

**Drinking-
Water
Standards
for
New Zealand
2000**

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Preface

I am pleased to release the *Drinking-Water Standards for New Zealand 2000*.

Since the publication of the *Drinking-Water Standards for New Zealand 1995* our knowledge of the quality of the drinking-water available to our communities, and the features that contribute to that quality, has grown enormously.

It was therefore timely for the Ministry of Health to lead a review of the Standards taking into account what we now know about the toxicological and microbiological hazards of our drinking-water supplies.

The *Drinking-Water Standards for New Zealand 2000* provide much important information for owners and operators to assist in the management of public and private drinking-water supplies.

I wish to extend my appreciation to those many people who have contributed to the revised Standards. I would especially thank the members of the Working Party for their efforts in reviewing and revising the many technical draft proposals that were part of the process. The result will significantly contribute to improving and protecting the public health of New Zealanders.

A handwritten signature in blue ink, appearing to read 'K. Poutasi', with a stylized flourish at the end.

Karen O Poutasi (Dr)
Director-General of Health

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1 Overview of the Drinking-Water Standards

1.1 Introduction

Safe drinking-water, available to everyone, is a fundamental requirement for public health.

The *Drinking-Water Standards for New Zealand 2000* (DWSNZ 2000) replace the *Drinking-Water Standards for New Zealand 1995* with effect from 1 January 2001. They detail how to assess the quality and safety of drinking-water. The Standards define drinking-water: that is, water intended to be used for human consumption, food preparation, utensil washing, oral hygiene or personal hygiene. The Standards provide criteria applicable to all drinking-water (except bottled water which must comply with the Food Act 1981).

Drinking-Water Standards for New Zealand 2000 list the maximum concentrations of chemical, radiological and microbiological contaminants acceptable for public health in drinking-water. For community drinking-water supplies, the Standards also specify the sampling protocols that must be observed to demonstrate that the drinking-water complies with the Standards. Community drinking-water supplies are water supplies that serve more than 25 people for at least 60 days per year. All community drinking-water supplies known to the Ministry of Health are listed in the *Register of Community Drinking-Water Supplies in New Zealand*.

Because of the wide variety of circumstances relating to individual household drinking-water supplies, no general sampling recommendations are made for such supplies. If there is any concern about the quality of a household's drinking-water, advice on appropriate sampling programmes can be obtained either from the Environmental Health Officers of the local territorial authority or the Health Protection Officers at the public health service provider.

Toxic chemical contaminants in drinking-water rarely lead to acute health problems except through massive accidental contamination of a supply. Before it presents a health risk the water usually becomes undrinkable due to unacceptable taste, odour or appearance.

The problems associated with chemical contaminants of drinking-water arise primarily from their ability to cause adverse health effects after prolonged periods of exposure. Of particular concern are contaminants which have cumulative toxic properties, such as some heavy metals and carcinogenic substances.

Because chemical contaminants of drinking-water do not usually give rise to acute effects, they are placed in a lower priority category than microbiological contaminants, the effects of which are potentially acute and widespread. The control of risks arising from microbiological contamination is, therefore, given priority over the control of risks from chemical contaminants.

The *Drinking-Water Standards for New Zealand 2000* are intended to:

- set out the requirements for compliance with the Standards
- facilitate consistency of application throughout New Zealand
- protect public health while minimising unnecessary monitoring
- be appropriate for both large and small drinking-water supplies.

DWSNZ 2000 revise a number of small errors in the 1995 edition, update the analytical methods, and make a number of minor changes to improve the interpretation and robustness of the Standards. In addition, DWSNZ 2000 include the following significant changes:

- use of Bayesian statistics to guide the derivation of monitoring frequencies
- a change from faecal coliforms to *E. coli* as the indicator organism used for assessment of microbiological quality
- provision of tighter definitions (and a time frame for changing to a 0.1 NTU standard) of the turbidity requirements for meeting the protozoa (*Giardia* and *Cryptosporidium*) compliance criteria applicable to chemical coagulation and filtration treatment
- introduction of monitoring requirements for ozone and chlorine dioxide for meeting the protozoa compliance criteria applicable to disinfection.

1.2 Scope of the Standards

DWSNZ 2000 are applicable to water intended for drinking, irrespective of its source, treatment, distribution system, whether it is from a public or private supply or where it is used. The exception is bottled water, which is subject to different standards set under the Food Regulations.

The Standards specify maximum acceptable values (MAVs) for the microbiological, chemical and radiological determinands of public health significance in drinking-water and provide compliance criteria and procedures for verifying that the water supply is not exceeding these values.

The companion publication, *Guidelines for Drinking-Water Quality Management in New Zealand*, provides additional information about determinands listed in the Standards, the management of drinking-water quality, the derivation of the concepts used in the Standards and references to the publications on which the Standards are based.

Aesthetic considerations are not covered by the Standards. Guideline values for determinand concentrations that should avoid public complaints are given in Table 14.6 and are discussed in the Guidelines.

These Standards are for the general protection of public health. For people with special medical conditions, or for uses of the water for purposes other than drinking, additional or other water quality criteria may apply.

1.3 Development of the Standards

The Standards were developed by the Ministry of Health with the assistance of an Expert Working Group. Extensive use was made of the World Health Organization's *Guidelines for Drinking-Water Quality* and addenda up to 1998. Reference was also made to the *Drinking-Water Standards for New Zealand* 1984 and 1995 and to the *Australian Drinking Water Guidelines* 1996.

The Standards are based on the following principles.

1. The Standards define concentrations of health significant determinands which, based on current knowledge, constitute no significant risk to health to a person who consumes 2L of the water a day over their lifetime (taken as 70 years). It is usually not possible to define a concentration of contaminant (other than zero) at which there is zero risk because there is always some degree of uncertainty over the magnitude of the risk.
2. The Standards give top priority to health risks arising from microbiological contaminants. Control of microbial contamination is of paramount importance and must not be compromised in an attempt to correct chemical problems, such as disinfection by-product formation.

3. The Standards set priorities to ensure that, while public health is protected, scarce resources are not diverted to monitoring substances of relatively minor importance.
4. The Standards are set to protect public health and apply to health significant determinands only. However, as the public generally assesses the quality of its water supply on aesthetic perceptions, guideline values for aesthetic determinands are also provided. Refer to the Guidelines for more details.

Where feasible, the sampling protocols are designed to give 95 percent confidence that the supply has complied with the Standards for at least 95 percent of the time. A minimum of 38 samples, none of which transgresses the MAV, is required before the Ministry can be 95 percent confident that the supply complies with the Standards for 95 percent of the time. Not more than one transgression in 78 samples is acceptable if the Ministry is to remain 95 percent confident that the water complies with the Standards for 95 percent of the time.

However, for those determinands monitored monthly it will take several years of results before this degree of confidence can be attained.

1.4 Role of the Standards

The *Drinking-Water Standards for New Zealand 2000* contribute to the safety and quality of drinking-water by:

- defining safety standards for drinking-water
- detailing how compliance with these Standards is to be demonstrated
- facilitating the development of a consistent approach to the evaluation of the quality of the country's drinking-water supplies.

In the provision of safe drinking-water four barriers to disease are available:

1. protection of the quality of the raw water source
2. removal of chemical and microbiological determinands by physical means
3. inactivation of pathogenic micro-organisms by disinfection processes
4. prevention of contamination of treated water while it is in the network reticulation.

The Standards provide performance criteria for the second, third and fourth barriers to infection.

1.5 Content of the Standards

The DWSNZ 2000 set standards for drinking-water constituents or properties (determinands) and contain the information necessary to demonstrate whether a water supply complies with these Standards. Three types of compliance are included in these Standards: microbiological, chemical and radiological.

The Standards define the Maximum Acceptable Value (MAV) for each determinand. For chemical determinands this is usually the concentration at which the risk resulting from consumption of the contaminant over a lifetime is considered to be insignificant in the light of present knowledge. The Maximum Acceptable Values (MAVs) are discussed in Chapters 2, 3, 4 and 5.

The determinands have been classified into four priority classes. These are discussed in Section 2.3.1.

The monitoring and analytical requirements needed to demonstrate compliance for those determinands in Priorities 1 and 2 are given in Chapters 3, 4 and 5 for microbiological, chemical and radiological determinands respectively. MAVs for each of the individual health significant determinands are listed in Chapter 14.

The *Guidelines for Drinking-Water Quality Management for New Zealand*, (Guidelines) provide background and supporting information for the Standards and contain:

- data sheets with background information about each determinand including sources, environmental forms and fates, typical concentrations in either New Zealand or overseas drinking-water supplies, processes for removing the determinand from drinking-water, analytical methods, health considerations, derivation of the MAV and the guideline values for determinands of aesthetic interest
- chapters on microbiological, chemical and radiological determinands providing background information about each group of determinands
- background information about chlorine and alternative disinfection systems and their effect on drinking-water quality
- guidelines and risk management principles for community drinking-water supplies.

1.6 Maximum Acceptable Values (MAVs)

The Maximum Acceptable Value (MAV) of a determinand in drinking-water represents the concentration of a determinand which, on the basis of present knowledge, is not considered to cause any significant risk to the health of the consumer over a lifetime of consumption of the water.

Nearly all of the MAVs for the determinands covered in these Standards are based on the World Health Organization (WHO) publication *Guidelines for Drinking-Water Quality 1998*. The method of derivation depends upon the particular way in which the determinand presents a health risk. For some chemical determinands, adaptation of the method of derivation to suit New Zealand conditions has resulted in a minor difference between the guideline value recommended by WHO and the MAVs in these Standards.

In addition, some chemical determinands not covered by the World Health Organization publication *Guidelines for Drinking-Water Quality* (editions and supplements up to 1998) have been added to these Standards because of their public health significance in New Zealand circumstances. MAVs of these determinands have been calculated using methods appropriate to the situation. In all cases the approach was conservative and considerable safety factors have been used.

A general discussion on the methodology of the derivation of the MAVs is given in the Guidelines, together with specific information about the derivation of the MAV for each individual determinand.

Note that:

1. the MAVs set in the Standards define water suitable for human consumption and hygiene. Water of higher quality may be required for special purposes, such as renal dialysis or certain industrial processes. The Standards do not address these issues
2. short-term excursions above a chemical MAV do not necessarily mean the water is unsuitable for consumption. Most MAVs have been derived on the basis of a lifetime exposure. The amount and the duration by which any MAV can be exceeded without affecting public health depends on the characteristics of the determinand
3. the chemical MAV values are set to be acceptable for lifelong consumption. The quality of drinking-water should not, however, be degraded to the MAV level. Ongoing effort should be made to maintain drinking-water quality at the highest possible level. Maximum Desirable Target Values (MDTVs) are given in the Guidelines to assist in treatment design.

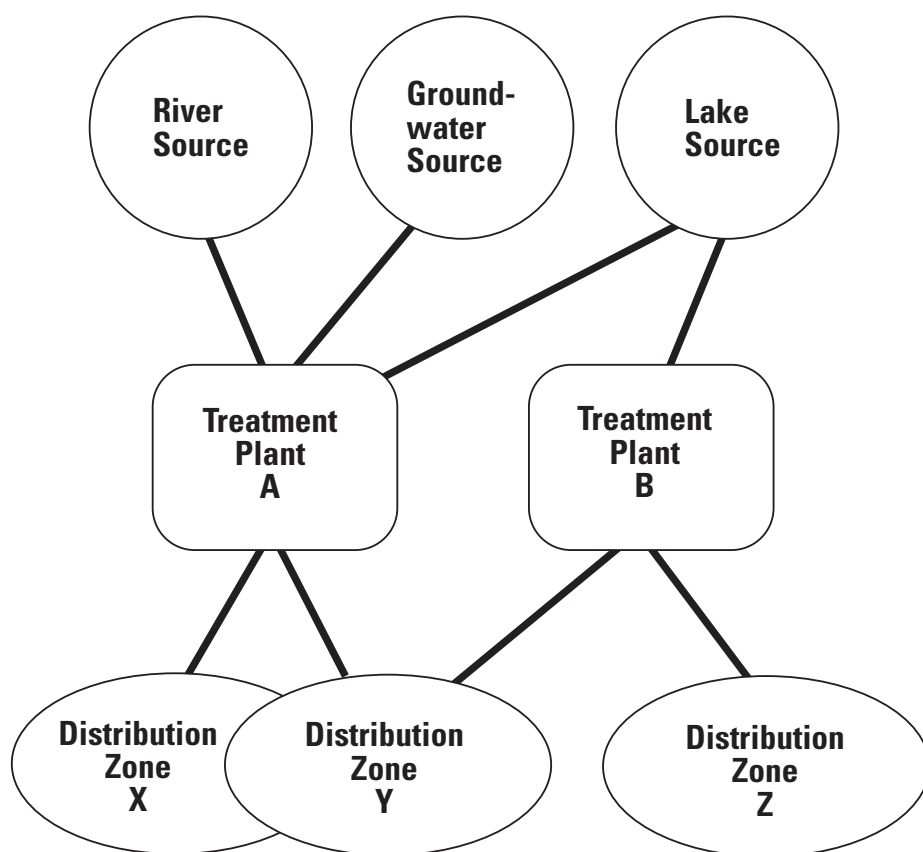
For radioactive substances, screening values for total alpha and total beta activity are given, based on a reference level of dose.

1.7 Components of a drinking-water supply

A community water supply comprises one or more of each of the following (see Figure 1.1):

- the source or raw water
- the treatment plant
- the distribution system.

Figure 1.1 Schematic diagram of a drinking-water supply system



1.7.1 Source water

A community water supply may abstract raw water from rainwater, surface water or groundwater sources.

Surface water is frequently contaminated by micro-organisms. Shallow groundwater and some springs are microbiologically equivalent to surface water, along with rivers, streams, lakes and reservoirs. Secure groundwater, as defined in Chapter 7 and in Section 3.2.4, is usually free from microbiological contamination.

A water supply may have more than one source of raw water. Secondary sources may be permanent or temporary.

1.7.2 The treatment plant

A treatment plant is a facility that treats raw water to make it safe and palatable for drinking. For administrative purposes, the treatment plant is considered to be that part of the system where raw water becomes the drinking-water. This can range from a full-scale water treatment plant comprising chemical coagulation, sedimentation, filtration, pH adjustment, disinfection and fluoridation, to simply being the point in a pipeline where the water main changes from a raw water main to a drinking-water supply main. In a simple water supply, the water may be merely abstracted from a river, passed through a coarse screen and piped to town; that is, the water supply acts like a diverted stream. If raw water is chlorinated, however, the water will not be considered to become drinking-water until it has been exposed to chlorine for the design contact time. A treatment plant may receive raw water from more than one source.

1.7.3 The distribution system

Once the water leaves the water treatment plant, it enters the distribution system (sometimes called the network reticulation) which consists of one or more distribution zones that serve the community. A distribution zone is defined as (Chapter 7):

“...part of the water supply network within which all consumers receive drinking-water of identical quality, from the same or similar sources, with the same treatment and usually at the same pressure. It is part of the supply network which is clearly separated from other parts of the network, generally by location, but in some cases by the layout of the pipe network. For example, in a large city, the central city area may form one zone, with outlying suburbs forming separate zones, or in a small town, the system may be divided into two distinct areas. The main purpose of assigning zones is to separately grade parts of the system with distinctly different characteristics.”

A distribution zone may receive water from more than one treatment plant. The distribution system may comprise more than one distribution zone (see Figure 1.1).

Distribution zones may be distinguished because they are either fed by a pumping station so that they are isolated from nearby zones by pressure or because they are fed from a service reservoir which can markedly increase the retention time. Some distribution zones may vary seasonally due to supplementary sources being used at peak draw-off times while for other zones the boundaries may vary due to changes in pressure or draw-off. Others may vary due to the materials used in common sections of the distribution system.

The distribution zones selected for public health grading of drinking-water supplies and for the Standards are based on water quality considerations and will not necessarily coincide with the distribution zones which the water suppliers identify for operational and management purposes. The Ministry of Health expects there would be more distribution zones based on hydraulics than there will be on water quality.

Some community drinking-water supplies may comprise one distribution zone only. Some very small community water supplies may not have a network of water mains. For example, drinking-water supplies at factories, rural schools and camping grounds may only have a communal tap. Some small drinking-water supplies may receive their water from another supply by tanker which pumps the water into a storage tank.

Some water suppliers may receive their drinking-water from a water supply wholesaler via bulk mains.

2 Determination of Compliance

2.1 Introduction

To comply with the Standards a determinand must be investigated according to the monitoring and analytical protocols given in Chapters 3, 4 and 5 for microbiological, chemical and radiological determinands respectively.

Laboratories approved by the Ministry of Health shall be used for all analyses carried out for the purpose of assessing compliance with these Standards, except where special procedures are authorised for small remote drinking-water supplies or for analyses in the field. The Ministry of Health maintains a register of laboratories approved for this purpose.

These laboratories will be expected to hold laboratory accreditation to ISO/IEC Guide 17025: 2000 (General requirements for the competence of calibration and testing laboratories – Sydney: Standards Australia, 1991), or equivalent, to use analytical methods that have been calibrated against the referee methods, to have quality assurance and control systems that provide evidence of competency in testing, and to ensure that all samples used for compliance testing are identified by the unique site identification code listed in the *Register of Community Drinking-Water Supplies in New Zealand* for the supply concerned. The site codes shall be provided by the water supplier generating the samples and shall accompany all samples sent for compliance testing.

In circumstances where accreditation is not feasible, alternative evidence of competence may be accepted by the Ministry of Health. This will require compliance with the relevant clauses of the ISO/IEC Guide 17025: 2000 to be demonstrated.

The referee methods specified in Chapter 11 shall be regarded as the definitive methods for demonstrating compliance with these Standards.

Alternative methods are acceptable but must have been calibrated against the referee methods. In the event of any dispute about differences in analytical results, results obtained using the referee method shall be deemed to be correct.

Compliance is determined by comparing the results of these monitoring programmes against the Standards' compliance criteria over 12 consecutive months. Records must

be kept for at least 10 years to enable trends to be detected and to establish the statistical significance of the results.

MAVs are provided for determinands of all Priority classes in Chapter 14. The tables in Chapter 12 will assist in selecting the appropriate sampling and analytical methods.

2.2 Compliance and transgression

The *Drinking-Water Standards for New Zealand 2000* specify maximum acceptable values (MAVs) for the microbiological, chemical and radiological determinands of public health significance in drinking-water and provide compliance criteria and procedures for verifying that the water supply is not exceeding these values.

The terms **compliance** and **non-compliance** apply to the supply. They are not applied to individual samples. Compliance is assessed on a running annual basis. In this way compliance can be assessed at any time during the year using the previous 12 months' monitoring results.

The term **transgression** applies to a single sample. If every determinand in a sample is below its MAV, the sample meets the requirements of the Standards. A sample is said to **transgress** the Standards when it does not meet the requirements of the Standards, eg, the MAV for one or more determinands is exceeded. Transgression of the Standards by a sample may not necessarily mean that the drinking-water supply itself is in non-compliance. This depends upon the verification requirements specified by these Standards for the determinand concerned. In the event of a sample transgressing the Standards, immediate action must be taken as set out in Sections 3.4 and 4.4.

2.3 Compliance with the Standards / MAVs

2.3.1 Priority classes for drinking-water determinands

Determinands of public health significance have been divided into four priority classes to minimise monitoring costs without compromising public health. To demonstrate compliance, only those relatively few determinands that fall into the classes with highest potential risk, Priorities 1 and 2, are required to be monitored. Monitoring of determinands in the lower potential risk, Priorities 3 and 4, is at the discretion of the supplier, unless required by the Medical Officer of Health for public health reasons.

2.3.1.1 Priority 1 determinands

Priority 1 determinands are determinands whose presence can lead to rapid and major outbreaks of illness.

Contamination of water supplies by pathogens usually arises from faecal material or wastes containing them. Humans, birds or animals may be the source. The determinands that are currently known to fall into this category include the pathogenic bacteria, viruses and protozoa.

Escherichia coli (*E. coli*), a common gut bacterium living in warm-blooded animals, is used as an indicator of the contamination of water by excrement and is a generally accepted indicator for the potential presence of pathogenic viruses and bacteria. However, *E. coli* is not a good indicator of the presence of the pathogenic protozoa *Giardia* and *Cryptosporidium*.

For this reason the current Priority 1 determinands are:

- *Escherichia coli* (*E. coli*)
- protozoa (*Giardia* and *Cryptosporidium*).

Priority 1 determinands apply to all community drinking-water supplies in New Zealand and must be monitored in all supplies because they constitute a major public health risk.

To comply with the Standards, Priority 1 determinands must be investigated according to the monitoring and analytical requirements given in Chapters 3, 4 and 5 for microbiological, chemical and radiological determinands as relevant. Compliance is determined by comparing the results of these monitoring programmes over 12 consecutive months against the compliance criteria set out in Section 3.2.

Records must be kept for at least 10 years.

Giardia and *Cryptosporidium* are widespread in natural waters in New Zealand, and are not always reliably removed by conventional water treatment.

E. coli cannot be used reliably as an indicator of the likely presence of *Cryptosporidium* and *Giardia*. There may be no correlation between the presence of *E. coli* and of pathogenic protozoa in drinking-water, but increases in the turbidity of water which has been treated by coagulation and filtration have been linked with elevated protozoa counts.

In view of the serious public health effects of contamination of a drinking-water supply by these protozoa, it is important that the likelihood of their presence in drinking-water is assessed. The most reliable methods currently available for direct determination of these organisms are expensive and require highly skilled analysts. Also the organisms tend to appear sporadically, so that direct measurement techniques do not always give a representative assessment of the true extent of their presence in a drinking-water supply.

If the water is subject to quiescent periods, the organisms may settle out so they are not present in the overlying water. Disturbance of the sediments can resuspend the organisms, causing a sudden upsurge in their numbers.

Because of these difficulties, direct determination of the presence of *Giardia* and *Cryptosporidium* is not used as a criterion of compliance with the Standards.

Alternative ways of assessing the likelihood of the absence of these protozoa are therefore used. These are based on checking that the drinking-water has received a level of treatment which has a high probability of having removed the organisms. In these Standards, the criteria used are based on the use of turbidity to assess the effectiveness of conventional coagulation/filtration treatment; effectiveness of particle removal to assess treatment by filtration without coagulation; disinfection C.t values by measurement of the disinfectant's residual to assess the adequacy of disinfection; or demonstration that the water has come from a "secure" groundwater source that will be free from these organisms.

The specific compliance criteria for each of these situations are given in Section 3.2.

2.3.1.2 Priority 2 determinands 2a–2c

Priority 2 determinands are those that are present in a specific supply or the distribution zone, usually at concentrations that exceed 50 percent of the MAV. The Ministry of Health will carry out investigations on water supplies from time to time to identify the presence of P2 determinands, until this process is adequately covered by water supply risk assessment procedures carried out by the drinking-water suppliers.

Determinands specified by the Ministry of Health to be Priority 2 determinands for the drinking-water supply under consideration are required to be monitored to establish compliance with the Standards.

Priority 2 determinands are divided into three types: 2a, 2b and 2c.

- **2a: Chemical and radiological determinands that could be introduced into the drinking-water supply by the treatment chemicals at levels potentially significant to public health (usually greater than 50 percent MAV).**

Priority 2a does not include disinfection by-products or determinands introduced into the drinking-water from piping or other construction materials.

- **2b: Chemical and radiological determinands of health significance that have been demonstrated to be in the drinking-water supply at levels potentially significant to public health (usually greater than 50 percent MAV).**

Priority 2b includes chemicals present in the raw water that may not be removed by the treatment process; any disinfection by-products; and determinands introduced into the drinking-water from piping or other construction materials that are present in the water when sampled under normal (flushed) protocols.

Priority 2b does not include determinands introduced by the treatment chemicals or determinands introduced by the consumer's plumbing.

A separate category of "aggressive" drinking-water is distinguished in which heavy metals are only found in the first flush of water collected from the tap but are not present at excessive levels in samples collected after flushing. These determinands are produced by corrosion of the consumer's plumbing when water stands in contact with taps or other fittings, so that one or more of lead, antimony, cadmium, nickel, copper or zinc dissolve from the fitting.

The presence of Priority 2a determinands will depend on the chemicals (and their impurities) used to treat the raw water or added to the water supply and, to some extent, the degree of management control over their use. The likelihood that a borderline determinand will be assigned to Priority 2a rather than Priority 3 will be much greater if the treatment process is operated in such a way that the concentration of the determinand varies greatly from time to time than if it is maintained at a relatively constant concentration.

Some chemicals of health significance, for example copper sulphate for algal control, may be used only intermittently in the course of drinking-water treatment. In these situations the water supplier must advise the Medical Officer of Health and consider an appropriate monitoring programme. The Medical Officer of Health must also be advised of any long-term changes to the chemical treatment process so the Ministry's drinking-water information system (WINZ) and the Register can be revised (refer to the Guidelines).

The frequency of monitoring of some Priority 2a determinands which can enter the

drinking-water supply as impurities of water treatment chemicals may be diminished if water suppliers demonstrate to the Medical Officer of Health's satisfaction (for example from flow rates, dosing equipment and the use of treatment chemicals with verified specifications) that the determinand cannot be introduced into the drinking-water supply at concentrations greater than 50 percent MAV.

- **2c: Micro-organisms of health significance that have been demonstrated to be present in the drinking-water supply.**

Micro-organisms listed in Table 14.1 may be listed as priority 2c determinands if there is reason to suspect that they are likely to be present in the drinking-water supply.

This may occur, for example, when high numbers of these organisms are present in the raw water and *E. coli* is present in water leaving the treatment plant. The Medical Officer of Health may declare such organisms to be Priority 2 if there are epidemiological grounds for suspecting the drinking-water supply.

The assignation of a Priority 2 determinand to a given supply will be based on monitoring and on knowledge of sources of health-significant determinands in the catchment, treatment processes and distribution system. The assignation will be notified directly to the water supplier, after prior consultation, to enable review of any contrary evidence. Priority 2 determinands will also be listed in the *Register of Community Drinking-Water Supplies in New Zealand*. The requirement to monitor a Priority 2 determinand commences with the date on which the Ministry of Health formally notifies the supplier it has assigned the determinand to Priority 2, not with the date of publication in the *Register*.

A Priority 2 determinand may be relegated to Priority 3 or 4 with the consent of the Ministry of Health when monitoring has demonstrated that it should be assigned a lower priority. (Refer to Section 4.2.3).

Information about the compliance criteria and the monitoring and analytical requirements for microbiological, chemical and radiological determinands is provided in Chapters 3, 4 and 5.

2.3.1.3 Priority 3 determinands 3a–3d

- **3a: Chemical and radiological determinands of health significance arising from treatment processes in amounts known not to exceed 50 percent MAV.**
- **3b: Chemical and radiological determinands of health significance which are not known to occur in the drinking-water supply at greater than 50 percent MAV.**

The chemicals listed in Tables 14.2 to 14.5 are Priority 3a or 3b determinands unless they have been assigned to Priority 2 for a particular supply.

- **3c: Micro-organisms of health significance which are not known to be present in the drinking-water supply.**

Except for *E. coli* and the protozoa, the micro-organisms listed in Table 14.1 are Priority 3c determinands unless they have been assigned to Priority 2 for a particular supply.

- **3d: Determinands of aesthetic significance known to occur in the drinking-water supply.**

Aesthetic determinands are classified as Priority 3 because they do not pose a direct threat to public health. People, however, judge drinking-water mainly by the aesthetic characteristics of appearance, taste and smell, and an aesthetically unacceptable drinking-water supply may cause them to change to an alternative, and potentially unsafe, supply or treatment process. For this reason it is preferable that water supply authorities monitor these determinands, although this is not required to comply with the Standards.

2.3.1.4 Priority 4 determinands 4a–4c

- **4a: Chemical and radiological determinands of health significance which are known not to be likely to occur in the drinking-water supply.**
- **4b: Micro-organisms of health significance which are known not to be likely to be present in the drinking-water supply.**
- **4c: Determinands of aesthetic significance not known to occur in the drinking-water supply.**

Priority 4 determinands for a specific supply will include those health-significant or aesthetic determinands for which there is sufficient information to consider it unlikely they would be present in a particular supply.

Some determinands, including some pesticides, will be Priority 4 for all New Zealand drinking-water because they are not used in this country at present. They are included in the tables to ensure that MAVs are available should the situation change.

Priority 4 determinands may become Priority 2 if the Ministry of Health considers this is warranted.

3 Microbiological Compliance

3.1 Rationale for microbiological MAVs

It is impracticable to monitor water supplies for all potential human pathogens. Surrogates have to be used to indicate possible contamination of the water supply with human and animal waste, the most frequent source of health-significant contamination of water supplies.

3.1.1 *E. coli*

The indicator organism chosen to indicate possible faecal contamination of drinking-water is *E. coli*.

Thermotolerant coliforms (faecal coliforms) and total coliforms (which include both faecal and environmental coliform bacteria) may also be used to monitor water quality, but the results are harder to interpret than those from *E. coli*. If total coliforms or faecal coliforms are used for drinking-water monitoring to demonstrate compliance with the Standards instead of *E. coli*, a positive result shall be treated as though it were an *E. coli* result.

E. coli should not be present in drinking-water in the distribution zones. However, unlike the drinking-water leaving the treatment plant, whose microbiological quality is under the control of the treatment plant management, the quality of drinking-water in the distribution zones may be subjected to contamination from a variety of influences. Some of these may arise from poor management practices, such as faulty reservoir construction and maintenance, or poor sanitary practices by water supply workers.

Other contamination sources arise from the water users themselves, such as poor sanitation while making connections to the service or inadequate backflow prevention. *E. coli* may, therefore, occasionally be found in the reticulation. The presence of *E. coli* must always be followed up.

If more than 0.2mg/L free available chlorine (FAC) is maintained in the drinking-water supply reticulation, coliform bacteria and *E. coli* are rarely, if ever, found. For this reason it is permissible to substitute monitoring of FAC for some (but not all) of the *E. coli* monitoring.

3.1.2 Protozoa: *Giardia* and *Cryptosporidium*

The protozoa *Giardia* and *Cryptosporidium* occur in many New Zealand water sources. They are found in wild, farm and domestic animals as well as in humans. Surface waters and non-secure groundwater must be considered to be potentially contaminated. The risk associated with secure groundwater is much lower. *Giardia* and *Cryptosporidium* are pathogens which should be eliminated from drinking-water supplies. They are given Priority 1 because of their public health significance.

The methods available for enumerating protozoan pathogens and determining their viability are still evolving and it is expected that an internationally accepted method will soon be available. Existing methods are not yet suitable for routine use but can be used to investigate suspected outbreaks. Until more rigorous procedures are available, criteria based on the probability that the treatment process used will have inactivated or removed any protozoa present will be used as criteria for compliance. These criteria for particle size removal, disinfection residual and contact times, and turbidimetric assessment of the efficiency of coagulation and filtration are used in these Standards instead of direct protozoa enumeration.

The incidence of protozoa is reduced substantially when the water treatment coagulation / filtration process produces drinking-water with a turbidity below 0.1 NTU.

The value of 0.5 NTU used in the DWSNZ 1995 (because the value of 0.1 NTU was not then thought to be attainable by many New Zealand drinking-water supplies) has been retained, but only until 1 January 2005. As from that date, the value of 0.1 NTU will be the standard. Avoidance of sudden increases in turbidity are also required by the compliance criteria as such increases often signal a fall in filter efficiency which enables protozoa to breach the filtration barrier.

3.2 Microbiological compliance criteria

Separate criteria for compliance with the Standards are set for *E. coli*, and for the protozoa *Giardia* and *Cryptosporidium*. These are provided in Sections 3.2.2–3.

In addition to these separate compliance criteria, the following general criteria apply to all micro-organisms in Section 3.2.

3.2.1 General microbiological compliance criteria

Drinking-water complies with the microbiological compliance criteria if:

- **general microbiological criteria 1a and 1b:**
 - 1a: samples are taken at the required sites and frequency for the determinand in question
 - 1b: the sampling and analytical techniques comply with the requirements of the Standards
- and
- **general microbiological criteria 2:**
 - the procedures specified in Section 3.4 (Remedial action to be taken when transgression of a microbiological MAV occurs) are followed and the action taken documented.

3.2.2 *E. coli* compliance criteria

E. coli compliance is assessed on the results of sampling for 12 consecutive months and requires that a drinking-water supply meets *E. coli* compliance criteria 1 and 2 below. If faecal, presumptive or total coliforms are measured, the counts are to be treated as though they were *E. coli*.

3.2.2.1 *E. coli* compliance criteria 1A and 1B (for drinking-water leaving a treatment plant)

E. coli compliance criteria 1A (for drinking-water leaving a treatment plant)

All of a–e are complied with.

- a. The water supply leaving the treatment plant is monitored for the presence of *E. coli*.
- b. The sampling and analytical techniques comply with the requirements of these Standards.
- c. Drinking-water leaving the treatment plant is sampled at any point at which the treatment process is fully complete but that is at, or before, entry into the network reticulation (see 3.3.1.1.1).

- d. The frequency of sampling is equal to or greater than that specified in Table 3.1 (water leaving the treatment plant) for the population band to which the water supply belongs.
- e. The maximum number of 100mL samples in which *E. coli* are found is equal to or less than:
 - 0 in 38–77 samples
 - 1 in 78–109 samples
 - 2 in 110–139 samples.

If the water leaving the treatment plant is fully chlorinated *E. coli* compliance criteria 1B may be used as an alternative to 1A.

***E. coli* compliance criteria 1B (for fully chlorinated drinking-water leaving a treatment plant)**

All of f–i are complied with.

- f. Free available chlorine (FAC) is monitored continuously in drinking-water leaving the treatment plant.
- g. The contact time is greater than 30 minutes and the downtime of the monitoring equipment is less than 1 hour in any week.
- h. The FAC concentration in the water leaving the plant never falls below a concentration that is equivalent to a minimum of 0.2mg/L of FAC at pH 8.0 and turbidity less than 0.5 NTU. If the pH is greater than 8.0 the equivalent FAC concentration shown in Figure 3.1 shall be used.
- i. Following changes in raw water quality that may increase the chlorine demand, chlorine measurements shall be made as frequently as necessary to demonstrate that the free available chlorine (FAC) at no time drops below the 0.2 mg/L of FAC equivalent (see Section 3.2.2.2.1) in the water leaving the treatment plant.

NB: For treatment plants serving fewer than 10,000 people, process control measurements of FAC concentration made after only a short contact time may be used instead of readings from drinking-water leaving the plant, provided that:

- a reliable correlation has been established, documented, and monitored, between the FAC concentration after the short contact time and the FAC concentration of drinking-water leaving the treatment plant
- the minimum value of the process control FAC concentration that has been established to be necessary to attain an FAC equivalent to a minimum of 0.2mg/L of FAC at pH 8.0 in drinking water leaving the treatment plant becomes the value used to demonstrate compliance.

3.2.2.2 *E. coli* compliance criteria 2A and 2B: (for drinking-water in a distribution zone in the network reticulation)

E. coli compliance criteria 2A (criteria using *E. coli* monitoring only)

All of a–e are complied with.

- a. The water supply in the distribution zone is monitored for the presence of *E. coli*.
- b. The sampling and analytical techniques comply with the requirements of these Standards.
- c. Drinking-water is sampled at distribution zone sampling sites as specified in Section 3.3.1.1.2.
- d. The frequency of sampling for *E. coli* in the network reticulation is equal to or greater than that specified in Table 3.2a (column 2 for criteria 2A; column 3 for criteria 2B) for the population band to which the water supply belongs.
- e. The maximum number of 100mL samples in which *E. coli* are found is equal to or less than:
 - 0 in 38–77 samples
 - 1 in 78–109 samples
 - 2 in 110–139 samples.

E. coli compliance criteria 2B (criteria allowing partial substitution of *E. coli* monitoring by FAC)

All of f–j are complied with.

- f. The population is greater than 30,000, and the water leaving the treatment plant always has a disinfection equivalent to 0.2 mg/L of FAC at pH 8.0. (This option is not available for smaller supplies.)
- g. The number of *E. coli* samples substituted by FAC does not exceed 75 percent of the number of *E. coli* samples that are specified in Table 3.2a to be used when no substitution by FAC measurements occurs.
- h. *E. coli* and FAC samples are taken at the frequency and distribution specified in Tables 3.2a and 3.2b for the situation where substitution for *E. coli* samples by FAC measurements occurs.

- i. The maximum number of 100mL samples in which *E. coli* are found is equal to or less than:

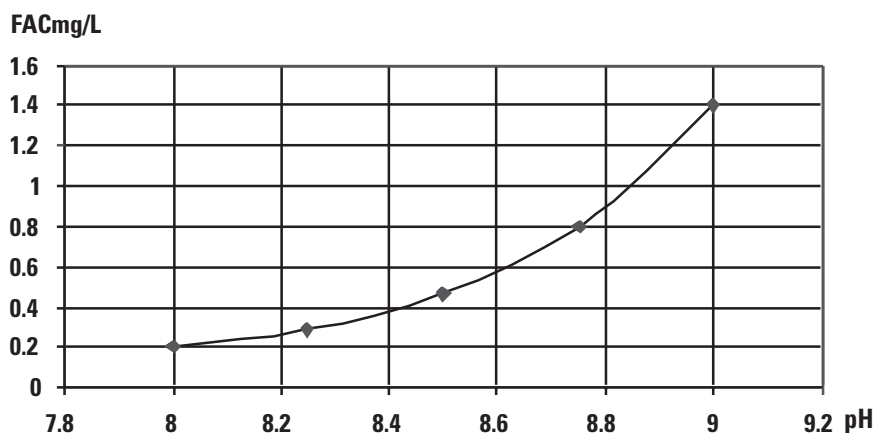
0	in	38–77 samples
1	in	78–109 samples
2	in	110–139 samples.
- j. All samples contain FAC equivalent to 0.2mg/L FAC at pH 8.0 and turbidity less than 0.5 NTU, except in areas of low flow where the FAC concentration may diminish to 0.1mg/L.¹ If this condition is not met for any particular sample *E. coli* is to be tested for.

3.2.2.2.1 FAC correction for pH greater than 8

All samples should contain a FAC concentration equivalent to at least 0.2mg/L of FAC at pH 8.0.

At pH values greater than 8 the disinfection equivalent of the FAC decreases. If, for any reason, the pH temporarily exceeds 8.0 the chlorine concentration shall be increased accordingly. The FAC concentration necessary to provide the disinfection equivalent of 0.2mg/L of FAC at pH 8.0 is shown in Figure 3.1.

Figure 3.1 FAC concentrations at different pHs required to provide the disinfection equivalent of 0.2mg/L of FAC at pH 8.0



¹ Note that this turbidity value only applies to free available chlorine measurement requirements. For protozoa compliance criteria relating to chemical coagulation and filtration treatment, the values given in *Giardia* and *Cryptosporidium* criteria 1b apply.

3.2.3 Protozoa (*Giardia* and *Cryptosporidium*) compliance criteria

Protozoa compliance criteria a, b, c and d apply to water in, or leaving, a treatment plant at the sampling points specified in Section 3.3.1. These criteria do not apply to drinking-water in the network reticulation.

Drinking-water complies with these criteria if any one or more of criteria a–d is met.

3.2.3.1 Protozoa compliance criteria a–d (for drinking-water leaving a treatment plant)

Protozoa criteria a (applicable to filtration without coagulation (eg, cartridge, membrane, diatomaceous earth and slow sand filtration))

- Water suppliers must be able to demonstrate the validity of their filter performance testing, satisfactory filter performance correlation, and monitoring by providing assurance that at least 99.99 percent of all particles in the 3–15µm size range are removed while the filter array is in service.
- For membrane filters compliance shall be demonstrated by an in situ membrane integrity testing and monitoring system. This system shall be verified using the Environmental Technology Verification Protocol for Equipment Verification Testing for Physical Removal of Microbiological and Particulate Contaminants (United States EPA and National Sanitation Foundation (NSF), 1999).
- For cartridge, bag, diatomaceous earth, and slow sand filter plants serving more than 10,000 people, compliance shall be demonstrated by periodic filter performance testing and continuous on-line particle counting.²
- For cartridge, bag, diatomaceous earth, and slow sand filter plants serving less than 10,000 people, compliance shall be demonstrated:
 - either i as for plants serving more than 10,000 people
 - or ii by microscopic particulate analysis (MPA) at the frequency shown in Table 3.3.

² At commissioning of a new filter array, a challenge test shall be used to establish a correlation between satisfactory filter performance and the particle size distribution (3–5, 5–7, 7–10, 10–15µm) counts as measured by the on-line particle counter over a period of at least three days of continuous running or on 30 successive batch samples over a period of four days following the challenge test.

Or

Protozoa criteria b (applicable for chemical coagulation and filtration treatment)

- All water has passed through the filters.
- Measurements of the turbidity of the water leaving each filter satisfy the following requirements:
 - 95 percent of the turbidity measurements over the reporting period (at the frequency specified in Table 3.4) do not exceed 0.5 NTU³
 - at any time during a filter run (excluding any period of filtering to waste) the turbidity does not exceed 1.0 NTU⁴
 - for continuous monitoring,⁵ no increases of more than 0.2 NTU shall occur in any 10-minute period, except that up to two turbidity records per day may exceed 1.0 NTU⁶ to allow for spurious peaks.

Or

Protozoa criteria c (applicable to disinfection with no prior filtration)

- The minimum contact with disinfectants (chlorine dioxide or ozone) shall be maintained at all times in accordance with at least the C.t values given for 99 percent inactivation of *Cryptosporidium* given in Chapter 13.⁷ Records must be kept to enable verification.

Or

Protozoa criteria d (applicable to secure groundwater)

- Water is solely drawn from secure groundwater. The water must be demonstrated to meet the criteria for demonstration of the security of groundwater given in Section 3.2.4.

Although reliable direct enumeration of *Giardia* and *Cryptosporidium* strains can now be made, this is not used as a compliance criterion because of the high degree of uncertainty as to the interpretation of the results. The method is suitable for use in the investigation of drinking-water supplies in the case of disease outbreaks.

³ As at 1 January 2005 this value will become 0.1 NTU.

⁴ As at 1 January 2005 this value will become 0.5 NTU.

⁵ As at 1 January 2005 all drinking-water suppliers servicing more than 10,000 people will be required to continuously monitor their filters and all filters must give an alarm to duty staff in the event of transgression.

⁶ As at 1 January 2005 this value will become 0.5 NTU.

⁷ From 1 January 2005 the minimum C.t values will be those for 99.9 percent inactivation of *Cryptosporidium*.

3.2.4 Criteria for demonstrating the security of groundwater

Groundwater is considered to be secure when it can be demonstrated not to be likely to be contaminated by pathogenic organisms because it is:

- not directly affected by surface or climate influences, as is demonstrated by compliance with criteria a, b and c below
 - abstracted via a secure well head or similarly proven structure.
- a. *E. coli* is absent from the groundwater.

The groundwater shall initially be monitored at the frequency required for an unsecure groundwater (Table 3.1) over 12 consecutive months. If no *E. coli* are found during this 12-month period, and criteria b and c below are met, the groundwater is classed as secure and monitoring can then revert to that required for secure groundwater in Table 3.1.

- b. The well head is secure.

For a well head to be classed as secure, there must be a sealed pumping and piping system including backflow prevention devices and restrictions on any potentially contaminating land use or activity in the vicinity of the well head (see Guidelines).

- c. The groundwater is not directly affected by surface or climate influences.

The lack of surface or climate influences can be demonstrated by the residence time in the aquifer or by the lack of significant and rapid shifts in determinands that are linked to surface effects as shown by:

- i. less than 0.005 percent of the water shall have been present in the aquifer for less than one year (demonstrated by the tritium and/or CFC methods) and/or
- ii. variations in the groundwater characteristics shall not exceed a coefficient of variation of more than:
 - 3.0 percent in conductivity
 - 4.0 percent in chloride concentration
 - 2.5 percent in nitrate concentration (standardised variance)
when measured at least:
 - monthly for one year
 - once every two months for two years
 - three monthly for three years.

3.3 Microbiological monitoring requirements

In all records and documents used for demonstrating compliance with DWSNZ 2000 the sampling site identification details shall include the source, treatment plant or zone code listed in the *Register of Community Drinking-Water Supplies in New Zealand*.

Priority 1 microbiological determinands *E. coli* and protozoa must be monitored regularly and frequently at the treatment plant. *E. coli* shall also be monitored in the network reticulation.

The sampling frequencies specified are based on the population served, the type of water source and the treatment employed. In community drinking-water supplies serving seasonal populations, additional samples must be collected during periods of peak population.

Procedures for sampling, sample preservation, storage and sample transport shall be agreed beforehand with the Ministry of Health approved laboratory carrying out the analysis, except where special procedures are authorised for small remote drinking-water supplies or for analyses in the field.

3.3.1 Microbiological sampling sites

3.3.1.1 *E. coli* sampling site specifications

3.3.1.1.1 For *E. coli* compliance criteria 1 (water leaving a treatment plant 3.2.2.1)

- For *E. coli* compliance criteria 1A, samples shall be taken from drinking-water leaving the treatment plant, which may be at any point before the first consumer.
- For *E. coli* compliance criteria 1B, the FAC sampling site shall be located at a point at which the adequacy of the chlorine residual, the 30-minute minimum disinfection contact time and the pH can be clearly demonstrated (refer to Guidelines), but before the first consumer.
- For untreated water, sampling shall be at the point of entry into the distribution system.
- If lime is added, turbidity sampling should be before the lime is added, for example samples can be taken from water leaving the filters.

3.3.1.1.2 For *E. coli* compliance criteria 2 (water in the network reticulation 3.2.2.2)

Samples shall be taken from sites that represent all of the various conditions that exist in the distribution zones and provide a complete geographical coverage. To ensure that the network reticulation is evaluated adequately, sampling locations shall be planned carefully, based on the characteristics of the reticulation and what is known about the age and state of repair of the various components, the number of households served by sections of the distribution system and so on. The sampling plan shall be provided to the Medical Officer of Health or an accredited Ministry of Health designated officer before the sampling programme commences and shall include:

- fixed points such as pumping stations and reservoirs
- random locations throughout the distribution zone
- extremities of the distribution zone
- taps representing the mains water being supplied to houses
- extra sampling in the event of mains construction and maintenance.

Ministry of Health approval of the water supplier's risk management plan for distribution zones satisfies this condition.

3.3.1.2 Protozoa sampling site specifications

3.3.1.2.1 For protozoa (*Giardia* and *Cryptosporidium*) criteria a (filtration without coagulation)

Samples shall be taken from water leaving each filter unit or array.

3.3.1.2.2 For protozoa (*Giardia* and *Cryptosporidium*) criteria b (chemical coagulation and filtration)

Turbidity samples shall be taken from water leaving the filter. (Refer to Table 3.4.)

3.3.1.2.3 For protozoa (*Giardia* and *Cryptosporidium*) criteria c (disinfection)

Samples shall be taken from water at the end of the contact period.

3.3.1.2.4 For protozoa (*Giardia* and *Cryptosporidium*) criteria d (secure groundwater)

The continued security of the groundwater shall be demonstrated. No further sampling is required.

3.3.2 Microbiological monitoring frequencies

3.3.2.1 *E. coli* monitoring frequencies

3.3.2.1.1 Sampling for *E. coli* in drinking-water leaving a treatment plant

Table 3.1: Minimum sampling frequency for *E. coli* in drinking-water leaving a treatment plant for *E. coli* compliance criteria 1A

Supply Type ^a	Minimum Samples per Calendar Quarter ^b	Maximum Interval Between Samples (Days)	Minimum Days of the Week Used ^c
Fully chlorinated supplies (surface or groundwater) satisfying <i>E. coli</i> compliance criteria 1B, ^d (regardless of population)	None	Not applicable	Not applicable
Secure groundwater supplies (regardless of population) ^e	3 ^f	40	3
All surface and non-secure groundwater supplies serving fewer than 500 people	3	40	3
Fully chlorinated surface and non-secure groundwater supplies serving 501–10,000 people	10 ^g	13	5
Unchlorinated surface and non-secure groundwater supplies serving 501–5,000 people	13	13	5
Unchlorinated surface and non-secure groundwater supplies serving 5001–10,000 people	26	5	6
All surface and non-secure groundwater supplies serving more than 10,000 people that are not fully chlorinated	92	2	7

- ^a Where the population fluctuates, additional sampling shall be performed so that the sampling frequency is that specified in the Table for the population actually present.
- ^b Testing is to be evenly distributed throughout the quarter and not on the same days of the week.
- ^c Sampling must not always be on the same day of the week. It should be carried out on at least the number of different days shown (eg, if 3 shown, then Monday, Wednesday and Friday could be the days chosen).
- ^d See *E. coli* criteria 1B (Section 3.2.2).
- ^e All groundwater sources for a treatment plant must be proven to be secure before the supply is considered a secure supply. Until a supply has been proven to be secure and the verification recorded, it is to be treated as not secure and monitored as though it was surface water.
- ^f Monitoring requirements for secure groundwater supplies may be reduced to 1 sample per quarter after no *E. coli* have been detected in 12 consecutive months of sampling after the initial compliance tests are complete.
- ^g 10 is the minimum number of samples per quarter to satisfy the 95 percent/95 percent target.

General Notes:

- 1 For the monitoring frequencies designated for secure groundwater to apply, the security of the groundwater must have been demonstrated as specified in Section 3.2.4.
- 2 The frequency of *E. coli* monitoring of drinking-water derived from secure groundwater shall be increased to at least weekly when the source water quality may have changed, for example at peak abstraction during dry spells, following flooding of the recharge area, or when chemical or physical water quality changes have occurred. Sampling shall continue for four weeks after surface conditions have returned to normal.
- 3 Where a treatment plant is supplied by both a secure groundwater and a non-secure source the supply shall be considered to be non-secure.
- 4 For supplies serving fewer than 500 people, samples prescribed to be taken from drinking-water leaving the treatment plant may be taken from the distribution zone instead if this is more convenient, on condition that the "treatment plant" samples are taken from the first available tap after the treatment plant; sampling is done at the frequency specified in Table 3.1; and no *E. coli* are found. These samples are additional to those required for the distribution zone in Tables 3.2a and 3.2b which are to be collected from points closer to the extremities of the distribution zone.
- 5 The samples prescribed to be taken from drinking-water leaving the treatment plant may be omitted for supplies to a single building (or a complex of not more than three buildings) that serve a population of less than 100 people and where, because of the short length of the reticulation system, contamination is unlikely to occur in the reticulation.
- 6 If *E. coli* is detected in a groundwater supply that has been classified as secure, that supply shall be monitored as a non-secure supply and must be fully reassessed to verify security.
- 7 Monitoring additional to that required for compliance monitoring shall be carried out after installation of new mains or following connection or repair in the network reticulation. This monitoring is to be carried out within 12 hours of completion of the connection, repair, or restoration of flow.

3.3.2.1.2 FAC monitoring frequency in water leaving a treatment plant

For *E.coli* compliance criteria 1B (Section 3.2.2.1) (water leaving the treatment plant), free available chlorine shall be measured continuously in all plants that chlorinate and serve more than 10,000 people. For small plants that chlorinate but do not have a continuous chlorine monitor, the frequency of measuring the chlorine residual shall be 92 times per calendar quarter, that is daily. If these sampling frequencies are not complied with, the supply is subject to *E. coli* compliance criteria 1A and shall be treated as an unchlorinated supply when determining sampling frequencies from Table 3.1. Measurements shall be made on site as soon as the sample is taken.

3.3.2.1.3 pH monitoring frequency in water leaving a treatment plant

When the FAC compliance criteria 1B is used, pH shall be continuously measured after leaving the contact tank in plants that serve more than 10,000 people. For smaller plants that do not have a continuous pH monitor, pH shall be monitored at the time FAC samples are collected.

3.3.2.1.4 Turbidity monitoring frequency in water leaving a treatment plant

For compliance with *E. coli* compliance criteria 1B turbidity shall be measured at the time the FAC measurements used for compliance purposes are made.

3.3.2.1.5 Sampling frequency for *E. coli* compliance criteria 2A in a distribution zone

The minimum sampling frequencies for *E. coli* in drinking-water in the distribution zones, when *E. coli* monitoring is not partially substituted by FAC monitoring, are given in Table 3.2a. Testing shall be carried out on different days throughout the week as shown in Table 3.2b.

The frequency of monitoring shall be increased if there is a flood, emergency operation or interruption to the supply system or when other circumstances may give rise to an increased risk of faecal contamination.

While for small communities the minimum sampling frequency is set at three per calendar quarter, all drinking-water supplies should ideally be monitored at least 10 times per quarter to provide improved statistical confidence in the results.

3.3.2.1.6 Sampling frequency for *E. coli* compliance criteria 2B in a distribution zone (*E. coli* monitoring partly substituted by FAC)

In cases where the FAC leaving a treatment plant is always greater than the equivalent of 0.2mg/L at pH 8.0 and the turbidity always less than 0.5 NTU, FAC monitoring may be substituted for up to 75 percent of the *E. coli* tests required in the distribution zone provided that:

- at least four FAC tests are performed for each *E. coli* test omitted
- pH is measured at the time of FAC sampling
- chlorine monitoring is carried out 92 times per calendar quarter, that is, daily.

FAC results at pH greater than 8.0 are to be calculated as their FAC equivalents at pH 8.0.

The number of FAC and *E. coli* tests needed is calculated from the formulae:

Number of FAC tests	=	percent / 100 of <i>E. coli</i> tests replaced x (number of <i>E. coli</i> tests required by Table 3.2a column 2 if no substitution with FAC testing is done) x 4
The number of <i>E. coli</i> tests	=	(1–percent /100) of <i>E. coli</i> tests replaced x (number of <i>E. coli</i> tests required by Table 3.2a column 2 if no substitution with FAC testing is done) (this is the number shown in Table 3.2a column 3)
EXAMPLE (for 75 percent replacement)		FAC = 0.75 x (number of <i>E. coli</i> tests required by Table 3.2a if no substitution with FAC testing is done) x 4
		<i>E.coli</i> = (1–0.75 <i>E. coli</i> tests replaced) x (number of <i>E. coli</i> tests required by Table 3.2 if no substitution with FAC testing is done)

The sampling protocols resulting from the application of these formulae are summarised in Table 3.2a The results of calculations for a range of distribution zone populations are rounded up to the nearest whole number. Any interpolations to the table using the formulae are to be rounded up on a similar basis.

E. coli monitoring shall be carried out regularly throughout the month on different days throughout the week, including weekends. The FAC tests are to be conducted daily.

The maximum number of days between collection of *E. coli* samples and the minimum number of days of the week on which samples shall be taken is shown in Table 3.2b.

Table 3.2a: Minimum sampling frequency for *E. coli* in a distribution zone

Population Served ¹	Minimum Number of <i>E. coli</i> Samples per Quarter Where No FAC Substitution ²	Minimum Number of Samples per Quarter Where FAC Testing Substitutes 75 Percent of <i>E.coli</i> Testing ³	
		<i>E. coli</i>	FAC
up to 500	3	Not Applicable	Not Applicable
501– 5,000	13	Not Applicable	Not Applicable
5,001–10,000	16	Not Applicable	Not Applicable
10,001–15,000	19	Not Applicable	Not Applicable
15,001– 20,000	22	Not Applicable	Not Applicable
20,001–25,000	25	Not Applicable	Not Applicable
25,001–30,000	28	Not Applicable	Not Applicable
30,001–35,000	31	8	93
35,001–40,000	34	9	102
40,001–45,000	37	10	111
45,001–50,000	40	10	120
50,001–55,000	43	11	129
55,001– 60,000	46	12	138
60,001–65,000	49	13	147
65,001–70,000	52	13	156
70,001–75,000	55	14	165
75,001–80,000	58	15	174
80,001–85,000	61	16	183
85,001–90,000	64	16	192
90,001–95,000	67	17	201
95,001–100,000	70	18	210
100,001–110,000	73	19	219
110,001–120,000	76	19	228
120,001–130,000	79	20	237
130,001–140,000	82	21	246
140,001–150,000	85	22	255
150,001–160,000	88	22	264
160,001–170,000	91	23	273
170,001–180,000	94	24	282
180,001–190,000	97	25	291
190,001–200,000	100	25	300
200,001–210,000	103	26	309
etc			

Notes

- ¹ When the population fluctuates, additional sampling will be performed so that the sampling frequency is that specified in the Table for the population actually present.
- ² Results of the calculations rounded up to nearest whole number.
- ³ Testing is to be evenly distributed through the quarter, carried out on different week days and shall give a representative geographical coverage of the zone (see microbiological site specification 2 for details). Calendar quarters are to be used (Jan–Mar, Apr–Jun etc.)

Table 3.2b: *E. coli* sample distribution

Number of <i>E. coli</i> Samples per Quarter	Maximum Interval Between <i>E. coli</i> Samples (Days) ¹	Minimum Number of Days of the Week Used
1–2	90	1
3–7	45	3
8–12	17	4
13–18	11	5
19–21	8	6
22–30	6	7
31–36	5	7
37–45	4	7
46–60	3	7
61–92	2	7
over 92	1	7

Note

- ¹ The maximum interval between *E. coli* samples is determined by the number of *E. coli* samples, not by the size of the population. (See the example below.)

Example

If the zone population is 68,155 and 75 percent replacement is used:

Without replacement 52 *E. coli* samples are required per quarter (Table 3.2a)

With 75 percent replacement of *E. coli* by FAC this requires:

13 *E. coli* per calendar quarter (ie 52 x 25 percent, rounded up if necessary) and

156 FAC per quarter (ie 52 x 75 percent x 4)

which, in accordance with Table 3.2b, have a maximum sampling interval of 11 days and are sampled over five different days of the week.

3.3.2.2 Monitoring frequency for protozoa (*Giardia* and *Cryptosporidium*)

3.3.2.2.1 Monitoring frequencies for protozoa compliance criteria a (criteria applicable to filtration without coagulation 3.2.3.1)

- For membrane filters the monitoring frequency shall be as specified in the Environmental Technology Verification Protocol for Equipment Verification Testing for Physical Removal of Microbiological and Particulate Contaminants (United States EPA and National Sanitation Foundation (NSF), 1999) or an equivalent internationally accepted Standard.
- For non-membrane filters monitoring shall be at the frequency specified in Table 3.3.

Table 3.3: Minimum measurement frequency for non-membrane plants for protozoa compliance criteria a

Population Served	Minimum Measurement Frequency per Calendar Quarter		Minimum Measurement Frequency per Calendar Quarter
	Online Particle Counting		MPA
over 10,000	Continuous	and	Not applicable
5,001–10,000	Continuous	or	92 (ie daily)
501–5,000	Continuous	or	46
500 or less	Continuous	or	13*

* Additional testing shall be carried out immediately after any adjustment to a filter (eg, change of bag or cartridge) until the effluent particle size distribution has stabilised.

3.3.2.2.2 Monitoring frequencies for protozoa compliance criteria b (criteria applicable to chemical coagulation and filtration treatment 3.2.3.1)

Turbidity is used as a measure of the efficacy of the coagulation / filtration process.

For compliance monitoring, the turbidity of drinking-water leaving the treatment plant shall be measured at each filter at the frequencies specified in Table 3.4 as a minimum and shall be measured continuously where possible. Continuous monitoring is required for water supplies servicing populations greater than 10,000.

Table 3.4: Minimum measurement frequency and reporting period for turbidity in water leaving each filter, for protozoa compliance criteria b

Population Served	Minimum Measurement Frequency		Reporting Period ¹	
	Continuous ²	Manual	Continuous	Manual
More than 10,000	on each filter	N/A	one day	N/A
5,001–10,000 ³	at least one turbidimeter to every 2 filters ⁴	184 (twice a day)	one day	2 weeks
501–5,000	at least one turbidimeter to every 4 filters ⁴	92 (daily)	one day	4 weeks
500 or less	at least one turbidimeter to every 4 filters ⁴	13 (weekly)	one day	6 months

Notes

- ¹ Reporting period is the length of time over which 95 percent of measurements shall meet the compliance criteria. Reporting periods are sequential. Continuous data records shall not be more than one minute apart. These should be compressed using a procedure that preserves accuracy of raw data, and reported as percent of time value exceeded on a reporting period basis.
- ² For continuous records up to two records per day may exceed 1.0 NTU (0.5 NTU after 1 January 2005) to allow for spurious peaks.
- ³ Continuous monitoring is highly desirable, but manual monitoring is acceptable for small plants.
- ⁴ Each filter shall be sampled sequentially (no blending) for five minutes (two filters/turbidimeter) or for two minutes (four filters/turbidimeter) before switching to next filter.

3.3.2.2.3 Monitoring frequencies for protozoa compliance criteria c (criteria applicable to disinfection see 3.2.3.1)

Flow and disinfectant residual concentration shall be monitored continuously to meet the minimum C.t values specified in Chapter 13. Temperature, turbidity and pH measurements are also required (at a minimum of hourly intervals). Refer to the *Guidelines for Drinking-Water Quality Management for New Zealand* for guidance on determining contact times.

3.3.2.2.4 Monitoring frequencies for protozoa compliance criteria d (criteria c water drawn from secure groundwater see 3.2.3.1)

The water shall comply with the specification of secure groundwater (Section 3.2.4). No further monitoring is required to demonstrate compliance.

3.3.2.2.5 Direct measurement of protozoa

Direct measurement of protozoa is not used as a compliance criterion. Protozoa enumeration and viability tests may be used to confirm suspected presence of protozoa but failure to find protozoa does not demonstrate that drinking-water is free from protozoa. The frequency of testing is at the water supplier's discretion, unless otherwise directed by the Medical Officer of Health.

3.3.2.3 Monitoring frequencies for Priority 2c micro-organisms

Micro-organisms designated as Priority 2c shall be monitored at a frequency specified by the Medical Officer of Health.

3.3.3 Microbiological sampling requirements

3.3.3.1 *E. coli*

Procedures for sampling, sample preservation, storage and sample transport shall be agreed beforehand with the Ministry of Health approved laboratory carrying out the analysis, except where special procedures are authorised for small remote drinking-water supplies or for analyses in the field (see Section 3.3.4).

In cases where special procedures are authorised, samples shall be collected aseptically, in sterile bottles, using thiosulphate to dechlorinate the sample if necessary. Ideally testing should take place within six hours of sample collection and it must never be

delayed more than 24 hours after collection. Samples shall be transferred to the laboratory in a cool, dark container. If delivery time exceeds one hour, samples shall be maintained at no more than 4°C but shall not be frozen.

3.3.3.2 Free available chlorine (FAC)

Measurement of FAC must be made in the field.

3.3.3.3 pH

All pH analyses shall be carried out as soon as possible after sampling, with a maximum delay of 4 hours.

3.3.3.4 Turbidity and particle counting

Manual measurement of turbidity and particle counts should preferably be made on-site using a continuous monitor. Otherwise a portable instrument or a laboratory remote from the water treatment plant may be used. In the latter case, samples shall be transported to the laboratory as soon as possible, at the latest within 36 hours.

3.3.3.5 Ozone

The appropriate site for an ozone on-line analyser shall be established by determining the decay curve of ozone in the contact tank by tracer studies or by computational fluid dynamics, verified by direct measurement. Tests shall be carried out at 5°C intervals throughout the whole range of water temperatures occurring in the ozone contact tank to establish the distance along the tank at which the integrated ozone C.t experienced by the water will be 90 percent of the relevant C.t specified in Table 13.2a. The residual ozone concentration at that point shall be recorded at the time of the test. The on-line analyser shall be placed at the point established to be appropriate for the prevailing water temperature.

3.3.4 Microbiological analytical requirements

3.3.4.1 Introduction

Laboratories approved by the Ministry of Health shall be used for all analyses carried out for the purpose of assessing compliance with these Standards, except where special procedures are authorised for small remote drinking-water supplies or for analyses in the field. The competence of field staff shall be verified by an assessor accredited for the purpose.

More detailed information about analytical requirements for *E. coli*, free available chlorine, turbidity and particle size is given in *Guidelines for Drinking-Water Quality Management in New Zealand*, 1995.

3.3.4.2 *E. coli*

For convenience, Presence/Absence tests or other rapid methods for *E.coli* which are acceptable to the Ministry of Health for the purpose may be used for routine monitoring. However, should a positive result be obtained it is essential that these results be confirmed and *E. coli* enumerated by a laboratory approved by the Ministry of Health. (See Section 2.1. The Ministry of Health maintains a register of laboratories approved for this purpose.

3.3.4.3 FAC

Measurement of free available chlorine must be made in the field.

Suitable methods are DPD tablets or powder in foil, and amperometric techniques may also be used as long as they are calibrated against the referee method, APHA 4500 Cl F DPD, ferrous ammonium sulphate titrimetric method, at least once every six months. When field tests involve colorimetric interpretation, all persons who have undertaken FAC tests shall undertake the calibration exercise against the referee method. The identity of the person performing each field test shall be recorded. The analyst making the measurement should be familiar with both the referee and field methods and possible causes of inaccuracy.

The reading from the continuously monitoring chlorine analyser shall be calibrated against a grab sample from the water at least once a week at the point at which it is continuously monitored. The reading on the continuous monitor at the time of taking the grab sample shall be noted. Checking by a Ministry of Health approved laboratory is preferred, but if the analyser is checked using a field test method, the field test method should be calibrated against the referee method at least once every six months by a Ministry of Health approved laboratory.

The instrument shall be recalibrated if the output as measured from a grab sample and that logged for compliance purposes varies by more than 0.1 mg/L. This reading may be not the same reading as observed on the instrument display.

The precautions specified in the Guidelines should be followed.

3.3.4.4 pH

The pH electrode should be calibrated before each set of measurements is made, and the manufacturer's instructions should be followed for the storage of the electrode when not in use. Calibration solutions used should be prepared by an approved laboratory using the formulations given in the above method, or purchased as a certified solution from a chemical manufacturing company.

Checking by a Ministry of Health approved laboratory is preferred, but if the analyser is checked using a field test method, the field test method should be calibrated against the referee method at least once every six months by a Ministry of Health approved laboratory.

Two buffers (7 then 4) shall be used to calibrate and set the slope of the pH meter. A pH 9 buffer shall be used to check that all is well over the whole range.

For potable waters, many of which are unbuffered in New Zealand, the laboratory shall note the time taken for the pH to return from measuring the 9 buffer to reading the pH of an unbuffered potable water. If this has become slow, then the electrode needs attention or is unsuitable.

Meters being used for potable water require a special thin glass electrodes to work properly on unbuffered waters. "Robust" electrodes are not suitable.

3.3.4.5 Turbidity

On-line turbidimeters and particle counters shall be installed in such a manner that air entrainment, temperature changes, long sample lines, low velocities or changing velocities, are minimised.

To operate a turbidimeter with confidence at around the 0.1 NTU level will require an instrument with a limit of detection better than 0.02 NTU and the use of sophisticated calibration techniques.

Continuous monitors must be calibrated at least as frequently as recommended by the manufacturer. Continuous turbidimeters which do not use the nephelometric technique need to be calibrated in NTU units. The reading from the turbidimeter shall be calibrated against a grab sample from the water leaving the filter at the time of the turbidimeter reading at least once a week.

The turbidimeter shall be calibrated using a technique which is traceable to a primary standard.

The test technique shall itself be checked and calibrated against a primary standard at least annually (see APHA 2130).

Checking by a Ministry of Health approved laboratory is preferred, but if the analyser is checked using a field test method, the field test method should be calibrated against the referee method at least once every six months by a Ministry of Health approved laboratory.

Note that different manufacturers' instruments, claiming to comply with the referee method, may not give the same results with the same water, even when each instrument has been calibrated in accordance with the manufacturer's manual. Refer to the *Guidelines for Drinking-Water Quality Management for New Zealand*.

3.3.4.6 Particle counting

The reading from the meter shall be calibrated against a grab sample from the water leaving the filter at the time of the meter reading at least once a week. Once every four weeks the grab sample is to be split and an interlaboratory calibration with a Ministry of Health approved laboratory carried out.

3.3.4.7 Ozone

Continuously monitoring ozone analysers shall be calibrated against a grab sample from the water at the point at which it is continuously monitored at the time of the meter reading at least once a week. Checking by a Ministry of Health approved laboratory is preferred, but if the analyser is checked using a field test method, the field test method should be calibrated against the referee method at least once every six months by a Ministry of Health approved laboratory.

3.3.4.8 Chlorine dioxide

Continuously monitoring chlorine dioxide analysers shall be calibrated against a grab sample from the water at the point at which it is continuously monitored at the time of the meter reading at least once a week. Checking by a Ministry of Health approved laboratory is preferred, but if the analyser is checked using a field test method, the field test method should be calibrated against the referee method at least once every six months by a Ministry of Health approved laboratory.

3.4 Remedial action to be taken when transgression of a microbiological MAV occurs

When transgression of the microbiological Standards occurs there must be an immediate response. The action to be taken in the different circumstances is summarised below. This should be documented in all cases.

3.4.1 Transgressions involving *E. coli*

When a positive result has been obtained using a Presence/Absence or equivalent test (faecal or total coliforms) carried out by field or works staff, a second sample must be collected within 12 hours and *E. coli* enumerated by a Ministry of Health approved laboratory.

3.4.1.1 Response to transgression involving *E. coli* in drinking-water leaving a treatment plant

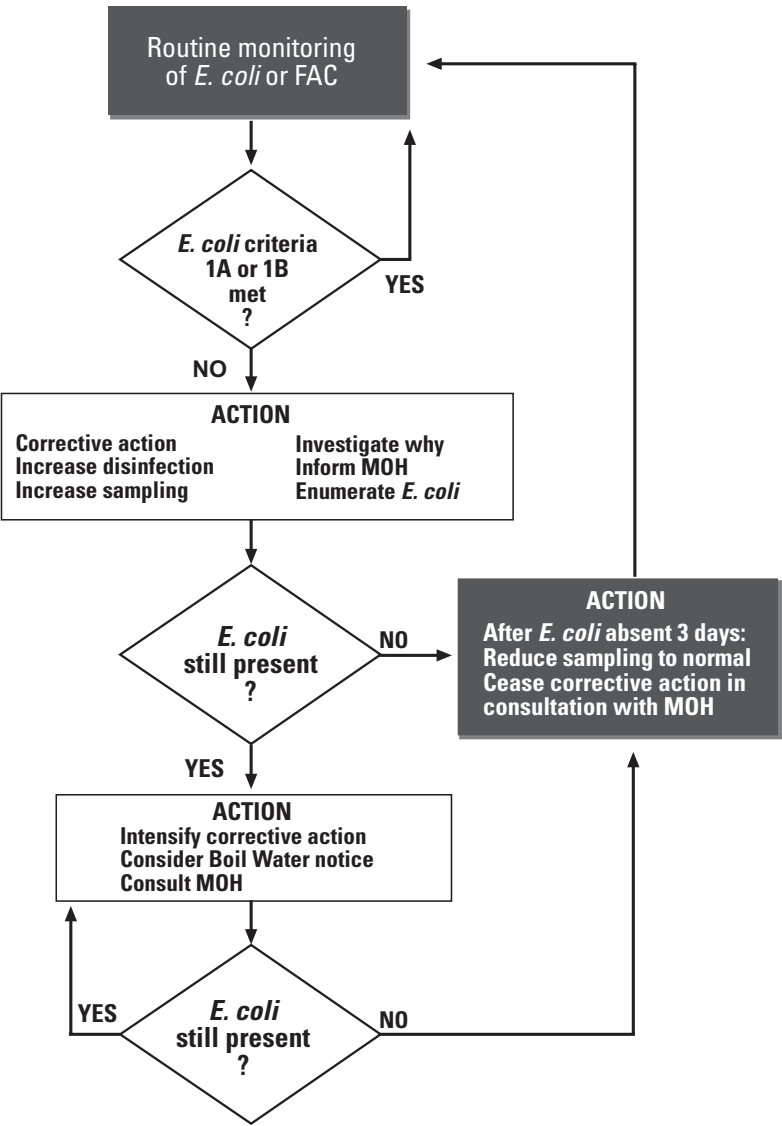
Because contaminated drinking-water leaving the treatment plant can affect the whole community, immediate action is required if a positive *E. coli* test (*E. coli* criteria 1A), or a failure in the requirements of *E. coli* criteria 1B, occurs (See Figure 3.2).

Corrective action to be taken includes inspecting the plant and equipment; increasing the disinfection if necessary; if no fault is found at the plant, inspecting the water supply catchment; increasing sampling; and advising the Medical Officer of Health. Any remedial action indicated shall be applied promptly.

If repeat samples continue to be positive, the Medical Officer of Health shall be consulted and remedial action, such as the issue of a “Boil Water” notice, shall be carried out if considered necessary. Corrective action shall be intensified.

Corrective and remedial action shall be continued until samples have tested free of *E. coli* for three successive days.

Figure 3.2: Response to *E. coli* contamination of drinking-water leaving a treatment plant



3.4.1.2 Response to transgression involving *E. coli* in drinking-water in a distribution zone

3.4.1.2.1 *E. coli* present in the distribution zone

Figure 3.3 summarises the degree of response depending on the number of *E. coli*

found. The response outlined in Figure 3.3 also applies to total coliforms or faecal coliforms when these are used in place of *E. coli* in the monitoring programme. When a positive result has been obtained by field or works staff using a Presence/Absence or equivalent test, a second sample must be collected within 12 hours for enumeration of *E. coli* by a Ministry of Health approved laboratory.

Figure 3.3 Response to *E. coli* contamination of a drinking-water supply distribution zone

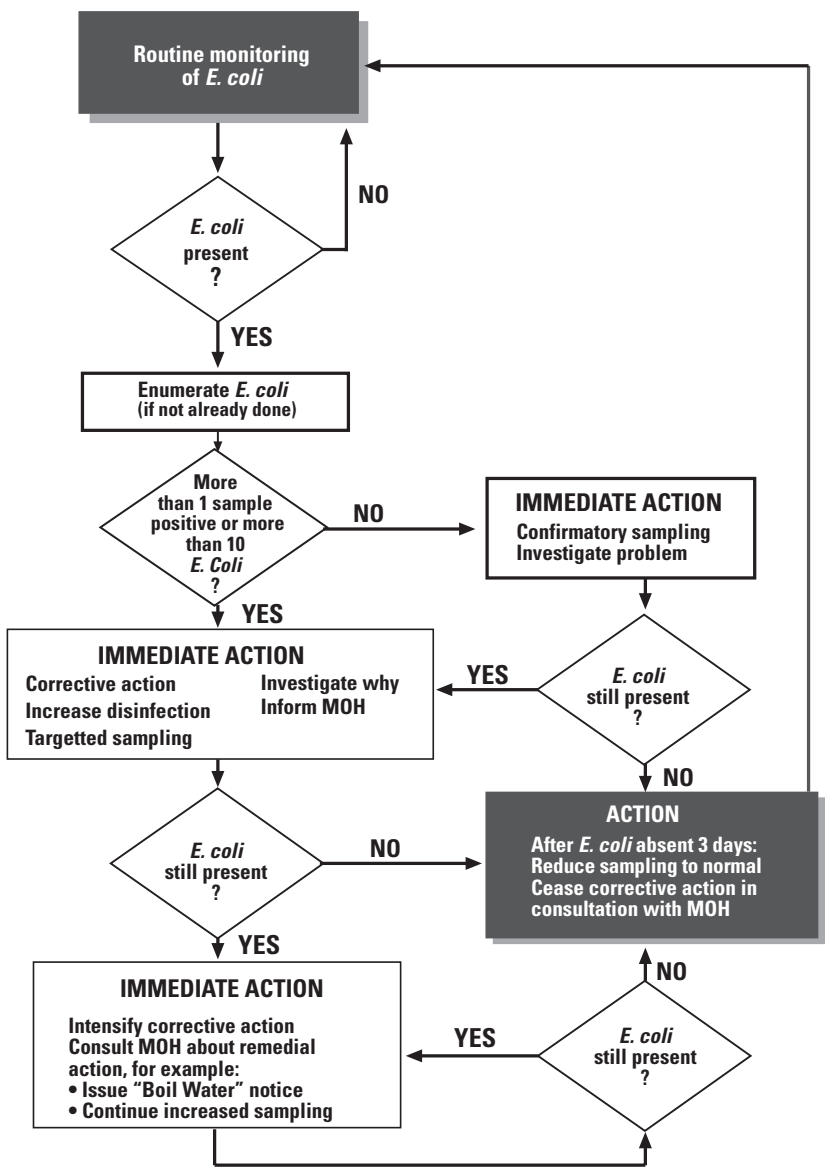


Figure 3.3 summarises the successive stages of response, reflecting the fact that a distribution zone sample containing 10 or more *E. coli* per 100mL or more than one sample testing positive must be considered to be seriously contaminated.

The response includes resampling to confirm whether *E. coli* is still present, ascertaining the source of the contamination and increasing the disinfectant dose if necessary. For a heavy contamination (more than 10 *E. coli* per 100mL) or a second positive result, the Medical Officer of Health must be advised. Daily sampling should be continued until samples have tested free of *E. coli* for three successive days.

3.4.1.2.2 FAC too low

If the FAC is less than the equivalent of 0.2mg/L at pH 8.0 more often than is prescribed in *E. coli* compliance criteria 2B, full monitoring of *E. coli* according to Table 3.2a should be carried out in addition to the FAC monitoring schedule. The FAC monitoring regime may be reinstated when the level of FAC has continuously met the requirements of the Standards for one week.

3.4.2 *Giardia* and *Cryptosporidium* transgressions

3.4.2.1 Response to particles in drinking-water leaving each filter (protozoa criteria a for filtration without coagulation)

In the event of a transgression, for example, the particle counter showing a particle distribution and/or total count that indicates that the filter performance is not satisfactory (distribution range counts and/or total count changes by more than 50 percent), the filter array shall be taken off-line and the transgression procedures implemented immediately.

The reason for the transgression shall be investigated.

For membrane filters, testing methods consistent with the verified integrity testing method shall be used to locate the fault and the faulty component either repaired or isolated pending later repair.

For cartridges, bag, diatomaceous earth and slow sand filters using:

- a. on-line particle counting – filter performance tests shall be carried out
- b. MPA – additional MPA testing shall be carried out

until the fault has been diagnosed and repaired and the test results are satisfactory.

The problem could be due to a failure of the filter material; a failure of the sealing of the filter membrane, cartridge or bag unit into its housing; or an overloading of the filter with particulates (eg, by raw water turbidity exceeding the filter rating). Once the fault has been remedied, the filter or the array shall be retested and if satisfactory the array brought back on line.

Where the particle compliance criteria required by the Standards cannot be met, the Medical Officer of Health should be advised.

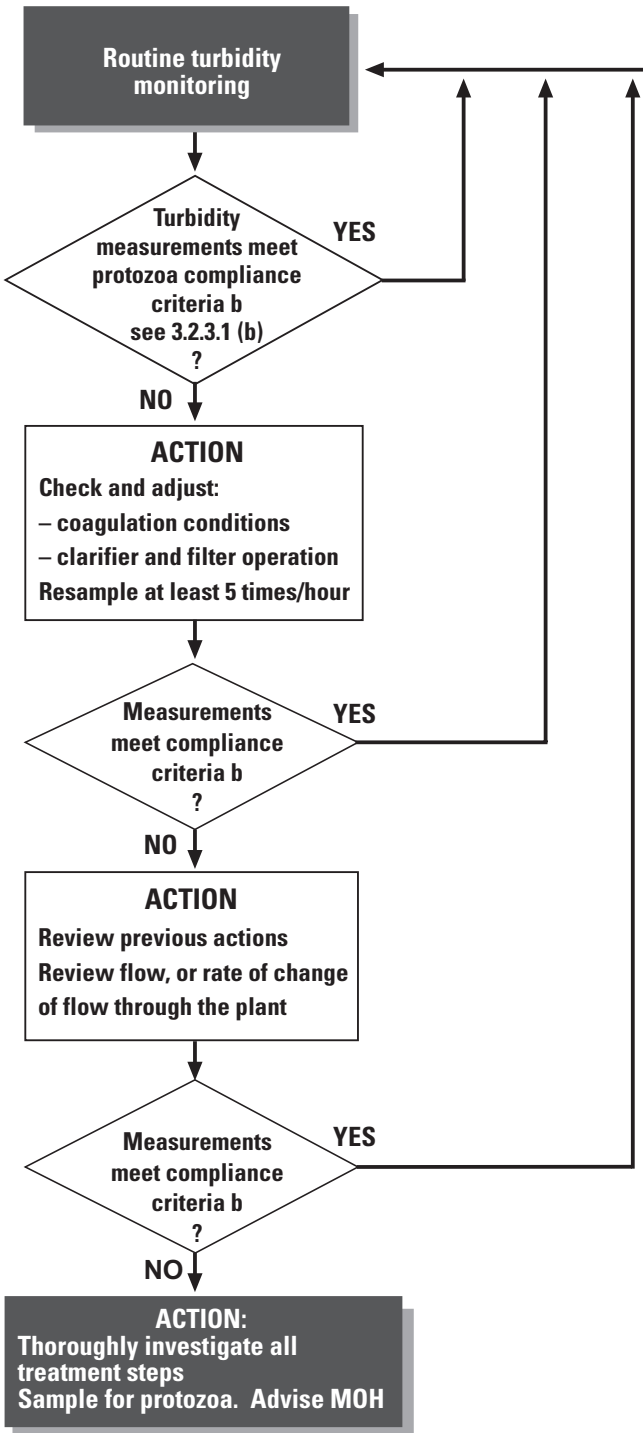
3.4.2.2 Response to turbidity in drinking-water leaving each filter (protozoa criteria b for filtration after coagulation)

The reason for sudden increases in turbidity or transgressions should be investigated immediately.

Investigations should consider the effect of possible occurrences in the catchment that affect the raw water quality and the need for any remedial action involving coagulant dose adjustment, floc carryover, filter operation, or individual filter condition. Refer to the *Guidelines for Drinking-Water Quality Management in New Zealand* for further guidance. For non-continuous monitoring, the frequency of testing the drinking-water leaving each filter should be increased until the turbidity compliance criteria are met.

Figure 3.4 shows the steps to be followed in response to turbidity transgression for water leaving a filter.

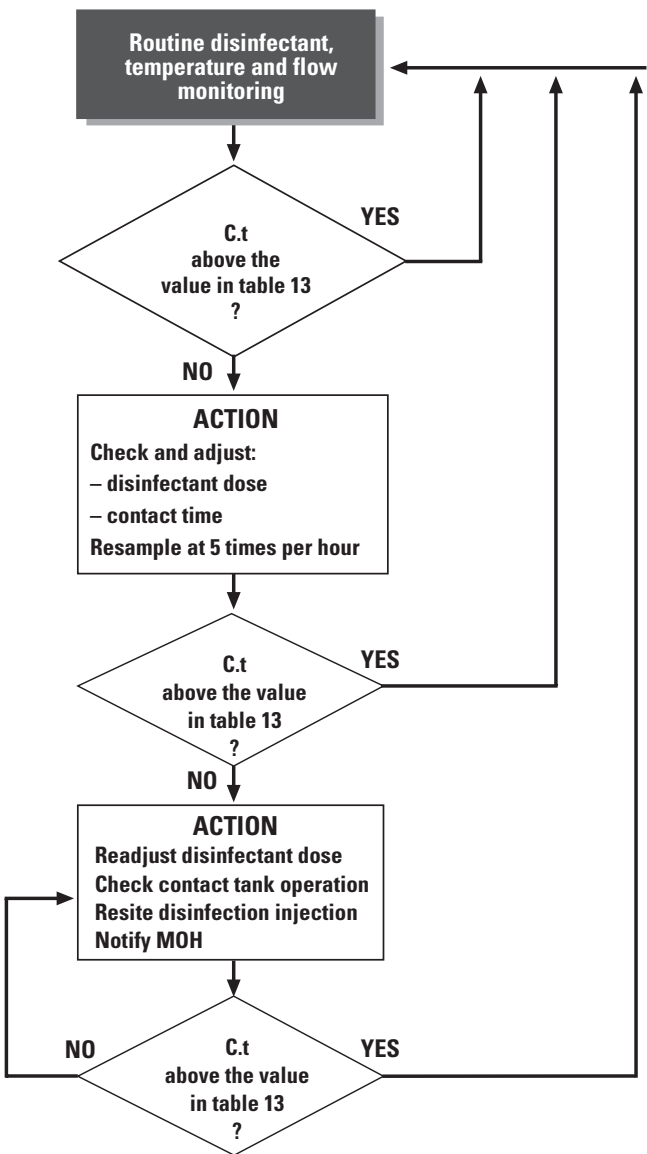
Figure 3.4: Response to turbidity transgression for drinking-water leaving a treatment plant



3.4.2.3 Response to incorrect disinfection C.t

If the disinfection C.t value specified for the temperature of the water has not been achieved, either the disinfectant dose rate, or the contact time, or both, should be increased. Where this does not achieve the C.t value required by the Standards, the Medical Officer of Health should be advised. Refer to the *Guidelines for Drinking-Water Quality Management in New Zealand 1995* for further guidance.

Figure 3.5: Response to disinfectant C.t transgression for drinking-water leaving a treatment plant



4 Chemical Compliance

4.1 Introduction

4.1.1 Purpose

To avoid concentrations of determinands of health significance being present in drinking-water at levels which present a significant risk to public health.

4.1.2 Rationale for setting chemical MAVs

For most carcinogenic substances, the MAV in these Standards is the concentration of the substance in drinking-water which has been estimated to cause one additional incidence of cancer in a population of 100,000 people who ingest 2L per day of water containing the substance at the MAV over a period of 70 years.

For most other chemicals, the MAV has been calculated using a Tolerable Daily Intake (TDI) approach which identifies the dose below which there is no evidence that significant adverse effects will occur and which will represent no significant risk from a lifetime of consumption of 2L of the water per day.

MAVs for chemical determinands of health significance are given in Chapter 14, Tables 14.1–14.7.

4.1.3 Sources of chemical contamination

Chemical constituents of drinking-water may come from the:

- source water
- treatment process
- distribution system
- consumer's plumbing.

The following sections detail the monitoring requirements necessary to demonstrate compliance for those determinands that have been designated as Priority 2 for a particular supply.

4.2 Compliance criteria for chemicals

There are two types of Priority 2 chemical determinands.

- Priority 2a:

Chemical determinands that could be introduced into the drinking-water supply by the treatment chemicals at levels potentially significant to public health (usually greater than 50 percent MAV). Priority 2a does not include disinfection by-products or determinands introduced into the drinking-water from piping or other construction materials.

- Priority 2b:

Chemical determinands of health significance, other than those introduced by the treatment chemicals, that have been demonstrated to be in the drinking-water supply at levels potentially significant to public health (usually greater than 50 percent MAV). Priority 2b includes determinands present in the raw water, disinfection by-products, and determinands introduced into the drinking-water from piping or other construction materials.

Determinands specified by the Ministry of Health as Priority 2 determinands for the drinking-water supply under consideration shall be monitored to establish compliance with the Standards. Priority 2 determinands may relate to individual distribution zones, or to the treatment plant if the determinand applies to more than one zone. Appropriate sampling sites are indicated in Chapter 12, Tables 12.1–12.3.

A further category of water is aggressive water. This is water in which levels of one or more of the corrosion products antimony, cadmium, copper, lead, or nickel are elevated to concentrations greater than 50 percent of the MAV when the water stands in contact with consumer's plumbing fittings, despite those metals being below this level in normal, "flushed" samples.

4.2.1 Compliance criteria for Priority 2 chemicals

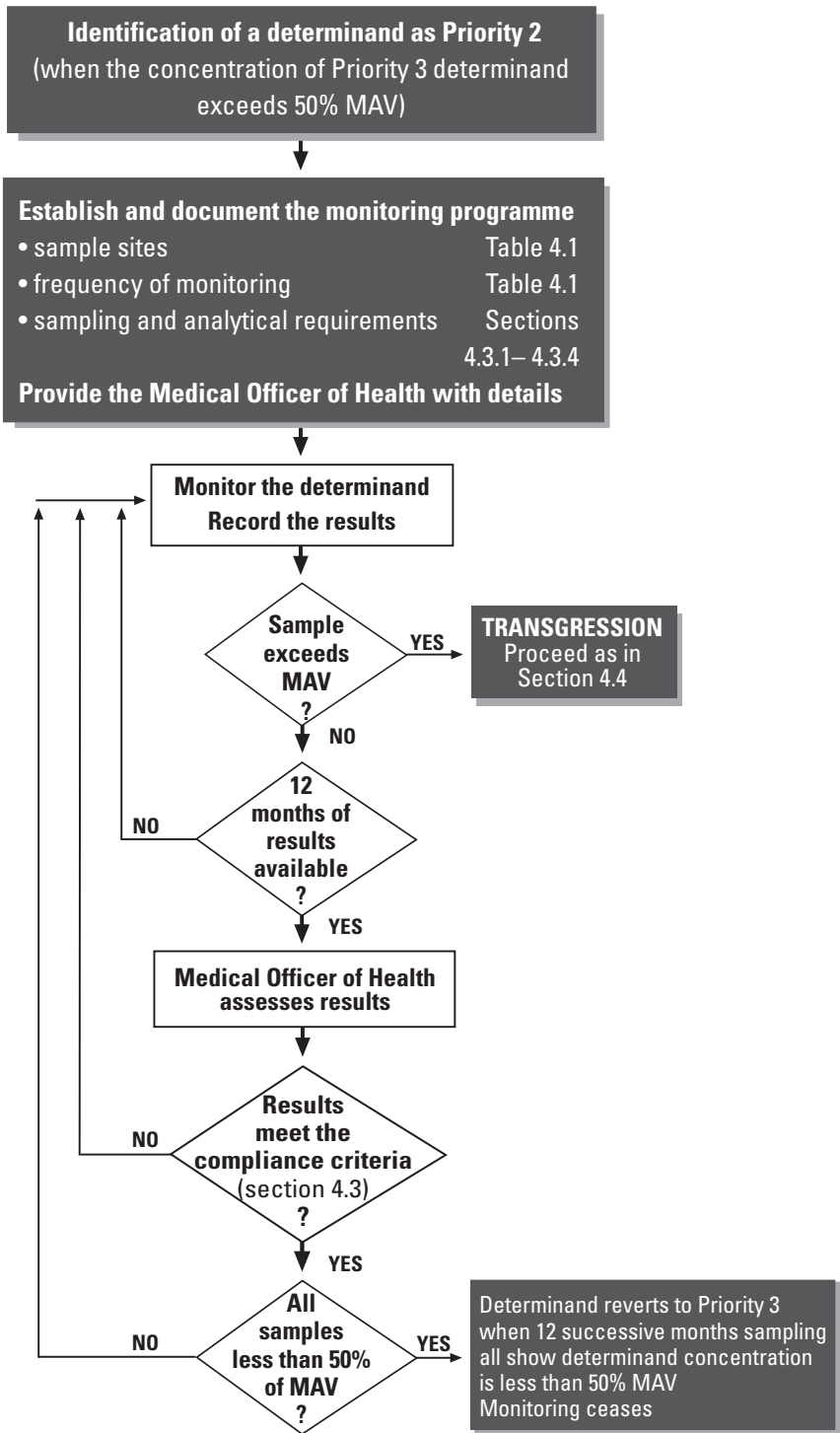
Chemical compliance is assessed from the results of sampling carried out over 12 consecutive months. The criteria for compliance are:

1. Samples are taken at the required sites and frequency for the determinand in question.

2. The sampling and analytical techniques comply with the requirements of these Standards.
3. Where more than one determinand which causes similar toxicological effects is present, for compliance with the Standards the sum of the ratios of the concentration of each determinand to its respective MAV does not exceed one.
4. The maximum number of transgressions found when sampling is carried out at the frequency specified in Table 4.1 is equal to or less than:
 - 0 in 38–77 samples
 - 1 in 78–109 samples
 - 2 in 110–139 samples.
5. The procedure outlined in Section 4.4 is followed when determinands exceed the MAV and the results and actions documented.

Figure 4.1 illustrates how to establish compliance of Priority 2 chemical determinands with the Standards.

Figure 4.1 Establishing compliance of Priority 2 determinands with the Standards



4.2.2 Compliance criteria for Priority 3 and 4 chemicals

Priority 3 and 4 chemicals do not have to be monitored.

A Priority 2 determinand may be relegated to Priority 3 when 12 successive monthly samples show concentrations below 50 percent MAV. When there is no obvious reason for the concentration decrease that led to the reversion of the determinand to Priority 3, monitoring should continue at once a quarter until the Medical Officer of Health is satisfied that the change is permanent.

4.2.3 Compliance criteria for aggressive water

The water supply will be considered to comply with the Standards provided the water supply owner provides public warning to consumers at least twice a year, for example, with each water supply bill or water rate demand and also publishes a public notice that states that:

- the water supplied in that district is mildly corrosive to plumbing fittings and may / will accumulate lead, cadmium, antimony or nickel if it lies for too long in the pipes
- before using the water for food preparation or drinking, at least 500mL of water should be flushed from the tap and discarded to flush away corrosion products.

4.3 Chemical monitoring requirements

4.3.1 Chemical sampling sites

4.3.1.1 Sampling sites for Priority 2a determinands

Sampling of Priority 2a determinands that are introduced with water treatment chemicals shall be carried out in the drinking-water leaving the treatment plant. Alternatively, compliance can be demonstrated by certified analysis of the treatment chemical and demonstration that the treatment process cannot introduce a sufficient amount of contaminant to cause the determinand to become Priority 2.

4.3.1.2 Sampling sites for Priority 2b determinands and aggressive water

Priority 2b determinands are of two main types.

Type 1: substances whose concentration is unlikely to vary during distribution.

Type 2: substances whose concentration may vary during distribution.

Aggressive water has been described in Section 4.2.

Priority 2b Type 1 determinands, whose concentration will not be affected by the distribution system, may be monitored either in the drinking-water leaving the treatment plant or in the distribution zone if this is more convenient.

Priority 2b Type 2 determinands, which have a source in the distribution system, or which react in or with it, shall be sampled from the distribution zone only.

Tables 12.1 to 12.3 in Chapter 12 indicate which sampling site(s) are appropriate for each determinand. A tick in the DZ column indicates the sample shall be taken from the distribution zone only. Ticks in both the TW and DZ columns indicate that the determinands can be sampled from either the drinking-water at the treatment plant or in the distribution zone.

Aggressive water shall be sampled in the relevant distribution zone(s).

Distribution zone sampling sites shall be selected to be either representative of the water quality in the distribution zone or appropriate for the determinand in question unless otherwise specified by the public health agencies. For example, samples for disinfection by-products should be collected near the ends of the distribution system.

Some sampling should be carried out at fixed sites so that water quality trends can be followed over time.

Further sampling at random sites may be useful to investigate the:

- effects of different reticulation materials
- effects of spatial and temporal effects on drinking-water quality
- representativeness of the fixed sites selected.

4.3.2 Chemical sampling frequencies

Sampling frequencies are summarised in Table 4.1. Sampling frequency requirements for Priority 2a and 2b determinands are given in more detail below.

4.3.2.1 Sampling frequencies for Priority 2a determinands

Fluoridated drinking-water supplies shall be monitored for fluoride at least 13 times per calendar quarter.

The free chlorine content of the drinking-water leaving the treatment plant shall be monitored at least weekly, that is 13 times per calendar quarter (See footnote 7 to Table 4.1).

Well-managed drinking-water supplies will undergo process monitoring of these determinands more frequently than 13 times per calendar quarter. These process monitoring results can be used to demonstrate compliance provided that the sampling and analytical procedures are shown to be suitable.

For Priority 2a determinands other than FAC and fluoride, the minimum monitoring frequency is three times per calendar quarter. For determinands introduced with water treatment chemicals, analysis will not be required if the water supply owner can demonstrate by calculation that impurities from the treatment chemicals will be less than 50 percent of the MAV using data from their maximum dose rates and verified certified analyses covering each batch from each source of the chemical used.

Additional sampling and analysis may be necessary when a change in operating conditions could affect the concentrations of determinands of health significance introduced by the treatment process.

- The chemicals used in treatment do not have a validated certificate of quality.
- A chemical of health significance is dosed into the water upstream of the treatment process in order to control water quality problems. The Medical Officer of Health shall also be advised.
- After process changes are implemented that could affect the concentration of the determinand in the drinking-water.

4.3.2.2 Sampling frequencies for Priority 2b determinands

Priority 2b, Type 1 determinands, sampled at the point where the drinking-water leaves the treatment plant, shall be monitored three times per calendar quarter at a minimum.

Priority 2b, Type 2 determinands, whose concentration may change in the distribution system, should be monitored at selected fixed site(s) at least three times per calendar quarter, and sufficient extra random samples should be collected throughout the year to detect any spatial variability and effects from the distribution system. The sampling dates for disinfection by-products (DBP) for the following 12 months shall be notified in advance to the verifying designated officer.

Table 4.1: Monitoring requirements for Priority 2a and 2b determinands

Priority	Sampling Site Locations	Number of Sampling Sites	Minimum Monitoring Frequency
Priority 2a	Drinking-water leaving the treatment plant	1	Fluoride: 13 per calendar quarter Chlorine: 13 per calendar quarter ⁷ All others: 3 per calendar quarter
Priority 2b, Type 1	Drinking-water leaving the treatment plant ⁸	1	3 per calendar quarter
Priority 2b, Type 2	Distribution zone	Sufficient sites chosen to reflect the problems associated with the determinand in relation to the materials used, and reaction time for disinfection by-products and corrosion products	3 per calendar quarter at each site, except where a water supplier declares its water is aggressive and advises the consumer of the necessary remedial action. In the latter case no further monitoring is required

4.3.2.3 Sampling frequencies for aggressive water

No sampling is required provided the supplier has met the compliance criteria specified for aggressive water in Section 4.2.3.

When a water supply has been designated as aggressive and the supplier wishes to demonstrate that the water is not aggressive, the concentrations of lead in the water shall be demonstrated to be below 50 percent of the MAV by 12 months of first flush sampling from a brass tap or field test rig approved by the Ministry of Health as suitable for the purpose.

⁷ The figure of 13 FAC samples per quarter is to demonstrate that the MAV is not exceeded. To demonstrate the maintenance of a FAC residue sufficient to inactivate pathogens, 92 measurements per calendar quarter (including the 13 samples for P2 purposes) are required (Section 3.3.2.1.2).

⁸ May also be monitored in the distribution zone if this is more convenient.

4.3.3 Chemical sampling procedures

Procedures for sampling, sample preservation, storage and sample transport shall be confirmed with the Ministry of Health approved laboratory carrying out the analysis, except where special procedures are authorised for small remote drinking-water supplies or for analyses in the field.

Except when sampling for corrosion products in testing for aggressive water, samples from the distribution zone are to be collected after flushing the tap for long enough to ensure that the sample is representative (about 5L of water).

To identify aggressive water by the presence of corrosion products produced from consumer's water supply pipes and fittings, a sample of no more than 150mL shall be drawn from the first flush from the tap, when the tap has not been used since the previous day.

4.3.4 Chemical analytical requirements

Only laboratories approved for the purpose by the Ministry of Health shall be used for analyses to check compliance with the Standards.

The laboratory's statistically determined detection limits (method detection limit) for each determinand should be ideally one-fifth, or less, of the MAV for that determinand. This may not be possible for all determinands.

Analytical requirements for chemicals are specified in Chapter 12, Tables 12.1 to 12.3. of

4.4 Transgression of a chemical MAV

4.4.1 General

Transgression of the MAV occurs when the measured value of a determinand in a sample exceeds the MAV.

Transgression of the MAV by a single sample will not necessarily result in the drinking-water supply failing to comply with the Standards provided that the number of transgressions is not more than:

- 0 in 38–77 samples
- 1 in 78–109 samples
- 2 in 110–139 samples.

After a transgression has occurred the water supplier shall immediately advise the Medical Officer of Health, resample the supply/site, investigate the problem and take appropriate action.

Weekly sampling shall continue until the MAV is not exceeded in three successive analyses. All incidents of transgression must be recorded, including monitoring results, action taken and outcomes.

The suitability of a drinking-water supply may need to be questioned if it suffers from persistent transgressions.

4.4.2 Corrosion by-products (due to aggressive water)

Provided the water supplier complies with the remedial action specified in Section 4.2.3, the water supply will then be exempted from the requirement to carry out a monitoring programme equivalent to that required if the corrosion by-product were a Priority 2 determinand.

In the event that the supplier wishes to demonstrate that the water is not aggressive, the supplier will have to undertake 12 months of first flush sampling to demonstrate compliance.

5 Radiological Compliance

5.1 Purpose

To avoid concentrations of radioactive determinands of health significance being present in drinking-water at levels which present a significant risk to public health.

5.2 Rationale for radiological MAVs

All living organisms are exposed to radiation from natural sources including cosmic radiation from outer space; external radiation from natural radionuclides (uranium and thorium and their decay products, and potassium-40) present in soils, rocks and building materials; and internal radiation due to potassium-40 and inhaled radionuclides, particularly radon decay products. Natural radiation exposure varies regionally as the compositions of soils and rocks change and increases with altitude as cosmic radiation intensity increases, and nothing can be done to prevent exposure.

In terms of health significance, radioactive materials in drinking-water can be divided into two categories: alpha-particle emitters and beta-particle emitters. The ingestion of either results in internal radiation exposure but alpha-particle emitting radionuclides are the more hazardous because of the greater energies of alpha particles. For this reason the Standards consider the two types of materials separately.

The *Drinking-Water Standards for New Zealand 2000* adopt MAVs for total concentrations of alpha-emitting and beta-emitting radionuclides, excluding radon-222 and potassium-40, which would limit the annual radiation dose resulting from the consumption of 2L of water per day to less than 5 percent of the average annual radiation dose due to all natural sources.

The MAVs are deliberately conservative, such that if the natural radionuclides uranium-238, uranium-234, radium-226 and radium-228 were all present in drinking-water at the MAV level, the annual radiation dose would still be less than 5 percent of the total annual natural dose.

5.3 Radiological compliance criteria

The MAVs given in Table 14.5 for radiological determinands shall not be exceeded.

The MAVs for alpha-emitting and beta-emitting radionuclides are:

- total alpha concentration: 0.10 becquerel per litre, excluding radon-222
- total beta concentration: 0.50 becquerel per litre, excluding potassium-40
- radon-222 concentration: 100 becquerels per litre.

5.4 Radiological monitoring requirements

A nationwide survey of radioactivity in drinking-water conducted by the National Radiation Laboratory (NRL) in 1980 indicated that radioactivity levels in all drinking-water supplies serving population groups of 5,000 or more were below 50 percent of the MAVs for alpha- and beta-radioactivity and radon-222. Drinking-water radioactivity is thus classed as Priority 3 so regular routine testing of public drinking-water supplies is not required.

Water from new underground sources shall be tested before connection to public drinking-water supplies.

If radiological sampling of water is contemplated, the NRL should be consulted.

5.5 Transgression of a radiological MAV

If the radioactivity of a drinking-water supply exceeds 50 percent of the MAV, the supply is to be analysed for contributing radioactive materials and an assessment should be made of their radiological significance by the NRL.

NRL provides both analytical and radiological advisory services appropriate for water-testing. If the alpha-radioactivity exceeds 0.1 becquerel per litre (excluding radon-222), the water should be analysed for uranium-238, uranium-234 and radium-226 and a radiological assessment should be undertaken. If the beta-radioactivity exceeds 0.5 becquerel per litre (excluding potassium-40), the water should be analysed for radium-228 and any other beta-emitting radionuclides which may be present, and a radiological assessment should be undertaken.

If the radiological MAV is transgressed, the NRL will advise the Medical Officer of Health and the water supplier of the remedial action to be taken.

6 Records

Records should be kept of the results of monitoring drinking-water determinands.

The records are necessary to demonstrate that the Drinking-Water Standards for New Zealand are being complied with. They are an essential requirement for the public health grading of drinking-water supplies.

The records should include the following information.

1. The name of the supply, treatment plant(s) and distribution zone(s) to which the information relates. The unique site code listed in the *Register of Community Drinking-Water Supplies in New Zealand* shall be included with every record. If the water supply has not been assigned site codes, these should be obtained from the Ministry of Health.
2. The treatment processes in operation at the beginning of the year being reported, and any modifications that changed the process during the year.
3. Anything that could affect water quality that has occurred in the drinking-water supply system or catchment.
4. The determinands monitored during the year, and the reasons for the omission of those Priority 1 and Priority 2 determinands not being monitored, with corroborating data where appropriate.
5. The sampling frequency for each determinand, the dates and times on which the measurements were made, the sampling site location and site code and the analytical results.
6. Any corrective action taken, either as a result of the level of a determinand exceeding the MAV or because it was considered necessary by the water supplier.
7. The name of the laboratory used for the analyses, as listed in the Ministry of Health *Register of Approved Laboratories*.
8. Any re-evaluation of the operational programme undertaken, and the reasons for this being done. Notes concerning treatment modification are included above, but changes in the operation or the materials used in the reticulation should also be noted where appropriate.
9. Operational records, including process changes and operational monitoring.

10. Staff supervisors and operators, together with details of their relevant qualifications and experience.

Proper internal documentation of the monitoring programme, as detailed in the *Guidelines for Drinking-Water Quality Management for New Zealand*, will enable suppliers to collate this information easily. Use of WINZ (the Water Information New Zealand information base operated by the Ministry of Health) will assist in maintaining the necessary records in the correct format. Records must be kept for a minimum of 10 years and must be made available to Ministry of Health designated officers as required.

7 Definitions

Acceptable Daily Intake (ADI)	The intake level in the human which is confidently believed to be without significant adverse health effects.
acute level	The dose of a determinand which causes an effect after a single or short-term exposure.
aesthetic determinand	A constituent or property of the water that can adversely affect the taste, odour, colour, clarity or general appearance of the water. These include substances such as manganese and iron compounds that can stain washing and utensils.
aggressiveness	The tendency of a water to corrode water supply pipes and fittings causing heavy metal concentrations to rise to above 50 percent of their MAVs.
alkalinity	Alkalinity is a measure of buffering capacity. A buffer limits the change in pH that occurs when water comes into contact with acidic or alkaline substances. The principle causes of alkalinity in most drinking-waters include at least one of bicarbonate, carbonate, and hydroxide. Alkalinity is measured by titrating with a standard acid to a designated pH.
analyte	See determinand .
becquerel	Radioactive activity of 1 nuclear transformation per second.
C.t value	The product of the concentration, C, of the disinfectant (in mg/L) and the contact time, (in minutes), t, required to cause a specified level of inactivation in a micro-organism. This is a measure of the exposure to the disinfectant.
chemical coagulation	The use of metallic salts (eg aluminium or iron) or organic polyelectrolytes (polyamines or polydadmecs) to destabilise fine suspended particles, causing them to clump together into larger particles.

chloramines	Compounds that may form through the reaction of free available chlorine (FAC) with nitrogen compounds. Chloramines formed from the reaction of FAC with ammonia are monochloramine, dichloramine or trichloramine.
chlorinated supplies	Supplies that are chlorinated but have not been demonstrated to consistently have a FAC concentration equivalent to at least 0.2mg/L of FAC at pH 8.0. See fully chlorinated water .
chronic level	The dose of a determinand that causes an effect after long-term exposure.
coliform organisms	The bacteria used as indicators that organic, possibly faecal, contamination of the water may have occurred. Sometimes referred to as total or presumptive coliforms.
committed effective dose (radioactivity)	The lifetime sum of the effective dose (50 years for adults: 70 years intake to age 70 for children).
community drinking-water supply	A publicly or privately owned drinking-water supply which serves more than 25 people for at least 60 days per year.
compliance	A drinking-water supply is said to be in compliance with the Standards when the results of monitoring of Priority 1 and 2 determinands show that the water supply satisfies the requirements of DWSNZ 2000.
compliance criterion	A condition that must be satisfied in order to achieve compliance.
compliance monitoring	Any monitoring conducted to test whether a drinking-water supply complies with DWSNZ 2000.
confidence interval	An interval which has a prescribed probability of containing the true value of an unknown parameter.
confidence level	The probability that an assertion about the value of a population parameter is correct.
confidence limits	The upper and lower boundaries of the confidence interval.

contaminant	A substance or organism in the water which can cause undesirable public health or aesthetic effects.
data sheets	The section in the <i>Guidelines for Drinking-Water Quality Management for New Zealand</i> which lists the sources, occurrence, removal process, analysis, health effects, and derivation of the MAVs of determinands.
designated officer	A Health Protection Officer or Medical Officer of Health designated by the Director-General of Health, pursuant to Section 7A(4) of the Health Act 1956 (as inserted by the Health Amendment Act 1993).
detection limit	See method detection limit .
determinand	A constituent or property of the water which is determined, or estimated, in a sample, for example, microbiological determinand–total coliforms; chemical determinand–chloride; physical determinand–pH, turbidity, colour; radiological determinand–radon.
disinfectant C.t value	See C.t value .
disinfection	The process used to inactivate micro-organisms in a drinking-water supply. The most common methods of disinfection are chlorination, ozonation, ultraviolet irradiation and boiling.
disinfection by-products	Contaminants produced in the drinking-water supply as by-products of the disinfection process.
disinfection residual	The amount of disinfectant that is still present in the water at any time. After disinfectant is added to drinking-water it is used up by the disinfection process and other chemical reactions. More disinfectant is usually added than is initially needed, so that enough disinfectant remains to guard against post-treatment contamination.
distribution system	All the trunk main, storage, and distribution system components which follow a treatment plant and any post-treatment storage facility at the treatment plant. See network reticulation .
distribution zone	The part of the drinking-water supply network within which all consumers receive drinking-water of identical quality, from the same or similar sources, with the same treatment

and usually at the same pressure. It is part of the supply network which is clearly separated from other parts of the network, generally by location, but in some cases by the layout of the pipe network

For example, in a large city, the central city area may form one zone, with outlying suburbs forming separate zones or, in a small town, the system may be divided into two distinct areas. The main purpose of assigning zones is to separately grade parts of the system with distinctly different characteristics.

down-time The length of time for which a process or monitoring equipment in the treatment plant is out of action.

drinking-water Water intended to be used for human consumption, food preparation, utensil washing, oral hygiene or personal hygiene.

Drinking-Water Standards

A yardstick to assess the quality of drinking-water. The Standards define the MAVs of health significant determinands and specify methods for determining whether a drinking-water supply complies with the Standards.

E. coli (Escherichia coli) A bacterium used as an indicator that faecal contamination of the water has almost certainly occurred and that, therefore, there is a possibility that pathogens are present.

effective dose (radioactivity)

The effective dose is the equivalent, uniform, wholebody dose having the same radiation health detriment as the actual dose distributed among the various organs of the body, with the unit sievert or millisievert (mSv). See **committed effective dose**.

enteric viruses Viruses occurring in the digestive system and found in faeces of human or animal origin.

exceedence The occurrence of a determinand in a sample at a concentration greater than the MAV.

faecal coliforms (thermotolerant coliforms)

A sub-group of total coliforms which will grow on a specific selective medium when incubated at $44.5^{\circ} \pm 0.2^{\circ}\text{C}$. The presence of faecal coliforms indicates that faecal

contamination has probably occurred and that steps need to be taken to ensure pathogens are not present. Included as faecal coliforms are: *Klebsiella* and *Escherichia*. Also referred to as thermotolerant. See also *E. coli*, **presumptive coliforms** and **total coliforms**.

free available chlorine (FAC)

The chlorine present in a chlorinated water in the form of hypochlorous acid and hypochlorite ion.

fully chlorinated water

Water in which the FAC concentration exceeds the equivalent of 0.2mg/L free available chlorine at pH 8.0.

guideline

A preferred course of action, process or procedure.

guideline value

The value for an aesthetic determinand which, if exceeded, will render the water unattractive to consumers.

[the] Guidelines

The *Guidelines for Drinking-Water Quality Management for New Zealand* published by the Ministry of Health.

health detriment

An adverse effect on health.

indicator organism

A determinand, for example *E. coli* or faecal coliforms, that is monitored to indicate the presence of faecal contamination.

Langelier Saturation Index

The Langelier Saturation Index (SI) is a measure of the corrosive or scale forming nature of a water, depending on whether it will dissolve or precipitate calcium carbonate. The Langelier Saturation Index is defined as the actual pH of the water minus the pH at which the water will be in equilibrium with solid calcium carbonate. It is measured on a positive/negative scale with waters of a SI of -0.5 or lower considered to be corrosive, waters with a SI of +0.5 or more considered to be scale forming and waters between -0.5 +0.5 considered to be well balanced. The SI is calculated using the calcium hardness, alkalinity, total dissolved solids and pH of the water. It does not always correlate well with aggressiveness in New Zealand waters and is therefore not used to define aggressiveness in DWSNZ 2000.

limit of detection

See **method detection limit**.

Lowest Observed Adverse Effect Level (LOAEL)

The lowest dose of a contaminant at which a statistically significant adverse effect has been observed in a group of test animals. Such a value would only be used to establish a

human TDI when an appropriate **No Observed Adverse Effect Level (NOAEL)** was not able to be determined. In the event that a LOAEL (rather than a NOAEL) is used as the basis for a TDI, it is likely that a higher uncertainty factor would be employed.

Maximum Acceptable Value (MAV)

The concentration of a determinand below which the presence of the determinand does not result in any significant risk to a consumer over a lifetime of consumption. For carcinogenic chemicals, the MAVs set in these Standards generally represent a risk of one additional incidence of cancer per 100,000 people ingesting the water at the concentration of the MAV for 70 years.

MDL Method detection limit.

Medical Officer of Health

The Medical Officer of Health appointed for a health district under the Health Act 1956, and includes any Deputy Medical Officer of Health; and, for the purposes of Part IV of the Act, includes any medical practitioner acting under the direction of the Medical Officer of Health.

method detection limit (MDL)

The constituent concentration which, when processed through the complete analytical method, produces a signal with a 99 percent probability that it is different from the blank. Seven replicate measurements of a solution containing the determinand of interest at a concentration near to the estimated MDL are used to calculate the standard deviation(s). The MDL is $3.14 \times s$.

micro-organism A very small (microscopic) organism. Includes viruses, bacteria, protozoa, algae and helminths.

MOH Medical Officer of Health.

monitoring The sampling and analysis of a drinking-water supply to test for compliance with the Standards or for process control, by detecting changes in the concentrations of its constituent determinands or deviations of these from target values. In New Zealand monitoring is the responsibility of the water supplier.

network reticulation	A network under the control of a network utility operator, that is, all parts of the drinking-water distribution system including pipes, treated water reservoirs, etc.
network utility operator	A person who undertakes the piped distribution of a drinking water supply. See also water supplier .
No Observed Adverse Effect Level (NOAEL)	The dose of a contaminant at which no adverse effect has been observed on a test animal.
parameter	A coefficient or factor in an expression or equation used to process data.
parasites	Refers to <i>Giardia</i> and <i>Cryptosporidium</i> in this document.
pathogen	An organism capable of inducing illness.
pesticides	A substance or mixture of substances used for the eradication or control of any pest. This includes behavioural and developmental modifiers, for example plant growth regulators, desiccants or defoliants, but not fertilisers or animal remedies.
pH	A measure of the concentration of hydrogen ions in water. It is the negative logarithm to base 10 of the concentration of H ⁺ in the water. A low pH indicates an acidic water, a high pH shows that the water is alkaline. A pH of 7 is neutral. The pH of water is particularly important in water treatment processes such as coagulation and disinfection.
potable water	Drinking-water which does not contain any determinands which exceed the Maximum Acceptable Values (MAVs) given in the DWSNZ 2000. See also wholesome drinking water .
presumptive coliforms	Bacteria whose identification in the early stages of bacteriological examination highlight the need for further identification of coliform organisms. If absent it is not necessary to proceed with further identification of coliform organisms. See also <i>E. coli</i> , faecal coliforms and total coliforms .
Priority class	One of the four classes of determinands defined in the <i>Drinking-Water Standards for New Zealand 2000</i> . The priority classes are ranked according to the potential impact of the determinand on public health if present in excess of

its Maximum Acceptable Value in drinking-water and the quantity of the determinand present in the water supply.

protozoa The Priority 1 protozoa are currently *Giardia* and *Cryptosporidium*.

public drinking-water supply See **community drinking-water supply**.

raw water Water which has not received any treatment to make it suitable for drinking.

referee method The referee methods specified in these Standards will be regarded as the definitive methods. Alternative methods may be used, but these must provide results comparable to those obtained by the referee methods. In the event of any dispute about differences in analytical results, results obtained using the referee method will be deemed to be correct.

Register of Community Drinking-Water Supplies in New Zealand

A list of community drinking-water supplies in New Zealand published by the Ministry of Health. It contains details of the water sources, treatment plants, distribution zones, site identification codes, Priority 2 determinands and public health grading of each drinking-water supply.

renal dialysis A method of treatment of patients who have a kidney disorder. Dialysis involves the diffusion of unwanted body electrolytes out of the patient across a semi-permeable membrane into dialysis water on the other side of the membrane. The dialysis water must be high quality to avoid the risk of any contaminants in the dialysis water diffusing back across the membrane and accumulating in the patient. The DWSNZ do not guarantee that water which meets these Standards is suitable for renal dialysis.

reticulation The network of pipes, pumps and service reservoirs that delivers the drinking-water from the water treatment plant to the consumers' boundary. See **network reticulation**.

sanitary survey A survey and analysis of the physical environment for the purpose of identifying the existence and hazard posed by existing and potential sources of health hazards and environmental contamination.

secure groundwater	<p>Water contained beneath the land surface which is abstracted via a secure well head or similarly proven structure. It must not be under the direct influence of surface water or demonstrate any significant and rapid shifts in characteristics such as turbidity, temperature, conductivity or pH which closely correlate to any climatological conditions, surface water conditions or land use practices, as demonstrated by:</p> <ul style="list-style-type: none"> • less than 0.005 percent of the water having been present in the aquifer for less than one year (demonstrated by the tritium and CFC methods) <p>and/or</p> <ul style="list-style-type: none"> • variations in the groundwater characteristics not exceeding a coefficient of variation of more than: <ul style="list-style-type: none"> – 3.0 percent in conductivity – 4.0 percent in chloride concentration – 2.5 percent in nitrate concentration (standardised variance). <p>There must also be no insects, other macro-organisms such as algae, organic debris, large diameter pathogens, or <i>E. coli</i> in 12 successive monthly samples.</p>
secure well head	<p>A well head that incorporates appropriate measures to prevent or minimise the risk of groundwater contamination. Measures include:</p> <ul style="list-style-type: none"> • a sealed pumping and piping system including backflow prevention devices • seals between the well casing, pipework and surrounding ground • restrictions on any potentially contaminating land use or activity in the vicinity of the well head.
service reservoir	<p>A reservoir present in the network reticulation for the purpose of managing water flow and pressure.</p>
short-term excursion	<p>The exceedence of the MAV of a contaminant for a short time which does not represent a public health risk.</p>
SI Units	<p>A system of coherent metric units (Système Internationale d'Unités) adopted by the General Conference on Weights and Measures, the international authority on units.</p>

slow sand filtration	Filter which consists of a bed of fine sand and relies on a biologically active layer on top of sand, called the <i>Schmutzdecke</i> , to filter out suspended particles. Loading rate is typically 0.2m ³ /m ² /hr (eg, m/hr).
surface water	The water on the land surface. It can be running, such as in streams and rivers or quiescent as in lakes, reservoirs, impoundments and ponds. Surface water is produced by runoff of precipitation and by groundwater seeping through the top layers of soil. Surface water can also be defined as all water open to the atmosphere and subject to surface runoff.
surrogate	A determinand used to assess the likely presence or concentration of another determinand which is difficult to determine directly. For example, <i>E. coli</i> is used to assess the likely presence of specific pathogenic organisms, as they are good indicator organisms and are easier to test for than the pathogens themselves.
surveillance	The process of checking that the monitoring of drinking-water supplies conforms to the specifications set in the Standards. Surveillance is usually conducted by the public health agency.
thermotolerant coliforms	See faecal coliforms .
Tolerable Daily Intake (TDI)	The intake level in humans which is confidently believed to be without significant adverse health effects. Essentially the same as ADI (Acceptable Daily Intake), except that the latter tends to refer to a level which has been formally established by the World Health Organization or some other authority.
total coliforms	Genera in the family <i>Enterobacteriaceae</i> , the total coliforms are bacteria which will grow on a specific selective medium when incubated at 35°C ±0.2°C. They are used to indicate the probable contamination of water by organic material, and that the possibility of faecal contamination needs to be checked. Total coliforms include the genera: <i>Erwinia</i> , <i>Klebsiella</i> , <i>Escherichia</i> , <i>Citrobacter</i> and <i>Enterobacter</i> . See also faecal coliforms and presumptive coliforms .

transgression	A drinking-water sample is said to transgress the Standards when a determinand of any priority class that is present in the sample exceeds the Maximum Acceptable Value (MAV) or the compliance criteria requirements.
turbidity	Loss of clarity in a sample caused by scattering of light by suspended particles in the sample. For these Standards, turbidity is measured by nephelometry.
USEPA	The United States Environmental Protection Agency.
virus	Very small parasitic organisms which can only reproduce if they can colonise a living cell by “highjacking” some of the host cell’s metabolic processes. They are submicroscopic particles of nucleic material enclosed in a protein coat. Viruses are responsible for several waterborne diseases such as infectious hepatitis and polio.
water supplier or water supply authority	Any person or entity that owns, or is responsible for operating, a drinking-water supply.
water treatment plant	The point where the drinking-water supply enters the distribution system, regardless of the treatment process.
water treatment process	A chemical, biological or physical process employed to enhance the quality of a drinking-water supply prior to distribution.
well head	The physical structure, facility or device at the land surface from which groundwater is abstracted from subsurface water-bearing formations.
WHO	World Health Organization.
wholesome drinking-water	Potable water which does not contain any determinands which exceed the Guideline Values for Aesthetic Determinands given in the DWSNZ 2000. See also potable .

8 Units

8.1 Basis for units

The Drinking-Water Standards for New Zealand 1995 use the International System of Units (SI) (Système Internationale d’Unités of the CIPM), consistent with the units used in the United States Environmental Protection Authority and the Australian Drinking-Water Standards.

The internationally recognised (Comité International des Poids et Mesures) (CIPM) unit of volume is the litre (L).

The SI unit of weight is the kilogram (kg).

The SI unit of length is the metre (m).

The decimal prefixes may be used to form names and symbols of multiples of the SI units. The choice of appropriate multiple is governed by convenience, to result in a numerical value within a practical range.

8.2 Units of concentration

Standard Unit	Standard Symbol	Other Units	Unit Symbol	Equivalent Units	Equivalent Units
milligrams per litre	mg/L or mgL^{-1}			parts per million, ppm	grams per cubic metre, g/m^3 or gm^{-3}
		micrograms per litre	$\mu\text{g/L}$ or μgL^{-1}	parts per billion, $\text{ppb} = 10^{-3} \text{ ppm}$	milligrams per cubic metre, mg/m^{-3} or mgm^{-3}
		nanograms per litre	ng/L or ngL^{-1}	parts per trillion $\text{ppt}=10^{-3} \text{ ppb}$	

1 mg/L = 1,000 or $10^3 \mu\text{g/L} = 1,000,000$ or 10^6 ng/L

1 ng/L = 0.001 or $10^{-3} \mu\text{g/L} = 0.000001$ or 10^{-6} mg/L

Note that one billion is one thousand million or 10^9 .

8.3 Microbiological

Colony forming units per millilitre (cfu/mL).

Most probable number per 100 millilitres (MPN/100 mL).

1 μm = 0.001 or 10^{-3} millimetres.

8.4 Physical and other

8.4.1 Aggressiveness

Drinking-Water Standards for New Zealand 1995 proposed use of the Langelier Saturation Index to quantify aggressiveness. In some waters it is found that the correlation is not good so the Langelier Saturation Index is not used for this purpose in the *Drinking-Water Standards for New Zealand* 2000.

The Langelier Saturation Index is defined as the actual pH of the water minus the pH at which the water will be in equilibrium with solid calcium carbonate, ie

$$\text{SI} = \text{pH}_{\text{ac}} - \text{pH}_{\text{s}}$$

Where SI = Langelier Saturation Index

pH_{ac} = the actual pH

pH_s = the pH of the water in equilibrium with calcium carbonate

The units of the Langelier Saturation Index are therefore pH units which are dimensionless.

8.4.2 C.t

= concentration of the disinfectant in mg/L X exposure time in minutes

8.4.3 Colour

Hazen Colour Unit (HU), sometimes referred to as True Colour Units (TCU). Strictly speaking, true colour is the colour of a filtered sample. The colour of an unfiltered sample is called "apparent colour".

1 HU = 1 mg platinum/L in the form of the chloroplatinate ion.

8.4.4 Conductivity

millisiemens per metre (mS/m or mS.m⁻¹).

$$1\text{mS/m} = 10\mu\text{mhos/cm}$$

$$1\mu\text{S/cm} = 1\mu\text{mhos/cm}$$

Note that conductivity is strongly influenced by the temperature of the sample being tested. Normal practice is to measure the conductivity at 25°C or to convert it to this temperature, including the temperature in the report.

8.4.5 pH

$$-\log(\text{hydrogen ion activity}) = -\log a\text{H}^+$$

$$\text{Approximated to indicate } -\log(\text{hydrogen ion concentration}) = -\log [\text{H}^+].$$

8.4.6 Temperature

degrees celsius (°C).

8.4.7 Turbidity

Nephelometric Turbidity Unit (NTU).

The turbidity of a specified concentration of formazin suspension (1.000g of hydrazine sulphate/100ml of water) is defined as 40 NTU. Alternative standards are defined relative to this standard.

8.5 Chemical

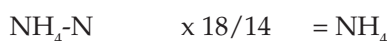
The concentration of some determinands can be expressed using different units.

8.5.1 Asbestos

Million fibres per litre (MF/L).

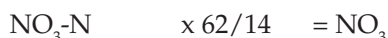
8.5.2 Ammonium

ammonium nitrogen $\times 18/14$ = ammonium



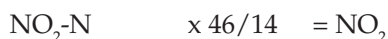
8.5.3 Nitrate

nitrate nitrogen $\times 62/14$ = nitrate



8.5.4 Nitrite

nitrite nitrogen $\times 46/14$ = nitrite



8.5.5 Hardness

total hardness = calcium hardness + magnesium hardness, expressed as mg/L CaCO_3

$$\text{Ca as CaCO}_3 = \text{Ca as Ca} \times 100/40$$

$$\text{Mg as CaCO}_3 = \text{Mg as Mg} \times 100/24.3$$

8.6 Radioactivity

8.6.1 Activity of radionuclide

becquerel per litre (Bq/L) or picocurie per litre (pCi/L)

$$1 \text{ picocurie} = 3.7 \times 10^{-2} \text{ Becquerel}$$

second to the power minus one, s^{-1}

$$1 \text{ curie (Ci)} = 3.7 \times 10^{10} \text{ Bq}$$

millisievert (msv)

9 Index of Synonyms

This index of synonyms lists chemicals of health significance and those for which health queries have been raised but no MAV can be set. The list can be used to determine which name for a compound has been used in these Standards when there is more than one possibility. For example, for “bendioxide, *see bentazone*”, “bendioxide” is the name looked up, and “bentazone” is the name by which bendioxide is referred to in the Standards.

acetyl chloride, *see chloroacetone*

acrylamide

alachlor

aldicarb

aldrin

anatoxin

anatoxin-a

atrazine

azinphos methyl

basudin, *see diazinon*

bendioxide, *see bentazone*

bentazone

benzene

benzo(a)pyrene

N,N-bis(carboxymethyl)glycine, *see nitrilotriacetic acid*

bis(2-ethylhexyl)adipate, *see di(2-ethylhexyl)adipate*

bis(2-ethylhexyl)phthalate, *see di(2-ethylhexyl)phthalate*

boron

bromacil

bromate

bromochloroacetonitrile

bromochloroethanenitrile, *see bromochloroacetonitrile*

bromodichloromethane

bromoform

carbofuran

carbon tetrachloride

chloracetone, *see chloroacetone*

chloral hydrate, *see trichloroacetaldehyde*

chloramines, *see monochloramine and dichloramine*

chlordanes

chloroacetic acid, *see monochloroacetic acid*

chloroacetone

chlorobenzene, *see monochlorobenzene*

chlorodibromomethane, *see dibromochloromethane*

3-chloro-1,2-dibromopropane, *see 1,2-dibromo-3-chloropropane*

3-chloro-4-(dichloromethyl)-5-hydroxy-2(h)-furanone, *see MX*

2-chloro-2',6'-dimethyl-N-methoxymethyl acetanilide, *see alachlor*

6-chloro-N,N'-dimethyl-1,3,5-triazine-2,4-diamine, *see simazine*

1-chloro-2,3-epoxypropane, *see epichlorohydrin*

chloroethanoic acid, *see monochloroacetic acid*

chloroethene, *see vinyl chloride*

chlorethene, *see 1,1,1-trichloroethane*

chloroethylene, *see vinyl chloride*

6-chloro-N-ethyl-N'-(1-methylethyl)-1,3,5-triazine-2,4-diamine, *see atrazine*

2-chloro-6'-ethyl-N-(2-methoxy-1-methylethyl)acet-o-toluidide, *see metolachlor*

chloroform

chloromethanenitrile, *see cyanogen chloride*

chloromethyl ethylene oxide, *see epichlorohydrin*

chloromethyl oxirane, *see epichlorohydrin*

4-chloro-2-methylphenoxyethanoic acid, *see MCPA*

2-chlorophenol

6-chloro-3-phenylpyridazin-4-yl-S-octyl thiocarbonate, *see pyridate*

chloropicrin

1-chloro-2-propanone, *see chloroacetone*

4-chloro-o-toloxycetic acid, *see MCPA*

3-(3-chloro-p-tolyl)-1,1-dimethyl urea, *see chlortoluron*

4-(4-chloro-o-toloxo)butanoic acid, *see MCPB*

2-(4-chloro-o-toloxo)propionic acid, *see mecoprop*

chlortoluron, *see chlortoluron*

chlorpyrifos
 chlortoluron
 cyanazine
 cyanide
 cyanogen chloride
 cylindropermopsin
 2,4-D
 2,4-DB
 DBCP, *see 1,2-dibromo-3-chloropropane*
 1,1-DCA, *see 1,1-dichloroethane*
 1,2-DCA, *see 1,2-dichloroethane*
 DCA, *see dichloroacetic acid*
 1,2-DCB, *see 1,2-dichlorobenzene*
 1,3-DCB, *see 1,3-dichlorobenzene*
 1,4-DCB, *see 1,4-dichlorobenzene*
 1,1-DCE, *see 1,1-dichloroethene*
 1,2-DCE, *see 1,2-dichloroethene*
 DCP, *see 1,3-dichloropropene*
 DCPA, *see propanil*
 DDT
 DEHA, *see di(2-ethylhexyl)adipate*
 DEHP, *see di(2-ethylhexyl)phthalate*
 di(2-ethylhexyl)adipate
 di(2-ethylhexyl)phthalate
 dialkyltins
 diazinon
 1,2-dibromo-3-chloropropane
 dibromoacetonitrile
 dibromochloromethane
 1,2-dibromoethane
 dibromoethanenitrile, *see dibromoacetonitrile*
 dichloramine
 dichloro-1,3-propene, *see 1,3-dichloropropene*
 dichloroacetic acid

dichloroacetonitrile
 1,4-dichlorobenzene
 1,2-dichlorobenzene
 1,3-dichlorobenzene
 dichlorobromomethane, *see bromodichloromethane*
 1,1 dichloroethane
 1,2 dichloroethane
 dichloroethanenitrile, *see dichloroacetonitrile*
 dichloroethanoic acid, *see dichloroacetic acid*
 1,1-dichloroethene
 1,2-dichloroethene
 dichloromethane
 2,4-dichlorophenol
 dichlorophenoxyacetic acid, *see 2,4-D*
 4-(2,4-dichlorophenoxy)butanoic acid, *see 2,4-DB*
 dichlorophenoxybutyric acid, *see 2,4-DB*
 2,4-dichlorophenoxyethanoic acid, *see 2,4-D*
 2-(2,4-dichlorophenoxy)propionic acid, *see dichlorprop*
 N-(3,4-dichlorophenyl)propionamide, *see propanil*
 1,2-dichloropropane
 1,3-dichloropropane
 1,3-dichloropropene
 dichlorprop
 dieldrin, *see aldrin/dieldrin*
 2,3-dihydro-2,2-dimethyl-7-benzofuranol methylcarbamate, *see carbofuran*
 1,2-dimethylbenzene, *see xylenes*
 1,4-dimethylbenzene, *see xylenes*
 1,3-dimethylbenzene, *see xylenes*
 2,6-dinitro-N,N-dipropyl-4-(trifluoromethyl)benzenamine, *see trifluralin*
 dioxins
 diquat
 diuron
 DMDT, *see methoxychlor*
 2,4-DP, *see dichlorprop*

dursban, *see chlorpyrifos*
 EDB, *see ethylene dibromide*
 edetic acid, *see EDTA*
 EDTA
 epichlorohydrin
 ethylbenzene
 ethylenediamine tetraacetic acid, *see EDTA*
 ethylene dibromide, *see 1,2-dibromoethane*
 ethylene dichloride, *see 1,1 dichloroethane or 1,2 dichloroethane*
 S-ethyl-N,N-hexamethylenethiocarbamate, *see molinate*
 N-(1-ethylpropyl)-2,6-dinitro-3,4-xylidine, *see pendimethalin*
 fenoprop
 fluoranthane
 formaldehyde
 gamma benzene hexachloride, *see lindane*
 gamma-BHC, *see lindane*
 gamma-HCH, *see lindane*
 gesapon, *see diazinon*
 HCB, *see hexachlorobutadiene*
 HCB, *see hexachlorobenzene*
 HEOD, *see dieldrin*
 heptachlor
 heptachlor epoxide, *see heptachlor/heptachlor epoxide*
 1,4,5,6,7,8,8-heptachloro-3a,4,7,7a-tetrahydro-4,7-methanoindene, *see heptachlor*
 hexachlorobenzene
 hexachlorobutadiene
 hexachlorocyclohexane, *see lindane*
 1,2,3,4,10,10-hexachloro-6,7-epoxy-1,4,4a,5,6,7,8,8a-octahydroendo,exo-1,4:5,8-dimethanonaphthalene, *see dieldrin*
 1,2,3,4,10,10-hexachloro-1,4,4a,5,8,8a-hexahydro-1,4:5,8-dimethanonaphthalene, *see aldrin*
 hexazinone
 homoanatoxin-a
 3-(4-isopropylphenyl)-1,1-dimethyl urea, *see isoproturon*

isoproturon
 lindane
 lorsban, *see chlorpyrifos*
 LPS endoxins
 MCB, *see monochlorobenzene*
 MCP, *see MCPA*
 MCPA
 MCPB
 MCPP, *see mecoprop*
 mecoprop
 metadichlorobenzene, *see 1,3-dichlorobenzene*
 metadimethylbenzene, *see xylenes*
 metalaxyl
 methanal, *see formaldehyde*
 methoxychlor
 methylbenzene, *see toluene*
 methylchloroform, *see 1,1,1-trichloroethane*
 methylene chloride, *see dichloromethane*
 3-(1-methylethyl)-1H-2,1,3-benzothiadiazin-4(3H)-one-2,2-dioxide, *see bentazone*
 2-methyl-2-(methylthio)propionaldehyde-O-methylcarbamoyloxime, *see aldicarb*
 metolachlor
 metribuzin
 microcystins
 molinate
 monochloramine
 monochloroacetic acid
 monochloroacetone, *see chloroacetone*
 monochlorobenzene
 MX
 N-(3,5-dichlorophenyl)-1,2-dimethylcyclopropane-1,2-dicarboximide, *see procymidone*
 nitrate & nitrite
 nitrilotriacetic acid
 nitrochloroform, *see chloropicrin*

N,N-bis(carboxymethyl)glycine *see* **nitrilotriacetic acid**
 nodularin
 NTA, *see* **nitrilotriacetic acid**
 1,2,4,5,6,7,8,8-octachloro-2,3,3a,4,7,7a-hexahydro-4,7-methano-1H-indene, *see* **chlordan**
 O,O-diethylO-2-isopropyl-6-methylpysimidin-4yl phophothioate, *see* **diazinon**
 orthochlorophenol, *see* **2-chlorophenol**
 orthodichlorobenzene, *see* **1,2-dichlorobenzene**
 orthodimethylbenzene, *see* **xylene**s
 oryzalin
 oxadiazon
 PAHs
 paradichlorobenzene, *see* **1,4-dichlorobenzene**
 paradimethylbenzene, *see* **xylene**s
 PCBs
 PCE, *see* **tetrachloroethene**
 PCP, *see* **pentachlorophenol**
 pendimethalin
 pentachlorophenol
 perchlorobenzene, *see* **hexachlorobenzene**
 permethrin
 3-phenoxybenzyl (1RS)-cis,trans-3-(2,2-dichlorovinyl)-2,2-dimethyl cyclopropane carboxylate, *see* **permethrin**
 phenyl chloride, *see* **monochlorobenzene**
 phenyl hydride, *see* **benzene**
 phenylethene, *see* **styrene**
 pirimiphos methyl
 primisulfuron, primisulfuron, primisulfuron-methyl
 polychlorinated biphenyls, *see* **PCBs**
 polycyclic aromatic hydrocarbons, *see* **PAHs**
 polynuclear aromatic hydrocarbons, *see* **PAHs**
 procymidone
 propanil
 propazine

propenamide, *see acrylamide*
 pyridate
 saxitoxins
 silvex, *see fenoprop*
 simazine
 sodium monofluoroacetate, *see 1080*
 sodium fluoroethanoate, *see 1080*
 sodium fluoroacetate, *see 1080*
 styrene
 sumisclex, *see procymidone*
 2,4,5-T
 TBTO, *see tributyltin oxide*
 1,1,1-TCA, *see 1,1,1- trichloroethane*
 TCA, *see trichloroacetic acid*
 1,2,3-TCB, *see trichlorobenzenes*
 1,2,4-TCB, *see trichlorobenzenes*
 1,3,5-TCB, *see trichlorobenzenes*
 TCE, *see trichloroethene*
 2,4,5-TCPA, *see fenoprop*
 terbuthylazine
 tetrachloroethene
 tetrachloroethylene, *see tetrachloroethene*
 tetrachloromethane, *see carbon tetrachloride*
 THM, *see bromodichloromethane or dibromochloromethane or tribromomethane or trichloromethane*
 thiabendazole
 toluene
 2,4,5-TP, *see fenoprop*
 triazine
 tribromomethane, *see bromoform*
 tributyltin oxide
 trichloramine, *see chloramines*
 trichloroacetaldehyde
 trichloroacetic acid

trichloroacetonitrile
 trichlorobenzenes
 1,2,3-trichlorobenzene, *see trichlorobenzenes*
 1,2,4-trichlorobenzene, *see trichlorobenzenes*
 1,3,5-trichlorobenzene, *see trichlorobenzenes*
 1,1,1-trichloro-2,2-bis(4-chlorophenyl)ethane, *see DDT*
 1,1,1-trichloro-2,2-bis(4-methoxyphenyl)ethane, *see methoxychlor*
 trichloroethanal, *see trichloroacetaldehyde*
 1,1,1-trichloroethane
 trichloroethanenitrile, *see trichloroacetonitrile*
 trichloroethanoic acid, *see trichloroacetic acid*
 trichloroethene
 trichloroethylene, *see trichloroethene*
 trichloromethane, *see chloroform*
 trichloronitromethane, *see chloropicrin*
 2,4,6-trichlorophenol
 2-(2,4,5-trichlorophenoxy)propionic acid, *see silvex*
 trichlorophenoxyacetic acid, *see 2,4,5-T*
 2,4,5-trichlorophenoxyethanoic acid, *see 2,4,5-T*
 3,5,6-trichloro-2-pyridyloxyacetic acid, *see triclopyr*
 3,5,6-trichloro-2-pyridyloxyethanoic acid, *see triclopyr*
 triclopyr
 trifluralin
 triglycine, *see nitrilotriacetic acid*
 trihalomethane, *see bromodichloromethane or dibromochloromethane or tribromomethane or trichloromethane*
 VC, *see vinyl chloride*
 vinyl chloride
 vinyl benzene, *see styrene*
 vinylidene chloride, *see 1,1-dichloroethene*
 xylenes
 666, *see lindane*
 1080

10 Tables of Synonyms

(for organic determinands of health significance and pesticides)

Tables 10.1 and 10.2 list the organic determinands of health significance and the pesticides in the alphabetical order in which they appear in the table of MAVs in Section 14. The name used in DWSNZ 2000 may appear in the column for IUPAC Nomenclature, Common Names or Abbreviation and is **given in bold**. Where available, other synonyms are given in the appropriate columns.

Table 10.1 Synonyms for organic determinands of health significance

IUPAC Nomenclature	Common Names	Abbreviation	CAS Registry Number
propenamide	acrylamide		79-06-1
benzene	phenyl hydride		71-43-2
benzo(a)pyrene			50-32-8
bromochloroethanenitrile	bromochloroacetonitrile		83463-62-1
bromodichloromethane	dichlorobromomethane		75-27-4
tribromomethane	bromoform		75-25-2
tetrachloromethane	carbon tetrachloride		56-23-5
monochloramine dichloramine trichloramine	chloramines, or combined chlorine		
1-chloro-2-propanone	chloroacetone , or chloracetone or acetyl chloride, or monochloroacetone		78-95-5
trichloromethane	chloroform		67-66-3
2-chlorophenol	orthochlorophenol		95-57-8
trichloronitromethane	chloropicrin , or nitrochloroform		76-06-2
dialkyltins			
1,2-dibromoethane	ethylene dibromide		103-93-4

Table 10.1 **Synonyms for organic determinands of health significance (continued)**

IUPAC Nomenclature	Common Names	Abbreviation	CAS Registry Number
dibromoethanenitrile	dibromoacetonitrile		3252-43-5
dibromochloromethane	chlorodibromomethane		124-48-1
dichloroethanoic acid	dichloroacetic acid	DCA	79-43-6
dichloroethanenitrile	dichloroacetonitrile		3018-12-0
1,2-dichlorobenzene	orthodichlorobenzene	1,2-DCB	95-50-1
1,3-dichlorobenzene	metadichlorobenzene	1,3-DCB	541-73-1
1,4-dichlorobenzene	paradichlorobenzene	1,4-DCB	106-46-7
1,1-dichloroethane	ethylene dichloride	1,1-DCA	75-34-3
1,2-dichloroethane	ethylene dichloride	1,2-DCA	107-06-2
1,1-dichloroethene	vinylidene chloride	1,1-DCE	75-35-4
1,2-dichloroethene	ethylene dichloride	1,2-DCE	540-59-0
dichloromethane	methylene chloride		75-09-2
2,4-dichlorophenol			120-83-2
di(2-ethylhexyl)adipate	bis(2-ethylhexyl)adipate	DEHA	103-23-1
di(2-ethylhexyl)phthalate	bis(2-ethylhexyl) phthalate	DEHP	117-81-7
ethylenediamine tetra-acetic acid	edetic acid	EDTA	60-00-4
1-chloro-2,3-epoxypropane	epichlorohydrin, or chloromethyl oxirane, or chloromethyl ethylene oxide		106-89-8
ethylbenzene			100-41-4
methanal	formaldehyde		50-00-0
hexachlorobutadiene		HCB	87-68-3
chloroethanoic acid	monochloroacetic acid, or chloroacetic acid		79-11-8
chlorobenzene	monochlorobenzene, or phenyl chloride	MCB	(50717-45-8) replaced by 108-90-7
3-chloro-4-(dichloromethyl)- 5-hydroxy-2(5h)-furanone		MX	77469-76-0

Table 10.1 **Synonyms for organic determinands of health significance (continued)**

IUPAC Nomenclature	Common Names	Abbreviation	CAS Registry Number
N,N-bis(carboxymethyl) glycine	nitriлотriacetic acid , or triglycine	NTA	139-13-9 556-33-2
1,2 - dibromoethane	ethylene dibromide		106-93-4
	polynuclear aromatic hydrocarbons	PAH	
phenylethene, or styrene	styrene , or vinyl benzene		100-42-5
tetrachloroethene	tetrachloroethylene	PCE	127-18-4
methylbenzene, or toluene	toluene		108-88-3
tributyltin oxide		TBTO	56-35-9
trichloroethanal	trichloroacetaldehyde , or chloral hydrate		75-87-6
trichloroethanoic acid	trichloroacetic acid	TCA	76-03-9
trichloroethanenitrile	trichloroacetonitrile		545-06-2
1,2,3-trichlorobenzene	trichlorobenzenes	1,2,3-TCB	87-61-6
1,2,4-trichlorobenzene		1,2,4-TCB	120-82-1
1,3,5-trichlorobenzene		1,3,5-TCB	108-70-3
1,1,1-trichloroethane	methylchloroform, or chloroethene	1,1,1-TCA	71-55-6
trichloroethene	trichloroethylene	TCE	79-01-6
2,4,6-trichlorophenol		TCP	88-06-2
	trihalomethane	THM	
chloroethene	vinyl chloride , or chloroethylene	VC	75-01-4
1,2-dimethylbenzene 1,3-dimethylbenzene 1,4-dimethylbenzene	xylenes , or orthodimethylbenzene, or metadimethylbenzene, or paradimethylbenzene		95-47-6 108-38-3 106-42-3

Table 10.2 Synonyms for pesticides

IUPAC Nomenclature	Common Names	Abbreviation	CAS Registry Number
2-chloro-2',6'-dimethyl-N-methoxymethyl acetanilide	alachlor		15972-60-8
2-methyl-2-(methylthio) propionaldehyde-O-methylcarbamoyloxime	aldicarb		116-06-3
1,2,3,4,10,10-hexachloro-1,4,4a,5,8,8a-hexahydro-1,4:5,8-dimethanonaphthalene	aldrin		309-00-2
6-chloro-N-ethyl-N'-(1-methylethyl)-1,3,5-triazine-2,4-diamine	atrazine		1912-24-9
S-(3,4-dihydro-4-oxobenzo(d)(1,2,3)-triazin-3-ylmethyl) O,O-dimethyl phosphorodithioate	azinphos methyl		86-50-0
3-(1-methylethyl)-1H-2,1,3-benzothiadiazin-4(3H)-one-2,2-dioxide	bentazone , or bendioxide		25057-89-0
5-bromo-3-sec-butyl-6-methyluracil	bromacil		314-40-9
2,3-dihydro-2,2-dimethyl-7-benzofuranol methylcarbamate	carbofuran		1563-66-2
1,2,4,5,6,7,8,8-octachloro-2,3,3a,4,7,7a-hexahydro-4,7-methano-1H-indene	chlordane		57-74-9
	chlorpyrifos		
3-(3-chloro-p-tolyl)-1,1-dimethyl urea	chlortoluron , or chlorotoluron		15545-48-9
	cyanazine		
2,4-dichlorophenoxy ethanoic acid	dichlorophenoxyacetic acid	2,4-D	94-75-7
4-(2,4-dichlorophenoxy) butanoic acid	dichlorophenoxybutyric acid	2,4-DB	94-82-6
1,1,1-trichloro-2,2-bis(4-chlorophenyl)ethane		DDT	50-29-3
O,O-diethyl O-2-isopropyl-6-methylpyridimidin-4-yl phosphorothioate	diazinon		333-41-5
1,2-dibromo-3-chloropropane	3-chloro-1,2-dibromopropane	DBCP	96-12-8

Table 10.2 Synonyms for pesticides (continued)

IUPAC Nomenclature	Common Names	Abbreviation	CAS Registry Number
1,2-dichloropropane			78-87-5
1,3-dichloropropane			
1,3-dichloropropene	dichloro-1,3-propene	DCP	542-75-6
2-(2,4-dichlorophenoxy) propionic acid	dichlorprop	2,4-DP	120-36-5
1,2,3,4,10,10-hexachloro-6,7-epoxy-1,4,4a,5,6,7,8,8a-octahydroendo,exo-1,4:5,8-dimethanonaphthalene	dieldrin	HEOD	60-57-1
9,10-dihydro-8a,10a-diazoniaphenanthrene; 6,7-dihydrodipyrido-(1,2- <i>a</i> :2',1' c) pyrazine-5,8-di-ium; 1,1'-ethylene-2,2'-bipyridyldiylum	diquat		2764-72-9
3-(3,4-dichlorophenyl)-1,1-dimethylurea	diuron		330-54-1
1,2-dibromoethane	ethylene dibromide	EDB	106-93-4
2-(2,4,5-trichlorophenoxy) propionic acid	fenoprop , or silvex	2,4,5-TCPPA, 2,4,5-TP	93-72-1
1,4,5,6,7,8,8-heptachloro-3a,4,7,7a-tetrahydro-4,7-methanoindene	heptachlor		76-44-8
	heptachlor epoxide		1024-57-3
hexachlorobenzene	hexachlorobenzene, or perchlorobenzene	HCB	118-74-1
3-cyclohexyl-6-dimethylamino-1-methyl-1,3,5-triazine	hexazinone		51235-04-2
3-(4-isopropylphenyl)-1,1-dimethyl urea	isoproturon		34123-59-6
hexachlorocyclohexane	lindane , or gamma benzene hexachloride	gamma-BHC, 666, gamma-HCH	58-89-9
4-chloro-2-methylphenoxyethanoic acid	4-chloro-o-toloxycetic acid	MCPA , MCP	94-74-6
4-(4-chloro-o-tolyloxy) butanoic acid		MCPB	94-81-5
2-(4-chloro-o-tolyloxy)propionic acid	mecoprop	MCPP	7085-19-0

Table 10.2 Synonyms for pesticides (continued)

IUPAC Nomenclature	Common Names	Abbreviation	CAS Registry Number
methyl N-(methoxyacetyl)-N-2,6-xylyl)-DL-alaninate	metalaxyl		57837-19-1 70630-17-0
1,1,1-trichloro-2,2-bis(4-methoxyphenyl)ethane	methoxychlor	DMDT	72-43-5
2-chloro-6'-ethyl-N-(2-methoxy-1-methylethyl)acet-o-toluidide	metolachlor		51218-45-2
4-amino-6- <i>tert</i> -butyl-3-(methylthio)-1,2,4-triazin-5-one	metribuzin		21087-64-9
S-ethyl-N,N-hexamethylenethiocarbamate	molinate		2212-67-1
3-chloro-4-(dichloromethyl)-5-hydroxy-2(h)-furanone	MX		
4-(dipropylamino)-3,5-dinitrobenzenesulphonamide	oryzalin		19044-88-3
3-(2,4-dichloro-5-(1-methylethoxy)phenyl)-5-(1,2-dimethylethyl)-1,3,4-oxdiazol-2-(3H)-one	oxadiazon		19666-30-9
N-(1-ethylpropyl)-2,6-dinitro-3,4-xylydine	pendimethalin		40487-42-1
pentachlorophenol	pentachlorophenol	PCP	87-86-5
3-phenoxybenzyl (1RS)-cis,trans-3-(2,2-dichlorovinyl)-2,2-dimethyl cyclopropane carboxylate	permethrin		52645-53-1
4-amino-3,5,6-trichloro-2-picolinic acid	picloram	grazon	1918-02-1
O-2-diethylamino-6-methylpyrimidin-4-yl O,O-dimethylphosphorothioate	pirimiphos-methyl		29232-93-7
methyl 2-((((4,6-bis(difluoromethoxy)-2-pyrimidinyl)amino)carbonyl)amino)sulphonyl)benzoic acid	primisulfuron methyl		86209-51-0
N-(3,5-dichlorophenyl)-1,2-dimethylcyclopropane-1,2-dicarboximide	procymidone, or sumisclex		

Table 10.2 Synonyms for pesticides (continued)

IUPAC Nomenclature	Common Names	Abbreviation	CAS Registry Number
N-(3,4-dichlorophenyl) propionamide	propanil		709-98-8
2,4-bis(isopropylamino)-6-chloro-s-triazine	propazine		139-40-2
6-chloro-3-phenylpyridazin-4-yl-S-octyl thiocarbonate	pyridate		55512-33-9
6-chloro-N,N'-dimethyl-1,3,5-triazine-2,4-diamine	simazine		122-34-9
2,4,5-trichlorophenoxyethanoic acid	trichlorophenoxyacetic acid	2,4,5-T	93-76-5
2-tert-butylamino-4-chloro-6-ethylamino-1,3,5-triazine	terbuthylazine		5915-41-3
2-(thiazol-4-yl)benzimidazole	thiabendazole		148-79-8
3,5,6-trichloro-2-pyridyloxyethanoic acid	trichlopyr , or 3,5,6-trichloro-2-pyridyloxyacetic acid		55335-06-3
2,6-dinitro-N,N-dipropyl-4-(trifluoromethyl) benzenamine	trifluralin		1582-09-8
sodium fluoroethanoate	sodium fluoroacetate, or sodium monofluoroacetate	1080	62-74-8

11 Methods of Analysis for Microbiological Compliance

11.1 Referee methods

The referee methods specified in Chapters 11 and 12 shall be regarded as the definitive methods for demonstrating compliance with the Drinking-Water Standards for New Zealand 2000.

Alternative methods are quite acceptable but must have been calibrated against the referee methods. In the event of any dispute about differences in analytical results, results obtained using the referee method shall be deemed to be correct.

Methods designated APHA are from *Standard Methods for the Examination of Water and Wastewater*, 20th edition, American Public Health Association, 1998.

11.1.1 Bacteriological referee methods

- APHA 9221: Multiple-tube fermentation technique for members of the coliform group.
- APHA 9221 B: Standard total coliform fermentation technique.
- APHA 9221 E: Faecal coliform procedure.
- APHA 9223 B: Enzyme Substrate Coliform Test (*E. coli*):
 - Presence/Absence
 - Multi-Well MPN (Quantitray)
 - MPN (multiple tube technique).
- APHA 10200 F and 10900 Cyanobacteria: cell counts.

Other methods for *E. coli* whose equivalence to the referee method has been demonstrated may be used for routine monitoring. However, should a positive result be obtained the results shall be confirmed by methods for enumerating *E. coli* approved by the Ministry of Health.

Detail on the enumeration of cyanobacteria and the characterisation of cyanotoxins is given in the Guidelines.

11.1.2 Protozoa referee method

New Zealand Interim Standard Methods for *Cryptosporidium* and *Giardia* in Water (JJ Learmonth et al, 2000; ISBN 0-473-06630-0) (Proposed).

11.1.3 Referee methods for routine treatment plant and distribution system tests

Where visual colorimetric tests are used, all operators shall first be checked for colour blindness. The identity of the person performing each test shall be recorded.

11.1.3.1 Free available chlorine (FAC) referee method

The referee method for measurement of FAC is APHA 4500 Cl F DPD, ferrous ammonium sulphate titrimetric method. Because residual chlorine is unstable, other generally accepted field methods, for example DPD tablets or powder in foil, and amperometric techniques may also be used, provided that they are validated against the referee method at least once every six months and adjusted as necessary.

All analysts making FAC measurements shall be familiar with the possible causes of inaccuracy in both the referee and field methods and shall themselves check their results against the referee method.

11.1.3.2 pH referee method

The pH referee method is APHA 4500-H⁺B /electrometric method. The pH electrode shall be calibrated before each set of measurements is made, and the manufacturer's instructions shall be followed for the storage of the electrode when not in use. Calibration solutions used shall be prepared by an analytical laboratory using the formulations given in the above method, or purchased from a chemical manufacturing company as a certified solution.

Two buffers (7 then 4) shall be used to calibrate and set the slope of the pH meter. Finally a pH 9 buffer shall be used to check that the calibration holds over the whole range.

For potable waters (which are often only weakly buffered in New Zealand waters), the laboratory shall note the time taken for the pH to return from measuring the 9 buffer to reading the pH of an unbuffered potable water. If this has become slow, then the electrode needs attention or is unsuitable.

Meters being used for potable water require special thin glass electrodes to work properly on unbuffered waters. "Robust" electrodes are not suitable.

11.1.3.3 Temperature referee method

A thermometer that has been calibrated according to TELARC technical guide no 3 *Working Thermometers Calibration Procedures* August 1986 shall be used. Checks against another similarly calibrated thermometer shall be made at least once every six months. If the readings diverge by more than 0.5°C both thermometers shall be recalibrated.

11.1.3.4 Odour referee method

Threshold odour method APHA 2150 B.

11.1.3.5 Colour referee method

Spectrophotometric method APHA 2120C at 465nm. The alternative visual comparison method (APHA 2120B using long Nessler tubes) requires an operator who can demonstrate that he or she is capable of reproducing results obtained by the spectrophotometric method.

11.1.3.6 Turbidity referee method

APHA 2130 Turbidity. To operate a turbidimeter with confidence at around the 0.1 NTU level will require an instrument with a limit of detection better than 0.02 NTU and will require the use of sophisticated calibration techniques.

11.1.3.7 Particle counting referee method

APHA 2560 Particle Counting and Size Distribution (Proposed).

11.1.3.8 Ozone referee method

APHA 4500-O₃ B. Indigo Colorimetric Method.

11.1.3.9 Chlorine dioxide referee method

4500-ClO₂ C. Amperometric Method 1. An alternative and easier method suitable for routine testing is 4500-ClO₂ D. DPD method.

11.1.3.10 Microscopic particulate analysis (MPA) referee method

The referee method will be developed from USEPA Report No. EPA/910/R-96/001.

11.1.3.11 Microsphere challenge referee method

The referee method will be developed from Li et al (*JAWWA*, 1997. 89:5).

11.1.3.12 Validation of online continuous monitoring analyser records

For validation of online continuous monitoring analyser records used to demonstrate compliance with these Standards, the value of the determinand recorded at a specified time shall be checked to be the same as that obtained by from a grab sample that has been taken at the same time from the designated sampling point for that determinand and that has been analysed by the referee method (or a subordinate method that has been verified against the referee method). If the monitor is checked using a subordinate method, the subordinate method shall be validated against the referee method at least once every six months by a Ministry of Health approved laboratory.

The result, together with any adjustments that are made to the instrument and the identity of the operator(s), shall be recorded. The frequency of checking for each class of instrument shall be at least the greater of that specified below or that recommended by the manufacturer and shall be increased if this is found necessary to ensure that the rate of "drift" of the instrument reading is insignificant.

11.1.3.13 Continuously monitoring chlorine analysers

Continuously monitoring chlorine analysers shall be checked against a grab sample at least once a week. The instrument shall be recalibrated if the record used for compliance

assessment varies from the grab sample value by more than 0.1mg/L. This reading may be not the same reading as observed on the instrument display.

11.1.3.14 Continuously monitoring pH monitors

Continuously monitoring pH monitors shall be checked against a calibrated handheld pH electrode once every four weeks.

11.1.3.15 Continuously reading thermometers

Continuously reading thermometers shall be calibrated against a thermometer calibrated as described in Section 11.1.3.3 at least once every six months.

11.1.3.16 Continuously monitoring turbidimeters

Continuously monitoring turbidimeters that do not use the nephelometric technique shall be calibrated in NTU units using any technique that is traceable to a primary standard. The reading from the continuous monitor shall be checked against a grab sample at least once a week.

11.1.3.17 Continuously monitoring ozone analysers

Continuously monitoring ozone analysers shall be checked at least once a week against a portable instrument that has been calibrated by a laboratory approved for the purpose by the Ministry of Health.

11.1.3.18 Continuously monitoring chlorine dioxide analysers

Continuously monitoring chlorine dioxide analysers shall be calibrated against a grab sample at least once a week. Once every four weeks the grab sample is to be split and an interlaboratory calibration with a Ministry of Health-approved laboratory carried out, or at least once a week against a portable instrument that has been calibrated by a laboratory approved for the purpose by the Ministry of Health.

12 Chemical Referee Methods, and Sampling Sites

The preservation and storage requirements for each method are those given in the specified method.

Table 12.1: Sampling requirements, referee method and some alternative analytical methods for inorganic determinands listed in table 14.2

Methods for metal analysis: Although APHA methods are quoted as the methods required for metal analysis, these methods do not define the method of sample preservation. Samples for metal analysis should be preserved with high purity nitric acid to pH<2.0 (APHA 3010B). Analysis is to be carried out directly on the preserved sample (ie, neither filtration at sampling nor digestion before analysis is required), unless sediment is present in which case a boiling nitric acid digestion (APHA 3030E) should be performed before analysis.

Name	Sampling Location		Container	Referee Method	Some Alternative Methods
	Tw	Dz			
Aggressiveness		✓	P(A)	See <i>Guidelines</i>	
Aluminium		✓	P(A)	GFAA (APHA 3113)	ICP (APHA 3120) ICP-MS (EPA 200.8) Colorimetric method (APHA 3500-AI B)

Table 12.1: Sampling requirements, referee method and some alternative analytical methods for inorganic determinands listed in table 14.2 (continued)

Name	Sampling Location		Container	Referee Method	Some Alternative Methods
	Tw	Dz			
Antimony		✓	G,P(A)	GFAA (APHA 3113) (pre-concentration may be necessary)	ICP-MS (EPA 200.8)
Arsenic	✓	✓	G,P(A)	GFAA (APHA 3113)	HGAA (APHA 3114) ICP-MS (EPA 200.8)
Barium	✓	✓	G,P(A)	GFAA (APHA 3113) MS (EPA 200.8)	FAA (APHA 3111) ICP (APHA 3120) ICP-
Beryllium	✓	✓	P(A)	ICP-MS (EPA 200.8)	
Boron	✓	✓	P	Colorimetric method (Boron in Waters, Effluents, Sewage and Some Solids, 1980 Azomethine-H Parts C,D HMSO [1981])	Colorimetric method (APHA 4500-B B) ICP-MS (EPA 200.8) ICP (APHA 3120)
Bromate		✓	P	IC (EPA 300.0)	IC (ref. JAWWA (1992), 84(11), 88)
Cadmium		✓	G,P(A)	GFAA (APHA 3113)	ICP (APHA 3120) ICP-MS (EPA 200.8)
Chloramines (Monochloramine, dichloramine, trichloramine)		✓	G	TITR (APHA 4500-CI F) DPD	TITR (APHA 4500-CI D) Amperometric Colorimetric DPD (APHA 4500-CI G)

Table 12.1: Sampling requirements, referee method and some alternative analytical methods for inorganic determinands listed in table 14.2 (continued)

Name	Sampling Location		Container	Referee Method	Some Alternative Methods
	Tw	Dz			
Chlorate		✓	P	C (EPA 300.0)	IC (ref. JAWWWA (1992), 84(11), 88)
Chlorine		✓	G	TITR (APHA 4500CI F)	TITR (APHA 4500CI D)
Chlorite		✓	P	CI (EPA 300.0)	IC (ref. JAWWWA (1992), 84(11), 88)
Chromium		✓	G,P(A)	GFAA (APHA 3113)	FAA (APHA 3111) ICP (APHA 3120) ICP-MS (EPA 200.8)
Copper		✓	G,P(A)	GFAA (APHA 3113)	FAA (APHA 3111) ICP (APHA 3120) ICP-MS (EPA 200.8)
Cyanide (total)	✓	✓	P	Total cyanide (APHA 4500-CN C)	
Cyanogen chloride		✓	G(S)	(APHA 4500-CN J)	
Fluoride	✓	✓	P	Ion selective electrode (APHA 4500-F C)	IC (APHA 4110) Colorimetric method, SPADNS (APHA 4500-F D)
Iodine		✓	G	(APHA 4500-I B)	

Table 12.1: Sampling requirements, referee method and some alternative analytical methods for inorganic determinands listed in table 14.2 (continued)

Name	Sampling Location		Container	Referee Method	Some Alternative Methods
	Tw	Dz			
Lead		✓	G,P(A)	GFAA (APHA 3113)	ICP (APHA 3120) (Pre-concentration may be needed) ICP-MS (EPA 200.8)
Lithium	✓	✓	G(A)	Flame emission (APHA 3500-Li B)	ICP-MS (EPA 200.8)
Manganese		✓	G,P(A)	GFAA (APHA 3113)	FAA (APHA 3111) ICP (APHA 3120) ICP-MS (EPA 200.8)
Mercury	✓	✓	G(A)	CVGAA (3112 B)	ICP-MS (EPA 200.8)
Molybdenum	✓	✓	G,P(A)	GFAA (APHA 3113)	ICP (APHA 3120) ICP-MS (EPA 200.8)
Nickel		✓	G,P(A)	GFAA (APHA 3113)	ICP (APHA 3120) ICP-MS (EPA 200.8)
Nitrate		✓	P, G	Cadmium reduction (APHA 4500-NO ₃ -E)	IC (APHA 4110) Ion selective electrode (APHA 4500-NO ₃ -D)
Nitrite		✓	P, G	Colorimetric Method (APHA 4500-NO ₂ -B)	IC (APHA 4110)
Selenium	✓	✓	G,P(A)	GFAA (APHA 3113)	HGAA (APHA 3114) ICP (APHA 3120) ICP-MS (EPA 200.8)

Table 12.1: Sampling requirements, referee method and some alternative analytical methods for inorganic determinands listed in table 14.2 (continued)

Name	Sampling Location		Container	Referee Method	Some Alternative Methods
	Tw	Dz			
Silver	✓	✓	P(A)	GFAA (APHA 3113)	ICP-MS (EPA 200.8)
Sodium	✓	✓	P(A)	Flame emission (APHA 3500-Na B)	ICP-MS (EPA 200.8)
Tin		✓	P(A)	GFAA (APHA 3113)	ICP-MS (EPA 200.8)
Uranium	✓	✓	P(A)	ICP-MS (EPA 200.8)	

Table 12.2: Sampling requirements, referee method and some alternative analytical methods for organic determinands of health significance as listed in table 14.3

Name	Sampling Location		Container	Referee Method	Some Alternative Methods
	Tw	Dz			
Acrylamide	✓	✓	G(S)	LLE/GC-ECD (EPA 8032)	HPLC/UV/D (Determination of acrylamide monomer in waters and polymers 1987. HMSO, 1988) LSE/HPLC-UV (EPA 8316)
Anatoxin (as STX eq)	✓	✓	G, P(S)	LLE/GC-MS (APHA 6410B) (Proposed)	LLE/GC-ECD APHA 6420-B
Anatoxin-a(S)	✓	✓	G, P(S)	LLE/GC-MS (APHA 6410B) (Proposed)	LLE/GC-ECD APHA 6630-B,C
Benzene	✓	✓	G(S)	P&T/GC-MS (APHA 6210D, EPA 524.2)	P&T/GC-HalI&PID (APHA 6230D, EPA 502.2)
Benzo(a)pyrene		✓	G(S)	LSE/GC-MS (EPA 525)	LLE/HPLC (EPA 550) LSE/HPLC (EPA 550.1)
Bromodichloroaceto-nitrile			G(S)	(EPA 551.1)	
Bromodichloromethane		✓	G(S)	P&T/GC-MS (APHA 6210D, EPA 524.2)	P&T/GC-HalI&PID (APHA 6230D, EPA 502.2) LLE/GC-ECD (EPA 551)
Bromoform		✓	G(S)	P&T/GC-MS (APHA 6210D, EPA 524.2)	P&T/GC-HalI&PID (APHA 6230D, EPA 502.2) LLE/GC-ECD (EPA 551)
Carbon tetrachloride		✓	G(S)	P&T/GC-MS (APHA 6210D, EPA 524.2)	P&T/GC-HalI&PID (APHA 6230D, EPA 502.2) LLE/GC-ECD (EPA 551)

Table 12.2: Sampling requirements, referee method and some alternative analytical methods for organic determinands of health significance as listed in table 14.3 (continued)

Name	Sampling Location		Container	Referee Method	Some Alternative Methods
	Tw	Dz			
Chloroacetone		✓	G(S)	(EPA 551.1)	
Chloroform		✓	G(S)	P&T/GC-MS (APHA 6210D, EPA 524.2)	P&T/GC-Hall&PID (APHA 6230D, EPA 502.2) LLE/GC-ECD (EPA 551)
2-Chlorophenol		✓	G(S)	LLE/GC-ECD (APHA 6420B)	LLE/GC/MS (APHA 6410B)
Chloropicrin		✓	G,P(S)	LLE/GC-ECD (USEPA 551.1)	
Cylindrospermopsin	✓	✓	G,P(S)	LLE/GC (APHA 6440-B) (Proposed)	LLE/GC-MS (APHA 6410B) (Proposed)
Di(2-ethylhexyl)adipate		✓	G(S)	LSE/GC-MS (EPA 525.2)	LLE or LSE/GC-PID (EPA 506)
Di(2-ethylhexyl)phthalate		✓	G(S)	LSE/GC-MS (EPA 525.2)	LLE or LSE/GC-PID (EPA 506)
Dibromoacetonitrile		✓	G(S)	LLE/GC-ECD (EPA 551)	
Dibromochloromethane		✓	G(S)	P&T/GC-MS (APHA 6210D, EPA 524.2)	P&T/GC (APHA 6230D, EPA 502.2) LLE/GC-ECD (EPA 551)
Dichloroacetic acid		✓	G(S)	LSE/GC-ECD (EPA 552.1)	LLE/GC-ECD (APHA 6251)
Dichloroacetonitrile		✓	G(S)	LLE/GC-ECD (EPA 551)	

Table 12.2: Sampling requirements, referee method and some alternative analytical methods for organic determinands of health significance as listed in table 14.3 (continued)

Name	Sampling Location		Container	Referee Method	Some Alternative Methods
	Tw	Dz			
1,2-Dichlorobenzene		✓	G(S)	P&T/GC-MS (APHA 6210D, EPA 524.2)	P&T/GC-Hall&PID (APHA 6230D, EPA 502.2) LLE/GC-MS (APHA 6410B)
1,3-Dichlorobenzene		✓	G(S)	P&T/GC-MS (APHA 6210D, EPA 524.2)	P&T/GC-Hall&PID (APHA 6230D, EPA 502.2) LLE/GC-MS (APHA 6410B)
1,4-Dichlorobenzene	✓	✓	G(S)	P&T/GC-MS (APHA 6210D, EPA 524.2)	P&T/GC-Hall&PID (APHA 6230D, EPA 502.2) LLE/GC-MS (APHA 6410B)
1,1-Dichloroethane		✓	G(S)	P&T/GC-MS (APHA 6210D, EPA 524.2)	P&T/GC-Hall&PID (APHA 6230D, EPA 502.2)
1,2-Dichloroethane		✓	G(S)	P&T/GC-MS (APHA 6210D, EPA 524.2)	P&T/GC-Hall&PID (APHA 6230D, EPA 502.2)
1,1-Dichloroethene	✓	✓	G(S)	P&T/GC-MS (APHA 6210D, EPA 524.2)	P&T/GC-Hall&PID (APHA 6230D, EPA 502.2)
1,2-Dichloroethene	✓	✓	G(S)	P&T/GC-MS (APHA 6210D, EPA 524.2)	P&T/GC-Hall&PID (APHA 6230D, EPA 502.2)
Dichloromethane		✓	G(S)	P&T/GC-MS (APHA 6210D, EPA 524.2)	P&T/GC-Hall&PID (APHA 6230D, EPA 502.2)
2,4-Dichlorophenol		✓	G(S)	LLE/GC-MS (APHA 6410B)	

Table 12.2: Sampling requirements, referee method and some alternative analytical methods for organic determinands of health significance as listed in table 14.3 (continued)

Name	Sampling Location		Container	Referee Method	Some Alternative Methods
	Tw	Dz			
EDTA	✓	✓	G,P(S)	Reverse phase ion pair liquid chromatography (ref. Bergers & de Groo, Wat. Res. (1994) 28(3), 639	
Epichlorohydrin	✓	✓	G(S)	P&T/GC-MS (EPA 8260)	GC/ECD (Pesselman and Feit, 1988, J.Chrom., 4,39, 448-542)
Ethylbenzene	✓	✓	G(S)	P&T/GC-MS (APHA 6210D, EPA 524.2)	P&T/GC-Hall&PID (APHA 6230D, EPA 502.2)
Formaldehyde		✓		LSE/HPLC (EPA 554)	LLE/HPLC-UV (EPA 8315)
Hexachlorobutadiene	✓	✓	G(S)	P&T/GC-MS (APHA 6210D, EPA 524.2)	P&T/GC-Hall&PID (APHA 6230D, EPA 502.2)
Homoanatoxin-a	✓	✓	G,P(S)	LLE/GC-MS (APHA 6410B) (Proposed)	HPLC-UV/CG-FID APHA 6440-B
Monochloroacetic acid		✓	G,P(S)	LSE/GC-ECD (EPA552.1)	
LPS Endoxins			G,P(S)	LLE/GC-MS (APHA 6410B) (Proposed)	LLE/GC (APHA 6440-B) (Proposed)
Microcystins	✓	✓	G,P(S)	LLE/GC-MS (APHA 6410B) (Proposed)	LLE/GC (APHA 6440-B) (proposed) BA (APHA 8711-B,C) (proposed) ELISA; Pphase inhibition. (proposed)

Table 12.2: Sampling requirements, referee method and some alternative analytical methods for organic determinands of health significance as listed in table 14.3 (continued)

Name	Sampling Location		Container	Referee Method	Some Alternative Methods
	Tw	Dz			
Monochlorobenzene	✓	✓	G(S)	P&T/GC-MS (APHA 6210D, EPA 524.2)	P&T/GC-Hall&PID (APHA 6230D, EPA 502.2)
Nitrioltriacetic acid	✓	✓	G(S)	GC-MSD (Malaivandi et al, 1979, Env. Sci. & Tech., 1,3, 59-61; Aue et al, 1972, J. of Chrom., 7,2, 259-267)	
Nodularin	✓	✓	G,P(S)	LLE/GC-MS (APHA 6410B) (Proposed)	LLE/GC (APHA 6440-B) BA (APHA 8711-B,C) ELISA; PPase inhibition
Saxitoxins	✓	✓	G,P(S)	LLE/HPLC (APHA 6610B) (Proposed)	LLE/GC (APHA 6440-B) (Proposed) Neuroblastoma bioassay (Proposed)
Styrene	✓	✓	G(S)	P&T/GC-MS (APHA 6210D, EPA 524.2)	P&T/GC-Hall&PID (APHA 6230D, EPA 502.2)
Tetrachloroethene		✓	G(S)	P&T/GC-MS (APHA 6210D, EPA 524.2)	P&T/GC-Hall&PID (APHA 6230D, EPA 502.2) LLE/GC-ECD (EPA 551)
Toluene		✓	G(S)	P&T/GC-MS (APHA 6210D, EPA 524.2)	P&T/GC-Hall&PID (APHA 6230D, EPA 502.2)
Tributyltin oxide	✓	✓	G(S)	LLE/GC-FPD (Greaves and Unger, 1988, Biomed. & Env. Mass Spec., 1,5, 565-569)	

Table 12.2: Sampling requirements, referee method and some alternative analytical methods for organic determinands of health significance as listed in table 14.3 (continued)

Name	Sampling Location		Container	Referee Method	Some Alternative Methods
	Tw	Dz			
Trichloroacetaldehyde/ chloral hydrate		✓	G(S)	LLE/GC-ECD (EPA 551)	
Trichloroacetic acid		✓	G(S)	LSE/GC-ECD (EPA 552.1)	LLE/GC-ECD (APHA 6251)
Trichloroacetonitrile		✓	G(S)	LLE/GC-ECD (EPA 551)	
Trichlorobenzenes	✓	✓	G(S)	P&T/GC-MS (APHA 6210D, EPA 524.2)	P&T/GC-Hall&PID (APHA 6230D, EPA 502.2)
1,1,1-Trichloroethane	✓	✓	G(S)	P&T/GC-MS (APHA 6210D, EPA 524.2)	P&T/GC-Hall&PID (APHA 6230D, EPA 502.2) LLE/GC-ECD (EPA 551)
Trichloroethene		✓	G(S)	P&T/GC-MS (APHA 6210D, EPA 524.2)	P&T/GC-Hall&PID (APHA 6230D, EPA 502.2) LLE/GC-ECD (EPA 551)
2,4,6-Trichlorophenol		✓	G(S)	LLE/GC-ECD (APHA 6251)	LLE/GC-ECD&FID (APHA 6420) LLE/GC-MS (APHA 6410B) Acetylation/LLE/GC-MS (EPA 1653)
Vinyl chloride		✓	G(S)	P&T/GC-MS (APHA 6210D, EPA 524.2)	P&T/GC-Hall&PID (APHA 6230D, EPA 502.2)
Xylenes		✓	G(S)	P&T/GC-MSD (APHA 6210D, EPA 524.2)	P&T/GC-Hall&PID (APHA 6230D, EPA 502.2)

Table 12.3: Sampling requirements, referee method and some alternative analytical methods for pesticides as listed in table 14.4

Name	Sampling Location		Container	Referee Method	Some Alternative Methods
	Tw	Ds			
Alachlor	✓	✓	G	LSE/GC-MS (EPA 525.2)	LLE/GC-NPD (EPA 507) LLE/GC-ECD (EPA 505)
Aldicarb	✓	✓	G	RP HPLC (EPA 531.1)	HPLC/FLD (APHA 6610)
Aldrin/Dieldrin	✓	✓	G	LLE/GC-MS (APHA 6410B)	LLE/GC-ECD (EPA 505)
Atrazine	✓	✓	G	LSE/GC-MS (EPA 525.2)	LLE/GC-NPD (EPA 507)
Azinphos-methyl	✓	✓	G	LLE/GC-ECD (EPA 8141A)	
Bentazone	✓	✓	G	LSE/GC-ECD (EPA 515.2)	LLE/GC-ECD (APHA 6640B) HPLC/UV/D (EPA 555)
Bromacil	✓	✓	G	LLE/GC-NPD (EPA 507)	
Carbofuran	✓	✓	G	RP HPLC (EPA 531.1)	HPLC-FLD (APHA 6610)
Chlordane	✓	✓	G	LLE/GC-MS (APHA 6630C)	LLE/GC-ECD (EPA 508)
Chlortoluron	✓	✓	G		
Chlorpyrifos	✓	✓	G	LSE/GC-MS (EPA 525.2)	LLE/GC-MS (EPA 8270) LLE/GC-NPD or FPD

Table 12.3: Sampling requirements, referee method and some alternative analytical methods for pesticides as listed in table 14.4 (continued)

Name	Sampling Location		Container	Referee Method	Some Alternative Methods
	Tw	Ds			
Cyanazine			G	LLE/GC-ECD (EPA 551.2)	
2,4-D	✓	✓	G	LSE/GC-ECD (EPA 515.2)	LLE/GC-ECD (APHA 6640B) HPLC/UV/D (EPA 555)
2,4-DB	✓	✓	G	LSE/GC-ECD (EPA 515.2)	LLE/GC-ECD (APHA 6640B) HPLC/UV/D (EPA 555)
DDT + isomers	✓	✓	G	LLE/GC-MS (APHA 6410B)	LLE/GC-ECD (APHA 6630B) LLE-GC-ECD (EPA 508)
Diazinon	✓	✓	G	LSE/GC-MS (EPA 525.2)	LLE/GC-NPD (EPA 507) LLE/GC-NPD or FPD
1,2-Dibromo-3-chloropropane	✓	✓	G	P&T/GC-MS (APHA 6210D, EPA 524.2)	P&T/GC-Hall&PID (APHA 6230D) LLE/GC-ECD (APHA 6231B) LLE/GC-ECD (EPA 551)
1,2-Dichloropropane	✓	✓	G	P&T/GC-MS (APHA 6210D, EPA 524.2)	P&T/GC-Hall&PID (EPA 502.2, APHA 6230D) (APHA 6210D, EPA 524.2)
1,3-Dichloropropene	✓	✓	G	P&T/GC-MS (APHA 6210D, EPA 524.2)	P&T/GC-Hall&PID (APHA 6230D, EPA 502.2)
Dichlorprop	✓	✓	G	LSE/GC-ECD (EPA 515.2)	LLE/GC-ECD (APHA 6640B) HPLC/UV/D (EPA 555)

Table 12.3: Sampling requirements, referee method and some alternative analytical methods for pesticides as listed in table 14.4 (continued)

Name	Sampling Location		Container	Referee Method	Some Alternative Methods
	Tw	Ds			
Diuron	✓	✓	G	LLE/LSE/HPLC (EPA 553)	LLE/LSE/HPLC-UV or HPLC-MS (EPA 8321B)
Ethylene dibromide	✓	✓	G	LLE/GC-ECD (EPA 551.2)	
Fenoprop	✓	✓	G	LSE/GC-ECD (EPA 515.2)	LLE/GC-ECD (APHA 6640B)
Heptachlor and heptachlor epoxide	✓	✓	G	LLE/GC-ECD (EPA 505)	LLE/GC-ECD (EPA 508)
Hexachlorobenzene	✓	✓	G	LSE/GC-MS (EPA 525.2)	LLE/GC-ECD (EPA 508) LLE/GC-ECD (EPA 505)
Hexazinone	✓	✓	G	LLE/GC-NPD (EPA 507)	
Isoproturon	✓	✓	G	LSE/GC-MS (EPA 525.2)	RPHPLC/ED (electrochemical)
Lindane	✓	✓	G	LSE/GC-MS (EPA 525.2)	LLE/GC-ECD (EPA 508) LLE/GC-ECD (EPA 505) LLE/GC (APHA 6630B)
MCPA	✓	✓	G	HPLC/UVD (EPA 555)	LLE/GC-ECD (APHA 6640B)
MCPB	✓	✓	G	HPLC/UVD (EPA 555)	LLE/GC-ECD (APHA 6640B)
Mecoprop	✓	✓	G		LLE/GC-ECD (APHA 6640B)

Table 12.3: Sampling requirements, referee method and some alternative analytical methods for pesticides as listed in table 14.4 (continued)

Name	Sampling Location		Container	Referee Method	Some Alternative Methods
	Tw	Ds			
Metolaxyl	✓	✓	G		
Methoxychlor	✓	✓	G	LSE/GC-MS (EPA 525.2)	LLE/GC (APHA 6630B) LLE/GC-ECD (EPA 508) LLE/GC-ECD (EPA 505)
Metolachlor	✓	✓	G	LLE/GC-NPD (EPA 507)	LSE/GC-MS (EPA 525.2) LSE/GC-MS (EPA 508.1)
Metribuzin	✓	✓	G	LLE/GC-NPD (EPA 507)	LSE/GC-MS (EPA 525.2) LSE/GC-MS (EPA 508.1)
Molinate	✓	✓	G	LLE/GC-NPD (EPA 507)	LSE/GC-MS (EPA 525.2) LSE/GC-MS (EPA 508.1)
Oryxalin	✓	✓	G		
Oxadiazon	✓	✓	G		
Pendimethalin	✓	✓	G	LLE/GC-ECD/NPD (EPA 8091)	
Pentachlorophenol	✓	✓	G	LSE/GC-MS (EPA 525.2)	LSE/GC-ECD (EPA 515.2) Acetylation/LLE/GC-MS (EPA 1653)
Permethrin	✓	✓	G	LLE/GC-ECD (EPA 508)	LLE/GC-ECD (EPA 8081)

Table 12.3: Sampling requirements, referee method and some alternative analytical methods for pesticides as listed in table 14.4 (continued)

Name	Sampling Location		Container	Referee Method	Some Alternative Methods
	Tw	Ds			
Picloram	✓	✓	G	LLE/GC-ECD (EPA 515.2)	HPLC/PDAUV (EPA 555)
Pirimiphos methyl	✓	✓	G	LSE/GC-MS (EPA 525.2)	
Pirimisulphuron			G		
Procymidone	✓	✓	G		
Propanil	✓	✓	G	LLE/HPLC/UV (EPA 632.1)	
Propazine	✓	✓			LLE/GC-NPD (EPA 507)
Pyridate	✓	✓	G		
Simazine	✓	✓	G	LSE/GC-MS (EPA 525.2)	LLE/GC-NPD (EPA 507)
2,4,5-T	✓	✓	G	LSE/GC-ECD (EPA 515.2)	LLE/GC-ECD (APHA 6640B) HPLC/UV/D (EPA 555)
Terbuthylazine	✓	✓	G	LLE/GC-ECD (EPA 1656)	LLE/GC-NPD (Chlorophenoxy acidic herbicides, trichlorobenzoic acid, chlorophenols, triazines and glyphosate in water 1985. HMSO, 1986)
Thiabendazole			G	HPLC –Fluorescence (EPA 641)	

Table 12.3: Sampling requirements, referee method and some alternative analytical methods for pesticides as listed in table 14.4 (continued)

Name	Sampling Location		Container	Referee Method	Some Alternative Methods
	Tw	Ds			
Triclopyr	✓	✓	G	LSE/CD-ECD (EPA 515.2)	LLE/GC-ECD (APHA 6640B) HPLC/UV/D (EPA 555)
Trifluralin	✓	✓	G	LLE/GC-ECD (EPA 508)	LLE/GC-MS (EPA 8270)
1080	✓	✓	G	LSE/GC-ECD Ozawu & Tsukioka, 1987, Anal. Chem., 59, 2914-2917 (Proposed)	

Note: In the analysis of the organic determinands it is the extraction method that is important. The choice of the final method of detection, eg MSD, ECD etc, affects the sensitivity and selectivity of the analysis.

Abbreviations:

Container:	G – glass, P – plastic, (A) – acid washed, (S) – solvent washed
DZ	distribution zone
TW	water leaving the treatment plant

Analytical Methods:

BA	bioassay
CVGAA	cold vapour atomic absorption method
ECD	electron capture detector
FAA	flame atomic absorption
FID	flame ionization detector
FLD	fluorescence detector
FPD	flame photometric detector
GC	gas chromatography
GFAA	graphite furnace atomic absorption
HGAA	hydride generation atomic absorption
HPLC	high pressure liquid chromatography
IC	ion chromatography
ICP	inductively coupled plasma spectrometry
LLE	liquid/liquid extraction
LSE	liquid/solid extraction
MS	mass spectrometer
ND	nitrogen specific detector
NPD	nitrogen/phosphorus detector
PID	photoionization detector
P&T	purge and trap
RPHPLC	reversed-phase HPLC
TITR	titrimetric method
UVD	ultraviolet detection

References:

APHA	<i>Standard methods for the examination of water and wastewater.</i> - Washington, DC: American Public Health Association, 20th Edition 1998.
EPA	US Environmental Protection Agency
HMSO	<i>Methods for the examination of waters and associated materials.</i> – London.

13 C.t Tables for the Inactivation of Protozoa by Ozone and Chlorine Dioxide

13.1 Purpose of C.t tables

For chemical disinfection the effectiveness of the process depends on the concentration of the disinfectant, C (mg/L), and the contact time of the disinfectant with the pathogen, t , (in minutes).

To enable the effectiveness of a chemical disinfection process to be determined, tables of C.t values have been developed for a range of disinfectants and pathogens. These may need to take into account the temperature and the pH if the process is dependent on these parameters.

13.1.1 Use of C.t tables

From the table, identify the C.t value corresponding to the temperature (and pH if necessary) of the water.

Determine the contact time (by tracer test or by a tested calculation procedure eg, USEPA integrated disinfection design framework (IDDF)) such that 90 percent of the through flow has equalled or exceeded the contact time value (t_{10}).

$$\text{Concentration for a specified percentage inactivation} = \frac{\text{C.t}}{\text{contact time}}$$

13.1.2 Application of C.t

Disinfection is used as the third barrier to infection for most pathogenic organisms. For most bacteria and viruses the FAC disinfection procedures specified in Chapter 3 provide effective protection. For *Cyanobacteria* chemical disinfection is unsuitable. It is likely to cause toxins to be released.

The FAC disinfection procedures specified in Chapter 3 will not provide effective protection against *Giardia* and *Cryptosporidium* which are prevalent in many

New Zealand water sources. *Cryptosporidium* is more resistant to disinfection than *Giardia*. Processes that will inactivate *Cryptosporidium* will also inactivate *Giardia*.

Where treatment does not include filtration, but relies on disinfection, to be effective the inactivation of protozoa by disinfectants must accomplish at least 99.9 percent inactivation of *Giardia* and *Cryptosporidium*. This will be required by 1 January 2005. (Filtration processes should accomplish at least 99.99 percent inactivation).

13.1.2.1 Chlorine

Chlorine can achieve 99.9 percent inactivation for *Giardia* but not for *Cryptosporidium*, and is therefore unable to provide protozoan compliance.

For this reason no C.t tables are given for chlorine.

13.1.2.2 Chlorine dioxide

Table 13.1 and Figures 13.1a and 13.1b show the C.t values for 99 percent and 99.9 percent inactivation of *Cryptosporidium* by chlorine dioxide, subject to the water always being less than 1.0 NTU and the pH being between 6.0 and 8.0. If chlorine dioxide is used, disinfectant, chlorite automatically becomes a Priority 2 determinand.

13.1.2.3 Ozone

Tables 13.1 and Figures 13.2a and 13.2b show the C.t values for 99 percent and 99.9 percent inactivation of *Cryptosporidium* by ozone, subject to the turbidity of the water always being less than 1.0 NTU and the pH being between 6.0 and 8.0.

Table 13.1 C.t values (mg.min/L) for 99.9% inactivation of *Cryptosporidium* by chlorine dioxide, ozone, and for 99% inactivation of *Cryptosporidium* by chlorine dioxide, ozone

Temp (°C)	Chlorine Dioxide		Ozone	
	99%	99.9%	99%	99.9%
0.5	1530	2170	57.9	83
5	829	1180	32.5	46.6
10	429	609	17.5	25.1
15	227	322	9.6	13.8
20	123	174	5.39	7.73
25	67.8	96.3	3.08	4.42
30	38.2	54.2	1.79	2.96

Figure 13.1a **C.t (mg.min/L) for chlorine dioxide: 99% inactivation of *Cryptosporidium***

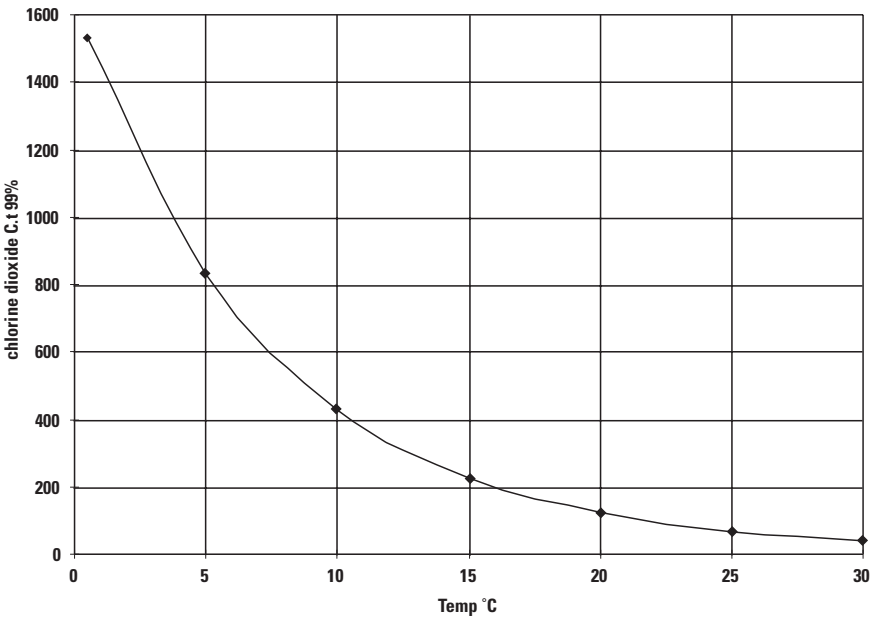


Figure 13.1b **C.t (mg.min/L) for chlorine dioxide: 99.9% inactivation of *Cryptosporidium***

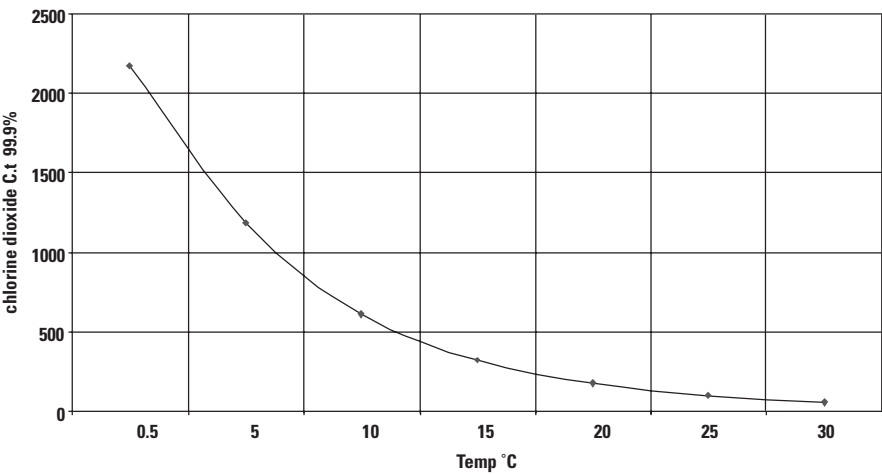


Figure 13.2a C.t (mg.min/L) for ozone: 99% inactivation of *Cryptosporidium*

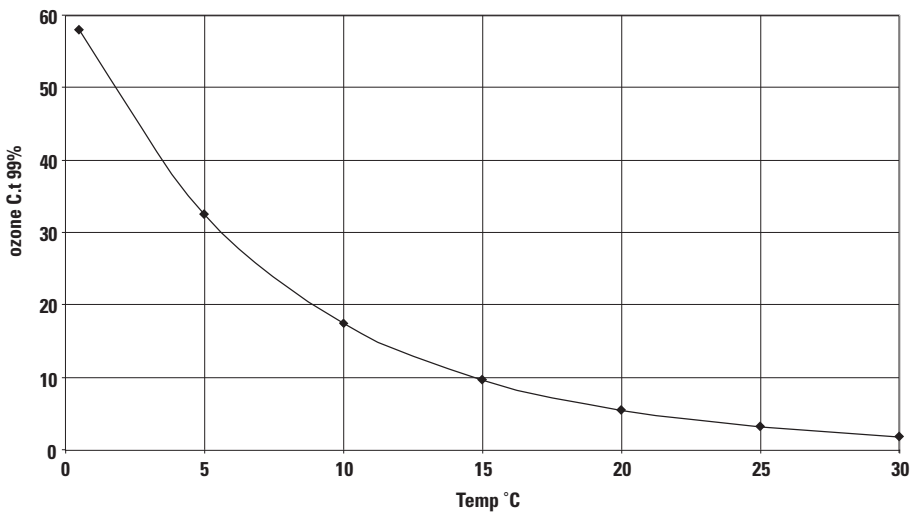
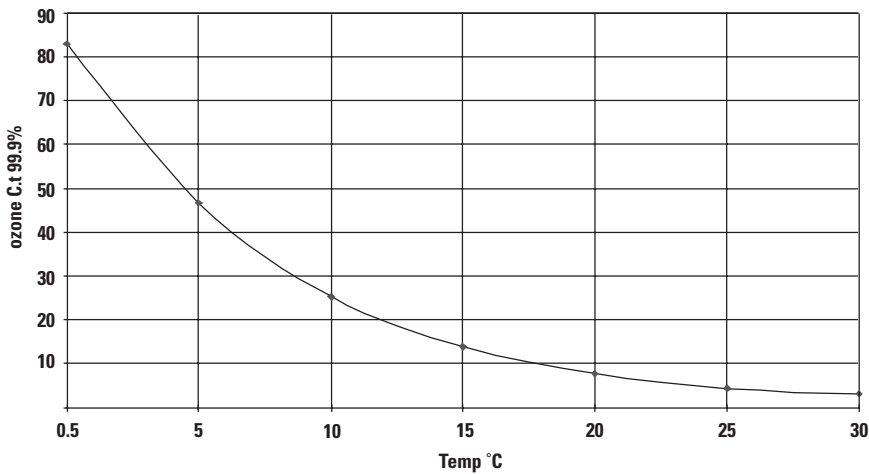


Figure 13.2b C.t (mg.min/L) for ozone: 99.9% inactivation of *Cryptosporidium*



14 Tables Of MAVs and GVs

Table 14.1 Maximum Acceptable Values (MAVs) for micro-organisms of health significance

Micro-organism	MAV
<i>Escherischia coli</i> (<i>E. coli</i>)	Less than 1 in 100 mL of sample
pathogenic bacteria	less than 1 in 100 mL of sample
Viruses	Less than 1 enteric virus in 100L of sample
Protozoa (pathogenic)	Less than 1 (oo)cyst in 100L sample
Helminths (pathogenic)	Less than 1 in 100L sample
Algae	Less than 1 toxic alga present in 10mL of sample
Cyanobacteria	Less than 1 potentially toxic cyanobacterium present in 10mL of sample

Table 14.2 Maximum Acceptable Values (MAVs) for inorganic determinands of health significance

Name	MAV	Units	Remarks
Antimony	0.003	mg/L	
Aggressiveness			Any heavy metal has elevated concentration in first flush sample
Arsenic	0.01	mg/L	For excess lifetime skin cancer risk of 6×10^{-4} PMAV, because of analytical difficulties
Barium	0.7	mg/L	
Beryllium	0.004	mg/L	PMAV
Boron	1.4	mg/L	
Bromate	0.025	mg/L	For excess lifetime cancer risk of 7×10^{-5}
Cadmium	0.003	mg/L	
Chlorate	0.3	mg/L	PMAV, disinfection must never be compromised
Chlorine (free)	5	mg/L as Cl_2	ATO, disinfection must never be compromised
Chlorite	0.3	mg/L as ClO_2	PMAV, disinfection must never be compromised
Chromium	0.05	mg/L	PMAV, limited information on health effects
Copper	2	mg/L	ATO
Cyanide (total)	0.08	mg/L	
Cyanogen chloride (as CN)	0.08	mg/L	
Fluoride *	1.5	mg/L	
Lead	0.01	mg/L	
Lithium	0.9	mg/L	PMAV
Manganese	0.5	mg/L	ATO
Mercury (total)	0.002	mg/L	
Molybdenum	0.07	mg/L	
Monochloramine	3	mg/L	
Nickel	0.02	mg/L	
Nitrate	50	mg/L expressed as NO_3	The sum of the ratio of the concentrations of nitrate and nitrite to each of their respective MAVs should not exceed 1
Nitrite	3	mg/L expressed as NO_2	The sum of the ratio of the concentrations of nitrate and nitrite to each of their respective MAVs should not exceed 1
Selenium	0.01	mg/L	
Silver	0.02	mg/L	U PMAV Australian provisional value
Tin	1	mg/L	U PMAV derived from WHO data
Uranium	0.002	mg/L	PMAV: WHO provisional

* The fluoride content recommended for drinking-water by the Ministry of Health for oral health reasons is 0.7–1.0 mg/L.

Table 14.3 Maximum Acceptable Values [MAVs] for organic determinands of health significance

Name	MAV	Units	Remarks
Acrylamide	0.0005	mg/L	for excess lifetime cancer risk of 10^{-5}
Anatoxin (as STX-eq)	0.003	mg /L	PMAV
Anatoxin-a(S)	0.001	mg /L	PMAV
Benzene	0.01	mg/L	for excess lifetime cancer risk of 10^{-5}
Benzo(a)pyrene	0.0007	mg/L	for excess lifetime cancer risk of 10^{-5}
Bromodichloromethane ^{THM}	0.06	mg/L	for excess lifetime cancer risk of 10^{-5}
Bromoform ^{THM}	0.1	mg/L	
Carbon tetrachloride	0.002	mg/L	
Chloroform ^{THM}	0.2	mg/L	for excess lifetime cancer risk of 10^{-5}
Cylindrospermopsin	0.003	mg/L	PMAV
Di(2-ethylhexyl)adipate	0.1	mg/L	
Di(2-ethylhexyl) phthalate	0.009	mg/L	
Dibromoacetone	0.2	mg/L	PMAV
Dibromochloromethane ^{THM}	0.1	mg/L	
Dichloroacetic acid	0.05	mg/L	PMAV
Dichloroacetone	0.1	mg/L	PMAV
1,2-Dichlorobenzene	1	mg/L	ATO
1,4-Dichlorobenzene	0.4	mg/L	ATO
1,2-Dichloroethane	0.03	mg/L	for excess lifetime cancer risk of 10^{-5}
1,1-Dichloroethene	0.03	mg/L	
1,2-Dichloroethene	0.06	mg/L	
Dichloromethane	0.02	mg/L	
1,2-Dichloropropane	0.05	mg /L	See 1998 WHO – also listed as pesticide
EDTA	0.7	mg/L	WHO
Epichlorohydrin	0.0005	mg/L	PMAV WHO
Ethylbenzene	0.3	mg/L	ATO
Fluoranthene	0.004	mg/L	WHO PMAV
Formaldehyde	1	mg/L	
Hexachlorobutadiene	0.0007	mg/L	
Homoanatoxin-a	0.001	mg/L	PMAV

Table 14.3 Maximum Acceptable Values (MAVs) for organic determinands of health significance (continued)

Name	MAV	Units	Remarks
LPS endoxins	0.003	mg/L	PMAV
Microcystins	0.001	mg/L	PMAV
Monochlorobenzene	0.3	mg/L	ATO
Nitrilotriacetic acid	0.2	mg/L	
Nodularin	0.001	mg/L	PMAV
Saxitoxins	0.001	mg/L	PMAV
Styrene	0.03	mg/L	ATO
Tetrachloroethene	0.05	mg/L	
Toluene	0.8	mg/L	ATO
Tributyltin oxide	0.002	mg/L	
Trichloroacetaldehyde/ chloral hydrate	0.01	mg/L	PMAV
Trichloroacetic acid	0.1	mg/L	PMAV
Trichloroacetonitrile	0.001	mg/L	PMAV
Trichlorobenzenes (total)	0.03	mg/L	ATO
1,1,1-Trichloroethane	2	mg/L	PMAV
Trichloroethene	0.08	mg/L	PMAV
2,4,6-Trichlorophenol	0.2	mg/L	for excess lifetime cancer risk of 10^{-5} , ATO
Trihalomethanes (THMs)			The sum of the ratio of the concentration of each to its respective MAV should not exceed 1. The individual members of this group are indicated in the table by ^{THM}
Vinyl chloride	0.005	mg/L	for excess lifetime cancer risk of 10^{-5}
Xylenes	0.6	mg/L	ATO

Abbreviations:

ATO	Concentrations of the substance at or below the health-based guideline value may affect the appearance, taste or odour of the water
PMAV	Provisional MAV
STX-eq	Saxitoxin-equivalent
THM	Trihalomethane

Table 14.4 Maximum Acceptable Values (MAVs) for pesticides^{1,2}

Name	Mav	Units	Remarks
Alachlor	0.02	mg/L	for excess lifetime cancer risk of 10 ⁻⁵
Aldicarb	0.01	mg/L	
Aldrin + Dieldrin	0.00003	mg/L	
Atrazine	0.002	mag/L	PMAV
Azinphos methyl	0.004	mg/L	PMAV
Bentazone	0.4	mg/L	
Bromacil	0.4	mg/L	PMAV
Carbofuran	0.008	mg/L	
Chlordane	0.0002	mg/L	
Chlorpyrifos	0.07	mg/L	
Chlortoluron	0.04	mg/L	
Cyanazine	0.0007	mg/L	
2,4-D	0.04	mg/L	
2,4-DB	0.1	mg/L	
DDT + isomers	0.002	mg/L	
Diazinon	0.01	mg/L	
1,2-Dibromo-3-chloropropane	0.001	mg/L	for excess lifetime cancer risk of 10 ⁻⁵
1,2-Dichloropropane	0.02	mg/L	PMAV
1,3-Dichloropropene	0.02	mg/L	for excess lifetime cancer risk of 10 ⁻⁵
Dichlorprop	0.1	mg/L	
Diquat	0.01	mg/L	
Diuron	0.02	mg/L	PMAV
Fenoprop	0.01	mg/L	
Heptachlor and heptachlor epoxide	0.00004	mg/L	
Hexachlorobenzene	0.001	mg/L	for excess lifetime cancer risk of 10 ⁻⁵
Hexazinone	0.4	mg/L	PMAV
Isoproturon	0.01	mg/L	
Lindane	0.002	mg/L	
MCPA	0.002	mg/L	

Table 14.4 Maximum Acceptable Values (MAVs) for pesticides^{1,2} (continued)

Name	Mav	Units	Remarks
Mecoprop	0.01	mg/L	
Metalaxyl	0.1	mg/L	PMAV
Methoxychlor	0.02	mg/L	
Metolachlor	0.01	mg/L	
Metribuzin	0.07	mg/L	PMAV
Molinate	0.007	mg/L	
Oryzalin	0.4	mg/L	PMAV
Oxadiazon	0.2	mg/L	PMAV
Pendimethalin	0.02	mg/L	
Pentachlorophenol	0.01	mg/L	PMAV
Permethrin	0.02	mg/L	
Picloram	0.2	mg/L	PMAV
Pirimiphos methyl	0.1	mg/L	
Pirimsulfuron methyl	0.9	mg/L	
Procymidone	0.7	mg/L	
Propanil	0.02	mg/L	
Propazine	0.07	mg/L	PMAV
Pyridate	0.1	mg/L	
Simazine	0.002	mg/L	
Simazine	0.02	mg/L	PMAV
2,4,5-T	0.01	mg/L	
Terbutylazine	0.008	mg/L	
Thiabendazole	0.4	mg/L	PMAV
Triclopyr	0.1	mg/L	PMAV
Trifluralin	0.03	mg/L	
1080	0.0035	mg/L	PMAV

¹ Refer to Section 9 for index of compound abbreviations and synonyms.

² Refer to Section 10 for table of compound abbreviations and synonyms.

Abbreviation:

PMAV Provisional MAV.

Table 14.5 Maximum Acceptable Values (MAVs) for radiological determinands

Radioactive Constituents	MAV	Unit
Total Alpha Activity	0.10	Bq/L, excluding radon
Total Beta Activity	0.50	Bq/L, excluding potassium-40
Radon	100	Bq/L

Table 14.6 Guideline values (GVs) for aesthetic determinands

Determinand	Guideline Value	Units	Comments
Aluminium	0.15	mg/L	Depositions, discoloration
Ammonia	1.5	mg/L	Taste, odour
Calcium: see hardness			
Chloride	250	mg/L	Taste, corrosion
Chlorine	0.6	mg/L	Taste, odour (MAV 5mg/L)
1,2-dichlorobenzene	0.001	mg/L	Taste, odour (MAV 1.0mg/L)
1,4-dichlorobenzene	0.003	mg/L	Taste, odour (MAV 0.4mg/L)
2-Chlorophenol	0.0003	mg/L	Taste
Colour	10	TCU	Appearance
Copper	1	mg/L	Staining of laundry and sanitary ware (PMAV 2mg/L)
2,4-Dichlorophenol	0.0003	mg/L	Taste
Ethylbenzene	0.002	mg/L	For odour and taste (MAV 0.3mg/L)
Hardness (total) (Ca + Mg)	200	mg/L	High hardness causes scale deposition, scum formation low hardness: possibly causes corrosion
Hydrogen sulphide	0.05	mg/L	Taste, odour
Iron	0.2	mg/L	Staining of laundry and sanitary ware
Magnesium (see hardness)			
Manganese	0.05	mg/L	Staining of laundry and sanitary ware (MAV 0.5mg/L)
Monochlorobenzene	0.01	mg/L	Taste, odour (MAV 0.3mg/L)
Odour	Threshold odour number 4		Odour
pH	7.0–8.5		Should be between 7.0 and 8.0. Low pH: aggressive water; high pH: taste, soapy feel. Preferably pH<8 for effective disinfection with chlorine

Table 14.6 Guideline values for aesthetic determinands (continued)

Determinand	Guideline Value	Units	Comments
Sodium	200	mg/L	Taste
Styrene	0.004	mg/L	Taste, odour (MAV 0.03 mg/L)
Sulphate	250	mg/L	Taste, corrosion
Taste	should be acceptable to most consumers		
Temperature	should be acceptable to most consumers		
Toluene	0.024–0.17	mg/L	Taste, odour (MAV 0.8 mg/L)
Total dissolved solids	1000	mg/L	Taste
Trichlorobenzenes (total)	0.005	mg/L	(MAV 0.03mg/L)
2,4,6-trichlorophenol	0.002	mg/L	Taste, odour (MAV 0.2 mg/L)
Turbidity	2.5	NTU	Appearance, for effective terminal disinfection, median turbidity <1 NTU, single sample < 5 NTU
Xylene	0.02-1.8	mg/L	Taste, odour (MAV 0.6 mg/L)
Zinc	3	mg/L	Appearance, taste

Table 14.7 Determinands for which health concerns have been raised but for which no MAV can be set

Name	Remarks
Aggressiveness	A characteristic of water that corrodes brass and other mixtures, causing heavy metal concentrations to rise above 50% of the MAV
Asbestos ¹	toxicological information suggests that oral ingestion (unlike inhalation) is unlikely to be a health risk
Bromochloroacetonitrile ^c	NAD
Chloroacetones ²	NAD
2-Chlorophenol ²	NAD (aesthetic guideline 0.0001mg/L)
Chloropicrin ²	NAD
Dialkyltins ²	NAD
1,2-Dibromoethane ²	NAD
Dichloramine ²	NAD
1,3-Dichlorobenzene ²	NAD
1,1-Dichloroethane ²	NAD
2,4-Dichlorophenol ²	NAD (aesthetic guideline 0.0003mg/L)
1,3-Dichloropropane ²	NAD
Dioxins ³	Many congeners. Very low water solubility
Ethylene dibromide ²	NAD
Iodine ²	NAD
MCPB ²	NAD
Monochloroacetic acid ²	NAD
MX ^{*2}	NAD
PAHs (polycyclic aromatic hydrocarbons) ³	Total PAH mixture (PMAV 0.001mg/L)
PCBs (polychlorinated biphenyls) ³	Refers to a mixture of chemicals
Triazine ³	Refers to a mixture of chemicals

¹ No health risk has been established.

² Likely health significance, but insufficient toxicological data to derive MAV.

³ Health significance, but MAV is difficult to derive because of technical reasons due to the number of different compounds of differing toxicities in this group.

NAD No adequate data to permit recommendation of a health-based MAV. Refer to the Guidelines for further information.

U Usually unnecessary to recommend health-based MAV because they are not hazardous to human health at concentrations normally found in drinking-water.

