampling stations is usually relatively straightforward. For example, a monitoring station for a baseline record of water quality can be chosen to permit the use of a convenient bridge, or to allow an upstream effluent discharge or tributary to be well mixed laterally before the station. Stations for monitoring water supply abstraction points might need to be fixed within narrow limits (i.e. in proximity to the abstractions).

In regions that receive seasonal rainfall only, and that have long periods without rain, river volumes and flows can vary tremendously, and sampling sites for regular use should be chosen so as to ensure that

they remain appropriate and practical for sampling during periods of both maximum and minimum flow.

Where it is necessary to carry out sampling through ice in winter, the chosen sampling site should be as close as possible to the sampling site used during other seasons of the year. If sampling is to be carried out near a bridge, the site should be located far enough upstream to avoid contamination from road salt and sand. Any deviations from the routine sampling point or given sampling coordinates should be discussed where possible with the sampling originator, and should be detailed as part of the data set and recorded with the analytical results, together with the new coordinates where applicable.

5.1.2 Importance of mixing

When the effects of a tributary or an effluent on the quality in a particular identified stretch of river or the main stream are of interest, at least two sampling sites should be chosen; one should be just upstream of the confluence and the other should be sufficiently far downstream to ensure that mixing is complete.

It is also important that the sample be collected at a well-mixed and flowing sampling point, i.e. not in an eddy or a backwater where the flow is not typical of the main water body.

The physical characteristics of the channels of watercourses largely control distances required for the complete mixing of effluents with stream flow.

Effluents mix in three dimensions in a stream, namely

a) vertically (from top to bottom),

b) laterally (from one side to the other), and

c) longitudinally (levelling out of peaks and troughs in the concentration of effluent constituents as water passes downstream).

The distances over which effluents mix in these three dimensions should be considered in the selection of sampling sites and points, and are affected by, amongst other factors, the water velocity. Tracer techniques using dyes can be useful in studying mixing processes and conductivity measurements can also be helpful.

NOTE The use of tracer techniques might be subject to licensing by the authority responsible for the watercourse, as there might be concerns over the release of chemicals into the environment. Where this is the case, it might be better to use determinants already present, such as pH, temperature, or conductivity, to study mixing processes.

Where mixing is relevant to the sampling regime, the sampling location and other associated parameters should preferably be defined clearly before the beginning of sampling.

The sampler should acknowledge that in watercourses near the coast there might be a tidal influence on the flow, quality, and mixing capability of the water body. Account of this should be taken where appropriate, and the sampler should take measurements of the flow and water depth to give an indication of the tidal status. Sampling at different states of the tide is usually necessary.

Vertical mixing, almost always, is the first of the three types to be complete in a stream. Shallow water and high velocities result in rapid vertical mixing, but even in deep water with low velocities, vertical mixing is relatively rapid. Effluents discharged to most streams mix vertically, within 100 metres or within a few hundred metres at most. Normally therefore a stream need not be sampled at more than one depth, although stratification can be induced in slow-moving rivers and streams by thermal and other density effects. In these cases, sampling at several depths might be necessary and preliminary tests should be carried out to assess the degree of stratification (see 5.2).

Lateral mixing usually occurs after vertical mixing has occurred, but before longitudinal mixing is complete. Differences in solids content and especially in temperature of effluents and stream water can cause the effluents to stratify and travel across the stream more rapidly on surface or bottom than

they would if mixed vertically at the point of discharge. This phenomenon is most significant at very low velocities since even moderate turbulence quickly destroys stratification, causes vertical mixing and slows the lateral movement of the wastes.

Change in direction of stream flow is also effective in lateral mixing. This, combined with normal vertical mixing, can cause rapid and fairly complete lateral mixing. However, even when a stream passes through two approximately 90° reverse bends that are reasonably close together it cannot be assumed that lateral mixing of upstream effluents is complete. For example, coloured effluents and turbidity from small tributaries have been observed to hug one bank of a stream for many kilometres in wide, shallow, swift streams, with rocky bottoms, in spite of several reverse bends in these distances.

Whereas turbulence can cause vertical mixing within a few hundred metres, the distance for lateral mixing generally is dependent on the occurrence of relatively sharp reverse bends. As a general rule, the distance for adequate lateral mixing is in kilometres rather than hundred metres. Frequently a stream needs to be sampled at two or more points at one or more locations downstream from an effluent discharge or a tributary stream because of slow lateral mixing.

Consideration of longitudinal mixing distances can be important in deciding on the frequency of sampling. To give representative results just below an irregular discharge, more frequent sampling is required than would be necessary some distance downstream where longitudinal mixing has been completed to a greater extent. See Informative Annex A for more information on longitudinal mixing.

5.1.3 Consideration of time-of-travel data

Time of travel is the time taken for a given mass of water to move between two defined points. This can be from a point of discharge to the next point of discharge or from a point of discharge to an abstraction point, etc. Information on the time of travel or river retention of substances in this mass of water is important for the following main reasons.

a) It provides information on the lateral mixing characteristics of a given stretch of river which assists in defining the most representative point on that river system from which to take a sample.

b) It provides information on the longitudinal velocity profiles in the river, which can be used to calculate re-aeration rates to predict the assimilative capacity of a reach for biodegradable organic matter. The self-purification, or river recovery rate, can be presented as a mathematical model. Such models are very important as they assist in the prediction of oxygen sag curves, and the re-use capability of a river. Time-of-travel measurements can also be used to study the rates of change of other unstable constituents in rivers, e.g. the oxidation of ammonia, the decomposition of phenol and the decay of radionuclides.

c) It provides information on mean flow velocities under a set of given discharge conditions which is extremely valuable in assessing the distance travelled from pollution source. This information can enable remedial action to be taken before the pollution arrives at a water abstraction point, or allow the water treatment processes to be varied to compensate for the effects of the pollution or to predict the time interval necessary for the abstraction to be stopped.

d) Time-of-travel data can often be of relevance to the choice of sampling location. For example, sampling sites might have to be arranged to allow certain constituents or pollutants to be traced through a system, particularly from a discrete source of pollution. This necessitates knowledge of the residence time within the system under investigation (i.e. the time of travel). Knowledge of the time of travel is also important in sampling studies to investigate the rate of change of unstable constituents (e.g. in the self-purification of a water body, the time of travel can provide information on kinetic rate coefficients). It therefore provides information on the selection of sampling locations and for deciding the length of a river reach to be studied. It can be used to estimate the subsequent downstream position of a mass of water in which some abnormal result was obtained at one or more sampling locations. This allows additional sampling to be carried out to confirm or revise any idea or conclusion based on the abnormal result.

In determining the time of travel, one of the three principal methods should be used, namely the use of surface floats (see ISO 748[5]), the use of tracers (see ISO 9555[3]), or the measurement of flow rate with knowledge of cross-sectional areas (see ISO 748[5] and ISO 1070[6]).

Measurements should be made at a minimum of five different flow rates and the resulting times of travel plotted against the corresponding flow rates, thereby enabling other travel times to be obtained by extrapolation or interpolation. However, extrapolation outside 10 % of a measured flow rate value can provide inaccurate information on time of travel.

Also note that time of travel can vary greatly between seasons in regions that experience seasonal rainfall only.

ISO 5667-1 should be consulted for general guidance on time-of-travel and ISO/TR 8363[7] should be consulted for guidance on the measurement of liquid flow in open channels.

5.1.4 Non-homogeneous sites

Problems arise in selecting suitable sampling sites whenever the determinands are not homogeneously distributed throughout the water body of interest. In general, such sampling sites should be avoided if possible, except when the sites themselves are of direct interest, as they might not yield representative samples of the major part of the water body. If there is any possibility of a non-homogeneous distribution of the determinands of interest at the chosen site, experimental tests on the nature and magnitude of any heterogeneity in all three dimensions should be made. If such tests show that the determinands are distributed homogeneously, any sampling point suffices. Otherwise another site should be sought where the determinands are homogeneously distributed.

If it is impossible to find such a sampling site, samples should be taken from sufficient points at the chosen site to ensure representative results. Ideally, samples should be taken from many different points, but the following approach is suggested to restrict the amount of work involved. The portion of the cross-section through which a large proportion (say 90 %) of the total flow passes is decided approximately. Within that portion, say six samples should be taken spread across the portion. Large rivers might require more lateral and vertical samples. To determine whether any apparent differences between samples are caused by non-homogeneous distribution or by analytical errors, a statistical analysis of the results is necessary. All such samples should be collected as close to the same time as possible to avoid the effects of temporal variation. Samples should preferably be taken from at least three flows corresponding as closely as possible to the minimum, modal and maximum flows expected during the period of the tests. Factors other than flow can affect the degree of heterogeneity of certain parameters, e.g. climatic conditions can affect dissolved oxygen. Ideally again, each one of these factors should be identified and investigated but this is usually impractical. It is suggested that consideration of such factors be deferred until the results from the tests suggested in the preceding are available.

It is imperative that great care be taken if such samples are combined to give a single representative sample for analysis; this can be carried out, but only if there is complete certainty of the variability between these samples. In addition, the combination of samples in this way cannot be undertaken when sampling for dissolved gases or other volatile constituents.

If there are many sites requiring heterogeneity tests, the locations can be divided into various classes, and tests made at least in one location from each class. The classes are best decided from local experiences; examples of river characteristics that might be useful for classification are: wide and narrow, deep and shallow, straight and tortuous, polluted and unpolluted, flashy and non-flashy, lowland and upland. If the locations tested initially were adequately homogeneous, other work could proceed but with the longer aim of checking all locations as soon as practicable.

It should be noted that different determinands can show different degrees of heterogeneity. It is suggested that the following determinands (provided they are required for the routine programme) should be checked at each sampling location to be tested: pH, conductivity, chloride, ammonia, suspended solids, dissolved oxygen, colour, iron, chlorophyll, total organic carbon, and biochemical oxygen demand. Other determinands should be included if they are of special interest or are indicated by local circumstances.

5.2 Frequency and time of sampling

It is essential that the sampling programme be properly statistically designed in order that the statistical summary information produced from the analytical results provides an estimate of the required information to within the tolerance limits of the programme's objectives. If the objectives do not include a definition of the magnitude of the tolerable error, a statistically based sampling programme is impossible. Implement the guidance and recommendations on the application of statistics to sampling frequency given in ISO 5667-1.

Where cyclic or other persistent variations are present, better precision should be sought in estimating mean concentrations by systematic rather than by random sampling (for any given number of samples), provided that the sampling interval is short enough for consecutive samples to reveal the variations.

When using systematic sampling, ensure that the frequency of sampling does not coincide with any natural cycle present in the system or with some other time-based effect (e.g. a pump just upstream starting once an hour), a study of the effects of which are not part of the sampling objectives.

In river systems, regular cyclic variations in water quality can occur, for example, with periods of one day, one week and one year. Sampling times should be carefully chosen to assess the nature of these variations. If variations are not persistent or if their amplitude is appreciably smaller than that of random variations, it is usually adequate either to choose the sampling times randomly or to select them in a systematic manner with samples evenly distributed throughout the period of interest. It is important when systematic sampling is undertaken over a long period that sampling programme designers take account of possible changes in local time throughout the sampling period. In all other cases, the timings should be chosen so that different parts of the cycle are sampled, unless the extreme concentrations are of interest, when samples should be taken at the corresponding times of each cycle. Further guidance on these issues is given in ISO 5667-1.

If the sampling programme is designed to detect trends in water quality, care should be taken during its design to ensure that all variations of interest are detected. These temporal surveys show the changes in the chemical and/or physical conditions of the river or stream due to contamination or natural variation over time. The surveys should be carried out using fixed sampling points and standardized methodology in accordance with an established programme. This might require samples to be taken at the same time, the same day or same month, depending on the possible duration and flushing rate of the trend under investigation.

All sampling equipment and procedures should be documented and any field observations and measurements recorded on appropriate field sheets or in an appropriate logbook in order to facilitate accurate repeat surveys in accordance with the temporal scale on which the surveys are being undertaken.

6 Preparation for sampling

River sampling often involves working in relatively remote areas for the majority of the day, but nevertheless lone working should be avoided if possible and team working is preferred, although at a greater cost. As a result, sampling operatives and vehicles should be self-contained, and all sampling staff should be properly trained and should receive clear sampling instructions. These instructions might be in the form of a sampling folder or manual containing details of each sampling site including the items tabulated in the following, together with a description of the sampling site, a site plan, and information about any special features of the sampling site (e.g. key holders, safety precautions). Gloves should be available for wearing by the operative to avoid contamination (see 12.1).

The following information should be available as a minimum:

a) a precise description of and documentation on the sampling point;

b) the type of sample required;

c) the applicable sampling techniques and protocols;

d) information, if necessary, about any sub-samples, e.g. bottles, filtration, preservation, or any field measurements, etc.;

e) the order of filling containers, which can be important in some conditions, for example to minimize contamination.

If necessary, storage should be provided for clean sampling equipment and containers. Facilities should always be available to ensure that all sampling equipment can be kept clean. It is imperative that contamination be prevented at all times.

New or cleaned containers should not be stored near those containing preservative agents.

Many of the considerations taken into account for storing equipment at the depot apply to the sampling vehicle as well (see 11.2). A cooling device capable of maintaining samples at a temperature of (5 ± 3) °C for transportation should be available in the vehicle. Transport precautions: the vehicle should be fitted with racks to hold the equipment and prevent any movement that might cause a breakage. This is especially important for glass bottles, bottles with preservatives and hand-held meters.

7 Sampling at specific locations

7.1 General

The choice of sampling location of certain single sampling stations can be reasonably flexible. For example, a monitoring station for a baseline record of water quality can be moved upstream or downstream several kilometres to permit use of a convenient bridge or to allow an upstream effluent discharge or tributary to be well mixed laterally when the stream arrives at the station.

When selecting a series of sampling locations to establish a baseline record of water quality, it is desirable that the locations be established at marked changes in physical characteristics of the stream channel. For example, a stream reach between two adjacent stations should not include both a long rapids section of swift shallow water with a rocky bottom and a long section of deep, slow-moving water with a muddy bottom. Stations at each end of the combined reach would yield data on certain rates of change such as re-aeration that would be of an unrealistic average to two widely different rates. Much more would be learned of the actual natural purification characteristics of the stream by insertion of a third station within the reach between the rapids and the quiet water sections.

When the effects of a tributary or an effluent on the quality in a particular reach of the main stream are of interest, at least two locations are necessary, one just upstream of the confluence and the other sufficiently far downstream that lateral and vertical mixing are complete. It might be necessary to sample the tributaries and effluents themselves just before they reach the main river and further upstream, if considered necessary. In some cases, it might be desirable to project the concentration or load of some unstable constituent from the sampling station above the effluent discharge to the point of discharge. In such cases, it might be desirable to locate two or three stations above the effluent discharge to establish the rate at which the unstable constituent is changing. The time of travel between the stations should be sufficient to permit accurate measurement of the change in the constituent under consideration. The sampling location on a tributary should be as near the mouth as possible. This, frequently, might bridge some distance upstream from the mouth. Two or three stations on the tributary, to establish the rates of change of unstable constituents, might be desirable when projection of data on unstable constituents from the tributary station to the main stream is necessary. When tributaries are being sampled, care should be taken to avoid collecting water from the main stream that can flow into the mouth of the tributary on either the surface or bottom because of differences in density resulting from temperature, dissolved salts, or turbidity differences.

In detailed studies, for example, in investigating the nature of a decline and recovery in dissolved oxygen, more sampling positions downstream of an effluent discharge might be necessary. In such studies, the distance between the sampling points should be such that it is possible to carry out the required calculations to define the shape of the self-purification curve. The number of intermediate points depends on the rate of flow, the degree of pollution, the self-purification capacity of the river, the

existence of sludge deposits, etc. and especially on the use to be made of the results; the more detailed the information needed, the more sampling points are required.

Cross-sectional mixing in a river usually proceeds more rapidly than longitudinal mixing and the distance downstream of an effluent or tributary at which to sample can sometimes be chosen using this phenomenon. For example, if interest is centred on short-term variations in quality due to temporal variations in an effluent, then this distance should be as small as possible, consistent with adequate cross-sectional mixing. Alternatively, if the long-term average quality were of prime interest, it is preferable to make the distance as large as possible so that the short-term variations tended to be smoothed out by the longitudinal dispersion. When the peak concentration of an effluent passes an island, the peak can be split to form two peaks of different concentration when mixing occurs again downstream of the island.

Care should be taken that particular local features of a river or stream do not affect the validity of samples. For example, weirs promote re-oxygenation, heavy growths of weeds, or sewage fungus can affect a number of determinands, drainage ditches can be a source of heavy pollution during rainstorms, and inflow of ground water can cause changes in quality. In addition, the river water quality can be affected by other discharges, adsorption on bottom deposits and re-suspension of settled material. A special problem in river sampling arises when non-conservative determinands (for example, biochemical oxygen demand, bacteria) disperse into a river because the rate at which the concentration of the determinand changes (as a result, for example, of biochemical degradation) might be more rapid than the process of dispersion. No recommendations can be given to overcome this problem, but it is as well to recognize it. Another example is the change in the chemical form of a determinand in an effluent or tributary, when mixing with a river, e.g. the precipitation of iron.

Generally, sampling at or near the surface, bottom, bank, stagnant areas, and pools should be avoided. Particular care is needed not to disturb bottom sediments and to avoid non-representative films on the surface. Whenever possible, samples collected from positions at least 30 cm above the bottom of a stream and at a similar distance below the surface are usually satisfactory.

See Clause 15 on health and safety precautions to be taken to ensure sampler safety; however, appropriate personal protection equipment (such as wearing high visibility jackets) and a flotation aid (lifejacket) should be worn if appropriate.

7.2 Sampling from bridges

When selecting the place on a bridge from which to take a sample, ensure that

a) there is a sufficient depth of water to submerge the sampling container,

b) when submerged, the container does not disturb bottom deposits,

c) there is sufficient clearance on the bridge when suspending the container to avoid dislodging, potentially contaminating material from the bridge structure, and

d) when sampling on the upstream side of the bridge, the sampling operative does not become unsighted, i.e. the container is not carried under the bridge by the current.

The collection containers should be submerged in the main flow of the river channel, preferably upstream of the bridge.

The water sample should be collected from the homogeneous zone in such a way as to avoid including the surface film and avoid eddy water caused by the bridge abutments that can aerate the water, thereby biasing certain measurements.

Table 1 lists the advantages and disadvantages of collecting samples upstream or downstream of a bridge.

In light of these contrasting effects, it is recommended that practitioners use the sample sheet to record whether the sample was taken upstream or downstream of the bridge, visible turbidity, and signs of pollution or local anomalies.

Table 1 — Advantages and disadvantages of sampling upstream or downstream of a bridge

Sample collection from a bridge	Downstream of the bridge	Upstream of the bridge
Safety while sampling	Difficult to see boats or drift debris arriving and react to avoid them. Have a quick look upstream before collecting samples	Easy to see boats or drift debris arriving under bridge and to react to avoid them
Equipment visibility	Good visibility, as the current carries the equipment downstream	Less visibility, as the current carries the equipment under the bridge
Homogeneity of the water body	Mediocre, as turbulence caused by bridge abutments can introduce bias into *in situ* measurements	Good, as flow is laminar. Recommended for *in situ* measurements
Particles dropping into the water due to vibrations in the bridge	Potential risk	Minimal risk
Particles dropping into the water due to chain friction on the bridge sidewall	Little risk, as the equipment is carried downstream	Heaviest chain friction against the bridge sidewall

If the depth of water is insufficient, select the most appropriate alternative sampling approach (see 9.3, 9.4, and 10.5). It might be possible to use a small sampling vessel on an extension pole if there is insufficient depth of water to use a vessel on a rope.

7.3 In-stream sampling

In all cases, and in particular where sampling can be a source of contamination or loss of determinand (e.g. pesticides, oils or trace metals), bottles should preferably be filled directly from the body of water to be sampled. This same technique should also be employed at the discretion of the sampling operative where small numbers of sub-samples are used. However, care should be taken to avoid sample contamination by disturbance of either the bed or the bank of the watercourse.

For samples collected from a shallow (<50 cm) river or stream, sample collection is performed by wading. The person responsible for collecting the sample wades into the water and collects the sample from upstream of their position so as not to contaminate the water volume being sampled. With this type of sampling, it is essential that all relevant health and safety precautions be followed (see Clause 15) during the sampling.

The collection containers should be submerged in the main flow of the water channel and in the homogeneous zone in such a way as to collect a water sample without including the surface film or eddy water. Where possible, water samples should be collected at around 30 cm under the surface, or otherwise at mid-height between bed and surface. Record the visible turbidity of the water body on the sample sheet, also noting down any signs of pollution or any local anomalies observed.

7.4 Sampling from the bank side

Where a sample is to be obtained from the bank side, care should be taken to avoid sample contamination by disturbance of either the bed or the bank of the watercourse. Usually, an extension pole is required, but often a vessel on a rope can be used. In addition, it is essential that sampling only be carried out where the bank is stable.

Silted up zones on convex river banks should be avoided. Location preference should be given to more concave reaches of the bank with faster flow zones. As far as possible, samples should be collected using a pole or a ballasted sample collector, which allow sampling up to several metres from the bank side. For small streams or channels that are narrower, operatives should attempt to take the sample from mid-channel over the stream bed.

The collection containers should be submerged in a homogeneous zone in such a way as to collect a water sample without including the surface film or eddy water.

Where possible, samples should be collected at around 30 cm under the surface, or otherwise at mid-height between the bed and surface. Record the visible turbidity of the sample on the sample sheet (see Clause 13), also noting any signs of pollution or any local observed anomalies.

7.5 Sampling from craft

When sampling from a boat, care should be taken to avoid contamination of the sample with disturbed deposits or any discharges from the boat. A properly maintained boat that is appropriate for the work should be used. The staff and crew should all be properly trained. Attention is drawn to the existence in some countries of legislative requirements for the safety of personnel and craft.

Studies often require samples to be collected from a boat. In such cases, work to the sampling depth stipulated in the requirements. Otherwise, a sample collected from 30 cm under the surface should suffice. The collection containers should be submerged in the homogeneous zone in such a way as to collect a water sample without including the surface film or eddy water. The sampling points can be flagged using marker buoys.

When the sample is collected, the boat engine should be cut, and the samples collected from the prow of the boat or off the sides so as not to contaminate the samples with fuel hydrocarbons (on motor boats). Samples should not be taken when the boat has just turned round and possibly contaminated the water being sampled.

7.6 Sampling under ice

The winter sampling location should be as close as possible to the one used during other seasons of the year. If an alternative sampling point is chosen because of ice, this should be mentioned in the sampling report. If any ice safety concerns exist, samples should be collected from an alternative sampling location. The sampling staff should be sufficiently trained.

NOTE Where there is a small area of open water, otherwise covered by ice, for instance under or near bridges, and where waterfowl or other birds are present, it is likely that contamination is also present.

8 Sampling methods

8.1 Single, discrete samples

In cases where sub-surface sampling (e.g. within 30 cm of the water surface) is acceptable, it is often sufficient to immerse a clean container (e.g. a bucket or can) in the river or stream of interest. The contents are then poured into appropriate sample bottles. Alternatively, the sample bottles or containers can be directly immersed in the river or stream. However, sampling of surface films should be avoided, unless these are particularly required for analysis.

8.2 Sampling from specific depths

When a sample is required from a specific depth, special sampling equipment, which is lowered into the water to enable a single sealed or continuous sample to be taken from the chosen depth, should be used (see ISO 5667-1). This can be in the form of bottles fitted with an opening mechanism to remove the stopper at the required depth or devices that draw a sample into the bottle via an inlet suspended at the required depth.

Continuous sampling systems for rivers should be carefully selected and installed to avoid blockage of the inlet by debris in the water. Surrounding the inlet with both a coarse and fine mesh should protect it, but frequent inspection and removal of accumulated debris can be required and these factors should be borne in mind when selecting the sampling point. Sampling systems at exposed locations (e.g. on

river banks) might need protection from vandalism and effects such as extremes of water level and temperature (freezing).

If the rate of pumping is very slow, the effect of gravity on suspended solids can reduce their concentration in the sample. If suspended material or determinands that can adsorb on to it are being investigated, slow pumping rates are not recommended. This often precludes the use of the low-powered peristaltic pumping systems common to many automatic sampling machines. Ideally, sampling should take place under isokinetic conditions but, where this is impracticable, the linear flow velocity within the intake tube should not fall below 0,5 m/s nor exceed 3,0 m/s.

The aim should be that the concentration of determinands in the sample and the main body of water should not be significantly different.

For representative sampling of insoluble materials, the rate of sampling should be adjusted so that the velocity of water in the inlet of the sampling system is the same as that of the water being sampled (i.e. sampling should take place under isokinetic sampling conditions). This also requires that the inlet of the sampling system faces the direction of the river or stream flow.

Where there are significant variations in water level, sampling can be facilitated by mounting the sampling system or inlet on a floating platform; however, a floating platform can be vulnerable to damage. Alternatives include the use of submerged inlets suspended from floating buoys (or similar devices) where the floating inlet is connected to the sampling device via flexible tubing anchored to weighted blocks set in the river bed. A more costly but permanent arrangement is to connect the sampling device to a permanent multi-point inlet which enables samples to be taken at the most suitable depth for the particular sampling purpose.

9 Sampling equipment

9.1 Single, discrete samples

Samples are frequently collected directly into laboratory bottles as this method is perceived to be the least contaminating. Where this is not possible, samples should be collected indirectly using open-mouthed vessels.

All equipment and devices should as far as possible consist of materials that are inert with respect to the component(s) to be analysed. Before any sampling equipment is used, tests should be performed to show that its use has no effect on the determinand to be analysed. In some cases, if samples are required from under ice or when analysis might be compromised by using an indirect method (e.g. for trace organic analysis), various pieces of equipment are available into which the bottles can be fitted and then lowered into the river.

It is essential that all equipment and devices to be used be properly maintained and cleaned so that the representativeness of the samples taken is not adversely affected. The devices should be regularly mechanically and chemically cleaned. In the case of the funnel and sampling scoop, the outside should also be checked when doing this. The appearance for example of dull or discoloured patches on the devices might be a sign that the device is no longer suitable for sampling.

To ease the collection of samples, a range of sampling vessels from 50 ml to 3 l should be employed. In order to achieve the analytical detection limits often required for clean rivers, even larger volumes of sample can be necessary and physical handling issues might therefore arise.

Vessels can be lowered by means of a rope or by flexible wire covered in polytetrafluoroethylene (PTFE) or polyethylene. Any material that does not affect the determinand can be used. If the sample is to be taken from a bridge, a small length of stainless-steel chain can be used to connect the wire or rope to the sampling vessel in order to aid the submersion of the vessel and help prevent contamination. Reference should be made to ISO 5667-1 and ISO 5667-3 for further information on sampling materials.

If the use of a rope leads to insufficient control of the sampling position, a sampling pole can be used. Poles can be fixed or extensible in nature and have either the sampling bottle itself or sampling equipment clamped at the end.

If samples from rivers of varying quality are to be taken or different analytical detection limits are required, it might be necessary to carry different sets of sampling equipment to prevent cross-contamination. In extreme cases, this might require one set of sampling equipment per site.

In cases when the sample should not include the surface layer, two simple alternative processes are available. If it is possible to enter the water safely, a small-mouthed bottle can be lowered to 30 cm below the surface before the stopper is removed. Alternatively, an open bottle can be fixed upside down on a pole, lowered to the required depth, the pole rotated through 180° along its axis and the bottle allowed to fill.

9.2 Sampling of surface layers for LNAPL (e.g. oils) or surface films

A wide-mouthed vessel should be used for sampling surface layers. The sampling vessel should be controlled either by hand or using a pole, but not by means of a rope as it is not possible sufficiently to control the sampling vessel at the surface.

9.3 Devices for sampling from specific depths

In situations where it is essential to sample at specified depths below the surface (or where sampling for dissolved gases), ensure that specialized sampling devices are used. Guidance and recommendations on the use of such devices are given in 9.4 and ISO 5667-1. Bottles or other sampling equipment used for single discrete samples can also be used provided that they are fitted with an opening mechanism to remove the stopper at the required depth.

9.4 Automatic sampling devices

Automatic sampling devices can be used in many river and stream sampling situations, since they enable a continuous sample or series of samples to be collected without manual intervention. They are particularly useful in preparing composite samples in situations where samples need to be taken to study variations in river quality with time.

The choice of the most suitable type of machine depends on the particular sampling situation. For example, sampling in order to estimate the average load of dissolved trace metals in a river or stream might best be carried out using a continuous flow-proportional device, utilizing a peristaltic pumping system.

In all cases, the sampling machine should be tested to ensure satisfactory performance in the situation being investigated.

Simple automatic machines can be programmed to take samples at pre-set time intervals or be operated by an external trigger such as a signal generated by excessive rainfall. More refined flow-proportional machines continuously measure the flow in the river or stream and take samples after a fixed volume of water has passed the sampling point.

It is essential that the automatic sampling machine or the storage time and conditions of the samples within it do not result in any significant deterioration. Samples should be preserved in accordance with ISO 5667-3.

Further guidance and recommendations on automatic sampling machines and their use is given in ISO 5667-1 and Reference [11].

9.5 Other sampling equipment

If filtering is required in the field, suitable equipment should be taken to the sampling site and, if necessary, advice sought from the laboratory analysing the samples on the specification for the filtering equipment (see 11.1 and ISO 5667-3).

At some locations, it is necessary to take samples through thick ice during winter. This requires specialized equipment such as an auger or ice drill.

10 Taking the sample

10.1 Risk factors

As far as possible exclude risk factors that might cause contamination or some effect on the sample and indicate these factors on the sampling form. Factors that might give rise to a detrimental effect on the sample include:

a) environmental factors:

— exhaust gases (cars/motorboats);

— painting work in the vicinity of the sampling point;

— use of plant protection products or fertilizing activities in the vicinity of the sampling site.

b) method or procedure:

— disturbance of the river bed such that bottom deposits are also sampled;

— co-sampling of floating layers;

— contamination of the sample with algae or "anti-fouling" material as a result of scraping the bucket along for example the sampling ship's hull or quay;

— aeration of the sample when filling sampling bottles resulting in a loss of the volatile substances to be sampled, aeration can also increase the oxygen content if the water is low in oxygen or decrease it if the water is supersaturated;

— not mixing when filling bottles as a result of which the undissolved components present with the impurities bound to them are not evenly spread through the sampling bottles.

c) sampling materials:

— dirty or insufficiently cleaned sampling bottles and/or devices for sampling;

— wrong material choice resulting in adsorption/desorption of the substances to be determined.

Also see 12.1 for more guidance on avoidance of contamination.

10.2 Arrival on site

If the site procedures require, the sampling operative(s) should identify themselves to the site owner and follow their safety instructions. The sampling site should be confirmed using the information contained in the sampling folder or manual (description, pictures, coordinates, etc.) to make sure that it is the correct location. Global positioning system (GPS) equipment can be helpful as it allows quick and accurate positioning.

An on the spot site safety assessment should be carried out prior to the sampling. This should include, for example, a quick review of potential hazards in getting to the sampling spot (e.g. slippery or icy bank) and the water hazards (e.g. upstream logjams) water swiftness and depth, etc. Mitigation of these

hazards should then be considered (i.e. use of appropriate safety equipment — or not even collecting a sample if it cannot be taken safely).

10.3 Rinsing the equipment

All the equipment that comes in contact with the water should be rinsed, preferably up to three times. Take sufficient volume of the body of water to be sampled for a thorough rinsing of all the equipment, using the sampling technique being used at the site. If using a rope, pour some of the contents of the vessel over the final metre of the rope (including the chain, if used) to wash off all traces of previous samples. Remove as much excess liquid as possible by shaking. Do not allow this part of the rope to be re-contaminated by, for example, allowing it to come in contact with the ground. Similarly, rinse the end of the sampling pole if used. If, but only if, the laboratory instructions require the sample bottles to be rinsed, remove the caps prior to taking the rinse water, handling the caps in such a way that the interior surface does not become contaminated, preferably holding them in one hand or keeping them in a polyethylene bag.

Follow the instructions in ISO 5667-3 for rinsing sampling bottles. It is important that sample bottles are not rinsed if they contain preservatives.

10.4 Direct sampling

Direct sampling provides the minimum risk of contamination while ensuring a representative sample. However, it should not be employed with bottles containing preservatives. Direct sampling should only be used when it is considered to be safe and non-hazardous. Prior to direct sampling, the bottles should be rinsed as specified in 10.3.

Enter the body of water to be sampled, face upstream towards the flow of the water, remove the cap of the bottle (if still in place) and retain this in one hand. Plunge the neck of the open bottle under the surface of the water until it is submerged to a depth of about 30 cm. If there is little depth of water, ensure that the sample is not contaminated by bottom sediment.

Tilt the neck of the bottle such that it points slightly upwards towards the surface and towards the flow. Allow the bottle to fill as needed. In most cases, fill the bottle right to the top to exclude air, as gas exchange might rapidly change the quality of the sample. In some cases, such as when a solvent is added directly to the bottles, as in oil analysis for instance, the bottle should only be filled to the shoulder. Guidance on the filling level of the bottle should be sought from the laboratory. Freezing of the sample should not be allowed unless it is essential that the integrity of the sample be preserved prior to analysis, when a space should be left at the top of the bottle. When as full as needed, remove the bottle from the water and replace the cap securely. Return to the shore and label the bottle as detailed in 12.2.

10.5 Indirect sampling using a sampling vessel

Gently lower the sampling vessel to the surface of the water, ensuring the vessel is not contaminated on the descent. Allow the vessel to fill. Try not to collect a high proportion of liquid from the surface and try to avoid any floating material. Do not let the vessel contact the river bottom. Remove the vessel from the water, again ensuring no contamination occurs.

A pole gives better control, so contamination from the bottom and floating objects can be more easily avoided but, as the volume collected can be much less than with a rope and large vessel, many aliquots can be needed. These aliquots can be used to produce a bulk sample before filling each sample bottle (see 10.8).

Pour the sample carefully into any bottle required, either directly or using a funnel and making sure no sediment has time to settle out. If sediment material has settled out in the sample, then the bottle should be shaken thoroughly before pouring to re-suspend the material. If preservatives are present, ensure that overfilling the bottle does not cause contamination to the watercourse. Stopper the bottles and label as detailed in 10.10.

10.6 Sampling through ice

Clear loose ice and snow from around the sampling location, and drill through the ice with an auger or ice drill. Ensure the area around the hole remains clean and free of potential contamination (gas, dirt from drill and boots, snowmobile exhaust, etc.).

Remove all ice chips and slush from the hole, using a plastic sieve. Wait several minutes for the water to flow freely under the ice, allowing potential contaminants to clear before taking the samples. Take the sample from well below the lower layer of ice.

10.7 Sampling of surface layers or films

Sampling can be achieved either by entering the watercourse or by using a sampling pole. If a bottle is to be used directly, remove the stopper and store as specified in 9.2. Arrange for the sampling vessel or bottle to face upstream and lay it so that it is horizontal to, and slightly below the surface of the water, such that half the mouth of the bottle is submerged, and allow the bottle to fill so that it contains a proportion of the surface layer. Remove the vessel from the water as soon as it is full as practicable. If it is allowed to overfill, there is a chance that the surface layer might be displaced. Alternatively, or if sampling a thin oil film, the proprietary sampling machines specified in ISO 5667-1 can be used.

10.8 Sampling by increments

In conditions of low river flow or where the source of water is difficult to access, a sample can be prepared from small volumes by using small vessels and transferred into a suitable-sized bulk bottle. Care should be taken not to contaminate any of the increments. When there is sufficient volume in the bulk sample, the contents can be transferred homogeneously (using constant swirling) to the individual sample bottles. For the sample to be considered as "single, discrete", the total time for all the increments to be taken should be such that no change in the river composition would be expected. If this is not known, the time for all increments to be taken should be less than 5 min.

10.9 Adding preservatives in the field

The preservation of certain types of sample is required in the field. Some sample bottles should already contain preservatives and others should have the preservative added at the time of sampling, e.g. when sampling for dissolved oxygen. Reference should be made to ISO 5667-3 and specific analytical standards for information on preservation of samples. Follow any specific manufacturer's instructions for adding the preservatives and take care not to contaminate the inside or outside surfaces of any funnel with the preservative. The funnel should be rinsed thoroughly both inside and out with a quantity of the sample before using again. Appropriate safety gear (usually gloves and safety glasses) should be worn when handling and dispensing the preservative.

10.10 Labelling

Samples should be labelled as specified in 12.2 at the time of collection and before going on to the next sampling site. For further detail on issues of traceability, chain of custody, quality systems, and registration, see 11.3.2 and 12.3.

11 Stabilization, transport, and storage of samples

11.1 Stabilization

The stability and integrity of the samples is of paramount importance.

Samples should be stabilized or preserved in accordance with the provisions of ISO 5667-3 and appropriate analytical standards.

The following specific guidance should be noted.

For some applications, sampling is concerned with an assessment of soluble species (e.g. trace metals in river water). If this is the case, then it is necessary to separate the "dissolved" from the "particulate" material as soon as practicable after sampling (i.e. preferably at the sampling site before transportation to the laboratory). This minimizes changes in composition that can otherwise occur after the sampling operation, but before any subsequent laboratory pre-treatment or analysis. Several techniques are available, but the most convenient for use in the field (i.e. outside the laboratory) is filtration, details of which are presented in ISO 5667-3.

All preservation steps should be recorded in the report and the storage temperature measured and recorded.

11.2 Transportation

Follow the general guidance on transport, stabilization, and storage of samples is provided in ISO 5667-3.

11.3 Security and traceability of samples during storage and delivery

11.3.1 Routine samples

The sampling operative has a responsibility towards the security and traceability of any samples, sub-samples and sample registration documents in their care.

The sampling operative should check that samples, sub-samples, labels, sample registration documents, etc, are undamaged and deposited in the designated place. If any containers are lost, damaged or broken in transit, this should be recorded by the sampling operative on the sample registration form. If a courier is involved then the courier should make a similar record while the samples are in his/her care. The courier should deliver the samples in accordance with laboratory instructions, especially if delivery takes place when the laboratory is unmanned.

11.3.2 Samples which might be used for legal purposes

Rules which should be followed if samples are to be used for legal purposes can be much more onerous, depending on the legal system operating in a particular jurisdiction.

NOTICE Attention is drawn to the existence in some countries of national legislation, with which all persons involved at any stage in the sampling, storage or delivery of samples, or in the associated documentation, should be thoroughly familiar.

12 Quality assurance

12.1 Avoidance of contamination

Specific written instructions should be provided to the sampling staff on protocols to follow to avoid contamination on sampling surface waters. Sampling staff should be encouraged to document any deviation to the foreseen risks to aid interpretation of results.

Avoiding contamination during sampling is essential. All possible sources of contamination should be taken into account and the appropriate control applied if necessary. Risk factors in taking the sample are discussed in 10.1.

NOTE Procedures to monitor contamination and its control are presented in ISO 5667-14.

Sampling operatives should wear disposable gloves during the whole of the sampling procedure, both to protect themselves from contact with the sample and to prevent sample contamination. It is important to avoid cross contamination from one sample location to another by handling protective clothing and sampling equipment in such way as to avoid cross contamination.

Examine each sample or sample bottle for large particles such as leaves or detritus. If these are observed, discard the sample and collect a new one.

NOTE If the sample is to be discarded because the sample bottle contains chemicals as a preservative, then samples are intended to be disposed of in an environmentally friendly manner to ensure that the sampling source is not contaminated.

NOTICE In all cases, if contamination is seen, known, or suspected to have occurred by any route, the sample should be discarded and the sampling repeated. However, if it is not possible to take a sample without contamination from sediment, decant the sample immediately and record the procedure on the sample container.

12.2 Sample identification and records

All sampling equipment and procedures should be documented and recorded on an appropriate field sheet or in a logbook in order to facilitate accurate repeat surveys in accordance with the temporal scale on which the surveys are being undertaken.

Sample containers should be clearly and unambiguously identified, so that subsequent analytical results can be properly interpreted. All details relevant to identification of the sample should be recorded on a label attached to the sample container.

Where the samples are identified through a pre-printed label with the site details and a unique machine-readable code, duplicated on both sample label and laboratory sample registration document, fewer details need to be recorded. Only details that can change, such as date, time, and perhaps operative's identification (which can be in the form of a signature), are required.

No further samples should be taken until all sample bottles have been labelled.

12.3 Assurance and quality control

Quality control measures the quality requirement of a process and uses techniques to correct any deviation from a process. Refer to ISO 5667-14 for full details of such techniques for use for river sampling. These techniques include training, equipment calibration and recording of data, and the use of blanks to detect cross contamination. The use of appropriate quality control measures is strongly recommended to optimize the quality of results.

13 Reports

13.1 Analytical reports

The detailed form of the sampling report depends on the objectives of sampling. All conditions that can influence the analytical results should be noted. Matters that could be considered for inclusion are

a) the name of the river or stream,

b) the sampling point (i.e. the sampling position in the cross-section at the sampling site),

c) information on sampling at specific locations (bridge, in stream, from the bank),

d) the date and time of sample collection,

e) the name of the sample collector,

f) the weather conditions at the time of sampling (including air temperature) or immediately prior to sampling (e.g. amount of rainfall, cloud, sunshine),

g) the appearance, condition, and temperature of the water body,

h) the flow condition of the water body (it can also be useful to record any marked variations in flow prior to sampling),

i) the appearance of the sample (e.g. the colour of the water and suspended solids, clarity, nature and amount of suspended solids, odour),

j) the type of sampling device used,

k) the information on any sample preservation technique used,

l) the information on any sample filtration technique used,

m) the information on any sample storage conditions,

n) any deviations from standard protocols,

o) the information on *in situ* measurements,

p) anything noted by the sample collector that can have potentially influenced the sample (e.g. dust in air, fish spawning, nearby traffic.), and

q) a reference to this part of ISO 5667 (ISO 5667-6:2014).

An example of a sampling report protocol is given in the Annex B.

13.2 Sampling protocols

A "history" of changes to sampling protocols and procedures should be kept to allow a person examining data the opportunity to evaluate the impacts of procedural changes in both the field and the laboratory on the series of observations collected. Laboratory changes such as detection limits and precision are usually recorded, but changes in sampling methods, sampling points and personnel should all be part of the record. Sometimes this applies to a specific station, and at other times to an entire network. All too often the understanding of a data record is wrongly attributed (see Reference [13]).

14 Certification, registration, or accreditation

In many parts of the world, quality management systems have been developed or adopted and applied to water quality sampling. These systems attempt to control the factors that affect the quality of the final data produced.

NOTE An example is ISO/IEC 17025.[8]

The systems themselves do not specify the quality of the data, which is defined by the reason for its production. For instance, water quality data can be used to protect water treatment plant intakes from pollution events. In this case, it is not important to produce highly accurate results, but it is important to produce them quickly before the pollution reaches the intake. Conversely, reporting results for regulatory purposes can require the highest accuracy and lowest detection limits possible. These requirements should be specified by the user of the data prior to sampling.

15 Safety precautions

The collection of water samples has some elements of danger, particularly when sampling frozen-over rivers or streams, or sampling directly from shore or by wading during high, swift water conditions, and it is particularly important that relevant safety guidance be followed.

For each sampling event, personal safety concerns should always be assessed and if appropriate a risk assessment carried out for the site. Appropriate personal protection equipment, such as flotation aids, depth rod and hi-visibility clothing, should be provided to ensure safety,

Chest waders should not be worn as they present a safety risk.

