REVIEW OF THE PUBLIC HEALTH GRADING FRAMEWORK FOR WATER SUPPLIES: INCORPORATION OF PHRMP INFORMATION

Prepared as part of a Ministry of Health
contract for scientific services

by

Chris Nokes

2009

Client Report
FW09078

REVIEW OF THE PUBLIC HEALTH GRADING FRAMEWORK FOR WATER SUPPLIES: INCORPORATION OF PHRMP INFORMATION

Vivienne Smith
Water Programme Manager

Chris Nokes
Project Leader

Alan Ferguson and Jan Gregor
Peer Reviewers

ACKNOWLEDGMENTS
The author is grateful to those stakeholders who responded to the survey undertaken in 2008. He also wishes to thank Jan Gregor and Alan Ferguson (ESR) for peer reviewing the report, and Hilary Michie for her advice in improving the text.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

SUMMARY

The Ministry of Health has been encouraging water suppliers to prepare and implement public health risk management plans (PHRMPs) for their water supplies since 2001. With the enactment of the Health [Drinking Water] Amendment Act 2007, the implementation of a PHRMP has become a legal requirement for water suppliers.

Information about the level of risk to water supplies and how well this risk is managed is required for the public health grading of water supplies. The purpose of the grading of water supplies is stated to be (MoH, 2003):

> "to provide a public statement of the extent to which a community drinking-water supply achieves and can ensure, a consistently safe wholesome product".

The grading of a water supply needs to take account of information regarding the quality of water in a supply and the degree of risk to the water quality. Previously, the information on which the grading was based was gathered through grading questionnaires. As PHRMPs document risk information about a supply, the ministry is considering how information from PHRMPs can be introduced into the grading.

Phase 1 of this initiative examined the extent to which the present grading framework is achieving its purpose (ESR technical report to MoH FW07100). This report is the output of Phase 2 of the initiative. It presents the results of a 2008 survey of water supply stakeholders aimed at gathering opinions on factors influencing the design of a new framework.

The results of the survey made clear the general views on some factors that need to be taken into account when revising the grading. However, for some design criteria the preference was less clear-cut. From this it was apparent that several framework models needed to be presented as the starting point for a grading revision which would allow PHRMP incorporation.

Three framework models have been prepared, each placing emphasis on different design features. The key features of each model are as follows:

a) Model 1

- It is based on the logic supporting the Ministry's PHRMP preparation framework (MoH, 2001), so that where possible, risk is evaluated from consequence and likelihood;
- Risk assessment and water quality (compliance) information are kept separate until the final step of grade determination, so that the contribution of each to the final grade is clear;
- Information about preventive measures contained within PHRMPs is used;
- Tables are used extensively to establish levels of likelihood and consequence for hazardous events;

- A source-treatment plant grade is determined for each of four contaminant classes (bacteria/virus, protozoa, chemicals, cyanobacteria) and a final source-treatment plant grade determined from them;
- Seven hazardous events, considered generic to all distribution zones, are explicitly identified and used to determine the distribution zone grade;
- While more complex than the existing (2003) framework in some respects, it should provide a more accurate assessment of risk.

b) Model 2

- It retains as much of the existing grading framework as possible;
- The source-treatment plant grade questionnaires and grading tables are retained, but are slightly modified, to accommodate information from the PHRMP;
- Information about the adequacy of preventive measures contained within the PHRMP is required;
- The seven key hazardous events identified in Model 1 as the basis for the distribution zone grading are also used in this model;
- Demerit points are used to evaluate the distribution zone grade;
- The demerit points are assigned to try to reflect the weighting given to them in the existing framework;

c) Model 3

- It is designed to be as simple as possible;
- Grades are determined using decision trees;
- Only the status of the PHRMP (whether approved and implemented) is taken into account, except in the distribution zone grade determination when the adequacy of five specific barriers or preventive measures is required;
- The influence on the grade of both the PHRMP status, and the compliance status of the supply with respect to *Escherichia coli*, protozoa and overall compliance, is clear from the decision trees.

The grading is not a statement solely about water quality or about risk. It draws on both types of information to achieve its purpose. The challenge is how best to convey this combined role to the layperson. By providing an interpretation that says something about the quality of the water and how well the risk is managed, the layperson may develop a better understanding of what the grade is conveying about the water supply.

From knowledge of the PHRMP information the grading will use, and an understanding of how the grading uses the information, drinking-water assessors (DWAs) will become aware of key hazardous events that approved PHRMPs need to address.

Where to next?

The model frameworks presented here are a starting point. The results of the stakeholder survey guided their design, but there was no direct input into the model design from stakeholders who will have to work with the grading.

If plans for grading revision are to proceed, the suggested next step is to refine the models by consulting with a small group of water suppliers (or consultants who work closely with them) and drinking water assessors. This process may reject some models altogether, and possibly create a hybrid from the best features of two or three of the models. The refined models resulting from this consultation can then be presented to the wider group of stakeholders.

1 INTRODUCTION

The Health [Drinking Water] Amendment Act 2007 (HDWAA) requires water suppliers to prepare and implement public health risk management plans (PHRMPs). This requirement is to be phased in over several years and the date at which it takes effect will be determined by the size of the supply. Eventually, all networked and bulk water suppliers, and any other supplier who registers voluntarily, will have a document specifying how they manage the risks to their supply.

Information about the level of risk to water supplies and how well this risk is managed is required for the public health grading of water supplies. The purpose of the grading, as stated in 2003 (MoH, 2003), is:

> *to provide a public statement of the extent to which a community drinking-water supply achieves and can ensure, a consistently safe wholesome product*.

Water quality information, expressed in terms of a water supply's compliance status, shows how well a supply *achieves* the production of safe water. Risk information shows whether the supply can *ensure* the production of safe water.

Until now, information about the risks to a water supply and their management has been gathered for grading through a suite of questionnaires. The requirement for water supplies to produce PHRMPs potentially provides a more detailed and reliable source of risk information for use in grading.

The Ministry of Health (MoH) is investigating how PHRMPs can be incorporated into a grading framework. Phase One of this process evaluated how well the existing 2003 grading framework is achieving the grading's purpose. This evaluation was presented in an ESR report to the MoH in 2007 (Report no. FW07100)[1]. The report did not contain recommendations for the way in which PHRMPs might be incorporated into the grading. After comparing the 2003 grading framework with a model framework aligned with the framework developed by the MoH for preparing PHRMPs, the report concluded that:

> *The 2003 PHG* [public health grading] *framework works under the constraints of needing to be simple and practicable, and compresses a potentially large and complex set of information into two letters. To achieve this, it sacrifices the accurate (qualitative) assessment of the likelihood of contamination which is needed to achieve the purpose of the grading. The introduction of PHRMPs, or the information they collect, into the grading framework may help to address some of the difficulties identified by this comparison with the model framework.*

Phase Two of the process started with a survey, in 2008, of water supply stakeholders. The survey canvassed stakeholder opinion on factors potentially influencing the design of a revised grading framework. The second part of Phase Two has developed three model grading frameworks. These provide examples of the different ways in which PHRMPs might be incorporated into the grading process.

[1] A brief history of the development of the public health grading is given in FW07100.

In considering the three frameworks, the reader should focus on the principles on which each model is based. Identifying the desirable features of each framework will assist in establishing which framework is preferable, or guide the design of a hybrid framework drawing on the best features of more than one model.

This report summarises the findings of the survey, sets out how the three frameworks would work and identifies the pros and cons of each, and is the output from Phase Two. Tables and diagrams that would be required for the operation of each framework have been drafted, but a set of notes to guide their use has not been developed as they are considered prototypes.

A feature common to all three frameworks is that the distribution zone grade is evaluated separately from the source-treatment plant grade. Put another way, contaminants in the water leaving the treatment plant are not assumed to add to the risk to water quality in the distribution zone. This does not reflect physical reality, but it avoids water supplies being penalised twice for poor risk management at the source and in the treatment plant. This follows the existing framework. The worse of the two grades offers the best assessment of a water supply's ability to provide consistently safe water.

The discussion of the report focuses on the evaluation of the risk component for the grading; determination of compliance is set out in the *Drinking-water Standards for New Zealand* (DWSNZ).

2 STAKEHOLDER VIEWS – THE 2008 SURVEY

2.1 Introduction

In 2001 water supply stakeholders were surveyed to determine their views on the grading and the incorporation of public health risk management plans (PHRMPs) into the public health grading. Since then, water suppliers, drinking water assessors (DWAs) and consultants have gained experience in the development, approval and implementation of PHRMPs. The views held on PHRMPs and their relationship to the grading may have changed with the experience gained in PHRMP preparation and in light of the enactment of the HDWAA. To update our understanding of stakeholder views, a new survey was undertaken in March 2008.

The questionnaire was despatched to DWAs with a request that they distribute it to water suppliers providing water to more than 500 people in their jurisdictions. It was also sent to other stakeholders (primarily consultants) who had provided comment to the Ministry of Health on the *Drinking-water Standards for New Zealand* (DWSNZ 2005). Thirty responses to the survey were received: 18 from water suppliers; ten from DWAs and two from consultants.

Appendix 1 contains the questionnaire and a summary of the responses. The key points arising from the survey are recorded in Section 2.2.

2.2 The survey's key findings

The following is a summary, with comments, of the opinions expressed in the survey:

- A little under half of the water suppliers who responded had developed approved PHRMPs at the time of the survey, indicating that there was limited experience in preparing PHRMPs.
- The great majority of water suppliers were responsible for supplies that had been graded using the 2003 grading framework, and hence were in a position to comment on the 2003 framework.
- Despite the enactment of the HDWAA, and its requirement for the preparation of PHRMPs, a need for the grading was still seen.
- The purpose of the grading was still regarded as satisfactory.
- Respondents strongly supported the incorporation of water quality information (compliance status) into the grading.
- The majority of respondents considered that the 2003 grading framework does not satisfactorily assess risk. This could reflect the shortcomings of the framework, but it is probably also a consequence of the fact that the grading is not intended to be only an indicator of risk to water quality.
- The great majority of water suppliers supported the proposal of using PHRMPs in some way to determine the grade. There was a split over whether risk information from other sources should be used. A comment was made that the public sees the grade as an indicator of water quality, and that they do not

understand the risk component. Reconsideration of how grades are explained may assist with this.

- There were differing opinions over the level of detail from the PHRMP that should be used in determining the grade.
- There was unanimous support for the factors leading to the grade being clear.
- There was little support for decreasing the number of questions used to collect information on which to base the grade.
- The general preference was for the risk assessment undertaken for the grading to be accurate and simple. However, if the grading cannot be both, an accurate, more complex framework was preferred over a simple, poor assessment of risk.
- Respondents considered a simple representation of the grade to be important.
- There was a range of feelings over whether the existing grading system should be retained *in toto*, with PHRMP information being added to it.
- A range of opinions was also expressed over the value of the existing questionnaires.
- A majority were in favour of retaining a demerit points scoring system, despite the general agreement that a scientific justification for the assignment of the scores is problematic.
- The majority favoured, or were neutral concerning, the use of tables in the grading, such as those presently used to derive the source-treatment plant grade.
- There was general agreement that the notes for the grading are very important and that they need to set out objective criteria for answering the questions.

2.3 Summary

Water supply stakeholders still regard the grading, which communicates information about the ability of a water supply to provide safe water, as an important tool. Further, there is clear interest in having PHRMPs involved in determining a water supply's grade.

The survey yields clear messages concerning some factors that need to be considered in developing a grading framework. However, there are many other factors, important in the design of a framework, on which opinion is divided. Given the lack of clear guidance on some of these design factors, the proposed framework models have been created with markedly different approaches to grade determination. Each shows the consequences of designing the framework giving emphasis to particular design factors.

3 MODEL 1 GRADING FRAMEWORK

3.1 Introduction

Model 1 aims to base the logic of the grading framework on that used in the ministry's approach to the development of PHRMPs (MoH, 2001). It evaluates risk through explicit consideration of likelihood and consequences. In doing so, it departs from the approach presently used.

The compliance status of the water supply is also taken into account in the model. The risk and compliance components are brought together as two separate factors to establish the grade. This makes clear the role each component plays in determining the grade.

Compliance shows whether the supply is providing safe water, and the assessment of the level of risk to the water quality provided to consumers is an indicator of how reliably the water quality can be maintained. This provides the basis for the approach in determining the grade.

As with the existing grading, accompanying notes would be vital to the functioning of the framework and ensuring consistency in the grade derivation.

In most parts of the framework, information already obtained through routine compliance assessment, or PRHMP preparation, approval and implementation, has been used to avoid duplication of effort and disagreement over the factors determining the grade.

3.2 Source-treatment plant grading

3.2.1 Introduction

The nature of the risks associated with the source and treatment plant of a water supply depends on the sources of contamination in the catchment and the treatment processes in operation at the supply. Further, different contaminants present potentially different levels of risk to the supply. To provide the flexibility needed to accommodate the different types of risk, the source-treatment plant grading assesses the risk associated with four classes of contaminants (to match the types of compliance established in the DWSNZ 2005). These classes are:

- Bacteria/viruses
- Protozoa
- Chemicals
- Cyanotoxins

Differentiation of these classes will allow the water supplier to see the importance of each in influencing the overall grade. Where a supply's PHRMP has identified a shortcoming in managing the risk associated with a particular contaminant class, this should be reflected in the supply's grade.

At present, the DWSNZ 2005 do not have separate compliance criteria for viruses. Bacteria and viruses are included in the same class in Model 1 because chlorine which is effective against bacteria, is also effective against some viruses. Should compliance criteria with respect to viruses be included in the next edition of the DWSNZ, the Model 1 framework could accommodate this by separating the proposed "Bacteria/viruses" contaminant class into two separate classes.

3.2.2 Overview

Fig.3.1 depicts the conceptual basis for the source-treatment plant grading.

The risk to the quality of the water leaving the treatment plant is determined by evaluating:

- the levels of contaminants entering the treatment plant;
- the capacity of the treatment processes to remove the contaminants; and,
- the likelihood of the treatment processes failing.

The risk and the compliance status of the treatment plant are then used to obtain the source-treatment plant grade.

A grade for each contaminant class is obtained using this process before a final overall source-treatment plant grade is determined.

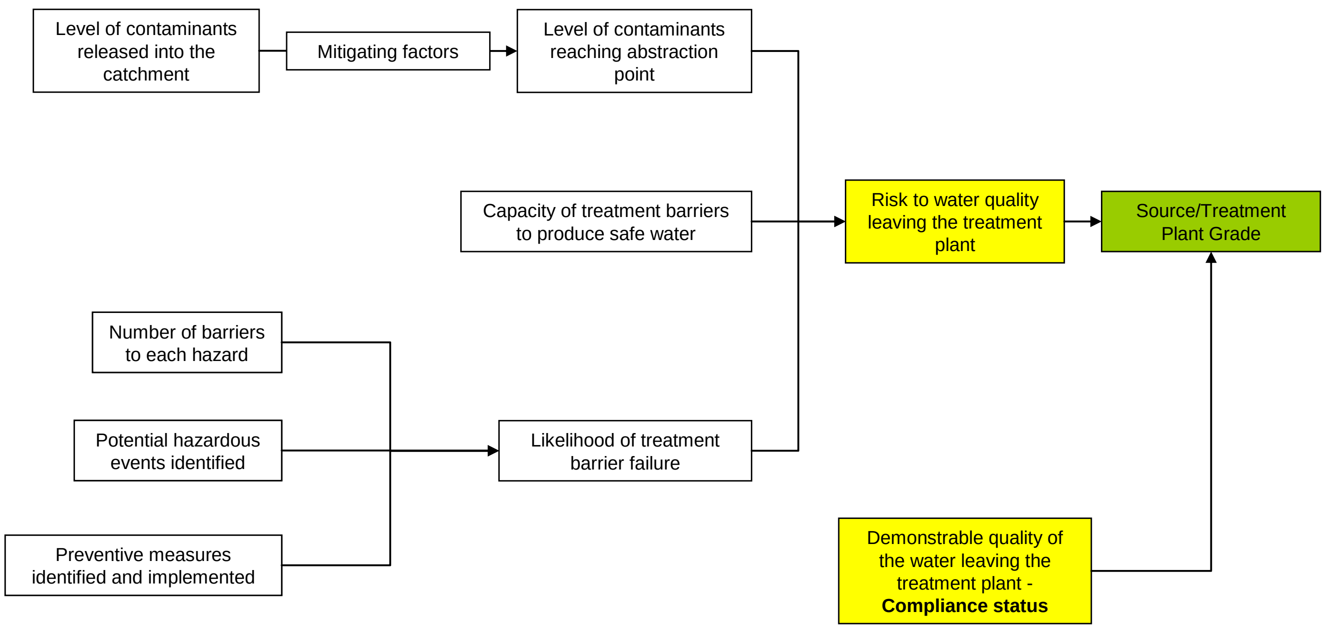


Fig. 3.1 Conceptual basis for the source-treatment plant grading - Model 1

3.2.3 Contaminant levels in source water

An estimate of the contaminant levels in the source water allows an indication of the consequences for the quality of water leaving the treatment plant to be assessed should there be treatment failure. The risk to the water quality increases with increasing contaminant levels in the source water.

Diagrams for classifying contaminant levels are given Appendix 2. The levels of microbiological contaminants (bacteria/viruses and protozoa) at the abstraction point are based on the protozoal risk categories given in Table 5.1a of the DWSNZ:2005. (A *High* level of contamination equates to 5 log credits; *Moderate* to 4 log; *Low* to 3 log; *Very Low* to 2 log; and *Extremely Low* level to 0 log credits.)

The situation is potentially more complex for chemicals. The concentrations of several chemicals may contribute to the chemical quality of the water, each requiring specialised treatment. The only chemicals of potential concern with regard to the safety of the water are those that have been found at concentrations exceeding 50% of their maximum allowable value (MAV). In supplies serving more than 500 people, these will likely have been assigned to the supply as P2 determinands[2]. The level of contaminant in the water is therefore based on what has been determined from P2 monitoring. A precautionary approach is taken with regard to assigned P2 determinands that have been inadequately monitored, i.e., they are assumed to be present in the water at concentrations in excess of their MAV until evidence to the contrary is provided. When a supply has more than one P2 determinand assigned to it, the risk to the chemical quality of the water is taken as the greatest of the risk levels determined for each determinand.

Disinfection by-products (DBPs) are P2 determinands in many chlorinated water supplies. These determinands will not be found in the source water. However, their assignation to the distribution zone as P2 determinands indicates the presence of their precursors in the source water and the need for treatment processes capable of reducing the precursor concentrations.

Cyanotoxins are chemical determinands, but the protocol by which they are assigned as P2 determinands is different from other chemicals. Classification of the potential levels of cyanotoxins in the source water is based on a mix of monitoring results, history of bloom development, the nature of land use in the catchment and actions taken prior to abstraction to limit bloom formation.

3.2.4 Treatment barrier capacity

To produce safe water, a process, or processes, capable of reducing a contaminant's concentration in the source water to a satisfactory level water must be in place. The likelihood of producing safe water is low if the treatment processes do not meet this requirement no matter what preventive measures are in place to protect against process failure.

The proposed criteria for determining whether the treatment barriers can remove contaminants to a safe level are given in Appendix 3.

3.2.5 Likelihood of barrier failure

Evaluation of the likelihood of treatment barrier failure is the point in the framework at which information from the PHRMPs is needed. There are three components to evaluating this likelihood:

a) the number of barriers to each class of contaminant;

[2] Metals originally assigned as P2 determinands but which arise from corrosion should have been reassigned as P3 determinands once monitoring has confirmed their origin. Metals derived from corrosion of the reticulation network or residential plumbing should not be included in this evaluation.

b) identification of potential hazardous events by the PHRMP – possible causes of treatment process failure must be identified before they can be managed;

c) implementation of preventive measures in the PHRMP to limit the likelihood of the hazardous events occurring.

Component a) is included because of the reduced risk to water quality if more than one barrier to a contaminant class is present. More than one barrier to a particular contaminant class will also assist in reducing the concentration of the contaminant in the water. Making implementation of the multiple-barrier principle explicit in the grading may encourage water suppliers to give consideration to this principle if they have not already done so.

Combinations of processes that can be considered as constituting more than one barrier to a particular class of contaminant are listed in Appendix 4

Table 3.1 provides the basis for classifying the likelihood of barrier failure. Hazardous events and their associated preventive measures are not specified. It is assumed that an approved and implemented PHRMP will have identified at least the key hazardous events and their preventive measures. [Key events may have to be explicitly identified in the grading notes, as is done for distribution zones (see Table 3.4), to help maintain consistency. This can be done if wider consultation indicates it is necessary].

In addition to the information obtained from the PHRMP, there is a third question (in Table 3.1) to be answered seeking more general risk management information:

> Is the overall management of risk to source waters and treatment barriers satisfactory?

This question allows supervision and training (already in the existing grading) to be included, as well as requirements of the HDWAA. To answer "Yes" to this question, ALL the following statements must be true:

a) The water supplier is taking reasonable steps to contribute to the protection of the source water(s) feeding this treatment plant (Section 69U of the HDWAA);

b) The water supplier is keeping records that meet the requirements of Section 69ZD of the HDWAA;

c) The level of supervision of the treatment plant is appropriate;

d) The level of training of staff at the treatment plant is appropriate.

The relative importance of the combinations of the three factors in Table 3.1 can be modified following wider consultation if necessary.

The approach presented condenses a substantial amount of information regarding the preventive measures into a "Yes/No" answer. It is the *key* preventive measures for each key hazardous event that are expected to be in place for a "Yes" to be recorded. Key preventive measures for the possible hazardous events appropriate to a given supply will have been checked by the DWA in approving the PHRMP. Consequently, a "Yes" response should follow automatically from an approved PHRMP.

The grading should take account of risks to water quality *at the time the grade is being assessed*. Therefore, when the grade is being determined, only preventive measures that have been implemented should be considered. This includes temporary measures in place to deal with the hazardous event until the permanent measure(s) can be implemented.

As noted in Appendix 4, situations where multiple barriers exist at the treatment plant for chemical contaminants are rare. Provided there is at least one barrier for a chemical contaminant in place, a "Yes" response may be given to this question for chemicals.

Table 3.1 Derivation of the likelihood of barrier failure - Model 1

Factors influencing likelihood of barrier failure	**Response**				
Is more than one barrier effective against the contaminant class?	Yes	No	Yes/No	Yes/No	Yes/No
Are preventive measures in place for key hazardous events associated with the treatment processes?	Yes	Yes	Yes	No	No
Is the overall management of risk to source waters and treatment barriers satisfactory?	Yes	Yes	No	Yes	No
Likelihood of barriers to contaminant class failing	**Extremely Low**	**Very Low**	**Low**	**Moderate**	**High**

3.2.6 Risk to water quality

Three factors discussed above are taken into account in assessing the risk to the water quality leaving the treatment plant, i.e.:

a) The contaminant levels in the water being abstracted by the treatment plant (Section 3.2.3);

b) The capacity of the treatment plant barriers to provide safe water (Section 3.2.4);

c) The likelihood of treatment-barrier failure (Section 3.2.5).

Table 3.2 provides the matrix that determines the risk to drinking-water quality from the raw water quality (consequence) and the likelihood of barrier failure. The likelihood values from *Extremely Low* to *Moderate* are assigned to treatment plants in which the treatment processes have the capacity to produce safe water from the source water. Although a treatment plant may have the necessary capacity, the likelihood of it consistently providing safe water depends on how well the risk to treatment operations is managed. The assignment of a treatment plant to one of these classes is discussed in Section 3.2.5, and depends on the supply's PHRMP.

The *High* likelihood value may apply to a treatment plant in which the treatment capacity is adequate but risk management is very poor, or a system in which the treatment capacity is inadequate or there is no treatment.

<table>
<tr><td rowspan="2"></td><td colspan="4">Treatment processes have sufficient capacity</td><td>No treatment or treatment capacity inadequate</td></tr>
<tr><td colspan="5">Likelihood of treatment barrier failure (from Table 3.1)</td></tr>
<tr><td>Level of contaminant in source water (from Appendix 2)</td><td>Extremely Low</td><td>Very Low</td><td>Low</td><td>Moderate</td><td>High</td></tr>
<tr><td>Extremely Low</td><td colspan="5">Extremely Low</td></tr>
<tr><td>Very Low</td><td colspan="2">Extremely Low</td><td>Very Low</td><td>Low</td><td>Moderate</td></tr>
<tr><td>Low</td><td rowspan="3"></td><td>Very Low</td><td>Low</td><td>Moderate</td><td></td></tr>
<tr><td>Moderate</td><td rowspan="2">Low</td><td rowspan="2">Moderate</td><td colspan="2" rowspan="2">High</td></tr>
<tr><td>High</td></tr>
</table>

Table 3.2 Matrix to assess the risk to drinking-water quality leaving the treatment plant – Model 1

As discussed later, the ability of a treatment plant to obtain an "A" grade depends on its ability to achieve an *Extremely Low* or *Very Low*, risk rating. The risk to treated water quality is rated as *Extremely Low* in three situations:

a) the source water has an *Extremely Low* level of contaminant, e.g. a secure groundwater, irrespective of the level of treatment and how well risk to the treatment is managed—the water quality is already excellent.

b) there is an *Extremely Low* likelihood of a treatment barrier failure, irrespective of the quality of the source water, which ensures that large sophisticated treatment plants are not penalised because of the quality of their source water.

c) Both the likelihood of barrier failure and the level of contaminants in the source water are *Very Low*.

3.2.7 Compliance

Each year ESR surveys all registered water suppliers to collect information for assessing their compliance with respect to the DWSNZ. The survey determines the compliance status for bacteria (*Escherichia coli*), protozoa and chemicals, and these can be used to determine the annual grade. The compliance status with respect to cyanotoxins is not presently determined, but as discussed later, this does not affect the framework's ability to make a grade assessment.

3.2.8 The source-treatment plant grade

Two factors determine the source-treatment plant grade for a particular contaminant class (see Fig. 3.1):

a) The compliance status of the treatment plant with respect to the DWSNZ;

b) The risk to water quality leaving the treatment plant.

The compliance status provides evidence that the water quality has met the MAVs (requirements of the DWSNZ) *at the time that samples were taken* (with the exception of the protozoa for which compliance is not based on protozoa monitoring). The level of risk to the water quality indicates the likelihood that the water quality will have been satisfactory during the periods when direct measurement of water quality were not made. Assuming the risk assessment is accurate, the match between the water quality expected from risk assessment and the actual water quality should improve with increasing sampling frequency. Table 3.3 sets out how compliance and risk are combined to yield a grade for each of the four contaminant classes.

Compliance with the DWSNZ alone is insufficient to establish a high grade; low risk to the water quality must also be demonstrated. Indeed, if the risk to water quality is assessed to be high despite the treatment plant being in compliance with the DWSNZ, it is reasonable to assign a "failing" source-treatment plant grade ("D"). Such a situation could arise when the monitoring frequency is low (small population). With few samples taken during a year, there is a greater likelihood that a MAV exceedence will go undetected. The level of risk associated with the source-treatment plant combination then provides a more reliable indication of how consistent provision of safe water will be. This is also true when the P2 determinands for a supply have not been identified.

This approach to the incorporation of the compliance status into the grade is different from that in the existing grading, where compliance and risk are not maintained as two explicitly separate components.

Once a source-treatment plant grade has been determined for each contaminant class, an overall source-treatment plant grade has to be derived.

Use of the lowest grade of the four contaminant classes as the overall grade is a simple approach but unsatisfactory because it does not recognise that there are differences in health significance between the contaminant classes. Table 3.4 shows how the overall grade might be obtained by providing less weight to the chemical grade.

Compliance with respect to cyanotoxins may not be available for all water supplies. Table 3.4 allows an overall source-treatment plant grade to be determined, but ignoring the Cyanotoxins column, and determining the grade from the remaining grades.

In summary, Table 3.4 requires all contaminant classes to achieve an "A" grade for an overall "A" Grade. The other overall grades are defined by, the lowest grade obtained for the bacteria/viruses, protozoa and cyanotoxins. In the present grading a "C" grade can be achieved without P2 compliance. This is reflected in Table 3.4 by allowing an overall "C" grade despite the "E" Chemical grade.

Table 3.3 Grade derivation from DWSNZ compliance status and risk to the quality of the water leaving the treatment plant, for a contaminant class – Model 1

	Risk to water quality leaving the treatment plant (from Table 3.2)				
DWSNZ Compliance status	*Extremely Low*	*Very Low*	*Low*	*Moderate*	*High*
Compliant (Demonstrated to be supplying safe water when monitored)	**A**	**A**	**B**	**C**	**D**
Non-compliant (Demonstrated NOT to be supplying safe water when monitored, or inadequately monitored so that safety cannot be demonstrated)	**C***	**C***	**D**	**D**	**E**

* The "C" grade for a non-compliant supply is suggested to allow for situations in which a procedural problem with the monitoring has resulted in non-compliance, e.g. a day too many between samples being taken.

Table 3.4 Derivation of the overall grade from the individual contaminant class grades – Model 1

To obtain an overall grade of	**The minimum contaminant class grades are**			
	Bacteria/Viruses	*Protozoa*	*Cyanotoxins*	*Chemicals*
A	**A**	**A**	**A**	**A**
B	**B**	**B**	**B**	**C**
C	**C**	**C**	**C**	**E**
D	**D**	**D**	**D**	
E	**E**	**E**	**E**	

3.3 Distribution zone grading

3.3.1 Introduction

The distribution zone grade is derived from the risk to water quality and the compliance status of the distribution zone. Likelihood and consequence are used to determine risk, although the detail of the approach is different from that used for deriving the source-treatment plant grade. The different approach was taken for the following reasons:

a) Hazardous events are generic to all distribution zones (perhaps with minor exceptions); a much greater variety of hazardous events is possible in the source-treatment plant combination.

b) Chemical or microbiological determinands, or both, may enter the distribution zone as the result of most hazardous events, making it difficult to assess risk separately for the different contaminant classes considered for the source-treatment plant grading.

A consequence of b) is that a separate distribution zone grade is not determined for each of the four separate contaminant classes. Contaminants in the distribution zone are generic.

3.3.2 Overview

Fig.3.2 shows the information components used in the distribution zone grading.

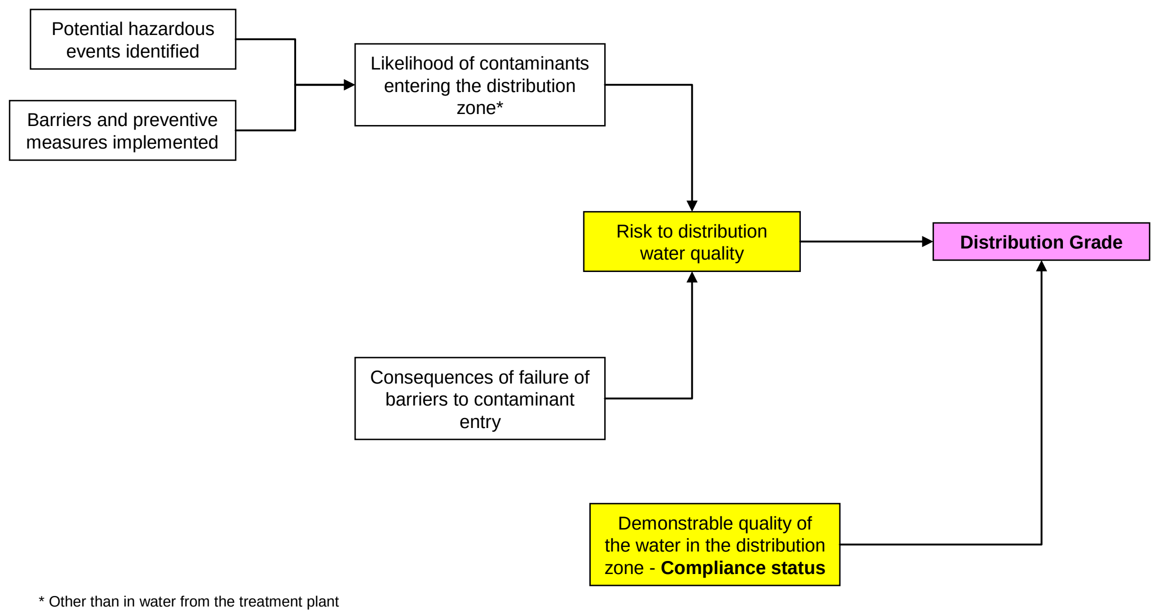


Fig. 3.2 Overview of the distribution zone grading framework - Model 1

3.3.3 Likelihood of contaminants entering the distribution zone

The factors to be considered in making this evaluation are:

- the key hazardous events;

- key barriers to these events, and
- the preventive measures that have been put in place to minimise the likelihood the barriers failing.

This information comes from the supply's PHRMP.

Table 3.5 Key barriers to be in place for the key hazardous events – Model 1

Key Hazardous Events	Key Barriers
Contamination through **backflow/cross-connection**	• Maintenance of adequate mains pressure • Installation of backflow prevention devices (BPD) at appropriate locations
Contamination through **leaky pipes**	• Maintenance of adequate mains pressure • Implemented network maintenance programme
Contaminant introduction during **network maintenance and repairs**	• Implemented Code of Practice for pipe repair and maintenance
Contaminant entry into **storage facilities**[1]	• Facilities covered • Grills over air vents to stop animal intrusion • Security of access to the facility • Adequate turnover • Implemented regular facility inspection and maintenance programme
Contaminant entry through **fire hydrants**	• Use of appropriate hydrant types
Biofilm development which protects pathogens	• Maintenance of an adequate chlorine residual • Implemented programme for regular pigging and flushing
Microbial contaminant entry into the distribution zone[2]	• Maintenance of an adequate chlorine residual

[1] Storage capacity is not included as a key barrier to contaminant entry into the storage facility. It should be considered as a preventive measure against the failure of "Maintenance of adequate mains pressure" where this is a key barrier.

[2] This is not a true hazardous event, it is the consequence of an event. Neither is the maintenance of a chlorine residual a barrier to contaminant entry, it is a measure to control the consequences of an event. However, it is important action in reducing the likelihood of microbiologically unsafe water in the distribution zone, and is therefore included.

To assist in maintaining national consistency, generic key hazardous events are identified in Table 3.5. Also contained in this table are the barriers considered necessary to minimise the likelihood of these events. Details of the preventive measures that must be implemented to minimise the likelihood of barrier failure are not specified, except for supervision, which must be adequate for the suite of preventive measures to be considered adequate. It is left to the DWA, through the PHRMP assessment process, to determine whether the preventive measures put in place by the PHRMP are adequate. This provides flexibility to suit the conditions of the particular supply.

The maintenance of an adequate chlorine residual is something that needs to be included in evaluating the risk to the water quality. It is not strictly a barrier to contaminant entry into the distribution zone; it is a "backstop" that affords some protection in the event of other barriers failing. See the notes below Tables 3.5 and 3.6.

Broader consultation will help to establish whether all key hazardous events have been identified.

Table 3.6 Derivation of descriptors for the likelihood of contaminants entering the distribution zone – Model 1

Are all key barriers in place for the hazardous event being considered*?	Are preventive measures adequate?	Likelihood of contaminants entering the distribution zone
Yes	Yes	Extremely Low
	No	Low
No	Yes	Moderate
	No	High

* A distribution zone without a chlorine residual can answer "Yes" to this question and receive a "Low" likelihood rating, provided the frequency at which *E. coli* sampling is undertaken exceeds the requirements of the DWSNZ by 50%.

Table 3.6 defines how the descriptors for likelihood are reached. The rationale for the table is as follows:

- A system that has all key barriers against a particular hazardous event and adequate preventive measures in place to minimise the likelihood of the event occurring has an extremely low likelihood of contaminants entering the distribution zone as a result of the event.

- Any other system will be substantially more vulnerable to the specified hazardous event.

- A system with all barriers in place, but having inadequate preventive measures is less likely to suffer contaminant entry than one in which at least one barrier is missing, even if the preventive measures are adequate for the other barriers.

Barriers need to be present continuously. Inadequate preventive measures only become apparent when a barrier fails.

- A system that is missing barriers and also has inadequate preventive measures protecting those barriers is the most likely to experience contamination.

Table 3.6 is used to derive the likelihood for contaminant entry for each hazardous event listed in Table 3.5.

3.3.4 Consequences of barrier failure to contaminant entry

One of the factors not accounted for in the present grading system is the differing degrees to which barriers to contaminant entry are challenged. For instance, the risk to water quality arising from system pressure loss is greater in a distribution system with a high percentage of connections to industrial operations than one with a low percentage of such connections. This factor needs to be taken into account when assessing the risk to water quality in the distribution zone.

Several factors can influence the consequences of an event, including the nature of the contaminant, its concentration and event duration. Obtaining an estimate of these, even a qualitative one, can be difficult without creating unwanted additional complexity.

With the exception of biofilm development (and microbial contaminant entry), which is primarily a source of microbiological contaminants, the key hazardous events identified in Table 3.5 can be sources of microbiological or chemical contaminants. Therefore, the relative severity of the consequences cannot readily be distinguished based on the nature of the contaminants. Event duration is specific to the particular incident and cannot be generalised for the grading, and there is no easy means by which contaminant concentration can be assessed.

The most accessible means of evaluating the consequence of a barrier failure is the number of locations, or frequency, at which the event could occur, or has been found to occur. These give a qualitative measure of the amount of a contaminant that might enter the system should a barrier fail. For example, the potential consequences of pressure failure increase as the number of industrial connections increases.

Initial suggestions for assessing consequence for the hazardous events are set out in Table 3.7. Where possible, these have been aligned with the criteria used in Q13 of the existing distribution zone grading. Suggestions, from consultation, for alternative or improved metrics for evaluating consequence could be incorporated, as could more appropriate criteria for distinguishing the consequence descriptors for each event.

Some suggested metrics in Table 3.8 are linked to the size of the water supply. Large water suppliers may consider that they are being penalised because of their size. However, provided they have the necessary preventive measures in place, the risk to their distribution system will be determined to be “extremely low” (see Section 3.3.5).

Table 3.7 Criteria for distinguishing consequence descriptors – Model 1

Key Hazardous Events	Measure of amount of contaminant that could potentially enter the distribution zone	Consequence Descriptor
Backflow/Cross-connection	Percentage of connections that are industrial or agricultural is less than 5%	Minor
	Percentage of connections that are industrial or agricultural is 6-20%	Moderate
	Percentage of connections that are industrial or agricultural is greater than 20%	Substantial
Leaking pipes	Water loss less than 15%, or length of pipe in the network less than ?? km	Minor
	Water loss 15-25%, or length of pipe in the network ?? - ??km	Moderate
	Water loss more than 25%, or length of pipe in the network more than ?? km	Substantial
Network maintenance and repairs	Repair and maintenance jobs undertaken per year less than ?? per km of pipe	Minor
	Repair and maintenance jobs undertaken per year ?? - ?? per km of pipe	Moderate
	Repair and maintenance jobs undertaken per year more than ?? per km of pipe	Substantial
Storage facilities	Number of storage facilities linked to the network less than ?? per km of pipe	Minor
	Number of storage facilities linked to the network ?? - ?? per km of pipe	Moderate
	Number of storage facilities linked to the network more than ?? per km of pipe	Substantial
Fire hydrants	No ball hydrants in the system	Minor
	Some ball hydrants	Substantial
Biofilms	Regular flushing or pigging, or monitoring shows pipes are kept clear	Minor
	Limited flushing or pigging	Moderate
	No flushing or pigging undertaken during the year	Substantial
Microbial contamination of distribution zone	FAC at least 0.2 mg/L to the farthest end of the distribution zone, and median turbidity less than 1 NTU.	Minor
	E. coli monitoring increased to 150% of that required by the DWSNZ.	Moderate
	No, or inadequate, FAC residual and monitoring not increased by 50% of DWSNZ requirements	Substantial

Notes:

General: Question marks denote values for metrics that will need to be determined through consultation with water suppliers and other stakeholders.

1. **Leaking pipes** – Where water loss data are unavailable, the length of pipe in the network could be used as a metric, on the assumption that one of the factors influencing the amount of loss is the length or pipe from which leakage could occur.

2. **Maintenance and repairs** – Each time a system is opened for repair or maintenance there is the possibility of contaminant introduction. This is the rationale for using the number of repairs as the metric for consequence. While this could be regarded as creating a disincentive for maintenance, provided the risk associated with the activity is well managed, the risk, as determined by Table 3.8, will still be acceptable.

3. **Storage facilities** – The potential for contaminant entry through storage facilities increases as the number of storage facilities increases and will generally be greater for larger supplies. The likelihood of such events can be controlled through suitable barriers and preventive measures.

4. **Fire hydrants** – Only two descriptors are considered here. This follows the existing grading's approach of any ball hydrants being a concern.

5. **Biofilms** – the criteria used for this hazardous event are based on those in the existing grading, but some guidance may need to be provided on how "limited" is defined.

6. **Microbial contamination of distribution zone** – Review of these criteria will probably be required to ensure the combination with the likelihood from Table 3.6 has an acceptable outcome.

3.3.5 Risk to distribution zone water quality

Table 3.8 provides the generic matrix that brings together the likelihood and consequence components of the risk. There are four classes of likelihood and three of consequence, but the table reduces the description of the risk to "Acceptable" or "Unacceptable". Table 3.8 is used to evaluate the acceptability of risk for each of the seven key hazardous events.

Table 3.8 Risk matrix for distribution zone water quality – Model 1

		Likelihood of contaminants entering the distribution zone (from Table 3.6)			
		Extremely Low	Low	Moderate	High
Consequences of barrier failure for each event (from Table 3.7)	Minor	Acceptable Risk	Acceptable Risk	Acceptable Risk	Unacceptable Risk
	Moderate	Acceptable Risk	Acceptable Risk	Unacceptable Risk	Unacceptable Risk
	Severe	Acceptable Risk	Unacceptable Risk	Unacceptable Risk	Unacceptable Risk

For each key hazardous event, the level of risk is classed as either "Acceptable" or "Unacceptable", using Table, 3.8 and the likelihood (Table 3.6) and consequence (Table 3.7) values already assigned. Table 3.9 is then used to classify the overall level of risk to the water quality. The approach is similar to that presently used for determining the source-treatment plant grade.

A"Y" is recorded in Table 3.9 if the level of risk for that key hazardous event is acceptable (Table 3.8). The combination of "Y" responses for all seven hazardous events is identified in the table, and the overall risk read from the column on the left. Some risk descriptors may be obtained from more than one combination of responses. Any combination of affirmative answers ("Y") that does not appear in the table results in a "high" overall risk.

Table 3.9 Table for determining the overall level of risk to the distribution zone water quality – Model 1

	Key Hazardous Events						
	Backflow/cross-connection	*Leaking Pipes*	*Network Maintenance/Repair*	*Storage facilities*	*Fire hydrants*	*Biofilms*	*Microbial contamination*
Overall Risk to water quality in the distribution zone	***Is the level of risk from the hazardous event acceptable? (from Table 3.8)***						
Extremely Low	Y	Y	Y	Y	Y	Y	Y
Very Low	Y	Y	Y	Y			Y
Very Low	Y	Y	Y	Y	Y	Y	
Low	Y		Y	Y			Y
Low	Y	Y	Y				Y
Moderate	Y	Y	Y				
Moderate	Y		Y				Y
Moderate		Y	Y				Y
High	Any other combination of acceptabilities						

This approach to classifying the overall risk to the water quality does not follow the assignment of demerit points used in the existing framework. The reasons for this are:

a) Demerit points arising from different combinations of shortcomings in risk management can produce similar scores; this limits control over the hazardous events that must be adequately managed to achieve a particular grade. Table 3.9 makes explicit the hazardous events that have to be adequately managed for each overall level of risk.

b) The approach taken in Table 3.9 allows the presence of an FAC residual (which contributes to risk of “Microbial contamination” being acceptable) to compensate for poor management of the barriers against such things as leaky pipes. Note, however, that having adequate barriers to prevent contaminant entry in the first place, is preferable to relying on chlorine inactivation of microbial contaminants after the event.

The relative importance of the seven hazardous events that have been identified for consideration in distribution systems is reflected in the overall levels of risks assigned to the combinations of “Y” in Table 3.9; these may need to be revised following further consultation. The stringency in defining the consequence and likelihood combinations that define “acceptable risk” can also be tuned by modification of Table 3.7.

3.3.6 Distribution zone grade

The risk to distribution zone water quality (from Table 3.9) and the overall compliance status (i.e., *E. coli* and chemical) of the distribution zone are used to determine the distribution zone grade (see Table 3.10). The approach is the same as that used for the source-treatment plant grade determination (Section 3.2.3), except that grades for the individual contaminant classes do not have to be determined.

Table 3.10 Grade derivation from DWSNZ compliance status and risk to the quality of the water in the distribution zone – Model 1

	Risk to water quality leaving the treatment plant (from Table 3.2)				
DWSNZ Compliance status	*Extremely low*	*Very low*	*Low*	*Moderate*	*High*
Compliant (Demonstrated to be supplying safe water when monitored)	**A**	**A**	**B**	**C**	**D**
Non-compliant (Demonstrated NOT to be supplying safe water when monitored, or inadequately monitored so that safety cannot be demonstrated)	**C***	**C***	**D**	**D**	**E**

* The “C” grade for a non-compliant supply is suggested to allow for situations in which a procedural problem with the monitoring has resulted in non-compliance, e.g., a day too many between samples being taken.

3.4 Interpretation of grades

A set of interpretation statements for the five grades is given in Table 3.11. Interpretation statements containing two clauses (one for water quality and one for risk) were considered. In preference, the statements are centred on “confidence”. Compliance status and risk both contribute to confidence in the water quality. Confidence in the safety of the water is high when tests and risk assessment both point to the water being consistently safe. Confidence is much reduced if either monitoring data or the risk assessment indicate a problem, and confidence is very low when both types of assessment conclude that the supply is not well managed and this is confirmed with poor monitoring results.

Table 3.11 Grade interpretation

Grade	Interpretation
A	Very high level of confidence the water is consistently safe
B	High level of confidence the water is consistently safe
C	Moderate level of confidence the water is consistently safe
D	The water may be unsafe at times
E	The water is probably unsafe at times

A point to note is that while the grade applies to either the treatment plant or the distribution zone, the "confidence" relates to the *quality of the water* leaving the treatment plant, or in the distribution zone.

3.5 Model 1 framework summary .

3.5.1 Cons

a) Substantial departure from the approach of the present grading framework, which may result in resistance to its acceptance

b) Apparent increase in complexity through:

- the number of steps required to determine a grade;
- the requirement for grades for the individual contaminant classes to be derived for the source-treatment plant grade;

c) The degree of subjectivity (expert opinion of scientists and those with practical knowledge of water supplies) involved in establishing criteria for the various levels of likelihood, consequence and risk.

Point c) has been a criticism of the existing framework. The use of expert opinion for assigning relative importance to risk factors, hazardous events etc., is necessary given the paucity of quantitative information on which to base these assignments. Stakeholder concern over doing this can best be minimised by consulting with a group of suitably experienced people. Scores and criteria can be adjusted to give results that are considered fair.

3.5.2 Pros

a) Substantial departure from the approach of the present grading framework, which helps in providing a robust basis to the logic of the framework;

b) The approach follows risk assessment methodology, which requires the estimation of risk as the product of likelihood and consequence;

c) Where possible, use is made of criteria established in the present grading framework;

d) Where possible, the source-treatment plant and the distribution zone gradings take account of the levels of contaminants challenging barriers to contamination;

e) Key barriers in the distribution zone are identified to provide guidance on which barriers are considered important, and to achieve consistency in establishing grades;

f) Flexibility is provided to allow the DWA and water supplier to use the PHRMP to establish the adequacy of the preventive measures;

g) Reference to the PHRMP for information required for the grading may identify deficiencies in the PHRMP that can be rectified;

h) The approach to establishing the grade from the risk to water quality and compliance status as a clear, stand alone step, fits with the components of the public health grading's purpose;

i) The need for the PHRMP to show that the water supplier has implemented barriers and preventive measures for the seven key hazardous events identified in the distribution zone, will provide a check that the PHRMP is adequate, and assist in ensuring that PHRMPs have a minimum level of risk management, nationally;

j) It is simple to trace back to identify where actions can be taken to improve the grade.

3.5.3 Comparison with the present grading framework

A grading framework based on Model 1 differs from the present grading framework in the following ways:

a) it considers more explicitly the different classes of contaminant in establishing a source-treatment plant grade;

   This helps the water supplier identify which classes of contaminant are likely to present the greatest risk to the quality of water leaving the treatment plant.

b) the factors in the catchment that influence and mitigate levels of contamination have a greater influence on the grade than they presently do;

   Source water quality is only taken into account in the present framework when treatment is inadequate. By doing so, when treatment is adequate, the framework assumes that the risk to the water quality leaving the treatment plant is not influenced by its source water quality. This may be true for well-designed, sophisticated treatment plants. In these instances, failure of the system to provide safe water is likely only under extreme circumstances (e.g. natural disaster). For less robust treatment systems, source water quality is important in establishing the risk to the treated water quality, and the model caters for this.

c) it requires greater reference to tables and diagrams in determining the grade;

Examination of this feature will show that it is not a complicating factor, but will assist in providing consistency. The model sets the structure of the tables, but their outputs are open for debate while the framework is being developed. Care with provision of suitable notes, will help to streamline the grading process.

d) a greater number of steps is required to establish the grade, although there are fewer questions to which answers are required;

The present framework requires responses to a series of questions, and from these a grade is determined from a single table or the sum of demerit points. Model 1 requires responses to a small number of questions (partly because use is made of assessments already made in approving the PHRMP) and from these the grade is determined in a series of steps, each of which uses a table or diagram to provide the input to the next step.

e) The linkage between consequence, likelihood and risk is clear in Model 1, but not so in the existing framework.

4 MODEL 2 GRADING FRAMEWORK

4.1 Introduction

Model 2 has been developed using as much as possible of the existing framework.

4.2 Source-treatment plant grading

4.2.1 The source questionnaire

As noted in s.3.4.3, the existing framework collects information that reflects the likelihood of source water contamination (Q12), but only uses it in limited circumstances. Model 2 does not change this, but Q12 needs to determine whether the requirement of Section 69U of the HDWAA is being met, i.e., the water supplier is taking reasonable steps to contribute to the protection of the source water(s) feeding the treatment plant. This could be done through either ensuring that this is explicitly included the definition of *protected catchment,* or through an additional question as shown below. Whichever approach is taken, the information should be available from the PHRMP.

Q12 is modified as follows:

12	**Quality of source (surface waters and non-secure groundwaters only)**	
	Catchment protection	*Tick only one box*
	Protected catchment	☐
	Unprotected catchment	☐
	Condition of catchment	*Tick only one box*
	Highly erodible catchment	☐
	Erodible catchment	☐
	Stable catchment	☐
	Fairly consistent quality	☐
		Tick if true
	Reasonable steps have been taken to contribute to the protection of the source water	☐

The answer to the additional question is included in the source-treatment plant grading tables, see Tables 4.4 and 4.5 below.

4.2.3 The treatment plant questionnaire

Q11 of the plant questionnaire seeks information about the types of treatment processes used at the plant, but makes no use of this information in determining the grade. The PRHMP is not needed to obtain this information, and Model 2 retains the question as it is.

Q12 seeks further information about treatment processes controlling the aesthetic quality of the water. Monitoring data are required to answer this question, not PHRMP information. The question is retained unmodified.

Q13 assesses the level of water quality produced at the treatment plant. The majority of the questions concern compliance with respect to the DWSNZ, and these are not associated with PHRMPs. Two questions seek disinfection information. There is also a question regarding the NZS/ISO 9001:2000 quality assurance standard or equivalent, which may be covered by the PHRMP.

PHRMP information needs to be gathered to understand how well the risk of treatment system failure is managed at the treatment plant. This information will augment the compliance information from Q13 to give a more robust picture of the water quality and the reliability of production.

To gather this information, Model 2 adds a new question, Q13A, as given below. Tables 4.1-4.3 are used to convert the answers from Parts 1-5 of Q13A to the risk management ratings required in Parts 6, 7 and 8. Tables 4.1 – 4.3 (over page) would be provided in the notes.

13 A **Indicate the adequacy of steps to manage risks to treatment processes.**

Tick box if met

1. There is more than one treatment barrier to **bacteria**. ☐
2. Measures to prevent failure of the barriers to **bacteria** are adequate. ☐
3. There is more than one treatment barrier to **protozoa**. ☐
4. Measures to prevent failure of the barriers to **protozoa** are adequate. ☐
5. Measures to prevent failure of the barriers to **chemicals** are adequate ☐

Use the answers from 1-5 and Tables 4.1 – 4.3 to determine the ratings in 6,7 and 8.

6. Rating of management of risk of **bacterial** contamination
   - Good ☐
   - Adequate ☐
   - Poor ☐
7. Rating of management of risk of **protozoal** contamination
   - Good ☐
   - Adequate ☐
   - Poor ☐
8. Rating of management of risk of **chemical** contamination
   - Good ☐
   - Adequate ☐
   - Poor ☐

Table 4.1 Level of risk management with respect to bacteria

Bacteria		Level of risk management
Is there more than one barrier to bacteria?	*Have all preventive measures been implemented for key hazardous events?*	
Y	**Y**	*Good*
N	**Y**	*Adequate*
N	**N**	*Poor*

Table 4.2 Level of risk management with respect to protozoa

Protozoa		Level of risk management
Is there more than one barrier to bacteria?	*Have all preventive measures been implemented for key hazardous events?*	
Y	**Y**	***Good***
N	**Y**	***Adequate***
N	**N**	***Poor***

Table 4.3 Level of risk management with respect to chemicals

Chemicals	Level of risk management
Have all preventive measures been implemented for key hazardous events?	
Y	*Good*
N	*Poor*

Known P2 determinands are not taken into account in Table 4.3. They influence the source-treatment plant grade through Tables 4.4 and 4.5.

Q14, Q15, Q16 and Q17 in the existing questionnaire seek risk management information. PHRMPs may be used to answer the questions, but modification of the questions is not required.

4.2.3 The overall source-treatment plant grade

Model 2 strengthens the importance of risk management in deriving the source-treatment plant grade by incorporating the answers to Q13A (bold in the tables) in the existing grading tables in the following way:

Table 4.4 Grading assessment for source and treatment criteria from 2003 Grading – Secure groundwater – Model 2

Criteria	A1	A	B	C	D
• Reason steps are being taken to protect the source water and • Priority 2 Monitoring compliance and • Adequate record keeping and • *E. coli* compliance and • **Risk management for bacteria "Adequate" or "Good"**	Y	Y	Y	Y	
• Adequate supervision and • Compliance with chemical MAVs and • **Risk management for chemicals "Adequate" or "Good"**	Y	Y	Y		
• Disinfection with residual	Y	Y			
• Meets aesthetic criteria and • ISO 9001:2000 series of equivalent	Y				

Responses in the present grading to the "Disinfection with residual" criterion are frequently incorrect. This would need to be addressed either through changes to the grading notes or to the statement of the criterion in the table. The same is true for the same criterion in Table 4.5.

Table 4.5 Grading assessment for source and treatment criteria from 2003 Grading – Surface sources and non-secure groundwater – Model 2

Criteria	A1	A	B	C	D	E
• Low risk of source water contamination And • *E. coli* compliance					Y	
• Reason steps are being taken to protect the source water and • *E. coli* compliance and • Protozoan compliance and • Priority 2 Monitoring compliance and • Adequate record keeping and • Disinfection and • **Risk management for bacteria "Adequate" or "Good"** and • **Risk management for protozoa "Adequate" or "Good"**	Y	Y	Y	Y		
• Compliance with chemical MAVs and • Appropriate supervision and • **Risk management for bacteria AND protozoa "Good"** And • **Risk management for chemical "Adequate" or "Good"**	Y	Y	Y			
• Continuous quality control and • Disinfection with residual	Y	Y				
• Meets aesthetic criteria and • ISO 9001:2000 series of equivalent	Y					

4.3 Distribution zone grading

4.3.1 Introduction

The existing framework is based on a demerit points system. The hazardous events common to all distribution systems have been identified in developing Model 1. These are still the events that need to be addressed by Model 2 and to which demerit points need to be assigned.

The existing distribution zone questionnaires seek information about the generic hazardous events identified in Model 1, but the questionnaire does not try to assess the risk in a systematic way. Model 2 gathers the additional information needed from the PHRMP and revises the way this information is processed to assign demerit points.

4.3.2 The distribution zone questionnaire

For each of the generic hazardous events already identified in the Model 1 discussion, Table 4.6 notes the related questions within the existing questionnaires. The key barriers to these events from Table 3.5 are also listed in Table 4.6. For a water supplier to avoid accruing demerit points, the PHRMP must contain these barriers and the associated preventive measures designed to protect against their failure.

To derive a distribution zone grade, a demerit score is required for each event. The score is determined from "Yes"/"No" answers to two questions as shown in Table 4.7, which also contains the proposed score. The importance scores are the maximum demerits that each hazardous event accrues. They are calculated from the demerits that have been assigned to the associated questions (see Table 4.6) in the 2003 grading framework (see Appendix 5).

Table 4.6 Key hazardous events that may occur in the distribution zone, related questions in the existing questionnaires and the key barriers to protecting against contamination through these events – Model 2

Event No.	Key Hazardous Events	Related questions in existing framework	Key Barriers
1	Backflow/Cross-connection	• Q15 – Backflow preventers – factor to reduce likelihood • Q17 – System Pressure – factor to reduce likelihood	• Maintenance of adequate mains pressure • Installation of backflow prevention devices (BPD) at appropriate locations
2	Leaking pipes	• Q13 (a) – pipe age and records – factors increasing likelihood • Q13 (b) – evidence of leakage • Q13 (d) – corrosion - factor that will increase likelihood • Q17 - System Pressure – factor to reduce likelihood	• Maintenance of adequate mains pressure • Implemented network maintenance programme
3	Network maintenance and repairs	• Not obviously addressed in existing framework (mentioned in the notes for Q14, but not the need for care in ensuring adequate disinfection during and following maintenance)	• Implemented Code of Practice for pipe repair and maintenance
4	Storage facilities	• Q16 – reservoir storage and turnover	• Facilities covered • Grills over air vents to stop animal intrusion • Security of access to the facility • Adequate turnover
5	Fire hydrants	• Q13 (c) – presence of ball hydrants – factor that will increase likelihood	• Use of appropriate hydrant types
6	Biofilms	• Q13 (e) – mains flushing and cleaning – factor to reduce likelihood	• Maintenance of an adequate chlorine residual • Implemented programme for regular pigging and flushing
7	Microbial contaminant entry into the distribution zone	• Q19 – FAC residual maintenance	• Maintenance of an adequate chlorine residual
		General measures taken to manage risk • Q18 – Supervision	

Table 4.7 Derivation of demerit scores for the Distribution Zone grade - Model 2

Event No.	Hazardous Event	Importance Score	Are all key barriers in place?	Are preventive measures to prevent barrier failure in place?	Demerit Score
1	Backflow/Cross-connection	9	Y	Y	0
			Y	N	3
			N	Y/N	9
2	Leaking pipes	12	Y	Y	0
			Y	N	6
			N	Y/N	12
3	Network maintenance and repairs	6	Y	Y	0
			Y	N	3
			N	Y/N	6
4	Storage facilities	12	Y	Y	0
			Y	N	6
			N	Y/N	12
5	Fire hydrants	1	Y	Y	0
			Y	N	1
			N	Y/N	1
6	Biofilms	2	Y	Y	0
			Y	N	1
			N	Y/N	2
7	Microbial contaminant entry into the distribution zone	12	Y	Y	0
			Y	N	6
			N	Y/N	12

In addition to the demerit points given in Table 4.7, two other factors are taken into account in assigning demerit points. Q18 of the existing grading framework seeks information about supervision of the distribution system at management and operational levels. The maximum demerit points that Q18 can attract is 13 (10 relating to management supervision and 3 for operational supervision).

The existing framework also assigns a substantial number of demerit points for non-compliance with the DWSNZ. The demerit points for *E. coli* and chemical compliance are based on the assignments in the present grading as given in Table 4.8.

Table 4.8 Demerit points for compliance status of the distribution zone – Model 2

Compliance status	Demerit Points
E. coli Compliance	
E. coli compliant with no transgressions	0
E. coli compliant with permissible number of transgressions	4
Not *E. coli* compliant	23
Chemical Compliance	
Chemically compliant with no P2 determinand exceeding 50% MAV[1]	0
Chemically compliant	2
Not chemically compliant	10

[1] This includes not having P2 determinands assigned to the distribution zone

A paper by Craun and Calderon (2001) reports the results of a survey of waterborne disease outbreaks in the USA, and their links to distribution zone deficiencies. The relative importance of hazardous events found by the survey is different from that indicated by the weighting of demerit points in the existing grading framework. For example, Craun and Calderon reported that the greatest percentage of outbreaks were associated with backflow problems. If a model similar to Model 2 is favoured, consideration should be given to re-evaluating the demerit weightings.

4.3.3 The distribution zone grade

As with the existing framework, the Model 2 framework assigns the grade based on the number of demerit points. Model 2 provides for a maximum of 100 demerit points. The maximum number of demerit points that could be accrued through the existing framework is 98. Proposed demarcation boundaries between grades in Model 2 are listed in Table 4.9

Table 4.9 Distribution zone grade assignments based on accrued demerit points – Model 2

Demerit Point total	Grade	Comment
0 - 5	a	This point range allows the barriers and preventive measures protecting against some hazardous events to be inadequate. However, there can be no barriers or preventive measures missing for the three priority (according to the 2003 grading framework) hazardous events (leaking pipes, storage facilities and FAC residual maintenance). This matches the existing framework, which allows an "a" grade with shortcomings in any one aspect of the distribution system except leakages, storage facilities and FAC residual. *E. coli* compliance and chemical compliance are required.
6 - 12	b	This range allows the barriers to contaminant entry to be incomplete (i.e. maximum demerit points accrued) for only one the priority hazardous events. In the existing framework, the maximum number of demerits points can be scored for any of the priority hazardous events and the distribution zone still receive a "b" grade. *E. coli* compliance is required.
13-24	c	The barriers may be incomplete for no more than two priority hazardous events for a distribution zone to receive a "c" grade.
25-40	d	This point range allows for up to three priority hazardous events to have major failings (i.e., maximum demerit points) in their barriers and preventive measures.
>41	e	

4.4 Interpretation

The interpretations given in the explanatory notes for the 2003 grading would be retained for Model 2.

4.5 Model 2 framework summary

4.4.1 Cons

a) Risk assessment methodology (assessing likelihood and probability) is not used.

b) Similar total demerit point scores can be accrued from markedly different combinations of contributing factors, which does not assist in ensuring that specific, priority hazardous events are required to be in place to achieve a particular grade;

c) There is subjectivity in the assignment of demerit points.

d) Because of the way in which the distribution zone demerit points can be accrued, it is difficult to provide a systematic interpretation of the grades.

4.4.2 Pros

a) The overall concept of the existing framework is retained, which should minimise the impact of the grading change and help in providing consistency between the grades achieved through the old and new frameworks; this should encourage acceptance of the framework.

b) Familiarisation with a totally new approach to grading by water suppliers and DWAs will not be necessary because of the similarity with the existing framework.

c) As much as possible, the weighting given to factors that may lead to distribution zone contamination has been retained, and reflected in the assignment of demerit points.

d) The key hazardous events that need to be managed in a distribution zone are clearly identified.

e) The need for the PHRMP to show that the water supplier has implemented barriers and preventive measures for the seven key hazardous events, will provide a check that the PHRMP is adequate, and assist in ensuring that PHRMPs have a minimum level of risk management, nationally.

5 MODEL 3 GRADING FRAMEWORK

5.1 Introduction

Model 3 provides an extremely simplified approach to the derivation of grades, based on a approach contained in a report to the Government of New Caledonia (Gregor, 2006). It incorporates information about compliance with respect to the DWSNZ and the implementation of a PHRMP to determine the grades for the source-treatment plant and distribution zone components of the water supply.

The model aims to provide interpretations of each grade in terms of the stated purpose of the grading: the extent of compliance with the DWSNZ provides a measure of the safety of the water is being supplied, and the presence, or otherwise, of an approved and implemented PHRMP has a bearing on the likelihood of the supply being able to *consistently* produce safe water.

The rationale for Model 3 is that the information needed for grading has already been gathered by the annual evaluation of compliance with the DWSNZ, and assessments of the adequacy of the supply's PHRMP and its implementation. Therefore, derivation of a grade should be achievable on compliance status and PHRMP status alone.

5.2 Source-treatment plant grading

A questionnaire is not used in deriving the source-treatment plant grade, only the flow diagram shown in Fig. 5.1.

As proposed here, the Model 3 framework does not produce grades for each contaminant class, although compliance for the different classes is used in distinguishing grades.

In developing both Fig. 5.1 and the flow diagram for the distribution zone grade (Fig. 5.2), a key rule that has been used is:

> D is the highest grade that can be obtained if an approved PRHMP has not been implemented.

This is to reflect:

a. the shift from monitoring-based to risk-based management of water supplies

b. the importance placed on PHRMPs in the HDWAA.

Once the above rule has been taken into account, the importance placed on the various criteria in the existing framework was used to construct Fig. 5.1. A suggested interpretation of the grades is given in Table 5.1

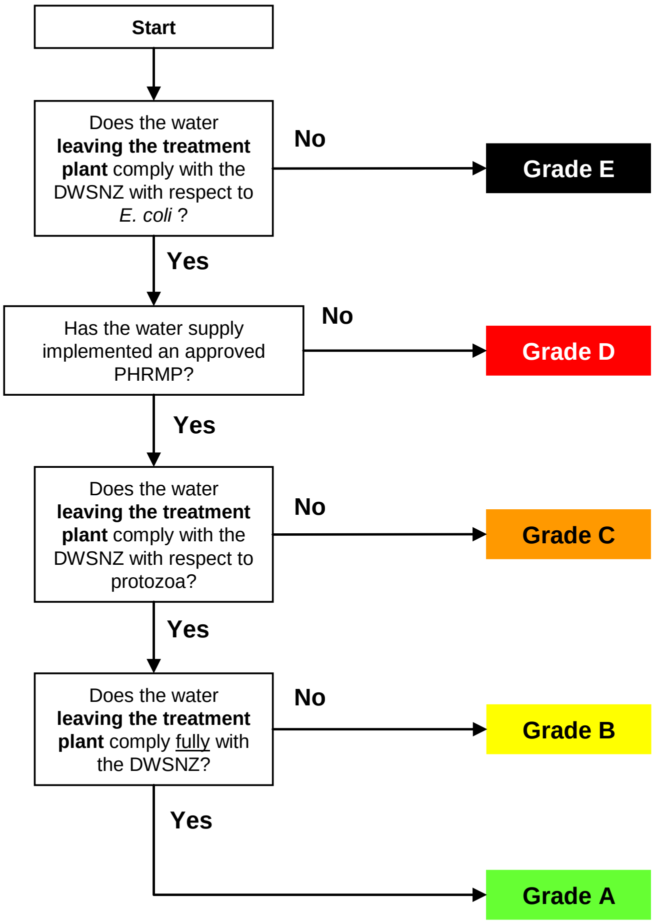


Fig. 5.1 Derivation of source-treatment plant grades – Model 3

Table 5.1 Interpretation of source-treatment plant grades – Model 3

Grade	Interpretation
A	The treatment plant is able to remove all classes of contaminants from the water. It is expected to be able to do this reliably because the plant is well managed and operated.
B	The treatment plant is able to remove bacteria and parasites from the water. It is expected to be able to do this reliably because the plant is well managed and operated.
C	The treatment plant is able to remove bacteria from the water. It is expected to be able to do this reliably because the plant is well managed and operated.
D	The treatment plant is able to remove bacteria from the water. However, its ability to do this reliably is uncertain.
E	The treatment plant has been unable to show the ability to remove any contaminant class from the water to an acceptable extent.

5.3 Distribution zone grading

As with the source-treatment plant grade, this model does not use a questionnaire to obtain information for determining the distribution zone grade, although a check list of barriers and preventive measures is needed. The grades are derived using the flow diagram in Fig. 5.2

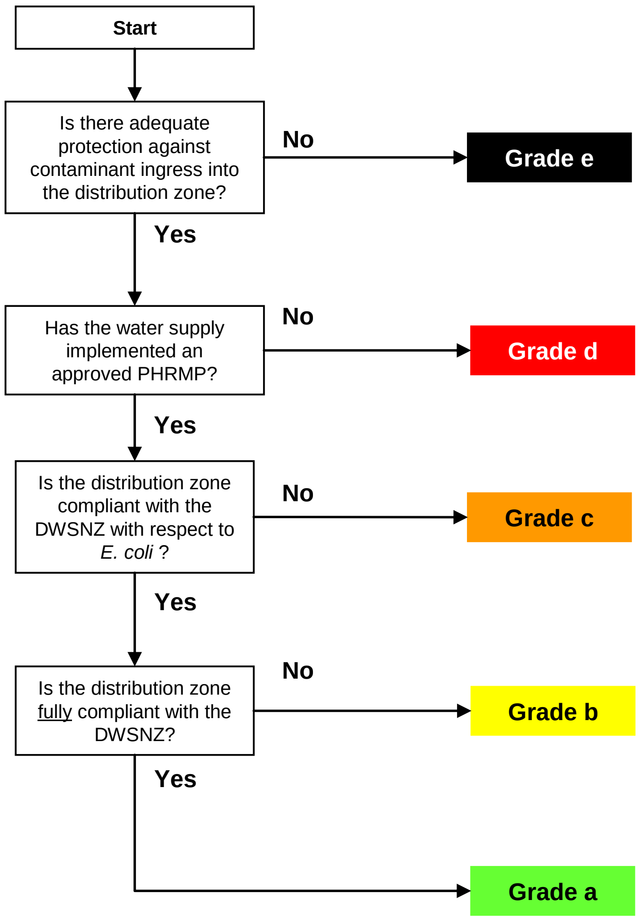


Fig. 5.2 Derivation of distribution zone grades – Model 3

In addition to compliance and PHRMP information, Fig.5.2 makes use of information about the adequacy of the barriers to contaminant ingress into the distribution zone. This is done to allow distinction to be made between grades. Protozoal compliance does not apply to the distribution zone, which reduced the number of compliance criteria that could be used for distinguishing between grades.

A table of criteria (Table 5.2) is used in conjunction with Fig. 5.2 for determining whether protection against contaminant ingress into the distribution zone is adequate.

Table 5.2 Barriers/preventive measures that must be in place for the level of protection against contaminant ingress into the distribution zone to be considered "adequate" – Model 3.

Barriers/preventive measures
Backflow preventers in all appropriate locations
Maintenance of system pressure in the range 200 - 900 kPa
Implemented code of practice for system maintenance
FAC residual of at least 0.2 mg/L
Covered and secured storage facilities
Regular flushing and cleaning

Suggested interpretation of the distribution zone grades is given in Table 5.3.

Table 5.3 Interpretation of distribution zone grades – Model 3

Grade	Interpretation
A	Contaminants are very unlikely to enter the water provided to consumers, and sampling has shown the water to be microbiologically and chemically safe.
B	Contaminants are unlikely to enter the water provided to consumers, and sampling has shown the water to be microbiological safe.
C	Contaminants are unlikely to enter the water provided to consumers, but there is insufficient testing evidence to confirm the safety of the water.
D	Barriers to contamination are in place, but their ability to reliably protect against the entry of contaminants into the water provided to consumers is uncertain.
E	Barriers to contaminants entering the water provided to consumers are inadequate.

5.4 Model 3 framework summary

5.4.1 Cons

a) The approach is simple, and does not look directly at key risk management steps in sufficient detail – only the approval status is considered. Note, though, that risk management detail has been considered as part of the approval process. A PHRMP may be approved because preventive measures not presently implemented are planned for in the improvement schedule. However, if this is the case, temporary preventive measures should still be in place.

b) Unless a supply has all the key barriers for the distribution zone in place, the highest grade it would be able to receive is an “e”.

PHRMP approval implies key barriers are in place. An approved PHRMP should then result in a “c” grade at least. The list contained in Table 5.2 is based on what might be expected for medium and large supplies. Small supplies may have adequate barriers that do not exactly match the descriptions given in Table 5.2, and modification of the descriptions may be required if the framework is to be used for small supplies.

c) Unchlorinated supplies will be unable to state that they have adequate protection against contaminant entry because of the need to maintain an FAC residual of ca. 0.2 mg/L. As a result, they will receive an “e” grade. A dispensation could be provided contingent on other requirements being met.

5.4.2 Pros

a) The link between the information used to derive the grade and the grade itself is very clear.

b) The grade interpretation aligns with the grading’s purpose statement

c) There is no duplication of effort in deriving the grade because the model uses the end results of compliance assessment and assessment of the supply’s PHRMP.

d) Derivation of grades is rapid and based on processes that should be nationally consistent already.

6 CONCLUSIONS

The 2008 survey of stakeholders made clear the general views on some factors that need to be taken into account in revising the grading. However, for some design criteria the preference was less clear-cut. From this it was apparent that several framework options needed to be presented to act as the starting point for a grading revision to allow PHRMP incorporation.

Three framework models have been prepared, each placing emphasis on different design features. The key features of each model are as follows:

d) Model 1

- It is based on the logic supporting the Ministry's PHRMP preparation framework (MoH, 2001), so that where possible risk is evaluated from consequence and likelihood;
- Risk assessment and water quality (compliance) information are kept separate until the final step of grade determination, so that the contribution of each to the final grade is clear;
- Information about preventive measures contained within PHRMPs is used;
- Tables are used extensively to establish levels of likelihood and consequence for hazardous events;
- A source-treatment plant grade is determined for each of four contaminant classes (bacteria/virus, protozoa, chemicals, cyanobacteria) and a final source-treatment plant grade determined from them;
- Seven hazardous events, considered generic to all distribution zones, are explicitly identified and used to determine the distribution zone grade;
- While more complex than the existing (2003) framework in some respects, it should provide a more accurate assessment of risk.

e) Model 2

- It retains as much of the existing grading framework as possible;
- The source-treatment plant grade questionnaires and grading tables are retained, but are slightly modified, to accommodate information from the PHRMP
- Information about the adequacy of preventive measures contained within the PHRMP is required;
- The seven key hazardous events identified in Model 1 as the basis for the distribution zone grading are also used in this model;
- Demerit points are used to evaluate the distribution zone grade;

- The demerit points are assigned to try to reflect the weighting given to them in the existing framework;

f) Model 3

- It is designed to be as simple as possible;
- Grades are determined using decision trees;
- Only the status of the PHRMP (whether approved and implemented) is taken into account, except in the distribution zone grade determination when the adequacy of five specific barriers or preventive measures is required;
- The influence on the grade of both the PHRMP status, and the compliance status of the supply with respect to *Escherichia coli*, protozoa and overall compliance, is clear from the decision trees.

The grading is not a statement solely about water quality or about risk. It draws on both types of information to achieve its purpose. The challenge is how best to convey this combined role to the layperson. By providing an interpretation that says something about the quality of the water and how well the risk is managed, the layperson may develop a better understanding of what the grade is conveying.

By using the PHRMP to provide information on the necessary barriers and preventive measures in a water supply, the grading will act as a check on the PHRMP ensuring it contains the fundamental components needed for managing the risk to water quality.

REFERENCES

Craun G F and Calderon R L, 2001,Waterborne disease outbreaks caused by distribution system deficiencies, *J. Am. Wat. Wks. Assn*., 93(9) 64-75

Gregor J, 2006, Assessment of Health Risks Relating to Drinking-water and the Development of Health Safety Plans for Drinking-waters, ESR Client report CSC0609 for the Government of New Caledonia.

MoH, 2001, *How to prepare and Develop Public Health Risk Management Plans for Drinking-water Supplies*, Ministry of Health, Wellington

MoH, 2003, *Public Health Grading of Community Drinking-water Suppliers 2003 – Explanatory Notes and Grading Forms*, Ministry of Health, Wellington

APPENDIX 1 – 2008 SURVEY FOR THE GRADING REVIEW

Public Health Grading of Water Supplies Review 2008

Questionnaire

This questionnaire has three purposes:

- To help you identify issues that you wish to comment on
- To provide a systematic way to record your opinion on issues concerning revision of the grading framework
- To assist ESR in developing options that might be considered for incorporating PHRMPs into the grading framework

Name of person responding --

Position: ------------------------ Organisation: ------------------------

Business (please tick one):

Water supplier	☐
Drinking Water Assessor	☐
Other	☐

Describe if "other" --

Many of the sections below seek your responses to a series of statements. The possible responses are labelled from 1 to 5 and range from "Strongly agree" to "Strongly disagree". Mark the degree to which you agree with each statement. If returning electronic copy, **BOLD** your response. If returning hardcopy please circle your response.

General Experience with PHRMPs and opinion on the present public health grading framework

1	Do you have an approved PHRMP prepared for your water supply?	Yes	No	N/A
2	Has your supply been graded using the 2003 Grading framework?	Yes	No	N/A

		Strongly Disagree ←				→ Strongly Agree
3	Public health grading is no longer required because of the Health [Drinking water] Amendment Act	1	2	3	4	5
4	The presently stated purpose of the public health grading is satisfactory: *…to provide a public statement of the extent to which a public water supply achieves and can ensure, a consistently safe wholesome product.*	1	2	3	4	5

If you "Strongly agreed" or "Strongly disagreed" in Q.3, please state how you would like to see it changed.

In considering the following statements, recall that the present purpose of the grading requires information about the *risk to the water quality* and about the actual *water quality* (compliance information) for calculating the grade.

		Strongly Disagree	←		→	Strongly Agree
5	The 2003 grading framework provides a satisfactory means of evaluating the risk to the quality of the water.	1	2	3	4	5
6	The grading needs to take account of actual water quality information (compliance information).	1	2	3	4	5
7	Information obtained from PHRMPs should be used in determining a supply's grade.	1	2	3	4	5

If your response was 1 or 2 for any of these statements, please provide your reasons:

Incorporating PHRMPs into the grading

8 Of the three statements below, please select the ONE that most closely matches your view of the extent PHRMP information should be used in grading:

PHRMP information is all the risk information that is needed to evaluate the level of risk to water quality	1
A mix of PHRMP information and risk information from other information sources is required to evaluate the level of risk to water quality	2
Risk information from other information sources other than PHRMPs is ALL that is needed to evaluate the level of risk to water quality, i.e. PHRMP information is not needed.	3

If you have selected 2 or 3 above, please state what additional risk information other information sources would provide that has not been considered in the preparation of PHRMPs.

Level of detail required from PHRMPs

The following definitions will help to answer the question below:

- *Status of the supply's PHRMP* means whether the PHRMP has been: prepared; prepared and approved; approved and implemented.
- *Summarised detail* means evaluation of how well the risk to each of the elements of the water supply is being managed. E.g., all preventive measures necessary for ensuring satisfactory disinfection are in place.
- *Key details* means evaluation of how well each of the possible hazardous events associated with each element of the supply is being managed. E.g., in the case of chlorination, whether all preventive measures are in place to avoid excessive formation of disinfection by-products.

9 Please select ONE statement from the following that best matches your view on the level of information detail (associated with PHRMPs) that should be used in the grading.

The status of the supply's PHRMP is sufficient for the grading.	1
Summarised detail is sufficient for the grading.	2
Key details are needed for the grading.	3
No information from PHRMPs is needed	4
It's too early in the process to consider the level of detail required, other matters need to be considered first.	5

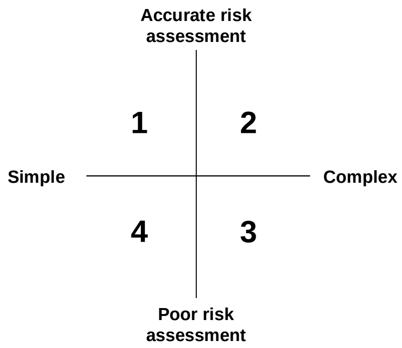
If you responded 5 to Q.9, identify other matters you would like to see addressed first.

Calculation of the grade and representation of the grade

The following statements are intended to help understand which aspects of the grade calculation are most important to you. This includes your preference with respect to a trade-off between simplicity of calculation and the accuracy with which it determines the risk to water quality.

		Strongly Disagree	⟵	⟶		Strongly Agree
10	The process by which the grade is determined must be transparent so that the reason for the resulting grade is clear.	1	2	3	4	5
	Consideration of the simplicity of the grading process:					
11	• A computer should not be needed to calculate reliably the grade.	1	2	3	4	5
12	• Fewer questions than are presently used would be adequate for grading.	1	2	3	4	5
13	• The grading should not require as much explanation as is presently needed in the notes	1	2	3	4	5
14	The grading framework should accurately assess the level of risk to water quality.	1	2	3	4	5

To help in understanding the relative importance you place on simplicity and accuracy, consider the diagram below, where the quadrants represent the possible characteristics of a grading framework.



15	Select the quadrant with the combination of characteristics you would prefer to see in a grading framework	1	2	3	4	
16	If you had to choose between a grading framework with the characteristics represented by quadrants 2 or 4 which would you prefer?		2		4	

		Strongly Disagree ↔				Strongly Agree
17	Any new grading framework needs to be able to provide a simple overall representation of the grade, e.g. A-E scale	1	2	3	4	5

Relationship between the 2003 grading framework and a new grading framework

The following statements aim to understand which features of the present grading framework you wish to see retained in a new grading framework.

		Strongly Disagree ↔				Strongly Agree
18	The existing grading framework should be retained as is, and PHRMP information added to it.	1	2	3	4	5
19	*Pro forma* questionnaires, as presently used, are too inflexible to allow an accurate assessment of risk.	1	2	3	4	5
20	The use of demerit points in establishing a grade should be retained	1	2	3	4	5
21	The use of tables from which grades can be determined should be retained	1	2	3	4	5

		Strongly Disagree	⟷			Strongly Agree
22	It is difficult to justify scientifically some of the assignments of demerit points in the existing distribution zone grading	1	2	3	4	5
	If you selected 4 or 5 in response to Q.22, state the question numbers in Part 3 of the grading that concern you most:					
23	The grading notes play a key role in the grading framework.	1	2	3	4	5
24	The grading notes must set out black and white criteria for responding to grading questions.	1	2	3	4	5

Having completed the questionnaire, if there are aspects of a revised grading, *including whether public health grading is still needed*, you wish to comment on further, please do so below (and on additional pages if needs be).

Summary of responses

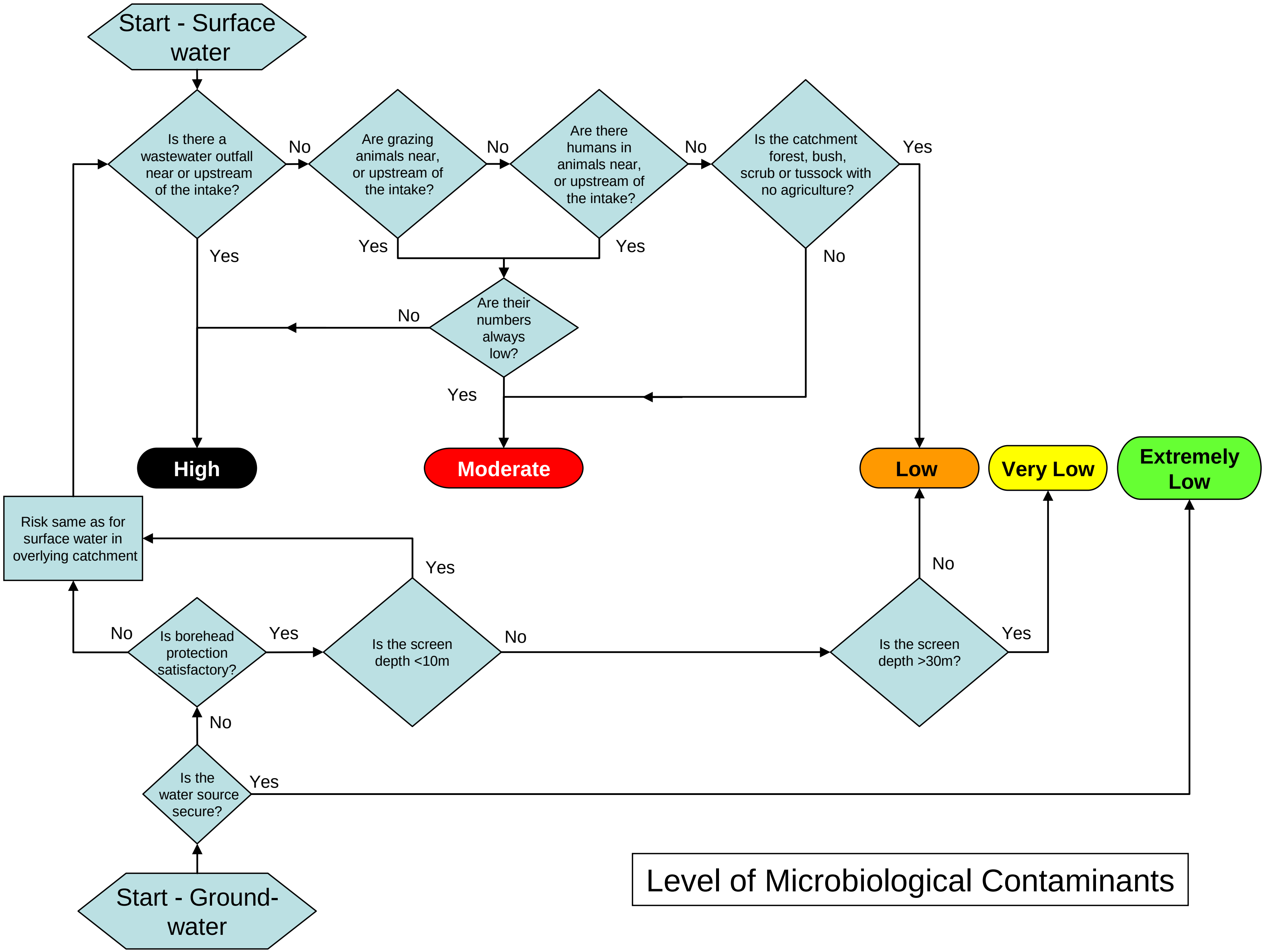
The number of each response to the questions of the 2008 stakeholder survey are given in the table below.

	Response Number				
	1	**2**	**3**	**4**	**5**
Question					
1	Yes - 7	No - 11	N/A - 12		
2	Yes - 14	No - 4	N/A - 12		
3	9	12	3	3	3
4	2	4	6	11	7
5	3	11	7	8	1
6	0	0	3	12	15
7	1	1	3	12	12
8	14	16	0		
9	10	10	9	1	0
10	0	0	0	10	20
11	2	2	7	7	12
12	10	4	12	3	1
13	9	8	7	3	3
14	2	0	1	6	21
15	25	4	0	1	
16		24		6	
17	1	0	3	10	16
18	5	7	9	6	2
19	3	6	7	7	6
20	3	3	6	9	8
21	3	2	10	8	6
22	0	3	10	9	7
23	0	1	2	12	15
24	0	2	6	14	8

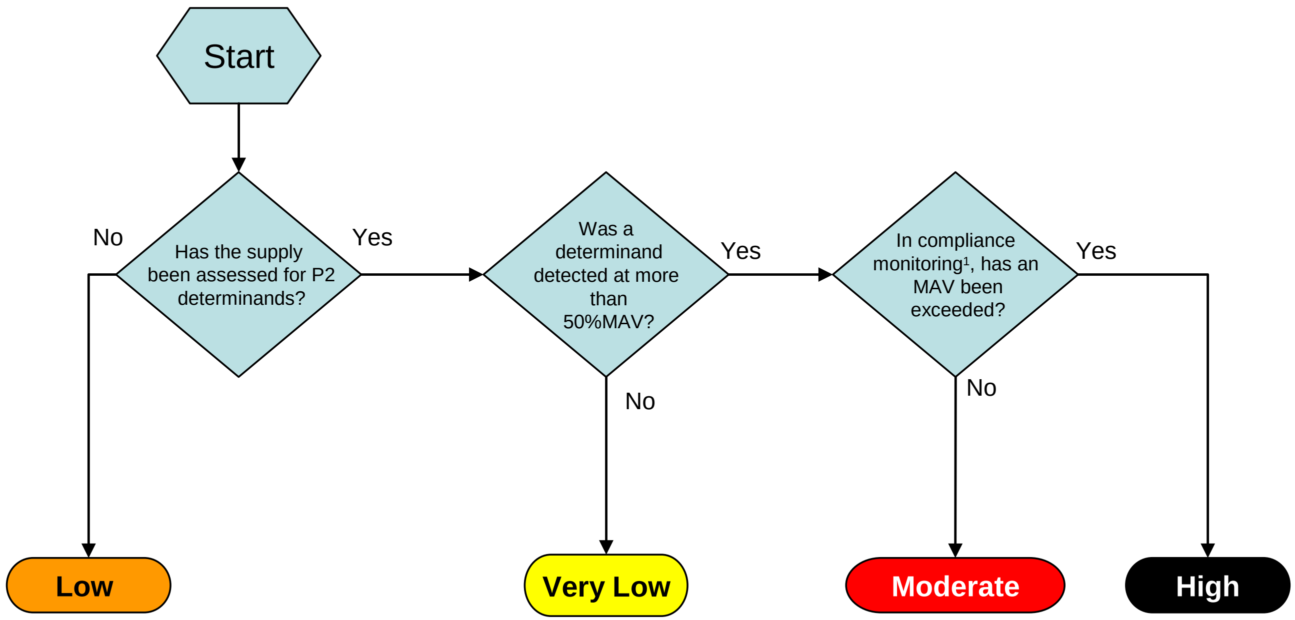
APPENDIX 2 SOURCE WATER CONTAMINANT LEVELS

These diagrams provide the means of classifying the source water with regard to the contaminant levels of the four contaminant classes. The levels of bacterial and protozoal contaminants are determined from the *Level of Microbiological Contaminants* diagram. In this diagram, select the “Start” box which best describes the situation for your source.

What constitutes a groundwater, in the *Level of Cyanotoxins* diagram, has not been defined. Further review of the literature is required to determine whether cyanotoxins may be present in water from infiltration galleries and shallow bores.

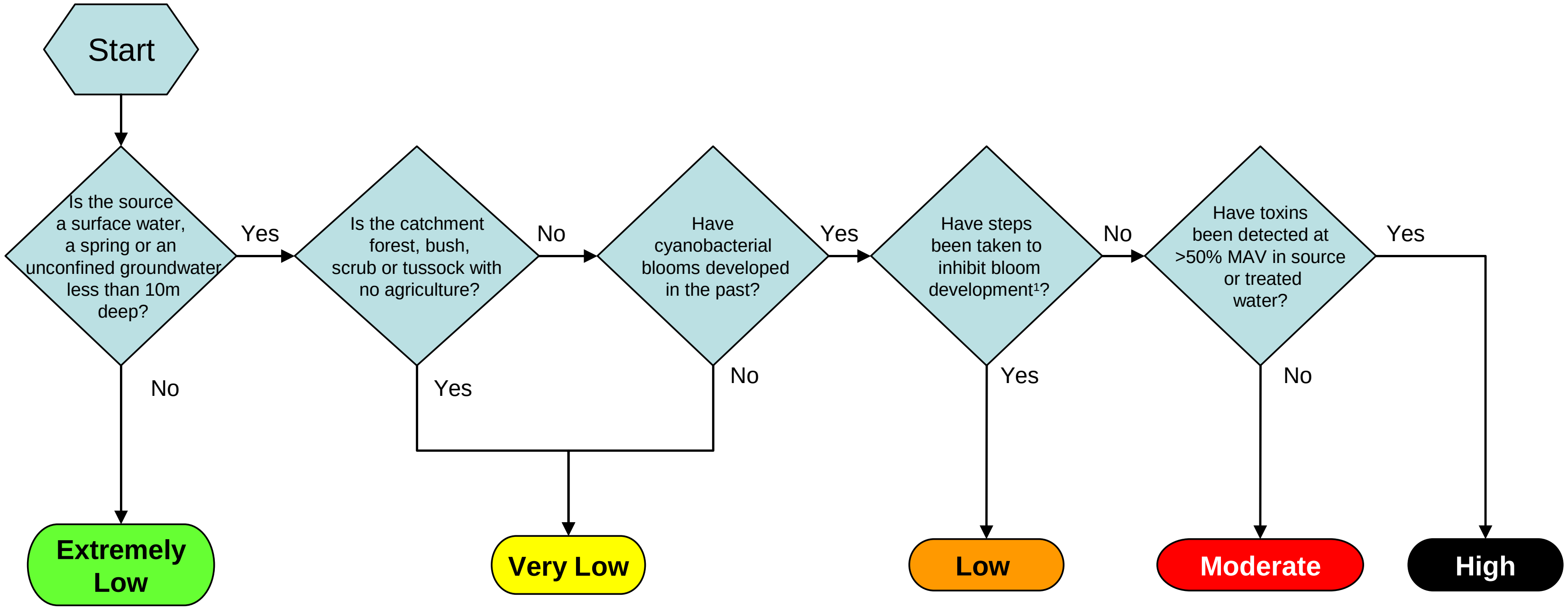


Level of Microbiological Contaminants



[1] If compliance monitoring has not been undertake, or has been inadequate, it is assumed the contaminant level is HIGH

Level of Chemical Contaminants



[1] This means not allowing bloom development. **It does not include** steps take to kill off cyanobacteria once the bloom has occurred, because these actions result in cell lysis and the release of toxins.

Level of Cyanotoxins

APPENDIX 3 CRITERIA FOR ESTABLISHING THE CAPACITY OF THE TREATMENT PLANT FOR CONTAMINANT REMOVAL

Bacteria/viruses:
For the treatment plant to be considered capable of providing protection against bacteria and viruses one or more of the following processes must be in place and their associated criteria met:

Treatment Process	Criteria to be meet
Chlorination	• Sufficient chlorine can be dosed into the water to produce an FAC residual of at least 0.2 mg/L AND • A minimum chlorine contact time of 30 minutes can be achieved AND • Preceding treatment can reduce turbidity to 1.0 NTU or less, or the source water turbidity does not exceed 1.0 NTU
Chlorine dioxide treatment	• Sufficient chlorine dioxide can be dosed into the water to produce a ClO_2 + FAC residual of at least 0.2 mg/L AND • A minimum disinfectant contact time of 30 minutes can be achieved AND • Preceding treatment can reduce the turbidity to 1.0 NTU or less, or the source water turbidity does not exceed 1.0 NTU OR • The C.t value is sufficient to achieve at least 0.25 protozoa log credits AND • Preceding treatment can reduce the turbidity to 1.0 NTU or less, or the source water turbidity does not exceed 1.0 NTU
Ozonation	• The C.t value is sufficient to achieve at least 0.25 protozoa log credits
UV irradiation	• The UV dose is at least 40 mJ/cm^2 AND • Transmittance of the water is at least 80% AND • Flow rate through the treatment unit is no greater than the unit’s maximum flow rating.

Protozoa

The treatment process in place must be capable of achieving the protozoal log credits required for compliance with the DWSNZ for the quality of the source water.

Secure groundwaters are considered to have adequate capacity for microbiological contaminant removal.

Chemicals

The capability of the treatment system for removing chemical contaminants is based on its ability to avoid chemical transgressions. The treatment plant has the capacity to treat for chemicals of concern, if there have not been any transgressions in samples taken for compliance monitoring.

Cyanotoxins

The treatment plant is considered to have the capacity to remove cyanotoxins if:

- Testing during a bloom has shown toxin concentrations greater than their MAV in the source water have been reduced to less than 50% of their MAV in the treated water,

  OR

- Toxins have been identified in a source water, and the treatment processes at the plant are considered to be effective against the identified toxins, according to the *Guidelines for Drinking-water Quality Management for New Zealand*.

APPENDIX 4 MULTIPLE BARRIERS

The following treatment trains are considered to constitute more than one effective barrier for each of the contaminant classes:

Contaminant Class	Possible treatment trains
Bacteria/viruses†	• Coagulation/clarification/filtration + disinfection* • Coagulation/filtration + disinfection* • Slow sand filtration + disinfection* • Diatomaceous earth filtration + disinfection* • Membrane filtration + disinfection* Or any train containing the above plus additional processes.
Protozoa	• Any of the particle removal processes identified in the DWSNZ plus ozone or UV irradiation or chlorine dioxide
Chemicals	• In general, there will be only one barrier for a chemical determinand at a treatment plant. Because of the specialised nature of chemical removal, the demonstration of a P2 determinand being removed by more than one process is not required.
Cyanotoxins	Particle removal processes can remove algal cells from the water and with them the toxins they contain. However, these processes are also capable of lysing (rupturing) cells so that their toxins are released into the water. Multiple barriers to cyanotoxins are considered to exist if at least two of the following are true: • the total toxin concentration (toxins contained in cells plus free toxins in the water) is being reduced by the particle removal processes; • oxidizing disinfectants capable of destroying the toxins of concern are operational**; • activated carbon adsorption is in place and is considered capable to effectively removing the toxins of concern**. • membrane filtration is in use and there is documented evidence of it removing the type of cyanotoxin challenging the treatment plant.

† These barriers are effective against bacteria. They will need to be re-evaluated with respect to viruses, when the DWSNZ contain a section for these organisms.

* Disinfection = chlorination or ozonation or chlorine dioxide treatment, or UV irradiation

** Effectiveness of toxin destruction by oxidising agents depends on the toxin and agent. Similarly, activated carbon is not equally effective in adsorbing all toxins.

APPENDIX 5 DISTRIBUTION ZONE DEMERIT POINTS

Maximum demerit points assigned to questions in the 2003 grading framework

Question	Maximum Demerits
13(a)	2
13(b)	2
13(c)	1
13(d)	2
13(e)	2
14	6
15	9
16(a)	9
16(b)	3
17	6
18	11
19	12
20	23
21	10
Total	**98**

Maximum demerit points assigned to key hazardous events proposed in Model 2 based on the demerits given to the related questions in the 2003 grading framework

Key hazardous Event	Maximum demerits
1	9
2	12
3	6
4	12
5	1
6	2
7	12
Total	**54**