A Guide to the Ministry of Health Drinking-water Standards for New Zealand

Prepared for the Ministry for the Environment

by Chris Nokes

Environmental Science & Research Ltd

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TABLE OF CONTENTS

LIST OF FIGURES

1 INTRODUCTION

The National Environmental Standard (NES) for Sources of Human Drinking Water comes into force in June 2008. In implementing the NES[1], regional councils and resource consent applicants will need to understand the key factors that determine whether water is safe to drink. The *Drinking-water Standards for New Zealand* (DWSNZ) are an important resource for doing so. The present guide provides regional council staff and resource consent applicants with the information they need about the DWSNZ, when they are assessing whether a new activity in a catchment may compromise the ability of a water treatment plant to produce safe water.

This guide will assist those who have had little previous involvement with water quality in relation to public health. It is a "beginner's guide" to understanding those parts of the DWSNZ considered to be most relevant to the implementation of the NES. Reading this guide will not provide an expert understanding of the DWSNZ. The DWSNZ themselves, in conjunction with their companion document, *Guidelines for Drinking-water Quality Management in New Zealand*, should be consulted if the reader needs a more detailed understanding of the DWSNZ. Drinking water assessors[2] at the public health units of the local district health board can also provide assistance.

The structure of this guide follows the order in which the topics of interest are presented in the DWSNZ.

- overview of the DWSNZ
- water quality standards
- general compliance concerns at the treatment plant
- how compliance is assessed for the main contaminant groups: bacteria, protozoa, cyanotoxins, chemicals ,and radioactive contaminants.

It also discusses contaminants in the source water that could lead to the presence of other contaminants in the treated water, and constituents of the water that can affect its taste, smell or appearance.

The final two sections of this guide discuss two sources of information about supplies: the *Annual Review of Drinking-water Quality in New Zealand* and the Water Information New Zealand (WINZ) database. These sources provide information about supply water sources, the nature of treatment processes used in the treatment plants, and the extent of their compliance with the DWSNZ.

Where there is an important implication for implementation of the NES, this is discussed in an "NES note" box.

[1] Throughout this guide, the abbreviation NES refers to the National Environmental Standard for sources ofhuman drinking water.

[2] Drinking water assessors are health protection officers who have received additional training in water supply management and treatment, and water supply regulations. Part of their responsibility is assessing the compliance of water supplies with the DWSNZ.

1.1 Water supply management and the multiple barrier principle

Water quality monitoring involving the collection and analysis of water samples, has been the backbone of water supply[3] management for many years. Relying solely on monitoring as the basis for water supply management, however, is a poor defence against water-borne contaminants. Unless monitoring is continuous, results always provide historical water quality information because of the time taken to analyse samples[4]. Consequently, consumers may have been receiving contaminated water for some time before a water supplier learns of contamination of the supply. Furthermore, each water test provides only a snapshot of the water quality, which is limited to the contaminants tested. The quality of water between testing is unknown.

Recently, the principles and techniques of risk management have been introduced into the management of water supplies. A risk-based approach to supply management requires water suppliers to identify what might go wrong with each part of their supply and to reduce the likelihood of these things happening. Monitoring is not dispensed with and is still necessary to check that the precautions taken by each water supplier are actually working. This approach gives water suppliers much greater confidence that they are providing water of consistent quality to their consumers.

The multiple barrier principle is internationally recognised as a cornerstone in managing risk in water supplies. The use of more than one barrier is encouraged in the DWSNZ. The presence of more than one barrier between water consumers and possible sources of pollution means that consumers are less likely to receive contaminated water. So, if one barrier fails then there are other barriers in place to protect consumers. Key barriers include:

- protection of source water from contamination eg, fencing of rivers or streams so that animals cannot get direct access to the water source. This reduces the range and concentrations of contaminants that have to be dealt with by the water treatment plant.
- Treatment plant processes:
    - Filtration improves water quality by removing particles
    - Disinfection follows the particle removal steps and inactivates[5] disease-causing micro-organisms (pathogens)
- Protection of the water after treatment so that it is not re-contaminated (eg, ensuring there is some chlorine in all the pipes between the treatment plant and consumers, and undertaking regular checks to make sure there are no leaks in the pipes).

[3] A water supply is a system for providing consumers with safe drinking water. It consists of three components: a source, treatment plant and distribution system (section2.1). Whenever the term is used in this document it includes all three components together.

[4] *E. coli* analysis takes c. 24 hours; chemical analyses take minutes or hours, but usually have to be batched for economy, and results may take weeks to be reported. The delay in microbiological analyses is of greater concern because the onset of illness caused by microbes is more rapid than illness caused by chemicals

[5] The term "inactivate" rather than "kill" is used, because disinfection processes may stop an organism from being able to reproduce, without killing it. In this condition they are still viable and capable of revival.

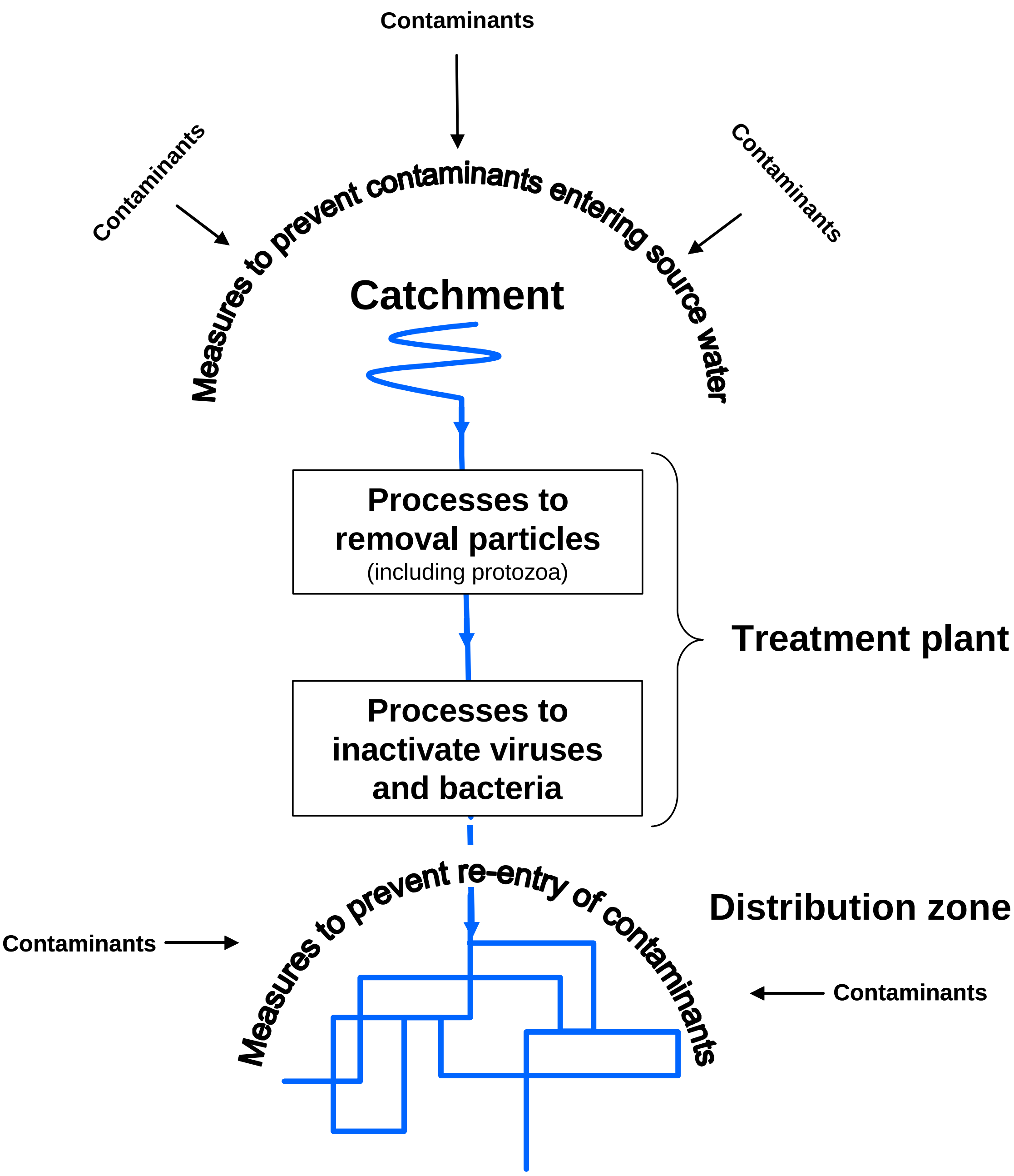

Figure 1 Elements of the multiple barrier principle

Protection of the source water is possibly the most important barrier because it reduces the contaminant load that later barriers have to remove. The reason for the development of the National Environmental Standard (NES) for human drinking water sources is to strengthen this barrier.

2 WATER SUPPLY MANAGEMENT

2.1 Structure of water supplies

The DWSNZ divide water supplies into three components: source, treatment plant and distribution system (Figure 2). All water supplies that have been identified and recorded in the Ministry of Health's *Register of Community Water Supplies* (www.drinkingwater.org.nz) have at least one of each of these components. Each is assigned a unique identifying code. The treatment plant and distribution system have different compliance criteria. The following subsections describe each of these components.

2.1.1 Source

There are three main source types:

- surface water – eg, streams, rivers, lakes, or reservoirs
- groundwater – water drawn from bores or wells
- roof catchment – rain water collected on roofs and stored for later use[6].

Often water suppliers have limited control over activities in the catchment (or the recharge zone of a groundwater source), and therefore over the quality of the water they have to treat.

2.1.2 Treatment plant

Treatment plants may range from large operations that consist of a series of treatment processes running under automated control, through small plants using a single treatment process with manual control, to a pump drawing water from a source (usually groundwater) without any treatment. Where there is no treatment, the borehead is regarded as the treatment plant by the DWSNZ.

2.1.3 Distribution system

The distribution system carries water from the treatment plant to the consumers. The DWSNZ define the distribution system as the pipes, water storage facilities (tanks or reservoirs) and any other components situated between the treatment plant and consumers' property boundary. Storage facilities at the treatment plant are considered to be part of the treatment plant.

Distribution systems can be divided into separate distribution zones. Each distribution zone is a part of the distribution system in which consumers should receive water of the same quality.

[6] Roof catchments are mentioned for completeness, but they are rarely a water source that services communities. The catchment activities of concern for this type of source *(ie, roof water)* are those introducing contaminants into the air, or encouraging the congregation of birds eg, landfill sites.

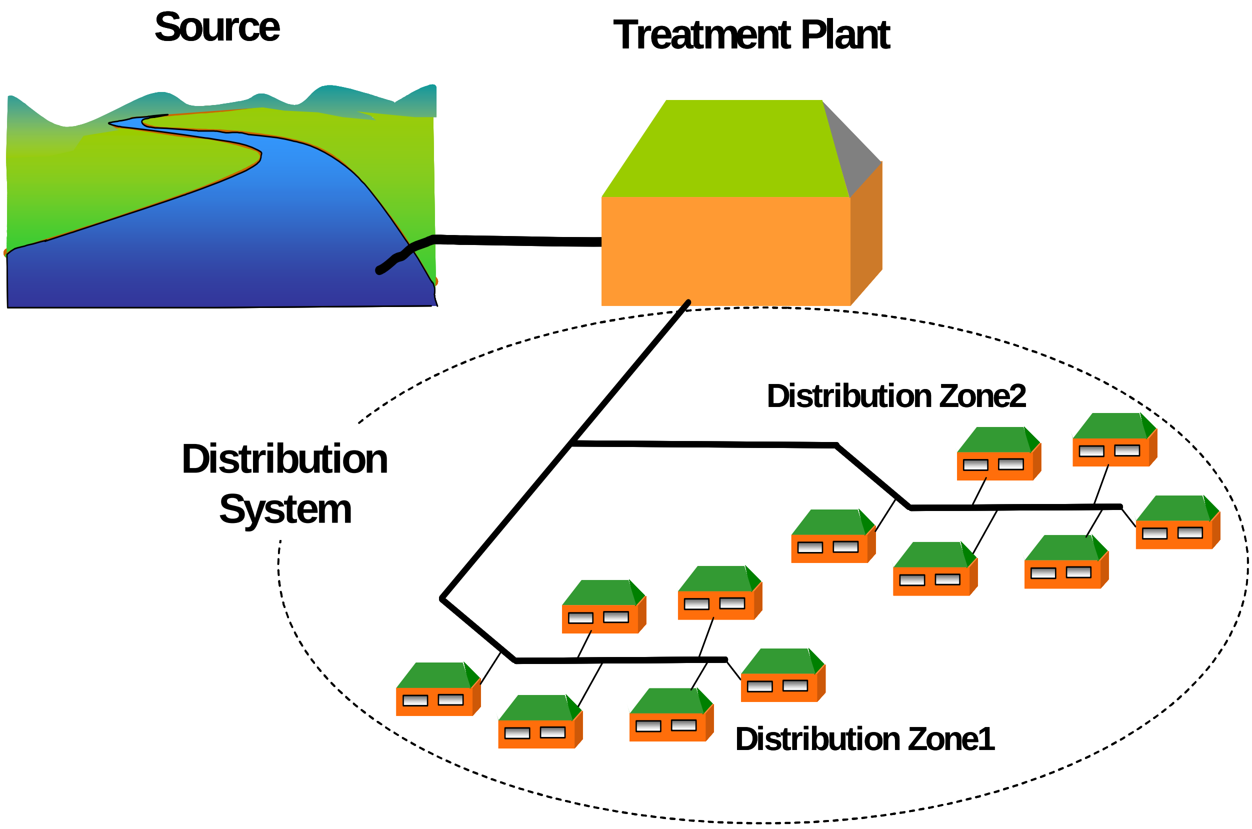

Figure 2 Water supply system components – distribution system containing two distribution zones

2.2 Drinking-water Standards for New Zealand

2.2.1 Introduction

The primary purpose of the DWSNZ is to protect public health by explaining how to assess the quality and safety of drinking water.

They do this by providing two types of information:

- **Water quality standards**[7], which define the maximum concentrations of contaminants that are acceptable in safe drinking water. This is done in the form of maximum acceptable values (MAVs). An MAV is the maximum concentration of a contaminant (microbes or chemicals) in drinking water that will not make consumers ill even if they drink the water all their lives[8]. MAVs provide a

[7] Although the DWSNZ use the word "standards", the term does not provide any legal status to these values.
[8] MAVs for most chemical contaminants that are suspected of causing cancer represent a risk of one additional incidence of cancer per 100,000 people drinking 2L of water containing the contaminant at the concentration of the MAV for 70 years. MAVs for non-carcinogenic chemicals are based on doses with no observed health effects (animal data for some MAVs and human data for others).
E. coli does not cause sickness. Its MAV is based on the observation that waters with *E. coli* below the MAV of 1 organism per 100mL rarely result in waterborne disease. The other microbial MAV (for protozoa) is set for regulatory purposes. It is not derived from a dose/response relation.

yardstick by which the safety of drinking water can be judged. Water is safe to drink as long as none of the contaminants it contains exceeds its MAV. MAVs apply to treated waters.

- **Compliance criteria** specify how a water supplier is to show that its water quality standards are being met. It is the responsibility of the water supplier to show that their water supply complies with the DWSNZ.

  Compliance criteria make up most of the DWSNZ and can be complicated. The reader is not expected to be familiar with the detail of compliance requirements. The purpose of providing information about compliance criteria is to give an overview of processes associated with the DWSNZ, and to assist understanding of how to apply the NES to a particular consent application.

The DWSNZ can apply to drinking water supplies of any size, irrespective of whether they are public or private. They specify requirements for ensuring drinking water is safe, while minimising unnecessary monitoring.

When this guide was prepared, compliance with the DWSNZ was voluntary. No law currently requires water supplies to comply with the DWSNZ, although the Building Act 2004 (s.123 (c)) does require buildings to be supplied with potable water. Despite this, most water suppliers aim to meet the requirements of the DWSNZ[9].

2.2.2 MAVs and source water quality

The concentrations of contaminants in source waters are not required to be less than their MAV (although some groundwaters may be of this quality), but contaminant concentrations in source waters should be minimised as much as practicable. *MAVs should not be considered as a "pollute up to" limit*. This is an important principle in protecting public health. An increase in contaminant level in the source water, or a drop in the effectiveness of a treatment process, will readily result in the MAV being exceeded if the MAV is the target level for water quality.

[9] As presently drafted, the proposed Health [Drinking-water] Act Amendment Bill will require all water suppliers to take all practicable steps to comply with the DWSNZ.

3 WATER CONTAMINANTS OF HEALTH SIGNFICANCE

For public health purposes, drinking water contaminants fall into three broad classes:

- microbiological contaminants
- chemical contaminants
- radiological contaminants.

This guide focuses on microbiological and chemical contaminants, because they are the most frequently encountered.

Microbiological contaminants

In general, microbiological contaminants are considered to be a greater threat to health than chemical contaminants. This is because they are:

- fast acting, usually causing sickness in a few days or weeks
- capable of multiplying within a host
- transmittable from person to person
- capable of causing fatal illness.

In New Zealand, exposure to microbiological contaminants is a concern because of our relatively high density of domesticated animals. Conversely, New Zealand's low level of heavy industry reduces the likelihood of industrial chemical contaminants in source waters.

Chemical contaminants

The health effects of greatest concern associated with chemical contaminants are those arising from prolonged exposure to low concentrations. Three notable exceptions to this, when chemical contaminants can have immediate consequences for health, are:

- nitrate (specifically for bottle-fed infants)
- cyanotoxins (the toxins produced by cyanobacteria)
- copper, which may arise from the corrosion of copper plumbing (if present in high enough concentrations).

Exposure to chemical contaminants can also have immediate consequences when a contaminant's concentration is very high, as may happen as the result of an accidental spillage.

Section 2 of the DWSNZ provides tables of MAVs (see s2.2.1). These assist water suppliers and health professionals to assess the health importance of the concentrations of contaminants in a water supply.

3.1 Microbiological contaminants

The DWSNZ recognise three classes of micro-organisms that may cause disease (see Table 2.1 of DWSNZ): bacteria, viruses and protozoa.

3.1.1 Bacteria

The indicator organism *Escherichia coli* (*E. coli*) is used in the DWSNZ to assess the bacterial quality of water. The bacterial quality of treated water is satisfactory if the *E. coli* concentration is less than 1 organism per 100ml. Except for a few strains, *E. coli* is not a disease-causing organism (pathogen). It is found in very high numbers in the gut of all warm-blooded animals. Fresh faeces always contains *E. coli*, although it may not survive in the environment as long as some pathogens do. When *E. coli* is detected in water it shows that the water has been in contact with faeces: this means that pathogens may also be present. The types of pathogen and their concentrations will depend on the nature of the organisms infecting the animals or humans that are the source of the faeces, and the number of animals or humans that are infected.

3.1.2 Viruses

There is too little information available on which to base an MAV for a viral indicator or individual viruses. A virus suitable to act as a viral indicator (similar to *E. coli* for bacteria) has yet to be found. Possible candidates have proved unsatisfactory because:

- they respond differently from viral pathogens to treatment with disinfectants, or
- there is no correlation between their concentration and those of viral pathogens in the water, or
- test methods are unsuitable (incubation time too long, too complex, or too expensive).

Although there is no MAV for viruses in the DWSNZ, this does *not* mean that they do not present a threat to health. Faecally polluted water can harbour disease-causing viruses (viral pathogens). The presence of *E. coli* in water, although a bacterial indicator, may also signal that a water contains viral pathogens.

Viruses that cause waterborne disease tend to be *enteric viruses*, ie, they infect the gastrointestinal tract and are excreted by infected humans. Some viruses that infect animals may also infect humans. Human and animal viruses are highly infective.

3.1.3 Protozoa

Protozoa (eg.,. *Giardia* and *Cryptosporidium)* are among the most common causes of infection and disease in humans and other animals[10]. The largest recorded outbreak of waterborne disease in a first-world country occurred in Milwaukee in the USA in 1993 due to *Cryptosporidium*, with an estimated 400,000 people becoming ill.

Giardia and *Cryptosporidium* exist as environmentally robust spores outside of a host. Both organisms are resistant to water treatment processes, but *Cryptosporidium* is more difficult to remove by filtration because it is smaller. It is also more resistant to chlorine.

The DWSNZ give an MAV for the total concentration of protozoa in treated water of less than 1 organism per 100L (note that the units for protozoa are “litres” of water not “millilitres” as for bacteria). *Giardia* and *Cryptosporidium* are the protozoa of primary concern in drinking waters, so that “total” in the DWSNZ refers to these two protozoa.

3.2 Chemical contaminants

Maximum acceptable values for chemical contaminants, both natural and of human origin, are listed in two tables in the DWSNZ. The first table (Table 2.2 in the DWSNZ) contains chemicals such as nitrate, metals, and chemicals used to disinfect water. These are inorganic chemicals. The classes of chemical contaminants in the table are:

- metals and metalloids
- inorganic disinfection by-products[11]
- disinfectants
- a miscellaneous group outside the above classifications: beryllium, boron, cyanide, fluoride, nitrate and nitrite.

The second table of chemical contaminants contains organic substances (chemical substances containing carbon):

- compounds utilised in industry (including contaminants in water treatment products)
- agrichemicals (eg, pesticides)
- substances formed in the water during the disinfection process (disinfection by-products)
- cyanotoxins (toxins produced by cyanobacteria, blue-green algae)
- polycyclic aromatic hydrocarbons, PAHs (resulting from incomplete combustion)

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[10] WHO *Guidelines for Drinking-water Quality* 3rd Ed, 2004, Section 11.3.

[11] These are compounds formed when a disinfectant reacts with organic matter in the water. They are discussed more fully in s8.4.1

NES Note: Some readers may be used to using the Australian and New Zealand Environment and Conservation Council (ANZECC) *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (2000) when considering resource consents. If you are used to working with the ANZEEC guidelines, be aware that some MAVs given in the DWSNZ are lower than ANZECC guideline values. Note also that some MAVs exist in the DWSNZ for contaminants not covered by the ANZECC guidelines.

3.3 Radioactive contaminants

The final table of MAVs covers radioactive contaminants of water. These are seldom a concern and are expected to arise only from natural sources.

3.4 Risk categories for contaminants: priority classes

The DWSNZ use the concept of priority classes for contaminants to ensure that water suppliers monitor the contaminants of greatest health significance for their supply in the most efficient way.

Many contaminants are listed in the DWSNZ. Water suppliers cannot afford to test all of them frequently enough to adequately check the quality of their water. Water suppliers are therefore only required to monitor the contaminants of greatest health concern for their supply.

There are four priority classes. Priority 1 (microbial contaminants) is highest priority, as these contaminants pose the greatest immediate threat to health.

- Priority 1 contaminants: microbial

  These contaminants are all microbial contaminants: *E. coli* and the protozoa[12]. They are of greatest health significance because they can lead to rapid and major outbreaks of illness. Moreover, because their concentrations in source waters are often very variable, samples for testing need to be taken more frequently than for other contaminants.

  Priority 1 contaminants may arise in any source water and are therefore assigned to all water supplies ie, all suppliers are required to monitor them, or show that their treatment processes are capable of removing them (discussed in more detail in sections 5 and 6).

- Priority 2 contaminants: chemical

  In principle, Priority 2 contaminants can be chemical, radiological or microbial[13], but in practice only chemical Priority 2 contaminants have been assigned to water

[12] Viruses are not presently included in this priority class. Compliance criteria have yet to be established for them. When a suitable indicator organism for viruses is found, or the efficacies of treatment processes to inactivate them have been determined, compliance criteria will be set and they too will become Priority 1 contaminants.

[13] Specific microbial contaminants that may appear for a limited time in a supply because of an event or events are classed as Priority 2 contaminants not Priority 1 contaminants. The monitoring requirements for them are established when they are assigned a Priority 2 status. They are different from Priority 1 contaminants which require on-going monitoring of the indicator *E. coli* or the performance of the treatment process (for protozoa).

supplies. Since the sources of chemical contaminants can vary among supplies, the Priority 2 contaminants assigned to a supply depend on the situation at each supply. (The process of identifying these contaminants for each supply is discussed later; see section 8.1)

Priority 1 and Priority 2 contaminants that have been assigned to the supply must be monitored for a water supplier to show that the water they produce is safe to drink (by complying with the DWSNZ). All monitoring to meet the requirements of the DWSNZ is the responsibility of the water supplier.

Priority 3 and Priority 4 contaminants are of lower risk than Priority 1 and Priority 2 contaminants and do not have to be monitored, but can be monitored at the discretion of the water supplier. A drinking water assessor may require monitoring of these lower risk contaminants for public health reasons (see section section 8.3 for further explanation). Like Priority 2 contaminants, the characteristics of each supply determine which contaminants are classed as Priority 3 and Priority 4.

When monitoring of a Priority 2 contaminant no longer shows it to be a potential health concern, perhaps because of improved treatment, the contaminant may be reassigned to Priority 3 status. No official assignments of Priority 3 or 4 status are otherwise made.

4 ASSESSING COMPLIANCE WITH THE DWSNZ

4.1 Purpose

The drinking water that consumers receive should ideally be of consistently good quality. To achieve this, the water treatment plant must consistently produce water of good quality, and there must be no degradation in water quality as it passes through the distribution system from the treatment plant to the consumer. The purpose of assessing the compliance of a water supply is to determine whether these goals are being met.

4.2 Assessment

To attain overall supply compliance, the treatment plant and the distribution zone must comply. Furthermore, compliance must be achieved with respect to all contaminant types ie, bacteria, protozoa and any chemicals, cyanotoxins or radiological contaminants that have been assigned as Priority 2 contaminants.

The NES is concerned with the ability of the treatment system to remove contaminants. For contaminants that are monitored at the treatment plant, the results of this monitoring will provide a good indication of how well they are being removed by treatment. For most chemical contaminants, however, compliance monitoring is undertaken in the distribution zone[14], so that these data too can be considered in assessing the efficacy of treatment. An important exception to the usefulness of distribution zone monitoring is monitoring for heavy metals.

Several heavy metals (antimony, cadmium, chromium, copper, lead and nickel) are almost always derived from the corrosion of household plumbing materials. In the past, monitoring of the levels of metals derived from corrosion was undertaken. This is no longer required, and these historical data provide no guidance on the efficacy of treatment processes. Although there are only a few instances, to date, of heavy metals being present in New Zealand's source waters, new catchment activities could contaminate source waters with heavy metals.

4.2.1 Compliance monitoring

To determine whether water quality is being maintained over time, compliance is based on monitoring results collected over a 12-month period. Assessing compliance is therefore based on a series of samples – a single sample cannot be said to comply with the DWSNZ.

Water suppliers are responsible for taking these samples. The results of the sampling are evaluated each year, in collaboration with the drinking water assessor, as part of the annual compliance assessment. The district health board saves a summary of these results in the Ministry of Health's database *Water Information New Zealand* (WINZ) and they are transferred to Environmental Science and Research (ESR) for the preparation of the

[14] Some chemical contaminants must be monitored in the distribution zone because their concentrations may change after treatment (disinfection by-products, for example). Chemicals that are not expected to change in concentration could be monitored at the treatment plant or in the distribution zone, but in most cases their monitoring is assigned to the distribution zone. This is more convenient if samples are already being taken in the distribution zone, and it provides a check on the concentrations to which consumers are actually being exposed.

Annual Review of Drinking-water Quality in New Zealand which is publicly available (www.moh.govt.nz/water) (See also sections 11 and 12)

4.2.1.1 Bacteria and chemicals

The nature of a contaminant determines the way it is monitored. Contaminants that can be simply and cheaply measured are monitored directly, by collecting water samples and measuring the contaminant concentration. These contaminants include bacteria, chemicals and radiological contaminants. Cyanotoxins are also directly monitored, but their analysis is more expensive than the other contaminants listed.

4.2.1.2 Protozoa

For protozoa, sampling and analysis are more complex and expensive. For these organisms, *performance parameters* linked to treatment processes are measured. Performance parameters show whether treatment processes capable of removing the protozoa are operating satisfactorily, eg, the turbidity of the treated water or the intensity of an ultraviolet lamp. Performance parameters do not have MAVs. The equivalent benchmarks are *operational requirement limits*. These apply to the operation of treatment processes and are not associated with contaminants in the source or finished water.

Monitoring of performance parameters may also be used as the basis for bacterial compliance, if the chlorination process is continuously monitored and the water supplier wishes to take this approach.

4.2.2 Compliance criteria

Many factors, other than monitoring results, are taken into account when compliance with the DWSNZ is being assessed. These are not relevant to the NES as the assessments made for the NES will be based on MAV transgressions (see s4.2.3) only. The additional factors are noted below, so that the reader is aware of what else might influence the ability of a water supply to comply with the DWSNZ.

A water supply (or a component of a supply ie, treatment plant or distribution zone) is compliant when all of the following requirements are met:

- the MAV of a contaminant, or the operational requirement limit for a treatment process, has not been exceeded (transgressed – see section 4.2.3 below) more than the permitted number of times
- the contaminant concentration, or the performance parameter for the treatment process, has been measured at the required frequency (or more frequently) over the 12-month period
- the monitoring procedures are correct (equipment has been calibrated as required; the correct test method has been used; and the analysis has been performed by a Ministry of Health-recognised laboratory)
- the required actions to protect public health have been taken in the event of a transgression occurring, and steps have been taken to make recurrence of a transgression for the same reason, unlikely.

The details of these requirements are set out in the DWSNZ. Their discussion is beyond the scope of this guide, although more general points specific to the particular contaminants are discussed in later sections.

NES Note: From the set of bulleted points above it can be seen that a treatment plant might be non-compliant, but not as a result of the concentration of a contaminant being too high. Consequently, if the effectiveness of a treatment plant in removing a contaminant is being assessed and the treatment plant is non-compliant, the reason for non-compliance must be determined to make an accurate assessment.

4.2.3 Transgressions

The term *transgression* is used in the DWSNZ to denote when an MAV or operational requirement limit has been exceeded. It refers to a single sample or event and may be either of two types, depending on which parameter is being exceeded:

- an *MAV transgression*: the concentration of a contaminant is greater than its MAV
- a *performance transgression*: a performance parameter is outside the operational requirement limits for longer than permitted.

A transgression is undesirable, but does not necessarily result in the treatment plant being non-compliant with the DWSNZ. Some transgressions are allowed provided enough other samples without transgressions have also been collected. The number of permitted transgressions before a treatment plant is non-compliant is given in Tables A1.3 and A1.4, in Appendix A1.8 of the DWSNZ. (These tables are reproduced in Appendix 1 of the present guide.)

5 COMPLIANCE REQUIREMENTS FOR BACTERIA

5.1 *E. coli* monitoring

Disease-causing bacteria, such as *Campylobacter* and *Salmonella*, can be transmitted through drinking water, but monitoring of specific pathogens is not required by the DWSNZ. Instead, the indicator *E. coli* is monitored (see section 3.1.1a). The assumption made is,that if the disinfection process has reduced the *E. coli* concentration to less than 1 organism per 100mL, the concentrations of any pathogens originally in the water will also have been reduced to an acceptable level.

The frequency at which *E. coli* samples must be taken depends on several factors:

- the nature of the disinfection process(es) in use: chlorination, treatment with chlorine dioxide, ozone or UV light, or no disinfection at all
- whether the disinfectant concentration in the water is monitored continuously or non-continuously
- the number of people being supplied with water from the treatment plant (if the disinfectant is chlorine or chlorine dioxide and is not continuously monitored[15])
- the "secure" status of a groundwater source.

Direct *E. coli* monitoring is required at all treatment plants, except where treatment is by continuously monitored chlorine or continuously monitored chlorine dioxide. To show compliance with the DWSNZ in these treatment plants, the water supplier can monitor performance parameters that show the treatment process is operating properly, if they wish, or monitor *E. coli* if they prefer.

5.1.1 Secure groundwater

The microbiological quality of groundwaters is often better than that of surface waters because concentrations of microbes in the water are reduced as the water percolates into the ground and moves through the aquifer. This improvement in water quality occurs because of processes such as filtration, adsorption and natural die-off of the organisms as they are carried through the soil, sands and gravels underground.

Where there is little opportunity for these processes to improve the water quality (eg, where groundwater is shallow), the microbial quality of the water may vary in response to weather events at the surface in much the same way as surface water quality may vary. For monitoring purposes, these shallow groundwaters are treated as surface waters.

Groundwaters that are isolated from events at the surface, because of their depth or protection by impermeable overlying strata, are of constant, high microbial quality. These groundwater sources are termed "secure". A secure status allows a marked reduction in monitoring requirements for *E. coli* (see DWSNZ Sections 4.3.10 and 4.5).

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[15] Without continuous monitoring there is the possibility of a system failure. The additional requirement of *E. coli* monitoring provides another check on the water quality. As the number of people supplied increases, the consequences of a treatment failure increase (ie, more people get sick), therefore there is a need to increase checks on water quality.

Treatment of secure groundwater is often not undertaken (eg, Christchurch City) because of the protection afforded by overlying strata and the further reduction of contaminants by natural processes, such as adsorption, filtration and in the case of micro-organisms, die-off. The time the water travels underground is a key factor in improving the microbial quality of the water as longer times allow for larger numbers of micro-organisms to die. Die-off does not occur with chemical contaminants; as a result a "secure" status is only an indicator of good microbial, not chemical, water quality.

NES Note: When the potential effects of a proposed activity are being considered in relation to a secure groundwater, the following must be taken into account:

Disturbance of the substrata, such as might happen during quarrying or well drilling, could affect the secure status of the supply by opening the aquifer to more direct influence from the surface. Rigorous hydrogeological assessment of the potential effect of the activity is therefore important.

Where an activity is unlikely to disturb substrata, increased release of animal or human faeces into the environment may not affect the quality of a secure groundwater. However, it is still desirable that the level of pollution by the activity is kept to a minimum so that the natural treatment processes occurring underground are not overwhelmed.

5.2 Disinfection

Disinfection effectiveness depends on:

- residual disinfectant concentration – the disinfectant concentration that remains after the disinfectant has reacted with any contaminants in the water
- contact time – the minimum time an adequate disinfection residual is in the water
- acidity/alkalinity (pH, for chlorine and chlorine dioxide-treated systems)
- turbidity – microbes can stick to the surface of particles in the water that cause turbidity, and by doing so are protected from the disinfectant
- flow rate through the treatment plant (for ozone- and UV- treated systems).

Problems controlling these factors can result in inadequate disinfection of the water, and *E. coli* being detected in the treated water.

Although all these factors are controlled at the treatment plant, contaminants in the source water can affect the turbidity (see ESR Report FW0778 s.5.4.4.1) and the residual disinfectant concentration by reacting with the disinfectant.

NES Note: New catchment activities that lead to high levels of organic matter or turbidity in the source water, especially if combined with substantial variability in these contaminant levels, may lead to inadequate disinfection and thus to *E. coli* being present after treatment.

6 COMPLIANCE REQUIREMENTS FOR PROTOZOA

6.1 Introduction

Unlike bacteria, compliance with the protozoa criteria of the DWSNZ does not require the water supplier to monitor the organism directly. Testing for protozoa is expensive. Compliance is based on the ability of the treatment plant to remove protozoa, and more particularly, to remove *Cryptosporidium* which is a more difficult task than removing *Giardia*. *Giardia* is a larger organism than *Cryptosporidium* and its physical removal by particle removal processes is easier. The level of chlorine required to inactivate *Cryptosporidium* is too high for use in water treatment, but *Giardia* can be inactivated by chlorine during water treatment. However, the necessary chlorine concentration or the contact time of chlorine with the water, or both, are somewhat higher than those required for inactivation of *E. coli*.

The approach to basing protozoal compliance on the treatment process and its performance requires knowledge of:

i. the concentrations of *Cryptosporidium* in the source water

ii. the efficiency of the treatment plant processes at removing or inactivating *Cryptosporidium*

Comparing i) with ii) shows whether the treatment plant can remove or inactivate enough of the protozoa in the source water to produce safe drinking water.

Chlorine is used as a disinfectant by most water treatment plants in New Zealand, because of its effectiveness against bacteria and viruses. However, it is relatively ineffective against *Cryptosporidium*. Treatment plants must include other treatment processes to achieve compliance with respect to protozoa.

6.2 Treatment processes for protozoa

Two types of treatment processes protect against protozoa:

- processes designed to remove particles from the water – because *Cryptosporidium* is just another particle
- disinfection processes that inactivate the organism.

Processes that physically remove *Cryptosporidium* have varying degrees of effectiveness, and include various types of filters[16]. Their effectiveness is often increased by a preceding coagulation/flocculation stage, which clumps small particles together and assists in their sedimentation or filtration.

Disinfectants that inactivate *Cryptosporidium* at an acceptable rate are chlorine dioxide, ozone and UV radiation. The percentage of the organism that they inactivate depends on the concentration of the disinfectant (or intensity, in the case of UV radiation) and the time that the *Cryptosporidium* is exposed to the disinfectant.

[16] Particle removal processes take *Cryptosporidium* out of the water. Inactivation by disinfection does not take the *Cryptosporidium* out of the water, but renders the organisms incapable of causing infection.

A water supply that has a groundwater source that is classified as secure does not need any additional treatment to achieve compliance with the DWSNZ with respect to protozoa.

6.2.1 Log credits

The capacity of a treatment process to reduce the number of infectious[16] *Cryptosporidium* oocysts in water is specified by the number of log credits[17] it is assigned. The greater the number of log credits assigned to a treatment process, the larger the percentage of oocysts the process is able to remove or inactivate. The DWSNZ specify the number of log credits each treatment process can earn.

Treatment plants often have more than one treatment process that can remove or inactivate *Cryptosporidium*. The overall effectiveness of the treatment plant ie, the total contribution made by all treatment processes, is calculated by adding the log credits of the individual processes together[18].

6.2.2 Turbidity

The ability of a treatment process to remove or inactivate *Cryptosporidium* depends on how well it is operated. A poorly run process may achieve very little removal, despite it being capable of scoring a substantial number of log credits. The assessment of compliance therefore depends on the water supplier being able to show satisfactory operation of each process.

Turbidity is one performance parameter used to show satisfactory operation for several processes that remove particles from water. Turbidity is measured by the water supplier after treatment. Clear, treated water shows the process is working well and that if there was *Cryptosporidium* in the raw water it will have been reduced to a safe level. Turbid water leaving the treatment process does not necessarily contain *Cryptosporidium*, because there may have been no *Cryptosporidium* in the raw water. However, the poor performance of the process does make it more likely that any *Cryptosporidium* that was in the raw water will not have been removed.

NES note: Catchment activities that affect the levels and variability of raw water turbidity increase the difficulty for a treatment plant to comply with the DWSNZ. Full conventional treatment[19] can handle high levels of turbidity, but fluctuations in turbidity levels make producing good-quality water difficult. Where other treatment processes are in use, an increase in raw water turbidity may exceed the treatment plant's design specifications.

Turbid water leaving the filters also threatens the efficacy of the following disinfection process, whether it is intended to inactivate protozoa and bacteria, or just the bacteria.

6.3 *Cryptosporidium* in the source water

Cryptosporidium concentrations in source waters are very variable, even over short time scales. Increased *Cryptosporidium* concentrations are often associated with increased

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[17] Log credits are a measure of the level of removal of oocysts by a treatment process. It is a logarithmically based scale. For example, 1 log credit means there is a 10^1 (10)-fold reduction in the oocyst concentration, 2 log credits is a 10^2 (100)-fold reduction, and so on.

[18] Although this is generally true, some combinations of processes are exceptions. These are specified in the DWSNZ.

[19] Treatment using coagulation/flocculation, clarification, filtration and chlorination

turbidity of untreated water. Note, however, clear raw water is not guaranteed to be free of the organism.

To determine whether the number of log credits accrued by the treatment plant is enough to produce safe water, the water supplier needs to know the average concentration of *Cryptosporidium* in the source water. Once this has been measured directly, or estimated from a risk assessment of activities in the catchment, the minimum number of log credits required to treat the water can be determined. The DWSNZ provide a table that specifies the number of log credits required to treat a source water based on the results of the monitoring or catchment risk assessment.

The water supplier is responsible for monitoring *Cryptosporidium*, or undertaking a catchment risk assessment, to assess the log credits required to treat its source water[20]. Supplies serving more than 10,000 people are required to take source water samples for direct *Cryptosporidium* measurements (fortnightly samples over 12 months). Supplies serving 501–10,000 people may use the catchment risk assessment option[21].

NES Note: Catchment activities that are likely to increase the concentration of *Cryptosporidium* in a source water could lead to an increase in the log credits a water supply requires, to achieve compliance with the DWSNZ with respect to protozoa.

[20] The supplier may seek information from its regional council to assist in undertaking the catchment risk assessment.

[21] A survey to assist in linking the results of the risk assessment to the expected *Cryptosporidium* concentration in the water is being planned at the time of preparing this guide.

7 COMPLIANCE REQUIREMENTS FOR CYANOTOXINS

7.1 Introduction

Blooms of cyanobacteria (blue-green algae) in New Zealand's freshwaters have increased in frequency over recent years. The toxins (cyanotoxins) produced by organisms forming these blooms have potentially severe health effects (eg, damage to the liver and the central nervous system). To address the increased threat to health posed by these two factors, the DWSNZ 2005 contain a separate section that specifies what steps have to be taken to show compliance with respect to cyanotoxins.

7.2 Characteristics of cyanotoxins

Cyanotoxins are chemicals of biological origin. The monitoring requirements, however, are different from other chemicals because cyanotoxins:

- are present in water irregularly, or seasonally
- are present at concentrations of health concern for only short periods, so that monitoring throughout the year is unnecessary
- have health effects that are acute and potentially fatal at low concentrations; even in the absence of acute effects they may cause long-term damage
- can increase rapidly in concentration (as do the numbers of the cyanobacteria producing them), hence sampling frequencies need to be higher than those required for other chemical contaminants when toxins are present.

Preventing algal bloom formation is the best defence against the presence of this type of contaminant in drinking water. Catchment control to prevent bloom formation, however, is beyond the control of water suppliers. Water suppliers depend on controlling levels of nutrients in water bodies as the primary barrier against the presence of these contaminants in their supplies. The NES could help ensure that activities in the catchment do not introduce large quantities of nutrients into waters that are susceptible to algal blooms.

When algal blooms occur, care in abstracting water from the source can minimise the cell numbers and toxin concentrations entering the treatment plant. When water entering a treatment plant contains cyanobacteria or cyanotoxins, or both, producing safe water can be difficult.

Cyanotoxins are present within cyanobacterial cells as well as in the surrounding water. The rupture of cells (lysis) during treatment can result in further release of toxin into the water. The water supplier therefore faces the difficulty of trying to remove cells whole without further damage to them. The destruction or removal of any free toxin that is present in the water also presents a difficulty. The efficacy of activated carbon in adsorbing toxins depends on the toxin; the efficacy of chemical oxidation by disinfectants (chlorine, chlorine dioxide, or ozone) depends on the treatment process and the toxin(s) in question.

NES Note: The difficulty in treating water to remove cyanotoxins places the emphasis on good management of the catchment as the first defence against water becoming unsafe due to these contaminants. Warm temperatures, high light levels and high nutrient concentrations encourage the growth of cyanobacteria. The first two factors cannot be controlled, but when assessing the effects of a new catchment activity, any increase in nutrient loading of the source that might result from the activity must be taken into account. This is particularly important if the source is a lake or reservoir. An activity that decreases the water flow or water level in a source may also predispose it to algal blooms.

7.3 DWSNZ approach to cyanotoxins

Cyanotoxin measurement is expensive; for some toxins, any methods that can measure their concentration below their MAVs are unavailable. The DWSNZ encourages water suppliers to use surrogate measurements, or observations, to warn of an impending increase in the concentration of cyanobacteria cells – and therefore cyanotoxin concentrations – in the source water. The surrogate measurements used could include: algal cell counts, chlorophyll concentration, nutrient concentrations, water temperature, and the appearance of scum on the water surface. Collection of information about surrogates associated with a source is required if a source water has experienced algal blooms in the past, or a drinking water assessor considers the source to be at risk of a bloom.

The nature of the surrogate measurements and the frequency at which these measurements have to be made by the water supplier are not specified in the DWSNZ. Water suppliers should identify which surrogate, or group of surrogates, they believe will be the most valuable for indicating bloom formation in their source water. Several surrogates may be monitored over a period of years to determine which surrogate, or combination of surrogates, is most helpful in predicting when a bloom is imminent.

Surrogate measures cannot provide a reliable estimate of toxin concentrations. Therefore, direct cyanotoxin measurements by the water supplier in the source water are required to establish the level of health risk. These measurements start when the surrogate reaches a level considered likely to signal elevated toxin concentrations in the source water. This action level is determined by the drinking water assessor in conjunction with the water supplier using data collected by the water supplier, and is situation-specific. Toxin monitoring in treated water must also be undertaken by the water suppliers if the toxin concentration in the source water approaches 50% of its MAV.

8 COMPLIANCE REQUIREMENTS FOR CHEMICALS

8.1 Identification of Priority 2 contaminants

The Ministry of Health funds a programme that identifies the chemical contaminants (Priority 2 contaminants) that water suppliers need to monitor for demonstrating compliance with the DWSNZ. The programme is named *The Priority 2 Chemical Determinands Identification Programme* (known as the "P2 Programme") and is administered by ESR. It achieves its purpose through a combination of risk assessment and monitoring.

The P2 Programme assesses all water distribution zones containing more than 100 people for chemical contaminants of potential health concern. The assessment of a particular zone needs to consider all treatment plants supplying the zone, and all water sources feeding these treatment plants. The assessment process for each supply (described below) takes a little over one year, and since 1995, approximately 1050 distribution zones (somewhat fewer supplies, as many have more than one zone) have been assessed. Most distribution zones and their treatment plants have been assessed only once. Repeat assessments are only carried out under the P2 Programme if the drinking-water assessor becomes aware of something having changed in the supply that might affect the contaminant concentrations in the water. Drinking-water assessors are usually reliant on the water supplier to inform them of such changes. Recently, some water suppliers themselves have undertaken reassessments of which contaminants should be tested for in the water, with guidance from ESR.

The first step in identifying possible chemical contaminants is the collection of information about the:

i) Catchment

Possible sources of natural, agricultural and industrial contamination in the catchment are identified by a questionnaire completed by the drinking water assessor (or in the past the health protection officer) and the water supplier. The boundaries of the catchment are not defined in the questionnaire; it is left to the discretion of those completing the questionnaire to decide which activities or geological features (such as mineral deposits) need to be considered. No samples are taken from the catchment.

ii) Treatment plant

A questionnaire is used to obtain information about features of the treatment plant that may lead to contamination of the water, eg, the treatment processes and chemicals used, and materials used in the construction of the plant.

iii) Distribution zone

A third questionnaire is used to obtain information about features of the distribution zone and its operation that may result in chemical contamination of the water eg, materials used in the network of pipes, compounds used to seal pipe joints, and whether back-flow preventers are in place to stop contaminated water being back-siphoned into the water supply.

During this stage of the assessment, a sample is also taken from the distribution zone and analysed for: metals that could arise from corrosion; contaminants that have MAVs in the DWSNZ but for which information about their occurrence in New Zealand waters is limited eg, uranium; and chemical contaminants for which the hydrogeological factors that influence their occurrence are not fully understood eg, arsenic.

NES Note: With the exception of samples for total organic carbon (a measure of organic matter in the water) and bromide measurements, which are taken from untreated water, all sampling done during the P2 Programme is from treated water. Some of these samples are for the analysis of contaminants that could originate in the catchment, but the concentrations of the contaminants may have been modified by passage through the treatment plant.

Once the possible hazards have been identified from the first stage of the assessment, they are included in a list of chemicals for monitoring. Monitoring samples are collected twice during the assessment of a supply (once in early spring and once in late summer).

Contaminants that exceed 50% of their MAV in any sample taken during an assessment are recommended to the Ministry of Health for assignment to the supply as a Priority 2 contaminant. This means the water supplier is required to monitor them if they are to comply with the DWSNZ. Each water supplier is informed of these recommendations, and given the opportunity to contest any recommendations before the assignments are made official. Priority 2 contaminants are only officially assigned to supplies of more than 500 people[22], therefore it is only these supplies that need to undertake compliance monitoring.

Hardcopies of the results of water analyses from the P2 Programme are provided to district health boards. It is standard practice for copies of the test results to be forwarded to the water supplier.

NES Note: When identifying possible contaminants that could arise from a catchment activity, particular attention needs to be paid to Priority 2 contaminants already assigned to the water supply. An increase in their concentration from a new activity may result in their concentration exceeding the MAV and the water becoming unsafe, because of the concentration already being close to the MAV. Of course, attention also needs to be paid to contaminants that could be introduced into the water by an activity, but which are present at low concentrations or are not known to be already in the source water.

8.2 Types of Priority 2 contaminants

Priority 2 contaminants are of two types:

- P2a contaminants

  These are contaminants introduced into the water in treatment chemicals and are not relevant to an NES assessment.

[22] The P2 Programme collects information about Priority 2 contaminants from supplies for 500 people or fewer. No official Priority 2 contaminant assignments are made for these supplies, but the monitoring results make smaller supplies aware of chemical contaminants in their water without burdening them with having to monitor official Priority 2 assignments.

- P2b contaminants

  All other chemical contaminants are of this type. Some may originate from the catchment and are therefore important for the NES; others may arise from sources after treatment, such as dissolution of pipe materials, and these are not important for the NES. There are two subcategories of P2b contaminants:

  - Type 1 – chemical contaminants that are unlikely to change in concentration after the water leaves the treatment plant

  - Type 2 – chemical contaminants that may change in concentration following treatment[23].

Priority 2 contaminants are assigned either to the treatment plant or the distribution zone; this determines the location at which monitoring samples should be taken. P2b Type 1 contaminants may be assigned to the treatment plant or the distribution zone, and can be monitored at whichever location is more convenient. P2b Type 2 contaminants are assigned to the distribution zone and must be monitored there.

NES Note: A check should be made for Priority 2 contaminants assigned to the treatment plant *and the distribution zone*. Contaminants in the source water may be assigned to the distribution zone rather than the treatment plant. For example, manganese originates in the catchment, but because its concentration may change during distribution (precipitation and settling) monitoring will be required in the distribution zone, not at the treatment plant. Nitrate also originates in the catchment, but it does not change in concentration after the treatment plant, and could therefore be monitored at the treatment plant or in the distribution zone. If the water supplier has other Priority 2 contaminants to monitor in the distribution zone, they may also monitor nitrate there.

From the perspective of implementing the NES, the assignment of a Priority 2 contaminant to the distribution zone only raises concerns about the ability of the treatment plant to remove the contaminant from the water if the contaminant is associated with the source water ie, it is present in the source water or formed from something in the source water. Except for corrosion-derived metals, contaminants monitored in the distribution system are usually associated with the source water[24].

8.3 Compliance criteria for Priority 2 contaminants

With the exception of fluoride, chlorine and the cyanotoxins, all Priority 2 contaminants must be monitored at least monthly. Fluoride and chlorine require weekly monitoring, and the cyanotoxins must be monitored twice weekly during algal blooms. Priority 2 contaminant monitoring is ongoing until 12 consecutive monthly samples have been

[23] Some contaminants in the source water, or formed through reaction with constituents of the source water, may change in concentration after the treatment plant. Manganese, for example, may continue to precipitate after the treatment plant and settle out in parts of the distribution system. Disinfection by-products (see s.8.4.1) will tend to increase in concentration throughout the distribution system because of continuing slow reactions between the chlorine and organic matter in the water in the pipes. Where a water supplier has been required to monitor these contaminants, this will have been done in the distribution zone.

[24] The exceptions are metals that could arise from corrosion in the distribution system, chemicals used in the joints or seals of water pipes, chemicals arising from leaking underground fuel tanks in the community, and chemicals that might be drawn into the water supply by back-siphoning from industrial or agricultural operations. Contamination of water in the distribution system from back-siphoning or underground fuel tanks is direct pollution. It does not mean that pollution of the source water is occurring.

shown to contain the contaminant at a concentration of 50% of its MAV or less. Once this is shown, the water supplier can ask their drinking-water assessor for the contaminant to be reclassified as a Priority 3 contaminant, and monitoring ceases.

Compliance for all chemical contaminants requires that they not exceed their MAV. As with microbial contaminants, and operational parameters, an MAV transgression can occur without resulting in non-compliance if sufficient samples have been taken in which the contaminant did not transgress the MAV (see section 4.2.3 and Appendix 1). In practice, an MAV transgression effectively results in non-compliance, because samples for chemical contaminants are usually only collected 12 times a year, and a minimum of 78 samples must be taken for a single transgression to be allowed (see Appendix 1).

For most chemical contaminants, the health effect of an *individual* contaminant is what is considered in assessing whether its concentration represents a threat to health. A comparison of the contaminant's concentration against its MAV shows whether it is at an unacceptably high concentration. However, there are some chemically related groups of contaminants that have similar health effects eg, nitrate and nitrite; and several disinfection by-product families, namely trihalomethanes, haloacetic acids and the haloacetonitriles. For these groups, the combined health effect of the group has to be considered. This is done through the following equation:

$$SummedRatio = \frac{[A]}{MAV_A} + \frac{[B]}{MAV_B} + \frac{[C]}{MAV_C} + ...$$

where A, B, C, … are members of the group of contaminants being considered, [A] is the concentration of contaminant A, MAV_A is the MAV of the contaminant A, etc.

If the summed ratio exceeds 1, the group of contaminants as a whole transgresses the MAV. Taking account of the possible health effects of a family of contaminants as a whole can result in a group transgression, without the transgression of any individual compound.

As with other contaminants, a Ministry of Health-recognised laboratory must undertake the measurements using a method that meets the requirements of the DWSNZ, and remedial actions must be taken in the event of a transgression. An appropriate corrective action must be taken if a chemical transgression occurs. Unlike a microbial transgression, when pathogens may rapidly cause sickness, a rapid response to a chemical transgression is not required unless the contaminant is a cyanotoxin.

8.4 Comments on specific chemical contaminants

8.4.1 Disinfection by-products

Disinfection by-products are formed during treatment through the reaction of the disinfectant eg, chlorine, with organic matter in the water. Their suspected health effects include cancer, and liver and kidney damage.

Although disinfection by-products are not present in the source water, organic matter in the source water that is not removed by the first treatment processes will react with the disinfectant when it is added to the water. The levels of organic matter in the source water can therefore influence the levels of disinfection by-products in the treated water.

Disinfection by-products are not monitored at the treatment plant because they continue to form after treatment[25] with the result that their concentrations increase as the water moves from the treatment plant out into the distribution system.

The extent of disinfection by-product formation can be reduced by reducing the concentration of organic matter reaching the point of disinfectant addition in the treatment plant. Organic matter can be removed from the water by some treatment processes eg, the combination of coagulation/flocculation, clarification and sand filtration.

NES Note: Unless a catchment activity is discharging disinfected water, or industrial solvents (several of the disinfection by-products are also used industrially) into the source water, the source will not contain disinfection by-products. Catchment activities are more likely to increase disinfection by-product formation by increasing the loading of organic matter in the water. This can be mitigated to some extent by treatment processes operating before disinfection that remove organic matter from the water. The degree of organics removal by these processes is variable, and dependent on how well the process is being operated, but in the most common process (coagulation/flocculation) removal is about 70% at best.

Naturally-occurring organic substances that result from the decay of vegetation and animal remains are the usual precursors to disinfection by-product formation. These are large complex molecules. Other substances containing similar structures can also lead to the formation of disinfection by-products. As a rule of thumb, activities likely to increase the colour (yellow-brown) of the water or the total organic carbon concentration are likely to increase disinfection by-product formation. An example is activity that increases run-off from a peaty or swampy area.

8.4.2 Heavy metals

The chemical contaminants occurring most frequently in New Zealand drinking waters are heavy metals derived from the corrosion of metals in contact with the water in the distribution system. This problem is widespread because of the low alkalinity and softness of New Zealand's source waters. The DWSNZ therefore classify all water supplies as "plumbosolvent" ie, they will dissolve metals, and particularly lead from plumbing fittings.

Monitoring is not required for metals released into the water by the dissolution of consumers' plumbing fittings because of the water's plumbosolvency. Metals in the water supplied to consumers that are present at more than 50% of their MAV, however, are classified as Priority 2 contaminants and must be monitored for compliance with the DWSNZ.

NES Note: Very few water supplies contain heavy metals originating at the source; plumbosolvency is the main reason for the presence of metals in the water people drink. (A few supplies still have heavy metals assigned as Priority 2 contaminants that arise from corrosion of consumers' plumbing. These are gradually being identified and reclassified as Priority 3 contaminants so that monitoring is not required.)

Activities in catchments where there have been, or still are, mining operations, metal industries, or operations employing geothermal water could introduce heavy metals into the source water. If their concentrations were high enough they would be classified as Priority 2 contaminants, and their monitoring would be required.

[25] This occurs because of continuing slow reactions between the disinfectant and the organic matter.

9 COMPLIANCE REQUIREMENTS FOR RADIOLOGICAL CONTAMINANTS

Radiological contaminants are contaminants that are radioactive. In New Zealand, only natural sources of radioactivity need to be considered. The DWSNZ provide MAVs for two general types of radiation, irrespective of their source: alpha particles and beta particles; and an MAV for a specific radioactive contaminant: the gas radon. Radon is a concern in groundwaters because they are in close contact with rock and soil, which are the source of the gas. Use of water containing radon will increase the concentration of gas in buildings and therefore the amount inhaled.

The DWSNZ 2005 require new groundwater sources to be tested for radiological contaminants and groundwater sources in general are required to be tested every 10 years[26].

[26] This is a new requirement introduced in the 2005 edition of the DWSNZ.

10 OTHER CONTAMINANTS

10.1 Introduction

Compliance with the DWSNZ is designed to ensure that the concentrations of contaminants in a water supply do not exceed their MAV, and consequently that the water is safe to drink.

As well as health-significant contaminants, source waters may also contain constituents that:

- are not damaging to health in themselves and therefore have no specified MAV, but can affect the water's potability by leading to the formation of other contaminants
- affect the aesthetic properties of the water (taste, odour, appearance).

These constituents need to be considered when assessing the impact of a new activity in a catchment on the drinking water received by a community. The acceptability of a water supply to a community can be as strongly influenced by these constituents as by those with MAVs.

10.2 Contaminants that affect potability

At least three types of contaminant exist that have no health significance in themselves, but can affect the potability of water because they can result in treated water containing contaminants that are a health concern. These are:

- nutrients, which encourage the development of algal blooms (section 7.3)
- organic matter, which leads to the formation of disinfection by-products (section 8.4.1)
- turbidity, which can affect the ability of treatment plants to remove protozoa from the water (section 6.2.2).

These have already been discussed in the sections noted.

10.3 Contaminants that affect the aesthetic properties of a water

The constituents of a water that affect its taste, odour and appearance, collectively called the *aesthetic properties* of the water, are important in determining the acceptability of the water. Problems with a water's aesthetic properties usually become evident to consumers more rapidly than MAV transgressions by contaminants that affect health.

The World Health Organization *Guidelines for Drinking-water Quality* (3rd Ed., 2004) state:

> *The provision of drinking-water that is not only safe but also acceptable in appearance, taste and odour is of high priority. Water that is aesthetically unacceptable will undermine the confidence of consumers, lead to complaints and, more importantly, possibly lead to the use of water from sources that are less safe.*

The DWSNZ contains a list of guideline values for constituents of water that can influence its aesthetic properties (Appendix 2, DWSNZ). The DWSNZ use the term "wholesome" to describe water that is potable and meets these guidelines. Waters that meet the guidelines are expected to be acceptable to consumers with respect to taste, odour or appearance. Meeting the guidelines is not a requirement for compliance with the DWSNZ; achieving them is at the discretion of the water supplier.

Water can be treated to improve its aesthetic properties, although this is not always straightforward. The removal of cloudiness from water (ie, the turbidity) is achieved by the processes used for removing protozoa (eg, coagulation/flocculation, sedimentation and filtration in combination). Tastes and odours caused by contaminants produced by some micro-organisms (eg, algae and actinomycetes – a type of bacteria) however, are detectable by humans at very low concentrations. Treatment of water to remove these compounds to acceptable levels is difficult and expensive. Other causes of undesirable tastes and odours (eg, sulphides and metals) are easier to treat.

NES Note: Awareness of the possible effects of a new catchment activity on the aesthetic properties of a source water is important because of the potential difficulty in making the water aesthetically acceptable, and the impact that an aesthetically unacceptable water will have on those having to drink it. A community cannot be expected to drink water that is unpalatable, even if it is safe.

Monitoring of the aesthetic properties of drinking water is not undertaken as part of the P2 Programme. Any monitoring of this type is done by water suppliers. The two most likely reasons for them undertaking this monitoring are to:

- address complaints about the water quality from their consumers
- achieve a high (A1) public health grade[27].

Monitoring water quality to address consumers' complaints will occur when a complaint arises. As it is designed to address a particular concern, the monitoring programme is likely to be of a relatively short duration (until the problem is identified and a solution found), unless it is an on-going problem that the water supplier is having difficulty overcoming. Sampling in response to complaints will occur more frequently than monitoring for health significant contaminants, and samples may be taken from the source water and/or following treatment, depending on where the investigation leads. The contaminants included in the testing will be determined by the nature of the complaint.

The public health grading carried out by public health units for the Ministry of Health, is described more fully in ESR Report FW0778 s.3.6. A grade, ranging from A1 at the top to E at the bottom, is given to the source and treatment plant combined. To obtain an A1 grade, the water produced by the treatment plant must meet the guideline values for the aesthetic properties of the water given in the DWSNZ (its table A3.5).

The Ministry of Health publication, *Public Health Grading of Community Drinking-water Supplies 2003 – Explanatory Notes and Grading Forms*, Appendix B, specifies how a water supplier is to show that the guideline values have been met. A minimum of one sample is taken per year to allow analysis of all constituents. The frequency of any further

[27] See ESR Report FW0778 s.3.6.2.2

sampling is determined by the nature of constituents of concern[28], and is given in a table in the explanatory notes.

When this guide was being prepared, only two treatment plants had A1 grades, but others may be collecting information to try to attain the grade.

[28] The monitoring scheme set out in the table does not have to be followed if the supplier opts to show that the guidelines are being met on the basis of responses to consumer complaints.

11 THE ANNUAL REVIEW OF DRINKING-WATER QUALITY IN NEW ZEALAND

11.1 Introduction

Each year ESR prepares the *Annual Review of Drinking-water Quality in New Zealand* (the *Review*) for the Ministry of Health. The *Review* contains information from all registered community water supplies. These are supplies that are contained in the *Register of Community Drinking-water Supplies in New Zealand*[29].

The *Review*, which contains information about both the microbiological and the chemical quality of drinking water supplies, provides

- an overview of drinking water quality in New Zealand. This assists the Ministry of Health in evaluating the effectiveness of its policies and water supply management "tools" (eg, public health risk management plans) in improving the quality of drinking water and therefore minimising the risk of waterborne disease
- for district health boards, an overview of drinking water in their district, so that they are better able to plan where their efforts for improving drinking water quality should be directed
- detailed information on the performance of individual water supplies for those wanting to know about the quality of their water supply.

The preceding discussions in this guide show that a large amount of information may be required in assessing the impact of a new activity on a water supply. Much of the information that is needed regarding the performance of a water treatment plant is already available in the *Review* and the Water Information New Zealand (WINZ) database (see below).

11.2 How the review is conducted

Information for preparing the review is collected by a national survey of water suppliers, which is undertaken through public health units. Water monitoring data collected by water suppliers, together with other information about the supply and its operation, are used as the basis for the review. The water supplier provides the raw compliance information, or a summary of it, to the drinking water assessor, or health protection officer, who then assesses the supply's compliance, or checks the water supplier's compliance calculation[30] if one has been done.

When the compliance calculations have been checked, a summary of the compliance information is forwarded by the drinking water assessor to ESR using the WINZ database

[29] The Register is maintained by ESR for the Ministry of Health in the *Water Information New Zealand* (WINZ) database (see s.12). Community supplies (see s.2.2.2) are registered by public health unit staff, once they become aware of a supply's existence. It is likely that a substantial number of small water supplies are not registered, but it is very unlikely that supplies serving more than 500 people are unregistered, unless they are marae. The extent to which marae have been registered varies regionally.

[30] This is a check on all the compliance requirements to see that they have been met. It takes into consideration such things as the frequency of monitoring, sampling locations, use of recognised laboratories, and appropriateness of corrective actions if they have been required.

(see section 12). ESR prepares the *Review* from the summary information; detailed monitoring data are not included in the *Review*.

ESR prepares a draft of the *Review* and circulates it to the Ministry of Health and public health units for comment. Public health units provide water suppliers with copies of the information relevant to their supply for this to be checked. Once all checking has been carried out and any corrections needed are made, the final version is provided to the Ministry of Health for publication.

11.3 Information collected for the *Review*

Electronic forms are used to collect compliance information for the survey. The following information is collected by the survey – it may be of assistance in implementing the NES.

1. *E. coli* compliance at the treatment plant:

    - type of disinfectant used
    - whether *E. coli* monitoring was undertaken
    - number of *E. coli* samples taken
    - number of samples containing *E. coli*, but not the *E. coli* concentrations
    - whether the source was a secure groundwater
    - whether the treatment plant was compliant with respect to *E. coli* (this will have taken account of the above information, and other compliance criteria).

2. Protozoa compliance at the treatment plant:

    - treatment processes used to protect against protozoa
    - details about the type of filtration used (if used)
    - details about UV maintenance and management (if used)
    - whether the treatment plant was compliant with respect to protozoa (this will have taken account of the above information, and other compliance criteria).

3. Priority 2 chemical contaminants

    The electronic form identifies the Priority 2 contaminants that have been assigned to each distribution zone and the treatment plants feeding that zone. (Many zones and treatment plants do not have Priority 2 contaminants assigned to them. See sections 3.4 and 8.1).

    The following information is collected for both the distribution zone and treatment plants for supplies to which Priority 2 contaminants have been assigned:

    - number of samples taken for each Priority 2 contaminant
    - number of samples in which the contaminant concentration was over 50% and up to 100% of the MAV

- number of samples in which the contaminant was more than 100% of the MAV
- maximum concentration of the contaminant found
- whether monitoring at the treatment plant or in the distribution zone was compliant with respect to each assigned Priority 2 contaminant (this will have taken account of the above information, and other compliance criteria).

11.4 Information contained within the *Review*

11.4.1 National Summary

The National Summary section of the *Review* identifies the key findings of the *Review*, discusses them and places them in the context of levels of compliance found in previous years, so that trends can be identified.

11.4.2 Summary statistics

National statistics and statistics for each local authority district are provided. These consider bacterial, protozoal and chemical compliance separately and within each of these categories statistics for local authority supplies, school supplies, and "other" supplies are provided. The numbers and percentages of water supply zones complying and the populations in these zones are presented, as are the reasons for non-compliance.

11.4.3 Supply-specific information

The summary statistics provide no detailed information about individual water supplies. Supply-specific information is contained in Appendix 1 of the *Review*. This appendix lists:

- all registered supplies[31] within each local authority district
- the population of each distribution zone
- whether the distribution zone complied with the DWSNZ with respect to bacteria (*E. coli*), and if not, the reasons for non-compliance
- whether there was compliance with respect to protozoa for all treatment plants supplying the zone
- the Priority 2 contaminants (chemical) for each distribution zone and any treatment plants supplying the zone, and whether there was compliance with respect to these contaminants
- any changes in compliance status from the previous year for both bacterial and chemical contaminants.

The specific information contained in the *Review*'s appendix is of limited use for establishing how well treatment plants performed with respect to micro-organisms, for the following reasons:

[31] These are the drinking water supplies recorded in the drinking water register maintained by the Chief Executive of the Ministry of Health.

- The bacterial compliance information relates to the distribution zone only, not the treatment plant. Treatment plant compliance information is gathered during the survey of water suppliers, but is not published[32].

- With respect to protozoa, the appendix records whether there was compliance for *all* treatment plants serving each zone. Where there is more than one treatment plant serving a zone, an entry of "non-compliant" does not provide any information about which treatment plants were compliant. Moreover, there is no information provided about the nature of the treatment processes.

The supply-specific information in the appendix is more valuable for determining how the treatment plant performed with respect to chemical contaminants. Only distribution zones with Priority 2 contaminants assigned to them are listed in the appendix (no monitoring is required for other zones). The compliance status of each Priority 2 contaminant assigned to the zone and to treatment plants feeding the zone is given. Non-compliance because of an MAV transgression is identified. One complication with the interpretation of chemical contaminant information arises when more than one treatment plant feeds a distribution zone. In this situation it is impossible to determine which source water is responsible for any Priority 2 contaminants assigned to the distribution zone.

Compliance information gathered by the survey but not published, is held by a number of organisations, and can be obtained from them. Local authorities hold information concerning their own water supplies and public health units hold the information for water supplies in their jurisdiction. ESR holds the information for all water supplies, and can provide compliance information for water supplies within a particular regional council's jurisdiction.

11.5 Availability of the *Review*

An electronic copy of the complete *Review* is available on the Ministry of Health website: www.moh.govt.nz/water.

[32] This information can be obtained from ESR: Water Programme, PO Box 29-181 Christchurch, 8540.

12 WATER INFORMATION NEW ZEALAND (WINZ)

12.1 Introduction

Water Information New Zealand (WINZ) is a national database developed by ESR for the Ministry of Health. It provides an up-to-date source of national water supply information required for drinking-water quality management, including the characteristics of supplies, public health grades, and compliance with the DWSNZ. Both permanent (location and details of the supply system) and transitory (compliance with DWSNZ and grading) data are stored in the database.

WINZ software is developed and maintained by the Water Information Systems group of ESR. The group distributes software up-dates to water suppliers, district health boards and other organisations that may be running WINZ. The group also maintains a website (www.drinkingwater.org.nz) where some of the information contained within WINZ and other general information about water supply management can be accessed.

12.2 WINZ and its use

Three levels of WINZ have been developed to meet the specific needs of different organisations involved in the management of drinking water supplies.

12.2.1 WINZ for water suppliers

Not all water suppliers use WINZ. Those that wish to, are provided with a version of WINZ that contains information relevant to their water supply only. From the supply-specific information, the software is able to calculate the monitoring requirements and to provide a suggested sampling schedule for the supply. Once monitoring data are generated, the water supplier can store it in WINZ and the software will determine the compliance status of the supply when sufficient information is available to do this. Events such as transgressions, and the actions taken in response to them, can be recorded and stored in WINZ. Warnings of the need to take corrective actions in the event of a transgression are generated by the software.

12.2.2 WINZ for district health boards

All district health boards use a version of WINZ that is essentially the same as that provided to the water suppliers, but with some additional functions. The database provided to individual suppliers contains information about their supply only; district health boards receive information about all supplies in their district.

For the preparation of the *Review*, the district health board collects compliance information from the water suppliers and uploads a summary of the information to National WINZ maintained by ESR. The collection of information from water suppliers may occur in one of three ways:

- The water supplier uploads raw monitoring data which is processed by the district health board to assess compliance.
- The water supplier processes its raw data to calculate compliance and uploads a summary of this to the district health board.

- The district health board collects raw monitoring data from water suppliers who are not using WINZ and enters this information into their WINZ database.

12.2.3 National WINZ

National WINZ is maintained by ESR on behalf of the Ministry of Health. It stores high-level information, rather than sample details, uploaded from public health units as well as supply details, public health grading information. The data stored within National WINZ is used for:

- the compilation of the Ministry of Health publications: *Register of Community Drinking-water Supplies and Suppliers in New Zealand*, and the *Review*
- analysis of water supply information to assist the Ministry of Health in policy development
- research requiring national level information about water supplies and compliance, or information about specific water supply systems eg, the treatment processes in use.

12.3 WINZ information relevant to NES implementation

Two types of information contained within WINZ will be relevant in implementing the National Environmental Standard. Drinking-water assessors in public health units are a useful first point of contact for obtaining and understanding information in WINZ about individual water supplies.

12.3.1 Supply details

When a water supply is registered, each component of the supply is given a unique identification code and some basic details about each supply component are stored in WINZ. For treatment plants, these details include the grid reference of the treatment plant, and the regional authority in whose territory the plant is located.

Details about treatment operations and treatment chemicals used at each treatment plant are also retained within WINZ. This information is gathered through the P2 Programme and the public health grading of supplies undertaken by the Ministry of Health through the public health units. The types of contaminants the treatment plant should be able to reduce in concentration, can be identified from knowledge of the treatment processes in use at the plant. Use of WINZ for this purpose should be as a first approximation only. A check should be made with the water supplier to confirm which processes are operational, and whether they can advise on the degree to which the treatment plant's existing processes will reduce the concentrations of expected contaminants.

12.3.2 Compliance information

Compliance information can help to establish how well a water supply's treatment plant is functioning, and therefore how well it will deal with the challenge of new contaminants or increased levels of existing contaminants. The *Review* has already been identified as a possible source of compliance information, but details about bacterial and protozoal compliance at the treatment plant in the *Review* are inadequate for assessing the effectiveness of the treatment plant. WINZ contains treatment plant compliance information that was not published in the *Review*. This information is available from the sources noted in the last paragraph of section 11.4.3.

12.4 Future developments

The next major step forward is the development of web-based WINZ. Use of this version of WINZ will require only a PC with a web browser and an internet link. No download of WINZ software will be needed.

All information presently held in National WINZ will in principle be accessible through the website, but the areas of the database available to an individual will depend on the level of access they have been given.

The web version of WINZ is under development at the time of preparing this guide: it will take over a year to make all the information currently available through individual access WINZ (PC-based) accessible through the web also.

APPENDIX 1 TERMINOLOGY IN THE DWSNZ

Some of the terms used in the DWSNZ are explained below, either because the word or phrase is not commonly used, or because an understanding of the term is important for implementation of the NES.

Community drinking water supply: Water supplies consist of the three components discussed before: source, treatment plant, and distribution system. Community water supplies are reticulated (ie, supplied by pipe networks) public- or privately owned water supplies 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)[33]. Supplies of fewer than 1500 person days a year can be registered as community supplies, but do not have to be. Community supplies are registered by public health units once they become aware of a supply's existence.

Determinand: A constituent or property of the water that is determined, or measured, in a sample. The reader may find the word "contaminant" easier to understand than "determinand", and this replacement is made in this guide. The word "determinand" is used in the DWSNZ to:

- allow a single term to be used to cover, microbiological, chemical, and radiological constituents, and physical properties of a water;
- to avoid the connotation of pollution of the water through the use of the term "contaminant", because many determinands are naturally-occurring and are not present because of pollution (eg, calcium).

Potable water: Water that is safe to drink because monitoring that meets the requirements of the DWSNZ has shown it not to contain any contaminants that exceed their MAV more frequently than is allowed by the DWSNZ.

Wholesome drinking water: This is water that has been shown to be potable, and in addition does not contain contaminants that make it taste, smell or appear unpleasant (the aesthetic properties of the water). Consumers readily identify problems with taste, smell or appearance of a water. Unless these water quality concerns are addressed, consumers may seek their own solution to obtaining acceptable water, which may result in their drinking palatable, but unsafe, water, eg, untreated water drawn from a spring that is not properly protected from pasture run-off.

[33] This definition may include a supply owned by an individual if that person supplies water to one or more other buildings they do not own. Water suppliers are self-suppliers when owning a water supply that is exclusively used to supply water to one property that they also own, or to one or more buildings they also own.

APPENDIX 2 TABLES A1.3 AND A1.4 FROM THE DWSNZ

Table A1.3: Allowable exceedances (for 95% confidence that the MAV is exceeded for no more than 5% of the time)

Exceedances	Number of samples
0	38–76
1	77–108
2	109–138
3	139–166
4	167–193
5	194–220
6	221–246
7	247–272
8	273–298
9	299–323
10	324–348

Table A1.4: Allowable exceedances (for 95% confidence that the MAV is exceeded for no more than 2% of the time)

Exceedances	Number of samples
0	95–193
1	194–274
2	275–349
3	350–420
4	421–489
5	490–556
6	557–621
7	622–686
8	687–750
9	751–813
10	814–875

The following may assist in interpretation of these tables. It is based on Table A1.3 which is appropriate for *E. coli* monitoring.

> *For a supply to comply with respect to* E. coli, E. coli *must not be detected (ie, there must be fewer than 1 organism per 100mL) in any sample if the total number of samples taken is no more than 76. If the number of samples taken is between 77 and 108 then* E. coli *may be detected in one sample. If the sample number is between 109 and 138 two samples may be positive for* E. coli*, and so on. Clearly, one positive sample is also acceptable if more than 108 samples have been taken.*