MANAGING RISK TO DRINKING WATER – A FRESH PERSPECTIVE ON BACKFLOW PREVENTION

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ABSTRACT

The amendment to the Health Act 1956, in force since 1 July 2008 has redefined the landscape for all governing local authorities, drinking water suppliers, monitoring agencies - essentially all stakeholders involved in the delivery of drinking water to the community. The overall objective '*...to protect the health and safety of people and communities by promoting adequate supplies of safe and wholesome drinking water from all drinking-water supplies'*. Critical to this protection is the responsibility to *'implement Risk Management Plans'*, involving a wider range of participants in the 'source to tap' management of drinking water in New Zealand – and it makes good sense.

One essential (but often overlooked) aspect of maintaining wholesome drinking water in the distribution system is the need for a thorough, effective, risk based Backflow Prevention Programme. Numerous Acts, Regulations and National Standards detail how to prevent backflow at differing points between source and tap, but these separate approaches cannot always achieve the overall objective in isolation without significant cost, duplication and administrative burdens to all involved. The most effective means of protecting the health and safety of communities from risk of backflow is to get commitment from all stakeholders to an integrated programme. Stakeholders in this shared objective include consumers, plumbers, merchants and maintenance contractors among others. As key stakeholders, Networked Suppliers, Public Health, Building Consent Authorities and Local Authorities have different legislative mandates and monitoring accountabilities, but all have a common thread and can be aligned toward this shared objective.

An integrated, risk based approach doesn't require protection at every boundary but can take into consideration a wide range of contributing factors such as consequence (including hazard), likelihood of an event, and a range of existing and alternative mitigating controls. The result in many cases, could be properties with robust controls already in place, by way of adequate internal protection and meticulous *'inspection and maintenance procedures'*.

The required drive to achieve this outcome can come from a networked supplier who is committed to delivering wholesome drinking water by managing risk in a manner that is integrated, transparent and minimises the cost of that delivery to the community.

KEYWORDS

Backflow prevention, hazard, contamination, public health, risk management, drinking water, cross connection, networked supplier, distribution system.

1 INTRODUCTION

Throughout the history of community drinking water supplies there have been documented incidents of chemical contamination and waterborne disease outbreaks resulting in illness and death and many of these have been directly attributable to backflow from private cross-connections. While incidents in New Zealand have been relatively infrequent to date, due to a range of factors, the current situation in many distribution networks may result in unacceptable levels of residual risk unless the necessary controls are more widely enforced. Given the potential magnitude of the effect on community health of one such incident, particularly to vulnerable members such as the elderly, sick or children, this is a risk that can no longer be trivialised.

New Zealand is not alone in facing this contamination risk nor in having an assortment of regulations to assist in mitigation of the risk but the specific coverage and application of these regulations establishes a context unique to New Zealand. A result of fragmentation in the application of legislation, standards and guidelines in this area can create ambiguity in responsibility and in some cases, duplication of the necessary controls in practice.

Each district throughout New Zealand is uniquely represented by District, Regional and City Councils and in some cases, independent Drinking Water Suppliers. The 1989 rationalisation of local authorities was to include a number of guiding principles, including '*operational efficiencies…clear non-conflicting objectives…accountability… mandatory information flo*w'. However, many local authorities today still appear to suffer internal discord and communication barriers preventing Drinking Water Suppliers, Environmental Health Officers, Building Enforcement Officers, Building Consent, other Council staff and the community from contributing their role in mitigation of backflow contamination risk.

Drinking Water Suppliers in New Zealand now have an unmistakable duty under the Health Act 1956 to maintain wholesome drinking water within the distribution network. The key mechanism for quantifying any risk and outlining any necessary mitigating controls is through an approved Public Health Risk Management Plan (PHRMP), with a key requirement, '*reducing the likelihood of contaminants entering supplies'*. Transgressions or non-compliance with Ministry of Health guidelines can attract demerit points under the Public Health Grading of Community Drinking-Water Supplies, and potential prosecution for negligent management. In addition, The Ministry for the Environment has released its Draft National Environmental Standard for Sources of Human Drinking Water, suggesting a wider range of participants in the 'source to tap' management of drinking water thereby *'reducing the risk of contamination – from source through to the treatment plant and distribution system.*'

Such an overall objective is no simple feat, but requires interaction and a commitment from a wide range of stakeholders, from both within a local authority and the wider community. A thorough, well researched, integrated policy is an essential component, as is a methodology that seeks effective solutions that minimise duplication of controls and monitoring.

Defining true backflow risk has historically been problematic and inconsistent due to the almost exclusive use of backflow hazard as the assessment tool. As defined under the Building Act 2004 or AS/NZS 3500.1, hazard is the likely consequence to human health resulting from a cross-connection within a private system but does not consider other relevant factors such as likelihood or the cumulative effect of multiple hazards. A better practice for Drinking Water Suppliers is the definition and implementation of a true risk assessment methodology, based on an holistic set of contributing risk factors, including backflow hazard.

2 BACKFLOW PRINCIPLES

2.1 DISTRIBUTION NETWORK CONTAMINATION BARRIERS

The multiple barrier approach is recognised as a sound basis for managing all areas of risk to a drinking water supply and is encouraged in the Drinking Water Standards for New Zealand (DWSNZ).

One approach within the distribution network is to categorise preventative measures in three key areas of network integrity: Physical Integrity, Hydraulic Integrity and Water Quality Integrity. For the purpose of this paper, we will briefly consider each barrier only in relation to risk of contamination through backflow.

2.1.1 PHYSICAL INTEGRITY

This barrier broadly includes any physical method of protecting the distribution network from exposure to private contamination or cross-connections and includes vacuum columns, air gaps and testable backflow prevention devices. Supplementary equipment such as non-testable backflow prevention devices, meter check valves, isolating valves and one-way diaphragm valves can create additional barriers, but verification of effectiveness is not easily achieved. Typical physical integrity failures and contributing factors are summarized in Table 1.

Physical Integrity Failure	Contributing Factor
No backflow prevention device installed	Property risk not correctly assessed Non-notified change of property use Poor records of device locations Inadequate communication with relevant stakeholders
Installed backflow prevention device inadequate for property risk	Property risk not correctly assessed Non-notified change of property use
Faulty backflow prevention device	Unavoidable mechanical failure Vandalism or accidental damage Incorrect / outstanding device test Insufficient auditing of device testing
Incorrectly installed backflow prevention device	Insufficient auditing of device installation standards Property risk not correctly assessed Inadequate communication with relevant stakeholders
Installed backflow prevention device subsequently ineffectual	Property risk not correctly assessed Subsequent device bypass / removal or plumbing change

Table 1: Typical Physical Integrity Failures and Contributing Factors.

2.1.2 HYDRAULIC INTEGRITY

This barrier is achieved by maintaining the supply of water at an acceptable level of service. Indicators of the achievement of this objective include: maintaining adequate pressure and flow for predicted demand, minimising pressure fluctuations, avoiding excessive pressure and providing adequate fire flow. Typical hydraulic integrity failures and contributing factors are summarized in Table 2.

Hydraulic Integrity Failure	Contributing Factor
Zero network pressure	Supply interruptions due to: - Planned maintenance - Leak detection drop-testing - Shutdown error - Break/burst repair - Network pump failure
Low network pressure / partial vacuum	High flow from break/burst High hydrant flows - fire/flushing Pipe encrustation/corrosion Network pump failure
Network pressure fluctuations	Network inadequate for demands Pipe encrustation/corrosion
Increased network pressure	Pump / Pressure Reducing Valve failure Compromise of distinct pressure zones Private pump causing localised pressure increase

Table 2: Typical Hydraulic Integrity Failures and Contributing Factors.

2.1.3 WATER QUALITY INTEGRITY

This barrier is based on the disinfection capacity of supplied water to deal with microbial contaminants, thereby achieving the disinfection residual required by the DWSNZ within the distribution network.

The DWSNZ give highest priority to health risks arising from microbial contaminants because they can lead to rapid and major outbreaks of illness. The primary indicator in this objective in based on sampling for residual Free Available Chlorine (FAC) at a chosen point in the network. Typical water quality integrity failures and contributing factors are summarized in Table 3.

Water Quality Integrity Failure	Contributing Factor
Taste and Odour Complaints	Treatment or internal distribution network contamination Backflow from private system internal contamination, no cross-connections Backflow from private cross-connection or other network physical barrier failure
Reported illness – water suspected	Treatment or internal distribution network contamination Backflow from private cross-connection or other network physical barrier failure
Death or multiple illnesses – water confirmed	Treatment or internal distribution network contamination Backflow from private cross-connection or other network physical barrier failure

Table 3: Typical Water Quality Integrity Failures and Contributing Factors.

2.2 NETWORK BARRIERS AND BACKFLOW

Backflow due to *back-siphonage* occurs due to failure of Hydraulic Integrity where pressure in the distribution network is less than the pressure in a private system. Backflow due to *backpressure* occurs due to a unique failure of Hydraulic Integrity where there is increased pressure from a pump operating within a private system, thereby exceeding the pressure in the distribution network. For backflow to occur in either of these situations, there must be a coincident failure of both Hydraulic and Physical Integrity in the network, affecting the private system in question.

This event, however does not necessarily lead to contamination of drinking water unless a cross-connection also exists. Cross-connections occur when a source of liquid, solid or gas contamination is in contact with or connected to a system supplying drinking water - effectively a failure of Physical Integrity within a private system. In this situation, contaminated water then has the potential to flow back initially within the private system and subsequently entering the distribution network, should a backflow event occur.

In the undesirable event of backflow contamination through a cross-connection, Water Quality Integrity is the last defence to prevent the contaminant from causing a health risk to the community. However, factors such as water age or network contamination due to biofilm can significantly reduce the disinfectant capability and in the case of a chemical contaminant a disinfectant may be of little benefit. This barrier is also not available to 23% of the population connected to registered drinking water supplies due to the absence of residual disinfectant in treated water (source: Ministry of Health. *Annual Review of Drinking-Water Quality in New Zealand 2008/9*). It is no oversight that backflow prevention criteria in Public Health Grading of Community Drinking-Water Supplies applies four demerit points per graded zone for 'Legislative requirements not met, but [with] residual disinfectant' and nine demerit points for 'Legislative requirements not met, no residual disinfectant'.

3 THE UNPLEASANT TRUTH ABOUT BACKFLOW

3.1 BARRIER SUCCESS IN PRACTICE

In the absence of a functioning containment backflow prevention device at every network connection within an affected zone, a degree of back-siphonage may occur each time pressure in the distribution network is sufficiently reduced. The practice of flushing following routine network isolation subsequently assists to minimise the effect of any resulting backflow contamination by removing the majority (but not all) of the residual water within the affected zone, and in some cases by introducing water with a reduced age and improved disinfection.

Network isolation in a zone without universal, functioning containment backflow prevention devices must logically present an elevated risk of a contamination incident. However in practice, undetected backflow contamination incident(s) may be indirectly mitigated by any or all of the following practices or measures.

- Effective residual disinfection suitable for counteracting any introduced contaminants.
- Thorough supplier flushing prior to fully pressurizing affected zone.
- Absence of hazardous private cross-connections within affected zone.
- Effective functioning of existing non-testable physical barriers such as meter non-return valves.
- Adequate physical barriers within private systems such as air gaps or testable backflow prevention devices.
- Contaminated water causing aesthetic customer concern (including entrapped air), requiring private system flushing and therefore no human consumption – incident not reported for further investigation.
- Contaminated water causing aesthetic customer concern (including entrapped air), requiring supplier and private system flushing and therefore no human consumption. - reported, but no further investigation into likely cause or correlation.
- Contaminated water causing no aesthetic customer concern and unwittingly supplied to customers but fortuitously, no human consumption. Contamination flushed to waste through normal use.
- Resulting illness from consumption of contamination not attributed to water by customers. Not reported for further investigation.

Given that it is often difficult to determine how many people become ill after drinking contaminated water unless there is a large outbreak of disease, it is possible that undetected backflow events occur on a regular basis due to unplanned fluctuations or issues within the operational distribution network but where the actual water returned contains either; no contaminants, non-hazardous contaminants or hazardous contaminants that are fortuitously inconsequential (or not consumed) and are unreported.

3.2 BACKFLOW CONTAMINATION INCIDENTS

There have been a number of documented incidents of contaminants of varying toxicity entering the drinking water supply in New Zealand. One well known serious incident in 1994 involved a small town supplied with drinking water from the local dairy processing facility. Sadly, a customer was burned by caustic soda in his residential shower due to a backflow incident affecting the town supply.

New Zealand generally has relatively high rates of largely preventable enteric or gastro-intestinal disease and while there are a variety of contributing factors, the Ministry of Health has published a number of confirmed backflow related cases, including an outbreak of waterborne cryptosporidiosis affecting 170 people in the Waikato in 1997. Backflow from farms in the area was concluded as the probable source. In 1991 a cluster of 12 campylobacteriosis cases in the Hawkes Bay were investigated and a potential for back siphoning was discovered where water may have entered the reticulation system via a roadside drain contaminated with a high level of faecal coliforms.

There are also numerous more recent New Zealand cases described by drinking water suppliers involving discoveries of compressed air, paint, beer, orange juice, fish, tomato sauce and black water from stagnant fire sprinklers among other contaminants. Fortunately these and similar cases did not result in adverse health effects so were not necessarily documented but people working in fields of water supply or commercial plumbing could regularly describe actual cases of contamination by backflow.

Numerous cases studies from Australia and the United States describe incidents of backflow contamination resulting in illness and in some cases, death. While these incidents involve a wide range of contaminants from a variety of industry types, some more recent cases have involved recycled or pumped wastewater cross-connections within private systems. A 2006 report by the U.S. National Research Council Committee on Public Water Supply Distribution Systems: Assessing and Reducing Risks (USNRCC report) concluded that one of most common means of contaminating distribution systems is through a cross connection. It is clear that former New Zealand drinking-water legislation gave little effective protection or deterrence against a major outbreak of disease caused by deliberate or accidental contamination of drinking water supplies. However, despite recent initiatives by the Ministry of Health to further promote '*adequate supplies of safe and wholesome drinking water from drinking-water supplies'* through the DWSNZ and the Health (Drinking Water) Amendment Act 2007, it is likely that the risk of contamination through backflow remains a very real threat to community health in New Zealand.

3.3 SUPPLIER AND CONSUMER TRENDS

International trends in effective water supply network management are promoting improvements in Physical, Hydraulic and Water Quality Integrity with the intention of improving levels of service, minimising leakage and improving water quality in general. Despite an abundance of good quality source water in most areas of New Zealand, drinking water suppliers also face drivers for these improvements in the form of regulatory requirements, water resource allocation and industry best practice initiatives.

If minimising supply interruptions and fluctuations is becoming standard practice, we would assume a corresponding benefit would be decreased instances of back-siphonage where physical barriers fail. Conflicting with this practice, however, can be efforts to detect previously unreported leakage, improve maintenance of network assets and these efforts can require additional supply interruptions, be it through improved customer communication, reduced interruption time and often during periods of low-demand.

It is also likely that consumer trends influencing private systems have an increasing impact on drinking water suppliers in the area of backflow risk. Potential factors, although not exhaustive, could include:

- An increasing range of 'must have' consumer products with cross-connection potential. Examples include irrigation systems, bidets, spa pools, chemical applicators.
- Global decreases in product price and corresponding quality, which can include internal cross-connection protection standards.
- Changes in customer water use. Examples include flexible shower outlets, super-tubs, wider use of automated commercial machines and system pumps.
- Increases in domestic rain/retention tanks, grey water reuse.
- New Zealand DIY approach. Plumbing repairs and installations are no exception.
- Aging and poor quality private plumbing resulting in biofilm or corrosion.
- General prevalence of cross-connections due to the unknown and uncontrollable nature of private plumbing system changes.

4 THE EXTERNAL DRIVERS FOR SAFE DRINKING WATER

4.1 THE LOCAL GOVERNMENT ACT 2002

The Local Government Act 2002 is the primary legislation defining the general purpose and obligations of **local authorities** (includes provision of water services).

> ***Section 10 Purpose of local government***
> *(b) To promote the social, economic, environmental, and cultural well-being of communities, in the present and for the future.*

4.2 THE HEALTH (DRINKING WATER) AMENDMENT ACT 2007

The Health (Drinking Water) Amendment Act 2007 (HDWAA2007) specifically defines the overall purpose of a **drinking water supplier** and revokes the Water Supplies Protection Regulations 1961, of which backflow prevention was a vital component. This amendment, considered here in isolation from the principal Act, inserts updated responsibilities to protect the distribution network from risk of contamination from backflow but has no jurisdiction to protect customers from health risks associated with backflow contamination entirely contained within their private system.

> ***Part 2A Drinking Water***
> *The purpose of this Part is to protect the health and safety of people and communities by promoting adequate supplies of safe and wholesome drinking water from all drinking-water supplies.*
>
> ***69G Interpretation***
> *…point of supply…as defined in any bylaw, supply agreement or local Act that applies…*
>
> ***69ZZZ Protecting water supplies from risk of back-flow***
> ***(1)*** *This section applies if a networked supplier considers that there is a need to protect the networked system from risks of pollution caused by water and other substances on properties connected to the networked system.*
>
> ***(2) (a) (i)*** *A networked supplier may, if the supplier considers it desirable or necessary, install a back-flow prevention system in the network on the side of the point of supply for which the supplier is responsible for maintaining;*
>
> ***(2) (b) (i)*** *A networked supplier may require the owner of the property in respect of which the back-flow prevention system operates or the person who is required (whether under the Local Government Act 2002 or any contract) to pay for drinking water supplied to that property, to reimburse the supplier for the cost of that system (including the cost of installation, testing, and on-going maintenance);*
>
> *OR*
>
> ***(2) (a) (ii)*** *A networked supplier may, if the supplier considers it desirable or necessary, allow the owner of property to which water is supplied to install a back-flow prevention system that incorporates a verifiable monitoring system (being a monitoring system approved by both the supplier and a drinking-water assessor):*
>
> ***(2) (b) (ii)*** *A networked supplier may require the owner of the property in respect of which the back-flow prevention system operates or the person who is required (whether under the Local Government Act 2002 or any contract) to pay for drinking water supplied to that property, to repair or modify any back-flow prevention system that, in the opinion of the supplier, is not functioning adequately.*
>
> ***(3)*** *A person who installs a back-flow protection device must take all reasonable steps to ensure it can operate in a way that does not compromise the operation of any automatic sprinkler system connected to the water supply.*
>
> ***(4)*** *A networked supplier—*
> ***(a)*** *must test each back-flow protection device operating in its network at least once a year; and*
> ***(b)*** *must advise the territorial authority in its area of the results; and*
> ***(c)*** *may require the occupier of the property in respect of which the device operates to pay the reasonable costs involved in conducting the test.*

The **drinking water supplier** must clearly define the *point of supply* in published literature as the interface where responsibility for ownership and maintenance is reassigned from supplier to customer - irrespective of proximity to the property boundary, and covering all connection configurations.

With careful consideration of requirements for automatic fire sprinklers, device monitoring and testing notification, the supplier has the option of:

- Installing device(s) the supplier *considers desirable or necessary*, redefining the point of supply where required and forwarding all costs to the customer; OR

- Approving customer installation and monitoring of device(s) the supplier *considers desirable or necessary*.

4.3 THE HEALTH ACT 1956

The Health Act 1956 outlines powers and duties of **local authorities** in respect of public health and allowing them to make bylaws for the protection of public health. These duties are typically undertaken by the regulatory units of local authorities.
Note the term "drinking water" inserted into S23 (f) by the Health (Drinking Water) Amendment Act 2007.

Section 23 General powers and duties of local authorities in respect of public health
Subject to the provisions of this Act, it shall be the duty of every local authority to improve, promote, and protect public health within its district, and for that purpose every local authority is hereby empowered and directed—
(a) *To appoint all such Environmental Health Officers and other officers and servants as in its opinion are necessary for the proper discharge of its duties under this Act:*
(b) *To cause inspection of its district to be regularly made for the purpose of ascertaining if any nuisances, or any conditions likely to be injurious to health or offensive, exist in the district:*
(c) *If satisfied that any nuisance, or any condition likely to be injurious to health or offensive, exists in the district, to cause all proper steps to be taken to secure the abatement of the nuisance or the removal of the condition:*
(d) *Subject to the direction of the Director-General, to enforce within its district the provisions of all regulations under this Act for the time being in force in that district:*
(e) *To make bylaws under and for the purposes of this Act or any other Act authorising the making of bylaws for the protection of public health:*
(f) *To furnish from time to time to the Medical Officer of Health such reports as to diseases, drinking water, and sanitary conditions within its district as the Director-General or the Medical Officer of Health may require.*

4.4 THE BUILDING ACT 2004

The Building Act 2004 (BA2004) - including amendments - outlines the duties of the building consent authority (BCA) and territorial authority with respect to the regulation of all building work. The Act and relevant building regulations/codes cover all private plumbing work and specified systems (including '*Automatic back-flow preventers connected to the potable water supply*') within a private property boundary.

4.4.1 WORK REQUIRING BUILDING CONSENT

Duties covered by the BA2004 do not apply to a NUO (Network Utility Operator), so the options for the drinking water supplier to install a backflow prevention device in section 4.2 above, appear to fall outside of the requirements of the BA2004.

S9 Building: what it does not include
(a) *In this Act, building does not include a NUO system, or part of a NUO system, that-*
(i) *is external to the building, and*
(ii) *is connected to the building or is intended to be connected to, the building to provide for the successful functioning of the NUO system in accordance with the system's intended design and purpose;*

S7
network utility operator means a person who undertakes or proposes to undertake the distribution of water for supply (including irrigation).

4.4.2 BACKFLOW PROTECTION AT SOURCE

The New Zealand Building Code Clause G12 (NZBC G12) under the BA2004 promotes protection at contamination source by a suitable 'air gap' or an approved device.

G12.1
The objective of this provision is to safeguard people from illness caused by contaminated water…

G12.2
Buildings provided with water outlets, sanitary fixtures or sanitary appliances must have safe and adequate water supplies.

G12.3.2
A potable water supply system shall be protected from contamination; and installed in a manner which avoids the likelihood of contamination within the system and the watermain…

G12.3.7
Water supply systems must be installed in a manner that…allows the system and any backflow prevention devices to be isolated for testing and maintenance.

4.4.3 HAZARD DEFINITION AND APPROPRIATE DEVICES

Compliance Document for the NZBC G12 Water Supplies – Third Edition: Acceptable Solution G12/AS1 provides guidance on hazard ratings for various types of facilities, appliances and promotes protection at contamination source.

3.3.1 High Hazard
Any condition, device or practice which, in connection with the potable water supply system, has the potential to cause death.

3.3.2 Medium Hazard
Any condition, device or practice which, in connection with the potable water supply system, has the potential to injure or endanger health.

3.3.3 Low Hazard
Any condition, device or practice which, in connection with the potable water supply system, would constitute a nuisance, by colour, odour or taste, but not injure or endanger health.

3.4.1 Backflow Prevention
Backflow protection shall be provided where it is possible for water or contaminants to backflow into the potable water supply system.

4.4.4 COMPLIANCE SCHEDULES

The BA2004 also requires all non-residential and residential developments with backflow prevention devices to also have an annual Building Warrant of Fitness (BWOF) to manage the required inspection, and maintenance and reporting procedures for specified systems under a compliance schedule.

Section 100 Requirement for compliance schedule

(2) A compliance schedule is required for a building (except a building used wholly as a single household unit) if the building has any specified systems.

Section 103 Content of compliance schedule

***(1)** A compliance schedule must state-*

(a) the specified systems that are covered by the compliance schedule; and

(b) the performance standards for the specified systems; and

(c)the inspection, maintenance, and reporting procedures to be followed by licensed building practitioners [or other persons] in respect of the specified systems to ensure that those systems are capable of, and are, performing to the performance standards;

The BA2004 requires building consent for private backflow prevention device(s) installed at the source of hazard, inside a property boundary for the purpose of protecting both building occupants and the distribution network. Building consent initiates a compliance schedule and requires thorough recording, maintenance and annual testing of all devices. Backflow prevention devices forming part of the distribution network appear to fall outside of the requirements of the BA2004 relating to consent or compliance schedule.

4.5 AS/NZS 3500.1 PLUMBING AND DRAINAGE – WATER SERVICES

This standard provides alternative guidance on hazard ratings for various types of facilities and appliances, specifying the requirements for the design, installation and commissioning of cold water services (including backflow prevention devices) from connection to points of discharge. It applies to new installations and alterations to existing installations and may be used for compliance with the NZBC G12.

A number of drinking water suppliers have adopted this standard to define hazard ratings and suitable backflow prevention device types and installation standards within the distribution network.

4.6 NZS 4541 AUTOMATIC FIRE SPRINKLER SYSTEMS

This standard specifies the requirements for backflow prevention within supplies to automatic fire sprinkler systems - to protect public and on-site drinking water supplies in accordance with the NZBC G12.

404.3.1

Backflow prevention shall be installed to protect public and on-site potable water supplies. In-ground hydrants that are part of the building shall be backflow protected. The method of protection shall be as required by Compliance Documents of the New Zealand Building Code Clause G12.

604.1.6 Connections for hose reels and other low demand uses

***(e)** Where required by the Building Consent Authority, such connections are fitted with an approved backflow prevention device.*

604.1.7 Connections for industrial and/or high demand use

***(g)** Where required by the Building Consent Authority, such connections are fitted with an approved backflow prevention device.*

1202.4 Yearly checks

***(d)** Backflow prevention devices forming part of the water supply system being supplied with potable water shall be tested annually according to the procedure specified in the New Zealand Building Code Clause G12;*

4.7 NZS 4517 FIRE SPRINKLER SYSTEMS FOR HOUSES

This standard specifies the requirements for backflow prevention in accordance with the New NZBC G12.

6.5.2 Backflow Protection
Backflow protection is required for independent systems.

C6.5.2 Backflow Protection
Regardless of the requirements of this Standard, the water supply authority may require backflow prevention to be provided where a combination system in installed.

K3 Annual checks
The following checks should be carried out annually:
(b) *Backflow prevention device, if fitted, should be tested to AS 2845.3.*

5 ESTABLISHING THE CONTEXT

Despite the range of occasionally contradictory Acts, Regulations and National Standards prescribing backflow prevention requirements in a manner and at various points in the distribution system between source and tap, there is clearly a common objective – the supply of safe drinking water to an entire community. If each responsible organisation were to operate in an acceptable but isolated manner, the outcome based on these separate approaches, while presumably effective, must surely result in duplication and additional cost, resourcing, and administrative burdens to all involved. A significant step in a common objective would require the drinking water supplier identifying and consulting the full range of stakeholders and participants in order to achieve the required commitment.

5.1 STAKEHOLDERS

Stakeholders could be defined as people or parties with…

- *power of influence over…*
- *interest or gain in…*
- *potentially positive / negative affect on...* the success of the objective.

Key stakeholders are considered to have a more significant role in determining the success of this common objective. In a number of cases, these parties are also directly involved in maintaining the integrity of more than one of the three key contamination barriers outlined in section 2.1. While not an exhaustive list, Table 4 outlines a range of typical stakeholders for consideration.

Key stakeholders	Other stakeholders
Consumers / property owners	Licensed plumbers
Drinking Water Suppliers	Independently Qualified Person (IQP) backflow testers
Drinking Water Assessors	Merchants / manufacturers
Building Consent Authorities	Industry technical and training organisations
Local Authorities	Developers / fire and building services designers
Regional collaborations	Hydrant users
Network water technicians	Central Government

Table 4: Stakeholders in a Common Objective: Supplying Safe Drinking Water.

5.2 METHODOLOGY

There currently exists a wide range of approaches to backflow prevention within local government throughout New Zealand. Some drinking water suppliers have enforced mandatory testable backflow prevention devices at all network connections with minimal or no consideration to controls that may exist within a private system. In contrast, many local authorities leave the responsibility solely on the shoulders of the BCA or regulatory unit with the disclaimer *"issues inside a property are the role of the building people"*. This statement is neither untrue nor entirely true. As previously outlined in section 4.4.2, NZBC G12 requires that source protection within a private system also contributes to the protection of the distribution network. Similarly, automatic fire sprinkler standards outlined in sections 4.6 and 4.7 require backflow prevention devices for this common benefit.

The USNRCC report recommends five primary elements of an effective cross-connection control programme. Experience in developing an integrated program at Waitakere City Council has prioritised substantially similar concepts, categorised in a slightly different manner. For the purpose of this paper, I will use the five USNRCC report elements with supporting concepts from experience in the New Zealand context.

5.2.1 AUTHORITY

Legislation clearly authorises a range of participants within the functions of local government to assess backflow contamination risk, enforce appropriate action, install and test devices given that:

- Agreement is reached by all key stakeholders – preferably written
- A thorough, integrated and legally robust policy is in place with clear references to:
    - Supplier customer contract
    - Supplier connection application
    - Supplier standard installation drawings
    - Bylaws (if relevant)
    - Enforcement and management process
    - Property entry criteria (where necessary)
    - Supplier device testing and maintenance program

5.2.2 INSPECTION AND TESTING

Effective management of cross-connections can only be achieved by proper assessment on all fronts. This includes:

- Building consent processing
- Supplier connection applications
- Supplier water quality and consumption alerts
- Compliance schedule testing
- Notified change of use of properties
- Proactive surveillance of the community and regular property inspections through employed officers or contracted services
- Testing of supplier owned devices
- Auditing of all testing and assessment QA processes – both internal and external

5.2.3 TRAINING AND CERTIFICATION

Ongoing training and certification of persons responsible for risk assessment, device installation and testing is a core requirement for achieving the common objective. This element involves perhaps the widest range of participants – beginning with central government. Many local authorities have individual or regional Independently Qualified Person (IQP) registration systems in place under the BA2004. Drinking water suppliers generally have similar criteria for testing of devices within the distribution network although there is no national consistency.

In order to resolve the inconsistency, the Department of Building and Housing is currently finalising an industry represented body, the New Zealand IQP Registration Board Incorporated, supported by Water New Zealand, in order to nationally regulate the qualification and re-certification criteria for all IQP backflow testers.

5.2.4 RECORD KEEPING

The significance of thorough, robust records cannot be underestimated in an effective program. Firstly, under the BA2004, '*a compliance schedule should be specifically tailored to a building and its specified system(s) to ensure the ongoing performance of the specified systems to the required performance standards and to allow those carrying out and auditing the compliance schedule requirements to understand what is required'*. Responsibility for developing the compliance schedule lies with the BCA, inspection and maintenance procedures with the property owner. Secondly, the HDWAA 2007 requires a verifiable monitoring system for devices installed by a property owner, as considered desirable or necessary by the drinking water supplier. Suppliers could consider utilising an existing or newly created compliance schedule for the property concerned. Thirdly, a degree of auditing of all inspections and device testing must be achieved annually. Fourthly, contingency plans also required under the PHRMP rely on accurate local information. Finally, in order to also prepare meticulous records of all inspections, correspondence and decisions are necessary to allow enforcement action to proceed. This is particularly critical in situations subject to legal challenge by disgruntled property owners.

5.2.5 PUBLIC EDUCATION

This is perhaps the primary mechanism for engaging external stakeholders and it is vitally crucial that all approaches are undertaken in a manner that is simple, clear, non-technical where possible, visually appealing and customer service oriented. Effective public awareness can be achieved in the form of:

- Brochures, posters for merchandisers and manufacturers
- Online information
- Newspaper advertisements
- Mail-outs to selected groups such as pool owners
- Engagement in local plumbing exhibitions, training programs, IQP meetings
- Simplifying and collating building consent and compliance schedule documentation

6 CONNECTION RISK ASSESSMENT CRITERIA

When developing a PHRMP, drinking water suppliers are primarily required to demonstrate how a comprehensive plan will reduce the risk of contaminants entering supplies, based on the multiple barrier approach. Although the Ministry of Health guiding documents provide a good basis for developing such a plan, I suggest the risk tables for backflow prevention are little more than *hazard* definition from G12/AS1 or AS/NZS 3500.1 relabeled as *risk* without consideration to the wide range of contributing factors.

A better practice for drinking water suppliers is to define and implement a true backflow risk assessment methodology based on an holistic set of contributing risk factors. Factors such as the potential *consequence* of an event on the community (including hazard), the *likelihood* of an event occurring, and a range of existing and alternative options to achieve the necessary controls (physical barriers) must be considered. Such a practice doesn't need to provide backflow prevention devices at every network connection. Rather, existing controls in place by way of adequate internal protection and meticulous *'inspection and maintenance procedures'* under the BA2004 can be considered.

Defining a true backflow risk assessment methodology involves identifying a range of key factors in determining the *consequence* and *likelihood* of an actual backflow contamination event and incorporating these key factors in an assessment template for each network connection. The assessment of *consequence* and *likelihood* can then be qualitatively used to determine *risk and necessary controls* (including auditing) and these can be appropriately elevated if evidence available for assessment is insufficient.

Please note, the following draft assessment methodology is proposed purely as an example, having been developed in the draft form shown for a specific distribution network. Drinking water suppliers are advised to develop, test and implement risk assessment tools unique to their local community in order to contribute to an overall PHRMP for each supply. The intended application of this methodology is in no way quantitative –

rather a judgement can be made by denoting property specific factors on each assessment table, followed by an overall judgement of residual risk using a suitable risk level matrix.

6.1 CONSEQUENCE ASSESSMENT TABLE

While not an exhaustive list, the range of hazards defined in G12/AS1 or AS/NZS 3500.1 is essentially a collection of simplistic potential consequences to the human occupants of a property, resulting from a cross-connection with any of the listed hazards within that property.

Using hazard alone to determine the necessary controls, however, can be problematic and inconsistent. By this definition alone, for example, chemical added irrigation is just as hazardous as dental equipment. In reality, the former constitutes a significantly higher backflow risk due to the potential for highly toxic and substantial quantities of chemicals, pumps and a larger volume of water contained within the private system.

A networked supplier must take a fairly conservative approach when considering the backflow risk to the wider community so while hazard definitions are primarily concerned with the initial consequences of a backflow event within a private system, the subsequent consequences within the distribution network of the same event are of greater concern.

The following list is not exhaustive, but covers a range of factors that can be incorporated in an assessment of consequence.

- Degree of property Hazard(s) and quantities (combined effect of hazards)
- Hazard water supply inlet diameter (effect of quantity/rate likely to backflow)
- Water Network connection diameter (bulk or dilution effect of any stored contaminants)
- Onsite pumps / tanks / toxic storage (toxic nature and quantity of hazards)
- Proximity to concentration of local connections - particularly residential (effect on surrounding network – modeled or estimated)

Figure 1 is a proposed tool for assessing the consequence of a backflow event on the distribution network.

CONSEQUENCE TO THE NETWORK OF BACKFLOW POTENTIAL

	CONSEQUENCE				
ASSESSED PROPERTY / CONNECTION FACTORS	1	2	3	4	5
Hazard degree and quantity [cumulative effect of hazard(s)]	1 low hazard or no hazards	1 med hazard and/or multiple low hazards	1 med hazard or multiple med/high devices with internal protection	1 high hazard and/or multiple medium hazards	Multiple high hazards OR hazard unknown
Hazard supply inlet diameter [effect of quantity/rate likely to backflow]	≤ 8mm	8-15mm	15-25mm	25-50mm	≥ 50mm
Water Network connection diameter [bulk effect of stored contaminants]	15-20mm	25-40mm	50-80mm	100-150mm	≥ 200mm
Onsite pumps / tanks / toxic (gas/liquid) storage [toxic nature and quantity of hazards]	No onsite storage / chemicals	Fire / potable rain water storage	Minor stored non-toxic contaminants and/or processing tanks	Minor stored toxic chemicals / contaminants and/or toxic processing tanks	Bulk toxic chemicals / contaminants
	Negligible	Minor	Moderate	Major	Severe
Proximity to concentration of local connections - particularly residential [effect on surrounding network – modelled or estimated]	Network fringe. Minimal / no effect	Local main to minimal pop density	On bulk main to low pop density	On bulk main to small / residential community	On bulk main to large / residential community

Figure 1: Proposed Consequence Assessment Table

6.2 LIKELIHOOD ASSESSMENT TABLE

In keeping with the need for a fairly conservative approach when considering the backflow risk to the wider community, we must assess the likelihood of a backflow event occurring if the hydraulic integrity of the distribution network is compromised. The following list is not exhaustive, but covers a range of network connection and property related factors that can be incorporated in this assessment of likelihood.

- Site access / security / commercial sensitivity (likelihood of undetected hazardous operations)

- Device access (likelihood of containment device removal/bypass/damage)
- Site elevation (likelihood of back siphonage)
- Site plant (likelihood of backpressure from pumps etc)
- Number of separately tenanted units (cumulative hazardous use likelihood)
- Internal controls / maintenance (likelihood of poor device/equipment maintenance)
- Piping complexity & extent (likelihood of internal change/negligence/device bypass)
- Tenanted properties - years since last property backflow inspection / notified change of use
- BWOF status (likelihood of sufficient controls, managed by local authority)
- Appropriate internal protection (likelihood of mitigation by internal control)
- Current test cert status (likelihood of proper device functioning)

Figure 2 is a draft tool for assessing the likelihood of backflow occurrence.

LIKELIHOOD OF BACKFLOW OCCURANCE

	LIKELIHOOD				
SITE / PROPERTY CONDITIONS	**A**	**B**	**C**	**D**	**E**
Site access / security / commercial sensitivity [likelihood of undetected hazardous operations]	Full access				No / limited access
Device access [likelihood of containment device removal/bypass/damage]	Device visible from boundary	Good access, not boundary visible	Poor device access	Cant sight device	No access
Site Elevation [likelihood of back siphonage]	>10m below main	Below main	Above main		>10m above main
Site plant [likelihood of backpressure]	No pumps		Backup pumps	Pumps / undetermined	
Number of separately tenanted units [cumulative hazardous use likelihood]	Single	2-3	3-5	6-10	>10
Internal controls / maintenance [likelihood of poor device/equipment maintenance]	Good		Average	Poor / undetermined	
Piping complexity & extent [likelihood of internal change/negligence/device bypass]	Simple, small system	Simple, large system			Complex, large system/ undetermined
Tenanted properties - years since last property inspection / notified change of use	<2Y	>5Y			>10Y / undetermined
BWOF status [likelihood of sufficient controls, managed by local authority]	BWOF			BWOF no BF / No BWOF	No BWOF
Appropriate internal protection [likelihood of mitigation by internal control]	Internal containment protection	Internal zone / source protection	Internal containment protection	Multiple internal source / zone protection	No internal protection evidence
Current test cert status [likelihood of proper device functioning]	Regular test cert.		No test cert.		

Figure 2: Proposed Likelihood Assessment Table

6.3 RISK AND NECESSARY CONTROLS - PROPOSED

The assessment of network connection and property related raw backflow risk can then be qualitatively superimposed onto a suitable matrix for determining the level of residual risk and any (additional) controls considered necessary by the supplier. The fringe areas of each risk level should be carefully analysed in order to confirm these proposed boundaries.
Figure 3 is an example of a proposed backflow risk level matrix with the following risk categories.

6.3.1 LOW RISK

- Adequate private source/zone protection as a minimum
- Current BWOF, including category ‘automatic backflow preventers’
- Supplier containment control – Dual Check Valve

6.3.2 MEDIUM RISK

- Adequate private source/zone protection as a minimum
- Current BWOF, including category ‘automatic backflow preventers’
- Proposed 10% audit of all device testing
- Supplier containment control – testable Double Check Valve

6.3.3 HIGH RISK

- Supplier or private containment device mandatory (regardless of private source/zone protection)
- Current BWOF if containment device private, including category 'automatic backflow preventers'
- Supplier or private testing of containment device
- Proposed 10% audit of all device testing
- Supplier containment control – testable Double Check Valve or Reduced Pressure Zone Device (based on assessed consequence)

6.3.4 VERY HIGH RISK

- Supplier or private containment Reduced Pressure Zone Device mandatory - at point of connection only
- Supplier or private testing of containment device
- Proposed 15% audit (or higher) of all device testing

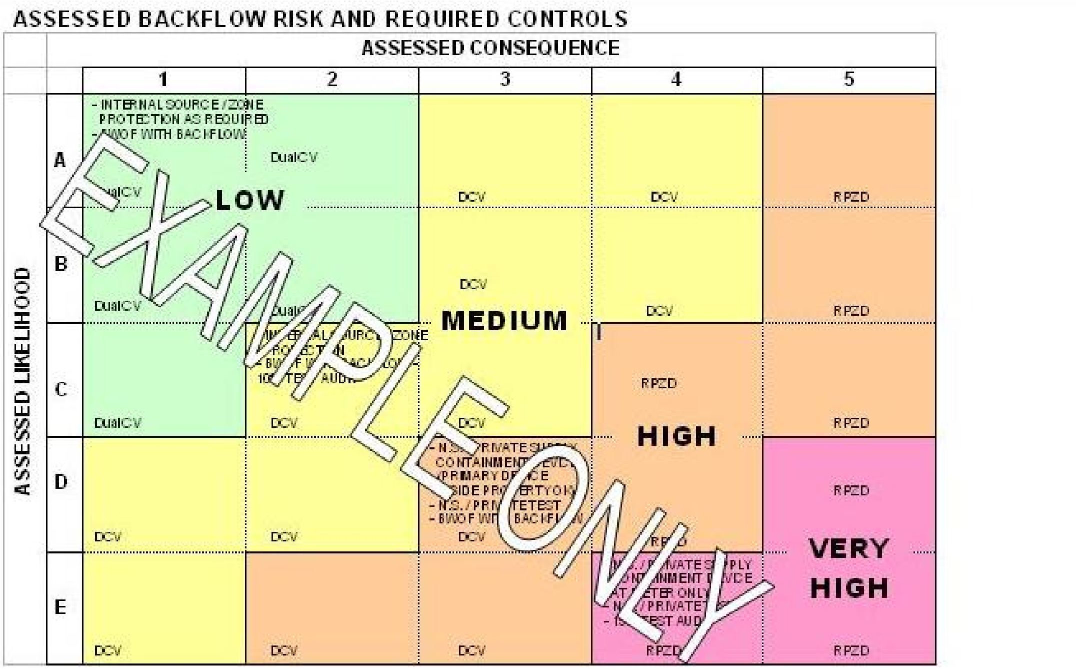

Figure 3: Proposed Backflow Risk Level and Required Controls Matrix

As can be observed from Figure 3, the required controls include a range of device types, device locations, verifiable monitoring systems and audit levels. In some cases, non-testable devices can be considered as adequate controls in relatively low risk situations.

7 CONNECTION RISK ASSESSMENT CASE STUDIES

The proposed backflow risk assessment methodology outlined in section 6 is in its infancy and is currently being tested as part of the proactive surveillance of properties connected to the drinking water network by Waitakere City Council. The case studies in Table 5 are drawn from Waitakere City experience of risk assessment over a period of 3-4 months. The author has endeavoured to briefly summarise the significant factors relevant to each site, however in some instances evidence for readers may be limited in the absence of a full property inspection report.

Property	**Features**	**Hazard(s)**	**Hazard only assessment**	**Risk assessment (using proposed methodology)**
Industrial building, largely vacant with	Disused bore with intact plumbing -	Domestic use with appropriate	Low hazard (no cross-connections)	Medium Risk – limited future site

disused fish farm.	formerly supplying, empty fish tanks. Domestic facilities, hose fixtures with vacuum breakers.	measures, bore “abandoned”, fish tanks in separate building with no potable supply.	– Dual Check Valve (DualCV) at meter.	access, poor internal controls, likelihood of internal change/negligence.
Industrial complex, 13 separately tenanted spaces.	Small scale food manufacturing, storage, light industrial, some vacant units. Low consumption.	Domestic use with appropriate measures, no direct plumbed equipment, minimal non-hazardous hose fixtures with vacuum breakers.	Low hazard (no cross-connections) – DualCV at meter.	Medium Risk – quantity of tenanted units, likelihood of internal change/negligence.
Large scale meat processing facility.	Extensive private system with numerous hazards, recirculating heating / cooling systems. 150mm connection. Thorough BWOF compliance.	Numerous high and medium hazards protected by source / zone devices. Containment Reduced Pressure Zone Device (RPZD) within secure perimeter but out of sight.	Numerous High Hazards – RPZD at meter (in duplication of private controls).	High Risk – privately tested source/zone devices and internal containment RPZD.
Small shellfish processing plant.	Moderate private system with numerous hazards. Thorough BWOF compliance.	Numerous high and medium hazards with adequate measures and testable devices. Containment Double Check Valve (DCV).	Numerous high and medium hazards but no unprotected cross-connections – upgrade containment DCV to RPZD.	High Risk - privately tested source/zone devices but containment DCV only.

Table 5: Case Studies from Waitakere City.

Commonly, previous approaches to containment protection (protection of the distribution network) have insisted on a meter containment device of equal or higher protection level to internal hazards, irrespective of existing internal protection. By contrast, an assessment of true risk using an holistic range of contributing factors can result in lower residual risk and subsequently down-graded meter containment controls.

A conscientious drinking water supplier may arrive at a similar assessment of required meter containment controls in some cases without the aid of the proposed assessment methodology, but I suggest the proposed process can provide a more rigorous and transparent justification for decisions – particularly in support of any resulting enforcement.

8 CONCLUSIONS

Backflow is considered a current risk to many drinking water suppliers in New Zealand due to the unknown and uncontrollable nature of private plumbing systems. A variety of regulatory drivers exist for backflow prevention at various points between source and tap, but separate approaches easily result in duplication and additional cost and administrative burdens to all. A true risk based approach doesn’t require protection at every boundary, rather a solid policy and an integrated methodology that can determine effective controls in a more rigorous and transparent manner, taking into consideration a wide range of contributing factors. The Health (Drinking Water) Amendment Act 2007 has empowered Networked Suppliers to lead a committed approach to delivering wholesome drinking water by implementing a Public Health Risk Management Plan that can involve all stakeholders and minimise the cost of that delivery to the community.

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