

Drinking-water Standards for New Zealand 2005 (Revised 2008)

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(Revised 2008)**

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Foreword

I am pleased to release Drinking-water Standards for New Zealand 2005 (Revised 2008).

The availability of safe drinking-water for all New Zealanders, irrespective of where they live, is a fundamental requirement for public health. The revised Drinking-water Standards are a significant achievement in New Zealand's endeavours to maintain and improve the quality of drinking-water.

Since the publication of Drinking-water Standards for New Zealand 2000 the approach to managing drinking-water quality has changed. The focus has moved from quality control to a broader approach of quality assurance. This has been necessary due to changes in technology, an improvement in our scientific knowledge and the requirement to address a broader range of issues than previously covered.

The Health (Drinking Water) Amendment Act 2007 amended the Health Act 1956 to require all drinking-water suppliers providing water to more than 500 people to develop and start to implement a Public Health Risk Management Plan to guide the safe management of their supply before 2013. A Public Health Risk Management Plan is a tool to help suppliers identify, manage and minimise events that could cause water quality to deteriorate.

The quality of the water that is provided will continue to be governed by the DWSNZ, which prescribe the maximum allowable concentrations of potentially harmful contaminants that may be present in the water.

I wish to extend my appreciation to the many people who have been involved in the development of this edition of the standards. I especially wish to thank members of the expert working groups for their efforts in reviewing and revising the many technical draft proposals that were part of this process. The result will significantly contribute to improving and protecting the public health of all New Zealanders.

Stephen McKernan
Director-General of Health

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1 Overview of Drinking-water Standards

1.1 Key terms

Key terms used in the **Drinking-water Standards for New Zealand (DWSNZ)** are defined in the Definitions. They are highlighted in bold type on their first use in this document.

1.2 Introduction

1.2.1 Minimum standards for drinking-water

Safe **drinking-water**, available to everyone, is a fundamental requirement for public health. The DWSNZ define the minimum standards for drinking-water in New Zealand.

Every attempt has been made to ensure the DWSNZ:

- protect public health
- minimise unnecessary **monitoring**
- are appropriate for large and small, publicly and privately owned water supplies.

1.2.2 Health Act 1956

The Health (Drinking Water) Amendment Act 2007 amended the Health Act 1956. It marks a milestone in New Zealand in that, for the first time, all **water suppliers** have a duty to ensure their water is safe to drink.

The amended Act (hereinafter called the Act) introduces a statutory requirement that all drinking-water suppliers providing drinking-water to over 500 people must develop and implement a **Public Health Risk Management Plan (PHRMP)** to guide the safe management of their supply. This **quality assurance** approach is complemented by the DWSNZ, which specify the maximum acceptable concentrations of harmful **contaminants** in the water.

The Act also provides for the appointment of **drinking-water assessors (DWAs)**. Their functions are set out in section 69ZL of the Act.

The DWSNZ have two further aspects. They provide criteria for ensuring that monitoring of drinking-water quality is carried out to a consistent standard and they specify, in general, the **remedial actions** where the public health risk that is identified for the supply needs to be managed, or to be taken in the event of the standards being breached. The PHRMP details the remedial actions specific to its supply. They thus minimise uncertainty on the part of the supplier as to whether the supply is meeting the quality requirements, and what to do in the case of things going wrong.

The Act also requires the development of a section on rural agricultural drinking-water supplies (RADWS) in the DWSNZ (now section 12). RADWS will be required to comply with the Act by 2013.

1.2.3 Other changes since the 2005 drinking-water standards

The introduction of the requirement for PHRMPs necessitated minor adjustments in the DWSNZ to ensure compatibility with the Act.

The *Drinking-water Standards for New Zealand 2005* were the result of a consensus among members of the Expert Committee on Drinking-water Quality set up to advise the Ministry of Health (Ministry of Health 2005a). Following submissions from water suppliers, section 10 (small supplies) was

significantly rewritten for this edition and other sections were clarified as required. The opportunity was also taken to update the **maximum acceptable value (MAV)** tables based on the latest **World Health Organization (WHO)** information.

1.2.4 Key references

In the preparation of the DWSNZ, extensive use was made of:

- *Guidelines for Drinking-water Quality 2004* (WHO GDWQ) (WHO 2004)
- *Drinking-water Standards for New Zealand 1984, 1995, 2000 and 2005* (Ministry of Health 1984, 1995, 2000, 2005a respectively)
- *National Primary Drinking Water Regulations: Long Term 2 Enhanced Surface Water Treatment Rule: Final Rule* (USEPA 2006a).

1.3 Scope of the drinking-water standards

The three main themes of the DWSNZ are:

- the MAVs or **water quality standards**
- the **compliance criteria** and reporting requirements
- remedial actions.

The DWSNZ are applicable to water intended for drinking by the public irrespective of the water's source, treatment or **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 standards set under the Food Act 1981.

The DWSNZ do not set quality standards for water used for industrial or agricultural purposes.

For people with certain medical conditions, or for uses of the water for purposes other than drinking, additional or other water quality criteria may apply (eg, the requirements of the Animal Products Act 1999, Food Act 1981, Dairy Industry Act 1952 and Meat Act 1981).

The Ministry of Agriculture and Forestry's Farm Dairy Water Standard, Standard D106.2 (MAF 2002) covers water quality for water used in farm dairies for milking and cleaning equipment that comes in contact with milk.

The DWSNZ specify MAVs for the microbial, chemical and **radiological determinands** of public health significance in drinking-water and provide compliance criteria and procedures for verifying the water supply is not exceeding these values. The actions to be followed when a **transgression** of the DWSNZ occurs are described.

The companion publication *Guidelines for Drinking-water Quality Management in New Zealand* (the Guidelines) (Ministry of Health forthcoming) provides additional information about the:

- **determinands** listed in this publication
- management of drinking-water quality
- derivation of the concepts used in this publication
- publications on which the DWSNZ are based.

The DWSNZ are intended to be used in conjunction with the PHRMP for the water supply. The PHRMP describes how to manage the supply using quality assurance principles. The DWSNZ provide the quality specifications for drinking-water.

The public health safety of the water is best protected if multiple barriers to contamination are in place. These barriers include:

- minimising the extent of contaminants in the source water that must be dealt with by the treatment process
- removing undesirable soluble and particulate matter
- disinfecting to inactivate any pathogenic organisms present
- protecting the treated water from subsequent contamination.

The DWSNZ are based on the following principles.

1. The DWSNZ define the maximum concentrations of chemicals of health significance (MAVs) in water that, based on current knowledge, constitute no significant risk to the health of a person who consumes 2 L of that water a day over their lifetime (usually taken as 70 years).

Potable water is drinking-water that does not contain or exhibit any determinand to any extent that exceeds the MAVs specified in the DWSNZ (see the definition of ‘potable’ in section 69G of the Act).

The DWSNZ do not purport to specify a concentration of contaminant at which zero risk exists because a degree of uncertainty over the magnitude of the risk always exists. The **datasheets** in the Guidelines (vol 3) provide information on each determinand.

2. The DWSNZ give highest priority to health risks arising from microbial contaminants because they can lead to rapid and major outbreaks of illness. 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 (DBP)** formation.
3. The DWSNZ set priorities on how to ensure that, while public health is protected, scarce resources are not diverted to monitoring substances of relatively minor importance.
4. The DWSNZ set out to protect public health and apply only to health-significant determinands. However, because the public generally assesses the quality of its water supply on aesthetic perceptions, **guideline values for aesthetic determinands** are also provided (section 2), although they are not part of the water quality standards.

Wholesome drinking-water is potable water that does not contain or exhibit any determinands that exceed the guideline values for aesthetic determinands in the DWSNZ (see the definition of ‘wholesome’ in section 69G of the Act). For more details, see the Guidelines, chapter 18.

5. To demonstrate **compliance** with the MAVs, water suppliers need to follow the relevant sampling and testing programmes detailed in sections 4, 5 and 7 to 12.
6. Where feasible, the sampling protocols are designed to give 95 percent confidence that no determinand in a supply has exceeded its MAV for more than 5 percent of the time.

1.4 Structure of the document

The DWSNZ set out the standards for drinking-water constituents or properties (determinands) and the criteria used to demonstrate whether a water supply complies with these standards.

Section 2 contains the water quality standards, which specify the maximum concentrations of microbial, chemical and radiological determinands in drinking-water that are acceptable for public health. These are the MAVs of the determinands. The water quality standards are the yardstick by which water’s suitability for drinking is assessed. This section also contains a table of aesthetic determinands with guideline values.

Section 3 discusses compliance with, and transgressions of, the DWSNZ. The determinands have been divided into four **priority classes**.

Sections 4 to 9 contain the microbial, chemical and radiological determinands compliance criteria, which specify the sampling protocols and other criteria that need to be satisfied to demonstrate the drinking-water complies with the DWSNZ.

Section 10 covers the compliance requirements for small drinking-water supplies (serving fewer than 500 people).

Section 11 covers **tankered drinking-water**.

Section 12 covers rural agricultural drinking-water supplies.

Appendix 1 explains the units used in the DWSNZ, **referee methods** of analysis are tabulated in Appendix 2, and Appendix 3 contains the Catchment Risk Categorisation Survey Result Form.

Key terms used in the DWSNZ are defined in the Definitions section and are highlighted in bold type on their first use in this document.

References cited in this publication are listed at the end of the publication.

1.5 Maximum acceptable values

The MAV of a chemical determinand in drinking-water is the highest concentration of a determinand in the water that, on the basis of present knowledge, is considered not to cause any significant risk to the health of the consumer over 70 years of consumption of that water. Wherever possible, the MAVs have been based on the latest WHO guideline values. The WHO used a body weight of 60 kg to calculate its guideline values, but in the DWSNZ the MAVs are based on a body weight of 70 kg to better represent the average weight of New Zealand adults. MAVs are applicable to all categories of drinking-water. Compliance criteria have been derived for different categories or treatment processes.

WHO calls their guideline values provisional when there is a high degree of uncertainty in the toxicology and health data, or if there are difficulties in water treatment or chemical analysis. The DWSNZ adopt the same approach. Provisional MAVs (PMAVs) have also been applied to chemical determinands when the Ministry of Health has derived a MAV in the absence of a WHO guideline value. In terms of compliance with the DWSNZ, PMAVs are considered to be equivalent to MAVs.

Note the following.

1. The MAVs for **micro-organisms** are determined differently from those for chemicals.
 - a. The MAV of a micro-organism is its concentration in drinking-water above which there is a significant risk of contracting a waterborne (enteric) disease. See Table 2.1.
 - b. Because of the limitations of existing microbial technology, MAVs are not given for all micro-organisms of health significance (eg, all **pathogens**). Instead MAVs are given for the representative organisms *Escherichia coli* (*E. coli*) for the **bacteria** and *Cryptosporidium* plus *Giardia* (representing the **protozoa**).
 - c. *E. coli* is used as an indicator of bacterial risk because it indicates the presence of faecal material and, therefore, the potential presence of pathogenic bacteria.
2. MAVs for chemical determinands of health significance are given in Tables 2.2 and 2.3. Because the relationship between cyanobacterial numbers and toxin production is highly variable, no attempt is made to develop MAVs for **cyanobacteria**, but they are developed for their **cyanotoxins**.

3. For most **carcinogens**, the MAVs in the DWSNZ are the concentrations of substances in drinking-water that have been estimated to cause one additional incidence of cancer in a population of 100,000, each member of which ingests 2 L per day of water containing the substance at the MAV for a lifespan of 70 years.
4. For most other chemicals, MAVs have been calculated using a tolerable daily intake (TDI) approach that identifies the dose below which no evidence exists that significant adverse effects will occur and that will represent no significant risk to a consumer from a lifetime of consumption of 2 L of the water per day. The derivation of the MAVs are explained in the datasheets in the Guidelines.
5. For radioactive substances, screening values for total alpha and total beta activity are given, based on a reference level of dose. See Table 2.4.
6. The MAVs set in the DWSNZ define water suitable for human consumption and hygiene. Water of higher quality may be required for special purposes, such as for renal dialysis, for people who are immunocompromised, or for certain industrial or agricultural purposes. The DWSNZ do not address these issues.
7. The WHO assesses determinands for which health concerns have been raised and has found many are unlikely to occur in drinking-water or occur at levels well below those at which toxic effects are observed. Datasheets for these determinands appear in the Guidelines.

1.6 Operational requirement values

Where MAVs cannot be (or are not) used to measure compliance, measurement of treatment efficacy is used as the **surrogate** method for establishing compliance.

When surrogate criteria are used, the DWSNZ specify **operational requirements**, compliance with which is considered to give a high level of confidence that the water will be safe to drink, rather than determinand MAVs. **Free available chlorine (FAC)**, **free available chlorine equivalent (FACE)** (see section 4.3.2), and assessing protozoal compliance with filter performance parameters such as **turbidity** are examples of this.

1.7 Population data

The population served by a drinking-water supply is taken to be that recorded in the **Register of Community Drinking-water Supplies and Suppliers in New Zealand** (eg, Ministry of Health 2008b). Monitoring frequency requirements for a supply are calculated on the base population serviced by the supply.

Where the population fluctuates seasonally, the monitoring frequency must be adjusted to reflect changes in population. The sampling frequency must be that required for the higher population for the duration of the higher population, plus at least two weeks before the population is expected to increase. For water supplies that are shut down or operate at a very small fraction of the peak rate, this period may be required to be extended to a month.

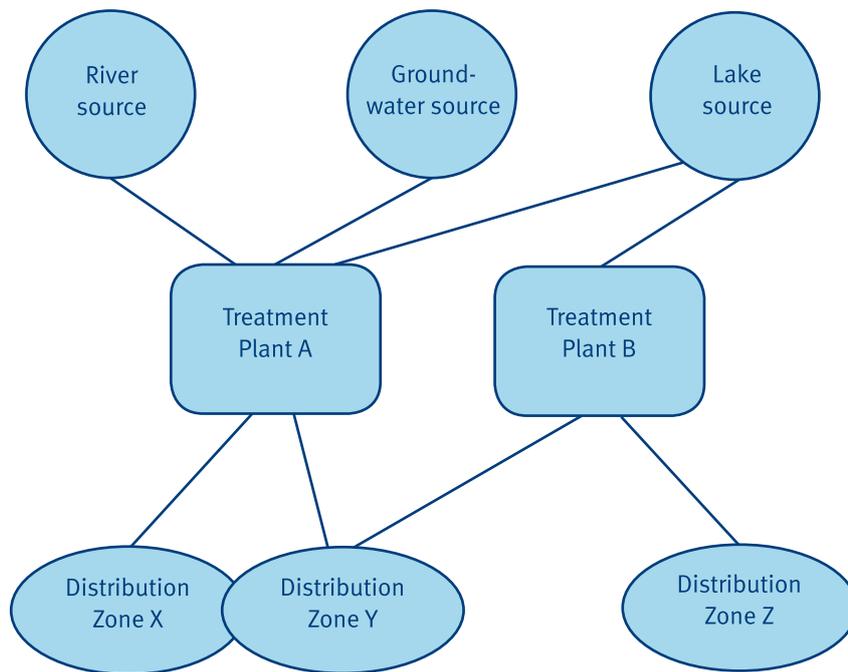
1.8 Components of drinking-water supply

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

- source of raw water¹
- treatment plant
- distribution system.

Compliance criteria are given for water leaving the treatment plant and in the distribution system. Source water quality issues are covered in PHRMPs.

Figure 1.1: Schematic diagram of drinking-water supply system



1.9 Appeal process

Water suppliers may appeal any decision or finding of a DWA in relation to compliance with the requirements of these standards using the following process.

1. The water supplier may submit an appeal in writing to the technical manager of the Drinking Water Assessment Unit that issued the finding.
2. If the water supplier is dissatisfied with the result, the technical manager must refer the submission to the National Drinking Water Co-ordination Service to independently review the decision.
3. If the water supplier is still dissatisfied, they may use the appeal provisions in section 69ZW of the Act and request review by the Director-General of Health.

1. The Ministry for the Environment's National Environmental Standard for Sources of Human Drinking-water requires regional councils to ensure that effects on drinking-water sources are considered in council decisions on resource consents and regional plans.

2 Water Quality Standards

2.1 Introduction

This is the principal section of the DWSNZ. It specifies the water quality standards to which all drinking-water supplies must comply.

The standards in Tables 2.1 to 2.4 and the associated compliance criteria in sections 4, 5 and 7 to 12 came into effect on 14 September 2008.

Section 2.2 includes Tables 2.1 to 2.4, which constitute the MAVs in the DWSNZ.

Section 2.3 includes Table 2.5, which contains the guideline values for aesthetic determinands. These values are not part of the water quality standards, but are included in the DWSNZ as additional information.

Section 2.4 explains the abbreviations used in Tables 2.1 to 2.5. Units of measurement are explained in Appendix 1.

For the basis for and calculations of the MAVs and guideline values, see the datasheets in the Guidelines. The datasheets include determinands the WHO found are unlikely to occur in drinking-water or occur at levels well below those at which toxic effects are observed. References are included in the datasheets.

2.2 The standards

Table 2.1: Maximum acceptable values for microbial determinands

Micro-organism	Maximum acceptable value ¹
<i>Escherichia coli</i> ²	Less than one in 100 mL of sample ³
viruses	No values have been set due to lack of reliable evidence
total pathogenic protozoa	Less than one infectious (oo)cyst per 100 L of sample ⁴

Notes:

1. These are maximum acceptable values for regulatory purposes. They do not represent a dose/response relationship that can be used as the basis for determining acceptable concentrations of pathogens in drinking-water.
2. Indicator organism.
3. For the purposes of any notification requirement set in Part 1 of Schedule 2 of the Public Health Act 2008, 10 in 100 mL of sample. This relies on the assumption at the time of writing that the Public Health Bill is expected to pass in 2008. If it passes in a subsequent year then this should be read as referring to the Public Health Bill passed at a later date.
4. The methods available for enumerating pathogenic protozoa are becoming less expensive and more reliable, but they are not yet suitable for routine monitoring of treated water quality. Although new methods of assessing the infectiousness of protozoa by using human cell cultures have been developed, they are not yet suitable for routine monitoring of *Cryptosporidium* contamination of drinking-water. The referee method cannot identify the species of *Giardia* or *Cryptosporidium*, nor can it determine the viability or infectivity of detected cysts or oocysts (ie, (oo)cysts). Until the methodology improves, results are to be reported as verified (oo)cysts.

Table 2.2: Maximum acceptable values for inorganic determinands of health significance

Name	MAV (mg/L)	Remarks
antimony	0.02	
arsenic	0.01	For excess lifetime skin cancer risk of 6×10^{-4} . PMAV, because of analytical difficulties
barium	0.7	
boron ¹	1.4	
bromate	0.01	For excess lifetime cancer risk of 7×10^{-5} . PMAV
cadmium	0.004	
chlorate	0.8	PMAV. Disinfection must never be compromised. DBP (chlorine dioxide)
chlorine	5	Free available chlorine expressed in mg/L as Cl ₂ . ATO. Disinfection must never be compromised
chlorite	0.8	Expressed in mg/L as ClO ₂ . PMAV. Disinfection must never be compromised. DBP (chlorine dioxide)
chromium	0.05	PMAV. Total. Limited information on health effects
copper	2	ATO
cyanide	0.6	Total cyanides, short-term only
cyanogen chloride	0.4	Expressed in mg/L as CN total. DBP (chloramination)
fluoride ²	1.5	
lead	0.01	
manganese	0.4	ATO
mercury	0.007	Inorganic mercury
molybdenum	0.07	
monochloramine	3	DBP (chlorination)
nickel	0.08	
nitrate, short-term ³	50	Expressed in mg/L as NO ₃ . The sum of the ratio of the concentrations of nitrate and nitrite to each of their respective MAVs must not exceed one
nitrite, long-term	0.2	Expressed in mg/L as NO ₂ . PMAV (long term)
nitrite, short-term ³	3	Expressed in mg/L as NO ₂ . The sum of the ratio of the concentrations of nitrate and nitrite to each of their respective MAVs must not exceed one
selenium	0.01	
uranium	0.02	PMAV

Notes:

1. The WHO guideline value (provisional) is 0.5 mg/L.
2. For oral health reasons, the Ministry of Health recommends that the fluoride content for drinking-water in New Zealand be in the range of 0.7–1.0 mg/L; this is *not* a MAV.
3. Now short-term only. The short-term exposure MAVs for nitrate and nitrite have been established to protect against methaemoglobinaemia in bottle-fed infants.
4. For information about determinands of possible health significance but which do not have a MAV, refer to the datasheets in the Guidelines.

Table 2.3: Maximum acceptable values for organic determinands of health significance (including cyanotoxins and pesticides)

Name	MAV (mg/L)	Remarks
acrylamide	0.0005	For excess lifetime cancer risk of 10 ⁻⁵
alachlor	0.02	Pesticide. For excess lifetime cancer risk of 10 ⁻⁵
aldicarb	0.01	Pesticide
aldrin + dieldrin	0.00004	Pesticide. The sum of, not each
anatoxin-a	0.006	Cyanotoxin. PMAV
anatoxin-a(s)	0.001	Cyanotoxin. PMAV
atrazine	0.002	Pesticide. Cumulative for atrazine and congeners
azinthos methyl	0.004	Pesticide. PMAV
benzene	0.01	For excess lifetime cancer risk of 10 ⁻⁵
benzo(α)pyrene	0.0007	For excess lifetime cancer risk of 10 ⁻⁵
bromacil	0.4	Pesticide. PMAV.
bromodichloromethane	0.06	For excess lifetime cancer risk of 10 ⁻⁵ . THM
bromoform	0.1	THM
carbofuran	0.008	Pesticide
carbon tetrachloride	0.005	
chlordane	0.0002	Pesticide
chloroform	0.4	THM
chlorotoluron	0.04	Pesticide
chlorpyrifos	0.04	Pesticide
cyanazine	0.0007	Pesticide
cylindrospermopsin	0.001	Cyanotoxin. PMAV
2,4-D	0.04	Pesticide
2,4-DB	0.1	Pesticide
DDT + isomers	0.001	Pesticide. Sum of all isomers
di(2-ethylhexyl)phthalate	0.009	
1,2-dibromo-3-chloropropane	0.001	Pesticide. For excess lifetime cancer risk of 10 ⁻⁵
dibromoacetonitrile	0.08	DBP (chlorination)
dibromochloromethane	0.15	THM
1,2-dibromoethane	0.0004	Pesticide. PMAV, for excess lifetime cancer risk of 10 ⁻⁵
dichloroacetic acid	0.05	PMAV. DBP (chlorination)
dichloroacetonitrile	0.02	PMAV. DBP (chlorination)
1,2-dichlorobenzene	1.5	ATO
1,4-dichlorobenzene	0.4	ATO
1,2-dichloroethane	0.03	For excess lifetime cancer risk of 10 ⁻⁵
1,2-dichloroethene	0.06	Total of cis and trans isomers
dichloromethane	0.02	
1,2-dichloropropane	0.05	Pesticide. PMAV
1,3-dichloropropene	0.02	Pesticide. Total of cis and trans isomers. For excess lifetime cancer risk of 10 ⁻⁵
dichlorprop	0.1	Pesticide
dimethoate	0.008	Pesticide
1,4-dioxane	0.05	For excess lifetime cancer risk of 10 ⁻⁵
diuron	0.02	Pesticide. PMAV

Name	MAV (mg/L)	Remarks
EDTA (editic acid)	0.7	
endrin	0.001	Pesticide
epichlorohydrin	0.0005	PMAV
ethylbenzene	0.3	ATO
fenoprop	0.01	Pesticide
hexachlorobutadiene	0.0007	
hexazinone	0.4	Pesticide. PMAV
homoanatoxin-a	0.002	Cyanotoxin. PMAV
isoproturon	0.01	Pesticide
lindane	0.002	Pesticide
MCPA	0.002	Pesticide
mecoprop	0.01	Pesticide
metalaxyl	0.1	Pesticide. PMAV
methoxychlor	0.02	Pesticide
metolachlor	0.01	Pesticide
metribuzin	0.07	Pesticide. PMAV
microcystins	0.001	Cyanotoxin. PMAV. Expressed as MC-LR toxicity equivalents
molinate	0.007	Pesticide
monochloroacetic acid	0.02	DBP (chlorination)
nitrilotriacetic acid (NTA)	0.2	
nodularin	0.001	Cyanotoxin. PMAV
oryzalin	0.4	Pesticide. PMAV
oxadiazon	0.2	Pesticide. PMAV
pendimethalin	0.02	Pesticide
pentachlorophenol	0.009	Pesticide. PMAV
picloram	0.2	Pesticide. PMAV
pirimiphos methyl	0.1	Pesticide. PMAV
primisulfuron methyl	0.9	Pesticide. PMAV
procymidone	0.7	Pesticide. PMAV
propazine	0.07	Pesticide. PMAV
pyriproxifen	0.4	Pesticide
saxitoxins	0.003	Cyanotoxin. Expressed as STX eq. PMAV
simazine	0.002	Pesticide
styrene	0.03	ATO
2,4,5-T	0.01	Pesticide
terbacil	0.04	Pesticide. PMAV.
terbuthylazine	0.008	Pesticide
tetrachloroethene	0.05	
thiabendazole	0.4	Pesticide. PMAV
toluene	0.8	ATO
trichloroacetic acid	0.2	DBP (chlorination)
trichloroethene	0.02	PMVA
2,4,6-trichlorophenol	0.2	For excess lifetime cancer risk of 10^{-5} . ATO
triclopyr	0.1	Pesticide. PMAV

Name	MAV (mg/L)	Remarks
trifluralin	0.03	Pesticide. Technical grade may contain carcinogens
trihalomethanes (THMs)		The sum of the ratio of the concentration of each THM to its respective MAV must not exceed one. The individual members of this group are indicated in the table as THM
vinyl chloride	0.0003	For excess lifetime cancer risk of 10^{-5}
xylene (total)	0.6	ATO
1080	0.0035	Pesticide. PMAV

Notes:

1. Abbreviations are explained in section 2.4.
2. For information about determinands of possible health significance but which do not have a MAV, refer to the datasheets in the Guidelines.

Table 2.4: Maximum acceptable values in Becquerel per litre 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

2.3 Other determinands

Table 2.5: Guideline values for aesthetic determinands

Determinand	GV	Unit	Comments
aluminium	0.10	mg/L	Above this, complaints may arise due to depositions or discoloration
ammonia	1.5	mg/L	Odour threshold in alkaline conditions
calcium			See hardness
chloride	250	mg/L	Taste, corrosion
chlorine	0.6–1.0	mg/L	Taste and odour threshold (MAV 5 mg/L)
2-chlorophenol	0.0001	mg/L	Taste threshold
	0.01		Odour threshold
colour	10	TCU	Appearance
copper	1	mg/L	Staining of laundry and sanitary ware (MAV 2 mg/L)
1,2-dichlorobenzene	0.001	mg/L	Taste threshold
	0.002		Odour threshold (MAV 1.5 mg/L)
1,4-dichlorobenzene	0.0003	mg/L	Odour threshold
	0.006		Taste threshold (MAV 0.4 mg/L)
2,4-dichlorophenol	0.0003	mg/L	Taste threshold
	0.04		Odour threshold
ethylbenzene	0.002	mg/L	Odour threshold
	0.08		Taste threshold (MAV 0.3 mg/L)

Determinand	GV	Unit	Comments
hardness (total) (Ca + Mg) as CaCO ₃	200	mg/L	High hardness causes scale deposition, scum formation. Low hardness (<100) may be more corrosive
	100–300		Taste threshold
hydrogen sulphide	0.05	mg/L	Taste and odour threshold
iron	0.2	mg/L	Staining of laundry and sanitary ware
magnesium			See hardness
manganese	0.04	mg/L	Staining of laundry
	0.10		Taste threshold (MAV 0.4 mg/L)
monochlorobenzene	0.01	mg/L	Taste and odour threshold
pH	7.0–8.5		Should be between 7 and 8. Most waters with a low pH have a high plumbosolvency. Waters with a high pH: have a soapy taste and feel. A pH less than 8 is preferable for effective disinfection with chlorine
sodium	200	mg/L	Taste threshold
styrene	0.004	mg/L	Odour threshold (MAV 0.03 mg/L)
sulphate	250	mg/L	Taste threshold
taste			Should be acceptable to most consumers
temperature			Should be acceptable to most consumers, preferably cool
toluene	0.03	mg/L	Odour
	0.04		Taste threshold (MAV 0.8 mg/L)
total dissolved solids	1000	mg/L	Taste may become unacceptable from 600–1200 mg/L
trichlorobenzenes (total)	see below		
1,2,3-trichlorobenzene	0.01	mg/L	Odour threshold
1,2,4-trichlorobenzene	0.005	mg/L	Odour threshold
1,3,5-trichlorobenzene	0.05	mg/L	Odour threshold
2,4,6-trichlorophenol	0.002	mg/L	Taste threshold
	0.3	mg/L	Odour threshold (MAV 0.2 mg/L)
turbidity	2.5	NTU	Appearance. See compliance criteria for effects on disinfection
xylene	0.02	mg/L	Odour threshold (MAV 0.6 mg/L)
zinc	1.5	mg/L	Taste threshold. May affect appearance from 3 mg/L

Notes:

1. Potable water that does not contain or exhibit any determinands that exceed these guideline values is defined as wholesome water, see section 1.3.
2. Abbreviations are explained in section 2.4.

2.4 Abbreviations used in Tables 2.1–2.5

The following abbreviations are used in Tables 2.1–2.5.

ATO	Concentrations of the substance at or below the health-based guideline value that may affect the water's appearance, taste or odour, see Table 2.5
DBP	Disinfection by-product. Any difficulty meeting a DBP MAV must never be a reason to compromise adequate disinfection. Trihalomethanes and haloacids are DBPs. Some DBPs may also have other sources
GV	Guideline value
MAV	Maximum acceptable value
MC-LR	Microcystin-LR
NTU	Nephelometric turbidity unit
PMAV	Provisional MAV (because it is provisional in the WHO Guidelines (GDWQ) or the WHO has no guideline value but the DWSNZ has retained a MAV or developed its own)
STXeq	Saxitoxin-equivalent
TCU	True colour unit. The colour after the sample has been filtered. One TCU is equivalent to 1 Hazen unit and to 1 Pt/Co unit. For more information, see the Guidelines, section 18.2.1
THM	Trihalomethane, of which there are four: bromoform, bromodichloromethane, chloroform and dibromochloromethane
WHO	World Health Organization

For a listing of determinand abbreviations and synonyms, see the Guidelines, Appendix 6.

3 Compliance and Transgressions

3.1 Introduction

This section of the DWSNZ introduces the compliance criteria that are used in sections 4 to 12 to assess whether the level of compliance with the water quality standards (section 2) is acceptable.

The DWSNZ specify the minimum compliance criteria for bacteria, protozoa, cyanotoxins, chemicals and radioactive materials of public health significance in drinking-water for different categories of water supply, including MAVs for determinands and operational requirements for associated treatment processes.

The assessment of bacterial, chemical and radiological compliance requires that the determinands or operational requirements specified in the DWSNZ be monitored.

The degree of treatment that raw water requires to enable it to comply with the Standards depends on the level of contaminants in the source water. Poor quality raw water requires a greater degree of treatment than does good quality raw water.

Apart from **bore waters** confirmed as **secure bore water**, all source waters are assumed to contain faecal bacteria, so require some form of **disinfection** or process that will reliably remove bacteria. The bacterial compliance criteria are in section 4.

Raw water from surface sources or non-secure bore water requires treatment that qualifies for 2, 3, 4 or 5 protozoa log credits, depending on the protozoal risk arising from the quality of the source water.

Monitoring for protozoa in treated water is currently impracticable, so treatment performance is assessed against operational requirements. The protozoal compliance criteria are in section 5. If water treatment fails to meet the required number of log credits or the operational requirements are not met, the supply is **non-compliant**. Protozoa that have been inactivated by disinfection processes will still be present, but they will not be **infectious**.

Sample sites must be representative of the water being tested. Procedures for sample collection, preservation, transport and storage, test methods and reporting must be agreed beforehand with the Ministry of Health **recognised laboratory** that will carry out the analysis. If a Ministry of Health recognised laboratory is not being used, the Ministry of Health must approve these procedures in writing. Recognised laboratories are recorded at www.moh.govt.nz/water and www.drinkingwater.org.nz

If testing the water supply for other than compliance purposes indicates a possible health risk, the results must be reported to the DWA.

The Water Information New Zealand (WINZ) database provides an up-to-date record of the data required for managing drinking-water quality, such as characteristics of the supply, public health grading and compliance with the DWSNZ². Most water suppliers have chosen to use WINZ. Data from WINZ are used to compile the Register of Community Drinking-water Supplies and Suppliers in New Zealand (eg, Ministry of Health 2008b).

To avoid confusion, all correspondence regarding the application of the provisions of the Act to a particular water supply must specify the relevant site identification codes as listed in the Register of Drinking-water Suppliers and Supplies in New Zealand.

2. Water Information New Zealand is a comprehensive drinking-water information system Environmental Science & Research (ESR) developed for the Ministry of Health.

3.1.1 Compliance

The steps necessary to demonstrate that a drinking-water supply is in bacterial, protozoal, cyanotoxin, chemical and radiological compliance with the DWSNZ are defined in their specific compliance criteria sections.

A drinking-water supply complies with the DWSNZ when the following occur.

1. The concentration of a determinand in a sample of the drinking-water does not exceed the MAV more often than is permitted in Table A1.4, Appendix A1.8.
2. An operational requirement does not move outside its limit for more than its allowed frequency or duration of the **compliance monitoring period**.
3. The number of measurements made for each compliance criterion is equal to or greater than that specified in the DWSNZ; for intermittent supplies, variations must be agreed with the DWA.
4. Sampling, **standardising**, testing and reporting procedures meet the requirements of the DWSNZ.
5. The requirements of the compliance criteria have been met throughout the previous 12 months.
6. The remedial actions specified in the DWSNZ have been carried out when there has been a transgression or an excursion beyond an operational requirement.

The compliance monitoring period is the period that a MAV or an operational requirement is monitored to check that it does not move outside its limit for more than the allowed frequency or duration. The compliance monitoring period varies from a day to a year, depending on the determinand and the circumstances. Its purpose is to enable sufficient time to gather data for assessment of compliance in a statistically meaningful manner.

The allowable number of MAV **exceedences** (Table A1.4) is calculated on the basis that there is 95 percent confidence that the supply complies with the DWSNZ for 95 percent of the time.

In section 5 (protozoal compliance), each qualifying treatment process is assigned a number of log credits based on the percentage removal or **inactivation** achieved by that process. Many treatment plants will operate more than one treatment process. If the sum of the log credits of each process in operation equals or exceeds the log credit requirements required for effective treatment of the **plant inlet water**, the plant will be in protozoal compliance.

If the operational requirements for a particular protozoal process meet their performance specifications, the log credits received become those specified in the relevant sections. A failure to meet an operational requirement will not cause the supply to fail compliance so long as it can achieve the necessary log credit total (section 5.2.1) through the accumulation of log credits from other processes being employed.

Laboratories conducting compliance testing must be recognised for the purpose by the Ministry of Health. This requires the laboratory to demonstrate compliance with the relevant clauses of the *General Requirements for the Competence of Testing and Calibration Laboratories* (NZS ISO/IEC 17025) (IANZ 2005). Special procedures may be authorised in writing by the Ministry for small or remote drinking-water supplies. Recognised laboratories are defined in section 69ZY of the Act.

The DWA must assess the competence of the analyst for commonly performed treatment plant or distribution system analyses (field tests) (see sections 69ZL(1)(e) and (f) and 69ZP(1)(h) of the Act). Analysts must be certified as competent if carrying out compliance testing.

Field tests include FAC, ozone, chlorine dioxide, **pH**, temperature, turbidity, particle counting, direct integrity, differential pressure, **ultraviolet light (UV)** irradiance, and some *E. coli* tests. For the standardisation of online instruments, see Appendix 2.

The referee methods specified in Appendix 2 are the definitive methods for demonstrating compliance with the DWSNZ. Alternative methods are acceptable but must have been **calibrated against the referee methods**, to the satisfaction of International Accreditation New Zealand (see NIWA 2007). In the event of any dispute about differences in analytical results, results obtained using the referee method will be deemed to be correct.

The tables in Appendix 2 assist in the selection of the appropriate sampling and analytical methods for the chemicals with MAVs.

3.1.2 Transgressions and non-compliance

Section 3.1.1 lists six requirements that need to be met to achieve compliance with the DWSNZ. As soon as a supplier is aware that there has been a failure to meet any of these requirements, they must advise the DWA and take the appropriate remedial action.

The supplier's monitoring programme should include additional samples to meet any deficiencies that arise from a failure to comply with the programme prescribed in the DWSNZ³. These additional results may offset any subsequent failure to carry out adequate monitoring, provided the DWA considers the circumstances giving rise to the deficit are justifiable.

Water suppliers may use the appeal provisions in the Act if they disagree with a determination of non-compliance (see section 1.9).

Well-managed water supplies will have **control limits**, which will trigger an appropriate response before a transgression or non-compliance occurs. A MAV transgression or an operational requirement moving outside its limit (even within its permitted frequency or duration), warns that the water supply or treatment process is approaching non-compliance. Water suppliers must start remedial action and inform the DWA as required in the relevant compliance criterion section. Water suppliers must not wait until a supply is non-compliant before taking remedial action.

A major transgression is an occurrence that immediately threatens the safety of the consumers of the drinking-water. Most major transgressions are likely to result from inadequate control of a treatment process or a failure to protect the distribution system. A major transgression may involve a situation not covered by the DWSNZ. Major transgressions can be identified by any of the following.

- The presence in the treated drinking-water of:
 - excessive concentrations of *E. coli* (more than 10 per 100 mL)
 - infectious protozoa or other micro-organisms
 - cyanotoxins or chemical determinands at a concentration sufficient to cause acute adverse health effects (ie, much higher than the MAV).
- The treatment system's inability to disinfect to the level necessary to achieve satisfactory disinfection.
- The treatment system's inability to provide an adequate barrier to chemicals or particles in the water.

Major transgressions are serious. The water supplier must carry out the actions specified in the DWSNZ immediately, which includes informing the DWA so the DWA can help to identify the steps needed to protect consumers. In the case of a major transgression, a medical officer of health may issue a water supplier with a compliance order to take appropriate action to protect public health under section 69ZZH of the Act.

3. WINZ can be used to check that a monitoring programme will be compliant.

3.2 Continuous monitoring requirements

Continuous monitoring of parameters to assess compliance must meet the following requirements.

1. The separation between data records is not to be more than:
 - a. one minute for measurements at the treatment plant of:
 - i. turbidity
 - ii. ozone concentration
 - iii. differential pressure
 - iv. flow
 - v. parameters for UV disinfection (section 5.16.3, Table 5.7)
 - vi. parameters used for indirect integrity testing for membrane filtration (section 5.11.2)
 - b. five minutes for measurements at the treatment plant of:
 - i. chlorine concentration
 - ii. pH
 - iii. chlorine dioxide concentration
 - c. 15 minutes for measurements in the distribution system.

Compliance with the DWSNZ requires some determinands not to exceed a certain value for more than three, five or 15 minutes. This requires **accuracy** in time measurement and recording to ensure no short-term transgressions go unrecorded. Generally, for remote measurements, unless a high-speed communications network is used, this requires the remote terminal unit to time-stamp the data as it is recorded. The sampling frequency must be as specified above. Where this cannot be achieved at present, suitable equipment must be installed and operating as stated in section 69C of the Act.

The data records may be compressed using a procedure that preserves the accuracy of the original measurements. Data must be reported as a percentage of the time (or duration, where required) that the value was exceeded (or met) during the compliance monitoring period.

2. Continuous monitors (where installed for compliance testing) must be standardised at least as frequently as recommended by the equipment suppliers and must provide an **alarm** system (eg, for **disinfection residual**, turbidity or to monitor dosage) that can prompt a site visit, without delay, to rectify any fault.
3. When disinfection dosing or its monitoring fails to meet the relevant criteria, there is no longer confidence that the water supply is safe. The water supplier must inform the DWA and take the following actions immediately if disinfection or disinfection monitoring equipment fails for more than one hour.
 - a. Check whether the problem relates to dosage or monitoring.
 - b. In the case of a dosage failure, carry out the remedial actions as specified in the relevant sections and Figures 4.1, 4.2 and 5.2 as applicable.
 - c. In the case of a monitoring failure, carry out manual monitoring (see the relevant sections).
 - d. To avoid a false record of non-compliance when the water is not being supplied for drinking, record and report the duration that the water supply or unit is off-line, and do not report the **compliance monitoring** results for the off-line period.
4. Where turbidity measurement is required at the treatment plant, all filters and treatment streams must have independent monitors. As an interim measure for small supplies where filters may share turbidimeters, until one turbidimeter is installed on each filter, monitoring must be carried

out in such a way as to give the greatest period of continuous monitoring possible with the existing configuration.

3.3 Priority classes for drinking-water determinands

The determinands of public health significance have been divided into four priority classes to minimise monitoring costs without compromising public health: Priorities 1 to 4.

To demonstrate compliance, only those relatively few determinands that fall into the classes with highest potential risk, Priorities 1 and 2, must be monitored.

Monitoring of determinands in the lower potential risk categories, Priorities 3 and 4, is at the supplier's discretion, unless the DWA requires it for public health reasons.

3.3.1 Priority 1 determinands

Priority 1 determinands are those 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 such materials. Humans, birds, or animals may be the source. Determinands that fall into this category in New Zealand include pathogenic bacteria, protozoa and **viruses**. This may change as new evidence becomes available.

E. coli, a common gut bacterium living in warm-blooded animals, is used as an indicator of the contamination of water by excrement. It is an internationally accepted indicator for faecal material, indicating the potential presence of pathogenic bacteria.

Priority 1 determinands are:

- *E. coli*
- protozoa (*Cryptosporidium*⁴ and *Giardia*).

Priority 1 determinands apply to all community drinking-water supplies and must be monitored in all supplies because they constitute major public health risks. The only exception is secure bore water (section 4.5). Water that has been granted **interim bore water security** status does not need to be monitored for protozoa (section 5.1).

Compliance with the bacterial criteria is determined by conventional bacteriological techniques or when the treatment process used meets specified performance requirements. Compliance with the protozoa criteria is achieved when the treatment process used meets specified performance requirements.

The criteria used for protozoal compliance in the DWSNZ are based on the use of:

1. turbidity, to assess the effectiveness of conventional treatment using coagulation plus filtration (direct filtration or filtration with sedimentation or dissolved air flotation), diatomaceous earth filtration and slow sand filtration
2. particle counting, once a relationship between particle counts and filtration efficiency has been established
3. **direct integrity testing** of membrane filtration plants

4. *Cryptosporidium* is the reference protozoan. It is more difficult to treat than *Giardia*, so any measures taken to manage risks from *Cryptosporidium* will also manage risks from *Giardia*.

4. indirect integrity testing (such as pressure drop, turbidity and some operating conditions) for **bag filters, cartridge filtration** and membrane filtration
5. **contact time** (C.t) values, monitoring the chemical disinfectant's residual and operating conditions to assess the adequacy of disinfection
6. specified dosage and operating conditions for effective UV disinfection
7. demonstrations that bore water is secure.

3.3.2 Priority 2 determinands

Priority 2 determinands are those determinands of public health significance in a specific supply or **distribution zone** that are present at concentrations that exceed 50 percent of the MAV and, for micro-organisms, are present at concentrations that represent an unacceptable risk to health. Determinands specified by the Ministry of Health to be Priority 2 for the supply under consideration must be monitored to establish compliance with the DWSNZ.

The assignment of a determinand to Priority 2 in a given drinking-water supply is based on **surveillance** monitoring and knowledge of the sources of health-significant determinands in the catchment, treatment processes and distribution system, based on The Priority 2 Chemical Determinands Identification Programme.

The DWA responsible for assessing the drinking-water supply notifies the water supplier of the designation after consulting the supplier and reviewing the evidence. Water suppliers may use the appeal provisions in the Act if they disagree with the designation of a Priority 2 determinand (section 1.9).

The Priority 2 determinands for individual drinking-water supplies are listed in the Register of Community Drinking-water Supplies and Suppliers in New Zealand (eg, Ministry of Health 2008b). The requirement to monitor starts from the date the Ministry of Health formally notifies the supplier of the determinand's designation as Priority 2, not from the date of its publication in the register.

Priority 2 determinands are divided into four types: Priorities 2a, 2b, 2c and 2d.

- *Priority 2a* determinands are chemical and radiological determinands that could be introduced into the drinking-water supply by the treatment chemicals at levels potentially significant to public health (taken as greater than 50 percent of the MAV).

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

- *Priority 2b* determinands are 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 of the 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 drinking-water from the distribution system other than the consumer's plumbing, or other materials present in the water when sampled under flushed protocols.

Cyanotoxins can develop rapidly in **surface waters** and many treatment processes will not remove them. There is no simple relationship between their appearance and the concentrations of the cyanobacteria (blue-green **algae**) that produce them. Because of this, and because they are very toxic, the monitoring requirements differ from those of most other Priority 2b chemical determinands.

- *Priority 2c* determinands are chemical determinands of health significance that may appear in consumers' drinking-water, having arisen from their plumbing or fittings.

The term ‘aggressiveness’ was used in the DWSNZ 2005. ‘Aggressiveness’ has been replaced by the term ‘plumbosolvency’ in these DWSNZ, but is not meant to imply that lead is the only determinand of concern.

Plumbosolvent water is a category of drinking-water in which metals of health concern are generally found in the first portion of water collected from the tap but occur at a much lower concentration after flushing the tap; metals in the water after flushing are Priority 2b determinands. Priority 2c determinands are produced by the corrosion of the consumer’s tap and associated fittings so that one or more metals (eg, lead, nickel, cadmium or antimony) dissolve into the water.

Similarly, the copper MAV may be exceeded at the consumer’s tap, particularly when water containing free (aggressive) carbon dioxide causes corrosion of copper tubing.

See sections 8.2.1.4 and 8.3.5.2 for issues related to chemical compliance for Priority 2c determinands.

- *Priority 2d* determinands are micro-organisms of health significance that have been demonstrated to be present in the drinking-water supply.

Any micro-organism may be listed as a Priority 2d determinand if there is reason to suspect it is likely to be present in the drinking-water supply at a concentration that represents an unacceptable risk to health. 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 DWA may declare such organisms as Priority 2d if a specific contamination situation or epidemiological grounds exist for suspecting the drinking-water supply.

The monitoring protocols that apply will be specified when the micro-organisms are assigned Priority 2d status and will usually include a **catchment assessment** to try to identify the source of the contamination.

A Priority 2 determinand may be relegated to Priority 3 or Priority 4 with the Ministry of Health’s consent when monitoring demonstrates that the Priority 2 assignation is no longer appropriate (see section 8.2.2).

3.3.3 Priority 3 determinands

The water supplier does not have to monitor Priority 3 determinands to demonstrate compliance with the DWSNZ. The Ministry of Health will carry out investigations on water supplies from time to time to assess whether Priority 3 determinands should be elevated to Priority 2 until the drinking-water suppliers’ risk assessment procedures are adequate for the supplier to do such investigations themselves.

Priority 3 determinands comprise:

- chemical and radiological determinands of health significance not known to occur in the drinking-water supply at greater than 50 percent of the MAV
- micro-organisms of health significance that could be present in the water supply
- determinands of aesthetic significance known to occur in water supplies.

Most determinands listed in Tables 2.2 to 2.4 are Priority 3 unless they have been assigned to Priority 2a or Priority 2b for a particular supply; a few are Priority 4.

Pathogenic micro-organisms are Priority 3 unless they have been assigned to Priority 2d for a particular supply. Although Priority 3 micro-organisms may have a MAV, no related compliance criteria exist until they are assigned to Priority 2, when the DWA will set compliance criteria depending on the circumstances.

Aesthetic determinands with guideline values (Table 2.5) are classified as Priority 3 because, although they do not pose a direct threat to public health, people judge drinking-water mainly on the aesthetic characteristics of appearance, taste and smell. Therefore, 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 suppliers monitor these determinands.

3.3.4 Priority 4 determinands

Priority 4 determinands comprise:

- chemical and radiological determinands of health significance known not to be likely to occur in the drinking-water supply
- micro-organisms of health significance known not to be likely to be present in the drinking-water supply
- determinands of aesthetic significance not known to occur in the drinking-water supply.

Priority 4 determinands for a specific supply include those health-significant or aesthetic determinands for which sufficient information exists 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-waters because they are not used in New Zealand. They are included in the tables to ensure MAVs are available should they be used in the future.

Priority 4 determinands of health significance may become Priority 2 if the Ministry of Health considers this warranted, and Priority 4 aesthetic determinands may become Priority 3 and be given a guideline value.

4 Bacterial Compliance Criteria

4.1 Introduction

It is impracticable to monitor water supplies for all potential human pathogens, so surrogates are used to indicate possible contamination with human and animal excrement, the most frequent source of health-significant microbial contamination of water supplies. In the DWSNZ, *E. coli* is used as an **indicator organism** for contamination of drinking-water by faecal material.

Total coliforms, presumptive coliforms or thermotolerant coliforms may be used to demonstrate compliance with the DWSNZ instead of *E. coli*, but these may lead to false assumptions that faecal contamination has occurred. If they are used, a positive result must be treated as though it were a positive *E. coli* result.

If any bacteria have been designated as Priority 2d, they must be monitored at a frequency and for a duration specified by the DWA.

E. coli must not be present in drinking-water leaving the **water treatment plant** or in the distribution zones. If present, the immediate response specified in the following sections must be followed and a record of the remedial actions provided to the DWA.

If more than 0.2 mg/L of FAC is maintained in the distribution system, **coliform bacteria** and *E. coli* are rarely found. For this reason, supplies serving a population greater than 500 may substitute monitoring of FAC for some *E. coli* monitoring in the distribution system; full substitution is acceptable for water leaving the treatment plant and water in a **bulk distribution zone**.

The efficacy of chlorine dioxide is equivalent to that of chlorine, that is, a concentration of 0.2 mg/L of chlorine dioxide (measured as ClO_2) is considered to have a similar disinfecting power as 0.2 mg/L of FACE (section 4.3.2).

Annual bacterial compliance requires that, depending on the compliance criterion in use, the appropriate requirements of sections 4.3 and 4.4 are met during each compliance monitoring period over 12 consecutive months.

4.2 Content

Separate bacterial compliance criteria have been established for:

- water leaving the treatment plant (section 4.3)
- water in the distribution system (section 4.4)
- secure bore water (section 4.5).

Section 4.3 deals with water leaving the treatment plant:

- undisinfected or *E. coli*-only monitoring (section 4.3.1, criterion 1)
- with a disinfectant residual (section 4.3.2) after:
 - **continuously monitored chlorination** (section 4.3.2.1, criterion 2A)
 - **non-continuously monitored chlorination** (section 4.3.2.2, criterion 2B)
 - chlorine dioxide treatment (section 4.3.3, criterion 3)

- disinfected but with no disinfectant residual:
 - ozone disinfected (section 4.3.4, criterion 4)
 - UV disinfected (section 4.3.5, criterion 5).

4.3 Compliance criteria for drinking-water leaving the treatment plant

To demonstrate bacterial compliance for water leaving the treatment plant, one of the bacterial compliance criteria 1 to 5 must be met.

When there is no disinfection, or if **chloramination** is used, criterion 1 must be used. The criteria for supplies disinfected with chlorine, chlorine dioxide, ozone and UV are in sections 4.3.2 to 4.3.5 respectively. Water suppliers may still use compliance criterion 1, provided they have previously nominated this criterion.

Compliance monitoring periods for bacterial compliance are listed in Table 4.1.

4.3.1 Compliance criterion 1 for drinking-water leaving the treatment plant

4.3.1.1 Compliance criteria

The following requirements apply to water leaving the treatment plant when *E. coli* monitoring is the only method being used to demonstrate bacterial compliance.

1. The water leaving the treatment plant must be monitored for the presence of *E. coli* at a frequency equal to or greater than that specified in section 4.3.8.1, Table 4.2a, for the population band to which the water supply belongs.
2. The number of 100 mL samples in which *E. coli* is found must be equal to or less than the allowable number of exceedences given in Table A1.4, Appendix A1.8, over the compliance monitoring period (Table 4.1).
3. The sampling and analytical requirements specified for *E. coli* in sections 4.3.6.2, 4.3.7.1 and 4.3.8.1 must be met.

4.3.1.2 Remedial action

See section 4.3.9 and Figure 4.1 for remedial actions if *E. coli* (or equivalent) is found in any sample.

Table 4.1: Compliance monitoring periods for bacterial compliance of water leaving the treatment plant

Determinand or operational requirement	Population served	Compliance monitoring period
Manual monitoring <i>E. coli</i> ¹	Up to 5000	One year
	5000 and over	One quarter
free available chlorine, turbidity and pH ²	Up to 500	One year
	501–5000	One quarter
Continuous monitoring chlorine dioxide, turbidity and pH ³ free available chlorine, turbidity and pH ⁴	All	One day

Notes:

For bacterial compliance monitoring of ozone and UV disinfection, see sections 5.15 and 5.16 respectively.

1. Does not apply to criterion 2A.
2. Refers to criterion 2B only.
3. If using section 4.3.3.1 option 1, see section 5.14.
4. Refers to criterion 2A only.

4.3.2 Compliance criterion 2 for drinking-water disinfected with chlorine leaving treatment plant with chlorine residual

For the purpose of criterion 2, chlorination is categorised as one of:

- continuously monitored chlorination (criterion 2A)
- non-continuously monitored chlorination (criterion 2B); not applicable to water supplies serving a population greater than 5000.

Criteria 2A and 2B apply when chlorination is continuous; otherwise criterion 1 must be used.

The FAC is monitored and FACE is calculated. FACE is the FAC concentration that would have the same disinfecting power as the chlorine solution would have when adjusted to a pH of 8.0. Appendix A1.5.12 includes an equation that converts FAC/pH readings to FACE.

4.3.2.1 Compliance criterion 2A for continuously monitored chlorine disinfected water leaving the treatment plant

Criterion 2A applies to drinking-water that receives continuously monitored chlorination before leaving the treatment plant. It allows bacterial compliance to be demonstrated without *E. coli* monitoring. The following requirements must be met.

1. The sampling and analytical requirements in sections 4.3.6 and 4.3.7 must be met, where applicable.
2. The FAC, pH and turbidity must be monitored continuously (sections 3.2 and 4.3.8.2 to 4.3.8.4).
3. The FACE in the water leaving the treatment plant must be at least 0.20 mg/L for 98 percent or more of the compliance monitoring period (Table 4.1).
4. The chlorine contact time must be more than 30 minutes, taking account of short-circuiting in the contact tank (advice on the contact time is in the Guidelines, section 15.2.9).

5. Measurements of the water's turbidity must satisfy the following requirements. See Figure 4.1 for remedial actions.
 - a. The turbidity is less than 1.0 **nephelometric turbidity unit (NTU)** for at least 95 percent of the compliance monitoring period (Table 4.1).
 - b. The turbidity does not exceed 2.0 NTU for the duration of any three-minute period.

4.3.2.2 Compliance criterion 2B for non-continuously monitored chlorine disinfected water leaving the treatment plant supplying populations up to 5000

Criterion 2B applies to drinking-water that receives 'non-continuously monitored chlorination' before leaving a treatment plant. Plants in which the chlorine is always dosed to achieve a FACE of at least 0.20 mg/L but that do not satisfy other requirements of criterion 2A are classed as receiving 'non-continuously monitored chlorination'. To comply with criterion 2B requirements, the following requirements must be met.

1. The water leaving the treatment plant must be monitored for the presence of *E. coli* at a frequency equal to or greater than that specified in section 4.3.8.1, Table 4.2a, for the population band to which the water supply belongs.
2. The number of 100 mL samples in which *E. coli* is found must be equal to or less than the allowable number of exceedences given in Appendix A1.8, Table A1.4, over the compliance monitoring period (Table 4.1).
3. The analytical and sampling requirements in sections 4.3.6 and 4.3.7.
4. The FAC, pH and turbidity must be monitored at least at the frequencies specified in sections 4.3.8.2 to 4.3.8.4 respectively and summarised in Table 4.2b.
5. The FACE must not be less than 0.20 mg/L in any sample.
6. The chlorine contact time must be more than 30 minutes, allowing for short-circuiting in the contact tank (advice on contact time is in the Guidelines, section 15.2.9).
7. Measurements of the water's turbidity must satisfy the following requirements.
 - a. The number of samples with turbidity greater than 1.0 NTU does not exceed the number allowed in Appendix A1.8, Table A1.4, over the compliance monitoring period (Table 4.1).
 - b. The turbidity does not exceed 2.0 NTU in any sample.

4.3.2.3 Remedial actions for criteria 2A and 2B

If any of the requirements of section 4.3.2.1 (criterion 2A) or section 4.3.2.2 (criterion 2B) are not met, perform the remedial actions in section 4.3.9 and Figure 4.1.

4.3.3 Compliance criterion 3 for drinking-water leaving the treatment plant disinfected with chlorine dioxide

Chlorine dioxide must not be used if the resultant chlorite concentration in the water exceeds the chlorite MAV (0.8 mg/L). Chlorite is potentially a Priority 2a determinand. See also sections 5.14 and 8.3.3.

4.3.3.1 Compliance criteria

Chlorine dioxide-disinfected water supplies can achieve bacterial compliance by meeting one of the following.

1. Satisfying the protozoal compliance requirements by using chlorine dioxide (section 5.14, 0.25 log credits or more) automatically achieves bacterial compliance, and no additional monitoring is required.

2. If chlorine dioxide is being used to achieve bacterial compliance only, the requirements of section 4.3.2.1 must be satisfied, except that references to FAC monitoring are replaced by chlorine dioxide and FAC (if present) monitoring. The concentrations of chlorine dioxide and FAC may be summed.

4.3.3.2 Remedial action

If any of the requirements of sections 4.3.3.1 are not met, perform the remedial actions in section 4.3.9 and Figure 4.1 (or Figure 5.2, if relevant).

4.3.4 Compliance criterion 4 for drinking-water leaving the treatment plant disinfected with ozone

Ozone must not be used if the resulting concentration of bromate exceeds the bromate MAV (0.01 mg/L). Bromate is potentially a Priority 2a determinand. See also sections 5.15 and 8.3.3.

4.3.4.1 Compliance criteria

Satisfying the protozoal compliance requirements by using ozone (section 5.15, 0.25 log credits or more) automatically achieves bacterial compliance, and no additional monitoring is required.

If ozone disinfection is used to achieve only bacterial compliance the following must be achieved.

1. The ozone dose must result in a C.t of at least 0.5 (eg, a residual of 0.05 mg/L after 10 minutes in the reactor).
2. All water must pass through the ozone contactor.
3. The ozone concentration and flow must be monitored at frequencies at least those specified in section 4.3.8.6. For information on the residual ozone sampling site and standardisation, see sections 5.15.2(2) and 5.15.3. For continuous monitoring, the requirements of section 3.2 must be met. For supplies serving up to 500 people, the flow through the equipment must be restricted so that the flow rate cannot exceed the flow that gives the contact time required to meet the target **C.t value**.
4. The C.t value must be calculated at the frequency specified in section 4.3.8.6, and for:
 - a. continuous monitoring, the C.t value determined from the measured ozone residual and contact time must be at least 0.5 for more than 95 percent of the compliance monitoring period
 - b. non-continuous monitoring, the number of C.t values determined from the measured ozone residual and contact time that fail to meet the C.t value of 0.5 must not exceed the number allowed in Appendix A1.8, Table A1.4, over the compliance monitoring period.
5. For *E. coli* monitoring:
 - a. water leaving the treatment plant must be monitored for the presence of *E. coli* at a frequency at least that specified in section 4.3.8.1 and Table 4.2a
 - b. the number of 100 mL samples in which *E. coli* is found must not exceed the allowable number of exceedences in Appendix A1.8, Table A1.4, over the compliance monitoring period
 - c. the sampling and analytical requirements specified for *E. coli* in sections 4.3.6, 4.3.7.1 and 4.3.8.1 must be met.
6. The turbidity of the water passing through the reactor:
 - a. for continuous monitoring, must not exceed 2.0 NTU for more than 5 percent of the compliance monitoring period

- b. for non-continuous monitoring, the number of samples with turbidity greater than 2.0 NTU must not exceed the number allowed in Appendix A1.8, Table A1.4, over the compliance monitoring period
- c. must be monitored according to the requirements of sections 4.3.7.4 and 4.3.8.4.

7. The compliance monitoring periods are in section 4.3, Table 4.1.

4.3.4.2 Remedial action

If any of the requirements of section 4.3.4.1 are not met, perform the remedial actions in section 4.3.9 and Figure 4.1 (or Figure 5.2, if relevant).

4.3.5 Compliance criterion 5 for drinking-water leaving the treatment plant disinfected with ultraviolet light

If the protozoal compliance requirements are met with UV light using a dose equivalent to 40 mJ/cm² (section 5.16), bacterial compliance is automatically achieved, and no additional monitoring is required; otherwise, bacterial compliance must be met by using bacterial compliance criterion 1, criterion 2, criterion 3 or criterion 4.

4.3.6 Compliance sampling and on-site analytical procedures

4.3.6.1 General

Compliance testing must be conducted by laboratories recognised by the Ministry of Health for this purpose. The competence of persons conducting field tests must be assessed by a DWA (section 3.1.1). Procedures for sample collection and storage, testing and reporting must be appropriate (sections 3.1, 3.2 and 13).

Referee methods for Priority 1 determinands and related operational requirements are in Appendix A2, which includes procedures for standardisation and verification, where appropriate. Sampling sites and frequencies are discussed in sections 4.3.7 and 4.3.8 (water leaving the treatment plant), 4.4.3 and 4.4.4 (water in the distribution zone), and 4.4.7.3 and 4.4.7.4 (water in bulk distribution zones).

When it is not reasonably practicable to follow the above procedures, see section 3.1.1.

4.3.6.2 *Escherichia coli*

Samples for *E. coli* testing must be collected aseptically, using sodium thiosulphate to dechlorinate the sample if necessary. Testing should start within six hours of sample collection and must not be delayed more than 24 hours after collection. Sample bottles must be transferred in a dark container. To be valid for compliance testing, samples must not be frozen and must arrive at the laboratory at a temperature not higher than 10°C or not higher than the temperature of the water being sampled. If samples cannot be processed immediately on their arrival in the laboratory, they must be stored in a refrigerator at a temperature not exceeding 5°C.

4.3.7 Sampling sites for bacterial compliance of water leaving the treatment plant

4.3.7.1 *Escherichia coli*

Samples for *E. coli* must be taken from drinking-water leaving the treatment plant at a point after the prescribed disinfection contact time has elapsed but before the first consumer. If samples are being collected to demonstrate bore water security criterion 3, they must be collected before any treatment or storage (section 4.5).

For supplies serving up to 500 people and with only one distribution zone, samples prescribed to be

taken from water leaving the treatment plant may be taken from the distribution zone instead. This is on condition the ‘treatment plant’ samples are taken from the first available tap after the treatment plant and sampling is at the frequency specified in Table 4.2a. These samples are additional to those required for monitoring the distribution zone (Table 4.3a) that are to be collected from points closer to the extremities of the distribution zone.

The samples prescribed to be taken from water leaving the treatment plant may be omitted for supplies to a single building (or a complex of not more than three buildings networked by reticulated pipework) that serve a population of less than 150 people.

4.3.7.2 Disinfectants

Chemical disinfectants are very reactive so must be measured in the field. Care is required in selecting the sample site when checking online instruments. For further discussion, see the Guidelines, section 15.5.1.3.

Samples for FAC (and, if relevant, chlorine dioxide) must be taken from drinking-water leaving the treatment plant at a point after the prescribed disinfection contact time has elapsed but before the first consumer. The disinfectant residual measurement must be made as close as practicable to where the *E. coli* samples are taken.

Online process control measurements of FAC or chlorine dioxide concentration made after only a short contact time may be used instead of readings from drinking-water leaving the plant provided:

- a reliable correlation has been established, documented and monitored, between the disinfectant concentration after the short contact time and its concentration in the water leaving the treatment plant
- the minimum value of the process control FAC or chlorine dioxide concentration that has been established to be necessary to attain a minimum FAC or chlorine dioxide concentration of 0.2 mg/L in the water leaving the treatment plant becomes the value used to demonstrate compliance.

Appliances used for disinfection with UV light must have a built-in, online UV sensor. Ozone dosing equipment for supplies serving a population greater than 500 must have a built-in sensor to continuously monitor the ozone residual.

4.3.7.3 pH

Samples must be taken close to where the disinfectant is measured.

4.3.7.4 Turbidity

Samples must be taken close to where the disinfectant is measured. There must be no settling of particles in the line between the sample point and instrument (for a discussion on sampling, see the Guidelines, section 17.2).

For plants that continuously monitor the turbidity of water leaving each filter, it is acceptable to calculate the turbidity of the water leaving the treatment plant by averaging the individual turbidity measurements.

Where lime is used for pH correction, samples may be taken before the lime dosing.

4.3.8 Sampling frequencies for compliance of water leaving the treatment plant

4.3.8.1 *Escherichia coli*

The sampling frequencies for *E. coli* are specified in Table 4.2a (column 3). The number of days between samples (Table 4.2a, column 4) must not be exceeded. The number of days of the week used

for sampling must not be fewer than specified in Table 4.2a (ie, different days of the week must be used).

Section 1.6 discusses the sampling frequency for water supplies that experience temporary population increases.

No monitoring is required while a treatment plant is out of service. The water supplier must record the period when the treatment plant is off-line and ensure by appropriate monitoring that the source is free of *E. coli* or that the plant is operating at its full treatment capability when placed back on line. A sample for *E. coli* testing must be taken within one hour of start-up.

Water supplies using slow sand filtration and bacterial compliance criterion 1 must monitor *E. coli* at twice the frequency listed in Table 4.2a (column 3) when the water temperature falls below 6°C.

Table 4.2a: Minimum sampling frequency for *E. coli* in drinking-water leaving the treatment plant

Supply type	Population served ¹	Minimum sampling frequency	Maximum days between samples ²	Minimum days of the week used
No or inadequate disinfection ³ (monitoring by <i>E. coli</i> only)	Up to 500	Weekly	13	5
	501–10,000	Twice a week	5	6
	More than 10,000	Daily	1	7
Chlorinated: non-continuously monitored ⁴ (criterion 2B)	Up to 500	Fortnightly	22	3
	501–5000	Weekly	13	5
Ozone disinfected (criterion 4) ⁵	All	Fortnightly	22	3

Notes:

1. Sampling frequencies for *E. coli* in participating supplies servicing fewer than 500 people are discussed in section 10.
2. 'Three days between' means if a sample is taken on Monday, the next sample must be taken on Thursday.
3. Supplies with no or inadequate disinfection must use criterion 1; others do so by choice.
4. Non-continuously monitored chlorination is covered in section 4.3.2.2.
5. No *E. coli* monitoring is needed if the relevant protozoa criteria are satisfied.
6. This table applies to all bacterial criteria except criteria 2A and 3, and when protozoal compliance exempts further monitoring.

Table 4.2b: Minimum sampling frequency for free available chlorine, pH and turbidity in criterion 2B drinking-water leaving the treatment plant

Population served	Minimum sampling frequency	Maximum days between samples ¹	Minimum days of the week used
Up to 500	13 per quarter (weekly)	11	5
501–5000	39 per quarter (three times a week)	4	7

Note:

'Three days between' means if a sample is taken on Monday, the next sample must be taken on Thursday.

4.3.8.2 Free available chlorine disinfection

All plants with chlorination that supply a population greater than 5000 must monitor FAC continuously. These requirements do not apply to secure bore water supplies. Continuous monitors must meet the requirements specified in section 3.2.

The manual (or non-continuous) sampling frequencies are specified in Table 4.2b (column 2). The number of days between samples (Table 4.2b, column 3) must not be exceeded. The number of days of the week used for sampling must not be fewer than the number specified in Table 4.2b (column 4).

Manual disinfectant residual sampling frequencies must be increased if there are any circumstances that may give rise to an increased risk of faecal contamination.

4.3.8.3 pH

For criteria 2A and 3, the pH must be monitored continuously. Continuous monitors must meet the requirements specified in section 3.2.

For criterion 2B, the pH of the water leaving the treatment plant must be monitored at the same time and frequency as the FAC is measured to enable the FACE to be determined (see section 4.3.8.2 and Table 4.2b)⁵.

4.3.8.4 Turbidity

All water treatment plants using bacterial compliance criteria 2A and 3 must monitor turbidity continuously. Continuous monitors must meet the requirements specified in section 3.2.

For bacterial criterion 2B (section 4.3.2.2), the turbidity must be monitored at the frequency specified in Table 4.2b.

For bacterial criterion 4 (ozone disinfection), turbidity must be monitored at the same frequency as for protozoal compliance (ie, section 5.15.2, requirement 5).

For bacterial criterion 5 (UV disinfection), turbidity must be monitored at the same frequency as for protozoal compliance (Table 5.7).

Plants using membrane filtration to comply with the protozoal compliance criteria do not need to measure or compute the turbidity of the final water, provided the turbidity is always less than 0.10 NTU in the water leaving each filter unit.

4.3.8.5 Chlorine dioxide

All supplies being disinfected with chlorine dioxide must meet the disinfectant requirements of either section 4.3.2.1 or 4.3.2.2 as appropriate, measuring chlorine dioxide instead of chlorine. Continuous monitors must meet the requirements specified in section 3.2.

4.3.8.6 Ozone and flow

Supplies serving a population greater than 500 must continuously monitor the ozone residual and flow rate, and continuously calculate the C.t value (based on the ozone concentration and flow rate). Continuous monitors must meet the requirements specified in section 3.2.

Supplies serving a population up to 500 must monitor the ozone residual and calculate the C.t value daily.

4.3.9 Response to transgressions in drinking-water leaving the treatment plant

Contaminated water leaving the treatment plant can affect the whole community so immediate action is required if a positive *E. coli* or equivalent (section 4.1) test result occurs. Additional responses are required for secure bore water (section 4.5.5). If the positive *E. coli* result was detected when using a presence/absence test, repeat samples must be tested using an enumeration technique, Figure 4.1.

Immediate action must be taken when the minimum FACE, chlorine dioxide, ozone C.t value or UV dose (criteria 2 to 5) is not achieved, or the turbidity exceeds the maximum specified, thereby compromising the efficacy of the disinfection.

5. The efficacy of chlorine dioxide is unaffected by pH. Because some FAC residual may be present in water treated with chlorine dioxide, pH must be measured when both disinfectants are present.

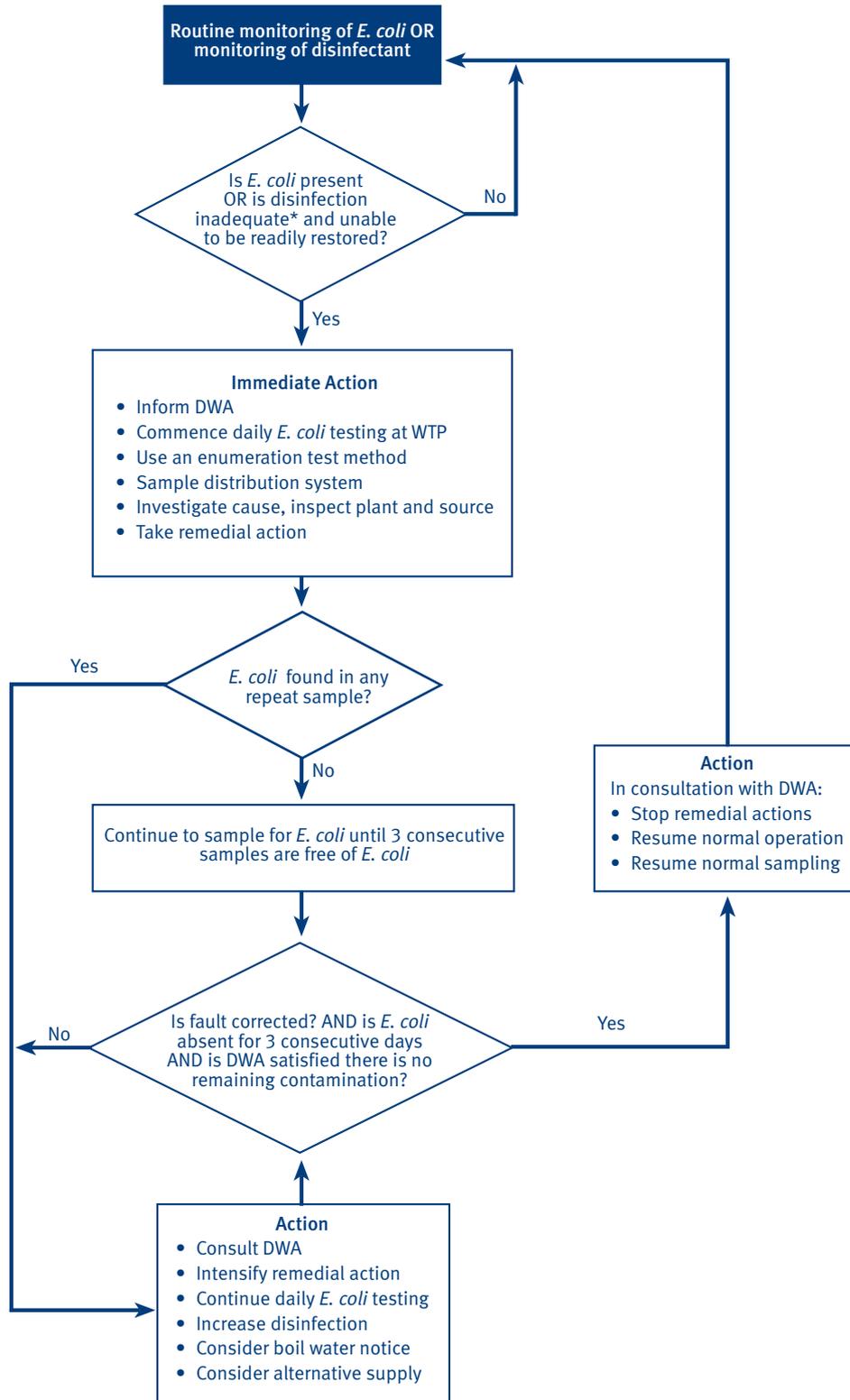
If the immediate investigation shows that faulty online monitoring is the cause, carry out a minimum of twice-daily manual measurement of the disinfectant, pH, turbidity (and flow if required) until the instrumentation is performing satisfactorily.

If the immediate investigation shows that disinfection dosage is faulty, the actions to be taken are summarised in Figure 4.1. These actions may be modified to suit particular circumstances with the DWA's agreement. Further actions are suggested in the Guidelines, section 6.5. The required actions must be applied promptly and reported fully. If the water supply is a bulk supply, downstream water suppliers must be informed as well.

Remedial action must be continued until the fault has been identified and remedied, *E. coli* is absent in all samples and the DWA is satisfied that remedial action is complete and no further contaminated water remains in the system. Should the cause of the fault not have been positively identified and remedied, sampling must be continued until samples from the treatment plant and the distribution system have tested free of *E. coli* on three successive days.

Samples collected as a result of a transgression or breach are not counted as part of the routine compliance monitoring programme, unless they are collected on a scheduled sample day, in which case only one sample need be taken on that day and used for both purposes.

Figure 4.1: Response to a transgression in drinking-water leaving the treatment plant



Note:

- * Inadequate disinfection occurs in the following situations.
 - For FACE and chlorine dioxide (criteria 2A, 2B and 3): when the residual in the water leaving the plant is less than 0.20 mg/L for more than an hour or falls below 0.10 mg/L.
 - Ozone (criterion 4): when the ozone C.t value is not achieved.
 - UV (criterion 5): when the target UV dose or intensity is not achieved.
 - When turbidity or UV transmittance are outside the compliance criteria.

4.4 Compliance criteria for drinking-water in the distribution system

A distribution system comprises one or more distribution zones. Compliance is required for each zone.

Water suppliers must nominate either bacterial compliance criterion 6A or criterion 6B for drinking-water in the distribution system, and criterion 7A or criterion 7B for drinking-water in a bulk distribution zone.

Bacterial compliance criterion 6B may be applied to **chlorinated water supplies** serving a population greater than 500 and where sufficient disinfectant residual exists in the distribution system for FAC or chlorine dioxide determination to be permitted in lieu of some *E. coli* testing; otherwise, bacterial compliance criterion 6A must be used.

For continuously monitored chlorinated bulk distribution systems, chlorine and/or chlorine dioxide residual tests may be fully substituted for *E. coli* tests (criterion 7B).

The compliance monitoring period for bacterial compliance in the distribution system and bulk distribution zones is one year, except for criterion 7B, which is one day.

Note: In the sections covering distribution systems, the term 'disinfectant residual' means FAC in chlorinated systems, and the sum of the residual chlorine dioxide and any FAC in systems disinfected with chlorine dioxide.

4.4.1 Compliance criterion 6A for drinking-water in a distribution zone

Bacterial compliance criterion 6A (using only *E. coli* monitoring) must be used:

- in water supply zones serving a population of up to 500
- when the residual maintained in the distribution system is less than 0.20 mg/L FAC or chlorine dioxide (measured as ClO₂).

To comply with criterion 6A, the following requirements must be met.

1. The water in the distribution system is monitored for the presence of *E. coli*.
2. The sampling sites and frequency of sampling for *E. coli* meet the requirements of sections 4.4.3 and 4.4.4 respectively.
3. The number of 100 mL samples in which *E. coli* is found is equal to or less than the allowable exceedences listed in Appendix A1.8, Table A1.4.
4. The sampling and analytical procedures comply with section 4.3.6.

4.4.2 Compliance criterion 6B for drinking-water in a distribution zone

Bacterial compliance criterion 6B, using partial substitution of *E. coli* monitoring by FAC or chlorine dioxide monitoring, may be used:

- in water supply zones servicing a population greater than 500
- when the residual maintained in the distribution system is at least 0.20 mg/L FAC or chlorine dioxide (measured as ClO₂).

To comply with criterion 6B, the requirements of section 4.4.1 must be met, together with all of the following requirements.

1. Either the:
 - a. water leaving the treatment plant complies with section 4.3.2.1 (criterion 2A) or section 4.3.3 (criterion 3), or the
 - b. distribution zone is fed from a bulk distribution zone complying with criterion 7B (section 4.4.7.2).
2. The disinfectant residual concentration is monitored in the distribution zone at the sites and frequencies specified in sections 4.4.3 and 4.4.4.
3. The number of *E. coli* samples substituted by disinfectant residual tests does not exceed 75 percent of the number specified in Table 4.3a (column 2).
4. All samples in the distribution system contain a disinfectant residual concentration of at least 0.20 mg/L, except in occasional areas of low flow where the disinfectant concentration may diminish to 0.10 mg/L. If the disinfectant residual is found to be less than 0.10 mg/L in any particular sample, *E. coli* must be tested for.

4.4.3 Sampling sites for compliance in the distribution zone

The sampling plan must provide geographical coverage of the distribution system and must take into consideration the following.

1. All samples must be taken from regular sampling points, such as pumping stations, **service reservoirs** and taps within the distribution zone. These sample sites will be allocated site numbers in the WINZ database.
2. Taps installed specifically for sampling purposes, attached directly to a street main and contained in locked cabinets are preferred to consumers' household taps.
3. The sampling plan must include frequently visited sites to enable some assessment of trends, and sites visited on rotation to enhance geographical coverage.

For a discussion on sanitary practices during, and the monitoring of, water supply pipeline construction and maintenance, see the Guidelines, chapter 16.

Table 4.3a: Minimum sampling frequency for *E. coli* in the distribution zone¹

Population served ²	Minimum number of <i>E. coli</i> samples per quarter with no disinfectant residual substitution (criterion 6A)	Minimum number of samples per quarter where disinfectant residual determination substitutes 75 percent of <i>E. coli</i> testing ³ (criterion 6B)	
		<i>E. coli</i>	Disinfectant residual
Up to 500 ⁴	3	<i>Not applicable</i>	<i>Not applicable</i>
501–5000	13	7	93
5001–10,000	16	7	93
10,001–15,000	19	7	93
15,001–20,000	22	7	93
20,001–25,000	25	7	93
25,001–30,000	28	7	93
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
etc			

Notes:

1. If there is any failure to take or deliver samples or to adhere to the specified sampling frequency requirements, resampling must take place as soon as practicable and the DWA must be advised. The DWA may grant an exemption, if the reasons for the failure are justifiable (section 3.1.2).
2. When the population increases, additional sampling must be performed so the sampling frequency is that specified for the population actually present (section 1.6).
3. Testing must be distributed evenly throughout the quarter, be carried out on different days of the week and give a representative geographical coverage of the distribution system (section 4.4.3). Use calendar quarters: January to March, April to June, July to September, and October to December. Ninety-three days per quarter means daily.
4. For participating supplies, see section 10.

Additional monitoring must be carried out after the installation of new mains or after connections or repairs in the network reticulation. For more information, see the Guidelines, chapter 16.

4.4.4 Sampling frequencies for compliance in a distribution zone

4.4.4.1 Compliance criterion 6A (*Escherichia coli* monitoring only)

The sampling frequencies for *E. coli* in drinking-water in the distribution zones are shown in Table 4.3a. For supplies serving more than 500 people monitoring must be carried out on different days throughout the week as shown in Table 4.3b.

In order to give 95 percent confidence that no determinand in a supply has exceeded its MAV for more than 5 percent of the time (section 1.3), a supply needs to be monitored at least 10 times per quarter (Appendix A1.8, Table A1.4). In the interests of affordability, a lesser level of confidence has been accepted for communities of up to 500 people. Note that the compliance criteria related to participating supplies are addressed in section 10.

Table 4.3b: Sampling intervals for *E. coli* in the distribution zone

Number of <i>E. coli</i> samples collected per quarter	Maximum interval between <i>E. coli</i> samples (days)	Minimum number of days of the week used
3	45	2
4–7	22	3
8–12	16	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
More than 92	1	7

Note:

The interval between samples is based on the number of *E. coli* samples, not by the size of the population. For example, if the zone population is 68,155:

- if there is no replacement of *E. coli* by FAC, 52 *E. coli* samples are required per quarter (Table 4.3a)
- with 75 percent replacement of *E. coli* by FAC, this requires:
 - 13 *E. coli* samples per quarter (ie, 52 x 25 percent, rounded up if necessary)
 - 156 FAC tests per quarter (ie, 52 x 75 percent x 4).

If 13 *E. coli* samples are required, the maximum sampling interval is 11 days, with samples to be collected on five different days of the week.

4.4.4.2 Compliance criterion 6B (*Escherichia coli* plus disinfectant monitoring)

The sampling frequencies for *E. coli* are determined by the following.

- (*E. coli* tests specified in column 2 of Table 4.3a if no substitution with disinfectant residual determination is done) x $([100 - \text{percent of } E. coli \text{ tests replaced}] / 100)$.
- Testing must be carried out on different days throughout the week as shown in Table 4.3b, not exceeding the specified interval.

The sampling frequencies for the disinfectant residual concentration are determined by the following.

- (*E. coli* tests that would be required in column 2 of Table 4.3a if no substitution with disinfectant residual determination is done) x 4 x $[\text{percent of } E. coli \text{ tests replaced}] / 100$.
- Disinfectant residual sampling must be carried out at least daily. For some supplies, substitution of less than 75 percent of *E. coli* samples will require more disinfectant residual samples to be taken than is calculated in the equation above.

Section 4.4.6 discusses transgression and consumer complaint samples.

4.4.5 Sampling and on-site analytical procedures for water in a distribution zone

These procedures are the same as detailed in section 4.3.6.

4.4.6 Remedial actions involving criteria 6A and 6B

Figure 4.2 details the response stages. These requirements may be modified to suit particular circumstances by agreement with the DWA.

If disinfectant levels fall below 0.20 mg/L (criterion 6B), the cause must be investigated immediately. If the level drops below 0.10 mg/L or other requirements are not met, *E. coli* monitoring must be carried out according to criterion 6A. Criterion 6B monitoring may resume after disinfectant levels have been restored above 0.20 mg/L for one week.

The response to a positive *E. coli* sample must include the following steps (see the Immediate Action box in Figure 4.2).

1. Immediately inform the DWA.
2. Begin collection of daily follow-up samples for *E. coli* enumeration from the original positive sample location and also locations downstream from the first positive site.
3. If no fault in the distribution system is immediately apparent and no routine *E. coli* sample was taken from water leaving the treatment plant at about the time the positive sample was taken from the distribution zone, then sample and enumerate *E. coli* in the water leaving the treatment plant also.
4. Investigate the possible causes of the positive sample (for suggestions, see Guidelines, chapter 6).
5. Correct any faults found during the investigation.

The required actions must be applied promptly and reported fully.

If any results from follow-up sampling are equal to or greater than 10 *E. coli* per 100 mL, the DWA must be consulted immediately and actions required to reduce the risk of illness, such as the issue of a 'Boil Water' notice, increasing the disinfectant dose or flushing the system, must be carried out. Investigations into the reason for the contamination must be intensified. In this situation, reliance only on the level of residual disinfectant in the water leaving the treatment plant is not sufficient to eliminate the plant as the source of contamination.

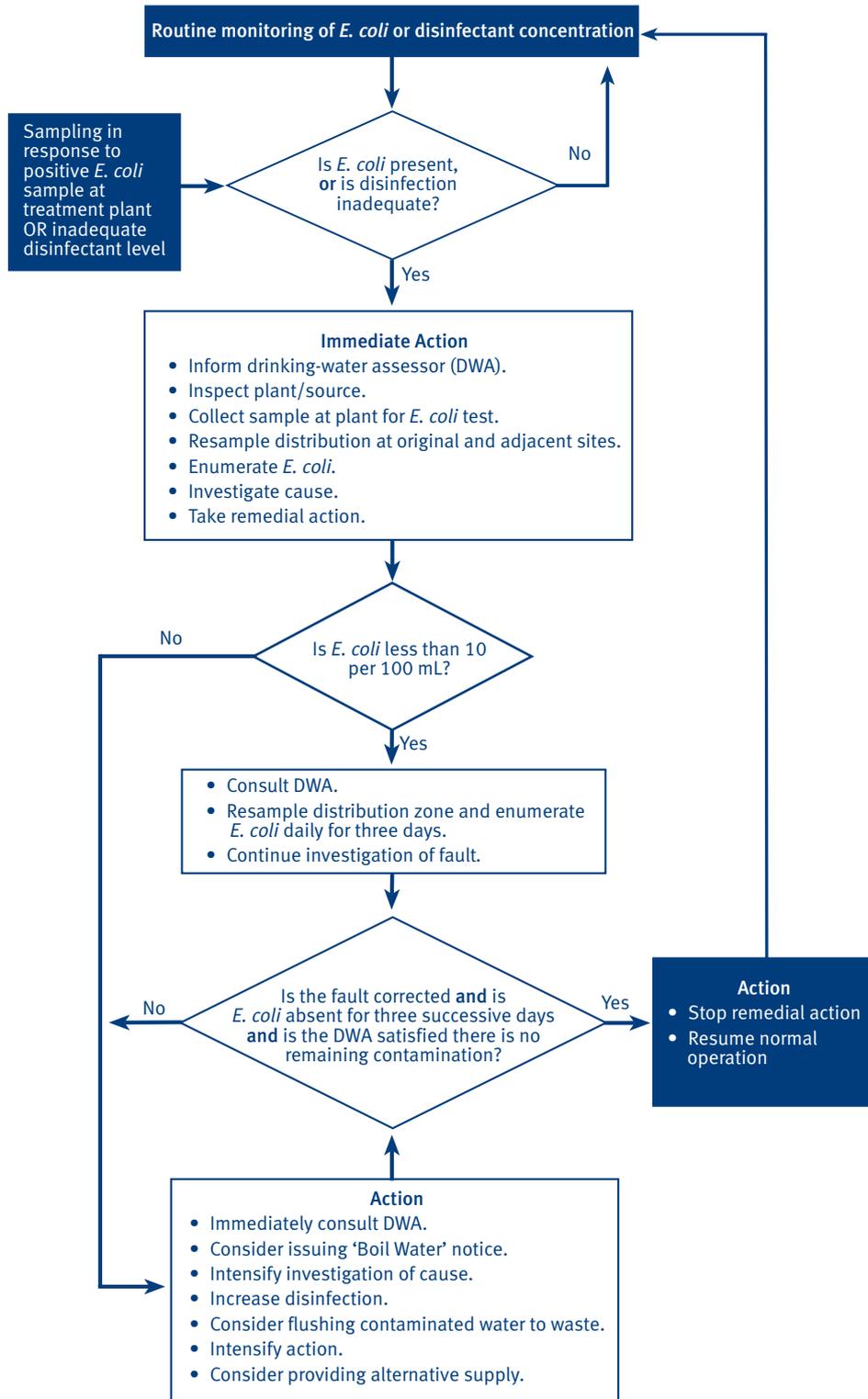
If any follow-up sample contains one to nine *E. coli* per 100 mL, the DWA must be informed and investigations must continue and any faults identified must be corrected.

The required actions must be continued until:

- samples from the treatment plant and the distribution system have tested free of *E. coli* on three successive days
- the DWA is satisfied that no further contaminated water remains in the system
- any remedial action is complete.

Samples collected as a result of a transgression or breach of an operational requirement are not counted as part of the routine compliance monitoring programme, unless they are collected on a scheduled sample day, in which case only one sample need be taken on that day and used for both purposes. Consumer complaint samples are not counted as part of the routine compliance monitoring programme.

Figure 4.2: Response to a transgression in a drinking-water supply distribution zone



4.4.7 Compliance in a bulk distribution zone

Either of the following criteria may be used.

- *E. coli* monitoring for compliance using *E. coli* (criterion 7A, section 4.4.7.1).
- Full substitution of *E. coli* monitoring with continuous monitoring of residual in supplies disinfected with chlorine or chlorine dioxide (criterion 7B, section 4.4.7.2).

4.4.7.1 Compliance criterion 7A using *Escherichia coli* monitoring only

To comply with criterion 7A the following requirements must be met.

1. The water is monitored for the presence of *E. coli*.
2. Sampling meets the requirements of sections 4.4.7.3 and 4.4.7.4.
3. The number of samples in which *E. coli* is found is equal to or less than the allowable number of exceedences shown in Appendix A1.8, Table A1.4.
4. The sampling and analytical procedures comply with section 4.3.6.

4.4.7.2 Compliance criterion 7B using continuous monitoring of disinfectant residual

To comply with criterion 7B the following requirements must be met.

1. The disinfectant residual is monitored (see section 3.2) in the bulk distribution zone at the frequencies specified in section 4.4.7.4.
2. The water leaving the treatment plant complies with criterion 2A (section 4.3.2.1) or criterion 3 (section 4.3.3).
3. The residual in the bulk distribution zone is at least 0.20 mg/L for at least 95 percent of the time.

The bacterial monitoring compliance period for FAC is one day.

4.4.7.3 Sampling sites for bulk water supplies

At least one bulk water supply point (ie, where the water leaves the bulk distribution zone) in each bulk zone must be monitored for the presence of *E. coli* or be continuously monitored for disinfection residual. The most distant bulk water supply point should be selected unless consultation with the client and the DWA results in another choice. More than one monitoring point per bulk zone may be necessary where the configuration of the bulk zone (including the treatment plant inputs and the supply points) is such that one monitoring point is not sufficient to represent the quality of water supplied. The additional points must be agreed with the bulk supplier's client and the DWA.

4.4.7.4 Sampling frequencies for bulk water supplies

Criterion 7A: Table 4.4 specifies the sampling frequency for *E. coli* from each bulk water supply point selected from a bulk distribution zone. The frequency depends on the population served by that bulk water supply point.

Criterion 7B: the disinfectant residual must be monitored continuously at the selected bulk water supply point(s).

Table 4.4: Minimum sampling frequency for *E. coli* in a bulk distribution zone

Nominal population served	Minimum sampling frequency	Maximum days between samples	Minimum days of the week used
10,000 or fewer	13 per quarter (weekly)	13	5
10,001–50,000	26 per quarter (twice a week)	5	6
More than 50,000	39 per quarter (three times a week)	3	7

Note:

‘Three days between’ means if a sample is taken on Monday, the next sample must be taken on Thursday.

4.4.7.5 Remedial actions involving criteria 7A and 7B

If *E. coli* is found in a bulk water supply sample, see section 4.4.6 and inform water suppliers downstream.

If the disinfectant level at a bulk supply point falls below 0.20 mg/L (criterion 7B), the cause must be investigated immediately. If the fall in the level is due to:

- faulty dosage, sample for *E. coli* according to criterion 7A until the disinfectant levels have been restored for two days
- faulty monitoring, conduct twice-daily manual residual testing until repaired.

4.5 Bore water security and compliance

4.5.1 Introduction

Bore water is considered secure when it can be demonstrated that contamination by pathogenic organisms is unlikely because the bore water is:

- not directly affected by surface or climate influences, as demonstrated by compliance with bore water security criteria 1 (section 4.5.2.1) and 3 (section 4.5.2.3), and
- abstracted from a **bore head** that provides satisfactory protection, bore water security criterion 2 (section 4.5.2.2).

Water drawn from **confined aquifers** that satisfies bore water criteria 1 and 2 and 3 will be considered secure bore water.

Water drawn from **unconfined aquifers** will not be given secure status when the **bore intake depth** is:

- less than 10 m below ground surface (includes **springs**)
- 10 to 30 m below ground surface, until complying with sections 4.5.2.2 and 4.5.2.3(2)
- more than 30 m below ground surface, until complying with sections 4.5.2.2 and 4.5.2.3(1).

Note that depth is the length of casing to the shallowest screen, rather than total bore depth. For a discussion of factors that can affect the status of secure bore water, see the Guidelines, section 3.2.4.5.

The bacterial compliance criteria for bore water that has entered the distribution system are covered in section 4.4.

4.5.2 Bore water security criteria

Sections 4.5.2.1 to 4.5.2.3 specify the criteria that must be met for demonstrating that a bore water is secure.

Once water from a bore has been declared secure, section 4.5.4 outlines the ongoing compliance monitoring requirements of secure bore water.

4.5.2.1 Bore water security criterion 1: bore water must not be directly affected by surface or climatic influences

A lack of surface or climate influences on the **groundwater** must be demonstrated by one of:

- water younger than one year not being detectable in the **aquifer**
- the lack of significant variability in determinands that are linked to surface effects.

Compliance with this criterion may be demonstrated in one or more of three ways.

Section 4.5.3 applies to multiple bores drawing from the same aquifer.

Demonstration 1: Residence time

A residence time determination carried out by a laboratory recognised by the Ministry of Health for the purpose must show that less than 0.005 percent of the water has been present in the aquifer for less than one year on the basis of reported methods and assumptions.

The residence time determination must be based on measurements of the concentration of tritium and chlorofluorocarbon and sulphur hexafluoride. The following criteria must be met.

1. The bore must have been properly purged to ensure samples are representative of the aquifer (Daughney et al 2006).
2. The zero point used for age determination of the water must be the time at which the water commences its passage underground.
3. A full description of the procedure used to determine the residence time must be provided, including the mixing model assumptions, justification and interpretation.

Demonstration 2: Constant composition

When testing a minimum of 12 samples spaced regularly over one to three years, variations in the concentrations of all of the following determinands do not exceed a:

- **coefficient of variation** of 3 percent in conductivity
- coefficient of variation of 4 percent in **chloride concentration**
- **standardised variance** of 2.5 percent in **nitrate concentration** (expressed as milligrams of NO₃-N/L).

For examples of the calculation and advice on sampling and analysis, see the Guidelines, section 3.2.4.2.

If the concentration of any one of these determinands is near its **limit of detection**, so that the coefficient of variation or standardised variance cannot be determined reliably, the results for that determinand may be disregarded at the DWA's discretion.

Demonstration 3: Verified model

If the residence time determination is not possible due to the presence of non-meteoritic chlorofluorocarbons, sulphur hexafluoride and tritium, and the water quality variation criteria do not satisfy the requirements for secure bore water status, the following method may be considered.

A verified hydrogeological model demonstrating that the bore is extracting water from a confined aquifer may be acceptable. The model must have been published in a peer-reviewed scientific journal, and be derived from a conservative evaluation of hydrogeologic parameters, and be suitable for the aquifer in question. The model must provide information about potential contaminant pathways and must indicate that contamination by pathogens is very unlikely taking into account predictive uncertainty, to the satisfaction of an independent person or people deemed qualified by the Ministry of Health.

4.5.2.2 Bore water security criterion 2: bore head must provide satisfactory protection

The bore head must be judged to provide satisfactory protection by a person recognised as an expert in the field.

The bore head must be sealed at the surface to prevent the ingress of surface water and contaminants, and the casing must not allow ingress of shallow groundwater. Animals must be excluded from within 5 m of the bore head.

The bore construction must comply with the environmental standard for drilling soil and rock (NZS 4411, Standards New Zealand (2001)), including providing an effective backflow prevention mechanism, unless agreed by the DWA.

The supply's PHRMP must address contaminant sources and contaminant migration pathways.

Potential sources of contamination such as septic tanks or other waste discharges must be situated sufficiently far from the bore so contamination of the groundwater cannot occur (for further discussion, see the Guidelines, section 3.2.3).

4.5.2.3 Bore water security criterion 3: *Escherichia coli* must be absent from bore water

There are two sets of requirements for demonstrating the absence of *E. coli* in bore water.

1. Water from bores complying with bore water security criterion 1, and from unconfined aquifers greater than 30 m deep drawing from a source for which hydrogeological evidence indicates that the bore water is likely to be secure, may be given **interim secure status** for the first 12 months of operation, provided:
 - a. they are monitored for *E. coli* in accordance with Table 4.5 and note 1
 - b. no *E. coli* is detected; if *E. coli* is found, see section 4.5.5.3.

Status as a secure bore water in this group requires compliance with all three bore water security criteria.

2. Bore water abstracted 10 to 30 m deep, drawn from an unconfined aquifer, will be considered secure, provided:
 - a. it is monitored for *E. coli* for five years in accordance with Table 4.5 and note 2
 - b. no *E. coli* is detected; if *E. coli* is found, see section 4.5.5.4.

Status as a secure bore water in this group requires compliance with bore water security criteria 2 and 3.

Until this water is classified as secure, it is considered equivalent to surface water. For bacterial compliance, see section 4.3. The protozoal log credit requirement is in Table 5.1a.

Escherichia coli monitoring

The sampling site is preferably at the bore head, but must precede any treatment, blending or storage. The monitoring procedures must comply with the requirements of section 4.3.6.

If the bore is used irregularly or intermittently, variations to the sampling frequency specified in Table 4.5 must be agreed with the DWA.

4.5.3 Multiple bores serving drinking-water supply

Water for a drinking-water supply may come from several bores. Separate monitoring of each could require a large number of samples to be tested for *E. coli*.

Reduced monitoring may be justified when it can be demonstrated that the bores supplying a single pumping station or distribution zone draw from the same aquifer. A verified hydrogeological model demonstrating that the bores all draw from the same confined aquifer may be acceptable to support an application for a reduced monitoring regime. The model must have been published in a peer-reviewed scientific journal and be suitable for use for the aquifer in question. The model must be derived from a conservative evaluation of hydrogeologic parameters and all assumptions specified. Such a model must be verified to the satisfaction of an independent person or people recognised as expert in the field.

To justify reduced monitoring in these circumstances, the water supplier must show that:

- the bores draw from the same aquifer under similar conditions
- any **aquitard** protecting the source is continuous at the **bore field**

- the chemical character of the water from each bore is similar
- each bore head meets bore water security criterion 2 (section 4.5.2.2).

The bore(s) chosen to represent the aquifer must be the one(s) most vulnerable to contamination. The sampling frequency must be in accordance with the requirements of Table 4.5 for the first three months, with sampling being monthly thereafter.

Provided no *E. coli* is detected, the security of water from the other bores intercepting that aquifer will be presumed, but must first be verified with three samples taken at one-month intervals for *E. coli* testing, being collected from each bore with no *E. coli* being found. This verification must be carried out for each aquifer.

Table 4.5: Minimum sampling frequency for *E. coli* in bore water

Supply type	Population served ⁶	Minimum sampling frequency	Maximum days between samples
Bore waters with interim security, ¹ bores 10 to 30 m deep, ² the bore representing a bore field, ³ provisionally secure bores ⁴	Up to 500 ⁷	Weekly	13
	501–10,000	Twice a week	5
	More than 10,000	Daily	1
Secure bore water supplies ⁵	All	Monthly	45 (135)

Notes:

1. Monitoring requirements for bore water granted *interim secure* status may be reduced to one sample per month for the remaining nine months independent of population band (maximum of 45 days between samples) provided no *E. coli* has been detected during the first three months (section 4.5.2.3).
2. Monitoring requirements for bores 10–30 m deep drawing from unconfined aquifers may be reduced to monthly (maximum of 45 days between samples) for the final four years and nine months provided no *E. coli* has been detected during the first three months. This is independent of population band (section 4.5.1).
3. Monitoring requirements for the bore representing a *multiple bore field* may be reduced to monthly independent of population band (maximum of 45 days between samples) provided no *E. coli* has been detected during the first three months (section 4.5.3). As a prerequisite, all bores drawing from the same field must have no *E. coli* in three consecutive monthly samples.
4. Monitoring requirements for secure bore water that has been downgraded to provisionally secure may be reduced to one sample per month for the remaining nine months independent of population band (maximum of 45 days between samples) provided no *E. coli* has been detected during the first three months (sections 4.5.5.1 and 4.5.5.2).
5. Monitoring requirements for *secure bore water supplies* may be reduced to one sample per quarter (maximum of 135 days between samples) after no *E. coli* has been detected in 12 consecutive months of sampling after the bore water has been granted fully secure status.
6. If the bore is not the sole source, determine the population band by agreement with the DWA.
7. Sampling frequencies for *E. coli* in participating supplies servicing fewer than 500 people are discussed in section 10.
8. If the bore is used irregularly, variations to the sampling frequency must be agreed with the DWA.

4.5.4 Ongoing compliance for secure bore water

This section specifies the compliance monitoring requirements associated with bore water that has been granted secure status by meeting the requirements of sections 4.5.1 to 4.5.3.

If the secure bore water receives treatment that could allow microbiological contamination, the water leaving the treatment plant must satisfy one of the bacterial criteria in section 4.3.

Where a treatment plant receives water from both secure and non-secure bore water, the supply must be classified as arising from non-secure bore water while the non-secure bore water is contributing to the treatment plant.

To demonstrate continued compliance with bore water security criterion 1, using:

- demonstration 1, the residence time must be re-assessed every five years, or earlier if the DWA specifies it is necessary
- demonstration 2, the determinands used to verify the bore water as secure must be tested annually to check that the results remain within the original range
- demonstration 3, a hydrogeological model must confirm every five years that the bore is extracting from a confined aquifer.

To demonstrate continued compliance with bore water security criterion 2, the **bore head protection** must be reviewed at least every five years and the water supply owner must report any changes to the DWA.

To demonstrate continued compliance with bore water security criterion 3:

- the water must be monitored, preferably at the bore head but before any treatment or storage, at a frequency at least that specified in Table 4.5 (secure bore water supplies), and detect no *E. coli*
- the bore water must be reclassified as **provisionally secure**, see section 4.5.5.2), if *E. coli* is detected in any sample, and the procedures specified in sections 4.3.9 and 4.5.5 must be carried out.

4.5.5 Response to *Escherichia coli* detection in bore water

Section 4.3.9 covers the minimum responses that must be followed if *E. coli* is found in any sample of drinking-water entering the distribution system, including the relevant responses in Figure 4.1. For bore waters, there are two additional requirements.

- Compliance with bore water security criterion 2 (section 4.5.2.2) must be confirmed as soon as practicable.
- Compliance with bore water security criterion 3 must be confirmed by additional *E. coli* monitoring in sections 4.5.5.1–4.5.5.5).

If a bore water becomes non-secure, to re-establish security all the procedures for demonstrating security outlined in section 4.5 must be carried out again.

4.5.5.1 Secure bore water

When *E. coli* is found in a sample of secure bore water, the supply will be given **provisional secure status** for the following 12 months of operation, provided:

- it is monitored for *E. coli* in accordance with Table 4.5 for the first three months after the positive *E. coli* sample was obtained
- it is monitored monthly for the remaining nine months
- no *E. coli* is detected during the 12-month provisional period.

A provisionally secure bore water that satisfies the above requirements will revert to its original secure status.

4.5.5.2 Provisionally secure bore water

If *E. coli* is obtained in a sample of provisionally secure bore water during the 12-month monitoring period, the water must be reclassified immediately as non-secure. If a secure bore water is classified as provisional more than twice in five years, retention of its secure status is at the discretion of the DWA.

4.5.5.3 Interim secure bore water

If a sample of bore water that has been given interim secure status (section 4.5.2.3) contains *E. coli*, the 12-month interim sampling regime must recommence (Table 4.5). If *E. coli* is found in a second sample during the 12-month interim period, the water must be reclassified immediately as non-secure.

4.5.5.4 Bores 10 to 30 m deep, drawn from unconfined aquifers

If any sample collected upstream of the treatment process contains *E. coli* during the five-year proving period, a repeat sample must be collected as soon as practicable for enumeration of *E. coli*, and daily thereafter until two consecutive samples are free from *E. coli*. If three consecutive samples contain *E. coli*, or if one repeat sample contains 10 or more *E. coli* per 100 mL, the five-yearly proving period must recommence. If any *E. coli* are found again during the five-year proving period, the bore will be considered to be supplying surface water.

4.5.5.5 Multiple bores

If a sample from the representative bore contains *E. coli* the bore is reassessed as provisionally secure, and monitored accordingly, as for secure bore water (section 4.5.5.1).

If *E. coli* is not detected when re-sampling the bore (Figure 4.1, immediate action box), the other bores do not need to be tested. If *E. coli* is detected in one or more of these repeat samples, all bores must be tested for *E. coli*. If any of these bores contains *E. coli*, the bore field will be considered provisionally secure, see section 4.5.5.2, and all bores must be sampled accordingly.

5 Protozoal Compliance Criteria

5.1 Introduction

Protozoa such as *Cryptosporidium* and *Giardia* occur in many New Zealand surface waters and non-secure bore waters. Their **cysts** or **ooocysts** (collectively **(oo)cysts**) are found in the faeces of humans and animals (wild, farm and domestic). *Cryptosporidium* and *Giardia* are Priority 1 determinands because of their public health significance.

The risk associated with secure bore water is much lower than that of surface waters. Secure bore waters, and bore waters granted interim security status (section 4.5.2.3), are considered to comply with protozoal compliance criteria (section 3.3.1).

Protozoa can be removed by filtration or inactivated by disinfection using ozone, chlorine dioxide or UV light. Inactivation is a process by which a micro-organism is rendered incapable of reproduction, so is unable to infect a host. Chlorine can be effective in inactivating *Giardia*, bacteria and viruses but is not effective for inactivating *Cryptosporidium*.

The compliance criteria for protozoa are based on the probability that the treatment process will have inactivated (eg, by disinfecting to achieve the prescribed C.t value) or removed (eg, by achieving target **filtrate** turbidity) any protozoa present.

Cryptosporidium is the most infectious and most difficult protozoan to remove or inactivate. The compliance criteria are constructed on the principle that if the treatment process deals successfully with *Cryptosporidium*, they will also deal successfully with other protozoa.

The protozoal compliance criteria in the DWSNZ:

- use risk-based criteria that are more stringent for contaminated raw water than for cleaner raw water
- acknowledge any additive effect of successive different treatment processes on the removal of protozoa where more than one treatment process is used
- use overseas data, chiefly from the **United States Environmental Protection Agency (USEPA)** (USEPA 2006a), on the log-removal efficacy (a measure of the percentage of organisms removed) of *Cryptosporidium* for a range of treatment processes
- specify the use of validated equipment (where appropriate), monitoring programmes and treatment performance measures
- require appropriate remedial actions to be taken.

5.2 Cumulative log credit approach

The risk of infection from drinking-water contaminated by waterborne protozoa is affected by the:

- concentration of *Cryptosporidium* or other protozoal (oo)cysts in the raw water
- extent to which (oo)cysts are inactivated or removed by the treatment processes.

To take account of the additive effect of a series of treatment processes on the removal of protozoa, 'log credits' are used, *Cryptosporidium* being used as the reference organism (for further discussion, see the Guidelines, section 8.3). The log credit for a treatment process is related to the percentage of the protozoa the process can remove, by the expression:

$$\text{log credit} = \log_{10}[1/\{1-(\text{percentage removal}/100)\}]$$

Table A1.2 converts percentage removal to logarithms.

The cumulative effect of successive treatment processes can be calculated by adding the log credits of all the qualifying processes in use. The cumulative effects cannot be added when the removal is expressed as a percentage.

Protozoal non-compliance occurs when one of the following occurs.

- A treatment process does not satisfy the conditions required to achieve the log credit specified for it in the relevant section 5.x.1: Log credit assessment, resulting in the treatment plant not reaching the total log credits required.
- The monitoring or operational requirements specified in the relevant section 5.x.3 (or section 5.x.4) are not met or exceed the number allowed in Appendix A1.8.
- Incorrect monitoring procedures are used (eg, inadequate sampling, incorrect standardisation of metering equipment, or analyses not carried out by a laboratory recognised for the purpose).

Note that despite an individual treatment process being non-compliant, other qualifying processes in use may still provide the required number of protozoal log credits.

Section 5.2.1 describes the process by which raw water is categorised with respect to the risk of *Cryptosporidium* in it. The log credits associated with the various treatment processes used to remove or inactivate *Cryptosporidium* are discussed in section 5.2.3.

5.2.1 Procedures for determining protozoal log credit requirements

Water suppliers can determine the protozoal log credit requirement using either:

- the catchment risk category approach; the standard approach for water supplies serving a population up to 10,000
- raw water *Cryptosporidium* monitoring; the standard approach for water supplies serving a population greater than 10,000.

5.2.1.1 Catchment risk category approach

The protozoal log removal requirement for supplies serving a population up to 10,000 is based on the perceived risk related to the surface water catchment or groundwater categories as defined in Table 5.1a.

Should the assignment of the log credit made by the Ministry be considered inappropriate, any appeal (section 1.9) must be supported by data obtained by monitoring *Cryptosporidium* (section 5.2.1.2).

The catchment risk categorisation procedure involves a survey of the catchment. The water supplier must commence the survey within six months of the DWSNZ 2008 revision coming into effect. The Catchment Risk Categorisation Survey Result Form for recording the survey results is in Appendix 3. When water is drawn from more than one catchment, the catchment being used with the highest log requirement will determine the log credit requirement for the treatment plant. The responses and the log credit requirement are to be recorded in WINZ.

Reassessments must be made at at least five-yearly intervals.

Table 5.1a: Log credit requirements for different catchment and groundwater categories

Catchment or groundwater protozoal risk category	Log credits
<i>Surface waters</i>	
Water from pastoral catchment with frequent high concentrations of cattle, sheep, horses or humans, or a waste treatment outfall nearby or upstream	5
Water from pastoral catchment that always has low concentrations of cattle, sheep, horses or humans in immediate vicinity or upstream	4
Water from forest, bush, scrub or tussock catchments with no agricultural activity	3
<i>Groundwaters</i>	
Springs and non-secure bore water 0 to 10 m deep are treated as requiring the same log credit as the surface water in the overlying catchment	3–5
Bore water drawn from an unconfined aquifer 10 to 30 m deep, and satisfies groundwater security criteria 2	3
Bore water drawn from deeper than 30 m, and satisfies bore water security criteria 2	2
Secure, interim secure, and provisionally secure bore water	0

5.2.1.2 *Cryptosporidium* monitoring

The log credit requirement for supplies serving a population greater than 10,000 is based on monitoring *Cryptosporidium* (see Table 5.1b). The minimum protozoal log removal requirement depends on the mean *Cryptosporidium* oocyst concentration of the water at the plant inlet for both surface waters and non-secure bore waters.

If the water supplier considers the *Cryptosporidium* monitoring option results in an inappropriate log credit requirement, the catchment risk categorisation approach as defined in section 5.2.1.1 and Table 5.1a may be adopted.

The monitoring programme must comprise at least 26 samples collected over a 12-month period at approximately equal time intervals to attempt to ensure representative samples and minimise seasonal bias. The samples must be tested quantitatively for *Giardia* and *Cryptosporidium* (oo)cysts. Subject to the services offered by the laboratory and delivery service, samples should be taken to cover every day of the week and must cover at least Monday to Friday three times during the sampling programme, which may be derived from the sampling scheduler facility in WINZ.

The monitoring programme is to be completed within 18 months of the DWSNZ 2008 revision coming into effect. Water supplies that completed the programme in accordance with DWSNZ 2005 may use those results. The results from the monitoring programme must be reported to the DWA. Water suppliers will be advised of the log credit requirement.

The protozoa monitoring programme must be repeated at at least five-yearly intervals.

Table 5.1b: Log credit requirements for surface waters, springs, and non-secure bore water 0–10 m deep, based on *Cryptosporidium* monitoring

<i>Cryptosporidium</i> , mean oocysts per 10 litres	Log credits
≥10	5
0.75–9.99	4
< 0.75	3

5.2.1.3 Recycling

Water treatment plants that recycle waste streams must:

- return the recycle stream so that it undergoes the full treatment process
- provide flow equalisation such that the instantaneous total return rate does not exceed 10 percent of the plant inflow, unless otherwise approved by the DWA
- monitor the recycle stream continuously for turbidity; separation between data points must not exceed one minute.

Turbidity monitoring is required to demonstrate that the recycled water has received effective solids/liquid separation.

These rules do not apply to water from rapid granular media filters being diverted during restart after backwash (often called ‘filter to waste’).

The required monitoring and control must be in place as required in section 69C of the Act.

5.2.2 Sampling and testing

5.2.2.1 Sampling location

The sampling location for collection of samples for *Cryptosporidium* testing must be:

1. upstream of any pretreatment process that contributes log credits to the overall treatment process: sampling may be from the raw water at the point of abstraction (raw water intake) if requirements 2 and 3 are also met
2. in the case of selective abstraction schemes with a choice of **abstraction points**, at the inlet to the treatment plant
3. at each raw water intake when a water supply can be drawn from more than one source water: calculate the weighted average based on the flows from each stream. Alternatively, the inlet water to the treatment plant may be monitored, provided all source waters are being abstracted and at a rate consistent with operational practice
4. downstream of the return point of any recycled liquid wastes. Samples are collected while the recycle is operating.

5.2.2.2 Analytical method and calculation

Analysis of raw water protozoa (*Giardia* and *Cryptosporidium*) must be carried out using the modified USEPA Method 1623 (USEPA 2004) referred to in Appendix 2, and in the Guidelines, Appendix 8. Results are to be reported as *Cryptosporidium* oocysts per 10 litres and *Giardia* cysts per 10 litres.

The mean number of *Cryptosporidium* oocysts per 10 litres will be used to determine the minimum protozoal log credits that the treatment system must provide to achieve compliance as per Table 5.1b. In calculating the mean value, all ‘less than’ values are to be treated as zeros. The number of oocysts

counted must be normalised using the formula:

$$N_R = N_C \times 40 / \% \text{recovery}$$

where N_R is the number reported and N_C is the number counted.

5.2.3 Log credits for treatment processes

International studies have measured log removal rates for protozoa for the different steps in **water treatment processes**. These show how different treatment processes can remove or inactivate protozoa. This is called the *efficacy* of the treatment, and it is measured as percentage removal/inactivation or is converted to *log removal/inactivation* rates (log credits) (see Table A1.2).

Table 5.2 provides the range of treatment technologies that can be used to achieve protozoal compliance, and the combinations of treatment processes for which the log credits can be added.

Water suppliers may apply to the Ministry of Health to have a treatment process covered in sections 5.3 to 5.16 assessed for a different log credit rating, based on a demonstration of performance. Water suppliers may also apply to the Ministry of Health to have other treatment processes assessed for a formal log credit rating. Section 5.17 indicates the supporting information required for developing compliance criteria for a new process, or for a new rating for an existing process. For further information, see the Guidelines, section 8.4.5.

Table 5.2: Protozoa treatment options, credits, criteria and combinations^{1,2}

1a Coagulation-based processes (using rapid granular media filtration):	
<ul style="list-style-type: none"> coagulation/sedimentation³/filtration coagulation/direct sand filtration 	3.0 log credits, or 2.5 log credit.
Additional log credits may be obtained for:	
<ul style="list-style-type: none"> enhanced combined filtration enhanced individual filtration secondary (fine grain) filtration 	0.5 log credit, or 1.0 log credit, or 0.5 log credit.
And further log credits obtained if the above options are followed by:	
<ul style="list-style-type: none"> cartridge filtration bag filtration 	0.5 log credit, or 0.5 log credit.
1b Coagulation-based processes (using membrane filtration):	
<ul style="list-style-type: none"> coagulation/sedimentation³/sand filtration coagulation/direct filtration coagulation/sedimentation 	3.0 log credits, or 2.5 log credits, or 0.5 log credit.
These processes (1a and 1b) may be followed by membrane filtration. ⁴	
1c Any of steps 1a and 1b can be followed or preceded by:	
<ul style="list-style-type: none"> chlorine dioxide disinfection ozone disinfection UV disinfection 	dose-dependant log credit, or dose-dependant log credit, or dose-dependant log credit.
Note that these disinfectants can be used singly or in combination, with log credits for the disinfection processes not exceeding 3.0.	

2a Filtration processes without coagulation (using a single filtration process):	
• diatomaceous earth	2.5 log credit, or
• slow sand	2.5 log credit, or
• membrane filtration	log credit: see note 4 or
• cartridge filtration	2.0 log credit, or
• bag filtration	1.0 log credit.
2b Any option in step 2a can be followed by:	
• chlorine dioxide disinfection	dose–dependant log credit, or
• ozone disinfection	dose–dependant log credit, or
• UV disinfection	dose–dependant log credit.
Note that these disinfectants can be used singly or in combination, with log credits for the disinfection processes not exceeding 3.0.	

3a Filtration processes (using two filtration processes):	
• diatomaceous earth	2.5 log credit, or
• slow sand	2.5 log credit
Followed by a filtration process used in a secondary role:	
• membrane filtration	log credit: see note 4, or
• cartridge filtration	0.5 log credit, or
• bag filtration	0.5 log credit.
3b Any option in step 3a can be followed by:	
• chlorine dioxide disinfection	dose–dependent log credit, or
• ozone disinfection	dose–dependent log credit, or
• UV disinfection	dose–dependent log credit.
Note that these disinfectants can be used singly or in combination, with log credits for the disinfection processes not exceeding 3.0.	

4 Disinfection only:	
• chlorine dioxide disinfection	dose–dependent log credit, or
• ozone disinfection	dose–dependent log credit, or
• UV disinfection	dose–dependent log credit.
Note that these disinfectants can be used singly or in combination. Total log credits for disinfection processes cannot exceed 3.0.	

Notes:

1. Treatment that provides multiple barriers to contamination is more reliable.
2. Surface waters undergoing bank filtration may also qualify for log credits (section 5.3).
3. Throughout the DWSNZ, dissolved air flotation is considered equivalent to sedimentation. Lime-softening plants that include sedimentation and filtration are also considered equivalent.
4. Log credit up to the lower value of the removal efficiency demonstrated during the challenge test or verified by the direct integrity test applied to the system.

5.3 Bank filtration of source water: treatment compliance criteria

Note the difference between **bank filtration** and an **infiltration gallery** (which is described in the Guidelines, section 8.4.1).

The use of bank filtration to obtain log credits is possible only when the water supplier can demonstrate good knowledge of the bank filter's performance and that the water abstracted is derived from the river or lake and not groundwater.

To do this, the system must have been in use for at least two years and sufficient data collected for an assessment of the system's ability to meet the requirements.

When there is uncertainty whether the source of the water abstracted from the bank filtration process is river water or groundwater, the log credits required for the water supply can be determined by monitoring *Cryptosporidium* in the abstracted water rather than the river water. If this is done, no log credits are available from the bank filtration process.

5.3.1 Log credit assessment

The credits available are based on the **setback distance**⁶. A setback distance of:

- 7.5 m is eligible for 0.5 log credits
- 15 m is eligible for 1.0 log credit.

To obtain this credit the process must meet the following requirements when treated water is being delivered to consumers.

1. Core samples from the **regolith** surrounding the well contain at least 10 percent fine-grained material (less than 1.0 mm diameter) in at least 90 percent of their length.
2. The water is drawn from an unconsolidated, predominantly sandy aquifer.
3. The monitoring requirements of section 5.3.2 are met.
4. Measurements of the turbidity of the water satisfy the following.
 - a. For continuous monitoring, the turbidity does not exceed:
 - i. 1.0 NTU for more than 5 percent of the time over the compliance monitoring period (see section 5.3.2)
 - ii. 5.0 NTU for the duration of any three-minute period.
 - b. For manual (or non-continuous) sampling:
 - i. the number of samples with turbidity greater than 1.0 NTU does not exceed the number allowed in Appendix A1.8, Table A1.4, over the compliance monitoring period (see section 5.3.2)
 - ii. the turbidity does not exceed 5.0 NTU in any sample.
5. Documented evidence shows the turbidity does not exceed 2 NTU during the week after a flood that affects the source water (for further discussion, see the Guidelines, section 8.4.1.1).

6. The setback distance is the distance between the vertical well and the surface water when the river or stream is in a flood with a 1 percent probability of recurrence (sometimes called a one-in-100-year flood). For horizontal wells, the setback is from the normal flow channel.

5.3.2 Monitoring

The protozoal compliance monitoring requirements are as follows.

1. The turbidity of the water leaving the bank filtration process must be monitored for a population of:
 - a. 5000 or more – continuously
 - b. fewer than 5000 – at least daily, sampled at evenly spaced times.
2. For continuously monitored parameters the requirements of section 3.2 must be met. The compliance monitoring periods are:
 - a. for continuous turbidity monitoring – one month
 - b. for daily turbidity monitoring – one quarter.

5.3.3 Preventive and remedial actions

The bank filtration process must be investigated as soon as the turbidity monitoring results exceed those specified in section 5.3.1. If the investigation results in the overall treatment process failing to achieve the total log credits required, the DWA must be informed.

The cause of the increased turbidity must be identified, and appropriate actions must be taken to restore the process to a **compliant** condition.

The investigation and actions taken must be documented.

5.3.4 Annual compliance

Annual compliance requires the compliance criteria set out in sections 5.3.1 to 5.3.3 to be met during each compliance monitoring period over 12 consecutive months.

5.4 Coagulation, sedimentation and filtration processes: treatment compliance criteria

This treatment option may include processes where **dissolved air flotation** is used instead of sedimentation. It also allows single-stage lime softening as an alternative, provided it includes all three processes – **chemical coagulation**, sedimentation and filtration. Modifications to the sedimentation process such as ballasted sand and buoyant media are also acceptable.

The situation where the coagulation/sedimentation process is not immediately followed by **rapid granular media filtration** is also covered.

5.4.1 Log credit assessment

1. To obtain 3.0 protozoa log credits, a coagulation, sedimentation and filtration process must meet the following requirements during periods when treated water is being delivered to the consumer.
 - a. Filtration is of a rapid granular media design (gravity or pressure equivalent).
 - b. All water passes through the full coagulation, **flocculation**, sedimentation and filtration process; all parts of which are continuous, excluding any periods when the filtered water is not going to supply.
 - c. The monitoring requirements of section 5.4.2 are met.
 - d. Measurements of the turbidity of the water leaving each filter satisfy the following requirements.
 - i. For continuous monitoring, the turbidity does not exceed:
 - A. 0.30 NTU for more than 5 percent of the time over the compliance monitoring period
 - B. 0.50 NTU for more than 1 percent of the time over the compliance monitoring period
 - C. 1.0 NTU for the duration of any three-minute period.
 - ii. For manual (or non-continuous) sampling (only for supplies up to 500):
 - A. the number of samples with turbidity greater than 0.30 NTU does not exceed the number allowed in Table A1.4 over the compliance monitoring period
 - B. not more than one sample exceeds 0.50 NTU over the compliance monitoring period
 - C. the turbidity does not exceed 1.0 NTU in any sample.
2. Alternative for when rapid granular media filtration does not immediately follow the chemical coagulation/sedimentation process (called coagulation-enhanced presedimentation in the process in *Long Term 2 Enhanced Surface Water Treatment Rule: Final Rule* (LT2ESWTR) (USEPA 2006a).

To obtain 0.5 log credits for the coagulation/sedimentation process alone, the following conditions must be met.

- a. The process must be in continuous operation and all the flow must pass through it.
- b. Coagulant must be added continuously.
- c. The sedimentation process must achieve at least a 70 percent reduction in turbidity each month.

This monthly demonstration of turbidity reduction must be based on the arithmetic mean of the turbidity of the raw water and the water leaving the sedimentation process measured at the frequency specified in section 5.4.2, requirement 4.

5.4.2 Monitoring

The protozoal compliance monitoring requirements are as follows.

1. The turbidity of the water leaving each filter must be measured at the frequencies specified in Table 5.3. Each filter's performance must be reported separately. Sample lines should be short and sample flows high enough to prevent adsorption or precipitation.
2. Supplies serving a population up to 500 may monitor turbidity manually, or continuously with one turbidimeter per filter, or shared between two filters in which case each filter must be sampled sequentially (no blending) for five minutes.
3. For continuously monitored parameters, the requirements of section 3.2 must be met.
4. Particle counting may be used as an alternative to turbidimetry (see the Guidelines, section 8.6.2.2) provided the relation between particle counts and process performance has been established and documented and transgression levels have been set to the satisfaction of the DWA.
5. Where the coagulation/sedimentation process is not immediately followed by rapid granular media filtration, the turbidity of the raw water and the water leaving the sedimentation process must be measured at the frequency specified in Table 5.3.
6. The compliance monitoring period is as specified in Table 5.3.

5.4.3 Preventive and remedial actions

The coagulation, sedimentation and filtration processes must be investigated as soon as the turbidity monitoring results exceed those specified in section 5.4.1. If the investigation results in the overall treatment process failing to achieve the total log credits required, the DWA must be informed.

The cause of the increased turbidity must be identified, and appropriate actions must be taken to restore the process to a compliant condition (Figure 5.1).

The investigation and actions taken must be documented.

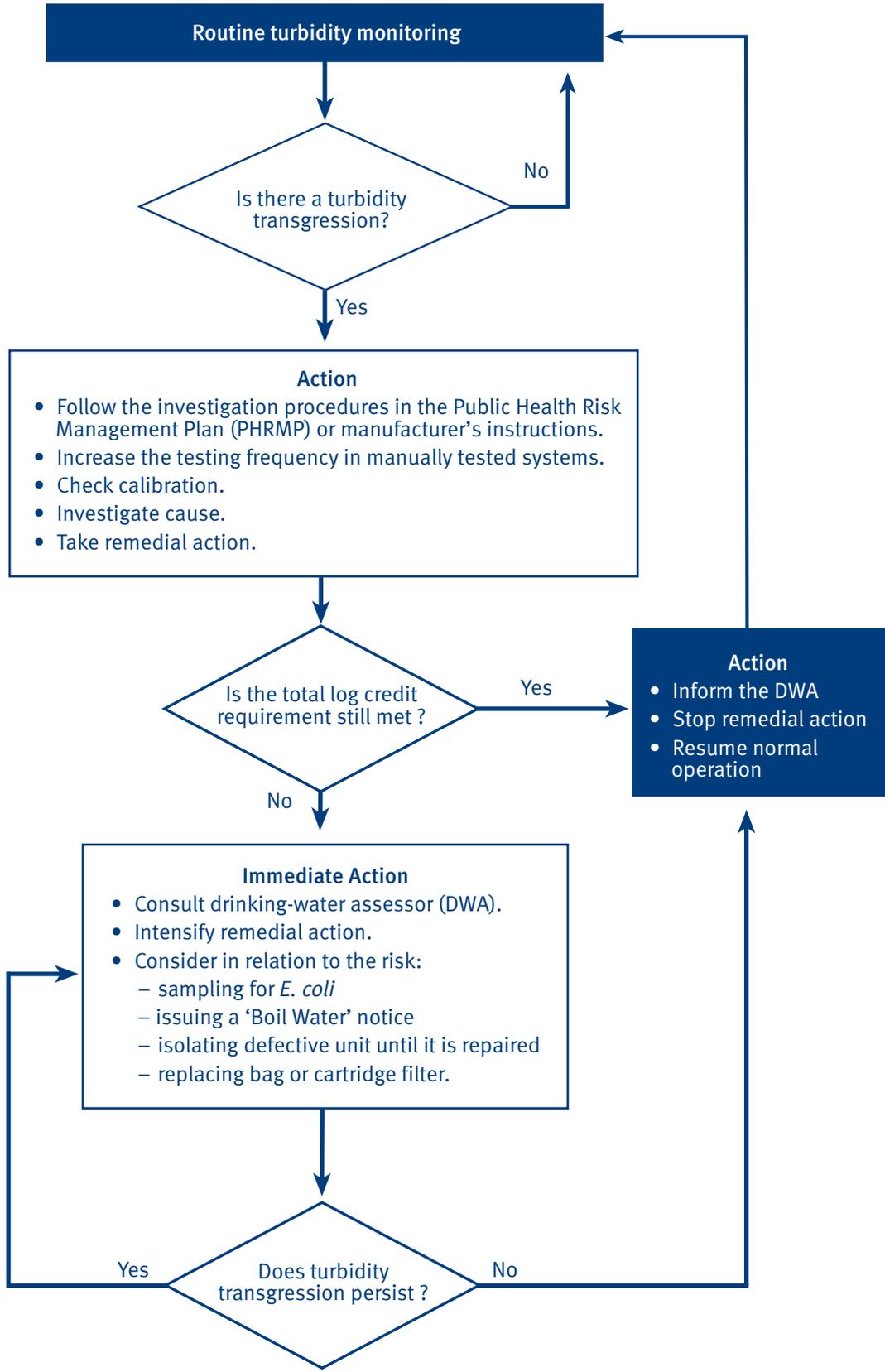
5.4.4 Annual compliance

Annual compliance requires that the treatment compliance criteria set out in sections 5.4.1 to 5.4.3 are met during each compliance monitoring period (Table 5.3) over 12 consecutive months.

Table 5.3: Minimum turbidity measurement frequency and compliance monitoring period

Population served	Number of turbidimeters for continuous monitoring	Minimum measurement frequency (manual measurement)	Compliance monitoring period	
			Continuous	Manual
More than 500	One on each filter (or housing)	<i>Not applicable</i>	One month	<i>Not applicable</i>
Up to 500	One per filter or pair of filters (or housing)	Twice a week per filter (or housing)	One month	One year

Figure 5.1: Response to turbidity transgression in water after treatment



5.5 Coagulation, direct filtration: treatment compliance criteria

5.5.1 Log credit assessment

To obtain 2.5 protozoa log credits, a coagulation, direct filtration process must meet the following requirements when treated water is being delivered to the consumer.

1. Filtration is of a rapid granular media design (gravity or pressure equivalent).
2. All water passes through the full process; all parts of which are continuous, excluding any periods when the filtered water is not going to supply.
3. The monitoring requirements of section 5.5.2 are met.
4. Measurements of the turbidity of the water leaving each filter satisfy all the following requirements.
 - a. For continuous monitoring the turbidity does not exceed:
 - i. 0.30 NTU for more than 5 percent of the time over the compliance monitoring period
 - ii. 0.50 NTU for more than 1 percent of the time over the compliance monitoring period
 - iii. 1.0 NTU for the duration of any three-minute period.
 - b. For manual (or non-continuous) sampling (only for supplies up to 500):
 - i. the number of samples with turbidity greater than 0.30 NTU does not exceed the number allowed in Table A1.4 over the compliance monitoring period (Table 5.3)
 - ii. not more than one sample exceeds 0.50 NTU over the compliance monitoring period
 - iii. the turbidity does not exceed 1.0 NTU in any sample.

5.5.2 Monitoring

The protozoal compliance monitoring requirements are as follows.

1. The turbidity of the water leaving each filter must be measured at the frequencies specified in Table 5.3. Each filter's performance must be reported separately. Sample lines should be short and sample flows high enough to prevent adsorption or precipitation.
2. Supplies serving a population up to 500 may monitor turbidity manually, or continuously with one turbidimeter per filter, or shared between two filters in which case each filter must be sampled sequentially (no blending) for five minutes.
3. For continuously monitored parameters, the requirements of section 3.2 must be met.
4. Particle counting may be used as an alternative to turbidimetry (see the Guidelines, section 8.6.2.2), provided the relation between particle counts and process performance has been established and documented and transgression levels have been set to the satisfaction of the DWA.
5. The compliance monitoring period is specified in Table 5.3.

5.5.3 Preventive and remedial actions

The coagulation and filtration processes must be investigated as soon as the turbidity monitoring results exceed those specified in section 5.5.1. If the investigation results in the overall treatment process failing to achieve the total log credits required, the DWA must be informed.

The cause of the increased turbidity must be identified, and appropriate actions must be taken to restore the process to a compliant condition (Figure 5.1).

The investigation and actions taken must be documented.

5.5.4 Annual compliance

Annual compliance requires that the treatment compliance criteria set out in sections 5.5.1 to 5.5.3 are met during each compliance monitoring period over 12 consecutive months.

5.6 Second-stage filtration: treatment compliance criteria

5.6.1 Log credit assessment

To obtain 0.5 protozoa log credits for second-stage filtration, the following requirements must be met during periods when treated water is being delivered to the consumer.

1. All water passes through a second filtration stage, which consists of rapid sand, dual media, granular activated carbon (GAC) or other fine grain media in a separate stage after granular media filtration. A cap, such as granular activated carbon, on a single stage of filtration will not qualify for this credit.
2. The treatment train includes chemical coagulation before the first filters, and both filtration stages treat all of the flow continuously.
3. Turbidity measurements of the combined second-stage filtrate must not exceed:
 - a. 0.15 NTU for more than 5 percent of the time during the compliance monitoring period
 - b. 0.30 NTU for more than 1 percent of the time over the compliance monitoring period
 - c. 0.50 NTU for the duration of any three-minute period.
4. The monitoring requirements of section 5.6.2 are met.

5.6.2 Monitoring

The protozoal compliance monitoring requirements for second-stage filtration are as follows.

1. The turbidity of the water leaving the filter units that comprise the second-stage filtration process must be measured continuously. Combined filtrates can be monitored, or a system that calculates the mean turbidity from the readings from online turbidimeters on each filter can be used.
2. For continuously monitored parameters, the requirements of section 3.2 must be met. The compliance monitoring period is one month.

5.6.3 Preventive and remedial actions

The second-stage filtration process must be investigated as soon as the turbidity monitoring results exceed those specified in section 5.6.1. If the investigation results in the overall treatment process failing to achieve the total log credits required, the DWA must be informed.

The cause of the increased turbidity must be identified, and appropriate actions must be taken to restore the process to a compliant condition (Figure 5.1).

The investigation and actions taken must be documented.

5.6.4 Annual compliance

Annual compliance requires that the treatment compliance criteria set out in sections 5.6.1 to 5.6.3 are met during each compliance monitoring period of one month over 12 consecutive months.

5.7 Enhanced combined filter performance: treatment compliance criteria

5.7.1 Log credit assessment

To obtain 0.5 protozoa log credits over and above those for coagulation, sedimentation and filtration (or coagulation and direct filtration), the following additional criteria must be met during periods when treated water is being delivered to the consumer.

1. The monitoring requirements of section 5.7.2 are met.
2. Turbidity measurements of the filtrate from the combined filters must not exceed:
 - a. 0.15 NTU for more than 5 percent of the time over the compliance monitoring period
 - b. 0.30 NTU for more than 1 percent of the time over the compliance monitoring period
 - c. 0.50 NTU for the duration of any three-minute period.

5.7.2 Monitoring

The protozoal compliance monitoring requirements for **enhanced combined filter performance** are as follows.

1. The turbidity of the combined water from all the filters must be measured continuously. Alternatively, a system that calculates the combined turbidity from the readings from online turbidimeters on each filter can be used.
2. For continuously monitored parameters, the requirements of section 3.2 must be met.
3. The compliance monitoring period is one month.

5.7.3 Preventive and remedial actions

The treatment process must be investigated as soon as the combined turbidity monitoring results exceed those specified in section 5.7.1. If the investigation results in the overall treatment process failing to achieve the total log credits required, the DWA must be informed.

The cause of the increased turbidity must be identified, and appropriate actions must be taken to restore the process to a compliant condition (Figure 5.1).

The investigation and actions taken must be documented.

5.7.4 Annual compliance

Annual compliance requires that the treatment compliance criteria set out in sections 5.7.1 to 5.7.3 are met during each compliance monitoring period over 12 consecutive months.

5.8 Enhanced individual filter performance: treatment compliance criteria

5.8.1 Log credit assessment

To obtain 1.0 protozoa log credit over and above the credit for coagulation, sedimentation and filtration (or coagulation and direct filtration), the following additional criteria must be met during periods when filtered water is going to supply.

1. The monitoring requirements of section 5.8.2 are met.
2. Turbidity measurements of the filtered water must not exceed:
 - a. 0.10 NTU for more than 5 percent of the time over the compliance monitoring period
 - b. 0.30 NTU for more than 1 percent of the time over the compliance monitoring period
 - c. 0.50 NTU for the duration of any three-minute period.

Systems that receive the additional 1.0 log credit for individual filter performance cannot also receive the additional 0.5 log credit for enhanced combined filter performance.

5.8.2 Monitoring

The protozoal compliance monitoring requirements for **enhanced individual filter performance** are as follows.

1. The turbidity of the water leaving each filter unit is measured continuously.
2. The requirements of section 3.2 are met.
3. The compliance monitoring period is one month.

5.8.3 Preventive and remedial actions

The treatment process must be investigated as soon as the turbidity monitoring results exceed those specified in section 5.8.1. If the investigation results in the overall treatment process failing to achieve the total log credits required, the DWA must be informed.

The cause of the increased turbidity must be identified, and appropriate actions must be taken to restore the process to a compliant condition (Figure 5.1).

The investigation and actions taken must be documented.

5.8.4 Annual compliance

Annual compliance requires that the treatment compliance criteria set out in sections 5.8.1 to 5.8.3 are met during each compliance monitoring period over 12 consecutive months.

5.9 Diatomaceous earth filtration: treatment compliance criteria

5.9.1 Log credit assessment

To obtain 2.5 protozoa log credits, the treatment process (described in the Guidelines, section 14.2), must meet the following requirements during periods when filtered water is being produced.

1. All water passes through the process, which is continuous while producing filtrate.
2. The minimum diatomaceous earth pre-coat thickness that will reliably remove protozoa in different raw water conditions is determined by testing.
3. The monitoring requirements of section 5.9.2 are met.
4. Measurements of the turbidity of the water leaving each filter satisfy the following requirements except in the case of fine colloidal material when the DWA may approve alternative criteria (for further discussion, see the Guidelines, section 8.4.3.1).
 - a. For continuous monitoring, the turbidity does not exceed:
 - i. 0.30 NTU for more than 5 percent of the time over the compliance monitoring period
 - ii. 0.50 NTU for more than 1 percent of the time over the compliance monitoring period
 - iii. 1.0 NTU for the duration of any three-minute period
 - iv. the turbidity of the water feeding the filter for the duration of any three-minute period.
 - b. For manual (or non-continuous) sampling (only for supplies up to 500):
 - i. the number of samples with turbidity greater than 0.30 NTU does not exceed the number allowed in Appendix A1.8, Table A1.4, over the compliance monitoring period
 - ii. not more than one sample exceeds 0.50 NTU over the compliance monitoring period
 - iii. the turbidity does not exceed 1.0 NTU in any sample
 - iv. the turbidity does not exceed the feed water turbidity in all samples.

5.9.2 Monitoring

The protozoal compliance monitoring requirements for diatomaceous earth filtration are as follows.

1. The turbidity of the water leaving each filter unit must be measured at the frequencies specified in Table 5.3. The feed water turbidity must be monitored at the same frequency as the filtered water. Each filter's performance must be reported separately. Sample lines should be short and sample flows high enough to prevent adsorption or precipitation.
2. Supplies serving a population up to 500 may monitor turbidity manually, or continuously with one turbidimeter per filter, or shared between two filters in which case each filter must be sampled sequentially (no blending) for five minutes.
3. For continuously monitored parameters, the requirements of section 3.2 must be met.
4. For compliance monitoring periods, see Table 5.3.

5.9.3 Preventive and remedial actions

The diatomaceous earth filtration process must be investigated as soon as the turbidity monitoring results exceed those specified in section 5.9.1. If the investigation results in the overall treatment process failing to achieve the total log credits required, the DWA must be informed.

The cause of the increased turbidity must be identified, and appropriate actions must be taken to restore the process to a compliant condition (Figure 5.1).

The investigation and actions taken must be documented.

5.9.4 Annual compliance

Annual compliance requires that the treatment compliance criteria set out in sections 5.9.1 to 5.9.3 are met during each compliance monitoring period (Table 5.3) over 12 consecutive months.

5.10 Slow sand filtration: treatment compliance criteria

5.10.1 Log credit assessment

To obtain 2.5 protozoa log credits for a slow sand filter used as a primary process (described in the Guidelines, section 14.3), the following requirements must be met during periods when filtered water is being produced.

1. All water passes through the process.
2. The filter does not dry out.
3. Disinfecting chemicals leaving a residual disinfectant are not dosed upstream of the filter beds.
4. Following maintenance, filtered water is not delivered to consumers until the filtration process has been demonstrated to be effective.
5. The filters are operated at a steady flow rate, which is less than 0.35 m per hour.
6. The temperature of the water entering the filter does not drop below 6°C for more than 24 hours.
7. The monitoring requirements of section 5.10.2 are met.
8. Measurement of the turbidity of the water leaving each filter must satisfy the following conditions.
 - a. For continuous monitoring, the turbidity does not exceed:
 - i. 0.50 NTU for more than 5 percent of the time over the compliance monitoring period
 - ii. 1.0 NTU for the duration of any three-minute period
 - iii. the turbidity of the water feeding the filters for the duration of any three-minute period.
 - b. For manual (or non-continuous) sampling (only for supplies up to 500):
 - i. not more than one sample exceeds 0.50 NTU over the compliance monitoring period
 - ii. the turbidity does not exceed 1.0 NTU in any sample
 - iii. the turbidity does not exceed the turbidity of the water feeding the filters in all samples.

5.10.2 Monitoring

The protozoal compliance monitoring requirements for slow sand filtration are as follows.

1. The turbidity of the water leaving each filter unit must be measured at the frequencies specified in Table 5.3. The feed water turbidity must be monitored at the same frequency as the filtered water. Each filter's performance must be reported separately. Sample lines should be short and sample flows high enough to prevent adsorption or precipitation.
2. Supplies serving a population up to 500 may monitor turbidity manually, or continuously with one turbidimeter per filter, or shared between two filters in which case each filter must be sampled sequentially (no blending) for five minutes.
3. For continuously monitored parameters, the requirements of section 3.2 must be met.
4. The temperature of the raw water entering the filters is measured daily.
5. The flow rate through each filter is measured at least daily.
6. For compliance monitoring periods, see Table 5.3.

5.10.3 Preventive and remedial actions

The slow sand filtration process must be investigated as soon as the turbidity monitoring results exceed those specified in section 5.10.1. If the investigation results in the overall treatment process failing to achieve the total log credits required, the DWA must be informed.

The cause of the increased turbidity must be identified, and appropriate actions must be taken to restore the process to a compliant condition (Figure 5.1).

The investigation and actions taken must be documented.

Appropriate provisions must be applied when the water temperature falls below 6°C.

5.10.4 Annual compliance

Annual compliance requires that the treatment compliance criteria set out in sections 5.10.1 to 5.10.3 are met during each compliance monitoring period (Table 5.3) over 12 consecutive months.

5.11 Membrane filtration: treatment compliance criteria

For the purpose of the DWSNZ, **membrane filtration** is defined as a pressure- or vacuum-driven separation process in which particulate matter larger than one micrometre is rejected by a non-fibrous, engineered barrier (primarily through a size exclusion mechanism), which has a measurable removal efficiency of a target organism that can be verified using a direct integrity test.

Membrane filtration includes **microfiltration**, **ultrafiltration**, **nanofiltration** and **reverse osmosis**.

- A membrane filter plant may be an assembly of units, trains or **modules** or even a single membrane.
- A unit is an assembly of modules or trains that can be isolated from the rest of the filter plant for testing or maintenance.
- A train (or bank) is an assembly of modules.
- A module is an assembly of membranes.
- An individual membrane may be one of several different types: ‘fibres’ (ie, a single filament), tubular, spiral wound, etc.

5.11.1 Log credit assessment

The maximum number of log credits that a membrane filtration process is eligible to receive depends on the manufacturer’s **certification** of the log removal that the filter plant can deliver. The manufacturer’s certificate (or validation) must specify the operational and maintenance requirements to ensure the **membrane units** will perform to specification and the **integrity testing** procedure that the water supplier must carry out to demonstrate that the plant is operating at the claimed log credit rating. It must also document the challenge, or other, tests that were carried out to verify the log credit rating. A suitable verification procedure is outlined in *Membrane Filter Guidance Manual* (USEPA 2005). Installed equipment using the validation described in the USEPA’s draft (2003c) manual is also satisfactory.

To obtain the claimed protozoa log credits, the membrane filtration plant must meet the following requirements during periods when the water that is treated is to be delivered to the consumer.

1. All water passes through the filter plant.
2. The monitoring requirements of section 5.11.2 are met.
3. The direct integrity test used in section 5.11.2 meets the following performance requirements.
 - a. Resolution: The test is applied in a manner such that a 3 µm hole affects the response from the test.
 - b. Sensitivity: The test is capable of verifying the log removal value claimed for the membrane process.
 - c. Frequency (see section 5.11.2).
 - d. For existing membrane filter plants that do not comply with these resolution and sensitivity requirements, the water supplier provides documentation of the procedures that have been used to validate the log credit rating claimed.
4. The continuous indirect integrity tests used in section 5.11.2 are carried out on each unit.
5. In addition to *routine* direct integrity testing (section 5.11.2), additional direct integrity testing is carried out as soon as practicable if any of the following occur.
 - a. The turbidity of the filtered water from the membrane filter unit (the default indirect integrity test) exceeds 0.10 NTU for more than 15 minutes. If the manufacturer has specified a lower maximum turbidity limit as part of the validation requirements, this must be adopted in place of the

0.10 NTU, or, the approved upper control limits of an alternative indirect integrity test specified by the manufacturer (eg, continuous particle counting) are exceeded in the filtrate for more than 15 minutes.

- b. The membrane filter unit has been out of service for maintenance. The testing must be done before the unit is returned to service.
6. The filtrate turbidity does not exceed the turbidity of the feedwater for the duration of any three-minute period.
7. No membrane filter unit may be used while it has failed its direct integrity test.
8. Manufacturers must certify each module's performance specifications and also provide the operational and maintenance requirements for ensuring the module will perform to these specifications, in relation to the claimed log credits.
9. **Validation testing** must have third-party verification by an agency accredited to ISO/IEC 17025 (IANZ 2005) or by the New Zealand National Metrology Institute (or **accreditation** to an equivalent standard accepted by the Ministry of Health).

5.11.2 Monitoring

The protozoal compliance monitoring requirements for membrane filtration are as follows.

1. Direct integrity tests must be performed on each membrane filter unit at least daily and must follow the manufacturer's test procedure⁷, including any special provisions for operating a new filter unit.
2. Indirect integrity testing must be undertaken by continuously monitoring the turbidity of the filtrate from each membrane filter unit⁸. To satisfy requirement 6 in section 5.11.1, the turbidity of the water feeding the membrane filter must be monitored continuously. Alternatively, if the manufacturer specifies a different continuous indirect integrity monitoring test, the water supplier must use this, and must achieve the operating targets. This alternative test must demonstrate that the membrane filtration process is achieving a removal efficiency equal to or greater than log credits awarded to the plant.
3. For continuously monitored parameters, the requirements of section 3.2 must be met.
4. Any additional monitoring required by the manufacturer to demonstrate that the filter is performing within specification must follow the procedures and frequency stated by the manufacturer.
5. The compliance monitoring period, where applicable, is one month.

5.11.3 Preventive and remedial actions

The membrane filtration process must be investigated, following the manufacturer's instructions, as soon as the direct integrity test results (or any other parameters specified by the manufacturer) exceed those validated to achieve the claimed log credit.

The membrane filtration process must be investigated as soon as the turbidity monitoring results (or approved particle count equivalent) exceed those specified in section 5.11.1. If the investigation results in the overall treatment process failing to achieve the total log credits required, the DWA must be informed.

The cause of the increased turbidity or particle counts must be identified, and appropriate actions (including carrying out a direct integrity test) must be taken to restore the process to a compliant condition.

7. If continuous direct integrity test methods become available that also meet the required sensitivity and resolution, they may be used in lieu of periodic testing, subject to Ministry of Health approval.

8. Smaller plants may be able to sample individual modules.

The results of investigations and actions taken must be documented.

5.11.4 Annual compliance

Annual compliance for membrane filtration requires that the treatment compliance criteria set out in sections 5.11.1 to 5.11.3 are met during each compliance monitoring period of one month over 12 consecutive months.

5.12 Cartridge filtration: treatment compliance criteria

A cartridge filter plant consists of a set of **housings** (or pressure vessels), each containing one or more cartridge filters.

A combination of bag filters and cartridge filters will not qualify for more than 2.0 log credits. When cartridge filtration is used for second-stage filtration (section 5.2.3, steps 1a and 3a in Table 5.2) it attracts only 0.5 log credits.

5.12.1 Log credit assessment

To obtain 2.0 protozoa log credits for cartridge filtration, the following requirements must be met during periods when the filtered water is being produced.

1. Each cartridge or housing has a certified *Cryptosporidium* removal efficiency of at least 3 log removal. Water suppliers may adopt the equipment or appliance supplier's certification provided:
 - a. it meets one of:
 - i. the conditions of the *Bag Filter and Cartridge Guidance Manual* (USEPA 2003a)
 - ii. the (oo)cyst reduction conditions of *Drinking Water Treatment Units: Health effects*, NSF/ANSI 53-2002 (NSF and ANSI 2002a)
 - iii. a standard the Ministry of Health has formally recognised as being equivalent
 - b. an appropriately accredited inspection body has performed the testing
 - c. the tests are made on entire housings, including filtration media, seals and other components integral to the process
 - d. the installed equipment (and its configuration) is identical (or validated as equivalent) to the equipment tested during the certification process.
2. All water passes through the cartridge filter plant.
3. The monitoring requirements of section 5.12.2 are met.
4. Measurements of the turbidity of the water leaving each housing must satisfy the following requirements, except where the water contains colloidal material that has been shown to be consistently below 1 µm, when the DWA may approve alternative criteria (see the Guidelines, section 8.4.3.1).
 - a. For continuous monitoring, the turbidity does not exceed:
 - i. 0.50 NTU for more than 5 percent of the time over the compliance monitoring period
 - ii. 1.0 NTU for the duration of any three-minute period
 - iii. the turbidity of the water feeding the cartridges for the duration of any three-minute period.
 - b. For manual (or non-continuous) sampling (only for supplies up to 500), the:
 - i. number of samples with turbidity greater than 0.50 NTU does not exceed the number allowed in Appendix A1.8, Table A1.4, over the compliance monitoring period
 - ii. turbidity does not exceed 1.0 NTU in any sample
 - iii. turbidity does not exceed the feed water turbidity in all samples.
5. Individual cartridge filters (or the packaging containing up to 50 individual cartridges) are labelled in accordance with clause 7.3 of NSF/ANSI 53-2002 (plus Addenda 1 and 2) or equivalent and housings are labelled in accordance with clause 7.2 of NSF/ANSI 53-2002 (plus Addenda 1 and 2) or equivalent (NSF and ANSI 2002a).

6. A slow opening/closing valve is fitted ahead of the cartridge filter plant, and the filtrate passes either through a pressure surge valve or directly to a tank before any subsequent process or pumping. (These steps are to minimise flow surges causing **unloading**.)
7. The flow through each housing is measured. A restrictor that maintains the flow below the certified maximum operating rate is fitted to each housing.
8. Differential pressure measurements across the housing are recorded to confirm that the minimum differential pressure always exceeds the differential pressure corresponding to a clean filter established during commissioning, and are kept within the manufacturer's recommendations.

Membrane material configured into a cartridge filtration device that meets the definition of membrane filtration and that can be direct integrity tested according to the criteria specified for membrane filters is eligible for the same removal credit as a membrane filtration process subject to meeting the requirements of section 5.11.

5.12.2 Monitoring

The protozoal compliance monitoring requirements for cartridge filtration are as follows.

1. Turbidity must be monitored as specified below.
 - a. Turbidity (or particle counts) must be measured in the water leaving each housing at the frequencies specified in Table 5.4. Sample lines should be short and sample flows high enough to prevent adsorption or precipitation. Supplies serving a population up to 500 may monitor turbidity manually, or continuously with one turbidimeter per filter housing, or shared between two housings in which case each must be sampled sequentially (no blending) for five minutes.
 - b. If particle counting is used instead of turbidity, particles in the 2–5 µm size range must be monitored in the water leaving each housing. The transgression level for the particle count must be set at a level that has been demonstrated to give a performance equivalent to that obtained when the manufacturer's operating specifications (eg, turbidity and differential pressure) are complied with.
 - c. The feed water turbidity (or particle counts) must be monitored at the same frequency as the filtered water is monitored.
2. The flow to each housing must be measured as specified in Table 5.4.
3. The differential pressure across each housing must be measured at the frequencies specified in Table 5.4. Differential pressure measurements must be made immediately after cartridge replacement to ensure proper seating and no damage to the cartridge. This must be done at maximum water flow rate (a post-filtration waste valve can be installed to achieve maximum flow).
 - a. For continuous monitoring, differential gauges or pressure transducers:
 - i. are fitted to each housing
 - ii. have a 1.0 kPa accuracy.
 - b. For manual monitoring (ie, for populations up to 500), pressure gauges:
 - i. are located before and after each housing
 - ii. have a dial of at least 100 mm diameter
 - iii. are a liquid-filled type
 - iv. have a range suitable for the process (ie, the system's maximum pressure is about 75 percent of the gauge range).
4. For all continuously monitored parameters, the requirements of section 3.2 are met.

Table 5.4: Minimum measurement frequencies for differential pressure, flow, turbidity and particle counting for cartridge and bag filtration

Population served	Differential pressure	Flow	Turbidity ¹	Particle counting ^{1, 2} (where used)
More than 10,000	<i>Not required</i>	Continuous	Continuous	Continuous
501–10,000	Continuous ¹	Continuous	Continuous	Twice a week
500 or less	Twice a week	Daily ³	Twice a week	<i>Not required</i>

Notes:

1. Measurement on each housing.
2. Particle counting is optional.
3. Obtained from water meter readings.

5.12.3 Preventive and remedial actions

The cartridge filtration process must be investigated as soon as the turbidity (or particle counting) or differential pressure monitoring results exceed those specified in section 5.12.1. If the investigation results in the overall treatment process failing to achieve the total log credits required, the DWA must be informed.

Remedial action is required when any other parameters fail to meet the requirements specified by the manufacturer as part of the equipment validation.

The cause of the increased turbidity or differential pressure must be identified, and appropriate actions must be taken to restore the process to a compliant condition (Figure 5.1) and the manufacturer’s instructions.

The results of investigations and actions taken must be documented.

5.12.4 Annual compliance

Annual compliance for cartridge filtration requires that the treatment compliance criteria set out in sections 5.12.1 to 5.12.3 are met during each compliance monitoring period of one month over 12 consecutive months.

5.13 Bag filtration: treatment compliance criteria

For the purposes of the DWSNZ, a bag filter unit comprises a single bag filter or a pair of bag filters operating in series or parallel.

A combination of bag and cartridge filters will not qualify for more than 2.0 log credits. When a bag filter is used for second-stage filtration (Table 5.2, steps 1a and 3a), it attracts only 0.5 log credits.

5.13.1 Log credit assessment

To obtain 1.0 protozoa log credit for bag filtration, the following requirements must be met during periods when the filtered water is being produced.

1. The bag filter has a certified *Cryptosporidium* removal efficiency of 2.0 log removal or greater. Water suppliers may adopt the equipment or appliance supplier's certification provided:
 - a. it meets one of:
 - i. the conditions of the *Bag Filter and Cartridge Guidance Manual* (USEPA 2003a)
 - ii. the (oo)cyst reduction conditions of NSF/ANSI 53-2002 (NSF and ANSI 2002a)
 - iii. a standard the Ministry of Health has formally recognised as equivalent.
 - b. an appropriately accredited inspection body has performed the testing
 - c. the tests are made on entire units, including filtration media, seals and other components integral to the process
 - d. the installed equipment is identical (or validated as equivalent) to the equipment tested during the certification process.
2. All water passes through the bag filter plant.
3. The monitoring requirements of section 5.13.2 are met.
4. Measurements of the turbidity of the water leaving each bag must satisfy the following requirements, except where the water contains colloidal material that has been shown to be consistently below 1 µm, when the DWA may approve alternative criteria (see the Guidelines, section 8.4.3.1).
 - a. For continuous monitoring, the turbidity does not exceed:
 - i. 0.50 NTU for more than 5 percent of the time over the compliance monitoring period
 - ii. 1.0 NTU for the duration of any three-minute period
 - iii. the turbidity of the water feeding the bag filter for the duration of any three-minute period.
 - b. For manual (or non-continuous) sampling (only for supplies up to 500):
 - i. the number of samples with turbidity greater than 0.50 NTU does not exceed the number allowed in Appendix A1.8, Table A1.4, over the compliance monitoring period
 - ii. the turbidity does not exceed 1.0 NTU in any sample
 - iii. turbidity does not exceed the feed water turbidity in all samples.
5. Bag filters are labelled in accordance with clause 7.3 of NSF/ANSI 53-2002 (plus Addenda 1 and 2) or equivalent and housings are labelled in accordance with clause 7.2 of NSF/ANSI 53-2002 (plus Addenda 1 and 2) or equivalent (NSF and ANSI 2002a).
6. A slow opening/closing valve is fitted ahead of the bag filter plant, and the filtrate passes either through a pressure surge valve or directly to a tank before any subsequent process or pumping. (These steps are to minimise flow surges causing unloading.)

7. The flow through each bag or pair of bags operating as a unit is measured. A restrictor that maintains the flow below the certified maximum operating rate is fitted to each bag or unit.
8. Differential pressure measurements across the bag or unit are recorded to confirm that the minimum differential pressure always exceeds the differential pressure corresponding to a clean filter established during commissioning, and is kept within the manufacturer's recommendations.

5.13.2 Monitoring

The protozoal compliance monitoring requirements for bag filtration are as follows.

1. Turbidity must be monitored as specified below.
 - a. Turbidity (or particle counts) must be measured in the water leaving each filter unit at the frequencies specified in Table 5.4. Sample lines should be short and sample flows high enough to prevent adsorption or precipitation. Supplies serving a population up to 500 may monitor turbidity manually, or continuously with one turbidimeter per filter unit, or shared between two filter units in which case each must be sampled sequentially (no blending) for five minutes.
 - b. If particle counting is used, particles in the 2–5 µm size range must be monitored in the water leaving each filter unit. The transgression level for the particle count must be set at a level that has been demonstrated to give a performance equivalent to that obtained when the manufacturer's operating specifications (eg, turbidity and differential pressure) are complied with.
 - c. The feed water turbidity (or particle counts) must be monitored at the same frequency as the filtered water.
2. The flow to each bag filter or unit must be measured as specified in Table 5.4.
3. Differential pressure measurements must be made immediately after each bag replacement to check the bag is properly seated and no damage has occurred. Pressure readings must be taken at maximum water flow. A valve and drain to waste must be fitted after the filter and flow restrictor and should be open when the pressure reading is taken and recorded.
 - a. For continuous monitoring, differential gauges or pressure transducers:
 - i. are fitted to each bag or pair of bags operating in as a unit
 - ii. have a 1.0 kPa accuracy.
 - b. For manual monitoring (ie, for populations up to 500), pressure gauges:
 - i. are located before and after each bag or pair of bags operating as a unit
 - ii. have a dial of at least 100 mm diameter
 - iii. are liquid filled
 - iv. have a range suitable for the process (ie, the system's maximum pressure is about 75 percent of the gauge range).
4. For all continuously monitored parameters, the requirements of section 3.2 must be met.

5.13.3 Preventive and remedial actions

The bag filtration process must be investigated as soon as the turbidity (or particle counting) or differential pressure monitoring results exceed those specified in section 5.13.1. If the investigation results in the overall treatment process failing to achieve the total log credits required, the DWA must be informed.

Remedial action is required when any other parameters fail to meet the requirements specified by the manufacturer as part of the equipment validation.

The cause of the increased turbidity or differential pressure must be identified, and appropriate actions must be taken to restore the process to a compliant condition (Figure 5.1) and the manufacturer's instructions.

The results of investigations and actions taken must be documented.

5.13.4 Annual compliance

Annual compliance for bag filtration requires that the treatment compliance criteria set out in sections 5.13.1 to 5.13.3 are met during each compliance monitoring period of one month over 12 consecutive months.

5.14 Chlorine dioxide: treatment compliance criteria

5.14.1 Log credit assessment

The credits available are based on the demonstration of inactivation as stated in the table of chlorine dioxide C.t values (Table 5.5). For discussions in determining contact times, see the Guidelines, sections 8.6.2.5 and 15.2.9, and *Toolbox Guidance Manual* (USEPA 2003b, Part 10).

Table 5.5: C.t values (min.mg/L) for *Cryptosporidium* inactivation by chlorine dioxide

Log credit	Water temperature (°C) ¹					
	1	5	10	15	20	25
0.25	153	107	69	45	29	19
0.5	305	214	138	89	58	38
1.0	610	429	277	179	116	75
1.5	915	643	415	268	174	113
2.0	1220	858	553	357	232	150
2.5	1525	1072	691	447	289	188
3.0	1830	1286	830	536	347	226

Notes:

1. C.t values between the indicated temperatures may be determined by interpolation.
2. Chlorine dioxide is measured as ClO₂.

The following requirements must be met when water is being delivered to the consumer.

1. All water is treated with chlorine dioxide.
2. The measured C.t value is not less than:
 - a. the C.t value given in Table 5.5 for the claimed log credit and measured water temperature for more than 5 percent of the compliance monitoring period (see section 5.14.2)
 - b. 80 percent of the C.t value in Table 5.5 for the claimed log credit and measured water temperature for the duration of any five-minute period (or no more than two readings in five minutes).
3. The monitoring requirements of section 5.14.2 are met.
4. Measurements of the turbidity of the water being disinfected satisfy all the following requirements.
 - a. For continuous monitoring, the turbidity does not exceed:
 - i. 1.0 NTU for more than 5 percent of the compliance monitoring period
 - ii. 2.0 NTU for the duration of any three-minute period.
 - b. For manual (or non-continuous) sampling, the:
 - i. number of samples with turbidity greater than 1.0 NTU does not exceed the number allowed in Appendix A1.8, Table A1.4, over the compliance monitoring period (see section 5.14.2)
 - ii. turbidity does not exceed 2.0 NTU in any sample.
5. The chlorite concentration in the water does not exceed a concentration of 0.8 mg/L. Chlorite is potentially a Priority 2a determinand (see section 8.3.3).

5.14.2 Monitoring

The protozoal compliance monitoring requirements for chlorine dioxide treatment are as follows.

1. The chlorine dioxide sampling site is at a point where the adequacy of the residual and the minimum disinfection contact time⁹ can be demonstrated clearly, but before the first consumer.
2. The chlorine dioxide residual is monitored continuously.
3. The flow is measured continuously.
4. The water temperature must be measured daily, if it has been shown to vary by less than 2°C in 24 hours over a month in summer; otherwise, measurements must be made at least every four hours. The measurements must be made at the same location at which the chlorine dioxide residual is measured or in the raw water.
5. The turbidity of the water leaving the disinfection process must be measured:
 - a. continuously for plants serving more than 10,000 people
 - b. at least twice a day for plants serving 5001–10,000 people
 - c. at least daily for plants serving 501–5000 people
 - d. twice a week for plants serving 500 or fewer people.
6. For continuously monitored parameters, the requirements of section 3.2 are met.
7. When the chlorite concentration is likely to exceed 50 percent of the MAV, a monitoring programme must be established to the DWA's satisfaction.

The compliance monitoring period for:

- C.t values is one month
- turbidity is:
 - a month for continuous readings
 - a quarter for manual readings, population 5001–10,000
 - a year for manual readings, populations up to 5000.

5.14.3 Preventive and remedial actions

The disinfection process must be investigated as soon as the water temperature, chlorine dioxide residual, flow, or contact time causes the C.t value to fall below that required to satisfy the log credit requirement as specified in section 5.14.1 (see Figure 5.2), the validation conditions and the manufacturer's instructions).

Appropriate action must be taken when the turbidity does not meet the requirements of section 5.14.1 (Figure 5.1), or when any other parameters fail to meet the requirements specified by the manufacturer as part of the equipment validation. If the investigation results in the overall treatment process failing to achieve the total log credits required, the DWA must be informed.

The cause for failing to meet the required C.t value or exceeding the turbidity requirements must be identified, and appropriate actions must be taken to restore the process to a compliant condition.

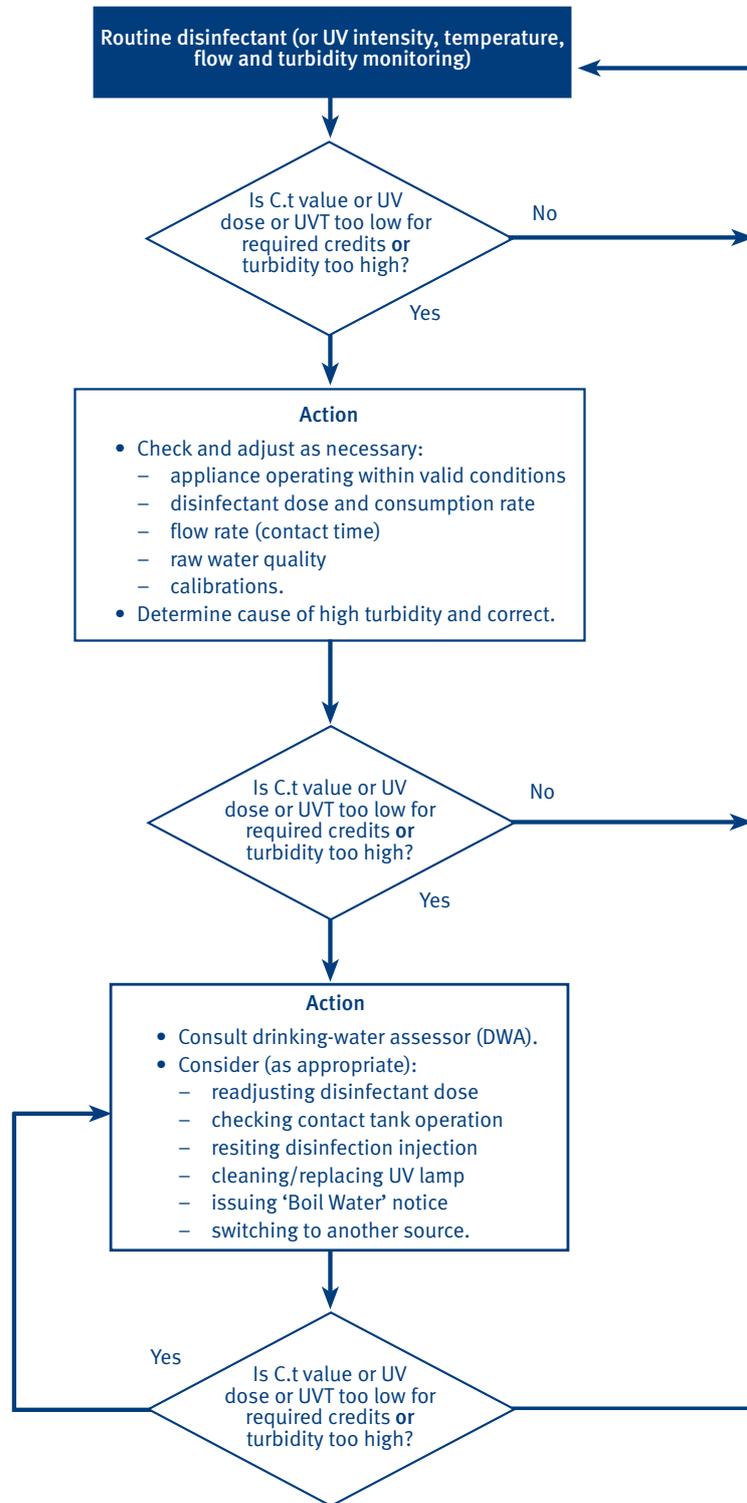
The results of investigations and actions taken must be documented.

9. The contact time is the average time, at peak daily flow, for the water to flow from the chlorine dioxide dose point to the sampling point, after making due allowance for short circuiting and variations in volume (see Guidelines, section 15.2.9).

5.14.4 Annual compliance

Annual compliance for disinfection using chlorine dioxide requires that the treatment compliance criteria set out in sections 5.14.1 to 5.14.3 are met during each compliance monitoring period over 12 consecutive months.

Figure 5.2: Response to disinfectant (chlorine dioxide, ozone, ultraviolet light) transgression for drinking-water leaving the treatment plant



5.15 Ozone disinfection: treatment compliance criteria

5.15.1 Log credit assessment

The credits available are based on the demonstration of inactivation as stated in the table of ozone C.t values (Table 5.6). For discussions on determining contact times, see the Guidelines, section 8.4.4.2, and *Toolbox Guidance Manual* (USEPA 2003b, Part 11).

Table 5.6: C.t values¹ (min.mg/L) for *Cryptosporidium* inactivation by ozone

Log credit	Water temperature (°C) ²					
	1	5	10	15	20	25
0.25	5.8	4.0	2.5	1.6	1.0	0.6
0.5	12	7.9	4.9	3.1	2.0	1.2
1.0	23	16	9.9	6.2	3.9	2.5
1.5	35	24	15	9.3	5.9	3.7
2.0	46	32	20	12	7.8	4.9
2.5	58	40	25	16	9.8	6.2
3.0	69	47	30	19	12	7.4

Notes:

- The C.t data in this table are valid for ozone concentrations in the range 0.2–5.0 mg/L. For further information, see the Guidelines, section 8.4.4.1.
- C.t values between the indicated temperatures may be determined by interpolation.

The following requirements must be met when water is being delivered to the consumer.

- All water passes through the ozone contactor.
- The C.t value determined from the measured ozone residual and flow rate, adjusted to incorporate the effects of ozone decay and reactor hydraulics (for further information, see the Guidelines, sections 8.4.4.2 and 8.6.2.5) meets the following requirements.
 - For continuous monitoring, the C.t value is not less than:
 - the C.t value given in Table 5.6 for the claimed log credit and measured water temperature for more than 5 percent of the compliance monitoring period (see section 5.15.2)
 - 80 percent of the C.t value in Table 5.6 for the claimed log credit and measured water temperature for the duration of any three-minute period.
 - For manual (or non-continuous) sampling:
 - the number of calculated C.t values failing to attain the C.t value given in Table 5.6 for the claimed log credit and measured water temperature does not exceed the number allowed in Appendix A1.8, Table A1.4, over the compliance monitoring period (see section 5.15.2)
 - no C.t value during the compliance monitoring period is less than 80 percent of the C.t value in Table 5.6 for the claimed log credit and measured water temperature.
- The monitoring requirements of section 5.15.2 are met.
- The bromate concentration in the treated water does not exceed a concentration of 0.01 mg/L. This can be determined by direct measurement of bromate or by showing that the bromide concentration in the water before **ozonation** does not exceed 0.006 mg/L. Bromate is potentially a Priority 2a determinand (see section 8.3.3).
- Measurements of the turbidity of the water being disinfected satisfy the following.

- a. For continuous monitoring, turbidity does not exceed:
 - i. 1.0 NTU for more than 5 percent of the compliance monitoring period (see section 5.15.2)
 - ii. 2.0 NTU for the duration of any three-minute period.
 - b. For manual (or non-continuous) sampling:
 - i. the number of samples with turbidity greater than 1.0 NTU does not exceed the number allowed in Appendix A1.8, Table A1.4, over the compliance monitoring period (see section 5.15.2)
 - ii. turbidity does not exceed 2.0 NTU in any sample in the compliance monitoring period.
6. Equipment is validated as described in the *Toolbox Guidance Manual* (USEPA 2003b, Part 11) or a standard the Ministry of Health has formally recognised as being equivalent.

Note that the turbidity requirements apply only when ozone is used for disinfection. They do not apply to the use of ozone for treatment before filtration for the purpose of controlling colour, organic matter or disinfection by-products.

5.15.2 Monitoring

The protozoal compliance monitoring requirements for ozone treatment are as follows.

1. The ozone residual must be monitored:
 - a. continuously for supplies serving more than 500 people
 - b. daily for supplies serving 500 or fewer people.
2. The residual ozone sampling site must be at a point in the contactor where the adequacy of the minimum disinfection contact time can be demonstrated clearly (for further information, see the Guidelines, section 15.5.4). The site for the ozone online analyser must 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 must 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 contact tank at which the integrated ozone C.t value experienced by the water will be 90 percent of the C.t that gives 0.5 log credits (Table 5.6).
3. C.t value calculations for supplies are as follows.
 - a. For supplies serving more than 500 people, calculations must be continuous.
 - b. For supplies serving 500 or fewer people, calculations must be daily, using ozone concentration measurements made at the peak hourly flow. Contact times do not have to be determined daily, only the concentration, but after the initial determination of the contact time it must be re-evaluated if modifications affect the process hydraulics.
4. The water temperature must be measured daily, if it has been shown to vary by less than 2°C in 24 hours over a month in summer, otherwise measurements must be made at least every four hours. The measurements must be made at the same location at which the ozone residual is measured or in the raw water. For batch process plants the temperature of each batch must be measured.
5. The turbidity of the water leaving the disinfection process must be measured:
 - a. continuously for plants serving more than 10,000 people
 - b. at least twice a day for plants serving 5001–10,000 people
 - c. at least daily for plants serving 501–5000 people
 - d. twice a week for plants serving 500 or fewer people.

6. Flow measurements must be made continuously for supplies serving more than 500 people. For supplies serving 500 or fewer people a flow restrictor must be fitted to ensure the flow rate cannot exceed the value determined to give the contact time required for the claimed log credit.
7. For continuously monitored parameters, the requirements of section 3.2 are met.
8. When the bromate concentration is likely to exceed 50 percent of the MAV, a monitoring programme is established to the DWA's satisfaction.

The compliance monitoring period for:

- continuously calculated C.t values is one month
- manually calculated C.t values is two months
- turbidity is:
 - a month for continuous readings
 - a quarter for manual readings, population 5001–10,000
 - a year for manual readings, population up to 5000.

5.15.3 Standardising the ozone analyser

Ozone analyser standardisation by a Ministry of Health recognised laboratory is preferred, but if the analyser is checked using a field test method, the field test method must be standardised against the indigo method, Standard Methods 4500-ozone (APHA 2005), at least once every six months by a Ministry of Health recognised laboratory. The preferred method for standardising the online ozone analyser is described in the Guidelines, section 15.5.4.

5.15.4 Preventive and remedial actions

The disinfection process must be investigated as soon as the water temperature, ozone residual, flow or contact time causes the C.t value to fall below that required to satisfy the log credit requirement as specified in section 5.15.1 (see Figure 5.2, the validation conditions and the manufacturer's instructions).

Appropriate action must be taken when the turbidity does not meet the requirements of section 5.15.1 or when any other parameters fail to meet the requirements specified by the manufacturer as part of the equipment validation. If the investigation results in the overall treatment process failing to achieve the total log credits required, the DWA must be informed.

The cause for failing to meet the required C.t value or exceeding the turbidity requirements must be identified, and appropriate actions must be taken to restore the process to a compliant condition.

The results of investigations and actions taken must be documented.

5.15.5 Annual compliance

Annual compliance for disinfection using ozone requires that the treatment compliance criteria set out in sections 5.15.1 to 5.15.4 are met during each compliance monitoring period over 12 consecutive months.

5.16 Ultraviolet light disinfection: treatment compliance criteria

5.16.1 Log credit assessment

The protozoal log credits available for UV disinfection are based on the UV dose (fluence) delivered by validated UV reactors or appliances. Validation is discussed in section 5.16.2. The number of log credits claimed must be one of:

- 3.0 log credits for reactors validated against DVGW Technical Standard W294, öNORM M5873-1 (Osterreichisches Normungsinstitut 2001) or NSF/ANSI 55-2002 (NSF and ANSI 2002b) for Class A systems (for populations up to 5000) that deliver a fixed dose or fluence of 40 mJ/cm²
- the number the reactor has been validated to achieve (up to 3 logs) following the procedures and requirements specified in *Ultraviolet Disinfection Guidance Manual* (USEPA 2006b).

To obtain the claimed protozoa log credit for UV disinfection, the following requirements must be met when treated water is being delivered to the consumer.

1. All water passes through the UV reactor(s).
2. The monitoring requirements of section 5.16.3 are met.
3. UV irradiance, measured by the UV intensity meter (UV sensor), is not less than:
 - a. the value (established by validation) required to achieve the claimed log credit for more than 5 percent of the compliance monitoring period (see section 5.16.3)
 - b. 80 percent of the value (established by validation) required for the claimed log credit for the duration of any three-minute period.
4. The water entering the UV reactor has done one of the following (a or b).
 - a. The water has passed through a cartridge filter nominally rated at a 5 µm or smaller pore size that has sufficient rigidity to remove contaminants and prevent unloading of these contaminants caused by pressure surges. Also, the filtered water has a turbidity that never exceeds 2.0 NTU (see Table 5.7 for monitoring frequency) except where the turbidity has been shown to be due to colloidal material that is consistently below 1 µm, when the DWA may approve alternative criteria (for further discussion, see the Guidelines, section 8.4.3.1).
 - b. The water has met the following turbidity requirements.
 - i. For continuous monitoring, the turbidity does not exceed:
 - A. 1.0 NTU for more than 5 percent of the compliance monitoring period (see section 5.16.3)
 - B. 2.0 NTU for the duration of any three-minute period.
 - ii. For manual (or non-continuous) sampling, the:
 - A. number of samples with turbidity greater than 1.0 NTU does not exceed the number allowed in Appendix A1.8, Table A1.4, over the compliance monitoring period (see section 5.16.3)
 - B. turbidity does not exceed 2.0 NTU in any sample.
 - iii. For bore water supplies serving a population up to 500 turbidity monitoring may cease if all samples for two years have a turbidity less than 1.0 NTU.

5. This requirement does not apply to UV disinfection systems that automatically adjust the UV dose as the UV transmittance (measured at 253.7 nm) of the water flowing through the reactor varies. Otherwise:
 - a. supplies serving a population over 500, the water entering the UV reactor has:
 - i. for continuous monitoring, a **UV transmittance** that:
 - A. is not less than 95 percent of the lowest **transmittance** for which the reactor has been validated for more than 5 percent of the time over the compliance monitoring period
 - B. is not less than 90 percent of the lowest transmittance for which the reactor has been validated for more than 2 percent of the time over the compliance monitoring period
 - C. does not read less than 80 percent (measured in a 10 mm cell) for the duration of any three-minute period
 - ii. for manual (or non-continuous) sampling:
 - A. the number of samples with transmittance less than 95 percent of the lowest transmittance for which the reactor has been validated does not exceed the number allowed in Appendix A1.8, Table A1.4, over the compliance monitoring period
 - B. no sample has less than 90 percent of the lowest transmittance for which the reactor has been validated
 - C. no sample has less than 80 percent transmittance (in a 10 mm cell)
 - b. supplies serving a population up to 500, the water entering the UV reactor has the following UV transmittance requirements:
 - i. no sample shall have less than 80 percent transmittance (in a 10 mm cell)
 - ii. UV transmittance monitoring of bore water supplies may cease if all samples for two years have a reading greater than 90 percent (measured in a 10 mm cell).
6. The equipment is operated within the flow range for which it was validated, for at least 95 percent of the time.

5.16.2 Validation

The UV disinfection equipment manufacturer is responsible for obtaining and providing certification of validation. The UV disinfection equipment must be validated to one of:

- the *Ultraviolet Disinfection Guidance Manual* (USEPA 2006b) (installed equipment that was validated to the draft *Ultraviolet Disinfection Guidance Manual* (USEPA 2003c) is also acceptable)
- DVGW Technical Standard W294 (DVGW 2006)
- öNORM M5873-1 (Österreichisches Normungsinstitut 2001)
- NSF/ANSI 55-2002 for Class A systems (for populations up to 5000) (NSF and ANSI 2002b).

The validation certificate must be an original (from the issuing authority), unique to the model of reactor, and relate to the parts comprising the reactor and to the name (or data) plate fixed to the reactor.

The validation certificate must define the operating conditions under which the reactor can deliver the UV dose required by the validation procedure. The **validation testing** must have third-party verification by an agency accredited to ISO/IEC 17025 (IANZ 2005) or by the New Zealand National Metrology Institute (or **accreditation** to an equivalent standard accepted by the Ministry of Health).

1. Validation testing of UV reactors must determine a range of operating conditions the reactor can monitor and under which the reactor delivers the required UV dose to achieve the target log credit. These operating conditions must include, at least:
 - a. flow rates
 - b. UV intensity (fluence rate) as measured by a UV intensity sensor
 - c. **UV lamp** status
 - d. minimum UV transmittance of the water for which the UV reactor has been validated to achieve the target inactivation.
2. The validated operating conditions determined by this testing must account for the:
 - a. UV transmittance or **absorbance** of the water
 - b. lamp type
 - c. lamp burn-in time, fouling and ageing
 - d. water temperature
 - e. measurement uncertainty of online sensors
 - f. UV dose distributions arising from the velocity profiles through the reactor
 - g. failure of UV lamps or other critical system components
 - h. inlet and outlet piping or channel configurations of the UV reactor.
3. Validation testing must include the:
 - a. full-scale testing of a reactor that conforms uniformly to the UV reactors to be used at the treatment plant
 - b. inactivation of a test micro-organism whose dose response characteristics have been quantified with a low pressure mercury vapour lamp.

5.16.3 Monitoring

For protozoal compliance monitoring of the water leaving the treatment plant the following requirements must be met.

1. The monitoring requirements stated in Table 5.7 and associated notes must be met.
2. The standardisation and replacement of the sensors, using the manufacturer's instructions, must meet the following requirements.
 - a. Duty sensors:
 - i. the standardisation of the sensor, which must be located at the same point in the reactor as that used for the validation, must be checked at least monthly against the reference sensor.¹⁰
 - ii. supplies serving up to 500 people may use a second duty sensor instead of a reference sensor when conducting the monthly standardisation of the duty sensor.
 - b. Reference sensors:
 - i. the reference sensor must be standardised at least annually in accordance with *Ultraviolet Disinfection Guidance Manual* (USEPA 2006b) or other traceable procedure, with third-party verification given by an agency accredited to ISO/IEC 17025 for this type of standardisation, or by the New Zealand National Metrology Institute (or accreditation to an equivalent standard approved by the Ministry of Health)

10. The sensors should be the same as those used during the validation. The sensor designated as the reference sensor must receive limited exposure to UV light and be stored so that its integrity and accuracy are maintained.

- ii. alternatively, after 12 months the reference sensor can be used as a duty sensor and a new standardised sensor can be purchased for use as a reference sensor.

3. For continuously monitored parameters, the requirements of section 3.2 are met.

The compliance monitoring period for continuously monitored parameters is one month; for all other measurement frequencies the compliance monitoring period is one year.

5.16.4 Preventive and remedial actions

The disinfection process must be investigated as soon as the UV sensor reading, UV transmission (UVT) or flow causes the process to operate outside the validation conditions for meeting the log credit requirement as specified in section 5.16.1 (see Figure 5.2 and the manufacturer's instructions).

Appropriate action must be taken when the turbidity does not meet the requirements of section 5.16.1 (Figure 5.1) or when any other parameters fail to meet the requirements specified by the manufacturer as part of the equipment validation.

If the investigation results in the overall treatment process failing to achieve the total log credits required, the DWA must be informed.

The cause for failing to meet the required UV irradiance (sensor reading) or exceeding the turbidity requirements must be identified, and appropriate actions must be taken to restore the process to a compliant condition.

The results of investigations and actions taken must be documented.

5.16.5 Annual compliance

Annual compliance for disinfection using UV light requires that the treatment compliance criteria set out in sections 5.16.1 to 5.16.4 are met during each compliance monitoring period over 12 consecutive months.

Table 5.7: Minimum monitoring requirements for ultraviolet (UV) disinfection

Population served	Parameter	Minimum monitoring frequency (or control)
More than 10,000	Flow (each reactor) ¹	Continuous
	Turbidity ¹	Continuous
	UV intensity ¹	Continuous
	UV transmittance ²	Continuous
	Lamp outage	Continuous
501–10,000	Flow (each reactor) ¹	Continuous
	Turbidity ¹	Continuous
	UV intensity ¹	Continuous
	UV transmittance ²	Twice a week ³
	Lamp outage	Continuous
101–500	Flow (total) ¹	Continuous
	Flow (each reactor) ⁴	Flow restrictor
	Turbidity	Weekly ⁵
	UV intensity ¹	Continuous
	UV transmittance ²	Weekly ^{3,6}
	Lamp replacement hour meter	Continuous
	Lamp outage	Continuous
100 or less	Flow (each reactor)	Flow restrictor
	Turbidity	Monthly ⁵
	UV intensity ¹	Continuous
	UV transmittance ²	Monthly ⁶
	Lamp replacement hour meter	Continuous
	Lamp outage	Continuous

Notes:

For a description of UV transmittance (or absorbance) units, see Appendix A1.5.9. For discussion on the measurement of UV transmittance (UVT), see the Guidelines, section 8.6.2.6.

1. An alarm must be installed to alert the operator in the event of the parameter being outside the range of its validated limits.
2. If the UV dose is automatically adjusted as the UVT of the water flowing through the reactor varies, UVT must be measured online, but the results do not need to be recorded for compliance purposes.
3. May be reduced to monthly if after 12 months' monitoring, transmittance is not less than that for which the reactor has been validated.
4. Flow restriction is an alternative to continuous flow measurement in individual reactors for populations up to 500.
5. Monitoring of bore water supplies may cease if all samples for two years have a turbidity less than 1.0 NTU.
6. Monitoring of bore water supplies may cease if all samples for two years have a transmittance greater than 90 percent (measured in a 10 mm cell).

5.17 Alternative processes: treatment compliance criteria

Water suppliers may apply to the Ministry of Health to have other treatment processes assessed for a log credit rating. Water suppliers may also apply for a variation for treatment that performs:

- demonstrably better than its compliance criteria
- to a lesser but reliable level than that specified in its compliance criteria or validation.

Information supporting the application must include (as a minimum):

- the site code of the supply
- a description of the quality of the raw water that will be treated
- a description of the treatment process and its limitations
- the intended maximum (and minimum, if relevant) treatment and flow rates
- the operating parameters that need to be met to confirm the claimed log removal
- for a new process, results from a bench-scale or pilot plant **challenge test**
- for a new process, a quantitative description of the performance of the full-scale process elsewhere, including details of (oo)cyst removal/inactivation or equivalent, including:
 - a description of the water the process treated
 - the treatment rates or loading rates the data provided relate to
 - monitoring results
- for a re-rating of an existing process, demonstration of *Cryptosporidium* removal efficiency (or equivalent) over a full range of expected operating conditions.

The supporting data must have been generated by organisations accredited by appropriate accreditation agencies.

A treatment plant cannot gain additional log credits using this section, if it is already claiming log credits for individual processes. For example, a coagulation–sedimentation–filtration plant (section 5.4) cannot claim demonstration of performance log credits, if it is already claiming log credits for enhanced combined filter performance (section 5.7).

Treatment plants claiming 3 log credits for a disinfection process cannot increase this by a demonstration of performance; when a water supply needs more than 3 log credits for protozoal compliance, a filtration technique must provide the additional log credits (ie, the application of the multiple barrier principle).

If a new process or variation satisfies the above requirements, compliance criteria specific to that process and site will be developed.

For further discussion, see the Guidelines, section 8.4.5.

6 Viral Compliance Criteria

Water that is sourced from a catchment in which there is human activity, in particular one with a sewage contamination upstream of the drinking-water abstraction point, is likely to contain some human-pathogenic viruses. It is possible some of the present water treatment options may not remove or inactivate all human-pathogenic viruses. However, insufficient information exists regarding the removal or inactivation of viruses through the various processes used in drinking-water treatment. Consequently, while the DWSNZ do not include viral criteria, it is intended they will be included in a future standard when the effectiveness of viral removal or inactivation by water treatment processes is better understood.

It is considered that if no human effluent is in the catchment, viruses will not pose a risk to public health.

Note that some forms of water treatment are known to be less effective at removing or killing viruses than others. For example, filtration without coagulation is not as effective at removing viruses as are coagulation and filtration, and UV treatment is less effective at killing viruses than the other disinfectants recognised in the DWSNZ. The UV disinfection criteria in section 5.16 may not provide adequate protection against viruses.

When the source is a low-risk surface water and the overall treatment process does not include filtration, at least two disinfectants, one of which may be chlorine, should be used to provide adequate protection against viruses as well as protozoa.

7 Cyanotoxin Compliance Criteria

7.1 Introduction

Cyanotoxins are the toxins produced by cyanobacteria (previously known as blue-green algae). Cyanotoxins may or may not be present when cyanobacteria are present.

Cyanotoxins are not found in groundwater, so this section does not apply to bore waters. However, unconfined bores less than 10 m deep and spring water (considered equivalent to surface water in the DWSNZ) could contain cyanotoxins due to runoff or seepage from ponded water or nearby wet soil that supports the growth of cyanobacteria.

Although cyanotoxins are chemical determinands, several factors mean their monitoring requirements are different from those of other chemical determinands.

7.2 Management protocols

When the source water has previously experienced algal blooms or the DWA judges it to be at risk of bloom development, the water supplier must adhere to the following.

1. Collect information about the source that will assist in determining:
 - a. whether cyanobacteria are present in the source water
 - b. when cyanotoxin concentrations reach or exceed 50 percent of the MAV.
2. Develop a protocol, approved by the DWA, that:
 - a. identifies which determinands or observations are to be monitored for assessing the development of cyanobacteria
 - b. specifies the actions that will be taken in the event of a cyanotoxin reaching a potentially health-significant concentration
 - c. initiates a cyanotoxin monitoring programme in the source water when the protocol indicates that the risk of cyanotoxins being present has reached a predetermined level based on evidence from 7.2(1)(b).
3. Collect source water samples for analysis of cyanotoxins (section 7.3.2).
4. Notify the DWA when the protocol shows the development of cyanobacteria and cyanotoxins in the source water has reached a stage where source water cyanotoxins are approaching 50 percent of the MAV.

Laboratories that undertake cyanobacteria cell counts and cyanotoxin analysis appear in the Ministry of Health's Register of Recognised Laboratories: Drinking water supplies at:

- <http://www.moh.govt.nz/water>
- <http://www.drinkingwater.org.nz>
- <http://www.ianz.govt.nz/services>.

7.3 Priority 2b determinands

7.3.1 Identification of Priority 2b determinands

A cyanotoxin is assigned as a Priority 2b determinand in the water leaving the treatment plant or in the distribution zone:

- when any sample of the treated water leaving the plant or water in the distribution zone shows the

toxin level to have exceeded 50 percent of the its MAV

- based on the outcome of the investigations discussed in section 7.2.

Cyanotoxins may be reassigned as Priority 3 determinands after three successive samples from the supply show:

- the toxin levels to be less than 50 percent of the MAV
- a trend of decreasing toxin concentration.

Compliance requirements then return to the protocol in section 7.2.

7.3.2 Compliance requirements for Priority 2b determinands

Once a cyanotoxin is assigned as a Priority 2b determinand to a supply, the requirements in this section must be met.

7.3.2.1 Sampling frequency

Source water, raw water and water from the treatment plant or distribution zone must be sampled at least twice weekly for cyanotoxin analysis, until the cyanotoxin is reclassified as a Priority 3 determinand.

7.3.2.2 Sampling location

Sampling of source water must be carried out where cell population densities are likely to be highest. In lakes and reservoirs, this is often at, or near, the down-wind or down-stream end of the water body (for further discussion, see the Guidelines, section 9.5.

Samples for cyanotoxin analysis of treated water must be taken from water leaving the treatment plant, or from the distribution zone if cyanotoxin breakthrough is suspected.

7.3.2.3 Analytical requirements

Only laboratories recognised by the Ministry of Health for the purpose may be used for the compliance testing of cyanotoxins. Analytical techniques for cyanotoxins are specified in Appendix 2, Table A2.2.

7.3.3 Remedial actions

A transgression occurs if a cyanotoxin MAV is exceeded in the drinking-water.

When a transgression occurs, the cause must be investigated as soon as practicable. For guidance on investigating the causes of transgressions, see the Guidelines, chapter 9.

In the event of a cyanotoxin MAV being exceeded, the water supplier must:

- inform the DWA
- provide consumers with an alternative source of water until toxin analysis of the water in the distribution system shows the cyanotoxin concentration to have diminished to below 50 percent of the MAV in three successive samples
- continue to work on reducing the levels of cyanobacteria in the source water
- assess why high toxin levels are being found and what actions can be taken to improve treatment effectiveness, when a treatment system is in place that should be capable of removing cyanotoxins.

8 Chemical Compliance Criteria

8.1 Introduction

The purpose of the chemical compliance criteria is to avoid determinands of health significance being present in drinking-water at levels that present a significant health risk.

Chemical constituents of drinking-water may come from the:

- source water
- treatment process
- distribution system
- consumers' plumbing.

Sections 8.2 to 8.4 detail the requirements needed to demonstrate compliance for those determinands that have been designated as Priority 2 for a particular supply. Section 3.3 includes a general discussion about priority classes.

8.2 Compliance criteria

Three types of Priority 2 chemical determinands exist.

- *Priority 2a:* Chemical determinands that could be introduced into the drinking-water supply by chemicals at the treatment plant at levels potentially significant to public health (usually greater than 50 percent of the 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, 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 of the MAV). Priority 2b includes determinands present in the raw water (some or all of which pass through the treatment process), disinfection by-products, cyanotoxins (section 7) and determinands introduced into the drinking-water from the water supplier's piping or other construction materials.
- *Priority 2c:* Chemical determinands of health significance, usually a metal, that may appear in drinking-water, having arisen from consumers' plumbing or fittings. When the concentration of a metal in a non-flushed sample, less its concentration in a flushed sample, is more than 50 percent of the MAV, the metal is assigned Priority 2c.

Priority 2c determinands arise from a property of the water supply, called 'plumbosolvency' in these standards. Elevated concentrations of metals of health concern caused by poor grade domestic plumbing, fittings or faulty installation are not covered in the DWSNZ.

Determinands specified by the Ministry of Health as Priority 2a or Priority 2b must be monitored to establish compliance with the DWSNZ. Priority 2a or Priority 2b determinands may be specific to individual distribution zones, or the treatment plant if the determinand applies to more than one zone. Appropriate sampling sites are in Tables A2.1 to A2.5 and the Guidelines, Appendix 3.

8.2.1 Compliance criteria for Priority 2 determinands

8.2.1.1 General

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

1. Samples are taken at the required sites and in the frequency for the determinand in question.
2. Sampling and analytical techniques comply with the requirements of the DWSNZ.
3. When more than one determinand that causes similar toxicological effects is present, the sum of the ratios of the concentration of each determinand to its respective MAV does not exceed one for compliance with the DWSNZ. In the DWSNZ, this applies to nitrate/nitrite, trihalomethanes (THMs), the haloacetic acids and haloacetonitriles.
4. The number of transgressions found, when sampling is carried out at the frequency specified, does not exceed the allowable number of transgressions in Appendix A1.8, Table A1.4. This table refers to the number of samples taken at equal intervals over the compliance period. For Priority 2 determinands, the compliance monitoring period is one year. In most cases, the number of samples tested during a year will be less than 76, in which case each transgression will result in non-compliance.
5. The procedure outlined in section 8.4 is followed when determinands exceed the MAV, and results and actions are documented.

Figure 8.1 illustrates how to establish compliance of Priority 2a and 2b determinands with the DWSNZ. Figure 8.1 also shows that if the results of all the samples required to be collected in 12 months (see Table 8.1) are less than 50 percent of the MAV, the determinand reverts to Priority 3 (but see section 8.2.2).

8.2.1.2 Compliance criteria for Priority 2a determinands

The monitoring requirements of section 8.3 are met.

Alternatively, compliance can be demonstrated by a certified analysis of the chemicals used in water treatment and a demonstration that the treatment process cannot introduce a sufficient amount of contaminant to cause the determinand to become Priority 2a.

8.2.1.3 Compliance criteria for Priority 2b determinands

Priority 2b determinands comprise two types.

- *Type 1*: Substances whose concentration is unlikely to vary in the distribution system.
- *Type 2*: Substances whose concentration may vary in the distribution system.

The monitoring requirements of section 8.3 are met.

8.2.1.4 Compliance criteria for Priority 2c determinands

Many of New Zealand's waters are soft, with moderate to low levels of **alkalinity** and pH. These properties can give the water a high solvation potential, so that the water may dissolve metals from plumbing fittings if it lies in the plumbing, for example, overnight. Waters with a high carbon dioxide content can also dissolve metals.

If the concentration of a metal in unflushed samples taken from consumers' taps less its concentration in flushed samples is more than 50 percent of the MAV, the water supply is called plumbosolvent water (in the DWSNZ).

Experience with New Zealand water supplies has shown that lead is the main metal of health concern found in unflushed samples taken from consumers' taps.

Some waters have been shown to cause copper to exceed its MAV in unflushed samples due to corrosion of the copper tubing.

Option a

Because the softness of most New Zealand waters is associated with the leaching of metals such as lead from plumbing fittings, all drinking-water supplies are assumed to be plumbosolvent, unless they have been demonstrated not to be by following option b. Where there is no evidence that the water is not plumbosolvent, water suppliers servicing more than 500 people must do the following (1 and 2).

1. Publish in a newspaper twice a year a public notice provided by the Ministry of Health that state the following.

Some plumbing fittings have the potential to allow minute traces of metals to accumulate in water standing in the fittings for several hours.

Although the health risk is small, the Ministry of Health recommends that you flush a mugful of water from your drinking-water tap each morning before use to remove any metals that may have dissolved from the plumbing fittings.

We are recommending this simple precaution for all households, including those on public and private water supplies.

2. Provide this public warning to all consumers at least twice a year, for example, with each water supply bill or water rate demand.

For general advice about plumbosolvent waters and flushing away metals of health concern, see the Guidelines, sections 10.2.2, 10.2.6, 10.3.3 and 10.4.2.

Option b

When a water supplier wishes to demonstrate that the water from its supply is not plumbosolvent, the procedures detailed in the Guidelines, sections 10.3.3 and 10.4.2, may be used (ie, determine lead in the 'first flush' and 'flushed' water samples from a high-lead brass fitting, for example, the C38500 alloy (designation used in AS/NZS1567)). See section 8.3.5.2 for monitoring procedures.

8.2.2 Compliance criteria for Priority 3 and 4 determinands

Priority 3 and 4 chemicals do not have to be monitored, unless assigned a Priority 2 determinand.

A Priority 2a or Priority 2b determinand may be relegated to Priority 3 when 12 successive monthly samples show concentrations below 50 percent of the MAV. When no obvious reason exists for the concentration decrease that led to the reversion of the determinand to Priority 3, monitoring must continue at once a quarter until the DWA is satisfied the change is permanent. The Ministry of Health will adjudicate if there is any disagreement about the need to continue monitoring.

8.3 Monitoring requirements

8.3.1 Sampling sites for Priority 2a determinands

If the procedure described in section 8.2.1.2 is not used, sampling of Priority 2a determinands that are introduced with water treatment chemicals may be carried out in the drinking-water leaving the treatment plant or from the distribution zone if the determinand concentration is unlikely to change during distribution.

8.3.2 Sampling sites for Priority 2b determinands

Priority 2b Type 1 determinands (those unlikely to vary in the distribution system) may be monitored in the drinking-water leaving the treatment plant or in the distribution zone if this is more convenient.

Priority 2b Type 2 determinands (those that may vary in the distribution system), which have a source in the distribution system, or which react in or with it, must be sampled from only the distribution zone.

The tables of referee methods in Appendix 2 (Tables A2.1 to A2.5) indicate which sampling site(s) are appropriate for each determinand. A tick in the distribution zone (DZ) column indicates the sample must be taken from only the distribution zone. Ticks in both the water leaving the treatment plant (TW) and DZ columns indicate the determinands may be sampled from the drinking-water at the treatment plant or in the distribution zone. The sampling location (distribution zone or treatment plant) will be identified when the Priority 2b assignment is made.

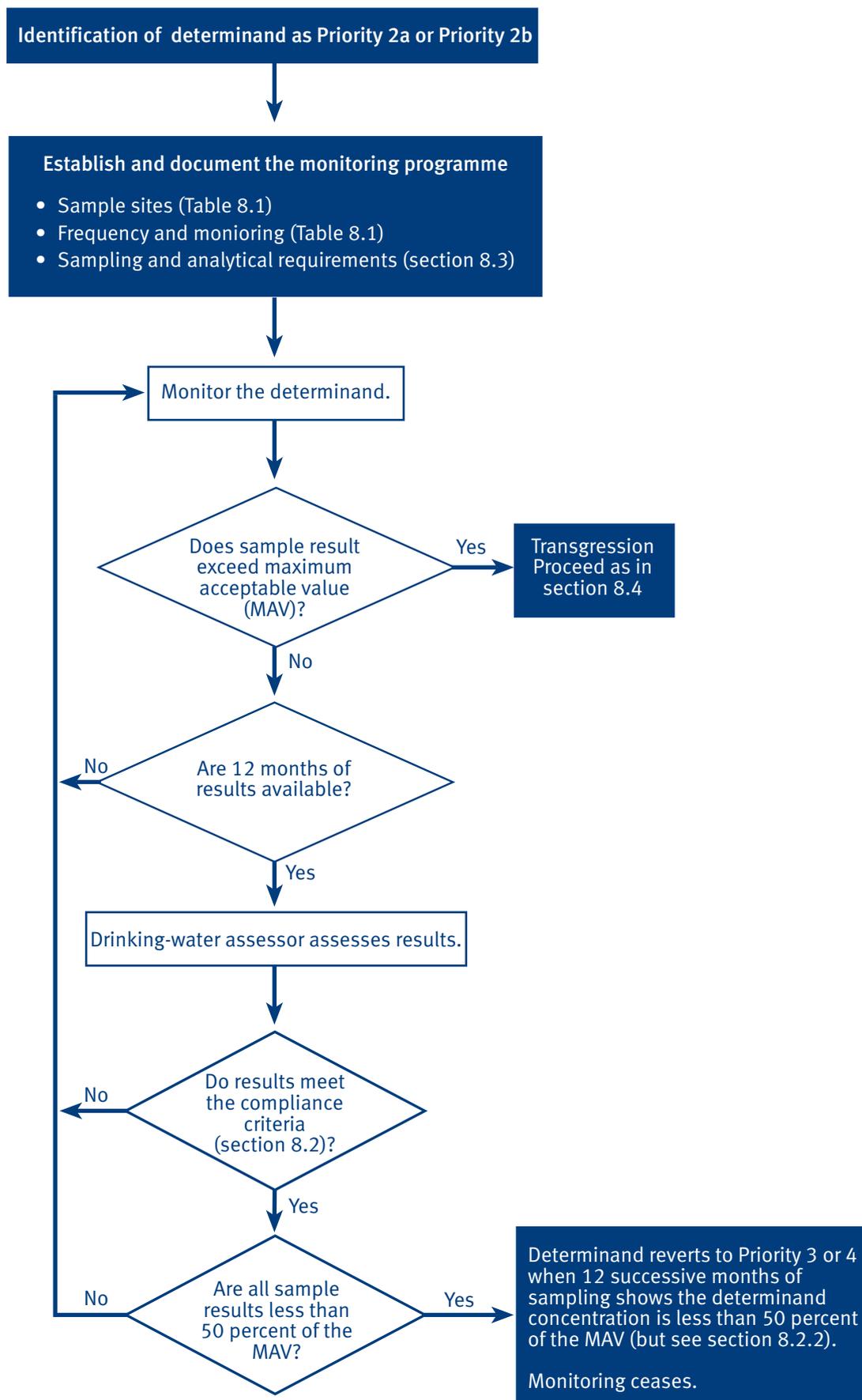
Distribution zone sampling sites must be selected to be representative of the water quality in the distribution zone or appropriate for the determinand in question, unless the DWA specifies otherwise. For example, samples for monitoring disinfection by-products (Priority 2b Type 2 determinands) must be collected from sampling sites near the ends of the distribution system, but samples should be collected only if the disinfection process has been operating normally for several days beforehand.

Once the appropriate sampling area of the distribution zone has been identified for the particular determinand, some sampling should be carried out at fixed sites so water quality trends can be followed.

Further sampling at random sites may be useful to investigate:

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

Figure 8.1: Establishing compliance of Priority 2a and 2b determinands



8.3.3 Monitoring frequencies for Priority 2a determinands

Sampling frequencies are summarised in Table 8.1.

The monitoring programme must include sufficient additional samples to meet any deficiencies that arise from a failure to comply with the programme prescribed in the DWSNZ (see section 3.1.2).

Well-managed drinking-water supplies will undergo process monitoring of these determinands more frequently than is specified above. These process monitoring results can be used to demonstrate compliance provided the sampling and analytical procedures are in accordance with the requirements of the DWSNZ for the determinand concerned; see section 3.2. For further discussion, see the Guidelines, section 10.3.2.

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, for example:

- 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 to control water quality problems (the DWA must also be advised)
- after process changes that could affect the concentration of the determinand in the drinking-water.

8.3.4 Monitoring frequencies for Priority 2b determinands

Sampling frequencies are summarised in Table 8.1.

The monitoring programme must include sufficient additional samples to meet any deficiencies that arise from a failure to comply with the programme prescribed in the DWSNZ (see section 3.1.2).

Priority 2b Type 1 determinands, which may be sampled at the point where the drinking-water leaves the treatment plant or in the distribution system, must be monitored at least monthly, from at least one site.

Priority 2b Type 2 determinands, whose concentration may change in the distribution system, must be monitored in relevant distribution zones. Monthly samples must be collected from at least three fixed sites, and sufficient extra random samples must be collected throughout the year to detect any spatial variability and effects from the distribution system.

When selecting the number of sites and samples, consider matters such as the size of the distribution system and the relevant zones, the determinand concerned, any seasonality, the number of source waters and or treatment plants involved.

Table 8.1: Monitoring requirements for Priority 2a and Priority 2b determinands

Priority	Sampling site locations	Number of sampling sites	Minimum sampling frequency	Maximum days between samples
2a	Drinking-water leaving the treatment plant	1	fluoride: weekly chlorine: weekly ¹ all others: monthly	13 13 45
2b, Type 1	Drinking-water leaving the treatment plant ²	1	monthly	45
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	A monthly sample taken from each of least three selected locations, except where a water supplier wishes to demonstrate the water is not plumbosolvent when sections 8.2.1.4 and 8.3.5.2 apply	45

Notes:

1. The weekly free available chlorine samples are to demonstrate the maximum acceptable value (5 mg/L) is not exceeded. This is not to be confused with the requirements of any bacterial compliance criteria.
2. May also be monitored in the distribution zone if this is more convenient.

8.3.5 Monitoring procedures

8.3.5.1 Priority 2a and 2b determinands

Procedures for sampling, sample preservation, storage and sample transport must be confirmed with the Ministry of Health recognised laboratory carrying out the analysis.

If the results of chemical analysis of water leaving the treatment plant will be affected by temporal changes in the condition of the raw water (eg, for disinfection by-products) the sampling schedule for the year's monitoring programme must be provided to the DWA before the programme starts.

Samples for Priority 2a and 2b determinands, obtained from the treatment plant or the distribution zone, must be collected after flushing the tap long enough to ensure the sample is representative of water from the distribution zone. Adequate flushing is especially important when monitoring heavy metals to avoid metals arising from the corrosion of plumbing contributing to the measurements. A flush volume of at least 20 L must be used. For further discussion, see the Guidelines, section 10.4.

8.3.5.2 Priority 2c (demonstrating non-plumbosolvency)

The standard plumbing fitting protocol described in the Guidelines, section 10.3.3, is recommended because it has been designed to minimise variability in the test for plumbosolvency. It controls several variables that may influence the results.

The following applies when using the standard fitting.

- Sample volume.

A volume of 150 mL ensures that the water collected is only that from the standard plumbing fitting and that there is very little influence from materials beyond the fitting that were in contact with the water.

- Contact time with the standard plumbing fitting.

A minimum contact time of 12 hours is required. This is intended to reflect the typical overnight standing time for water in the plumbing system.

- Composition of the fitting.

The brass selected for the fitting is the AS/NZS 1567 C38500 alloy. This has a relatively high lead content (2.5–4.5 percent) and has been used in the manufacture of some parts of taps. The standard fitting dimensions have been selected to provide a sample volume of approximately 140 mL, which has been in contact with the C38500 alloy only.

- Flushing before use.

The state of the brass surface used in the fitting will influence the rate at which metals dissolve from it. The variability in the nature of the surface can be reduced by flushing for a week before using the fitting. This can be done by filling the fitting, allowing it to stand for three to four hours, running the water to waste, then refilling and repeating the process. The fitting can be allowed to stand over night, then flushed and refilled in the morning.

- Direct connection to the distribution system.

This eliminates any uncertainties related to the composition and length of service pipe or tubing from the street to the tap, and any doubt about the age of the water if tested in high-rise buildings. Using a distribution system site instead of the treatment plant will allow any effects from, for example, concrete lining of pipes, to be taken into account.

- Test frequency and interpretation.

The water supply is non-plumbosolvent if the lead concentration in the unflushed sample, less that in the flushed sample, is less than 50 percent of the MAV, in monthly tests over a 12-month period.

Some water supplies may not cause lead to leach from fittings, yet may cause other metals, for example copper, to exceed the MAV due to corrosion of the water service. Section 8.4 discusses remedial actions when a MAV is exceeded.

8.3.6 Analytical requirements

Only laboratories recognised for the purpose by the Ministry of Health may be used for analyses to check compliance with the DWSNZ.

The laboratory's statistically determined limit of detection for each determinand ideally should be one-fifth, or less, of the MAV for that determinand. This may not be possible for all determinands. The limit of detection and uncertainty of test methods (see Appendix A1.2) must be included in all analytical reports. For further discussion on testing, see the Guidelines, section 17.5.

Analytical requirements for chemicals are specified in the tables in Appendix 2 and the Guidelines, Appendix 3.

8.4 Transgressions and remedial action

A chemical MAV transgression occurs when the measured value of a determinand in a sample exceeds the MAV.

A single sample exceeding the MAV will not necessarily result in non-compliance with the DWSNZ provided the requirements of section 3.1 are met and the number of exceedences is not more than that detailed in section 8.2.1.1, requirement 4.

To minimise risks to public health, however, appropriate action must be taken. After an exceedence has been confirmed, the water supplier must advise the DWA immediately, investigate the cause of the exceedence and take appropriate action.

An investigation and appropriate remedial action is required, if flushing consumers' taps does not prevent MAVs being exceeded.

All incidents of exceedence must be recorded, including monitoring results, actions taken and outcomes.

9 Radiological Compliance Criteria

9.1 Introduction

The purpose of the radiological compliance criteria is to avoid concentrations of determinands of public health significance being present in drinking-water at levels that present a significant health risk.

9.2 Rationale for radiological maximum acceptable value

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
- internal radiation due to ingested or inhaled **radionuclides**, particularly radon decay products.

Radon is a noble gas, which emanates from rocks and soil and can concentrate in buildings. Use of water can increase the indoor radon concentration, if radon is present in the water supply.

Natural radiation exposure varies regionally as the compositions of soils and rocks change and increases with altitude as cosmic radiation intensity increases. Nothing can be done to prevent exposure. Radionuclides in drinking-water contribute less than 5 percent to the exposure from natural sources.

Different radionuclides have different radio-toxicities, and for an accurate determination of the exposure, a detailed radioanalytical assessment is required. A quick, cost-effective screening can be performed by testing for total concentration of **alpha-emitting radionuclides** and **beta-emitting radionuclides** and for the concentration of radon-222. The first two tests allow an upper limit to be set for exposure from ingestion and the third test allows an upper limit to be set for exposure from the ingestion and inhalation of radon decay products.

The DWSNZ 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 2 L of water per day to less than 5 percent of the average annual radiation dose due to all natural sources. The MAV for radon-222 limits the exposure from radon in water to half the average exposure from radon in air.

9.3 Compliance criteria

The MAVs given in Table 2.4 for radiological determinands must not be exceeded.

9.4 Monitoring requirements

The monitoring frequency for radiological determinands is 10 years for bore water supplies that are not considered to be equivalent to surface water.

Water from new underground sources must be tested before connection to a reticulated drinking-water supply.

If radiological sampling of water is contemplated, the National Radiation Laboratory must be consulted. The National Radiation Laboratory will specify the sampling requirements.

If the radioactivity of a drinking-water supply exceeds 50 percent of the MAV, the determinand must be assigned as a Priority 2 determinand and the sampling frequency increased to once per year. Every three years, the data must be examined and the monitoring requirements re-evaluated by the DWA in consultation with the National Radiation Laboratory. When sufficient evidence exists that 50 percent of the MAV is no longer being exceeded, the radiological determinand will be reclassified as a Priority 3 determinand.

9.5 Exceedence of radiological maximum acceptable value

The National Radiation Laboratory provides analytical and radiological advisory services appropriate for drinking-water testing.

If the total alpha-concentration exceeds the MAV, the water must be analysed for uranium-238, uranium-234 and radium-226 and a **radiological assessment** must be undertaken.

If the total beta-concentration exceeds the MAV, the water must be analysed for radium-228 and any other beta-emitting radionuclides that may be present, and a radiological assessment undertaken.

If one of the radiological MAVs is exceeded, the National Radiation Laboratory advises the DWA and the water supplier of the remedial action to be taken.

10 Small Water Supplies, Alternative Compliance Criteria

Including neighbourhood drinking-water supplies and appropriate components of rural agricultural drinking-water supplies.

10.1 Introduction

The *Drinking-water Standards for New Zealand* (DWSNZ) have three main components.

- The **water quality standards**, which specify the maximum acceptable values (MAVs) at which the risk of disease or illness from drinking the water is negligible (section 2).
- The **compliance criteria** and reporting requirements, which define the checks needed to demonstrate the water supply is not exceeding these standards. The stringency of these checks reflects the level of risk that the water supply poses.
- The **remedial actions**.

This section of the DWSNZ applies to drinking-water supplies serving up to 500 people as defined in the Health Act 1956 as amended by the Health (Drinking Water) Amendment Act 2007 (hereinafter referred to as the Act): **Small**¹¹, **Neighbourhood**¹², and **Rural Agricultural Drinking-water Supplies**¹³.

The water quality standards are the same for all supplies, regardless of size or type, because they relate to the health effects on people. The compliance criteria provide different levels of certainty that the standards are being met, balancing the risks to public health and costs. From a public health perspective, the more people served the more certainty that is needed.

Small, neighbourhood and rural agricultural drinking-water supplies have two options for demonstrating compliance with the water quality standards.

1. Comply with the requirements in sections 4, 5 and 7 to 9.
2. Follow a Public Health Risk Management Plan (PHRMP) compliance criteria approach (sections 10.2 to 10.5). These are referred to as **participating supplies**.

11. Small drinking-water supply (the Act, section 69G) means a drinking-water supply that:

- a. supplies drinking-water to 101 to 500 people for at least 60 days per year; and
- b. is not a drinking-water supply to which paragraph (a) or paragraph (b) of the definition of neighbourhood drinking-water applies.

12. Neighbourhood drinking-water supply (the Act, section 69G) means a drinking-water supply that is used to supply drinking-water to:

- a. between 25 and 100 people (inclusive) for at least 60 days per year; or
- b. any number of persons for at least 60 days per year if:
 - i. the number of those persons when multiplied by the number of days per year during which those persons receive water from that supply is 6000 or greater, but
 - ii. the number of those persons is not greater than 100 on 60 or more days in any year.

13. Rural agricultural drinking-water supply (the Act, section 69G) means:

- a. a large, medium, minor, small, or neighbourhood drinking-water supply from which 75 percent or more of the water supplied:
 - i. is used for the purposes of commercial agriculture; and
 - ii. does not enter a dwellinghouse or other building in which water is drunk by people or other domestic and food preparation use occurs; but
- b. does not include a drinking-water supply using a single connection to provide water to:
 - i. a town; or
 - ii. a village or other place with a permanent population of 50 people or more that is used primarily for residential purposes.

10.2 Compliance requirements

The following compliance requirements must be met.

1. A PHRMP must have been approved by a drinking-water assessor (DWA) and be in the process of being implemented.
2. Appropriate bacterial and chemical treatment, as determined from the catchment assessment in the PHRMP must be in use.
3. Appropriate protozoal treatment (Table 10.1) must be in use.
4. Water quality must be monitored and meet the requirements of section 10.4.
5. The remedial actions that have been specified in the PHRMP must be undertaken when a MAV is exceeded or treatment process controls are not met.

When the water supplier can show these requirements have been met, the supply will be deemed to comply with the DWSNZ, otherwise the compliance requirements for the supply revert to those in sections 4, 5 and 7 to 9.

When monitoring data show that water quality is unsatisfactory but the steps specified in the PHRMP to improve the water quality are being taken, reversion to the requirements of sections 4, 5 and 7 to 9 may be delayed to provide time to establish the effectiveness of the remedial actions.

10.3 Treatment requirements

10.3.1 Background

The quality of drinking-water at the point of consumption needs to conform to the same standards throughout New Zealand. However, the quality of source waters, from which drinking-water is drawn, varies. Therefore, the degree of treatment required to provide safe water is greater for contaminated water than for clear waters.

Treatment requirements to remove chemical contaminants are typically based on the average concentration present or thought to be present. In drinking-water, chemicals just exceeding their MAV typically take a long time (months or years) to cause health problems.

For microbial contaminants, treatment requirements to remove hazardous pathogens are typically based on the maximum predicted contamination levels, not merely the average levels, because the effects of microbial contaminants can occur in just hours or days, so the greatest health risk is caused when contamination peaks.

As a minimum requirement, treatment processes must be operated and monitored according to the manufacturer's instructions.

10.3.2 Microbial treatment requirements

Most water needs to be treated before it is considered potable. The exception is bore water supplies that have been demonstrated to be secure (section 4.5), for which no additional treatment is required. If source waters cannot be shown to be free from contaminants, treatment is required to provide a barrier to contamination. If there is any doubt about the quality of the source water, treatment is required.

The likely nature and extent of contamination in the water source should be identified as part of the catchment assessment component of the development of the PHRMP for the water supply. In completing the catchment assessment, consideration should be given to the types of potential contamination sources identified in Table 10.1.

Table 10.1 sets out a scheme for identifying default treatment requirements based on the maximum contamination levels estimated to be present in source waters from catchments with particular characteristics. Alternative approaches can be adopted where these can be justified (section 5).

10.3.3 Chemical treatment requirements

Potential sources of chemical contamination (including cyanotoxins) of the source waters or during the treatment process must be identified in the PHRMP and dealt with by an appropriate process.

Steps should be taken to minimise the amount of contaminant entering the source water, and an appropriate treatment process used if further reduction in the concentration is needed to produce safe drinking-water.

10.4 Water quality monitoring

10.4.1 General

Sampling must be carried out according to a predetermined plan.

Analyses must be carried out by a laboratory recognised by the Ministry of Health as competent to carry out the drinking-water compliance testing, except where special procedures or field analyses are authorised by the Ministry of Health (DWSNZ section 3.1.1).

Procedures for the collection, preservation, storage and transport of samples must be agreed beforehand with the laboratory carrying out the analysis, except where the Ministry of Health authorises special procedures for isolated drinking-water supplies or field analyses.

The supplier must specify in the PHRMP the appropriate steps for providing assurance of satisfactory drinking-water quality management when a microbial sample cannot be sent to a recognised laboratory within the required period at the frequency described, because the supply is:

- isolated from courier routes
- temporarily inaccessible (eg, due to severe weather conditions)
- not able to be monitored by a person certified by a DWA as competent to undertake compliance monitoring.

Table 10.1: Microbial treatment requirements for small supplies of different levels of risk

Summary of catchment type as identified in the catchment assessment of the PHRMP	Minimum treatment requirements	Explanation
Secure bore water	No treatment required	Secure bore water is considered to be free from microbial contamination.
Protected catchment with controlled human access and no livestock operations (eg, non-secure bore water drawn from a depth greater than 30 m, or surface water that is selectively abstracted, or a rainwater supply)	<i>Bacterial treatment and low protozoal risk</i> Prefiltration or selective abstraction ^{1, 2} followed by chlorine disinfection ³ or <i>Bacterial and 2-log protozoal treatment</i> Prefiltration or selective abstraction ^{1, 2} followed by UV disinfection ⁴	Disinfection is required to inactivate bacterial pathogens, such as <i>Campylobacter</i> spp. and <i>Salmonella</i> spp., that are known to be present in wildlife.
Partially protected catchment with no sewage discharges or human habitations and no intensive livestock operations harbouring gatherings of pre-weaned and juvenile stock (eg, non-secure bore water drawn from a depth of 10–30 m, or a spring, lake or reservoir, stream or river, or surface water that is selectively abstracted)	<i>Bacterial and 3-log protozoal treatment</i> Prefiltration or selective abstraction ¹ followed by UV disinfection ⁴ or Microfiltration (eg, cartridge) ⁵ followed by chlorine disinfection ³ or Microfiltration (eg, cartridge) ⁶ followed by UV disinfection ⁴	Disinfection is required to treat bacterial pathogens such as <i>Campylobacter</i> spp. and <i>Salmonella</i> spp. that are known to be present in stock and wildlife; and the removal or disinfection of moderate levels of protozoan pathogens found in stock animals.
Unprotected catchment with septic tanks and/or sewage discharges from human habitations and/or intensive livestock operations harbouring gatherings of pre-weaned and juvenile stock (eg, non-secure bore water drawn from a depth less than 10 m, or a spring, lake or reservoir, stream or river)	<i>Bacterial and 4-log protozoal treatment</i> Microfiltration (eg, membrane filter) ⁵ followed by chlorine disinfection ³ or Microfiltration (eg, cartridge) ⁶ followed by UV disinfection ⁴	Disinfection is required to treat bacterial pathogens such as <i>Campylobacter</i> spp., <i>Salmonella</i> spp. that are known to be present in stock, sewage and wildlife; pathogens such as norovirus and hepatitis A virus that are known to be present in sewage; and high levels of protozoan pathogens found in stock animals.

Notes:

1. Selective abstraction (achieving a turbidity less than 1 NTU) means taking source water only at a time when it is least contaminated. This ensures substances that may interfere with disinfection are avoided and/or reduced to levels that will not overwhelm disinfection eg, large particles, turbidity, chlorine demand and UV-absorbing substances need to be kept within acceptable levels.
2. Selective abstraction for a rainwater supply includes use of a leaf screen, first flush diverter, bottom tank inlet or floating top draw-off.
3. To meet greater than 0.5 mg/L FAC after 30 minutes' contact with pH less than 8.5 or equivalent C.t.
4. The UV unit must meet (and operate within the specifications of) one of the following standards: NSF/ANSI 55-2002 Class A (NSF and ANSI 2002b); DVGW Technical Standard W294; öNORM M5873-1 (Osterreichisches Normungsinstitut 2001); or equivalent (ie, to deliver at least 40 mJ/cm² validated reduction equivalent dose at the UVT and turbidity present).
5. Pore size must be less than or equal to 1 µm absolute, or tested and rated to remove at least 99.9 percent (3-log) of *Cryptosporidium* spp. oocysts, and the vendor must guarantee the system will meet defined performance standards.
6. The final cartridge before the UV reactor must have a pore size no greater than 5 µm (nominal) and be a rigid cartridge (ie, not pleated), fabric or wound string.

10.4.2 Bacterial monitoring

Compliance monitoring for *E. coli* must be conducted at least three monthly with a maximum interval between successive samples of 135 days. Presence/absence tests or other rapid-test methods for *E. coli* or faecal coliforms that are acceptable to the Ministry of Health may be used for compliance monitoring.

Samples must be taken from randomly selected locations throughout the distribution system.

The testing of samples should start within six hours of sample collection and must not be delayed more than 24 hours after collection. Samples must be transferred to the laboratory in a cool, dark container. It is important the temperature of samples does not increase between the samples being taken and being analysed. To be valid for compliance testing, samples must not be frozen and must arrive at the laboratory at a temperature not greater than 10°C or not warmer than the temperature of the water when it was sampled. If samples cannot be processed immediately on their arrival in the laboratory, they must be stored in a refrigerator no warmer than 5°C.

10.4.3 Protozoal monitoring

Monitoring of protozoa is not required. As a surrogate, inspection and monitoring of the source protection, abstraction and treatment practices and the network protection is required.

The operational requirements that need to be monitored to demonstrate protozoal compliance are dependent on the water treatment process being used. The monitoring programme adopted must be given in the PHRMP.

10.4.4 Chemical monitoring

When any chemical is found in treated water at greater than 50 percent of its MAV it must be noted in the PHRMP and monitored at least annually until its concentration has been found to be less than 50 percent of its MAV in three consecutive samples and a reason for the drop in concentration has been identified.

If chlorine is used as a disinfectant and the presence of disinfection by-products is suspected, samples must be taken as far downstream of the point of disinfection as practicable.

10.5 Responses required when a maximum acceptable value is exceeded or treatment failure is detected

The sampling plan is used to determine whether the MAV or operational requirements:

- are exceeded continually
- are exceeded seasonally or intermittently
- have exceeded the **transgression limits** as the result of a once-only event.

Actions required to be taken when a MAV is exceeded are defined in the supply PHRMP, which must contain, but is not limited to, the following elements.

- When *E. coli* is detected in a sample there must be an immediate response to discover the reason and minimise the likelihood of a recurrence (Figure 4.2).
- When a protozoal treatment process fails to perform within its operational requirements defined in the PHRMP, remedial action must be agreed with the DWA or medical officer of health and carried out.

- A **sanitary inspection of the water supply** is conducted.
- If a permanent 'Boil Water' notice is issued, approved signage must be displayed next to all taps connected to the supply.
- If the concentration of any chemical exceeds its MAV, remedial action must be agreed with the DWA or medical officer of health and carried out.

In many places in New Zealand, the water is plumbosolvent (ie, it corrodes metal plumbing fittings) and may give rise to undesirable concentrations of lead or other metals in the supply. It is not necessary to test for this, but consumers must be warned at least annually of this fact and advised to flush about 500 mL of water (about two standard glasses) from the tap each morning before drawing water for drinking.

11 Tankered Drinking-water Compliance Criteria

11.1 Registration of water carriers

All water carriers who provide drinking-water to customers must be registered on the Ministry of Health's Register of Community Drinking-water Supplies and Suppliers (eg, Ministry of Health 2008b).

11.2 Sources and classes of water

Tankered drinking-water is water delivered by tanker and not through a water network reticulation. It is preferably sourced from water provided by a registered drinking-water supplier whose supply complies with the DWSNZ. It may be delivered by road or rail to the consumer's storage facility on a commercial or voluntary basis.

Every carrier of drinking-water in New Zealand must ensure any water sold or supplied for potable purposes – drinking, food preparation or personal hygiene – meets the requirements of this section and the water quality is protected from contamination at all times during its loading, transit and delivery.

When water is to be taken from a reticulated water supplier, the supplier's requirements in respect of backflow prevention, metering, access points and the use of the supplier's equipment must be complied with at all times.

Tankered water carriers may also carry water from a source that is not from a registered water supply and does not comply with the DWSNZ, but is in accordance with the requirements of Class 2 water, when such a class of water is specified by the customer. Whenever practicable, only the highest quality of water should be used.

Water delivered by tanker is categorised into two classes. These classes represent the expected risk/quality of water being delivered to the consumer and define the actions the tanker operator must take during the supply operation.

Class 1 drinking-water is divided into two subclasses.

- *Class 1(a)* is water taken from a reticulated supply that complies with the DWSNZ and is listed in the Register of Community Drinking-water Supplies and Suppliers in New Zealand.
- *Class 1(b)* is water taken from an independent participating supply that meets the compliance criteria for such systems (section 10).

Class 2 water is water that does not meet the *Class 1(a)* or *Class 1(b)* drinking-water criteria, but is intended for drinking purposes after appropriate treatment. The treatment that will be carried out must render the water potable. *Class 2* water may be taken only from water sources approved by a DWA.

11.3 Operation

Every tanker must maintain and carry a logbook that contains the details of each load transported and each cleaning schedule. Such a log book must be kept for at least 10 years.

The operator of any vehicle used to transport water must ensure the following.

- All tanks and the systems used for loading or unloading water have not been used for transporting any noxious, toxic or hazardous matter, non-food liquids, or human or animal wastes.
- All tanks and the systems used for loading or unloading water are protected from contamination during loading, transportation and delivery.
- All tanks and the systems used for loading or unloading water are kept clean and clear of any possible contaminants before sourcing the water to be delivered, with all openings and connections sealed to protect them from possible contamination. If unused for the transport of drinking-water for a period of 30 days, the tank and fittings must be disinfected by filling with potable water containing at least 5 mg/L chlorine or other approved disinfectant for not less than 30 minutes before discharging to waste.

Following the transport of non-potable water, or any other consumable liquid such as milk or beer, the tanker must be subjected to an appropriate cleaning and disinfection process.

Tankered drinking-water carriers are required to complete a public health risk management plan (PHRMP) in relation to the method of transporting water intended for drinking. The PHRMP must identify potential risk and put programmes in place to mitigate such risks. The PHRMP must be reviewed and revised regularly.

11.4 Monitoring

Samples from the delivery tank must be collected for *E. coli* testing at a Ministry of Health recognised laboratory.

- Every third month, if the water being carried is Class 1(a) and contains at least 0.2 mg/L FAC or equivalent at the filling point.
- Monthly, if the water being carried is Class 1(a) but contains less than 0.2 mg/L FAC or equivalent at the filling point.
- As specified by the DWA, if the water carried is Class 1(b) or Class 2.

Procedures for sampling are discussed in the Guidelines, section 6.4.

Whenever non-potable water has been transported by tank, the tank must be washed, cleaned and refilled with potable water and a sample collected after the refilling or during the next delivery for *E. coli* testing.

All samples must be collected during the unloading or discharge process.

All positive *E. coli* tests must be reported immediately to the DWA who may require no further water to be transported from that source or in that tanker until the reason for the positive test has been identified and dealt with to the DWA's satisfaction.

11.5 Delivery

When drinking-water is delivered, a written statement must be supplied to the consumer stating the:

- delivery date and volume of water delivered
- source and class of water delivered and, where applicable, the grading of the treatment plant and distribution system, including the meaning of such grading, from where the water was taken.

If the water is supplied to non-residential premises, the statement must be displayed in a prominent location that allows all potential consumers to read it.

If the water is Class 2 water, the statement must also contain information from the DWA, who may require the statement to include a 'Boil Water' notice.

11.6 Documentation and records

All documentation and logbook records must be in accordance with the *Guidelines for the Safe Carriage and Delivery of Drinking-water* (Ministry of Health 2008).

A log must be kept of the:

- nature of any cargo tankered
- details of filling and discharge points
- cleaning carried out before drinking-water is tankered if not used for more than 30 days, and after any cargo other than drinking-water has been tankered.

12 Rural Agricultural Drinking-water Supplies

The Health Act 1956 2007 amendment introduced a new category of drinking-water supply –

rural agricultural drinking-water supply, which means:

- a. a large, medium, minor, small, or neighbourhood drinking-water supply from which 75% or more of the water supplied
 - i. is used for the purposes of commercial agriculture; and
 - ii. does not enter a dwellinghouse or other building in which water is drunk by people or other domestic and food preparation use occurs; but
- b. does not include a drinking-water supply using a single connection to provide water to:
 - i. a town; or
 - ii. a village or other place with a permanent population of 50 people or more that is used primarily for residential purposes.

Drinking-water standards for Rural Agricultural Drinking-water Supplies are in the course of preparation and consultation and, when completed, will form section 12 of the *Drinking-water Standards for New Zealand*.

13 Compliance Criteria: Records

Records must be kept of the results of monitoring drinking-water determinands. The records are necessary to demonstrate that the DWSNZ are being complied with. They are an essential requirement for the public health grading of drinking-water supplies.

The records must include the following.

- The name of the supply, treatment plant(s) and distribution zone(s) to which the information relates and the unique supply component code listed in the Register of Community Drinking-water Supplies and Suppliers in New Zealand (eg, Ministry of Health 2008a). If the water supply has not been registered, this should be undertaken with the Ministry of Health.
- The relevant supply codes must be included in all correspondence with the Ministry of Health or drinking-water assessor (DWA).
- Up-to-date records of the resident population in the district served by the supply.
- The information that is recorded must, to the satisfaction of the DWA, be sufficient for the purposes of assessing compliance with the DWSNZ.
- Information collected during catchment assessments, sanitary inspections of the water supply, inspections of bore head protection, and data gathered during the protozoal risk categorisation process.
- All monitoring results of the raw water or water entering the treatment plant that are required for the protozoal risk categorisation.
- The treatment processes in operation at the beginning of the year being reported and any modifications that changed the process during the previous year.
- Unless analysing for Priority 2a determinands, the concentration of any impurities in the chemicals being dosed. This should include the calculations used that proved analysis of the impurities was not needed.
- Anything that could significantly affect water quality that has occurred in the drinking-water supply system or catchment.
- A log of observations made of the appearance of the source water where regular source inspections are required.
- The determinands monitored during the year. If any Priority 1 or Priority 2 determinands have not been monitored or have been monitored at less than the required frequency, the reasons must be recorded, with corroborating data where appropriate.
- The sampling frequency for each determinand, the dates and times on which the measurements were made (for samples before and after flushing where this is necessary), the sampling site location, the supply component code, the name of the sampler(s) and the analytical results.
- Any remedial action taken as a result of the level of a determinand exceeding the MAV or because the water supplier considered it necessary.
- The analytical method used and the limit of detection and uncertainty for each of test method.
- The name of the laboratory used for the analyses as listed in the Ministry of Health's Register of Recognised Laboratories: Drinking water supplies <http://www.moh.govt.nz/water>
- Any re-evaluation of the operational programme undertaken and the reasons for this. Notes concerning treatment modification have been discussed above, but changes in the operation or the materials used in the reticulation should also be noted where appropriate.

- Operational records, including process changes and operational monitoring.
- Copies of all equipment validations or certifications.
- The names, relevant qualifications and experiences of staff supervisors and operators.

The duty to keep records and make them available is covered in section 69ZD of the Act.

Proper internal documentation of the monitoring programme will enable water suppliers to collate this information easily. Using the Water Information New Zealand (WINZ) database system (available through the Ministry of Health) will assist suppliers to calculate compliance and maintain the necessary records in the correct format.

Appendix 1: Units, Test Results, Conversions and Exceedences

A1.1 Basis for units

The Drinking-water Standards for New Zealand (DWSNZ) use the International System of Units (SI) (Système Internationale d'Unités of the Comité International des Poids et Mesures (CIPM)), which is consistent with the units used by the United States Environmental Protection Agency (USEPA) and in the Australian drinking-water standards.

The internationally recognised (CIPM) unit of volume is the litre (L).

The **SI unit** of weight is the kilogram (kg) and unit of length is the metre (m).

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.

A1.2 Comparing a test result against a maximum acceptable value or operational requirement

A1.2.1 Bacterial results

To establish whether a transgression has occurred, the test result (measurement) must be compared with the maximum acceptable value (MAV).

A1.2.2 Chemical results

The *General Requirements for the Competence of Testing and Calibration Laboratories* (NZS ISO/IEC 17025:2005, IANZ 2005) requires laboratories to calculate their uncertainty of measurement, which is explained in the International Accreditation New Zealand's Technical Guide TG5 (IANZ 2004) and *Guidelines for Drinking-water Quality Management in New Zealand* (the Guidelines) (Ministry of Health forthcoming, section 17.6).

When testing drinking-water for chemical compliance, laboratories must report their uncertainty of measurement (U) with the test result (T).

A MAV is exceeded when the test result (T) is higher than the MAV.

Ideally, the limit of detection should be less than one-fifth of the MAV.

A1.2.3 Operational requirements

Operational requirements include online or manual compliance testing of pH, turbidity, temperature, free available chlorine (FAC), pressure differential, chlorine dioxide, ozone, ultraviolet light (UV) irradiance (sensor reading), UV transmission, and direct integrity (as used in microfiltration plants).

Equipment used to demonstrate compliance must be suitable for that purpose.

A1.3 Units and conversion tables

Table A1.1: 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	µg/L or µgL ⁻¹	parts per billion, ppb = 10 ⁻³ ppm	milligrams per cubic metre, mg/m ³ or mg.m ³
		nanograms per litre	ng/L or ngL ⁻¹	parts per trillion, ppt = 10 ⁻³ ppb	

Notes:

1 mg/L = 1000 or 10³ µg/L = 1,000,000 or 10⁶ ng/L

1 ng/L = 0.001 or 10⁻³ µg/L = 0.000001 or 10⁻⁶ mg/L

One billion is one thousand million or 10⁹.

A1.4 Microbial

Colony-forming units per millilitre (cfu/mL).

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

1 µm = 1 micrometre = 1 micron = 0.001 mm or 10⁻³ millimetres.

A1.5 Physical and other

A1.5.1 Plumbosolvency

The **Langelier Saturation Index** has been used to as an indicator of a water to corrode metals. The correlation between the index and plumbosolvency has been found to be poor in some waters, so the index is not used for this purpose in the DWSNZ.

The index is defined as the pH of the water minus the pH at which the water will be in equilibrium with solid calcium carbonate, that is:

$$SI = pH_{ac} - pH_s$$

where:

SI = Langelier Saturation Index

pH_{ac} = the actual pH

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

Therefore, the units of the Langelier Saturation Index are pH units, which are dimensionless.

A1.5.2 Contact time (C.t)

C.t is the concentration of the disinfectant in milligrams per litre (mg/L) multiplied by exposure or contact time in minutes (min.mg/L).

A1.5.3 Colour

The Hazen Colour Unit (HU) is sometimes referred to as the True Colour Unit (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.

A1.5.4 Conductivity

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

1 mS/m = 10 µmhos/cm

1 µS/cm = 1 µmhos/cm

Note: 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.

A1.5.5 Log removal

Log removal is a method for expressing the removal of particles or the removal or inactivation of organisms.

Table A1.2: Relationship between log removal and percentage removal

Log removal	Percentage removal (%)
1.0	90
2.0	99
2.5	99.7
3.0	99.9
3.5	99.97
4.0	99.99
5.0	99.999

A1.5.6 pH

pH is the negative log of the hydrogen ion activity = $-\log a_{H^+}$.

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

A1.5.7 Temperature

Degrees Celsius (°C) or centigrade.

A1.5.8 Turbidity

Nephelometric turbidity unit (NTU), which is considered to be comparable to the previously used formazin turbidity unit (FTU), and earlier Jackson turbidity unit (JTU).

APHA (2005) and ISO (1999) define the preparation of a 4000 NTU suspension of formazin by incubating a mixture of hexamine and hydrazine sulphate solutions. Both references specify the procedure for dilution and storage conditions.

A1.5.9 UV absorbance and transmittance¹⁴

Note: 'The spectral attenuation (absorbance) of the water must be lower' is synonymous with 'the transmittance (UVT) of the water must be higher'.

Absorbance (A) = $-\log_{10}(\text{transmittance})$, or $A = -\log T$.

An example of this calculation follows:

Say T = 83% or 0.83

$$\begin{aligned} A &= -\log 0.83 \\ &= -(\log 8.3 \times 10^{-1}) \\ &= -(0.919 - 1) \\ &= 0.081 \end{aligned}$$

Conversely, $\%T = 100 \times 10^{-A}$

Measurements of transmittance or absorbance are made in a spectrophotometer at 253.7 nm (rounded to 254 nm). The sample is placed in a silica cell; these have different path lengths, so the path length must be quoted. A transmittance of 94 percent measured in a 10 mm cell is equivalent to 78 percent measured in a 40 mm cell.

A1.5.10 Ultraviolet disinfection

Irradiance is the power per unit area incident from all upward directions on an infinitesimally small element of surface area dA, divided by dA; whereas fluence rate (intensity) is the power incident from all directions on to an infinitesimally small sphere of cross-section dA, divided by dA. Both have the SI unit of W/m².

The fluence (UV dose) and radiant exposure (both J/m² or mJ/cm² or mW.s/cm²) are the counterparts of irradiance and fluence rate respectively, where power is replaced by energy. UV dose is the product of the average fluence rate acting on a micro-organism from all directions and the exposure time.

A1.5.11 Volume

1 cubic metre equals 1000 litres.

1 litre equals 1000 mL.

A1.5.12 FAC disinfection equivalents (FACE) at different pH values

Figure A1.1 is pictorial. Free available chlorine equivalent (FACE) can be calculated accurately using spreadsheet software (eg, Microsoft Excel), as follows:

- enter the FAC readings in column A and pH in column B
- copy the following formula and paste into cell C2 to obtain FACE concentrations.

The formula is:

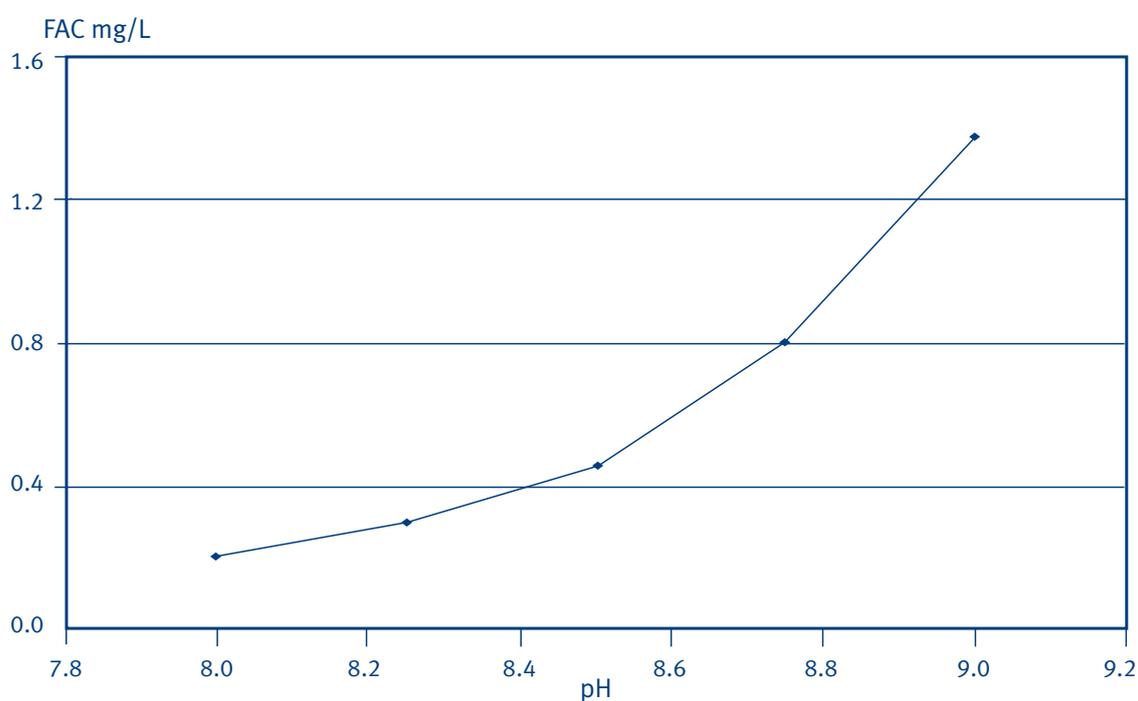
$$=IF(B2<8,A2,((A2*(1+((10^(-1*(3000/283-10.0686+(0.0253*283))))/10^(-8)))/(1+((10^(-1*(3000/283-10.0686+(0.0253*283))))/10^(-B2))))))$$

14. Sometimes colloquially called absorption and transmission.

Table A1.3: Example spreadsheet for converting FAC to FACE

	Column A	Column B	Column C
Row 1	FAC	pH	FACE
2	1.40	9.0	0.20
3	0.46	8.5	0.19
4	0.20	7.0	0.20
5	0.35	6.8	0.35
6	0.45	9.1	0.05

Figure A1.1: Free available chlorine (FAC) concentration at different pH values to provide disinfection equivalent of 0.2 mg FAC/L at pH 8.0



A1.6 Chemical

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

A1.6.1 Aluminium

A dose of 11 ppm commercial grade alum is equivalent to approximately 1 mg/L aluminium as Al. See NZWWA (1997).

A1.6.2 Asbestos

Million fibres per litre (MF/L).

A1.6.3 Ammonium

Ammonium nitrogen x 18/14 = ammonium ion.



A1.6.4 Hardness

Total hardness = calcium hardness + magnesium hardness, expressed as mg/L CaCO₃



A1.6.5 Nitrate

Nitrate nitrogen x 62/14 = nitrate



A1.6.6 Nitrite

Nitrite nitrogen x 46/14 = nitrite



A1.7 Radioactivity

Activity of radionuclide:

Becquerel per litre (Bq/L). A Becquerel is one nuclear transformation per second.

A1.8 Permitted exceedences

Appendix A1.8, Table A1.4, lists the number of exceedences that can be tolerated for 95 percent confidence that a benchmark is not being exceeded more than 5 percent of the time.

Table A1.4 refers to the number of samples, irrespective of the frequency of sampling. Thus, the number of permissible transgressions in 250 samples is the same (seven) whether all 250 samples were collected in one day or taken over the course of a year.

Table A1.4: Allowable exceedences (for 95 percent confidence that the maximum acceptable value (MAV) is exceeded for no more than 5 percent of the time)

<i>e</i>	<i>n</i>	<i>e</i>	<i>n</i>	<i>e</i>	<i>n</i>	<i>e</i>	<i>n</i>
0	38–76	40	1025–1046	80	1908–1929	120	2773–2793
1	77–108	41	1047–1069	81	1930–1951	121	2794–2815
2	109–138	42	1070–1091	82	1952–1973	122	2816–2836
3	139–166	43	1092–1113	83	1974–1994	123	2837–2858
4	167–193	44	1114–1136	84	1995–2016	124	2859–2879
5	194–220	45	1137–1158	85	2017–2038	125	2880–2900
6	221–246	46	1159–1181	86	2039–2060	126	2901–2922
7	247–272	47	1182–1203	87	2061–2081	127	2923–2943
8	273–298	48	1204–1225	88	2082–2103	128	2944–2965
9	299–323	49	1226–1247	89	2104–2125	129	2966–2986
10	324–348	50	1248–1270	90	2126–2146	130	2987–3007
11	349–372	51	1271–1292	91	2147–2168	131	3008–3029
12	373–397	52	1293–1314	92	2169–2190	132	3030–3050
13	398–421	53	1315–1336	93	2191–2211	133	3051–3072
14	422–445	54	1337–1358	94	2212–2233	134	3073–3093
15	446–469	55	1359–1381	95	2234–2255	135	3094–3114
16	470–493	56	1382–1403	96	2256–2276	136	3115–3136
17	494–517	57	1404–1425	97	2277–2298	137	3137–3157
18	518–541	58	1426–1447	98	2299–2320	138	3158–3178
19	542–564	59	1448–1469	99	2321–2341	139	3179–3200
20	565–588	60	1470–1491	100	2342–2363	140	3201–3221
21	589–611	61	1492–1513	101	2364–2384	141	3222–3243
22	612–635	62	1514–1535	102	2385–2406	142	3244–3264
23	636–658	63	1536–1557	103	2407–2427	143	3265–3285
24	659–681	64	1558–1579	104	2428–2449	144	3286–3307
25	682–704	65	1580–1601	105	2450–2471	145	3308–3328
26	705–727	66	1602–1623	106	2472–2492	146	3329–3349
27	728–751	67	1624–1645	107	2493–2514	147	3350–3371
28	752–774	68	1646–1667	108	2515–2535	148	3372–3392
29	775–796	69	1668–1689	109	2536–2557	149	3393–3413
30	797–819	70	1690–1711	110	2558–2578	150	3414–3434
31	820–842	71	1712–1733	111	2579–2600	151	3435–3456
32	843–865	72	1734–1755	112	2601–2621	152	3457–3477
33	866–888	73	1756–1776	113	2622–2643	153	3478–3498
34	889–910	74	1777–1798	114	2644–2664	154	3499–3520
35	911–933	75	1799–1820	115	2665–2686	155	3521–3541
36	934–956	76	1821–1842	116	2687–2707	156	3542–3562
37	957–978	77	1843–1864	117	2708–2729	157	3563–3583
38	979–1001	78	1865–1886	118	2730–2750	158	3584–3605
39	1002–1024	79	1887–1907	119	2751–2772	159	3606–3626

Note: 'e' is the maximum permissible number of exceedences of a 95 percentile limit for the stated range of samples 'n'. Calculations have been made using the theory stated in McBride and Ellis (2001), using 'Jeffreys' prior'. (See also McBride 2005, section 8.4.)

Appendix 2: Sampling Requirements and Referee Methods for Determinands

A2.1 Introduction

A referee method has been included for those determinands with a maximum acceptable value (MAV) and for operational requirements, wherever possible. In the event of any dispute about differences in analytical results, results obtained by a Ministry of Health recognised laboratory using the referee method will be deemed to be correct.

Alternative methods may be used for compliance testing and standardising online equipment but must have been **calibrated against the referee method** (see NIWA 2007). Standardising is discussed further in Chapter 17 of the Guidelines.

It is preferred that a Ministry of Health recognised laboratory standardise the online instrumentation used for testing water in the treatment plant and in the distribution system. If the instrumentation is standardised using a field test method, a Ministry of Health recognised laboratory must calibrate the field test method against the referee method at least once every six months.

When standardising online instruments (other than turbidimeters) used to demonstrate compliance, the value of the determinand recorded at a specified time must be checked to be the same as that obtained from a grab sample that has been taken at the same time from the designated sampling point for that determinand and that it has been analysed by the referee method (or an alternative method that has been calibrated against the referee method).

The result, together with any adjustments that are made to the instrument and the identity of the operator(s), must be recorded. The frequency of checking for each class of instrument must be at least the greater of that specified below or that recommended by the manufacturer, and must be increased if this is found necessary to ensure that the rate of 'drift' of the instrument reading is insignificant. For further information, see the *Guidelines for Drinking-water Quality Management in New Zealand* (the Guidelines) (Ministry of Health forthcoming, sections 17.3.3 and 17.5).

A2.2 *Escherichia coli*, faecal coliforms, total or presumptive coliforms

A2.2.1 *Escherichia coli* referee method

The *Escherichia coli* (*E. coli*) referee method is:

APHA 9223 B – Enzyme Substrate Coliform Test:

Presence / Absence; Multi-Well MPN (Quantitray); MPN (multiple tube technique).

A2.2.2 Faecal coliform referee method

The faecal coliform referee method is:

APHA 9221 E – Multiple Tube Fermentation (MPN) Technique (EC Medium)

A2.2.3 Total or presumptive coliform referee method

The total or presumptive coliform referee method is:

For a discussion on the use of MPN tables and calculations, see the Guidelines, section 6.4.2.

A2.3 *Cryptosporidium*

The *Cryptosporidium* enumeration procedure that is to be used for assessing the protozoal risk category of a raw water for the purposes of section 5.2.1 is a modified method of the United States Environmental Protection Agency, USEPA Method 1623 (USEPA 2004). Protozoal recovery must be assessed by the addition of colour seed to every sample. Both *Cryptosporidium* and *Giardia* are to be recorded.

The sample size must be a minimum of 10 L, and the entire pellet must be analysed.

The full method description is in the Guidelines, Appendix 8.

A2.4 Turbidimeters

Online and manual turbidimeters that are used as instruments for compliance monitoring must comply with the requirements of ISO 7027, or USEPA Method 180.1, or USEPA Method 10133, or GLI Method 2 (USEPA 1999), or have been approved by the USEPA for drinking-water compliance monitoring.

When using online turbidimetry:

- the signal averaging time is to be one minute or less
- where discrete readings are recorded, the interval between readings is not to be more than one minute.

Standardisation must be undertaken by personnel approved to do so by the DWA, and in accordance with the instrument manufacturer's specified procedures and frequency or three-monthly whichever is more frequent. Standardisation must be performed using StablCal (Hach) or PrimeTime (HF Scientific) (or other MoH-approved stabilised formazin preparation); or AMCO-AEPA-1 styrene divinylbenzene microsphere suspensions (Advanced Polymer Systems). Alternatively, user-diluted formazin preparations may be used, provided the:

- standardisation point is 20 NTU or greater
- 4000 NTU formazin preparation is obtained from a quality certified manufacturer or laboratory
- dilution is done immediately before use for standardisation.

The quality assurance procedures associated with standardisation must be approved by the drinking-water assessor (DWA).

Verification that the performance of the instrument has not changed since standardisation must be carried out on:

- online turbidimeters: weekly or after any interruption to continuous reading
- manual turbidimeters: daily, or each time it is switched on.

The manufacturer's secondary standards can be used for this purpose. If the instrument reading is outside the limits specified for the secondary standard, then that instrument must be restandardised.

Turbidity measurement is also discussed in the Guidelines, section 8.6.2.1.

A2.5 pH

The pH referee method is APHA 4500-H⁺B/electrometric method. The pH electrode must be standardised before each set of manual measurements is made, and the manufacturer's instructions must be followed for the storage of the electrode when not in use. The buffer solutions used must 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 (about 7, then 4) must be used to standardise and set the slope of the pH meter. Finally a pH 9 buffer must be used to check that the standardisation holds over the whole range.

Many New Zealand potable waters are weakly buffered which can present difficulties in pH measurement. Meters being used for potable water require special thin glass electrodes to work properly on unbuffered waters. Robust electrodes are not suitable.

For further information, see the Guidelines, section 10.5.1.

A2.6 Free available chlorine

The referee method for measuring free available chlorine (FAC) is the ferrous ammonium sulphate titration, APHA 4500-Cl F (2005). The referee method must be used to standardise online instrumentation, laboratory or field equipment, see also section A2.1.

A2.7 Chlorine dioxide

Most online instrumental methods used for measuring chlorine dioxide incorporate some type of amperometric cell. Chlorine dioxide test methods become complex in the presence of free available chlorine, requiring a high level of skill (for further information see the Guidelines, section 15.5.3).

Suitable standardisation techniques are in the chlorine dioxide datasheet in the Guidelines. See also section A2.1.

A2.8 Ozone

The referee method to be used for standardisation is 4500-O₃ B indigo colorimetric method. For a discussion on potential difficulties with this analysis, see the Guidelines, section 15.5.4.3. See also section A2.1.

A2.9 Temperature

A thermometer that has been standardised according to the International Accreditation New Zealand's Technical Guide 3, *Working Thermometers: Calibration Procedures* (IANZ 2008), must be used. Checks against another similarly standardised thermometer must be made at least once every six months. If the readings diverge by more than 0.5°C both thermometers must be restandardised.

A2.10 Other determinands

The above referee methods and comments (A2.1–A2.9) are related to Priority 1 testing. The sampling requirements and referee methods for other determinands with MAVs are listed in the following tables. The abbreviations to the tables are explained in section A2.11.

- Table A2.1: Inorganic determinands listed in Table 2.2 of the Drinking-water Standards for New Zealand (DWSNZ).

- Table A2.2: Cyanotoxins listed in Table 2.3 of the DWSNZ.
- Table A2.3: Organic determinands listed in Table 2.3 of the DWSNZ.
- Table A2.4: Pesticides listed in Table 2.3 of the DWSNZ.
- Table A2.5: Radiological determinands listed in Table 2.4 of the DWSNZ.

The sampling requirements and analytical methods for aesthetic determinands (Table 2.5) are in the Guidelines, Appendix 3.

Table A2.1: Inorganic determinands listed in Table 2.2; sampling requirements and referee methods

Name	Sampling location		Container	Referee method
	TW	DZ		
antimony		✓	P(A), G(A)	ICP-MS (APHA 3125, EPA 200.8)
arsenic	✓	✓	P(A), G(A)	ICP-MS (APHA 3125, EPA 200.8)
barium	✓	✓	P(A), G(A)	ICP-MS (APHA 3125, EPA 200.8)
boron	✓	✓	P	Colorimetric method (Department of Environment 1980, 1981)
bromate		✓	P	IC (EPA 300.1)
cadmium		✓	P(A), G(A)	ICP-MS (APHA 3125, EPA 200.8)
chlorate	✓	✓	P	IC (EPA 300.1)
chlorine		✓	G	TITR (APHA 4500CI F)
chlorite		✓	P	IC (EPA 300.1)
chromium		✓	P(A), G(A)	ICP-MS (APHA 3125, EPA 200.8)
copper		✓	P(A), G(A)	ICP-MS (APHA 3125, EPA 200.8)
cyanide	✓	✓	P	Total cyanide (APHA 4500-CN C; EPA 335.4)
cyanogen chloride		✓	G(S)	(APHA 4500-CN J)
fluoride	✓	✓	P	Ion selective electrode (APHA 4500-F C)
lead		✓	P(A), G(A)	ICP-MS (APHA 3125, EPA 200.8)
manganese		✓	P(A), G(A)	ICP-MS (APHA 3125, EPA 200.8)
mercury	✓	✓	G(A)	ICP-MS (APHA 3125, EPA 200.8)
molybdenum	✓	✓	P(A), G(A)	ICP-MS (APHA 3125, EPA 200.8)
monochloramine		✓	G	TITR (APHA 4500-CI F) DPD
nickel		✓	P(A), G(A)	ICP-MS (APHA 3125, EPA 200.8)
nitrate		✓	P, G	Cadmium reduction (APHA 4500-NO3-E)
nitrite		✓	P, G	Colorimetric method (APHA 4500-NO2-B)
selenium	✓	✓	P(A), G(A)	ICP-MS (APHA 3125, EPA 200.8)
uranium	✓	✓	P(A)	ICP-MS (EPA 200.8)

Note:

Abbreviations used in the table are explained in section A2.11.

Table A2.2: Cyanotoxins listed in Table 2.3; sampling requirements and preferred analytical methods

Name	Sampling location		Container	Preferred method	Alternative methods
	TW	DZ			
anatoxin-a	✓	✓	G(S) P(S)	LC-MS (Rao and Powell 2003); (Namikoshi et al 2003); (Dell'Aversano et al 2004); (Quilliam et al 2001); (Furey et al 2003)	HPLC-FLD (James et al 1998) HPLC-UV (Wong and Hindin 1982)
anatoxin-a(S)	✓	✓	G(S) P(S)	ChE Inhibition Assay (Mahmood and Carmichael 1987); (Barros et al 2004)	Mouse Bioassay (Falconer 1993)
cylindrospermopsin	✓	✓	G(S) P(S)	LC-MS (Eaglesham et al 1999); (Dell'Aversano et al 2004)	HPLC-PDA (Torokne et al 2004)
homoanatoxin-a	✓	✓	G(S) P(S)	LC-MS (Rao and Powell 2003); (Namikoshi et al 2003); (Dell'Aversano et al 2004); (Quilliam et al 2001); (Furey et al 2003)	HPLC-FLD (James et al 1998) HPLC-UV (Wong and Hindin 1982)
microcystins (expressed as MC-LR toxicity equivalents)	✓	✓	G(S) P(S)	HPLC-UV/PDA (Lawton et al 1994); (Meriluoto 1997)	LC-MS (Zweigenbaum et al 2000); (Barco et al 2002); (Spoof et al 2003) ADDA-ELISA (Fischer et al 2001) PP2A (An and Carmichael 1994); (Meriluoto 1997); (Ward et al 1997)
nodularin	✓	✓	G(S) P(S)	HPLC-UV/PDA (Lawton et al 1994); (Meriluoto 1997)	LC-MS (Zweigenbaum et al 2000); (Barco et al 2002); (Spoof et al 2003) ADDA-ELISA (Fischer et al 2001) PP2A (An and Carmichael 1994); (Meriluoto 1997); (Ward et al 1997)
saxitoxins (as STX-eq)	✓	✓	G(S) P(S)	HPLC-FLD (Lawrence & Niedzwiadek 2001); (Oshima et al 1989); (Oshima 1995a); (Oshima 1995b); (Thomas et al 2004)	LC-MS (Quilliam et al 2001); (Dell'Aversano et al 2004) Mouse Bioassay (Falconer 1993) Receptor Binding Assay (Powell and Doucette 1999); (Doucette et al 1997); (Ruberu et al 2003)

Note:

Abbreviations used in the table are explained in section A2.11.

Table A2.3: Organic determinands listed in Table 2.3; sampling requirements and referee methods

Name	Sampling location		Container	Referee method
	TW	DZ		
acrylamide	✓	✓	G(S)	LLE/GC-ECD (EPA 8032)
benzene	✓	✓	G(S)	P&T/GC-MS (APHA 6210D, EPA 524.2)
benzo[a]pyrene		✓	G(S)	LSE/GC-MS (EPA 525)
bromodichloromethane		✓	G(S)	P&T/GC-MS (APHA 6210D, EPA 524.2)
bromoform		✓	G(S)	P&T/GC-MS (APHA 6210D, EPA 524.2)
carbon tetrachloride		✓	G(S)	P&T/GC-MS (APHA 6210D, EPA 524.2)
chloroform		✓	G(S)	P&T/GC-MS (APHA 6210D, EPA 524.2)
di(2-ethylhexyl)phthalate		✓	G(S)	LSE/GC-MS (EPA 525.2)
dibromoacetonitrile		✓	G(S)	LLE/GC-ECD (EPA 551)
dibromochloromethane		✓	G(S)	P&T/GC-MS (APHA 6210D, EPA 524.2)
dichloroacetic acid		✓	G(S)	LSE/GC-ECD (EPA 552.1)
dichloroacetonitrile		✓	G(S)	LLE/GC-ECD (EPA 551)
1,2-dichlorobenzene		✓	G(S)	P&T/GC-MS (APHA 6210D, EPA 524.2)
1,4-dichlorobenzene	✓	✓	G(S)	P&T/GC-MS (APHA 6210D, EPA 524.2)
1,2-dichloroethane		✓	G(S)	P&T/GC-MS (APHA 6210D, EPA 524.2)
1,2-dichloroethene (cis/trans)	✓	✓	G(S)	P&T/GC-MS (APHA 6210D, EPA 524.2)
dichloromethane		✓	G(S)	P&T/GC-MS (APHA 6210D, EPA 524.2)
1,4-dioxane	✓	✓	G(S)	[No suitable method at present]
EDTA	✓	✓	G(S) P(S)	Reverse phase ion pair liquid chromatography (Bergers and De Groot 1994)
epichlorohydrin	✓	✓	G(S)	P&T/GC-MS (EPA 8260)
ethylbenzene	✓	✓	G(S)	P&T/GC-MS (APHA 6210D, EPA 524.2)
hexachlorobutadiene	✓	✓	G(S)	P&T/GC-MS (APHA 6210D, EPA 524.2)
monochloroacetic acid		✓	G(S) P(S)	LLE/GC-ECD (EPA 552.3)
nitrilotriacetic acid	✓	✓	G(S)	GC-MS (Malaiyandi et al 1979; Aue et al 1972)
styrene	✓	✓	G(S)	P&T/GC-MS (APHA 6210D, EPA 524.2)
tetrachloroethene		✓	G(S)	P&T/GC-MS (APHA 6210D, EPA 524.2)
toluene		✓	G(S)	P&T/GC-MS (APHA 6210D, EPA 524.2)
trichloroacetic acid		✓	G(S)	LSE/GC-ECD (EPA 552.1)
trichloroethene		✓	G(S)	P&T/GC-MS (APHA 6210D, EPA 524.2)
2,4,6-trichlorophenol		✓	G(S)	LLE/GC-ECD (APHA 6251)
vinyl chloride		✓	G(S)	P&T/GC-MS (APHA 6210D, EPA 524.2)
xylenes		✓	G(S)	P&T/GC-MS (APHA 6210D, EPA 524.2)

Note:

Abbreviations used in the table are explained in section A2.11.

Table A2.4: Pesticides listed in Table 2.3; sampling requirements and referee methods

Name	Sampling location		Container	Referee method
	TW	DZ		
alachlor	✓	✓	G	LSE/GC-MS (EPA 525.2)
aldicarb	✓	✓	G	RPHPLC-FLD (EPA 531.2)
aldrin/dieldrin	✓	✓	G	LLE/GC-MS (APHA 6410B)
atrazine	✓	✓	G	LSE/GC-MS (EPA 527)
azinphos-methyl	✓	✓	G	LLE/GC-ECD (EPA 8141)
bromacil	✓	✓	G	LSE/GC-MS (EPA 527)
carbofuran	✓	✓	G	RPHPLC-FLD (EPA 531.2)
chlordane	✓	✓	G	LLE/GC-MS (APHA 6630C)
chlorotoluron	✓	✓	G	LLE/LSE/HPLC (EPA 553)
chlorpyrifos	✓	✓	G	LSE/GC-MS (EPA 527)
cyanazine	✓	✓	G	LSE/GC-MS (EPA 526)
2,4-D	✓	✓	G	LLE/GC-ECD (APHA 6640B; EPA 515.3)
2,4-DB	✓	✓	G	LLE/GC-ECD (APHA 6640B; EPA 515.3)
DDT + isomers	✓	✓	G	LLE/GC-MS (APHA 6410B)
1,2-dibromo-3-chloropropane	✓	✓	G	P&T/GC-MS (APHA 6210D, EPA 524.2)
1,2 dibromoethane	✓	✓	G	P&T/GC-MS (APHA 6210D, EPA524.2)
1,2-dichloropropane	✓	✓	G	P&T/GC-MS (APHA 6210D, EPA524.2)
1,3-dichloropropene	✓	✓	G	P&T/GC-MS (APHA 6210D, EPA524.2)
dichlorprop	✓	✓	G	LLE/GC-ECD (APHA 6640B; EPA 515.3)
dimethoate	✓	✓	G	LSE/GC-MS (EPA 527)
diuron	✓	✓	G	LLE/LSE/HPLC (EPA 553)
endrin	✓	✓	G	LLE/GC-MS (APHA 6410B)
fenoprop	✓	✓	G	LLE/GC-ECD (EPA 515.2)
hexazinone	✓	✓	G	LSE/GC-MS (EPA 527)
isoproturon	✓	✓	G	LSE/GC-MS (EPA 525.2)
lindane	✓	✓	G	LSE/GC-MS (EPA 525.2)
MCPA	✓	✓	G	HPLC/UVD (EPA 555)
mecoprop	✓	✓	G	LSE/GC-ECD (EPA 515.2)
metalaxyl	✓	✓	G	LLE/GC-NPD (EPA 507)
methoxychlor	✓	✓	G	LSE/GC-MS (EPA 525.2)
metolachlor	✓	✓	G	LLE/GC-NPD (EPA 507)
metribuzin	✓	✓	G	LLE/GC-NPD (EPA 507)
molinate	✓	✓	G	LLE/GC-NPD (EPA 507)
oryxalin	✓	✓	G	LLE/LSE/HPLC (EPA 553)
oxadiazon	✓	✓	G	LLE/GC-NPD (EPA 507)
pendimethalin	✓	✓	G	LLE/GC-ECD/NPD (EPA 8091)
pentachlorophenol	✓	✓	G	LSE/GC-MS (EPA 525.2)
picloram	✓	✓	G	LLE/GC-ECD (EPA 515.3)
pirimiphos methyl	✓	✓	G	LSE/GC-MS (EPA 525.2)
primisulphuron methyl	✓	✓	G	[No suitable method at present]
procymidone	✓	✓	G	LLE/GC-NPD (EPA 507)

Name	Sampling location		Container	Referee method
	TW	DZ		
propazine	✓	✓	G	LSE/GC-MS (EPA 527)
pyriproxifen	✓	✓	G	[No suitable method at present]
simazine	✓	✓	G	LSE/GC-MS (EPA 525.2)
2,4,5-T	✓	✓	G	LLE/GC-ECD (APHA 6640B; EPA 515.3)
terbacil	✓	✓	G	LSE/GC-MS (EPA 525.2)
terbuthylazine	✓	✓	G	LLE/GC-ECD (EPA 1656)
thiabendazole	✓	✓	G	HPLC – Fluorescence (EPA 641)
triclopyr	✓	✓	G	LSE/CD-ECD (EPA 515.2)
trifluralin	✓	✓	G	LLE/GC-ECD (EPA 508)
1080	✓	✓	G	LSE/GC-ECD Ozawa and Tsukioka (1987)

Note:

Abbreviations used in the table are explained in section A2.11.

Table A2.5: Radiological determinands listed in Table 2.4; sampling requirements and referee methods

Name	Sampling location		Container	Referee method
	TW	DZ		
total alpha activity			[Kit supplied by NRL]	TAC by LSC (NRL)
total beta activity			[Kit supplied by NRL]	TBC by LSC (NRL)
radon			[Kit supplied by NRL]	Radon in water by LSC (NRL)

Notes:

Abbreviations used in the table are explained in section A2.11.

Samples must be collected as advised by the National Radiation Laboratory (NRL).

Table A2.6 Abbreviations used in Tables A2.1–A2.5

Sample sites	
DZ	distribution zone
TW	water leaving the treatment plant
Containers	
(A)	acid washed
G	glass
P	plastic
(S)	solvent washed
Analytical methods	
CVGA	cold vapour atomic absorption method
ECD	electron capture detector
ELISA	enzyme linked immunosorbent assay
FLD	fluorescence detector
GC	gas chromatography
GFAA	graphite furnace atomic absorption
HPLC	high pressure liquid chromatography
IC	ion chromatography
ICP	inductively coupled plasma
LC	liquid chromatography
LLE	liquid/liquid extraction
LSC	liquid scintillation counting
LSE	liquid/solid extraction
MS	mass spectrometer
NPD	nitrogen/phosphorus detector
P&T	purge and trap
PDA	photo-diode array
RPHPLC	reversed-phase HPLC
TAC	total alpha concentration
TBC	total beta concentration
TITR	titrimetric method
UVD	ultraviolet detection

Appendix 3: Catchment Risk Categorisation Survey Result Form

WATER SUPPLY	_____	
WINZ SOURCE CODE	_____	_____
Abstraction point:	_____ easting	_____ northing
Catchment area:	_____	
LAND USE	(estimate % of catchment area)	
Protected catchment	<input type="text"/>	
Bush/forest	<input type="text"/>	
Arable (cropping) land	<input type="text"/>	
Upland pasture	<input type="text"/>	
Lowland pasture	<input type="text"/>	
Urban	<input type="text"/>	
LIVESTOCK	(estimate numbers in catchment)	
Beef cattle	<input type="text"/>	
Dairy cows	<input type="text"/>	
Sheep	<input type="text"/>	
Deer/goats	<input type="text"/>	
Pigs	<input type="text"/>	
HUMAN WASTES	(estimate population served)	
Primary-treated sewage	<input type="text"/>	(river/land discharge)
Secondary-treated sewage	<input type="text"/>	(river/land discharge)
Septic tanks	<input type="text"/>	
ANIMAL WASTES	(number in catchment)	
Meatworks	<input type="text"/>	
Cattle feedlot	<input type="text"/>	
Piggeries	<input type="text"/>	
Dairy effluent ponds	<input type="text"/>	
MANAGEMENT PRACTICES	(yes/no)	Estimate of coverage/comment
Riparian management	<input type="text"/>	_____
Tile drains	<input type="text"/>	_____
Livestock access to waterway	<input type="text"/>	_____
Animal bridge/ford crossings	<input type="text"/>	_____
AVAILABLE DATA	(yes/no)	Data held by:
Faecal coliforms/ <i>E. coli</i>	<input type="text"/>	_____
<i>Cryptosporidium</i>	<input type="text"/>	_____
<i>Giardia</i>	<input type="text"/>	_____
Provider's contact details		_____

Definitions

Words appearing in bold type in the definitions below are also defined in this section.

A glossary is in *Guidelines for Drinking-water Quality Management in New Zealand* (the Guidelines) (Ministry of Health forthcoming, Appendix 7).

absorbance	The loss of light, usually at a specified wavelength, as it passes through water. Sometimes called absorption. See Appendix A1.5.9.
abstraction point	The point at which water that is intended for drinking comes under the control of the drinking-water supplier .
accreditation	Formal recognition that an organisation is meeting internationally accepted standards of quality, performance, technical expertise and competence; an independent endorsement of a commitment to these standards (IANZ 2007).
accuracy	The combination of bias and precision of an analytical procedure that reflects the closeness of a measured value to a true value.
aesthetic determinand	A constituent or property of the water that can adversely affect the water's taste, odour, colour, clarity or general appearance, including substances such as manganese and iron compounds that can stain washing and utensils.
alarm	A device that alerts the duty treatment plant operator in such a way that they can make an immediate response to address the problem that caused the alarm.
algae	Unicellular and multicellular plants that occur in fresh water, marine water and damp terrestrial environments. All algae possess chlorophyll. They may contribute to taste and odour problems in water.
alkalinity	A measure of buffering capacity. A buffer limits the change in pH that occurs when water comes in contact with acidic or alkaline substances. The principle cause of alkalinity in most drinking-waters includes at least one of bicarbonate, carbonate or hydroxide.
alpha-emitting radionuclide	A radionuclide that undergoes a nuclear transformation by emitting a helium-4 nucleus (alpha particle).
annual compliance	Compliance of a drinking-water supply with the Drinking-water Standards for New Zealand (DWSNZ) is assessed over 12 consecutive calendar months and reported to the Government and public annually.

aquifer	A water-saturated zone of the ground that will yield groundwater to bores or springs at a sufficient rate to serve as an adequate source of water. An aquifer contains pores or open spaces filled with water.
aquitard	A low-permeability layer that restricts the flow of groundwater from one aquifer to another, for example, sandy silt. The rate at which water can be abstracted from these layers is usually too low for the formation to be used as a source.
bacteria	The simplest form of life that can be unicellular or multicellular. Bacteria possess a simple nucleus, can reproduce rapidly and lack chlorophyll. Some members of the group are disease-causing.
bag filter	A pressure-driven separation process that removes particulate matter larger than 1 µm, using an engineered porous filtration media by surface filtration. A bag filter is typically constructed of a non-rigid, fabric filtration medium housed in a pressure vessel (housing) in which the direction of flow is from the inside of the bag to the outside.
bank filtration	<p>A water treatment process that uses one or more pumping wells to induce or enhance natural surface water infiltration and to recover that surface water from the subsurface after passage through a river bed or bank(s).</p> <p>The requirements for bank filtration are specific, so many existing infiltration galleries will not qualify.</p> <p>The mechanisms active in this type of system are believed to be similar to slow sand filtration, so provide a more reliable removal of protozoa than the mechanisms active in infiltration galleries.</p>
beta-emitting radionuclide	A radionuclide that disintegrates by emitting a negative (or positive) electron (beta particle).
bore	Any hole constructed to access groundwater for supply purposes.
bore field	More than one bore from the same aquifer connected to a single water supply.
bore head	The physical structure, facility or device at the land surface from which groundwater is abstracted from subsurface water-bearing formations.

bore head protection	<p>A bore head that effectively prevents contamination of the supply from the ground surface and complies with Environmental Standard for Drilling of Soil and Rock (NZS 4411, Standards New Zealand (2001)). Measures include a:</p> <ul style="list-style-type: none"> • grout pad and seal between the bore casing, pipework and the surrounding ground. • sealed pumping and piping system with some mechanism of backflow prevention
bore water	<p>Groundwater that has been extracted from the aquifer through a bore. See also secure bore water.</p>
bulk distribution zone	<p>The part of the distribution network that delivers water from the treatment plant(s) to one or more distribution zones. Usually, but not necessarily, it is owned and operated by a different water supplier, may or may not include service storage, and services only a nominal number of consumers directly. A bulk distribution zone may be identified from its operational characteristics or the characteristics of the water it supplies, by agreement between the water supplier(s) and the drinking-water assessor (DWA). Each bulk distribution zone is graded separately.</p>
calibration against a referee method	<p>Demonstrating that an alternative method will reliably give the same result to an acceptable strength-of-agreement (NIWA 2007) as the referee method, under the same range of circumstances, within a known uncertainty considered acceptable by independent peer review, thus demonstrating that the alternative method is fit for purpose. Refer to Chapter 17 in the Guidelines for further information.</p>
carcinogen	<p>A substance that induces cancer.</p>
cartridge filtration	<p>A pressure-driven separation process that removes particulate matter larger than 1 µm, using an engineered porous filtration media through surface or depth filtration. A cartridge filter is typically constructed as rigid or semi-rigid, self-supporting filter elements placed in a housing. The flow is from the outside of the cartridge to the inside.</p>
catchment assessment	<p>A survey of the area from which raw water for a drinking-water supply is obtained to allow potential contaminant sources to be identified, and the risk they present to the raw water quality is evaluated. See also protozoal risk categorisation.</p>

certification	<p>Issuing a certificate of satisfactory performance.</p> <p>Certification may be done by the manufacturer, vendor or installer. The certificate must be drafted in such a way that the manufacturer, vendor or installer guarantees that the treatment process will meet the specified performance standards provided the process is operated according to the procedures specified by the manufacturer, vendor or installer as being necessary to achieve the specified performance rating.</p> <p>Another form of certification can be provided by a certifying body accredited by International Accreditation New Zealand (or JASANZ) as competent to certify that an operator is capable of performing a function satisfactorily. For example, International Accreditation New Zealand will accredit the drinking-water assessors (DWAs) as competent to certify that drinking-water plant staff are competent to carry out presence/absence testing of free available chlorine (FAC) or <i>Escherichia coli (E. coli)</i>.</p>
challenge test	<p>A test of a treatment process (usually by the manufacturer or vendor of the process) to establish the performance parameters of that treatment process; that is, the degree of treatment it can achieve (eg, the log credit rating) and the operational requirements to ensure the specified performance rating can be sustainably achieved. This may be done in the factory.</p>
chemical coagulation	<p>The use of metallic salts (eg, aluminium or iron) or organic polyelectrolytes (polyamines or polydadmacs) to aggregate fine suspended or colloidal particles, causing them to clump together into larger particles.</p>
chloramination	<p>A disinfection process that produces (mainly) monochloramine by reacting chlorine with ammonia. See chloramines.</p>
chloramines	<p>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.</p>

chlorination	<p>Chlorinated water supply A term used for water in the distribution system. Water supplies that are chlorinated but have not been demonstrated consistently to have a free available chlorine (FAC) or chlorine dioxide concentration of at least 0.2 mg/L.</p> <p>Continuously monitored chlorination A term used for water leaving the treatment plant. Requires the use of an online continuous FAC monitor, standardised at least as frequently as recommended by the equipment suppliers, with an alarm system (FAC monitor or dosage monitor) that can prompt a site visit, without delay, to service the fault or condition. The free available chlorine equivalent (FACE) must be at least 0.2 mg/L.</p> <p>Non-continuously monitored chlorination A term used for water leaving the treatment plant. Chlorination in which the FACE is always at least 0.2 mg/L but that does not satisfy all the criteria for continuously monitored chlorination.</p>
coagulation	See chemical coagulation .
coefficient of variation	The standard deviation (s) divided by the estimate of the mean (\bar{x}); often expressed as a percentage. This statistic normalises the standard deviation and can help when comparing analyses that cover a wide range of concentrations. Also called relative standard deviation. See the example in the Guidelines , section 17.6.5.
coliform bacteria	The bacteria used as indicators that organic, possibly faecal, contamination of the water may have occurred. Sometimes referred to as total coliforms or presumptive coliforms and includes <i>Escherichia coli</i> (<i>E. coli</i>).
community drinking-water supply	A reticulated publicly or privately owned drinking-water supply connecting at least two buildings on separate titles and serving at least 1500 person-days a year (eg, 25 people at least 60 days per year).
compliance	A drinking-water supply is said to be in compliance with the Drinking-water Standards for New Zealand (DWSNZ) when all the compliance criteria requirements are met.
compliance criteria	Requirements that must be satisfied to achieve compliance .
compliance monitoring	The monitoring specified in the compliance criteria.
compliance monitoring period	The period that a maximum acceptable value (MAV) or operational requirement is monitored to check that it does not move outside its limit for more than the allowed frequency or duration.

compliant	See compliance .
confined aquifer	See unconfined aquifer .
contact time	The hydraulic residence time, determined by a tracer test or by a recognised calculation procedure, from the dosage point or point of entry to the disinfectant contact device to the point of exit. The contact time should ideally be within the treatment plant site, although ‘contact mains’ disinfection may be practised if the required contact time is met before the first consumer.
contaminant	A substance or organism in the water that can cause undesirable public health or aesthetic effects.
continuously monitored chlorination	See chlorination .
control limit	A value set by the water supplier for each compliance criterion , with the aim of triggering some action to prevent the value reaching the transgression level or operational requirement. The control limit is recorded in the Public Health Risk Management Plan (PHRMP) along with the preventive actions considered to be necessary when the control limit is reached.
conventional treatment	Is a series of processes including coagulation, flocculation, sedimentation and filtration , with sedimentation defined as a process for removing solids before filtration by gravity or separation.
<i>Cryptosporidium</i>	A member of the protozoa family. During its complex life cycle, thick-walled oocysts are formed that are 4–6 µm in diameter. The oocysts are excreted in faeces and are the infectious form of the organism. <i>C. parvum</i> is the species responsible for most human infection. <i>Cryptosporidium</i> generally causes self-limiting diarrhoea, which may include nausea, vomiting and fever. In immunocompromised people, infection can be life-threatening.
C.t value	The product of the concentration (C mg/L) of the disinfectant and the contact time (t minutes) required to cause a specified level of inactivation in a micro-organism . C.t is a measure of the exposure to the disinfectant. It has the unit min.mg/L.
cyanobacteria	A major group of bacteria (often with the ability to carry out photosynthesis) previously known as ‘blue-green algae ’. Cyanobacteria occur throughout the world in fresh and salt waters. Some species produce toxins.
cyanotoxin	A toxin secreted by certain cyanobacteria .
cyst	The non-motile dormant form of <i>Giardia</i> that serves to transfer the organism to new hosts. See also oocyst and (oo)cyst .

datasheets	Volume 3 of the Guidelines , that lists the sources, occurrence, removal process, analysis, health effects and derivation of the maximum acceptable values (MAVs) of determinands .
DBP	See disinfection by-product (DBP) .
determinand	A constituent or property of the water that is determined, or estimated, in a sample, for example: microbial determinand – total coliforms ; chemical determinand – chloride; physical determinand – turbidity ; and radiological determinand – radon.
diatomaceous earth filtration	Filtration that uses diatomaceous earth as the medium usually 0.01–0.2 mm in size in a process in which a precoat cake of filter media is deposited on a support membrane and additional filter media is continuously added to the feed water to maintain the permeability of the filter cake.
direct filtration	A water treatment process using chemical coagulation without a clarification step upstream of the filter(s).
direct integrity test	See integrity test .
disinfection	The process used to inactivate micro-organisms in a drinking-water supply. Common methods of disinfection include chlorination , ozonation , ultraviolet light (UV) irradiation and boiling.
disinfection by-product (DBP)	A contaminant produced in the drinking-water supply as a by-product of the disinfection process.
disinfection residual	The amount of disinfectant present in the water at any time.
dissolved air flotation (DAF)	A clarification process in which the flocs formed during coagulation and flocculation are floated to the surface for removal by air bubbles. This is in contrast to conventional clarification in which the flocs are removed by settling.
distribution system	All the trunk main, storage and distribution system components that 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 that 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; 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.

drinking-water	Water intended to be used for human consumption, food preparation, utensil washing, oral hygiene or personal hygiene.
drinking-water assessor (DWA)	An officer appointed as such under section 69ZK of the Health (Drinking Water) Amendment Act 2007, which amended the Health Act 1956.
Drinking-water Standards for New Zealand (DWSNZ)	A yardstick to assess the quality of drinking-water . The DWSNZ define the maximum acceptable values (MAVs) of health significant determinands and specify the methods for determining whether a drinking-water supply complies with the DWSNZ.
DWA	See drinking-water assessor (DWA) .
DWSNZ	See Drinking-water Standards for New Zealand (DWSNZ) .
enhanced combined filter performance	Additional log credits are earned when the filtrate turbidity satisfies the requirements of section 5.7. See USEPA 2006a.
enhanced individual filter performance	Additional log credits are earned when the filtrate turbidity satisfies the requirements of section 5.8. See USEPA 2006a.
<i>E. coli</i>	See <i>Escherichia coli (E. coli)</i> .
<i>Escherichia coli (E. coli)</i>	A bacterium used as an indicator that faecal contamination of the water has almost certainly occurred, so pathogens may be present in the water.
exceedence	The occurrence of a determinand in a sample at a concentration greater than the maximum acceptable value (MAV) .
FAC	See free available chlorine (FAC) .
FACE	See free available chlorine equivalent (FACE) .
faecal coliform	See thermotolerant coliform, <i>Escherichia coli (E. coli)</i>, presumptive coliform and total coliform .
filtrate	Water, other than wash water, leaving a filter.
filtration	A treatment process that removes suspended particles from water by passing the water through a medium such as sand or other suitable material.
flocculation	The gathering together of coagulated clumps of fine material to form floc.
free available chlorine (FAC)	The chlorine present in chlorinated water in the form of hypochlorous acid and hypochlorite ion.

free available chlorine equivalent (FACE)	The free available chlorine (FAC) concentration that would have the same disinfecting power as the chlorine solution would have when adjusted to a pH of 8. See Figure A1.1.
<i>Giardia</i>	A flagelated member of the protozoa family. <i>Giardia</i> infects the gastrointestinal tract of humans and certain animals. Cysts are the infectious form of the organism excreted by the host; they are ovoid in shape, 8–12 µm. <i>G. intestinalis (lamblia)</i> is the species usually responsible for human infection. <i>Giardia</i> causes abdominal cramps and diarrhoea, which is self-limiting in most cases.
groundwater	Water contained beneath the land surface. More particularly, water contained in the saturated zone of the soil, which can be extracted in usable quantities. Also see bore water.
guideline value (GV)	In the Drinking-water Standards for New Zealand (DWSNZ) , the value for an aesthetic determinand that, if exceeded, may render the water unattractive to consumers.
housing	The pressure vessel that is used to contain a cartridge or bag filter .
inactivation	Rendering organisms (usually micro-organisms) incapable of infection. Usually achieved by disinfection or by high temperatures.
indicator organism	A determinand , for example, <i>Escherichia coli (E. coli)</i> or faecal coliforms , that is monitored to indicate the presence of faecal contamination.
indirect integrity test	See integrity test .
infectious	An infectious organism is one that is liable to transmit a disease to or cause a disease in humans.
infiltration gallery	An artificial conduit, or series of conduits, used for collecting water, situated next to, or in, streams under layers of sands and gravel that provides a degree of prefiltration. Usually made from interconnected, buried, open-jointed or slotted pipes. Also referred to as river galleries but often not the same as bank filtration .
integrity test	Direct integrity test A physical test applied to a membrane unit to identify and isolate integrity breaches. An integrity breach is defined as one or more leaks that could result in contamination of the filtrate . The direct integrity test must be applied to the physical elements of the entire membrane unit including membranes, seals, potting material, associated valving and piping, and all other components that, under compromised conditions, could result in contamination of the filtrate. See membrane filtration .

Indirect integrity test

Involves **monitoring** some aspect of **filtrate** water quality that is indicative of the removal of particulate matter. If a continuous direct integrity test is implemented that meets the **membrane filtration** resolution and sensitivity criteria, continuous indirect integrity **monitoring** is not required.

interim bore water security

See **secure bore water**.

Langelier Saturation Index

A measure of the corrosive or scale-forming nature of water, depending on whether it will dissolve or precipitate calcium carbonate. It does not always correlate well with **plumbosolvency** in New Zealand waters so is not used to define plumbosolvency in the **Drinking-water Standards for New Zealand (DWSNZ)**. (See section A1.5.1.)

limit of detection

The criterion of detection is the minimum value that a single test result (or mean of replicates) may have for the analyst to say that something is present with 95 percent confidence. The limit of detection is defined as the upper confidence limit for a result that is exactly on the criteria of detection. It is used when reporting 'less than' results.

$$\text{Limit of detection} = \frac{2t\sqrt{2}S_R}{\sqrt{n}}$$

where S_R is the overall **standard deviation** of the method (IANZ 2004)

n is the number of replicates

t is the single-sided statistic

or for duplicate results at 95 percent confidence using the single sided statistic: Limit of detection = $3.4 S_R$

MAV

See **maximum acceptable value (MAV)**.

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 the **Drinking-water Standards for New Zealand (DWSNZ)** generally represent a risk of one additional incidence of cancer per 100,000 people ingesting the water at the concentration of the MAV for a lifetime of 70 years.

membrane filtration

A pressure- or vacuum-driven separation process in which particulate matter larger than $1 \mu\text{m}$ is rejected by a non-fibrous, engineered barrier, primarily through a size-exclusion mechanism, and which has a measurable removal efficiency of a target organism that can be verified through the application of a **direct integrity test**. This definition is intended to include the common membrane technology classifications: **microfiltration (MF)**, **ultrafiltration (UF)**, **nanofiltration (NF)** and **reverse osmosis (RO)**. See **module** and **unit**.

MF	See microfiltration (MF) .
membrane unit	A membrane unit is defined as a group of membrane modules that share common valving that allows the unit to be isolated from the rest of the system for testing or maintenance.
microfiltration (MF)	A type of relatively low pressure membrane technology in which the pore-size of the membrane is in the order of 0.1 µm, so it can remove protozoa and most bacteria. See membrane filtration, reverse osmosis (RO), nanofiltration (NF) and ultrafiltration (UF) .
micro-organism	A very small (microscopic) organism, including viruses, bacteria, protozoa, algae and helminths (worms).
module	The smallest component of a membrane unit in which a specific membrane surface area is housed in a device with a filtrate outlet structure (USEPA 2006a).
monitoring	The sampling and analysis of a drinking-water supply to test for compliance with the Drinking-water Standards for New Zealand (DWSNZ) , 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 water supplier's responsibility.
nanofiltration (NF)	A type of membrane technology in which the pore-size of the membrane is in the order of 0.001 µm, so it can remove bacteria, viruses, protozoa and chemical substances down to molecular weights of 200–1000 daltons. The cut-off for chemical substances is sufficiently small that some disinfection by-product (DBP) precursors will be removed. See also membrane filtration, reverse osmosis (RO), microfiltration (MF) and ultrafiltration (UF) .
neighbourhood drinking-water supply	See section 69G of the Health Act 1956. A drinking-water supply that is used to supply drinking-water to: <ul style="list-style-type: none"> a. 25–100 people for at least 60 days each year, or b. any number of people for at least 60 days each year if the number of those people when multiplied by the number of days per year during which they receive water from that supply is 6000 or greater, but is not greater than 100 on 60 or more days in any year.
nephelometric turbidity unit (NTU)	A measure of the clarity of water (turbidity). See Appendix A1.5.8.
non-compliant	A drinking-water supply that does not comply with the requirements of the Drinking-water Standards for New Zealand (DWSNZ) .

non-continuously monitored chlorination	See chlorination .
NTU	See nephelometric turbidity unit (NTU) .
online monitoring	<p>The process of measuring and recording a defined chemical or physical property by taking frequent measurements, using an electronic monitoring device specifically designed for the purpose, to prove the values of the measured property meet the requirements of the Drinking-water Standards for New Zealand (DWSNZ).</p> <p>Records from continuous monitoring instrumentation must report the duration of exceedences and their extent.</p>
(oo)cyst	Collective term for oozysts and cysts .
oocyst	A thick-walled structure within which <i>Cryptosporidium</i> zygotes develop and that serves to transfer the organism to new hosts. See also cyst and (oo)cyst .
operational requirement	Performance specifications necessary to ensure that an appliance or treatment process complies with its specifications.
ozonation	Treatment of water by dissolved ozone primarily for disinfection but also for the oxidation of chemical determinands .
participating supply	A small water supply and that has chosen to comply with the Drinking-water Standards for New Zealand (DWSNZ) by using section 10.
pathogen	An organism capable of inducing illness.
pesticide	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 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 .
PHRMP	See Public Health Risk Management Plan (PHRMP) .
plant inlet water	The water that is taken into the treatment plant for treatment. This will be raw water together with any recycled or backwash water.

plumbosolvent water	Water able to dissolve lead (from the Latin ‘plumbum’ ~Pb). This term is used in the Drinking-water Standards for New Zealand (DWSNZ) to describe water that causes metals of health concern from fittings or plumbing to appear in consumers’ drinking-water.
potable water	Drinking-water that does not contain or exhibit any determinand to any extent that exceeds the maximum acceptable values specified in the Drinking-water Standards for New Zealand (DWSNZ) . See also wholesome drinking-water .
presumptive coliform	Bacteria whose identification in the early stages of bacterial examination highlight the need for further identification of coliform bacteria . If absent, it is not necessary to proceed with further identification of coliform bacteria . See also <i>Escherichia coli (E. coli)</i> , faecal coliform and total coliform .
priority class	One of four classes of determinand defined in the Drinking-water Standards for New Zealand (DWSNZ) . The priority classes are ranked according to the determinand’s potential impact on public health if present in excess of its maximum acceptable value (MAV) in drinking-water and the quantity of the determinand present in the water supply .
protozoa	Free-living, aquatic, unicellular animals, larger and more complex than bacteria, and can be differentiated into 4 general types: ciliates, flagellates, sporozoans and amoebae. The Priority 1 protozoa are <i>Giardia</i> and <i>Cryptosporidium</i> . See also priority class .
protozoal risk categorisation	A survey of the potential for animal and human wastes in the catchment for determining the protozoal log credit requirement.
provisional secure status	See secure bore water .
Public Health Risk Management Plan (PHRMP)	A plan that: <ul style="list-style-type: none"> • identifies the elements present in a supply • identifies which of the four main barriers to contaminants are in place • sets out a risk information table appropriate for the supply • includes an improvements schedule, which identifies the preventive measures that have yet to be put in place; prioritises the measures for attention based on the risk they present to health and the availability of resources to provide them; sets a date by which they should be put in place; and identifies who has responsibility for doing this • notes other quality assurance systems that have links to the PHRMP • provides contingency plans applicable to the supply

- provides instructions for reviewing the PHRMP's performance
- provides instructions for reporting: what reports should contain, who should receive reports and how often should they receive reports.

quality assurance	A means of maintaining good management of a process by systematically keeping records, checking equipment and personnel performance and procedures, for example, the quality management system standard ISO 9001:2000.
radiological assessment	The determination of the radioactivity content in a water sample.
radiological determinands	In water quality analysis, radioactive substances, factors or elements in the drinking-water that are determinable. Radioactivity in drinking-water is principally derived from the leaching of radionuclides from rocks and soil and from the deposition of radionuclides from the atmosphere. Examples are total alpha activity, excluding radon; total beta activity, including potassium and radon concentration.
radionuclide	A radioactive atomic nucleus.
rapid granular media filtration	A process that generally follows chemical coagulation . The water passes through granules (traditionally sand) and particles are trapped by or on the grains, which are cleaned by backwashing.
raw water	Water intended for drinking that is after the abstraction point but has not yet received treatment to make it suitable for drinking.
recognised laboratory	A laboratory recognised by the Ministry of Health for testing compliance with the DWSNZ. The requirements are defined in section 69ZY of the Health Act 1956. The laboratories are listed in the <i>Register of Recognised Laboratories: Drinking water supplies</i> at http://www.moh.govt.nz/water or http://www.drinkingwater.org.nz
referee method	The analytical methods definitive for demonstrating compliance with the Drinking-water Standards for New Zealand (DWSNZ) . Alternative methods may be used, but these 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 will be deemed to be correct.
Register of Community Drinking-water Supplies and Suppliers in New Zealand	A list of community drinking-water supplies in New Zealand published by the Ministry of Health (eg, Ministry of Health 2008). The register contains each drinking-water supply's details about water sources, treatment plants, distribution zones , site identification codes, Priority 2 determinands and public health grading.

regolith	The layer of unconsolidated solid material above the bedrock.
relative standard deviation	See coefficient of variation .
remedial action	Action taken in the event of a transgression or breach of an operational requirement to protect public health and to reduce the likelihood of a transgression or breach recurring for the same reason.
residence time determination	Analysis of tritium, chlorofluorocarbon and sulphur hexafluoride concentrations in groundwater to determine the time the water has been isolated from the atmosphere.
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 .
reverse osmosis (RO)	The passage of water through a semi-permeable membrane under a pressure that is higher than the water's osmotic pressure. The semi-permeable membrane allows only water to pass through it, thus separating the water from most dissolved and suspended material, which is left behind. See also membrane filtration , microfiltration (MF) , ultrafiltration (UF) and nanofiltration (NF) .
RO	See reverse osmosis (RO) .
rural agricultural drinking-water supply	See section 69G of the Health Act 1956. A drinking-water supply that: <ul style="list-style-type: none"> a. is a large, medium, minor, small or neighbourhood drinking-water supply from which 75 percent or more of the water supplied: <ul style="list-style-type: none"> i. is used for the purposes of commercial agriculture ii. does not enter a dwellinghouse or other building in which water is drunk by people or other domestic and food preparation use occurs; but b. does not include a drinking-water supply using a single connection to provide water to a town or a village or another place with a permanent population of 50 people or more that is used primarily for residential purposes.
sanitary inspection of the water supply	A survey and analysis of the physical components of the water supply to identify the existence and hazard posed by existing and potential sources of health hazards and environmental contamination. Procedural details appear in the Public Health Risk Management Plan (PHRMP) .

second-stage filtration	A process consisting of rapid sand, dual media, granular activated carbon, or other fine grain media in a separate stage following filtration by granular media or membrane. The first stage of filtration must be preceded by a coagulation step and both filtration stages must treat 100 percent of the flow. A cap, such as granular activated carbon, on a single stage of filtration does not constitute second-stage filtration. See section 5.6 and USEPA 2006a.
secure bore water	<p>Water that is free from surface influences and free from contamination by harmful micro-organisms. It must be abstracted via a bore head demonstrated to provide protection from contamination. Water from springs and unconfined aquifers with bore intakes less than 10 m deep are excluded.</p> <p>Interim bore water security applies for the first 12 months of operation to bores abstracting from confined aquifers, and unconfined bores greater than 30 m deep, drawn from a source for which hydrogeological evidence indicates that the bore water is likely to be secure. Subject to conditions – see section 4.5.2.3.</p> <p>If <i>E. coli</i> is detected in a sample of secure bore water it is reclassified provisional secure, subject to conditions – see section 4.5.4.</p>
sedimentation	The process in which solid particles settle out of the water being treated in a clarifier or settling tank.
service reservoir	A reservoir or tank present in the network reticulation to manage water flow and pressure.
setback distance	In relation to bank filtration , the distance between the vertical bore and the surface water when the river/stream is in a flood with a 1 percent probability of recurrence (sometimes called a ‘one-in-100-year’ flood).
SI units	A system of coherent metric units (Système Internationale d’Unités) that the General Conference on Weights and Measures, the international authority on units, adopted.
slow sand filtration	A filter that consists of a bed of fine sand and relies on a biologically active layer on top of the sand, called <i>Schmutzdecke</i> , to filter out particles. The filtration rate is much slower than that with rapid granular media filtration .
small drinking-water supply	<p>See section 69G of the Health Act 1956.</p> <p>A drinking-water supply that:</p> <ol style="list-style-type: none"> a. is used to supply drinking-water to 101–500 people for at least 60 days each year b. is not a drinking-water supply to which paragraph (a) or paragraph (b) of the definition of neighbourhood drinking-water supply applies.

spring	Occurs when groundwater moves along the upper plane of an impervious rock formation that ends at the surface, or rock fissures. This discharge is susceptible to surface contamination from domestic, industrial and agricultural waste discharges.
standard deviation	<p>If a measurement is repeated many times under essentially identical conditions, the results of each measurement (x) will be distributed randomly about the mean value. If an infinite number of measurements were made, the true mean would be found, with all the results appearing about the mean in a 'normal distribution'. Measurements cannot be made an infinite number of times, so the true mean is estimated using a property of the normal distribution curve, the standard deviation (s):</p> $s = \left[\frac{\sum (x - \bar{x})^2}{(n - 1)} \right]^{1/2}$ <p>where: x is the measured value</p> <p>\bar{x} is the estimated mean</p> <p>n is the number of measurements made.</p> <p>See also coefficient of variation.</p>
standardisation	A process for enhancing analytical accuracy by use of traceable standards.
standardised variance	<p>Standardised variance is the standard deviation (s) squared (equals variance or s^2), divided by the estimate of the mean (\bar{x}), that is:</p> s^2 / \bar{x} <p>To express the value as a percentage, it is multiplied by 100. The standardised variance is smaller than the coefficient of variation when the standard deviation is less than one but greater when the standard deviation is greater than one. Nitrate concentrations are frequently close to the limit of detection, which can result in a high coefficient of variation. The standardised variance has been used in assessing the variation in nitrate data, as it provides a better match with known bore water security status than the coefficient of variation.</p>
surface water	The water on the land surface. It can be running (as in streams and rivers) or quiescent (as in lakes, reservoirs, impoundments and ponds). Surface water is produced by run-off 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 run-off.
surrogate	A determinand used to assess the likely presence or concentration of another determinand that is more difficult to determine. For example, <i>E. coli</i> is used to assess the likely presence of specific pathogenic organisms, as it is a good indicator organism and is easier to test for than the pathogens .

surveillance	The process of checking that the management of drinking-water supplies conforms to the specifications in the Drinking-water Standards for New Zealand (DWSNZ) . Usually conducted by the public health agency.
tankered drinking-water	Water collected from an external source and delivered in a tank to a consumer's drinking-water storage system.
test result	The concentration of a determinand measured by the analyst before any correction is made for experimental or method uncertainty.
thermotolerant coliforms	A subgroup of total coliforms that will grow on a specific selective medium when incubated at $44.5 \pm 0.2^{\circ}\text{C}$. The presence of faecal coliforms (thermotolerant 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: <i>Klebsiella</i> and <i>Escherichia coli (E. coli)</i> . See also presumptive coliform .
total coliforms	Genera in the family <i>Enterobacteriaceae</i> . Bacteria that will grow on a specific selective medium when incubated at $35^{\circ}\text{C} \pm 0.2^{\circ}\text{C}$. 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 coliform and presumptive coliform .
transgression	Of the Drinking-water Standards for New Zealand (DWSNZ) , occurs when a determinand of any priority class that is present in the sample exceeds the maximum acceptable value (MAV) or its allowable concentration specified in the compliance criteria or when the limit of an operational requirement is exceeded.
transgression limit	The limit in the Drinking-water Standards for New Zealand (DWSNZ) (maximum acceptable value (MAV) or operational requirement) that when exceeded defines a transgression . See also control limit .
transmittance	A measure of the amount of light, at a specified wavelength, that passes through water. Sometimes called transmission. See Appendix A1.5.9.
turbidity	A measure of the suspended particles in a sample that cause loss of clarity by scattering light. For the Drinking-water Standards for New Zealand (DWSNZ) , turbidity is measured by nephelometry.
UF	See ultrafiltration (UF).

ultrafiltration (UF)	<p>A method of filtration in which particles of colloidal dimensions are separated from molecular and ionic substances by drawing the colloidal suspension (sol) through a membrane whose capillaries are very small (in the order of 0.003 µm). It is able to remove protozoa, bacteria and viruses from the water.</p> <p>The mechanism is not simply a sieve effect, but depends on the electrical conditions of the membrane and colloid. See membrane filtration, microfiltration (MF), nanofiltration (NF) and reverse osmosis (RO).</p>
ultraviolet light (UV)	Light emitted with wavelengths from 200 – 400 nm, therefore outside the range visible to the human eye.
unconfined aquifer	A saturated water bearing formation that has a free water table and is not protected by an aquiclude from surface contamination.
United States Environmental Protection Agency (USEPA)	An agency of the federal United States government founded in 1970 with a mission to protect human health and the environment.
unloading	A breakthrough of particles held on a filter, usually caused by a pressure surge or other increase in the filtration rate.
USEPA	See United States Environmental Protection Agency (USEPA) .
UV	See ultraviolet light (UV) .
UV absorbance	See absorbance
UV disinfection	Disinfection using electromagnetic radiation (light) in the range of 200–400 nm.
UV lamp	<p>LP Lamp</p> <p>A mercury vapour lamp that operates at an internal pressure of 0.001–0.01 torr (2×10^{-5} to 2×10^{-4} psi) and electrical input of 0.5 W/cm. This results in essentially monochromatic light output at 254 nm.</p> <p>LPHO lamp</p> <p>An LP mercury vapour lamp that operates under increased electrical input (1.5–10 W/cm), resulting in a higher UV intensity than LP lamps. It also has essentially monochromatic light output at 254 nm.</p> <p>MP lamp</p> <p>A mercury vapour lamp that operates at an internal pressure of 100–10,000 torr (2–200 psi) and electrical input of 50–150 W/cm. This results in polychromatic (or broad spectrum) output of UV and visible light at multiple wavelengths, including the germicidal range.</p>

UV transmittance	See transmittance.
validation testing	Establishing the operating conditions whereby a process can deliver specified compliance requirements, and then demonstrating whether a particular piece of equipment achieves these operating conditions.
virus	A very small parasitic organism that can reproduce only if it can colonise a living cell by ‘hi-jacking’ some of the host cell’s metabolic processes. Submicroscopic particles of nucleic material are enclosed in a protein coat. Viruses are responsible for several waterborne diseases such as infectious hepatitis and poliomyelitis (polio).
water quality standards	The MAVs specified for health significant determinands and indicator organisms in the DWSNZ.
water supplier	Any person or entity that owns, or is responsible for operating, a drinking-water supply.
water leaving the treatment plant	Occurs at the point where the drinking-water supply enters the distribution system , regardless of the treatment process, if any.
water treatment plant	The place where raw water undergoes chemical, biological or physical treatment to remove particles or unwanted determinands , inactivate organisms or enhance the aesthetic quality of the water.
water treatment process	A chemical, biological or physical process used to enhance the quality of a drinking-water supply before its distribution.
WHO	See World Health Organization (WHO) .
wholesome drinking-water	Potable water that does not contain or exhibit any determinands that exceed the guideline values for aesthetic determinands included in the Drinking-water Standards for New Zealand (DWSNZ) .
World Health Organization (WHO)	An agency of the United Nations, founded in 1948. Its objective is the attainment by all peoples of the highest possible level of health (physical, mental and social, and not merely the absence of disease or infirmity).

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